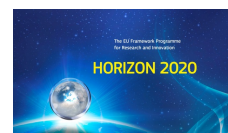




EUROPEAN COMMISSION
Innovation and Networks Executive Agency
Director



GRANT AGREEMENT

NUMBER — 653718 — ENOS

This **Agreement** ('the Agreement') is **between** the following parties:

on the one part,

the Innovation and Networks Executive Agency (INEA) ('the Agency'), under the power delegated by the European Commission ('the Commission')¹,

represented for the purposes of signature of this Agreement by Executive Director, Innovation and Networks Executive Agency, Dirk BECKERS,

and

on the other part,

1. 'the coordinator':

BUREAU DE RECHERCHES GEOLOGIQUES ET MINIERES (BRGM), 582056149, established in 3 AV CLAUDE GUILLEMIN, ORLEANS 45060, France, FR67582056149, represented for the purposes of signing the Agreement by Directeur Général Délégué, Pierre TOULHOAT

and the following other beneficiaries, if they sign their 'Accession Form' (see Annex 3 and Article 56):

2. **BUNDESANSTALT FUER GEOWISSENSCHAFTEN UND ROHSTOFFE (BGR)**, n.a., established in Stilleweg 2, HANNOVER 30655, Germany, DE811289832,

3. **NATURAL ENVIRONMENT RESEARCH COUNCIL (BGS)**, RC000740, established in Polaris House, North Star Avenue, SWINDON WILTSHIRE SN2 1EU, United Kingdom, GB618367325,

4. **CESKA GEOLOGICKA SLUZBA (CGS)**, N/A, established in Klarov 3/131, PRAGUE 1 11821, Czech Republic, 025798,

5. **CENTRO DE INVESTIGACIONES ENERGETICAS, MEDIOAMBIENTALES Y TECNOLOGICAS-CIEMAT (CIEMAT)**, Q2820002J, established in Avenida Complutense 40, MADRID 28040, Spain, ESQ2820002J,

6. **FUNDACION CIUDAD DE LA ENERGIA (CIUDEN)** ES3, 913, established in AVENIDA DEL PRESIDENTE RODRIGUEZ ZAPATERO SN, PONFERRADA 24492, Spain, ESG84737238,

7. **FLODIM SARL (flodim) SARL**, 399286020, established in 110 RUE DES RIZIERES TECHNOPARC DES GRANDES TERRES, MANOSQUE 04100, France, FR28399286020,

8. **GEOGREEN (GGR)** FR39, 499 836 831 R.C.S NANTERRE , established in Rue Eugene et Armand Peugeot 7, RUEIL MALMAISON 92563 , France, FR18499836831 ,

9. **I.D.I.L. SAS (INGENIERIE-DEVELOPPEMENT-INSTRUMENTATION-LASER) (IDIL) SAS**, 401282371, established in 21 RUE DE BROGLIE, LANNION 22300, France, FR10401282371,

¹ Text in *italics* shows the options of the Model Grant Agreement that are applicable to this Agreement.



10. **INTERNATIONAL RESEARCH INSTITUTE OF STAVANGER AS (IRIS) AS**, 988944459, established in PROFESSOR OLAV HANSENS VEI 15, Stavanger 4068 , Norway, NO988944459MVA,

11. **NHAZCA SRL (NHAZCA) SRL**, 1250972, established in VIA CORI S.N.C., ROMA 00177, Italy, IT10711191006,

12. **ISTITUTO NAZIONALE DI OCEANOGRAFIA E DI GEOFISICA SPERIMENTALE (OGS)**, 58665, established in Borgo Grotta Gigante 42/C, SGONICO-TRIESTE 34010, Italy, IT00055590327,

13. **PALENCIA 3 INVESTIGACION DESARROLLO Y EXPLOTACION SL (PLC-3) SL**, P6379, established in CALLE ERIC KANDEL 1, GETAFE 28906, Spain, ESB85971224, as 'beneficiary not receiving EU funding' (see Article 9),

14. **STATNY GEOLOGICKY USTAV DIONYZA STURA (SGIDS)**, 31753604, established in MLYNSKA DOLINA 1, BRATISLAVA 81704, Slovakia, SK2020719646 ,

15. **SILIXA LTD (SILIXA)**, 06207412, established in CENTENNIAL AVENUE 230 CENTENNIAL, ELSTREE HERTFORDSHIRE WD6 3SN, United Kingdom, GB919322914,

16. **SOTACARBO - SOCIETA TECNOLOGIE AVANZATE CARBONE SPA. (SOTACARBO) SPA**, CA-139833, established in C/O EX MINIERA DI SERBARIU, CARBONIA 09013, Italy, IT01714900923,

17. **NEDERLANDSE ORGANISATIE VOOR TOEGEPAST NATUURWETENSCHAPPELIJK ONDERZOEK TNO (TNO)**, 27376655, established in ANNA VAN BUERENPLEIN 1, DEN HAAG 2595 DA, Netherlands, NL002875718B01,

18. **UNIVERSITA DEGLI STUDI DI ROMA LA SAPIENZA (UNIROMA1)**, 80209930587, established in Piazzale Aldo Moro 5, ROMA 00185, Italy, IT02133771002,

19. **THE UNIVERSITY OF NOTTINGHAM (UNOTT)**, established in University Park, NOTTINGHAM NG7 2RD, United Kingdom, GB690391225,

20. **CO2GEONET - RESEAU D'EXCELLENCE EUROPEEN SUR LE STOCKAGE GEOLOGIQUE DE CO2 (CO2GeoNet) FR3**, 508292802, established in avenue Claude Guillemin 3, ORLEANS 45060 , France, FR06508292802, as 'beneficiary not receiving EU funding' (see Article 9),

Unless otherwise specified, references to 'beneficiary' or 'beneficiaries' include the coordinator.

The parties referred to above have agreed to enter into the Agreement under the terms and conditions below.

By signing the Agreement or the Accession Form, the beneficiaries accept the grant and agree to implement it under their own responsibility and in accordance with the Agreement, with all the obligations and conditions it sets out.



The Agreement is composed of:

Terms and Conditions

Annex 1 Description of the action

Annex 2 Estimated budget for the action

Annex 3 Accession Forms

3a Declaration on joint and several liability of linked third parties

Annex 4 Model for the financial statements

Annex 5 Model for the certificate on the financial statements

Annex 6 Model for the certificate on the methodology



TERMS AND CONDITIONS

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CHAPTER 1 GENERAL

ARTICLE 1 — SUBJECT OF THE AGREEMENT

This Agreement sets out the rights and obligations and the terms and conditions applicable to the grant awarded to the beneficiaries for implementing the action set out in Chapter 2.

CHAPTER 2 ACTION

ARTICLE 2 — ACTION TO BE IMPLEMENTED

The grant is awarded for the action entitled ‘*ENabling Onshore CO2 Storage in Europe — ENOS*’ (**‘action’**), as described in Annex 1.

ARTICLE 3 — DURATION AND STARTING DATE OF THE ACTION

The duration of the action will be **48 months** as of *1 September 2016* (**‘starting date of the action’**).

ARTICLE 4 — ESTIMATED BUDGET AND BUDGET TRANSFERS

4.1 Estimated budget

The **‘estimated budget’** for the action is set out in Annex 2.

It contains the estimated eligible costs and the forms of costs, broken down by beneficiary (*and linked third party*) and budget category (see Articles 5, 6, and 14). *It also contains the estimated costs of the beneficiaries not receiving EU funding (see Article 9).*

4.2 Budget transfers

The estimated budget breakdown indicated in Annex 2 may be adjusted by transfers of amounts between beneficiaries or between budget categories (or both). This does not require an amendment according to Article 55, if the action is implemented as described in Annex 1.

However, the beneficiaries may not add costs relating to subcontracts not provided for in Annex 1, unless such additional subcontracts are approved by an amendment or in accordance with Article 13.

CHAPTER 3 GRANT

ARTICLE 5 — GRANT AMOUNT, FORM OF GRANT, REIMBURSEMENT RATES AND FORMS OF COSTS

5.1 Maximum grant amount

The **‘maximum grant amount’** is **EUR 12,485,258.75** (twelve million four hundred and eighty five thousand two hundred and fifty eight EURO and seventy five eurocents).



5.2 Form of grant, reimbursement rates and forms of costs

The grant reimburses **100% of the action's eligible costs** (see Article 6) (**'reimbursement of eligible costs grant'**) (see Annex 2).

The estimated eligible costs of the action are EUR **12,485,258.75** (twelve million four hundred and eighty five thousand two hundred and fifty eight EURO and seventy five eurocents).

Eligible costs (see Article 6) must be declared under the following forms (**'forms of costs'**):

(a) for **direct personnel costs**:

- as actually incurred costs (**'actual costs'**) or
- on the basis of an amount per unit calculated by the beneficiary in accordance with its usual cost accounting practices (**'unit costs'**).

Personnel **costs for SME owners or beneficiaries that are natural persons** not receiving a salary (see Article 6.2, Points A.4 and A.5) must be declared on the basis of the amount per unit set out in Annex 2 (**'unit costs'**);

(b) for **direct costs for subcontracting**: as actually incurred costs (**'actual costs'**);

(c) for **direct costs of providing financial support to third parties**: *not applicable*;

(d) for **other direct costs**: as actually incurred costs (**'actual costs'**);

(e) for **indirect costs**: on the basis of a flat-rate applied as set out in Article 6.2, Point E (**'flat-rate costs'**);

(f) *specific cost category(ies): not applicable*.

5.3 Final grant amount — Calculation

The **'final grant amount'** depends on the actual extent to which the action is implemented in accordance with the Agreement's terms and conditions.

This amount is calculated by the *Agency* — when the payment of the balance is made (see Article 21.4) — in the following steps:

Step 1 – Application of the reimbursement rates to the eligible costs

Step 2 – Limit to the maximum grant amount

Step 3 – Reduction due to the no-profit rule

Step 4 – Reduction due to improper implementation or breach of other obligations

5.3.1 Step 1 — Application of the reimbursement rates to the eligible costs

The reimbursement rate(s) (see Article 5.2) are applied to the eligible costs (actual costs, unit costs and flat-rate costs; see Article 6) declared by the beneficiaries *and linked third parties* (see Article 20) and approved by the *Agency* (see Article 21).



5.3.2 Step 2 — Limit to the maximum grant amount

If the amount obtained following Step 1 is higher than the maximum grant amount set out in Article 5.1, it will be limited to the latter.

5.3.3 Step 3 — Reduction due to the no-profit rule

The grant must not produce a profit.

‘**Profit**’ means the surplus of the amount obtained following Steps 1 and 2 plus the action’s total receipts, over the action’s total eligible costs.

The ‘**action’s total eligible costs**’ are the consolidated total eligible costs approved by the *Agency*.

The ‘**action’s total receipts**’ are the consolidated total receipts generated during its duration (see Article 3).

The following are considered **receipts**:

- (a) income generated by the action; if the income is generated from selling equipment or other assets purchased under the Agreement, the receipt is up to the amount declared as eligible under the Agreement;
- (b) financial contributions given by third parties to the beneficiary *or to a linked third party* specifically to be used for the action, and
- (c) in-kind contributions provided by third parties free of charge and specifically to be used for the action, if they have been declared as eligible costs.

The following are however not considered receipts:

- (a) income generated by exploiting the action’s results (see Article 28);
- (b) financial contributions by third parties, if they may be used to cover costs other than the eligible costs (see Article 6);
- (c) financial contributions by third parties with no obligation to repay any amount unused at the end of the period set out in Article 3.

If there is a profit, it will be deducted from the amount obtained following Steps 1 and 2.

5.3.4 Step 4 — Reduction due to improper implementation or breach of other obligations — Reduced grant amount — Calculation

If the grant is reduced (see Article 43), the *Agency* will calculate the reduced grant amount by deducting the amount of the reduction (calculated in proportion to the improper implementation of the action or to the seriousness of the breach of obligations in accordance with Article 43.2) from the maximum grant amount set out in Article 5.1.

The final grant amount will be the lower of the following two:



- the amount obtained following Steps 1 to 3 or
- the reduced grant amount following Step 4.

5.4 Revised final grant amount — Calculation

If — after the payment of the balance (in particular, after checks, reviews, audits or investigations; see Article 22) — the *Agency* rejects costs (see Article 42) or reduces the grant (see Article 43), it will calculate the ‘**revised final grant amount**’ for the beneficiary concerned by the findings.

This amount is calculated by the *Agency* on the basis of the findings, as follows:

- in case of **rejection of costs**: by applying the reimbursement rate to the revised eligible costs approved by the *Agency* for the beneficiary concerned;
- in case of **reduction of the grant**: by calculating the concerned beneficiary’s share in the grant amount reduced in proportion to its improper implementation of the action or to the seriousness of its breach of obligations (see Article 43.2).

In case of **rejection of costs and reduction of the grant**, the revised final grant amount for the beneficiary concerned will be the lower of the two amounts above.

ARTICLE 6 — ELIGIBLE AND INELIGIBLE COSTS

6.1 General conditions for costs to be eligible

‘**Eligible costs**’ are costs that meet the following criteria:

(a) for **actual costs**:

- (i) they must be actually incurred by the beneficiary;
- (ii) they must be incurred in the period set out in Article 3, with the exception of costs relating to the submission of the periodic report for the last reporting period and the final report (see Article 20);
- (iii) they must be indicated in the estimated budget set out in Annex 2;
- (iv) they must be incurred in connection with the action as described in Annex 1 and necessary for its implementation;
- (v) they must be identifiable and verifiable, in particular recorded in the beneficiary’s accounts in accordance with the accounting standards applicable in the country where the beneficiary is established and with the beneficiary’s usual cost accounting practices;
- (vi) they must comply with the applicable national law on taxes, labour and social security, and
- (vii) they must be reasonable, justified and must comply with the principle of sound financial management, in particular regarding economy and efficiency;

(b) for **unit costs**:



(i) they must be calculated as follows:

{amounts per unit set out in Annex 2 or calculated by the beneficiary in accordance with its usual cost accounting practices (see Article 6.2, Point A)

multiplied by

the number of actual units};

(ii) the number of actual units must comply with the following conditions:

- the units must be actually used or produced in the period set out in Article 3;
- the units must be necessary for implementing the action or produced by it, and
- the number of units must be identifiable and verifiable, in particular supported by records and documentation (see Article 18);

(c) for **flat-rate costs**:

(i) they must be calculated by applying the flat-rate set out in Annex 2, and

(ii) the costs (actual costs or unit costs) to which the flat-rate is applied must comply with the conditions for eligibility set out in this Article.

6.2 Specific conditions for costs to be eligible

Costs are eligible if they comply with the general conditions (see above) and the specific conditions set out below for each of the following budget categories:

- A. direct personnel costs;
- B. direct costs of subcontracting;
- C. *not applicable*;
- D. other direct costs;
- E. indirect costs;
- F. *not applicable*.

‘Direct costs’ are costs that are directly linked to the action implementation and can therefore be attributed to it directly. They must not include any indirect costs (see Point E below).

‘Indirect costs’ are costs that are not directly linked to the action implementation and therefore cannot be attributed directly to it.

A. Direct personnel costs

Types of eligible personnel costs

A.1 **Personnel costs** are eligible, if they are related to personnel working for the beneficiary under an employment contract (or equivalent appointing act) and assigned to the action (**‘costs for employees (or equivalent)’**). They must be limited to salaries (including during parental leave), social security contributions, taxes and other costs included in the **remuneration**, if they arise from national law or the employment contract (or equivalent appointing act).



Beneficiaries that are non-profit legal entities² may also declare as personnel costs **additional remuneration** for personnel assigned to the action (including payments on the basis of supplementary contracts regardless of their nature), if:

- (a) it is part of the beneficiary's usual remuneration practices and is paid in a consistent manner whenever the same kind of work or expertise is required;
- (b) the criteria used to calculate the supplementary payments are objective and generally applied by the beneficiary, regardless of the source of funding used.

Additional remuneration for personnel assigned to the action is eligible up to the following amount:

- (a) if the person works full time and exclusively on the action during the full year: up to EUR 8 000;
- (b) if the person works exclusively on the action but not full-time or not for the full year: up to the corresponding pro-rata amount of EUR 8 000, or
- (c) if the person does not work exclusively on the action: up to a pro-rata amount calculated as follows:

{ {EUR 8 000

divided by

the number of annual productive hours (see below)},

multiplied by

the number of hours that the person has worked on the action during the year}.

A.2 The **costs for natural persons working under a direct contract** with the beneficiary other than an employment contract are eligible personnel costs, if:

- (a) the person works under the beneficiary's instructions and, unless otherwise agreed with the beneficiary, on the beneficiary's premises;
- (b) the result of the work carried out belongs to the beneficiary, and
- (c) the costs are not significantly different from those for personnel performing similar tasks under an employment contract with the beneficiary.

A.3 The **costs of personnel seconded by a third party against payment** are eligible personnel costs, if the conditions in Article 11.1 are met.

² For the definition, see Article 2.1(14) of the Rules for Participation Regulation No 1290/2013: '**non-profit legal entity**' means a legal entity which by its legal form is non-profit-making or which has a legal or statutory obligation not to distribute profits to its shareholders or individual members.



A.4 **Costs of owners** of beneficiaries that are small and medium-sized enterprises (**‘SME owners’**) who are working on the action and who do not receive a salary are eligible personnel costs, if they correspond to the amount per unit set out in Annex 2 multiplied by the number of actual hours worked on the action.

A.5 **Costs of ‘beneficiaries that are natural persons’** not receiving a salary are eligible personnel costs, if they correspond to the amount per unit set out in Annex 2 multiplied by the number of actual hours worked on the action.

Calculation

Personnel costs must be calculated by the beneficiaries as follows:

{ {hourly rate
multiplied by
the number of actual hours worked on the action},
plus
for non-profit legal entities: additional remuneration to personnel assigned to the action under the conditions set out above (Point A.1)}.

The number of actual hours declared for a person must be identifiable and verifiable (see Article 18).

The total number of hours declared in EU or Euratom grants, for a person for a year, cannot be higher than the annual productive hours used for the calculations of the hourly rate. Therefore, the maximum number of hours that can be declared for the grant is:

{the number of annual productive hours for the year (see below)
minus
total number of hours declared by the beneficiary for that person in that year for other EU or Euratom grants}.

The **‘hourly rate’** is one of the following:

(a) for personnel costs declared as **actual costs**: the hourly rate is the amount calculated as follows:

{actual annual personnel costs (excluding additional remuneration) for the person
divided by
number of annual productive hours}.

The beneficiaries must use the annual personnel costs and the number of annual productive hours for each financial year covered by the reporting period. If a financial year is not closed at the end of the reporting period, the beneficiaries must use the hourly rate of the last closed financial year available.

For the ‘number of annual productive hours’, the beneficiaries may choose one of the following:

(i) ‘fixed number of hours’: 1 720 hours for persons working full time (or corresponding pro-rata for persons not working full time);



- (ii) ‘individual annual productive hours’: the total number of hours worked by the person in the year for the beneficiary, calculated as follows:

{annual workable hours of the person (according to the employment contract, applicable collective labour agreement or national law)

plus

overtime worked

minus

absences (such as sick leave and special leave)}.

‘Annual workable hours’ means the period during which the personnel must be working, at the employer’s disposal and carrying out his/her activity or duties under the employment contract, applicable collective labour agreement or national working time legislation.

If the contract (or applicable collective labour agreement or national working time legislation) does not allow to determine the annual workable hours, this option cannot be used;

- (iii) ‘standard annual productive hours’: the ‘standard number of annual hours’ generally applied by the beneficiary for its personnel in accordance with its usual cost accounting practices. This number must be at least 90% of the ‘standard annual workable hours’.

If there is no applicable reference for the standard annual workable hours, this option cannot be used.

For all options, the actual time spent on **parental leave** by a person assigned to the action may be deducted from the number of annual productive hours;

- (b) for personnel costs declared on the basis of **unit costs**: the hourly rate is one of the following:

- (i) for SME owners or beneficiaries that are natural persons: the hourly rate set out in Annex 2 (see Points A.4 and A.5 above), or
- (ii) for personnel costs declared on the basis of the beneficiary’s usual cost accounting practices: the hourly rate calculated by the beneficiary in accordance with its usual cost accounting practices, if:
 - the cost accounting practices used are applied in a consistent manner, based on objective criteria, regardless of the source of funding;
 - the hourly rate is calculated using the actual personnel costs recorded in the beneficiary’s accounts, excluding any ineligible cost or costs included in other budget categories.

The actual personnel costs may be adjusted by the beneficiary on the basis of budgeted or estimated elements. Those elements must be relevant for calculating



the personnel costs, reasonable and correspond to objective and verifiable information;

and

- the hourly rate is calculated using the number of annual productive hours (see above).

B. Direct costs of subcontracting (including related duties, taxes and charges such as non-deductible value added tax (VAT) paid by the beneficiary) are eligible if the conditions in Article 13.1.1 are met.

C. Direct costs of providing financial support to third parties *not applicable*.

D. Other direct costs

D.1 Travel costs and related subsistence allowances (including related duties, taxes and charges such as non-deductible value added tax (VAT) paid by the beneficiary) are eligible if they are in line with the beneficiary's usual practices on travel.

D.2 The depreciation costs of equipment, infrastructure or other assets *(new or second-hand) as recorded in the beneficiary's accounts are eligible, if they were purchased in accordance with Article 10.1.1 and written off in accordance with international accounting standards and the beneficiary's usual accounting practices.*

The costs of renting or leasing equipment, infrastructure or other assets (including related duties, taxes and charges such as non-deductible value added tax (VAT) paid by the beneficiary) are also eligible, if they do not exceed the depreciation costs of similar equipment, infrastructure or assets and do not include any financing fees.

*The costs of equipment, infrastructure or other assets **contributed in-kind against payment** are eligible, if they do not exceed the depreciation costs of similar equipment, infrastructure or assets, do not include any financing fees and if the conditions in Article 11.1 are met.*

The only portion of the costs that will be taken into account is that which corresponds to the duration of the action and rate of actual use for the purposes of the action.

D.3 Costs of other goods and services (including related duties, taxes and charges such as non-deductible value added tax (VAT) paid by the beneficiary) are eligible, if they are:

- (a) purchased specifically for the action and in accordance with Article 10.1.1 or
- (b) contributed in kind against payment and in accordance with Article 11.1.

Such goods and services include, for instance, consumables and supplies, dissemination (including open access), protection of results, certificates on the financial statements (if they are required by the Agreement), certificates on the methodology, translations and publications.



D.4 Capitalised and operating costs of ‘large research infrastructure’³ directly used for the action are eligible, if:

- (a) the value of the large research infrastructure represents at least 75% of the total fixed assets (at historical value in its last closed balance sheet before the date of the signature of the Agreement or as determined on the basis of the rental and leasing costs of the research infrastructure⁴);*
- (b) the beneficiary’s methodology for declaring the costs for large research infrastructure has been positively assessed by the Commission (‘ex-ante assessment’);*
- (c) the beneficiary declares as direct eligible costs only the portion which corresponds to the duration of the action and the rate of actual use for the purposes of the action, and*
- (d) they comply with the conditions as further detailed in the annotations to the H2020 grant agreements.*

E. Indirect costs

Indirect costs are eligible if they are declared on the basis of the flat-rate of 25% of the eligible direct costs (see Article 5.2 and Points A to D above), from which are excluded:

- (a) costs of subcontracting and
- (b) costs of in-kind contributions provided by third parties which are not used on the beneficiary’s premises;
- (c) *not applicable*;
- (d) *not applicable*.

Beneficiaries receiving an operating grant⁵ financed by the EU or Euratom budget cannot declare indirect costs for the period covered by the operating grant.

³ ‘**Large research infrastructure**’ means research infrastructure of a total value of at least EUR 20 million, for a beneficiary, calculated as the sum of historical asset values of each individual research infrastructure of that beneficiary, as they appear in its last closed balance sheet before the date of the signature of the Agreement or as determined on the basis of the rental and leasing costs of the research infrastructure.

⁴ For the definition, see Article 2(6) of Regulation (EU) No 1291/2013 of the European Parliament and of the Council of 11 December 2013 establishing Horizon 2020 - the Framework Programme for Research and Innovation (2014-2020) (OJ L 347, 20.12.2013 p.104) (‘**Horizon 2020 Framework Programme Regulation No 1291/2013**’): ‘**Research infrastructure**’ are facilities, resources and services that are used by the research communities to conduct research and foster innovation in their fields. Where relevant, they may be used beyond research, e.g. for education or public services. They include: major scientific equipment (or sets of instruments); knowledge-based resources such as collections, archives or scientific data; e-infrastructures such as data and computing systems and communication networks; and any other infrastructure of a unique nature essential to achieve excellence in research and innovation. Such infrastructures may be ‘single-sited’, ‘virtual’ or ‘distributed’.

⁵ For the definition, see Article 121(1)(b) of Regulation (EU, Euratom) No 966/2012 of the European Parliament and of the Council of 25 October 2012 on the financial rules applicable to the general budget of the Union and repealing Council Regulation (EC, Euratom) No 1605/2002 (OJ L 218, 26.10.2012, p.1) (‘**Financial Regulation No 966/2012**’): ‘**operating grant**’ means direct financial contribution, by way of donation, from the budget in order to finance the functioning of a body which pursues an aim of general EU interest or has an objective forming part of and supporting an EU policy.

**F. Specific cost category(ies)**

Not applicable

6.3 Conditions for costs of linked third parties to be eligible

Costs incurred by linked third parties are eligible if they fulfil — mutatis mutandis — the general and specific conditions for eligibility set out in this Article (Article 6.1 and 6.2) and Article 14.1.1.

6.4 Conditions for in-kind contributions provided by third parties free of charge to be eligible

In-kind contributions provided free of charge are eligible direct costs (for the beneficiary *or linked third party*), if the costs incurred by the third party fulfil — *mutatis mutandis* — the general and specific conditions for eligibility set out in this Article (Article 6.1 and 6.2) and Article 12.1.

6.5 Ineligible costs

‘**Ineligible costs**’ are:

(a) costs that do not comply with the conditions set out above (Article 6.1 to 6.4), in particular:

- (i) costs related to return on capital;
- (ii) debt and debt service charges;
- (iii) provisions for future losses or debts;
- (iv) interest owed;
- (v) doubtful debts;
- (vi) currency exchange losses;
- (vii) bank costs charged by the beneficiary’s bank for transfers from the *Agency*;
- (viii) excessive or reckless expenditure;
- (ix) deductible VAT;
- (x) costs incurred during suspension of the implementation of the action (see Article 49);

(b) costs declared under another EU or Euratom grant (including grants awarded by a Member State and financed by the EU or Euratom budget and grants awarded by bodies other than the *Agency* for the purpose of implementing the EU or Euratom budget); in particular, indirect costs if the beneficiary is already receiving an operating grant financed by the EU or Euratom budget in the same period.

6.6 Consequences of declaration of ineligible costs

Declared costs that are ineligible will be rejected (see Article 42).



This may also lead to any of the other measures described in Chapter 6.

CHAPTER 4 RIGHTS AND OBLIGATIONS OF THE PARTIES

SECTION 1 RIGHTS AND OBLIGATIONS RELATED TO IMPLEMENTING THE ACTION

ARTICLE 7 — GENERAL OBLIGATION TO PROPERLY IMPLEMENT THE ACTION

7.1 General obligation to properly implement the action

The beneficiaries must implement the action as described in Annex 1 and in compliance with the provisions of the Agreement and all legal obligations under applicable EU, international and national law.

7.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 8 — RESOURCES TO IMPLEMENT THE ACTION — THIRD PARTIES INVOLVED IN THE ACTION

The beneficiaries must have the appropriate resources to implement the action.

If it is necessary to implement the action, the beneficiaries may:

- purchase goods, works and services (see Article 10);
- use in-kind contributions provided by third parties against payment (see Article 11);
- use in-kind contributions provided by third parties free of charge (see Article 12);
- call upon subcontractors to implement action tasks described in Annex 1 (see Article 13);
- call upon linked third parties to implement action tasks described in Annex 1 (see Article 14).

In these cases, the beneficiaries retain sole responsibility towards the *Agency* and the other beneficiaries for implementing the action.

ARTICLE 9 — IMPLEMENTATION OF ACTION TASKS BY BENEFICIARIES NOT RECEIVING EU FUNDING

9.1 Rules for the implementation of action tasks by beneficiaries not receiving EU funding

Beneficiaries not receiving EU funding must implement the action tasks attributed to them in Annex 1 according to Article 7.1.



Their costs are estimated in Annex 2 but:

- *will not be reimbursed and*
- *will not be taken into account for the calculation of the grant (see Articles 5.2, 5.3 and 5.4, and 21).*

Chapter 3, Articles 10 to 15, 20.6, 23a and 40 do not apply to these beneficiaries.

Articles 26.4, 27.2, 28.1, 28.2, 30.3, 31.5 do not apply to results generated without EU funds.

These beneficiaries will not be subject to financial checks, reviews and audits under Article 22 for their own costs.

Beneficiaries not receiving EU funding may provide in-kind contributions to another beneficiary. In this case, they will be considered as a third party for the purpose of Articles 11 and 12.

9.2 Consequences of non-compliance

If a beneficiary not receiving EU funding breaches any of its obligations under this Article, its participation of the Agreement may be terminated (see Article 50).

Such breaches may also lead to any of the other measures described in Chapter 6 that are applicable to it.

ARTICLE 10 — PURCHASE OF GOODS, WORKS OR SERVICES

10.1 Rules for purchasing goods, works or services

10.1.1 If necessary to implement the action, the beneficiaries may purchase goods, works or services.

The beneficiaries must make such purchases ensuring the best value for money or, if appropriate, the lowest price. In doing so, they must avoid any conflict of interests (see Article 35).

The beneficiaries must ensure that *the Agency*, the Commission, the European Court of Auditors (ECA) and the European Anti-Fraud Office (OLAF) can exercise their rights under Articles 22 and 23 also towards their contractors.

10.1.2 Beneficiaries that are ‘contracting authorities’ within the meaning of Directive 2004/18/EC⁶ or ‘contracting entities’ within the meaning of Directive 2004/17/EC⁷ must comply with the applicable national law on public procurement.

10.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under Article 10.1.1, the costs related to the contract concerned will be ineligible (see Article 6) and will be rejected (see Article 42).

⁶ Directive 2004/18/EC of the European Parliament and of the Council of 31 March 2004 on the coordination of procedures for the award of public work contracts, public supply contracts and public service contracts (OJ L 134, 30.04.2004, p. 114).

⁷ Directive 2004/17/EC of the European Parliament and of the Council of 31 March 2004 coordinating the procurement procedures of entities operating in the water, energy, transport and postal services sectors (OJ L 134, 30.04.2004, p. 1).



If a beneficiary breaches any of its obligations under Article 10.1.2, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 11 — USE OF IN-KIND CONTRIBUTIONS PROVIDED BY THIRD PARTIES AGAINST PAYMENT

11.1 Rules for the use of in-kind contributions against payment

If necessary to implement the action, the beneficiaries may use in-kind contributions provided by third parties against payment.

The beneficiaries may declare costs related to the payment of in-kind contributions as eligible (see Article 6.1 and 6.2), up to the third parties' costs for the seconded persons, contributed equipment, infrastructure or other assets or other contributed goods and services.

The third parties and their contributions must be set out in Annex 1. The *Agency* may however approve in-kind contributions not set out in Annex 1 without amendment (see Article 55), if:

- they are specifically justified in the periodic technical report and
- their use does not entail changes to the Agreement which would call into question the decision awarding the grant or breach the principle of equal treatment of applicants.

The beneficiaries must ensure that *the Agency*, the Commission, the European Court of Auditors (ECA) and the European Anti-Fraud Office (OLAF) can exercise their rights under Articles 22 and 23 also towards the third parties.

11.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the costs related to the payment of the in-kind contribution will be ineligible (see Article 6) and will be rejected (see Article 42).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 12 — USE OF IN-KIND CONTRIBUTIONS PROVIDED BY THIRD PARTIES FREE OF CHARGE

12.1 Rules for the use of in-kind contributions free of charge

If necessary to implement the action, the beneficiaries may use in-kind contributions provided by third parties free of charge.

The beneficiaries may declare costs incurred by the third parties for the seconded persons, contributed equipment, infrastructure or other assets or other contributed goods and services as eligible in accordance with Article 6.4.

The third parties and their contributions must be set out in Annex 1. The *Agency* may however approve in-kind contributions not set out in Annex 1 without amendment (see Article 55), if:

- they are specifically justified in the periodic technical report and



- their use does not entail changes to the Agreement which would call into question the decision awarding the grant or breach the principle of equal treatment of applicants.

The beneficiaries must ensure that *the Agency*, the Commission, the European Court of Auditors (ECA) and the European Anti-Fraud Office (OLAF) can exercise their rights under Articles 22 and 23 also towards the third parties.

12.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the costs incurred by the third parties related to the in-kind contribution will be ineligible (see Article 6) and will be rejected (see Article 42).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 13 — IMPLEMENTATION OF ACTION TASKS BY SUBCONTRACTORS

13.1 Rules for subcontracting action tasks

13.1.1 If necessary to implement the action, the beneficiaries may award subcontracts covering the implementation of certain action tasks described in Annex 1.

Subcontracting may cover only a limited part of the action.

The beneficiaries must award the subcontracts ensuring the best value for money or, if appropriate, the lowest price. In doing so, they must avoid any conflict of interests (see Article 35).

The tasks to be implemented and the estimated cost for each subcontract must be set out in Annex 1 and the total estimated costs of subcontracting per beneficiary must be set out in Annex 2. The *Agency* may however approve subcontracts not set out in Annex 1 and 2 without amendment (see Article 55), if:

- they are specifically justified in the periodic technical report and
- they do not entail changes to the Agreement which would call into question the decision awarding the grant or breach the principle of equal treatment of applicants.

The beneficiaries must ensure that *the Agency*, the Commission, the European Court of Auditors (ECA) and the European Anti-Fraud Office (OLAF) can exercise their rights under Articles 22 and 23 also towards their subcontractors.

13.1.2 The beneficiaries must ensure that their obligations under Articles 35, 36, 38 and 46 also apply to the subcontractors.

Beneficiaries that are ‘contracting authorities’ within the meaning of Directive 2004/18/EC or ‘contracting entities’ within the meaning of Directive 2004/17/EC must comply with the applicable national law on public procurement.

13.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under Article 13.1.1, the costs related to the subcontract concerned will be ineligible (see Article 6) and will be rejected (see Article 42).



If a beneficiary breaches any of its obligations under Article 13.1.2, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 14 — IMPLEMENTATION OF ACTION TASKS BY LINKED THIRD PARTIES

14.1 Rules for calling upon linked third parties to implement part of the action

14.1.1 The following **affiliated entities**⁹ and **third parties with a legal link to a beneficiary**¹⁰ ('**linked third parties**') may implement the action tasks attributed to them in Annex 1:

- *FUNDACION INSTITUTO PETROFISICO (IPF), affiliated or linked to PLC-3, if it has accepted joint and several liability with the beneficiary (see Annex 3a)*
- *ENAGAS INTERNACIONAL SL (ENAGAS), affiliated or linked to PLC-3, if it has accepted joint and several liability with the beneficiary (see Annex 3a)*
- *MIDDLE EAST TECHNICAL UNIVERSITY (METU), affiliated or linked to CO2GeoNet, if it has accepted joint and several liability with the beneficiary (see Annex 3a)*
- *GEOLOGISCHE BUNDESANSTALT (GBA), affiliated or linked to CO2GeoNet, if it has accepted joint and several liability with the beneficiary (see Annex 3a)*
- *HERIOT-WATT UNIVERSITY (HWU), affiliated or linked to CO2GeoNet, if it has accepted joint and several liability with the beneficiary (see Annex 3a)*
- *SVEUCILISTE U ZAGREBU RUDARSKO-GEOLOSKO-NAFTNI FAKULTET (UNIZG-RGNF), affiliated or linked to CO2GeoNet, if it has accepted joint and several liability with the beneficiary (see Annex 3a)*
- *Geological Survey of Denmark and Greenland (GEUS), affiliated or linked to CO2GeoNet, if it has accepted joint and several liability with the beneficiary (see Annex 3a)*
- *INSTITUTO GEOLÓGICO Y MINERO DE ESPAÑA (IGME), affiliated or linked to CO2GeoNet, if it has accepted joint and several liability with the beneficiary (see Annex 3a)*

⁹ For the definition, see Article 2.1(2) of the Rules for Participation Regulation No 1290/2013: '**affiliated entity**' means any legal entity that is:

- under the direct or indirect control of a participant, or
- under the same direct or indirect control as the participant, or
- directly or indirectly controlling a participant.

'Control' may take any of the following forms:

- (a) the direct or indirect holding of more than 50% of the nominal value of the issued share capital in the legal entity concerned, or of a majority of the voting rights of the shareholders or associates of that entity;
- (b) the direct or indirect holding, in fact or in law, of decision-making powers in the legal entity concerned.

However the following relationships between legal entities shall not in themselves be deemed to constitute controlling relationships:

- (a) the same public investment corporation, institutional investor or venture-capital company has a direct or indirect holding of more than 50% of the nominal value of the issued share capital or a majority of voting rights of the shareholders or associates;
- (b) the legal entities concerned are owned or supervised by the same public body.

¹⁰ '**Third party with a legal link to a beneficiary**' is any legal entity which has a legal link to the beneficiary implying collaboration that is not limited to the action.



- *INSTITUTUL NATIONAL DE CERCETARE-DEZVOLTARE PENTRU GEOLOGIE SI GEOECOLOGIE MARINA-GEOECOMAR (GEOECOMAR), affiliated or linked to CO2GeoNet, if it has accepted joint and several liability with the beneficiary (see Annex 3a)*
- *TALLINNA TEHNIKAULIKOOL (TTUGI), affiliated or linked to CO2GeoNet, if it has accepted joint and several liability with the beneficiary (see Annex 3a)*
- *INSTITUT ROYAL DES SCIENCES NATURELLES DE BELGIQUE (GSB-RBINS), affiliated or linked to CO2GeoNet, if it has accepted joint and several liability with the beneficiary (see Annex 3a)*
- *GEOINZENIRING DRUZBA ZA GEOLOSKI INZENIRING DOO (GEOINZ), affiliated or linked to CO2GeoNet, if it has accepted joint and several liability with the beneficiary (see Annex 3a)*

The linked third parties may declare as eligible the costs they incur for implementing the action tasks in accordance with Article 6.3.

The beneficiaries must ensure that the Agency, the Commission, the European Court of Auditors (ECA) and the European Anti-Fraud Office (OLAF) can exercise their rights under Articles 22 and 23 also towards their linked third parties.

14.1.2 The beneficiaries must ensure that their obligations under Articles 18, 20, 35, 36 and 38 also apply to their linked third parties.

14.2 Consequences of non-compliance

If any obligation under Article 14.1.1 is breached, the costs of the linked third party will be ineligible (see Article 6) and will be rejected (see Article 42).

If any obligation under Article 14.1.2 is breached, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 15 — FINANCIAL SUPPORT TO THIRD PARTIES

15.1 Rules for providing financial support to third parties

Not applicable

15.2 Financial support in the form of prizes

Not applicable

15.3 Consequences of non-compliance

Not applicable



ARTICLE 16 — PROVISION OF TRANS-NATIONAL OR VIRTUAL ACCESS TO RESEARCH INFRASTRUCTURE

16.1 Rules for providing trans-national access to research infrastructure

Not applicable

16.2 Rules for providing virtual access to research infrastructure

Not applicable

16.3 Consequences of non-compliance

Not applicable

SECTION 2 RIGHTS AND OBLIGATIONS RELATED TO THE GRANT ADMINISTRATION

ARTICLE 17 — GENERAL OBLIGATION TO INFORM

17.1 General obligation to provide information upon request

The beneficiaries must provide — during implementation of the action or afterwards and in accordance with Article 41.2 — any information requested in order to verify eligibility of the costs, proper implementation of the action and compliance with any other obligation under the Agreement.

17.2 Obligation to keep information up to date and to inform about events and circumstances likely to affect the Agreement

Each beneficiary must keep information stored in the 'Beneficiary Register' (via the electronic exchange system; see Article 52) up to date, in particular, its name, address, legal representatives, legal form and organisation type.

Each beneficiary must immediately inform the coordinator — which must immediately inform the *Agency* and the other beneficiaries — of any of the following:

- (a) **events** which are likely to affect significantly or delay the implementation of the action or the EU's financial interests, in particular:
 - (i) changes in its legal, financial, technical, organisational or ownership situation *or those of its linked third parties and*
 - (ii) *changes in the name, address, legal form, organisation type of its linked third parties;*
- (b) **circumstances** affecting:
 - (i) the decision to award the grant or
 - (ii) compliance with requirements under the Agreement.



17.3 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 18 — KEEPING RECORDS — SUPPORTING DOCUMENTATION

18.1 Obligation to keep records and other supporting documentation

The beneficiaries must — for a period of *five* years after the payment of the balance — keep records and other supporting documentation in order to prove the proper implementation of the action and the costs they declare as eligible.

They must make them available upon request (see Article 17) or in the context of checks, reviews, audits or investigations (see Article 22).

If there are on-going checks, reviews, audits, investigations, litigation or other pursuits of claims under the Agreement (including the extension of findings; see Articles 22), the beneficiaries must keep the records and other supporting documentation until the end of these procedures.

The beneficiaries must keep the original documents. Digital and digitalised documents are considered originals if they are authorised by the applicable national law. The *Agency* may accept non-original documents if it considers that they offer a comparable level of assurance.

18.1.1 Records and other supporting documentation on the scientific and technical implementation

The beneficiaries must keep records and other supporting documentation on scientific and technical implementation of the action in line with the accepted standards in the respective field.

18.1.2 Records and other documentation to support the costs declared

The beneficiaries must keep the records and documentation supporting the costs declared, in particular the following:

- (a) for **actual costs**: adequate records and other supporting documentation to prove the costs declared, such as contracts, subcontracts, invoices and accounting records. In addition, the beneficiaries' usual cost accounting practices and internal control procedures must enable direct reconciliation between the amounts declared, the amounts recorded in their accounts and the amounts stated in the supporting documentation;
- (b) for **unit costs**: adequate records and other supporting documentation to prove the number of units declared. Beneficiaries do not need to identify the actual eligible costs covered or to keep or provide supporting documentation (such as accounting statements) to prove the amount per unit.

In addition, for **direct personnel costs declared as unit costs calculated in accordance with the beneficiary's usual cost accounting practices**, the beneficiaries must keep adequate



records and documentation to prove that the cost accounting practices used comply with the conditions set out in Article 6.2, Point A.

The beneficiaries *and linked third parties* may submit to the Commission, for approval, a certificate (drawn up in accordance with Annex 6) stating that their usual cost accounting practices comply with these conditions (**‘certificate on the methodology’**). If the certificate is approved, costs declared in line with this methodology will not be challenged subsequently, unless the beneficiaries have concealed information for the purpose of the approval.

- (c) for **flat-rate costs**: adequate records and other supporting documentation to prove the eligibility of the costs to which the flat-rate is applied. The beneficiaries do not need to identify the costs covered or provide supporting documentation (such as accounting statements) to prove the amount declared at a flat-rate.

In addition, for **personnel costs** (declared as actual costs or on the basis of unit costs), the beneficiaries must keep **time records** for the number of hours declared. The time records must be in writing and approved by the persons working on the action and their supervisors, at least monthly. In the absence of reliable time records of the hours worked on the action, the *Agency* may accept alternative evidence supporting the number of hours declared, if it considers that it offers an adequate level of assurance.

As an exception, for **persons working exclusively on the action**, there is no need to keep time records, if the beneficiary signs a **declaration** confirming that the persons concerned have worked exclusively on the action.

For costs declared by linked third parties (see Article 14), it is the beneficiary that must keep the originals of the financial statements and the certificates on the financial statements of the linked third parties.

18.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, costs insufficiently substantiated will be ineligible (see Article 6) and will be rejected (see Article 42), and the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 19 — SUBMISSION OF DELIVERABLES

19.1 Obligation to submit deliverables

The coordinator must submit the **‘deliverables’** identified in Annex 1, in accordance with the timing and conditions set out in it.

19.2 Consequences of non-compliance

If the coordinator breaches any of its obligations under this Article, the *Agency* may apply any of the measures described in Chapter 6.



ARTICLE 20 — REPORTING — PAYMENT REQUESTS

20.1 Obligation to submit reports

The coordinator must submit to the *Agency* (see Article 52) the technical and financial reports set out in this Article. These reports include requests for payment and must be drawn up using the forms and templates provided in the electronic exchange system (see Article 52).

20.2 Reporting periods

The action is divided into the following ‘**reporting periods**’:

- RP1: from month 1 to month 18
- RP2: *from month 19 to month 32*
- RP3: *from month 33 to month 48*

20.3 Periodic reports — Requests for interim payments

The coordinator must submit a periodic report within 60 days following the end of each reporting period.

The **periodic report** must include the following:

(a) a ‘**periodic technical report**’ containing:

- (i) an **explanation of the work carried out** by the beneficiaries;
- (ii) an **overview of the progress** towards the objectives of the action, including milestones and deliverables identified in Annex 1.

This report must include explanations justifying the differences between work expected to be carried out in accordance with Annex 1 and that actually carried out.

The report must also detail the exploitation and dissemination of the results and — if required in Annex 1 — an updated ‘**plan for the exploitation and dissemination of the results**’;

- (iii) a **summary** for publication by the *Agency*;
- (iv) the answers to the ‘**questionnaire**’, covering issues related to the action implementation and the economic and societal impact, notably in the context of the Horizon 2020 key performance indicators and the Horizon 2020 monitoring requirements;

(b) a ‘**periodic financial report**’ containing:

- (i) an ‘**individual financial statement**’ (see Annex 4) from each beneficiary *and from each linked third party*, for the reporting period concerned.

The individual financial statement must detail the eligible costs (actual costs, unit costs and flat-rate costs; see Article 6) for each budget category (see Annex 2).



The beneficiaries *and linked third parties* must declare all eligible costs, even if — for actual costs, unit costs and flat-rate costs — they exceed the amounts indicated in the estimated budget (see Annex 2). Amounts which are not declared in the individual financial statement will not be taken into account by the *Agency*.

If an individual financial statement is not submitted for a reporting period, it may be included in the periodic financial report for the next reporting period.

The individual financial statements of the last reporting period must also detail the **receipts of the action** (see Article 5.3.3).

Each beneficiary *and each linked third party* must **certify** that:

- the information provided is full, reliable and true;
 - the costs declared are eligible (see Article 6);
 - the costs can be substantiated by adequate records and supporting documentation (see Article 18) that will be produced upon request (see Article 17) or in the context of checks, reviews, audits and investigations (see Article 22), and
 - for the last reporting period: that all the receipts have been declared (see Article 5.3.3);
- (ii) an **explanation of the use of resources** and the information on subcontracting (see Article 13) and in-kind contributions provided by third parties (see Articles 11 and 12) from each beneficiary *and from each linked third party*, for the reporting period concerned;
- (iii) *not applicable*;
- (iv) a ‘**periodic summary financial statement**’ (see Annex 4), created automatically by the electronic exchange system, consolidating the individual financial statements for the reporting period concerned and including — except for the last reporting period — the **request for interim payment**.

20.4 Final report — Request for payment of the balance

In addition to the periodic report for the last reporting period, the coordinator must submit the final report within 60 days following the end of the last reporting period.

The **final report** must include the following:

- (a) a ‘**final technical report**’ with a **summary** for publication containing:
- (i) an overview of the results and their exploitation and dissemination;
 - (ii) the conclusions on the action, and
 - (iii) the socio-economic impact of the action;



(b) a ‘**final financial report**’ containing:

- (i) a ‘**final summary financial statement**’ (see Annex 4), created automatically by the electronic exchange system, consolidating the individual financial statements for all reporting periods and including the **request for payment of the balance** and
- (ii) a ‘**certificate on the financial statements**’ (drawn up in accordance with Annex 5) for each beneficiary *and for each linked third party*, if it requests a total contribution of EUR 325 000 or more, as reimbursement of actual costs and unit costs calculated on the basis of its usual cost accounting practices (see Article 5.2 and Article 6.2, Point A).

20.5 Information on cumulative expenditure incurred

Not applicable

20.6 Currency for financial statements and conversion into euro

Financial statements must be drafted in euro.

Beneficiaries *and linked third parties* with accounting established in a currency other than the euro must convert the costs recorded in their accounts into euro, at the average of the daily exchange rates published in the C series of the *Official Journal of the European Union*, calculated over the corresponding reporting period.

If no daily euro exchange rate is published in the *Official Journal of the European Union* for the currency in question, they must be converted at the average of the monthly accounting rates published on the Commission’s website, calculated over the corresponding reporting period.

Beneficiaries *and linked third parties* with accounting established in euro must convert costs incurred in another currency into euro according to their usual accounting practices.

20.7 Language of reports

All reports (technical and financial reports, including financial statements) must be submitted in the language of the Agreement.

20.8 Consequences of non-compliance — Suspension of the payment deadline — Termination

If the reports submitted do not comply with this Article, the *Agency* may suspend the payment deadline (see Article 47) and apply any of the other measures described in Chapter 6.

If the coordinator breaches its obligation to submit the reports and if it fails to comply with this obligation within 30 days following a written reminder sent by the *Agency*, the Agreement may be terminated (see Article 50).

ARTICLE 21 — PAYMENTS AND PAYMENT ARRANGEMENTS

21.1 Payments to be made

The following payments will be made to the coordinator:



- one **pre-financing payment**;
- one or more **interim payments**, on the basis of the request(s) for interim payment (see Article 20), and
- one **payment of the balance**, on the basis of the request for payment of the balance (see Article 20).

21.2 Pre-financing payment — Amount — Amount retained for the Guarantee Fund

The aim of the pre-financing is to provide the beneficiaries with a float.

It remains the property of the *EU* until the payment of the balance.

The amount of the pre-financing payment will be EUR **5,410,278.79** (five million four hundred and ten thousand two hundred and seventy eight EURO and seventy nine eurocents).

The *Agency* will — except if Article 48 applies — make the pre-financing payment to the coordinator within 30 days either from the entry into force of the Agreement (see Article 58) or from 10 days before the starting date of the action (see Article 3), whichever is the latest.

An amount of EUR **624,262.94** (six hundred and twenty four thousand two hundred and sixty two EURO and ninety four eurocents), corresponding to 5% of the maximum grant amount (see Article 5.1), is retained by the *Agency* from the pre-financing payment and transferred into the '**Guarantee Fund**'.

21.3 Interim payments — Amount — Calculation

Interim payments reimburse the eligible costs incurred for the implementation of the action during the corresponding reporting periods.

The *Agency* will pay to the coordinator the amount due as interim payment within 90 days from receiving the periodic report (see Article 20.3), except if Articles 47 or 48 apply.

Payment is subject to the approval of the periodic report. Its approval does not imply recognition of the compliance, authenticity, completeness or correctness of its content.

The **amount due as interim payment** is calculated by the *Agency* in the following steps:

Step 1 – Application of the reimbursement rates

Step 2 – Limit to 90% of the maximum grant amount

21.3.1 Step 1 — Application of the reimbursement rates

The reimbursement rate(s) (see Article 5.2) are applied to the eligible costs (actual costs, unit costs and flat-rate costs ; see Article 6) declared by the beneficiaries *and the linked third parties* (see Article 20) and approved by the *Agency* (see above) for the concerned reporting period.

21.3.2 Step 2 — Limit to 90% of the maximum grant amount



The total amount of pre-financing and interim payments must not exceed 90% of the maximum grant amount set out in Article 5.1. The maximum amount for the interim payment will be calculated as follows:

{90% of the maximum grant amount (see Article 5.1)

minus

{pre-financing and previous interim payments} }.

21.4 Payment of the balance — Amount — Calculation — Release of the amount retained for the Guarantee Fund

The payment of the balance reimburses the remaining part of the eligible costs incurred by the beneficiaries for the implementation of the action.

If the total amount of earlier payments is greater than the final grant amount (see Article 5.3), the payment of the balance takes the form of a recovery (see Article 44).

If the total amount of earlier payments is lower than the final grant amount, the *Agency* will pay the balance within 90 days from receiving the final report (see Article 20.4), except if Articles 47 or 48 apply.

Payment is subject to the approval of the final report. Its approval does not imply recognition of the compliance, authenticity, completeness or correctness of its content.

The **amount due as the balance** is calculated by the *Agency* by deducting the total amount of pre-financing and interim payments (if any) already made, from the final grant amount determined in accordance with Article 5.3:

{final grant amount (see Article 5.3)

minus

{pre-financing and interim payments (if any) made} }.

At the payment of the balance, the amount retained for the Guarantee Fund (see above) will be released and:

- if the balance is positive: the amount released will be paid in full to the coordinator together with the amount due as the balance;
- if the balance is negative (payment of the balance taking the form of recovery): it will be deducted from the amount released (see Article 44.1.2). If the resulting amount:
 - is positive, it will be paid to the coordinator
 - is negative, it will be recovered.

The amount to be paid may however be offset — without the beneficiary's consent — against any other amount owed by the beneficiary to the *Agency*, the Commission or another executive agency (under the EU or Euratom budget), up to the maximum EU contribution indicated, for that beneficiary, in the estimated budget (see Annex 2).



21.5 Notification of amounts due

When making payments, the *Agency* will formally notify to the coordinator the amount due, specifying whether it concerns an interim payment or the payment of the balance.

For the payment of the balance, the notification will also specify the final grant amount.

In the case of reduction of the grant or recovery of undue amounts, the notification will be preceded by the contradictory procedure set out in Articles 43 and 44.

21.6 Currency for payments

The *Agency* will make all payments in euro.

21.7 Payments to the coordinator — Distribution to the beneficiaries

Payments will be made to the coordinator.

Payments to the coordinator will discharge the *Agency* from its payment obligation.

The coordinator must distribute the payments between the beneficiaries without unjustified delay.

Pre-financing may however be distributed only:

- (a) if the minimum number of beneficiaries set out in the call for proposals has acceded to the Agreement (see Article 56) and
- (b) to beneficiaries that have acceded to the Agreement (see Article 56).

21.8 Bank account for payments

All payments will be made to the following bank account:

Name of bank: SOCIETE GENERALE

Address of branch: 12, RUE DE LA REPUBLIQUE ORLEANS, France

Full name of the account holder: B R G M

Full account number (including bank codes):

IBAN code: FR7630003015400002092909668

21.9 Costs of payment transfers

The cost of the payment transfers is borne as follows:

- the *Agency* bears the cost of transfers charged by its bank;
- the beneficiary bears the cost of transfers charged by its bank;
- the party causing a repetition of a transfer bears all costs of the repeated transfer.

21.10 Date of payment

Payments by the *Agency* are considered to have been carried out on the date when they are debited to its account.



21.11 Consequences of non-compliance

21.11.1 If the *Agency* does not pay within the payment deadlines (see above), the beneficiaries are entitled to **late-payment interest** at the rate applied by the European Central Bank (ECB) for its main refinancing operations in euros ('reference rate'), plus three and a half points. The reference rate is the rate in force on the first day of the month in which the payment deadline expires, as published in the C series of the *Official Journal of the European Union*.

If the late-payment interest is lower than or equal to EUR 200, it will be paid to the coordinator only upon request submitted within two months of receiving the late payment.

Late-payment interest is not due if all beneficiaries are EU Member States (including regional and local government authorities or other public bodies acting on behalf of a Member State for the purpose of this Agreement).

Suspension of the payment deadline or payments (see Articles 47 and 48) will not be considered as late payment.

Late-payment interest covers the period running from the day following the due date for payment (see above), up to and including the date of payment.

Late-payment interest is not considered for the purposes of calculating the final grant amount.

21.11.2 If the coordinator breaches any of its obligations under this Article, the grant may be reduced (see Article 43) and the Agreement or the participation of the coordinator may be terminated (see Article 50).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 22 — CHECKS, REVIEWS, AUDITS AND INVESTIGATIONS — EXTENSION OF FINDINGS

22.1 Checks, reviews and audits by the *Agency and the Commission*

22.1.1 Right to carry out checks

The *Agency or the Commission* will — during the implementation of the action or afterwards — check the proper implementation of the action and compliance with the obligations under the Agreement, including assessing deliverables and reports.

For this purpose the *Agency or the Commission* may be assisted by external persons or bodies.

The *Agency or the Commission* may also request additional information in accordance with Article 17. The *Agency or the Commission* may request beneficiaries to provide such information to it directly.

Information provided must be accurate, precise and complete and in the format requested, including electronic format.

22.1.2 Right to carry out reviews

The *Agency or the Commission* may — during the implementation of the action or afterwards — carry out reviews on the proper implementation of the action (including assessment of deliverables



and reports), compliance with the obligations under the Agreement and continued scientific or technological relevance of the action.

Reviews may be started **up to two years after the payment of the balance**. They will be formally notified to the coordinator or beneficiary concerned and will be considered to have started on the date of the formal notification.

If the review is carried out on a third party (see Articles 10 to 16), the beneficiary concerned must inform the third party.

The *Agency or the Commission* may carry out reviews directly (using its own staff) or indirectly (using external persons or bodies appointed to do so). It will inform the coordinator or beneficiary concerned of the identity of the external persons or bodies. They have the right to object to the appointment on grounds of commercial confidentiality.

The coordinator or beneficiary concerned must provide — within the deadline requested — any information and data in addition to deliverables and reports already submitted (including information on the use of resources). The *Agency or the Commission* may request beneficiaries to provide such information to it directly.

The coordinator or beneficiary concerned may be requested to participate in meetings, including with external experts.

For **on-the-spot** reviews, the beneficiaries must allow access to their sites and premises, including to external persons or bodies, and must ensure that information requested is readily available.

Information provided must be accurate, precise and complete and in the format requested, including electronic format.

On the basis of the review findings, a '**review report**' will be drawn up.

The *Agency or the Commission* will formally notify the review report to the coordinator or beneficiary concerned, which has 30 days to formally notify observations ('**contradictory review procedure**').

Reviews (including review reports) are in the language of the Agreement.

22.1.3 Right to carry out audits

The *Agency or the Commission* may — during the implementation of the action or afterwards — carry out audits on the proper implementation of the action and compliance with the obligations under the Agreement.

Audits may be started **up to two years after the payment of the balance**. They will be formally notified to the coordinator or beneficiary concerned and will be considered to have started on the date of the formal notification.

If the audit is carried out on a third party (see Articles 10 to 16), the beneficiary concerned must inform the third party.

The *Agency or the Commission* may carry out audits directly (using its own staff) or indirectly (using external persons or bodies appointed to do so). It will inform the coordinator or beneficiary concerned



of the identity of the external persons or bodies. They have the right to object to the appointment on grounds of commercial confidentiality.

The coordinator or beneficiary concerned must provide — within the deadline requested — any information (including complete accounts, individual salary statements or other personal data) to verify compliance with the Agreement. The *Agency or the* Commission may request beneficiaries to provide such information to it directly.

For **on-the-spot** audits, the beneficiaries must allow access to their sites and premises, including to external persons or bodies, and must ensure that information requested is readily available.

Information provided must be accurate, precise and complete and in the format requested, including electronic format.

On the basis of the audit findings, a '**draft audit report**' will be drawn up.

The *Agency or the* Commission will formally notify the draft audit report to the coordinator or beneficiary concerned, which has 30 days to formally notify observations ('**contradictory audit procedure**'). This period may be extended by the *Agency or the* Commission in justified cases.

The '**final audit report**' will take into account observations by the coordinator or beneficiary concerned. The report will be formally notified to it.

Audits (including audit reports) are in the language of the Agreement.

The *Agency or the* Commission may also access the beneficiaries' statutory records for the periodical assessment of unit costs or flat-rate amounts.

22.2 Investigations by the European Anti-Fraud Office (OLAF)

Under Regulations No 883/2013¹⁵ and No 2185/96¹⁶ (and in accordance with their provisions and procedures), the European Anti-Fraud Office (OLAF) may — at any moment during implementation of the action or afterwards — carry out investigations, including on-the-spot checks and inspections, to establish whether there has been fraud, corruption or any other illegal activity affecting the financial interests of the EU.

22.3 Checks and audits by the European Court of Auditors (ECA)

Under Article 287 of the Treaty on the Functioning of the European Union (TFEU) and Article 161 of the Financial Regulation No 966/2012¹⁷, the European Court of Auditors (ECA) may — at any moment during implementation of the action or afterwards — carry out audits.

¹⁵ Regulation (EU, Euratom) No 883/2013 of the European Parliament and of the Council of 11 September 2013 concerning investigations conducted by the European Anti-Fraud Office (OLAF) and repealing Regulation (EC) No 1073/1999 of the European Parliament and of the Council and Council Regulation (Euratom) No 1074/1999 (OJ L 248, 18.09.2013, p. 1).

¹⁶ Council Regulation (Euratom, EC) No 2185/1996 of 11 November 1996 concerning on-the-spot checks and inspections carried out by the Commission in order to protect the European Communities' financial interests against fraud and other irregularities (OJ L 292, 15.11.1996, p. 2).

¹⁷ Regulation (EU, Euratom) No 966/2012 of the European Parliament and of the Council of 25 October 2012 on the financial rules applicable to the general budget of the Union and repealing Council Regulation (EC, Euratom) No 1605/2002 (OJ L 298, 26.10.2012, p. 1).



The ECA has the right of access for the purpose of checks and audits.

22.4 Checks, reviews, audits and investigations for international organisations

Not applicable

22.5 Consequences of findings in checks, reviews, audits and investigations — Extension of findings

22.5.1 Findings in this grant

Findings in checks, reviews, audits or investigations carried out in the context of this grant may lead to the rejection of ineligible costs (see Article 42), reduction of the grant (see Article 43), recovery of undue amounts (see Article 44) or to any of the other measures described in Chapter 6.

Rejection of costs or reduction of the grant after the payment of the balance will lead to a revised final grant amount (see Article 5.4).

Findings in checks, reviews, audits or investigations may lead to a request for amendment for the modification of Annex 1 (see Article 55).

Checks, reviews, audits or investigations that find systemic or recurrent errors, irregularities, fraud or breach of obligations may also lead to consequences in other EU or Euratom grants awarded under similar conditions (**‘extension of findings from this grant to other grants’**).

Moreover, findings arising from an OLAF investigation may lead to criminal prosecution under national law.

22.5.2 Findings in other grants

The *Agency or the* Commission may extend findings from other grants to this grant (**‘extension of findings from other grants to this grant’**), if:

- (a) the beneficiary concerned is found, in other EU or Euratom grants awarded under similar conditions, to have committed systemic or recurrent errors, irregularities, fraud or breach of obligations that have a material impact on this grant and
- (b) those findings are formally notified to the beneficiary concerned — together with the list of grants affected by the findings — no later than two years after the payment of the balance of this grant.

The extension of findings may lead to the rejection of costs (see Article 42), reduction of the grant (see Article 43), recovery of undue amounts (see Article 44), suspension of payments (see Article 48), suspension of the action implementation (see Article 49) or termination (see Article 50).

22.5.3 Procedure

The *Agency or the* Commission will formally notify the beneficiary concerned the systemic or recurrent errors and its intention to extend these audit findings, together with the list of grants affected.

22.5.3.1 If the findings concern **eligibility of costs**: the formal notification will include:



- (a) an invitation to submit observations on the list of grants affected by the findings;
- (b) the request to submit **revised financial statements** for all grants affected;
- (c) the **correction rate for extrapolation** established by the *Agency or the Commission* on the basis of the systemic or recurrent errors, to calculate the amounts to be rejected if the beneficiary concerned:
 - (i) considers that the submission of revised financial statements is not possible or practicable or
 - (ii) does not submit revised financial statements.

The beneficiary concerned has 90 days from receiving notification to submit observations, revised financial statements or to propose a duly substantiated **alternative correction method**. This period may be extended by the *Agency or the Commission* in justified cases.

The amounts to be rejected will be determined on the basis of the revised financial statements, subject to their approval.

If the *Agency or the Commission* does not receive any observations or revised financial statements, does not accept the observations or the proposed alternative correction method or does not approve the revised financial statements, it will formally notify the beneficiary concerned the application of the initially notified correction rate for extrapolation.

If the *Agency or the Commission* accepts the alternative correction method proposed by the beneficiary concerned, it will formally notify the application of the accepted alternative correction method.

22.5.3.2 If the findings concern **improper implementation** or a **breach of another obligation**: the formal notification will include:

- (a) an invitation to submit observations on the list of grants affected by the findings and
- (b) the flat-rate the *Agency or the Commission* intends to apply according to the principle of proportionality.

The beneficiary concerned has 90 days from receiving notification to submit observations or to propose a duly substantiated alternative flat-rate.

If the *Agency or the Commission* does not receive any observations or does not accept the observations or the proposed alternative flat-rate, it will formally notify the beneficiary concerned the application of the initially notified flat-rate.

If the *Agency or the Commission* accepts the alternative flat-rate proposed by the beneficiary concerned, it will formally notify the application of the accepted alternative flat-rate.

22.6 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, any insufficiently substantiated costs will be ineligible (see Article 6) and will be rejected (see Article 42).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 23 — EVALUATION OF THE IMPACT OF THE ACTION

23.1 Right to evaluate the impact of the action

The *Agency or the Commission* may carry out interim and final evaluations of the impact of the action measured against the objective of the *EU* programme.

Evaluations may be started during implementation of the action and up to *five* years after the payment of the balance. The evaluation is considered to start on the date of the formal notification to the coordinator or beneficiaries.

The *Agency or the Commission* may make these evaluations directly (using its own staff) or indirectly (using external bodies or persons it has authorised to do so).

The coordinator or beneficiaries must provide any information relevant to evaluate the impact of the action, including information in electronic format.

23.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the *Agency* may apply the measures described in Chapter 6.

SECTION 3 RIGHTS AND OBLIGATIONS RELATED TO BACKGROUND AND RESULTS

SUBSECTION 1 GENERAL

ARTICLE 23a — MANAGEMENT OF INTELLECTUAL PROPERTY

23a.1 Obligation to take measures to implement the Commission Recommendation on the management of intellectual property in knowledge transfer activities

Beneficiaries that are universities or other public research organisations must take measures to implement the principles set out in Points 1 and 2 of the Code of Practice annexed to the Commission Recommendation on the management of intellectual property in knowledge transfer activities¹⁸.

This does not change the obligations set out in Subsections 2 and 3 of this Section.

The beneficiaries must ensure that researchers and third parties involved in the action are aware of them.

23a.2 Consequences of non-compliance

If a beneficiary breaches its obligations under this Article, the *Agency* may apply any of the measures described in Chapter 6.

¹⁸ Commission Recommendation C (2008) 1329 of 10.4.2008 on the management of intellectual property in knowledge transfer activities and the Code of Practice for universities and other public research institutions attached to this recommendation.



SUBSECTION 2 RIGHTS AND OBLIGATIONS RELATED TO BACKGROUND

ARTICLE 24 — AGREEMENT ON BACKGROUND

24.1 Agreement on background

The beneficiaries must identify and agree (in writing) on the background for the action (**‘agreement on background’**).

‘Background’ means any data, know-how or information — whatever its form or nature (tangible or intangible), including any rights such as intellectual property rights — that:

- (a) is held by the beneficiaries before they acceded to the Agreement, and
- (b) is needed to implement the action or exploit the results.

24.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 25 — ACCESS RIGHTS TO BACKGROUND

25.1 Exercise of access rights — Waiving of access rights — No sub-licensing

To exercise access rights, this must first be requested in writing (**‘request for access’**).

‘Access rights’ means rights to use results or background under the terms and conditions laid down in this Agreement.

Waivers of access rights are not valid unless in writing.

Unless agreed otherwise, access rights do not include the right to sub-license.

25.2 Access rights for other beneficiaries, for implementing their own tasks under the action

The beneficiaries must give each other access — on a royalty-free basis — to background needed to implement their own tasks under the action, unless the beneficiary that holds the background has — before acceding to the Agreement —:

- (a) informed the other beneficiaries that access to its background is subject to legal restrictions or limits, including those imposed by the rights of third parties (including personnel), or
- (b) agreed with the other beneficiaries that access would not be on a royalty-free basis.

25.3 Access rights for other beneficiaries, for exploiting their own results

The beneficiaries must give each other access — under fair and reasonable conditions — to background needed for exploiting their own results, unless the beneficiary that holds the background



has — before acceding to the Agreement — informed the other beneficiaries that access to its background is subject to legal restrictions or limits, including those imposed by the rights of third parties (including personnel).

‘Fair and reasonable conditions’ means appropriate conditions, including possible financial terms or royalty-free conditions, taking into account the specific circumstances of the request for access, for example the actual or potential value of the results or background to which access is requested and/or the scope, duration or other characteristics of the exploitation envisaged.

Requests for access may be made — unless agreed otherwise — up to one year after the period set out in Article 3.

25.4 Access rights for affiliated entities

Unless otherwise agreed in the consortium agreement, access to background must also be given — under fair and reasonable conditions (see above; Article 25.3) and unless it is subject to legal restrictions or limits, including those imposed by the rights of third parties (including personnel) — to affiliated entities¹⁹ established in an EU Member State or **‘associated country’**²⁰, if this is needed to exploit the results generated by the beneficiaries to which they are affiliated.

Unless agreed otherwise (see above; Article 25.1), the affiliated entity concerned must make the request directly to the beneficiary that holds the background.

Requests for access may be made — unless agreed otherwise — up to one year after the period set out in Article 3.

25.5 Access rights for third parties

Not applicable

25.6 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

SUBSECTION 3 RIGHTS AND OBLIGATIONS RELATED TO RESULTS

ARTICLE 26 — OWNERSHIP OF RESULTS

26.1 Ownership by the beneficiary that generates the results

Results are owned by the beneficiary that generates them.

¹⁹ For the definition, see ‘affiliated entity’ footnote (Article 14.1).

²⁰ For the definition, see Article 2.1(3) of the Rules for Participation Regulation No 1290/2013: **‘associated country’** means a third country which is party to an international agreement with the Union, as identified in *Article 7 of Horizon 2020 Framework Programme Regulation No 1291/2013. Article 7 sets out the conditions for association of non-EU countries to Horizon 2020.*



‘Results’ means any (tangible or intangible) output of the action such as data, knowledge or information — whatever its form or nature, whether it can be protected or not — that is generated in the action, as well as any rights attached to it, including intellectual property rights.

26.2 Joint ownership by several beneficiaries

Two or more beneficiaries own results jointly if:

- (a) they have jointly generated them and
- (b) it is not possible to:
 - (i) establish the respective contribution of each beneficiary, or
 - (ii) separate them for the purpose of applying for, obtaining or maintaining their protection (see Article 27).

The joint owners must agree (in writing) on the allocation and terms of exercise of their joint ownership (**‘joint ownership agreement’**), to ensure compliance with their obligations under this Agreement.

Unless otherwise agreed in the joint ownership agreement, each joint owner may grant non-exclusive licences to third parties to exploit jointly-owned results (without any right to sub-license), if the other joint owners are given:

- (a) at least 45 days advance notice and
- (b) fair and reasonable compensation.

Once the results have been generated, joint owners may agree (in writing) to apply another regime than joint ownership (such as, for instance, transfer to a single owner (see Article 30) with access rights for the others).

26.3 Rights of third parties (including personnel)

If third parties (including personnel) may claim rights to the results, the beneficiary concerned must ensure that it complies with its obligations under the Agreement.

If a third party generates results, the beneficiary concerned must obtain all necessary rights (transfer, licences or other) from the third party, in order to be able to respect its obligations as if those results were generated by the beneficiary itself.

If obtaining the rights is impossible, the beneficiary must refrain from using the third party to generate the results.

26.4 Agency ownership, to protect results

26.4.1 *The Agency* may — with the consent of the beneficiary concerned — assume ownership of results to protect them, if a beneficiary intends — up to four years after the period set out in Article 3 — to disseminate its results without protecting them, except in any of the following cases:

- (a) the lack of protection is because protecting the results is not possible, reasonable or justified (given the circumstances);



- (b) the lack of protection is because there is a lack of potential for commercial or industrial exploitation, or
- (c) the beneficiary intends to transfer the results to another beneficiary or third party established in an EU Member State or associated country, which will protect them.

Before the results are disseminated and unless any of the cases above under Points (a), (b) or (c) applies, the beneficiary must formally notify the *Agency* and at the same time inform it of any reasons for refusing consent. The beneficiary may refuse consent only if it can show that its legitimate interests would suffer significant harm.

If the *Agency* decides to assume ownership, it will formally notify the beneficiary concerned within 45 days of receiving notification.

No dissemination relating to these results may before the end of this period or, if the *Agency* takes a positive decision, until it has taken the necessary steps to protect the results.

26.4.2 *The Agency* may — with the consent of the beneficiary concerned — assume ownership of results to protect them, if a beneficiary intends — up to four years after the period set out in Article 3 — to stop protecting them or not to seek an extension of protection, except in any of the following cases:

- (a) the protection is stopped because of a lack of potential for commercial or industrial exploitation;
- (b) an extension would not be justified given the circumstances.

A beneficiary that intends to stop protecting results or not seek an extension must — unless any of the cases above under Points (a) or (b) applies — formally notify the *Agency* at least 60 days before the protection lapses or its extension is no longer possible and at the same time inform it of any reasons for refusing consent. The beneficiary may refuse consent only if it can show that its legitimate interests would suffer significant harm.

If the *Agency* decides to assume ownership, it will formally notify the beneficiary concerned within 45 days of receiving notification.

26.5 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to the any of the other measures described in Chapter 6.

ARTICLE 27 — PROTECTION OF RESULTS — VISIBILITY OF EU FUNDING

27.1 Obligation to protect the results

Each beneficiary must examine the possibility of protecting its results and must adequately protect them — for an appropriate period and with appropriate territorial coverage — if:

- (a) the results can reasonably be expected to be commercially or industrially exploited and
- (b) protecting them is possible, reasonable and justified (given the circumstances).



When deciding on protection, the beneficiary must consider its own legitimate interests and the legitimate interests (especially commercial) of the other beneficiaries.

27.2 Agency ownership, to protect the results

If a beneficiary intends not to protect its results, to stop protecting them or not seek an extension of protection, *the Agency* may — under certain conditions (see Article 26.4) — assume ownership to ensure their (continued) protection.

27.3 Information on EU funding

Applications for protection of results (including patent applications) filed by or on behalf of a beneficiary must — unless the *Agency* requests or agrees otherwise or unless it is impossible — include the following:

“The project leading to this application has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 653718”.

27.4 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such a breach may also lead to any of the other measures described in Chapter 6.

ARTICLE 28 — EXPLOITATION OF RESULTS

28.1 Obligation to exploit the results

Each beneficiary must — up to four years after the period set out in Article 3 — take measures aiming to ensure ‘**exploitation**’ of its results (either directly or indirectly, in particular through transfer or licensing; see Article 30) by:

- (a) using them in further research activities (outside the action);
- (b) developing, creating or marketing a product or process;
- (c) creating and providing a service, or
- (d) using them in standardisation activities.

This does not change the security obligations in Article 37, which still apply.

28.2 Results that could contribute to European or international standards — Information on EU funding

If results are incorporated in a standard, the beneficiary concerned must — unless the *Agency* requests or agrees otherwise or unless it is impossible — ask the standardisation body to include the following statement in (information related to) the standard:

“Results incorporated in this standard received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 653718”.



28.3 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced in accordance with Article 43.

Such a breach may also lead to any of the other measures described in Chapter 6.

ARTICLE 29 — DISSEMINATION OF RESULTS — OPEN ACCESS — VISIBILITY OF EU FUNDING

29.1 Obligation to disseminate results

Unless it goes against their legitimate interests, each beneficiary must — as soon as possible — ‘**disseminate**’ its results by disclosing them to the public by appropriate means (other than those resulting from protecting or exploiting the results), including in scientific publications (in any medium).

This does not change the obligation to protect results in Article 27, the confidentiality obligations in Article 36, the security obligations in Article 37 or the obligations to protect personal data in Article 39, all of which still apply.

A beneficiary that intends to disseminate its results must give advance notice to the other beneficiaries of — unless agreed otherwise — at least 45 days, together with sufficient information on the results it will disseminate.

Any other beneficiary may object within — unless agreed otherwise — 30 days of receiving notification, if it can show that its legitimate interests in relation to the results or background would be significantly harmed. In such cases, the dissemination may not take place unless appropriate steps are taken to safeguard these legitimate interests.

If a beneficiary intends not to protect its results, it may — under certain conditions (see Article 26.4.1) — need to formally notify the *Agency* before dissemination takes place.

29.2 Open access to scientific publications

Each beneficiary must ensure open access (free of charge online access for any user) to all peer-reviewed scientific publications relating to its results.

In particular, it must:

- (a) as soon as possible and at the latest on publication, deposit a machine-readable electronic copy of the published version or final peer-reviewed manuscript accepted for publication in a repository for scientific publications;

Moreover, the beneficiary must aim to deposit at the same time the research data needed to validate the results presented in the deposited scientific publications.

- (b) ensure open access to the deposited publication — via the repository — at the latest:

- (i) on publication, if an electronic version is available for free via the publisher, or



- (ii) within six months of publication (twelve months for publications in the social sciences and humanities) in any other case.
- (c) ensure open access — via the repository — to the bibliographic metadata that identify the deposited publication.

The bibliographic metadata must be in a standard format and must include all of the following:

- the terms “*European Union (EU)*” and “*Horizon 2020*”;
- the name of the action, acronym and grant number;
- the publication date, and length of embargo period if applicable, and
- a persistent identifier.

29.3 Open access to research data

Not applicable

29.4 Information on EU funding — Obligation and right to use the EU emblem

Unless the *Agency* requests or agrees otherwise or unless it is impossible, any dissemination of results (in any form, including electronic) must:

- (a) display the EU emblem and
- (b) include the following text:

“This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 653718”.

When displayed together with another logo, the EU emblem must have appropriate prominence.

For the purposes of their obligations under this Article, the beneficiaries may use the EU emblem without first obtaining approval from the *Agency*.

This does not however give them the right to exclusive use.

Moreover, they may not appropriate the EU emblem or any similar trademark or logo, either by registration or by any other means.

29.5 Disclaimer excluding *Agency* responsibility

Any dissemination of results must indicate that it reflects only the author's view and that the *Agency* is not responsible for any use that may be made of the information it contains.

29.6 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).



Such a breach may also lead to any of the other measures described in Chapter 6.

ARTICLE 30 — TRANSFER AND LICENSING OF RESULTS

30.1 Transfer of ownership

Each beneficiary may transfer ownership of its results.

It must however ensure that its obligations under Articles 26.2, 26.4, 27, 28, 29, 30 and 31 also apply to the new owner and that this owner has the obligation to pass them on in any subsequent transfer.

This does not change the security obligations in Article 37, which still apply.

Unless agreed otherwise (in writing) for specifically-identified third parties or unless impossible under applicable EU and national laws on mergers and acquisitions, a beneficiary that intends to transfer ownership of results must give at least 45 days advance notice (or less if agreed in writing) to the other beneficiaries that still have (or still may request) access rights to the results. This notification must include sufficient information on the new owner to enable any beneficiary concerned to assess the effects on its access rights.

Unless agreed otherwise (in writing) for specifically-identified third parties, any other beneficiary may object within 30 days of receiving notification (or less if agreed in writing), if it can show that the transfer would adversely affect its access rights. In this case, the transfer may not take place until agreement has been reached between the beneficiaries concerned.

30.2 Granting licenses

Each beneficiary may grant licences to its results (or otherwise give the right to exploit them), if:

- (a) this does not impede the rights under Article 31 and
- (b) *not applicable*.

In addition to Points (a) and (b), exclusive licences for results may be granted only if all the other beneficiaries concerned have waived their access rights (see Article 31.1).

This does not change the dissemination obligations in Article 29 or security obligations in Article 37, which still apply.

30.3 Agency right to object to transfers or licensing

Not applicable

30.4 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such a breach may also lead to any of the other measures described in Chapter 6.



ARTICLE 31 — ACCESS RIGHTS TO RESULTS

31.1 Exercise of access rights — Waiving of access rights — No sub-licensing

The conditions set out in Article 25.1 apply.

The obligations set out in this Article do not change the security obligations in Article 37, which still apply.

31.2 Access rights for other beneficiaries, for implementing their own tasks under the action

The beneficiaries must give each other access — on a royalty-free basis — to results needed for implementing their own tasks under the action.

31.3 Access rights for other beneficiaries, for exploiting their own results

The beneficiaries must give each other — under fair and reasonable conditions (see Article 25.3) — access to results needed for exploiting their own results.

Requests for access may be made — unless agreed otherwise — up to one year after the period set out in Article 3.

31.4 Access rights of affiliated entities

Unless agreed otherwise in the consortium agreement, access to results must also be given — under fair and reasonable conditions (Article 25.3) — to affiliated entities established in an EU Member State or associated country, if this is needed for those entities to exploit the results generated by the beneficiaries to which they are affiliated.

Unless agreed otherwise (see above; Article 31.1), the affiliated entity concerned must make any such request directly to the beneficiary that owns the results.

Requests for access may be made — unless agreed otherwise — up to one year after the period set out in Article 3.

31.5 Access rights for the EU institutions, bodies, offices or agencies and EU Member States

The beneficiaries must give access to their results — on a royalty-free basis — to EU institutions, bodies, offices or agencies, for developing, implementing or monitoring EU policies or programmes.

Such access rights are limited to non-commercial and non-competitive use.

This does not change the right to use any material, document or information received from the beneficiaries for communication and publicising activities (see Article 38.2).

31.6 Access rights for third parties

Not applicable

31.7 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

SECTION 4 OTHER RIGHTS AND OBLIGATIONS

ARTICLE 32 — RECRUITMENT AND WORKING CONDITIONS FOR RESEARCHERS

32.1 Obligation to take measures to implement the European Charter for Researchers and Code of Conduct for the Recruitment of Researchers

The beneficiaries must take all measures to implement the principles set out in the Commission Recommendation on the European Charter for Researchers and the Code of Conduct for the Recruitment of Researchers²², in particular regarding:

- working conditions;
- transparent recruitment processes based on merit, and
- career development.

The beneficiaries must ensure that researchers and third parties involved in the action are aware of them.

32.2 Consequences of non-compliance

If a beneficiary breaches its obligations under this Article, the *Agency* may apply any of the measures described in Chapter 6.

ARTICLE 33 — GENDER EQUALITY

33.1 Obligation to aim for gender equality

The beneficiaries must take all measures to promote equal opportunities between men and women in the implementation of the action. They must aim, to the extent possible, for a gender balance at all levels of personnel assigned to the action, including at supervisory and managerial level.

33.2 Consequences of non-compliance

If a beneficiary breaches its obligations under this Article, the *Agency* may apply any of the measures described in Chapter 6.

ARTICLE 34 — ETHICS

34.1 Obligation to comply with ethical principles

The beneficiaries must carry out the action in compliance with:

²² Commission Recommendation 2005/251/EC of 11 March 2005 on the European Charter for Researchers and on a Code of Conduct for the Recruitment of Researchers (OJ L 75, 22.3.2005, p. 67).



- (a) ethical principles (including the highest standards of research integrity — as set out, for instance, in the European Code of Conduct for Research Integrity²³ — and including, in particular, avoiding fabrication, falsification, plagiarism or other research misconduct) and
- (b) applicable international, EU and national law.

Funding will not be granted for activities carried out outside the EU if they are prohibited in all Member States.

The beneficiaries must ensure that the activities under the action have an exclusive focus on civil applications.

The beneficiaries must ensure that the activities under the action do not:

- (a) aim at human cloning for reproductive purposes;
- (b) intend to modify the genetic heritage of human beings which could make such changes heritable (with the exception of research relating to cancer treatment of the gonads, which may be financed), or
- (c) intend to create human embryos solely for the purpose of research or for the purpose of stem cell procurement, including by means of somatic cell nuclear transfer.

34.2 Activities raising ethical issues

Activities raising ethical issues must comply with the ‘**ethics requirements**’ set out in Annex 1.

Before the beginning of an activity raising an ethical issue, the coordinator must submit (see Article 52) to the *Agency* copy of:

- (a) any ethics committee opinion required under national law and
- (b) any notification or authorisation for activities raising ethical issues required under national law.

If these documents are not in English, the coordinator must also submit an English summary of the submitted opinions, notifications and authorisations (containing, if available, the conclusions of the committee or authority concerned).

If these documents are specifically requested for the action, the request must contain an explicit reference to the action title. The coordinator must submit a declaration by each beneficiary concerned that all the submitted documents cover the action tasks.

34.3 Activities involving human embryos or human embryonic stem cells

Activities involving research on human embryos or human embryonic stem cells may be carried out only if:

²³ The European Code of Conduct for Research Integrity of ALLEA (All European Academies) and ESF (European Science Foundation) of March 2011.

http://www.esf.org/fileadmin/Public_documents/Publications/Code_Conduct_ResearchIntegrity.pdf



- they are set out in Annex 1 or
- the coordinator has obtained explicit approval (in writing) from the *Agency* (see Article 52).

34.4 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43) and the Agreement or participation of the beneficiary may be terminated (see Article 50).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 35 — CONFLICT OF INTERESTS

35.1 Obligation to avoid a conflict of interests

The beneficiaries must take all measures to prevent any situation where the impartial and objective implementation of the action is compromised for reasons involving economic interest, political or national affinity, family or emotional ties or any other shared interest (**‘conflict of interests’**).

They must formally notify to the *Agency* without delay any situation constituting or likely to lead to a conflict of interests and immediately take all the necessary steps to rectify this situation.

The *Agency* may verify that the measures taken are appropriate and may require additional measures to be taken by a specified deadline.

35.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43) and the Agreement or participation of the beneficiary may be terminated (see Article 50).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 36 — CONFIDENTIALITY

36.1 General obligation to maintain confidentiality

During implementation of the action and for four years after the period set out in Article 3, the parties must keep confidential any data, documents or other material (in any form) that is identified as confidential at the time it is disclosed (**‘confidential information’**).

If a beneficiary requests, the *Agency* may agree to keep such information confidential for an additional period beyond the initial four years.

If information has been identified as confidential only orally, it will be considered to be confidential only if this is confirmed in writing within 15 days of the oral disclosure.

Unless otherwise agreed between the parties, they may use confidential information only to implement the Agreement.

The beneficiaries may disclose confidential information to their personnel or third parties involved in the action only if they:



- (a) need to know to implement the Agreement and
- (b) are bound by an obligation of confidentiality.

This does not change the security obligations in Article 37, which still apply.

The *Agency* may disclose confidential information to its staff, other EU institutions and bodies or third parties, if:

- (a) this is necessary to implement the Agreement or safeguard the EU's financial interests and
- (b) the recipients of the information are bound by an obligation of confidentiality.

Under the conditions set out in Article 4 of the Rules for Participation Regulation No 1290/2013²⁴, the Commission must moreover make available information on the results to other EU institutions, bodies, offices or agencies as well as Member States or associated countries.

The confidentiality obligations no longer apply if:

- (a) the disclosing party agrees to release the other party;
- (b) the information was already known by the recipient or is given to him without obligation of confidentiality by a third party that was not bound by any obligation of confidentiality;
- (c) the recipient proves that the information was developed without the use of confidential information;
- (d) the information becomes generally and publicly available, without breaching any confidentiality obligation, or
- (e) the disclosure of the information is required by EU or national law.

36.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 37 — SECURITY-RELATED OBLIGATIONS

37.1 Results with a security recommendation

Not applicable

37.2 Classified results

Not applicable

²⁴ Regulation (EU) No 1290/2013 of the European Parliament and of the Council of 11 December 2013 laying down the rules for participation and dissemination in "Horizon 2020 - the Framework Programme for Research and Innovation (2014-2020)" (OJ L 347, 20.12.2013 p.81).



37.3 Activities involving dual-use goods or dangerous materials and substances

Not applicable

37.4 Consequences of non-compliance

Not applicable

ARTICLE 38 — PROMOTING THE ACTION — VISIBILITY OF EU FUNDING

38.1 Communication activities by beneficiaries

38.1.1 Obligation to promote the action and its results

The beneficiaries must promote the action and its results, by providing targeted information to multiple audiences (including the media and the public) in a strategic and effective manner.

This does not change the dissemination obligations in Article 29, the confidentiality obligations in Article 36 or the security obligations in Article 37, all of which still apply.

Before engaging in a communication activity expected to have a major media impact, the beneficiaries must inform the *Agency* (see Article 52).

38.1.2 Information on EU funding — Obligation and right to use the EU emblem

Unless the *Agency* requests or agrees otherwise or unless it is impossible, any communication activity related to the action (including in electronic form, via social media, etc.) and any infrastructure, equipment and major results funded by the grant must:

(a) display the EU emblem and

(b) include the following text:

For communication activities: *“This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 653718”.*

For infrastructure, equipment and major results: *“This [infrastructure][equipment][insert type of result] is part of a project that has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 653718”.*

When displayed together with another logo, the EU emblem must have appropriate prominence.

For the purposes of their obligations under this Article, the beneficiaries may use the EU emblem without first obtaining approval from the *Agency*.

This does not, however, give them the right to exclusive use.

Moreover, they may not appropriate the EU emblem or any similar trademark or logo, either by registration or by any other means.

38.1.3 Disclaimer excluding *Agency* responsibility



Any communication activity related to the action must indicate that it reflects only the author's view and that the *Agency* is not responsible for any use that may be made of the information it contains.

38.2 Communication activities by the *Agency*

38.2.1 Right to use beneficiaries' materials, documents or information

The *Agency* may use, for its communication and publicising activities, information relating to the action, documents notably summaries for publication and public deliverables as well as any other material, such as pictures or audio-visual material that it receives from any beneficiary (including in electronic form).

This does not change the confidentiality obligations in Article 36 and the security obligations in Article 37, all of which still apply.

However, if the *Agency's* use of these materials, documents or information would risk compromising legitimate interests, the beneficiary concerned may request the *Agency* not to use it (see Article 52).

The right to use a beneficiary's materials, documents and information includes:

- (a) **use for its own purposes** (in particular, making them available to persons working for the *Agency* or any other EU institution, body, office or agency or body or institutions in EU Member States; and copying or reproducing them in whole or in part, in unlimited numbers);
- (b) **distribution to the public** (in particular, publication as hard copies and in electronic or digital format, publication on the internet, as a downloadable or non-downloadable file, broadcasting by any channel, public display or presentation, communicating through press information services, or inclusion in widely accessible databases or indexes);
- (c) **editing or redrafting** for communication and publicising activities (including shortening, summarising, inserting other elements (such as meta-data, legends, other graphic, visual, audio or text elements), extracting parts (e.g. audio or video files), dividing into parts, use in a compilation);
- (d) **translation**;
- (e) giving **access in response to individual requests** under Regulation No 1049/2001²⁵, without the right to reproduce or exploit;
- (f) **storage** in paper, electronic or other form;
- (g) **archiving**, in line with applicable document-management rules, and
- (h) the right to authorise **third parties** to act on its behalf or sub-license the modes of use set out in Points (b),(c),(d) and (f) to third parties if needed for the communication and publicising activities of the *Agency*.

²⁵ Regulation (EC) No 1049/2001 of the European Parliament and of the Council of 30 May 2001 regarding public access to European Parliament, Council and Commission documents, OJ L 145, 31.5.2001, p. 43.



If the right of use is subject to rights of a third party (including personnel of the beneficiary), the beneficiary must ensure that it complies with its obligations under this Agreement (in particular, by obtaining the necessary approval from the third parties concerned).

Where applicable (and if provided by the beneficiaries), the *Agency* will insert the following information:

“© – [year] – [name of the copyright owner]. All rights reserved. Licensed to the *Innovation and Networks Executive Agency (INEA)* under conditions.”

38.3 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 39 — PROCESSING OF PERSONAL DATA

39.1 Processing of personal data by the *Agency and the Commission*

Any personal data under the Agreement will be processed by the *Agency or the Commission* under Regulation No 45/2001²⁶ and according to the ‘notifications of the processing operations’ to the Data Protection Officer (DPO) of the *Agency or the Commission* (publicly accessible in the DPO register).

Such data will be processed by the ‘**data controller**’ of the *Agency or the Commission* for the purposes of implementing, managing and monitoring the Agreement or protecting the financial interests of the EU or Euratom (including checks, reviews, audits and investigations; see Article 22).

The persons whose personal data are processed have the right to access and correct their own personal data. For this purpose, they must send any queries about the processing of their personal data to the data controller, via the contact point indicated in the ‘service specific privacy statement(s) (SSPS)’ that are published on the *Agency and the Commission* websites.

They also have the right to have recourse at any time to the European Data Protection Supervisor (EDPS).

39.2 Processing of personal data by the beneficiaries

The beneficiaries must process personal data under the Agreement in compliance with applicable EU and national law on data protection (including authorisations or notification requirements).

The beneficiaries may grant their personnel access only to data that is strictly necessary for implementing, managing and monitoring the Agreement.

The beneficiaries must inform the personnel whose personal data are collected and processed by the *Agency or the Commission*. For this purpose, they must provide them with the service specific privacy statement (SSPS) (see above), before transmitting their data to the *Agency or the Commission*.

²⁶ Regulation (EC) No 45/2001 of the European Parliament and of the Council of 18 December 2000 on the protection of individuals with regard to the processing of personal data by the Community institutions and bodies and on the free movement of such data (OJ L 8, 12.01.2001, p. 1).



39.3 Consequences of non-compliance

If a beneficiary breaches any of its obligations under Article 39.2, the *Agency* may apply any of the measures described in Chapter 6.

ARTICLE 40 — ASSIGNMENTS OF CLAIMS FOR PAYMENT AGAINST THE *AGENCY*

The beneficiaries may not assign any of their claims for payment against the *Agency* to any third party, except if approved by the *Agency* on the basis of a reasoned, written request by the coordinator (on behalf of the beneficiary concerned).

If the *Agency* has not accepted the assignment or the terms of it are not observed, the assignment will have no effect on it.

In no circumstances will an assignment release the beneficiaries from their obligations towards the *Agency*.

CHAPTER 5 DIVISION OF BENEFICIARIES' ROLES AND RESPONSIBILITIES

ARTICLE 41 — DIVISION OF BENEFICIARIES' ROLES AND RESPONSIBILITIES — RELATIONSHIP WITH COMPLEMENTARY BENEFICIARIES — RELATIONSHIP WITH PARTNERS OF A JOINT ACTION

41.1 Roles and responsibilities towards the *Agency*

The beneficiaries have full responsibility for implementing the action and complying with the Agreement.

The beneficiaries are jointly and severally liable for the **technical implementation** of the action as described in Annex 1. If a beneficiary fails to implement its part of the action, the other beneficiaries become responsible for implementing this part (without being entitled to any additional EU funding for doing so), unless the *Agency* expressly relieves them of this obligation.

The **financial responsibility** of each beneficiary is governed by Articles 44, 45 and 46.

41.2 Internal division of roles and responsibilities

The internal roles and responsibilities of the beneficiaries are divided as follows:

(a) Each **beneficiary** must:

- (i) keep information stored in the 'Beneficiary Register' (via the electronic exchange system) up to date (see Article 17);
- (ii) inform the coordinator immediately of any events or circumstances likely to affect significantly or delay the implementation of the action (see Article 17);
- (iii) submit to the coordinator in good time:



- individual financial statements for itself *and its linked third parties* and, if required, certificates on the financial statements (see Article 20);
- the data needed to draw up the technical reports (see Article 20);
- ethics committee opinions and notifications or authorisations for activities raising ethical issues (see Article 34);
- any other documents or information required by the *Agency or the Commission* under the Agreement, unless the Agreement requires the beneficiary to submit this information directly to the *Agency or the Commission*.

(b) The **coordinator** must:

- (i) monitor that the action is implemented properly (see Article 7);
- (ii) act as the intermediary for all communications between the beneficiaries and the *Agency* (in particular, providing the *Agency* with the information described in Article 17), unless the Agreement specifies otherwise;
- (iii) request and review any documents or information required by the *Agency* and verify their completeness and correctness before passing them on to the *Agency*;
- (iv) submit the deliverables and reports to the *Agency* (see Articles 19 and 20);
- (v) ensure that all payments are made to the other beneficiaries without unjustified delay (see Article 21);
- (vi) inform the *Agency* of the amounts paid to each beneficiary, when required under the Agreement (see Articles 44 and 50) or requested by the *Agency*.

The coordinator may not delegate the above-mentioned tasks to any other beneficiary or subcontract them to any third party.

41.3 Internal arrangements between beneficiaries — Consortium agreement

The beneficiaries must have internal arrangements regarding their operation and co-ordination to ensure that the action is implemented properly. These internal arrangements must be set out in a written ‘consortium agreement’ between the beneficiaries, which may cover:

- *internal organisation of the consortium;*
- *management of access to the electronic exchange system;*
- *distribution of EU funding;*
- *additional rules on rights and obligations related to background and results (including whether access rights remain or not, if a beneficiary is in breach of its obligations) (see Section 3 of Chapter 4);*



- *settlement of internal disputes;*
- *liability, indemnification and confidentiality arrangements between the beneficiaries.*

The consortium agreement must not contain any provision contrary to the Agreement.

41.4 Relationship with complementary beneficiaries — Collaboration agreement

Not applicable

41.5 Relationship with partners of a joint action — Coordination agreement

Not applicable

CHAPTER 6 REJECTION OF COSTS — REDUCTION OF THE GRANT — RECOVERY — PENALTIES — DAMAGES — SUSPENSION — TERMINATION — FORCE MAJEURE

SECTION 1 REJECTION OF COSTS — REDUCTION OF THE GRANT — RECOVERY — PENALTIES

ARTICLE 42 — REJECTION OF INELIGIBLE COSTS

42.1 Conditions

42.1.1 The *Agency* will — at the time of an **interim payment**, **at the payment of the balance** or **afterwards** — reject any costs which are ineligible (see Article 6), in particular following checks, reviews, audits or investigations (see Article 22).

42.1.2 The rejection may also be based on the **extension of findings from other grants to this grant**, under the conditions set out in Article 22.5.2.

42.2 Ineligible costs to be rejected — Calculation — Procedure

Ineligible costs will be rejected in full.

If the *Agency* rejects costs **without reduction of the grant** (see Article 43) or **recovery of undue amounts** (see Article 44), it will formally notify the coordinator or beneficiary concerned the rejection of costs, the amounts and the reasons why (if applicable, together with the notification of amounts due; see Article 21.5). The coordinator or beneficiary concerned may — within 30 days of receiving notification — formally notify the *Agency* of its disagreement and the reasons why.

If the *Agency* rejects costs **with reduction of the grant** or **recovery of undue amounts**, it will formally notify the rejection in the ‘**pre-information letter**’ on reduction or recovery set out in Articles 43 and 44.

42.3 Effects

If the *Agency* rejects costs at the time of an **interim payment** or **the payment of the balance**, it will deduct them from the total eligible costs declared, for the action, in the periodic or final summary

financial statement (see Articles 20.3 and 20.4). It will then calculate the interim payment or payment of the balance as set out in Articles 21.3 or 21.4.

If the *Agency* — **after an interim payment but before the payment of the balance** — rejects costs declared in a periodic summary financial statement, it will deduct them from the total eligible costs declared, for the action, in the next periodic summary financial statement or in the final summary financial statement. It will then calculate the interim payment or payment of the balance as set out in Articles 21.3 or 21.4.

If the *Agency* rejects costs **after the payment of the balance**, it will deduct the amount rejected from the total eligible costs declared, by the beneficiary, in the final summary financial statement. It will then calculate the revised final grant amount as set out in Article 5.4.

ARTICLE 43 — REDUCTION OF THE GRANT

43.1 Conditions

43.1.1 The *Agency* may — **at the payment of the balance or afterwards** — reduce the maximum grant amount (see Article 5.1), if the action has not been implemented properly as described in Annex 1 or another obligation under the Agreement has been breached.

43.1.2 The *Agency* may also reduce the maximum grant amount on the basis of the **extension of findings from other grants to this grant**, under the conditions set out in Article 22.5.2.

43.2 Amount to be reduced — Calculation — Procedure

The amount of the reduction will be proportionate to the improper implementation of the action or to the seriousness of the breach.

Before reduction of the grant, the *Agency* will formally notify a ‘**pre-information letter**’ to the coordinator or beneficiary concerned:

- informing it of its intention to reduce the grant, the amount it intends to reduce and the reasons why and
- inviting it to submit observations within 30 days of receiving notification

If the *Agency* does not receive any observations or decides to pursue reduction despite the observations it has received, it will formally notify **confirmation** of the reduction (if applicable, together with the notification of amounts due; see Article 21).

43.3 Effects

If the *Agency* reduces the grant at the time of **the payment of the balance**, it will calculate the reduced grant amount for the action and then determine the amount due as payment of the balance (see Articles 5.3.4 and 21.4).

If the *Agency* reduces the grant **after the payment of the balance**, it will calculate the revised final grant amount for the beneficiary concerned (see Article 5.4). If the revised final grant amount for the beneficiary concerned is lower than its share of the final grant amount, the *Agency* will recover the difference (see Article 44).



ARTICLE 44 — RECOVERY OF UNDUE AMOUNTS

44.1 Amount to be recovered — Calculation — Procedure

The *Agency* will — after **termination of the participation of a beneficiary, at the payment of the balance or afterwards** — claim back any amount that was paid but is not due under the Agreement.

Each beneficiary's financial responsibility in case of recovery is limited to its own debt (*including undue amounts paid by the Agency for costs declared by its linked third parties*), except for the amount retained for the Guarantee Fund (see Article 21.4).

44.1.1 Recovery after termination of a beneficiary's participation

If recovery takes place after termination of a beneficiary's participation (including the coordinator), the *Agency* will claim back the undue amount from the beneficiary concerned, by formally notifying it a debit note (see Article 50.2 and 50.3). This note will specify the amount to be recovered, the terms and the date for payment.

If payment is not made by the date specified in the debit note, the *Agency or the Commission* will **recover** the amount:

- (a) by '**offsetting**' it — without the beneficiary's consent — against any amounts owed to the beneficiary concerned by the *Agency*, the Commission or another executive agency (from the EU or Euratom budget).

In exceptional circumstances, to safeguard the EU's financial interests, the *Agency* may offset before the payment date specified in the debit note;

- (b) *if a linked third party has accepted joint and several liability (see Article 14), by **holding the third party liable up to the maximum EU contribution indicated, for the linked third party, in the estimated budget (see Annex 2) and/or***

- (c) by **taking legal action** (see Article 57) or by **adopting an enforceable decision** under Article 299 of the Treaty on the Functioning of the EU (TFEU) and Article 79(2) of the Financial regulation No 966/2012.

If payment is not made by the date specified in the debit note, the amount to be recovered (see above) will be increased by **late-payment interest** at the rate set out in Article 21.11, from the day following the payment date in the debit note, up to and including the date the *Agency or the Commission* receives full payment of the amount.

Partial payments will be first credited against expenses, charges and late-payment interest and then against the principal.

Bank charges incurred in the recovery process will be borne by the beneficiary, unless Directive 2007/64/EC²⁷ applies.

²⁷ Directive 2007/64/EC of the European Parliament and of the Council of 13 November 2007 on payment services in the internal market amending Directives 97/7/EC, 2002/65/EC, 2005/60/EC and 2006/48/EC and repealing Directive 97/5/EC (OJ L 319, 05.12.2007, p. 1).



44.1.2 Recovery at payment of the balance

If the payment of the balance takes the form of a recovery (see Article 21.4), the *Agency* will formally notify a ‘**pre-information letter**’ to the coordinator:

- informing it of its intention to recover, the amount due as the balance and the reasons why;
- specifying that it intends to deduct the amount to be recovered from the amount retained for the Guarantee Fund;
- requesting the coordinator to submit a report on the distribution of payments to the beneficiaries within 30 days of receiving notification, and
- inviting the coordinator to submit observations within 30 days of receiving notification.

If no observations are submitted or the *Agency* decides to pursue recovery despite the observations it has received, it will **confirm recovery** (together with the notification of amounts due; see Article 21.5) and:

- pay the difference between the amount to be recovered and the amount retained for the Guarantee Fund, **if the difference is positive** or
- formally notify to the coordinator a **debit note** for the difference between the amount to be recovered and the amount retained for the Guarantee Fund, **if the difference is negative**. This note will also specify the terms and the date for payment.

If the coordinator does not repay the *Agency* by the date in the debit note and has not submitted the report on the distribution of payments: the *Agency or the Commission* will **recover** the amount set out in the debit note from the coordinator (see below).

If the coordinator does not repay the *Agency* by the date in the debit note, but has submitted the report on the distribution of payments: the *Agency* will:

- (a) identify the beneficiaries for which the amount calculated as follows is negative:

$\{ \{ \{ \text{beneficiary's costs declared in the final summary financial statement and approved by the Agency multiplied by the reimbursement rate set out in Article 5.2 for the beneficiary concerned} \}$

plus

its linked third parties' costs declared in the final summary financial statement and approved by the Agency multiplied by the reimbursement rate set out in Article 5.2 for each linked third party concerned}

divided by

the EU contribution for the action calculated according to Article 5.3.1 }

multiplied by

the final grant amount (see Article 5.3) } ,



minus

{pre-financing and interim payments received by the beneficiary} }.

- (b) formally notify to each beneficiary identified according to point (a) a **debit note** specifying the terms and date for payment. The amount of the debit note is calculated as follows:

{ {amount calculated according to point (a) for the beneficiary concerned

divided by

the sum of the amounts calculated according to point (a) for all the beneficiaries identified according to point (a)}

multiplied by

the amount set out in the debit note formally notified to the coordinator}.

If payment is not made by the date specified in the debit note, the *Agency* will **recover** the amount:

- (a) by '**offsetting**' it — without the beneficiary's consent — against any amounts owed to the beneficiary concerned by the *Agency*, the Commission or another executive agency (from the EU or Euratom budget).

In exceptional circumstances, to safeguard the EU's financial interests, the *Agency* may offset before the payment date specified in the debit note;

- (b) by **drawing on the Guarantee Fund**. The *Agency or the Commission* will formally notify the beneficiary concerned the debit note on behalf of the Guarantee Fund and recover the amount:

(i) *if a linked third party has accepted joint and several liability (see Article 14), by **holding the third party liable** up to the maximum EU contribution indicated, for the linked third party, in the estimated budget (see Annex 2) and/or*

(ii) by **taking legal action** (see Article 57) or by **adopting an enforceable decision** under Article 299 of the Treaty on the Functioning of the EU (TFEU) and Article 79(2) of the Financial Regulation No 966/2012.

If payment is not made by the date in the debit note, the amount to be recovered (see above) will be increased by **late-payment interest** at the rate set out in Article 21.11, from the day following the payment date in the debit note, up to and including the date the *Agency or the Commission* receives full payment of the amount.

Partial payments will be first credited against expenses, charges and late-payment interest and then against the principal.

Bank charges incurred in the recovery process will be borne by the beneficiary, unless Directive 2007/64/EC applies.

44.1.3 Recovery of amounts after payment of the balance



If, for a beneficiary, the revised final grant amount (see Article 5.4) is lower than its share of the final grant amount, it must repay the difference to the *Agency*.

The beneficiary's share of the final grant amount is calculated as follows:

{ {beneficiary's costs declared in the final summary financial statement and approved by the *Agency* multiplied by the reimbursement rate set out in Article 5.2 for the beneficiary concerned

plus

its linked third parties' costs declared in the final summary financial statement and approved by the Agency multiplied by the reimbursement rate set out in Article 5.2 for each linked third party concerned

divided by

the EU contribution for the action calculated according to Article 5.3.1 }

multiplied by

the final grant amount (see Article 5.3) }.

If the coordinator has not distributed amounts received (see Article 21.7), the *Agency* will also recover these amounts.

The *Agency* will formally notify a **pre-information letter** to the beneficiary concerned:

- informing it of its intention to recover, the due amount and the reasons why and
- inviting it to submit observations within 30 days of receiving notification.

If no observations are submitted or the *Agency* decides to pursue recovery despite the observations it has received, it will **confirm** the amount to be recovered and formally notify to the beneficiary concerned a **debit note**. This note will also specify the terms and the date for payment.

If payment is not made by the date specified in the debit note, the *Agency* will **recover** the amount:

- (a) by '**offsetting**' it — without the beneficiary's consent — against any amounts owed to the beneficiary concerned by the *Agency*, the Commission or another executive agency (from the EU or Euratom budget).

In exceptional circumstances, to safeguard the EU's financial interests, the *Agency* may offset before the payment date specified in the debit note;

- (b) by **drawing on the Guarantee Fund**. The *Agency* or the Commission will formally notify the beneficiary concerned the debit note on behalf of the Guarantee Fund and recover the amount:

- (i) *if a linked third party has accepted joint and several liability (see Article 14), by **holding the third party liable** up to the maximum EU contribution indicated, for the linked third party, in the estimated budget (see Annex 2) and/or*

- (ii) by **taking legal action** (see Article 57) or by **adopting an enforceable decision** under Article 299 of the Treaty on the Functioning of the EU (TFEU) and Article 79(2) of the Financial Regulation No 966/2012.



If payment is not made by the date in the debit note, the amount to be recovered (see above) will be increased by **late-payment interest** at the rate set out in Article 21.11, from the day following the date for payment in the debit note, up to and including the date the *Agency or the Commission* receives full payment of the amount.

Partial payments will be first credited against expenses, charges and late-payment interest and then against the principal.

Bank charges incurred in the recovery process will be borne by the beneficiary, unless Directive 2007/64/EC applies.

ARTICLE 45 — ADMINISTRATIVE AND FINANCIAL PENALTIES

45.1 Conditions

Under Articles 109 and 131(4) of the Financial Regulation No 966/2012, the *Agency* may impose **administrative** and **financial penalties** if a beneficiary:

- (a) has committed substantial errors, irregularities or fraud or is in serious breach of its obligations under the Agreement or
- (b) has made false declarations about information required under the Agreement or for the submission of the proposal (or has not supplied such information).

Each beneficiary is responsible for paying the financial penalties imposed on it.

Under Article 109(3) of the Financial Regulation No 966/2012, the *Agency or the Commission* may — under certain conditions and limits — publish decisions imposing administrative or financial penalties.

45.2 Duration — Amount of penalty — Calculation

Administrative penalties exclude the beneficiary from all contracts and grants financed from the EU or Euratom budget for a maximum of five years from the date the infringement is established by the *Agency*.

If the beneficiary commits another infringement within five years of the date the first infringement is established, the *Agency* may extend the exclusion period up to 10 years.

Financial penalties will be between 2% and 10% of the maximum EU contribution indicated, for the beneficiary concerned, in the estimated budget (see Annex 2).

If the beneficiary commits another infringement within five years of the date the first infringement is established, the *Agency* may increase the rate of financial penalties to between 4% and 20%.

45.3 Procedure

Before applying a penalty, the *Agency* will formally notify the beneficiary concerned:

- informing it of its intention to impose a penalty, its duration or amount and the reasons why and
- inviting it to submit observations within 30 days.



If the *Agency* does not receive any observations or decides to impose the penalty despite of observations it has received, it will formally notify **confirmation** of the penalty to the beneficiary concerned and — in case of financial penalties — deduct the penalty from the payment of the balance or formally notify a **debit note**, specifying the amount to be recovered, the terms and the date for payment.

If payment is not made by the date specified in the debit note, the *Agency or the Commission* may **recover** the amount:

- (a) by '**offsetting**' it — without the beneficiary's consent — against any amounts owed to the beneficiary concerned by the *Agency*, the Commission or another executive agency (from the EU or Euratom budget).

In exceptional circumstances, to safeguard the EU's financial interests, the *Agency* may offset before the payment date specified in the debit note;

- (b) by **taking legal action** (see Article 57) or by **adopting an enforceable decision** under Article 299 of the Treaty on the Functioning of the EU (TFEU) and Article 79(2) of the Financial Regulation No 966/2012.

If payment is not made by the date in the debit note, the amount to be recovered (see above) will be increased by **late-payment interest** at the rate set out in Article 21.11, from the day following the payment date in the debit note, up to and including the date the *Agency or the Commission* receives full payment of the amount.

Partial payments will be first credited against expenses, charges and late-payment interest and then against the principal.

Bank charges incurred in the recovery process will be borne by the beneficiary, unless Directive 2007/64/EC applies.

SECTION 2 LIABILITY FOR DAMAGES

ARTICLE 46 — LIABILITY FOR DAMAGES

46.1 Liability of the *Agency*

The *Agency* cannot be held liable for any damage caused to the beneficiaries or to third parties as a consequence of implementing the Agreement, including for gross negligence.

The *Agency* cannot be held liable for any damage caused by any of the beneficiaries or third parties involved in the action, as a consequence of implementing the Agreement.

46.2 Liability of the beneficiaries

46.2.1 Conditions

Except in case of force majeure (see Article 51), the beneficiaries must compensate the *Agency* for any damage it sustains as a result of the implementation of the action or because the action was not implemented in full compliance with the Agreement.



Each beneficiary is responsible for paying the damages claimed from it.

46.2.2 Amount of damages - Calculation

The amount the *Agency* can claim from a beneficiary will correspond to the damage caused by that beneficiary.

46.2.3 Procedure

Before claiming damages, the *Agency* will formally notify the beneficiary concerned:

- informing it of its intention to claim damages, the amount and the reasons why and
- inviting it to submit observations within 30 days.

If the *Agency* does not receive any observations or decides to claim damages despite the observations it has received, it will formally notify **confirmation** of the claim for damages and a **debit note**, specifying the amount to be recovered, the terms and the date for payment.

If payment is not made by the date specified in the debit note, the *Agency or the Commission* may **recover** the amount:

- (a) by ‘**offsetting**’ it — without the beneficiary’s consent — against any amounts owed to the beneficiary concerned by the *Agency*, the Commission or another executive agency (from the EU or Euratom budget).

In exceptional circumstances, to safeguard the EU’s financial interests, the *Agency* may offset before the payment date specified in the debit note;

- (b) by **taking legal action** (see Article 57) or by **adopting an enforceable decision** under Article 299 of the Treaty on the Functioning of the EU (TFEU) and Article 79(2) of the Financial Regulation No 966/2012.

If payment is not made by the date in the debit note, the amount to be recovered (see above) will be increased by **late-payment interest** at the rate set out in Article 21.11, from the day following the payment date in the debit note, up to and including the date the *Agency or the Commission* receives full payment of the amount.

Partial payments will be first credited against expenses, charges and late-payment interest and then against the principal.

Bank charges incurred in the recovery process will be borne by the beneficiary, unless Directive 2007/64/EC applies.

SECTION 3 SUSPENSION AND TERMINATION

ARTICLE 47 — SUSPENSION OF PAYMENT DEADLINE

47.1 Conditions

The *Agency* may — at any moment — suspend the payment deadline (see Article 21.2 to 21.4) if a request for payment (see Article 20) cannot be approved because:



- (a) it does not comply with the provisions of the Agreement (see Article 20);
- (b) the technical reports or financial reports have not been submitted or are not complete or additional information is needed, or
- (c) there is doubt about the eligibility of the costs declared in the financial statements and additional checks, reviews, audits or investigations are necessary.

47.2 Procedure

The *Agency* will formally notify the coordinator of the suspension and the reasons why.

The suspension will **take effect** the day notification is sent by the *Agency* (see Article 52).

If the conditions for suspending the payment deadline are no longer met, the suspension will be **lifted** — and the remaining period will resume.

If the suspension exceeds two months, the coordinator may request the *Agency* if the suspension will continue.

If the payment deadline has been suspended due to the non-compliance of the technical or financial reports (see Article 20) and the revised report or statement is not submitted or was submitted but is also rejected, the *Agency* may also terminate the Agreement or the participation of the beneficiary (see Article 50.3.1(l)).

ARTICLE 48 — SUSPENSION OF PAYMENTS

48.1 Conditions

The *Agency* may — at any moment — suspend, in whole or in part, the pre-financing payment and interim payments for one or more beneficiaries or the payment of the balance for all beneficiaries, if a beneficiary:

- (a) has committed or is suspected of having committed substantial errors, irregularities, fraud or serious breach of obligations in the award procedure or under this Agreement or
- (b) has committed — in other EU or Euratom grants awarded to it under similar conditions — systemic or recurrent errors, irregularities, fraud or serious breach of obligations that have a material impact on this grant (**extension of findings from other grants to this grant**; see Article 22.5.2).

48.2 Procedure

Before suspending payments, the *Agency* will formally notify the coordinator:

- informing it of its intention to suspend payments and the reasons why and
- inviting it to submit observations within 30 days of receiving notification.

If the *Agency* does not receive observations or decides to pursue the procedure despite the observations it has received, it will formally notify **confirmation** of the suspension. Otherwise, it will formally notify that the suspension procedure is not continued.



The suspension will **take effect** the day the confirmation notification is sent by the *Agency*.

If the conditions for resuming payments are met, the suspension will be **lifted**. The *Agency* will formally notify the coordinator.

During the suspension, the periodic report(s) (see Article 20.3) must not contain any individual financial statements from the beneficiary concerned *and its linked third parties*. When the *Agency* resumes payments, the coordinator may include them in the next periodic report.

The beneficiaries may suspend implementation of the action (see Article 49.1) or terminate the Agreement or the participation of the beneficiary concerned (see Article 50.1 and 50.2).

ARTICLE 49 — SUSPENSION OF THE ACTION IMPLEMENTATION

49.1 Suspension of the action implementation, by the beneficiaries

49.1.1 Conditions

The beneficiaries may suspend implementation of the action or any part of it, if exceptional circumstances — in particular *force majeure* (see Article 51) — make implementation impossible or excessively difficult.

49.1.2 Procedure

The coordinator must immediately formally notify to the *Agency* the suspension (see Article 52), stating:

- the reasons why and
- the expected date of resumption.

The suspension will **take effect** the day this notification is received by the *Agency*.

Once circumstances allow for implementation to resume, the coordinator must immediately formally notify the *Agency* and request an **amendment** of the Agreement to set the date on which the action will be resumed, extend the duration of the action and make other changes necessary to adapt the action to the new situation (see Article 55) — unless the Agreement or the participation of a beneficiary has been terminated (see Article 50).

The suspension will be **lifted** with effect from the resumption date set out in the amendment. This date may be before the date on which the amendment enters into force.

Costs incurred during suspension of the action implementation are not eligible (see Article 6).

49.2 Suspension of the action implementation, by the *Agency*

49.2.1 Conditions

The *Agency* may suspend implementation of the action or any part of it:



- (a) if a beneficiary has committed or is suspected of having committed substantial errors, irregularities, fraud or serious breach of obligations in the award procedure or under this Agreement;
- (b) if a beneficiary has committed — in other EU or Euratom grants awarded to it under similar conditions — systemic or recurrent errors, irregularities, fraud or serious breach of obligations that have a material impact on this grant (**extension of findings from other grants to this grant**; see Article 22.5.2), or
- (c) if the action is suspected of having lost its scientific or technological relevance.

49.2.2 Procedure

Before suspending implementation of the action, the *Agency* will formally notify the coordinator:

- informing it of its intention to suspend the implementation and the reasons why and
- inviting it to submit observations within 30 days of receiving notification.

If the *Agency* does not receive observations or decides to pursue the procedure despite the observations it has received, it will formally notify **confirmation** of the suspension. Otherwise, it will formally notify that the procedure is not continued.

The suspension will **take effect** five days after confirmation notification is received by the coordinator (or on a later date specified in the notification).

It will be **lifted** if the conditions for resuming implementation of the action are met.

The coordinator will be formally notified of the lifting and the Agreement will be **amended** to set the date on which the action will be resumed, extend the duration of the action and make other changes necessary to adapt the action to the new situation (see Article 55) — unless the Agreement has already been terminated (see Article 50).

The suspension will be lifted with effect from the resumption date set out in the amendment. This date may be before the date on which the amendment enters into force.

Costs incurred during suspension are not eligible (see Article 6).

The beneficiaries may not claim damages due to suspension by the *Agency* (see Article 46).

Suspension of the action implementation does not affect the *Agency's* right to terminate the Agreement or participation of a beneficiary (see Article 50), reduce the grant or recover amounts unduly paid (see Articles 43 and 44).

ARTICLE 50 — TERMINATION OF THE AGREEMENT OR OF THE PARTICIPATION OF ONE OR MORE BENEFICIARIES

50.1 Termination of the Agreement by the beneficiaries

50.1.1 Conditions and procedure

The beneficiaries may terminate the Agreement.



The coordinator must formally notify termination to the *Agency* (see Article 52), stating:

- the reasons why and
- the date the termination will take effect. This date must be after the notification.

If no reasons are given or if the *Agency* considers the reasons do not justify termination, the Agreement will be considered to have been '**terminated improperly**'.

The termination will **take effect** on the day specified in the notification.

50.1.2 Effects

The coordinator must — within 60 days from when termination takes effect — submit:

- (i) a periodic report (for the open reporting period until termination; see Article 20.3) and
- (ii) the final report (see Article 20.4).

If the *Agency* does not receive the reports within the deadline (see above), only costs which are included in an approved periodic report will be taken into account.

The *Agency* will **calculate** the final grant amount (see Article 5.3) and the balance (see Article 21.4) on the basis of the reports submitted. Only costs incurred until termination are eligible (see Article 6). Costs relating to contracts due for execution only after termination are not eligible.

Improper termination may lead to a reduction of the grant (see Article 43).

After termination, the beneficiaries' obligations (in particular Articles 20, 22, 23, Section 3 of Chapter 4, 36, 37, 38 and 40) continue to apply.

50.2 Termination of the participation of one or more beneficiaries, by the beneficiaries

50.2.1 Conditions and procedure

The participation of one or more beneficiaries may be terminated by the coordinator, on request of the beneficiary concerned or on behalf of the other beneficiaries.

The coordinator must formally notify termination to the *Agency* (see Article 52) and inform the beneficiary concerned.

If the coordinator's participation is terminated without its agreement, the formal notification must be done by another beneficiary (acting on behalf of the other beneficiaries).

The notification must include:

- the reasons why;
- the opinion of the beneficiary concerned (or proof that this opinion has been requested in writing);
- the date the termination takes effect. This date must be after the notification, and



- a request for amendment (see Article 55), with a proposal for reallocation of the tasks and the estimated budget of the beneficiary concerned (see Annexes 1 and 2) and, if necessary, the addition of one or more new beneficiaries (see Article 56). If termination takes effect after the period set out in Article 3, no request for amendment must be included unless the beneficiary concerned is the coordinator. In this case, the request for amendment must propose a new coordinator.

If this information is not given or if the *Agency* considers that the reasons do not justify termination, the participation will be considered to have been **terminated improperly**.

The termination will **take effect** on the day specified in the notification.

50.2.2 Effects

The coordinator must — within 30 days from when termination takes effect — submit:

- (i) a report on the distribution of payments to the beneficiary concerned and
- (ii) if termination takes effect during the period set out in Article 3, a ‘**termination report**’ from the beneficiary concerned, for the open reporting period until termination, containing an overview of the progress of the work, an overview of the use of resources, the individual financial statement and, if applicable, the certificate on the financial statement (see Articles 20.3 and 20.4).

The information in the termination report must also be included in the periodic report for the next reporting period (see Article 20.3).

If the request for amendment is rejected by the *Agency*, (because it calls into question the decision awarding the grant or breaches the principle of equal treatment of applicants), the Agreement may be terminated according to Article 50.3.1(c).

If the request for amendment is accepted by the *Agency*, the Agreement is **amended** to introduce the necessary changes (see Article 55).

The *Agency* will **calculate** — on the basis of the periodic reports, the termination report and the report on the distribution of payments — if the (pre-financing and interim) payments received by the beneficiary concerned exceed the beneficiary’s EU contribution (calculated by applying the reimbursement rate(s) to the eligible costs declared by the beneficiary *and its linked third parties* and approved by the *Agency*). Only costs incurred by the beneficiary concerned until termination takes effect are eligible (see Article 6). Costs relating to contracts due for execution only after termination are not eligible.

- If the payments received **exceed the amounts due**:
 - if termination takes effect during the period set out in Article 3 and the request for amendment is accepted, the beneficiary concerned must repay to the coordinator the amount unduly received. The *Agency* will formally notify the amount unduly received and request the beneficiary concerned to repay it to the coordinator within 30 days of receiving notification. If it does not repay the coordinator, the *Agency* will draw upon the Guarantee Fund to pay the coordinator and then notify a **debit note** on behalf of the Guarantee Fund to the beneficiary concerned (see Article 44);



- in all other cases (in particular if termination takes effect after the period set out in Article 3), the *Agency* will formally notify a **debit note** to the beneficiary concerned. If payment is not made by the date in the debit note, the Guarantee Fund will pay to the *Agency* the amount due and the *Agency* will notify a debit note on behalf of the Guarantee Fund to the beneficiary concerned (see Article 44);
- if the beneficiary concerned is the former coordinator, it must repay the new coordinator according to the procedure above, unless:
 - termination is after an interim payment and
 - the former coordinator has not distributed amounts received as pre-financing or interim payments (see Article 21.7).

In this case, the *Agency* will formally notify a **debit note** to the former coordinator. If payment is not made by the date in the debit note, the Guarantee Fund will pay to the *Agency* the amount due. The *Agency* will then pay the new coordinator and notify a debit note on behalf of the Guarantee Fund to the former coordinator (see Article 44).

- If the payments received **do not exceed the amounts due**: amounts owed to the beneficiary concerned will be included in the next interim or final payment.

If the *Agency* does not receive the termination report within the deadline (see above), only costs included in an approved periodic report will be taken into account.

If the *Agency* does not receive the report on the distribution of payments within the deadline (see above), it will consider that:

- the coordinator did not distribute any payment to the beneficiary concerned and that
- the beneficiary concerned must not repay any amount to the coordinator.

Improper termination may lead to a reduction of the grant (see Article 43) or termination of the Agreement (see Article 50).

After termination, the concerned beneficiary's obligations (in particular Articles 20, 22, 23, Section 3 of Chapter 4, 36, 37, 38 and 40) continue to apply.

50.3 Termination of the Agreement or the participation of one or more beneficiaries, by the *Agency*

50.3.1 Conditions

The *Agency* may terminate the Agreement or the participation of one or more beneficiaries, if:

- (a) one or more beneficiaries do not accede to the Agreement (see Article 56);
- (b) a change to their legal, financial, technical, organisational or ownership situation (*or those of its linked third parties*) is likely to substantially affect or delay the implementation of the action or calls into question the decision to award the grant;



- (c) following termination of participation for one or more beneficiaries (see above), the necessary changes to the Agreement would call into question the decision awarding the grant or breach the principle of equal treatment of applicants (see Article 55);
- (d) implementation of the action is prevented by force majeure (see Article 51) or suspended by the coordinator (see Article 49.1) and either:
 - (i) resumption is impossible, or
 - (ii) the necessary changes to the Agreement would call into question the decision awarding the grant or breach the principle of equal treatment of applicants;
- (e) a beneficiary is declared bankrupt, being wound up, having its affairs administered by the courts, has entered into an arrangement with creditors, has suspended business activities, or is subject to any other similar proceedings or procedures under national law;
- (f) a beneficiary (or a natural person who has the power to represent or take decisions on its behalf) has been found guilty of professional misconduct, proven by any means;
- (g) a beneficiary does not comply with the applicable national law on taxes and social security;
- (h) the action has lost scientific or technological relevance;
- (i) *not applicable*;
- (j) *not applicable*;
- (k) a beneficiary (or a natural person who has the power to represent or take decisions on its behalf) has committed fraud, corruption, or is involved in a criminal organisation, money laundering or any other illegal activity affecting the EU's financial interests;
- (l) a beneficiary (or a natural person who has the power to represent or take decisions on its behalf) has — in the award procedure or under the Agreement — committed:
 - (i) substantial errors, irregularities, fraud or
 - (ii) serious breach of obligations, including improper implementation of the action, submission of false information, failure to provide required information, breach of ethical principles;
- (m) a beneficiary has committed — in other EU or Euratom grants awarded to it under similar conditions — systemic or recurrent errors, irregularities, fraud or serious breach of obligations that have a material impact on this grant (**'extension of findings from other grants to this grant'**).

50.3.2 Procedure

Before terminating the Agreement or participation of one or more beneficiaries, the *Agency* will formally notify the coordinator:

- informing it of its intention to terminate and the reasons why and



- inviting it, within 30 days of receiving notification, to submit observations and — in case of Point (l.ii) above — to inform the *Agency* of the measures to ensure compliance with the obligations under the Agreement.

If the *Agency* does not receive observations or decides to pursue the procedure despite the observations it has received, it will formally notify to the coordinator **confirmation** of the termination and the date it will take effect. Otherwise, it will formally notify that the procedure is not continued.

The termination will **take effect**:

- for terminations under Points (b), (c), (e), (g), (h), (j), and (l.ii) above: on the day specified in the notification of the confirmation (see above);
- for terminations under Points (a), (d), (f), (i), (k), (l.i) and (m) above: on the day after the notification of the confirmation is received by the coordinator.

50.3.3 Effects

(a) for **termination of the Agreement**:

The coordinator must — within 60 days from when termination takes effect — submit:

- (i) a periodic report (for the last open reporting period until termination; see Article 20.3) and
- (ii) a final report (see Article 20.4).

If the Agreement is terminated for breach of the obligation to submit the reports (see Articles 20.8 and 50.3.1(l)), the coordinator may not submit any reports after termination.

If the *Agency* does not receive the reports within the deadline (see above), only costs which are included in an approved periodic report will be taken into account.

The *Agency* will **calculate** the final grant amount (see Article 5.3) and the balance (see Article 21.4) on the basis of the reports submitted. Only costs incurred until termination takes effect are eligible (see Article 6). Costs relating to contracts due for execution only after termination are not eligible.

This does not affect the *Agency's* right to reduce the grant (see Article 43) or to impose administrative and financial penalties (Article 45).

The beneficiaries may not claim damages due to termination by the *Agency* (see Article 46).

After termination, the beneficiaries' obligations (in particular Articles 20, 22, 23, Section 3 of Chapter 4, 36, 37, 38 and 40) continue to apply.

(b) for **termination of the participation of one or more beneficiaries**:

The coordinator must — within 60 days from when termination takes effect — submit:

- (i) a report on the distribution of payments to the beneficiary concerned;



- (ii) a request for amendment (see Article 55), with a proposal for reallocation of the tasks and estimated budget of the beneficiary concerned (see Annexes 1 and 2) and, if necessary, the addition of one or more new beneficiaries (see Article 56). If termination is notified after the period set out in Article 3, no request for amendment must be submitted unless the beneficiary concerned is the coordinator. In this case the request for amendment must propose a new coordinator, and
- (iii) if termination takes effect during the period set out in Article 3, a **termination report** from the beneficiary concerned, for the open reporting period until termination, containing an overview of the progress of the work, an overview of the use of resources, the individual financial statement and, if applicable, the certificate on the financial statement (see Article 20).

The information in the termination report must also be included in the periodic report for the next reporting period (see Article 20.3).

If the request for amendment is rejected by the *Agency* (because it calls into question the decision awarding the grant or breaches the principle of equal treatment of applicants), the Agreement may be terminated according to Article 50.3.1(c).

If the request for amendment is accepted by the *Agency*, the Agreement is **amended** to introduce the necessary changes (see Article 55).

The *Agency* will **calculate** — on the basis of the periodic reports, the termination report and the report on the distribution of payments — if the (pre-financing and interim) payments received by the beneficiary concerned exceed the beneficiary's EU contribution (calculated by applying the reimbursement rate(s) to the eligible costs declared by the beneficiary *and its linked third parties* and approved by the *Agency*). Only costs incurred by the beneficiary concerned until termination takes effect are eligible (see Article 6). Costs relating to contracts due for execution only after termination are not eligible.

- If the payments received **exceed the amounts due**:
 - if termination takes effect during the period set out in Article 3 and the request for amendment is accepted, the beneficiary concerned must repay to the coordinator the amount unduly received. The *Agency* will formally notify the amount unduly received and request the beneficiary concerned to repay it to the coordinator within 30 days of receiving notification. If it does not repay the coordinator, the *Agency* will draw upon the Guarantee Fund to pay the coordinator and then notify a debit note on behalf of the Guarantee Fund to the beneficiary concerned (see Article 44);
 - in all other cases, in particular if termination takes effect after the period set out in Article 3, the *Agency* will formally notify a **debit note** to the beneficiary concerned. If payment is not made by the date in the debit note, the Guarantee Fund will pay to the *Agency* the amount due and the *Agency* will notify a debit note on behalf of the Guarantee Fund to the beneficiary concerned (see Article 44);



- if the beneficiary concerned is the former coordinator, it must repay the new coordinator the amount unduly received, unless:
 - termination takes effect after an interim payment and
 - the former coordinator has not distributed amounts received as pre-financing or interim payments (see Article 21.7)

In this case, the *Agency* will formally notify a **debit note** to the former coordinator. If payment is not made by the date in the debit note, the Guarantee Fund will pay to the *Agency* the amount due. The *Agency* will then pay the new coordinator and notify a debit note on behalf of the Guarantee Fund to the former coordinator (see Article 44).

- If the payments received **do not exceed the amounts due**: amounts owed to the beneficiary concerned will be included in the next interim or final payment.

If the *Agency* does not receive the termination report within the deadline (see above), only costs included in an approved periodic report will be taken into account.

If the *Agency* does not receive the report on the distribution of payments within the deadline (see above), it will consider that:

- the coordinator did not distribute any payment to the beneficiary concerned, and that
- the beneficiary concerned must not repay any amount to the coordinator.

After termination, the concerned beneficiary's obligations (in particular Articles 20, 22, 23, Section 3 of Chapter 4, 36, 37, 38 and 40) continue to apply.

SECTION 4 FORCE MAJEURE

ARTICLE 51 — FORCE MAJEURE

‘Force majeure’ means any situation or event that:

- prevents either party from fulfilling their obligations under the Agreement,
- was unforeseeable, exceptional situation and beyond the parties' control,
- was not due to error or negligence on their part (or on the part of third parties involved in the action), and
- proves to be inevitable in spite of exercising all due diligence.

The following cannot be invoked as force majeure:

- any default of a service, defect in equipment or material or delays in making them available, unless they stem directly from a relevant case of force majeure,



- labour disputes or strikes, or
- financial difficulties.

Any situation constituting force majeure must be formally notified to the other party without delay, stating the nature, likely duration and foreseeable effects.

The parties must immediately take all the necessary steps to limit any damage due to force majeure and do their best to resume implementation of the action as soon as possible.

The party prevented by force majeure from fulfilling its obligations under the Agreement cannot be considered in breach of them.

CHAPTER 7 FINAL PROVISIONS

ARTICLE 52 — COMMUNICATION BETWEEN THE PARTIES

52.1 Form and means of communication

Communication under the Agreement (information, requests, submissions, ‘formal notifications’, etc.) must:

- be made in writing and
- bear the number of the Agreement.

Until the payment of the balance: all communication must be made through the electronic exchange system and using the forms and templates provided there.

After the payment of the balance: formal notifications must be made by registered post with proof of delivery (‘formal notification on paper’).

Communications in the electronic exchange system must be made by persons authorised according to the ‘Terms and Conditions of Use of the electronic exchange system’. For naming the authorised persons, each beneficiary must have designated — before the signature of this Agreement — a ‘Legal Entity Appointed Representative (LEAR)’. The role and tasks of the LEAR are stipulated in his/her appointment letter (see Terms and Conditions of Use of the electronic exchange system).

If the electronic exchange system is temporarily unavailable, instructions will be given on the *Agency and Commission* websites.

52.2 Date of communication

Communications are considered to have been made when they are sent by the sending party (i.e. on the date and time they are sent through the electronic exchange system).

Formal notifications through the **electronic** exchange system are considered to have been made when they are received by the receiving party (i.e. on the date and time of acceptance by the receiving party, as indicated by the time stamp). A formal notification that has not been accepted within 10 days after sending is considered to have been accepted.



Formal notifications **on paper** sent by **registered post** with proof of delivery (only after the payment of the balance) are considered to have been made on either:

- the delivery date registered by the postal service or
- the deadline for collection at the post office.

If the electronic exchange system is temporarily unavailable, the sending party cannot be considered in breach of its obligation to send a communication within a specified deadline.

52.3 Addresses for communication

The **electronic** exchange system must be accessed via the following URL:

<https://ec.europa.eu/research/participants/portal/desktop/en/projects/>

The *Agency* will formally notify the coordinator and beneficiaries in advance any changes to this URL.

Formal notifications on paper (only after the payment of the balance) addressed **to the Agency** must be sent to the following address:

*Innovation and Networks Executive Agency
ENERGY RESEARCH
W910
B-1049 Brussels Belgium*

Formal notifications on paper (only after the payment of the balance) addressed **to the beneficiaries** must be sent to their legal address as specified in the 'Beneficiary Register'.

ARTICLE 53 — INTERPRETATION OF THE AGREEMENT

53.1 Precedence of the Terms and Conditions over the Annexes

The provisions in the Terms and Conditions of the Agreement take precedence over its Annexes.

Annex 2 takes precedence over Annex 1.

53.2 Privileges and immunities

Not applicable

ARTICLE 54 — CALCULATION OF PERIODS, DATES AND DEADLINES

In accordance with Regulation No 1182/71²⁸, periods expressed in days, months or years are calculated from the moment the triggering event occurs.

The day during which that event occurs is not considered as falling within the period.

²⁸ Regulation (EEC, Euratom) No 1182/71 of the Council of 3 June 1971 determining the rules applicable to periods, dates and time-limits (OJ L 124, 8.6.1971, p. 1).



ARTICLE 55 — AMENDMENTS TO THE AGREEMENT

55.1 Conditions

The Agreement may be amended, unless the amendment entails changes to the Agreement which would call into question the decision awarding the grant or breach the principle of equal treatment of applicants.

Amendments may be requested by any of the parties.

55.2 Procedure

The party requesting an amendment must submit a request for amendment signed in the electronic exchange system (see Article 52).

The coordinator submits and receives requests for amendment on behalf of the beneficiaries (see Annex 3).

If a change of coordinator is requested without its agreement, the submission must be done by another beneficiary (acting on behalf of the other beneficiaries).

The request for amendment must include:

- the reasons why;
- the appropriate supporting documents;
- for a change of coordinator without its agreement: the opinion of the coordinator (or proof that this opinion has been requested in writing).

The *Agency* may request additional information.

If the party receiving the request agrees, it must sign the amendment in the electronic exchange system within 45 days of receiving notification (or any additional information the *Agency* has requested). If it does not agree, it must formally notify its disagreement within the same deadline. The deadline may be extended, if necessary for the assessment of the request. If no notification is received within the deadline, the request is considered to have been rejected.

An amendment **enters into force** on the day of the signature of the receiving party.

An amendment **takes effect** on the date agreed by the parties or, in the absence of such an agreement, on the date on which the amendment enters into force.

ARTICLE 56 — ACCESSION TO THE AGREEMENT

56.1 Accession of the beneficiaries mentioned in the Preamble

The other beneficiaries must accede to the Agreement by signing the Accession Form (see Annex 3) in the electronic exchange system (see Article 52) within 30 days after its entry into force (see Article 58) *and for beneficiaries for which the Agency has requested joint and several liability of a linked third party, by also submitting — at accession — a declaration on joint and several liability (see Annex 3a) signed by the third party.*



They will assume the rights and obligations under the Agreement with effect from the date of its entry into force (see Article 58).

If a beneficiary does not accede to the Agreement within the above deadline, the coordinator must — within 30 days — request an amendment to make any changes necessary to ensure proper implementation of the action. This does not affect the *Agency's* right to terminate the Agreement (see Article 50).

56.2 Addition of new beneficiaries

In justified cases, the beneficiaries may request the addition of a new beneficiary.

For this purpose, the coordinator must submit a request for amendment in accordance with Article 55. It must include an Accession Form (see Annex 3) signed by the new beneficiary in the electronic exchange system (see Article 52).

New beneficiaries must assume the rights and obligations under the Agreement with effect from the date of their accession specified in the Accession Form (see Annex 3).

ARTICLE 57 — APPLICABLE LAW AND SETTLEMENT OF DISPUTES

57.1 Applicable law

The Agreement is governed by the applicable EU law, supplemented if necessary by the law of Belgium.

57.2 Dispute settlement

If a dispute concerning the interpretation, application or validity of the Agreement cannot be settled amicably, the General Court — or, on appeal, the Court of Justice of the European Union — has sole jurisdiction. Such actions must be brought under Article 272 of the Treaty on the Functioning of the EU (TFEU).

As an exception, if such a dispute is between the Agency and INTERNATIONAL RESEARCH INSTITUTE OFSTAVANGER AS, the competent Belgian courts have sole jurisdiction.

If a dispute concerns administrative or financial penalties, offsetting or an enforceable decision under Article 299 TFEU (see Articles 44, 45 and 46), the beneficiaries must bring action before the General Court — or, on appeal, the Court of Justice of the European Union — under Article 263 TFEU. *Actions against enforceable decisions must be brought against the Commission (not against the Agency).*



ARTICLE 58 — ENTRY INTO FORCE OF THE AGREEMENT

The Agreement will enter into force on the day of signature by the *Agency* or the coordinator, depending on which is later.

SIGNATURES

For the coordinator

For the *Agency*

Pierre TOULHOAT with ECAS id ntoupier signed in the Participant Portal on 13/07/2016 at 20:01:48 (transaction id SigId-163821-lzV8FBgddltjUuizexS1HoYrl2wcrRynk3Avs0gqQP8kJYodKAsXBgwLEZI9O7PBCLgZzziKdctoQTm9BBCCJc0-Jj71zxYb8yrYygdMV9MCry-cqzLrxZCpDXqQyg7kfAHeBzPtEyWBSazUbHCkbMgSbf8).
Timestamp by third party at
Wed Jul 13 21:01:58 CEST 2016

Signed by Dirk BECKERS with ECAS id beckedi as an authorised representative on 08-08-2016 14:12:10 (transaction id SigId-62901-9XVzNOZNp01eQXEQUyQXTzjGfcaZ01poH5EVabouikjVtFbv3rVzwrwtwACd78ssLyv7xc42ZxBQHczaP2uN0nq-Jj71zxYb8yr5dzX2DFZb8K-fyxmawFXmWmifqYfF9L2ysfyrv2i2znmwFhQrexP6Obo)
Mon Aug 08 14:12:23 CEST 2016



EUROPEAN COMMISSION
Innovation and Networks Executive Agency
ENERGY RESEARCH



ANNEX 1 (part A)

Research and Innovation action

NUMBER — 653718 — ENOS

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1.1. The project summary

Project Number ¹	653718	Project Acronym ²	ENOS
One form per project			
General information			
Project title ³	ENabling Onshore CO2 Storage in Europe		
Starting date ⁴	01/09/2016		
Duration in months ⁵	48		
Call (part) identifier ⁶	H2020-LCE-2015-1-two-stage		
Topic	LCE-15-2015 Enabling decarbonisation of the fossil fuel-based power sector and energy intensive industry through CCS		
Fixed EC Keywords	Carbon capture and sequestration		
Free keywords	CO2 geological storage, onshore Europe, safe storage, storage sites, pilots, field experiments		
Abstract ⁷			
To meet the ambitious EC target of an 80% reduction in greenhouse gas emissions by 2050, CO2 Capture and Storage (CCS) needs to move rapidly towards full scale implementation with geological storage solutions both on and offshore. Onshore storage offers increased flexibility and reduced infrastructure and monitoring costs. Enabling onshore storage will support management of decarbonisation strategies at territory level while enhancing security of energy supply and local economic activities, and securing jobs across Europe. However, successful onshore storage also requires some unique technical and societal challenges to be overcome. ENOS will provide crucial advances to help foster onshore CO2 storage across Europe through: 1) Developing, testing and demonstrating in the field, under “real-life conditions”, key technologies specifically adapted to onshore storage. 2) Contributing to the creation of a favourable environment for onshore storage across Europe. The ENOS site portfolio will provide a great opportunity for demonstration of technologies for safe and environmentally sound storage at relevant scale. Best practices will be developed using experience gained from the field experiments with the participation of local stakeholders and the lay public. This will produce improved integrated research outcomes and increase stakeholder understanding and confidence in CO2 storage. In this improved framework, ENOS will catalyse new onshore pilot and demonstration projects in new locations and geological settings across Europe, taking into account the site-specific and local socio-economic context. By developing technologies from TRL4/5 to TRL6 across the storage lifecycle, feeding the resultant knowledge and experience into training and education and cooperating at the pan-European and global level, ENOS will have a decisive impact on innovation and build the confidence needed for enabling onshore CO2 storage in Europe.			

1.2. List of Beneficiaries

Project Number ¹	653718	Project Acronym ²	ENOS

List of Beneficiaries

No	Name	Short name	Country	Project entry month ⁸	Project exit month
1	BUREAU DE RECHERCHES GEOLOGIQUES ET MINIERES	BRGM	France	1	48
2	BUNDESANSTALT FUER GEOWISSENSCHAFTEN UND ROHSTOFFE	BGR	Germany	1	48
3	NATURAL ENVIRONMENT RESEARCH COUNCIL	BGS	United Kingdom	1	48
4	CESKA GEOLOGICKA SLUZBA	CGS	Czech Republic	1	48
5	CENTRO DE INVESTIGACIONES ENERGETICAS, MEDIOAMBIENTALES Y TECNOLOGICAS-CIEMAT	CIEMAT	Spain	1	48
6	FUNDACION CIUDAD DE LA ENERGIA	CIUDEN	Spain	1	48
7	FLODIM SARL	flodim	France	1	48
8	GEOGREEN	GGR	France	1	48
9	I.D.I.L. SAS (INGENIERIE-DEVELOPPEMENT-INSTRUMENTATION-LASER)	IDIL	France	1	48
10	INTERNATIONAL RESEARCH INSTITUTE OFSTAVANGER AS	IRIS	Norway	1	48
11	NHAZCA SRL	NHAZCA	Italy	1	48
12	ISTITUTO NAZIONALE DI OCEANOGRAPHIA E DI GEOFISICA SPERIMENTALE	OGS	Italy	1	48
13	PALENCIA 3 INVESTIGACION DESARROLLO Y EXPLOTACION SL	PLC-3	Spain	1	48
14	STATNY GEOLOGICKY USTAV DIONYZA STURA	SGIDS	Slovakia	1	48
15	SILIXA LTD	SILIXA	United Kingdom	1	48
16	SOTACARBO - SOCIETA TECNOLOGIE AVANZATE CARBONE SPA.	SOTACARBO	Italy	1	48
17	NEDERLANDSE ORGANISATIE VOOR TOEGEPAST NATUURWETENSCHAPPELIJK ONDERZOEK TNO	TNO	Netherlands	1	48
18	UNIVERSITA DEGLI STUDI DI ROMA LA SAPIENZA	UNIROMA1	Italy	1	48

1.2. List of Beneficiaries

No	Name	Short name	Country	Project entry month ⁸	Project exit month
19	THE UNIVERSITY OF NOTTINGHAM	UNOTT	United Kingdom	1	48
20	CO2GEONET - RESEAU D'EXCELLENCE EUROPEEN SUR LE STOCKAGE GEOLOGIQUE DE CO2	CO2GeoNet	France	1	48

1.3. Workplan Tables - Detailed implementation

1.3.1. WT1 List of work packages

WP Number ⁹	WP Title	Lead beneficiary ¹⁰	Person-months ¹¹	Start month ¹²	End month ¹³
WP1	Ensuring safe storage operations	6 - CIUDEN	276.10	1	48
WP2	Ensuring storage capacities and cost-effective site characterisation	1 - BRGM	85.00	1	48
WP3	Managing leakage risks for protection of the environment and groundwater	3 - BGS	239.40	1	48
WP4	Integration of CO2 storage with local economic activities	17 - TNO	85.50	1	48
WP5	Coordination with local communities	18 - UNIROMA1	119.30	1	48
WP6	International Cooperation & seeding pilots and demos in Europe	4 - CGS	107.50	1	48
WP7	Spreading innovation	10 - IRIS	127.40	1	48
WP8	Promoting CCS through Training and education	20 - CO2GeoNet	50.80	1	48
WP9	Management	1 - BRGM	83.90	1	48
Total			1,174.90		

1.3.2. WT2 list of deliverables

Deliverable Number ¹⁴	Deliverable Title	WP number ⁹	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D1.1	Design of CO2 injection tests	WP1	6 - CIUDEN	Report	Confidential, only for members of the consortium (including the Commission Services)	6
D1.2	Report on installation, with constantly updated data and threshold assessments	WP1	2 - BGR	Report	Public	14
D1.3	Dynamic ranking of the impact of heterogeneities on plume movement	WP1	19 - UNOTT	Report	Confidential, only for members of the consortium (including the Commission Services)	25
D1.4	Benchmarking studies on deep sampling	WP1	1 - BRGM	Report	Public	25
D1.5	Design & optimization of seismic monitoring network for induced seismicity management	WP1	17 - TNO	Report	Public	25
D1.6	Report on fault activity	WP1	20 - CO2GeoNet	Report	Confidential, only for members of the consortium (including the Commission Services)	32
D1.7	Interpretation and history matching on CO2 injection activities	WP1	8 - GGR	Report	Confidential, only for members of the consortium (including the Commission Services)	37
D1.8	Risk model updated	WP1	5 - CIEMAT	Report	Confidential, only for members of the consortium (including the Commission Services)	37
D1.9	Benchmarking on different geophysical techniques	WP1	12 - OGS	Report	Public	37
D1.10	Assessment of KPI from measurements	WP1	12 - OGS	Report	Confidential, only for members of the consortium	38

Deliverable Number ¹⁴	Deliverable Title	WP number ⁹	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
					(including the Commission Services)	
D1.11	Specifications for future integrated and automated system	WP1	6 - CIUDEN	Report	Public	39
D1.12	Lessons learned on Geochemical modelling and sampling activities	WP1	1 - BRGM	Report	Public	39
D1.13	Results of induced seismic risk control activities	WP1	1 - BRGM	Report	Public	42
D1.14	integrated workflow for operational risk management	WP1	1 - BRGM	Report	Public	44
D2.1	Report on FEED study on light drilling	WP2	6 - CIUDEN	Demonstrator	Confidential, only for members of the consortium (including the Commission Services)	15
D2.2	Uncertainty Quantification of capacity estimates: coherent framework & applications	WP2	1 - BRGM	Report	Public	22
D2.3	High resolution simulation to determine heterogeneity effects on storage estimates in fractured reservoirs	WP2	19 - UNOTT	Report	Public	25
D2.4	Smart Characterization	WP2	20 - CO2GeoNet	Report	Public	28
D2.5	Report on drilling activities for extension to other sites	WP2	6 - CIUDEN	Report	Confidential, only for members of the consortium (including the Commission Services)	38
D2.6	Technical Guidelines on storage capacities estimates and cost-effective site characterisation	WP2	1 - BRGM	Report	Public	42
D3.1	Report on leakage through faults (T3.2.1 & 3.2.2)	WP3	18 - UNIROMA1	Report	Public	23

Deliverable Number ¹⁴	Deliverable Title	WP number ⁹	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D3.2	Assessment of leakage risk presented by old boreholes at onshore site (case study report) (T3.2.4)	WP3	20 - CO2GeoNet	Report	Public	26
D3.3	BGS optic fibre tool (T3.1.1)	WP3	3 - BGS	Demonstrator	Confidential, only for members of the consortium (including the Commission Services)	32
D3.4	BRGM-IDIL optic fibre tool (T3.1.1)	WP3	1 - BRGM	Demonstrator	Confidential, only for members of the consortium (including the Commission Services)	32
D3.5	UNIROMA1 probes (T3.1.1)	WP3	18 - UNIROMA1	Demonstrator	Confidential, only for members of the consortium (including the Commission Services)	32
D3.6	Silixa hybrid cable (T3.1.1)	WP3	15 - SILIXA	Demonstrator	Confidential, only for members of the consortium (including the Commission Services)	32
D3.7	IRIS biosensors (T3.1.1)	WP3	10 - IRIS	Report	Confidential, only for members of the consortium (including the Commission Services)	32
D3.8	OGS UAV drone (T3.3.1)	WP3	12 - OGS	Demonstrator	Confidential, only for members of the consortium (including the Commission Services)	33
D3.9	Report on field tests and modelling of impact of CO2 leakage on freshwater aquifers (T3.1.1)	WP3	1 - BRGM	Report	Public	33
D3.10	Report on Improvement in advanced soil gas monitoring techniques	WP3	2 - BGR	Report	Public	37

Deliverable Number ¹⁴	Deliverable Title	WP number ⁹	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
	and assessment of CO2 source (T3.3.2)					
D3.11	UNIROMA1 GasPro system (3.3.2)	WP3	18 - UNIROMA1	Demonstrator	Confidential, only for members of the consortium (including the Commission Services)	33
D3.12	UNIROMA1 ground mapper robot (T3.3.1)	WP3	18 - UNIROMA1	Demonstrator	Confidential, only for members of the consortium (including the Commission Services)	33
D3.13	Report on leakage detection and quantification tools (T3.3.3)	WP3	3 - BGS	Report	Confidential, only for members of the consortium (including the Commission Services)	37
D3.14	Report on the development of wide-area surface coverage tools and their efficacy) (T3.3.1)	WP3	18 - UNIROMA1	Report	Public	37
D3.15	Report on monitoring techniques which can detect CO2 migrating through fault planes (T3.2.2)	WP3	12 - OGS	Report	Public	35
D3.16	Technical guidelines for CO2 leakage detection and quantification: integration of monitoring tools developed through ENOS with existing state of the art tools in the context of full scale storage site operation (T3.4)	WP3	3 - BGS	Report	Public	40
D4.1	Novel Concepts for EOR with permanent storage of CO2	WP4	10 - IRIS	Report	Confidential, only for members of the consortium (including the Commission Services)	13
D4.2	Progress report on the economic evaluation on the project value	WP4	20 - CO2GeoNet	Report	Confidential, only for members of the consortium	20

Deliverable Number ¹⁴	Deliverable Title	WP number ⁹	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
	of the geo-technical uncertainties related to CO2 buffering and re-production for greenhouse horticulture, and to onshore CO2 storage and oil production				(including the Commission Services)	
D4.3	Progress report on identified key chemical processes	WP4	17 - TNO	Report	Confidential, only for members of the consortium (including the Commission Services)	22
D4.4	Summary report with gas stream scenarios and user specifications	WP4	17 - TNO	Report	Confidential, only for members of the consortium (including the Commission Services)	25
D4.5	Reservoir models of novel CO2-EOR concepts at LBr-1	WP4	10 - IRIS	Report	Confidential, only for members of the consortium (including the Commission Services)	30
D4.6	Assessment of transboundary effects at LBr-1 and regulatory solutions	WP4	4 - CGS	Report	Public	37
D4.7	Approaches to regulating CO2 with EHR in selected Member States	WP4	17 - TNO	Report	Public	37
D4.8	Economic evaluation on the project value of the geo-technical uncertainties related to CO2 buffering and re-production for greenhouse horticulture, and to onshore CO2 storage and oil production	WP4	20 - CO2GeoNet	Report	Public	37
D4.9	Report on separation technology options and recommendation for the gas stream scenarios	WP4	17 - TNO	Report	Confidential, only for members of the consortium (including the Commission Services)	38

Deliverable Number ¹⁴	Deliverable Title	WP number ⁹	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D4.10	Design of a CO2-EOR pilot	WP4	10 - IRIS	Report	Confidential, only for members of the consortium (including the Commission Services)	38
D4.11	Monitoring system for an integrated CO2 buffer and permanent CO2 storage project	WP4	17 - TNO	Report	Public	39
D4.12	Final report on gas phase quality assessment during CO2-EHR, buffering and storage	WP4	17 - TNO	Report	Confidential, only for members of the consortium (including the Commission Services)	40
D5.1	Presentation of the project's technical content in lay terms	WP5	18 - UNIROMA1	Report	Public	13
D5.2	Public Information Tool upgraded and ready for application to other CO2 storage sites	WP5	6 - CIUDEN	Other	Public	34
D5.3	CO2 Storage Best practice indications from the Hontomin site community	WP5	6 - CIUDEN	Report	Public	35
D5.4	CO2 Storage Best practice indications from Rotterdam area community	WP5	17 - TNO	Report	Public	37
D5.5	CO2 Storage Best practice indications from the GeoEnergy TestBed site community	WP5	19 - UNOTT	Report	Public	38
D5.6	CO2 Storage Best practice indications from the Sulcis site community	WP5	18 - UNIROMA1	Report	Public	40
D5.7	Guidelines for coordinating the development of CO2 storage projects with local communities	WP5	18 - UNIROMA1	Report	Public	44

Deliverable Number ¹⁴	Deliverable Title	WP number ⁹	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D5.8	Report on feed-back from citizens on ENOS activities	WP5	17 - TNO	Report	Public	45
D5.9	Report on the process of integration of indications coming from site communities in ENOS research and CO2 storage Best Practices	WP5	18 - UNIROMA1	Report	Public	46
D6.1	Detailed plan of international collaboration activities	WP6	1 - BRGM	Report	Confidential, only for members of the consortium (including the Commission Services)	3
D6.2	1st report on Twinning Programme	WP6	1 - BRGM	Report	Confidential, only for members of the consortium (including the Commission Services)	25
D6.3	1st report on European links, liaison and knowledge exchange	WP6	20 - CO2GeoNet	Report	Public	25
D6.4	State-of-the-art report identifying current lessons learned and future research priorities for EERA	WP6	3 - BGS	Report	Public	40
D6.5	Summary report on activities of the Leakage simulation alliance	WP6	3 - BGS	Report	Public	42
D6.6	Roadmap for CO2-Buffering in the Dutch greenhouse sector to 2030	WP6	17 - TNO	Report	Public	42
D6.7	Towards a strategic development plan for CO2 EOR in the Vienna Basin	WP6	17 - TNO	Report	Public	42
D6.8	Study on new pilot and demonstration project opportunities in Europe	WP6	20 - CO2GeoNet	Report	Public	42

Deliverable Number ¹⁴	Deliverable Title	WP number ⁹	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D6.9	Report on the focus group activities and recommendations	WP6	1 - BRGM	Report	Public	46
D6.10	Follow-up plan for continuation of ENOS pilot projects	WP6	4 - CGS	Report	Confidential, only for members of the consortium (including the Commission Services)	46
D6.11	2nd report on Twinning Programme	WP6	1 - BRGM	Report	Confidential, only for members of the consortium (including the Commission Services)	48
D6.12	2nd report on European links, liaison and knowledge exchange	WP6	20 - CO2GeoNet	Report	Public	48
D7.1	Plan for dissemination and exploitation of results	WP7	17 - TNO	Report	Confidential, only for members of the consortium (including the Commission Services)	6
D7.2	Web-platform	WP7	12 - OGS	Websites, patents filling, etc.	Public	7
D7.3	Results of OpenForum n°1	WP7	12 - OGS	Websites, patents filling, etc.	Public	7
D7.4	Newsletter 1	WP7	20 - CO2GeoNet	Websites, patents filling, etc.	Public	10
D7.5	Annual publication summary report n°1	WP7	10 - IRIS	Report	Public	13
D7.6	Results of OpenForum n°2	WP7	12 - OGS	Websites, patents filling, etc.	Public	19
D7.7	Short note summarizing knowledge integration workshop n°1	WP7	10 - IRIS	Report	Public	19

Deliverable Number ¹⁴	Deliverable Title	WP number ⁹	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D7.8	Newsletter 2	WP7	20 - CO2GeoNet	Websites, patents filling, etc.	Public	22
D7.9	Updated plan for dissemination and exploitation of results	WP7	17 - TNO	Report	Confidential, only for members of the consortium (including the Commission Services)	25
D7.10	Annual publication summary report n°2	WP7	10 - IRIS	Report	Public	25
D7.11	Results of OpenForum n°3	WP7	12 - OGS	Websites, patents filling, etc.	Public	31
D7.12	Short note summarizing knowledge integration workshop n°2	WP7	10 - IRIS	Report	Public	31
D7.13	Newsletter 3	WP7	20 - CO2GeoNet	Websites, patents filling, etc.	Public	34
D7.14	Best practice documents	WP7	20 - CO2GeoNet	Report	Public	40
D7.15	Annual publication summary report n°3	WP7	10 - IRIS	Report	Public	40
D7.16	Short note summarizing knowledge integration workshop n°3	WP7	10 - IRIS	Report	Public	43
D7.17	Newsletter 4	WP7	20 - CO2GeoNet	Websites, patents filling, etc.	Public	43
D7.18	Final plan for exploitation of results	WP7	17 - TNO	Report	Public	45
D8.1	E-book: Climate change and importance of CCS technology for decarbonisation of energy and industry	WP8	2 - BGR	Websites, patents filling, etc.	Public	10
D8.2	Joint education activities – Report 1, including outcome of	WP8	18 - UNIROMA1	Report	Confidential, only for members of the consortium	10

Deliverable Number ¹⁴	Deliverable Title	WP number ⁹	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
	internal workshop for the development of the joint curriculum				(including the Commission Services)	
D8.3	Report on awareness raising course for journalists workshop and interactions with media – months 1-12	WP8	20 - CO2GeoNet	Report	Public	13
D8.4	E-book: Geoscience applied to geological storage of CO2	WP8	2 - BGR	Websites, patents filling, etc.	Public	14
D8.5	ENOS Spring School 1 on CO2 storage	WP8	20 - CO2GeoNet	Websites, patents filling, etc.	Public	17
D8.6	E-book: Regulatory and social aspects of CCS technology	WP8	2 - BGR	Websites, patents filling, etc.	Public	22
D8.7	Report on awareness raising course for journalists workshop and interactions with media – months 13-24	WP8	20 - CO2GeoNet	Report	Public	25
D8.8	ENOS Spring School 2 on CO2 storage	WP8	20 - CO2GeoNet	Websites, patents filling, etc.	Public	29
D8.9	Report on awareness raising course for journalists workshop and interactions with media – months 25-36	WP8	20 - CO2GeoNet	Report	Public	37
D8.10	Evaluation of joint Master and post-graduate Master educational programme based on first experience	WP8	18 - UNIROMA1	Report	Public	37
D8.11	Outcome of building and providing an e-learning course	WP8	2 - BGR	Report	Public	38
D8.12	Outcome of WP8 - Promoting CCS through Training and education	WP8	20 - CO2GeoNet	Report	Public	39

Deliverable Number ¹⁴	Deliverable Title	WP number ⁹	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D8.13	ENOS Spring School 3 on CO2 storage	WP8	20 - CO2GeoNet	Websites, patents filling, etc.	Public	40
D8.14	Report on interactions with media and journalist final report 37-45	WP8	20 - CO2GeoNet	Report	Public	45
D9.1	Plan for site activities	WP9	6 - CIUDEN	Report	Confidential, only for members of the consortium (including the Commission Services)	4
D9.2	Minutes of Management Board and General Assembly meetings for Year 1	WP9	1 - BRGM	Report	Confidential, only for members of the consortium (including the Commission Services)	13
D9.3	Updates to site activity plans 1	WP9	6 - CIUDEN	Report	Confidential, only for members of the consortium (including the Commission Services)	16
D9.4	Minutes of Management Board and General Assembly meetings for Year 2	WP9	1 - BRGM	Report	Confidential, only for members of the consortium (including the Commission Services)	25
D9.5	Updates to site activity plans 2	WP9	6 - CIUDEN	Report	Confidential, only for members of the consortium (including the Commission Services)	28
D9.6	Minutes of Management Board and General Assembly meetings for Year 3	WP9	1 - BRGM	Report	Confidential, only for members of the consortium (including the Commission Services)	37
D9.7	Updates to site activity plans 3	WP9	6 - CIUDEN	Report	Confidential, only for members of the consortium (including the	40

Deliverable Number ¹⁴	Deliverable Title	WP number ⁹	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
					Commission Services)	
D9.8	Minutes of Management Board and General Assembly meetings for Year 4	WP9	1 - BRGM	Report	Confidential, only for members of the consortium (including the Commission Services)	48
D9.9	detailed Project Management Plan	WP9	1 - BRGM	Report	Confidential, only for members of the consortium (including the Commission Services)	3
D9.10	Update of detailed Project Management Plan 1	WP9	1 - BRGM	Report	Confidential, only for members of the consortium (including the Commission Services)	16
D9.11	Update of detailed Project Management Plan 2	WP9	1 - BRGM	Report	Confidential, only for members of the consortium (including the Commission Services)	28
D9.12	Update of detailed Project Management Plan 3	WP9	1 - BRGM	Report	Confidential, only for members of the consortium (including the Commission Services)	40

1.3.3. WT3 Work package descriptions

Work package number ⁹	WP1	Lead beneficiary ¹⁰	6 - CIUDEN
Work package title	Ensuring safe storage operations		
Start month	1	End month	48

Objectives

To demonstrate safe and environmentally sound onshore storage is essential for later development of CCS. Issues arising from the operational phase will be tackled in this WP, using real-life experience from running the Hontomin pilot site. Increased understanding on CO₂ injection and operational procedures will be acquired in ENOS at this far from ideal site, with settings far from ideal, but give an outstanding opportunity to demonstrate operational procedures, monitoring techniques and integrated risk management approaches taking advantage of the huge capabilities of an already existing facility.

The objectives of WP1 are the following:

- to demonstrate innovative injection strategies and history matching approaches for increased confidence of operators in managing sites safely
- to validate methodologies using microseismic monitoring network data to manage induced seismicity risk.
- to validate tools and methodologies for monitoring the CO₂ plume in the reservoir and for acquiring data on reservoir properties for improved understanding on reservoir behaviour.
- to develop the smart integration of the different monitoring data acquired during operation.
- to develop an integrated risk management workflow leading to reliable and safe CO₂ storage operation, fulfilling the requirements of the European Directive for CO₂ Storage, in order to meet the needs of regulators, local population and operators; encompassing monitoring activities, update of risk assessment and potential risk mitigation and corrective measures.
- to perform an integrated approach for the definition of technical guidelines for CO₂ storage operation, through cooperation in R&I of research institutions, industry and service providers.

Work in WP1 therefore aims at generating a TRL progress, where tools will be validated at Hontomin, i.e. at pilot scale, for a wide range of technologies and methodologies related to injection operations and associated monitoring.

Description of work and role of partners

WP1 - Ensuring safe storage operations [Months: 1-48]

CIUDEN, BRGM, BGR, CIEMAT, flodim, GGR, OGS, PLC-3, SILIXA, TNO, UNIROMA1, UNOTT, CO₂GeoNet
Task 1.1 Reliable CO₂ injection procedures in carbonates (CIUDEN, GGR, UNOTT, CO₂GeoNet-HWU)

State of the art

Extensive experience of CO₂ injection exists for enhanced hydrocarbon recovery (e.g. Weyburn, Canada), where reservoir history is typically available to help inform injection management. Injection into saline aquifers was only recently developed at the industrial scale (e.g. Sleipner, Snøvit, In-Salah) but mainly within sandstone formations. Experience in carbonate reservoirs for permanent storage of CO₂ is limited, such as the Michigan Basin site within the US DOE RCSP validation phase (finished in 2009), the Cholla site in Arizona, USA, during which CO₂ injection was not performed due to the lower permeabilities found during well drilling (WESTCARB, 2009), and the Williston Basin field demonstration (PCOR, 2009) in North Dakota, USA, in which up to 400t CO₂ were injected into the Mission Canyon carbonate formation at more than 2400m depth. This site demonstrated the importance of fracture networks on migration of the injected CO₂ plume given that the matrix permeability is typically lower than 0.5 mD and the same well was used for injection and oil production both before and after the test (with increasing values due to CO₂ injection). Field scale experiments complemented by well validated next-generation reservoir models are therefore urgently needed to better understand CO₂ injection into fractured carbonate saline formations and to demonstrate our ability to safely inject and store CO₂ at relevant scale.

Progress beyond the state of the art

The results from this task will increase the confidence of future storage operators in injecting CO₂ in deep saline formations, especially carbonate formations, providing a higher understanding on the risks and cost-effectiveness.

Task 1.1.1 Design and execution of CO₂ injection strategies at Hontomin (CIUDEN, GGR)

The operation of Hontomin TDP represents a core part of the efforts developed in ENOS. It will be linked with many activities within the project, including injection tests and pressure management. It involves the operation of the

Hontomin facility for a period of two years during which up to 10 kton of CO₂ will be injected in addition to the 3 kton currently injected. Innovation in the design, performance and interpretation of the different injection operations will be ensured by learning from the recommendations from twinned sites (see WP6) and from T.1.2 on induced seismicity risk management.

Partners will build on existing experiences in fractured carbonates, analyse the reservoir dynamic model, and define injection strategies with a special view on maintaining geomechanical integrity. Most of the past experiences were based on a continuous flow of CO₂, but in view of future storage operations at commercial scale different injection schemes are needed in order to face unexpected reservoir behaviour or intermittent supply during CO₂ capture. Detailed analysis will be done throughout this task in order to define the best approach for such injection strategies, i.e.:

- Discontinuous strategies: focusing on improving hydrodynamic stability in the fractured reservoir
- Continuous strategies: managing operational parameters (temperature, pressure and flow rates) to control storage integrity
- Alternative strategies: cold injection or co-injection of CO₂ and brine will be designed and tested, with the aim of finding the most efficient operation parameters

Geogreen will update and integrate existing data and models from Hontomin TDP within an advanced earth model using PETREL 2014™. The earth model will serve as a repository for ENOS project tasks and as a basis for numerical investigation of the different injection strategies. The dynamic model, using GEM™ shall be tuned to match the already performed tests on Hontomin TDP.

The injection scenarios will then be modelled, considering different options of injection protocols (mainly pressure, temperature, flow rate and duration) and parameters of the geological static model (permeabilities of the rock matrix and the fracture network of the reservoir and the overlaying formation from caprock to surface, including faults). The injection scenarios will then be performed and this task will allow the acquisition of operational data by CIUDEN associated with CO₂ injection in ENOS.

Task 1.1.2 Interpretation of CO₂ injection tests and history matching (GGR, CIUDEN, UNOTT, CO2GeoNet-HWU)

Based upon the models developed in T 1.1.1, Geogreen will perform an advanced history matching and uncertainty assessment tool for investigating and history matching the different scenarios to represent the injection test performed on site. Beyond the pressure and flow response from the storage and its immediate overburden, a particular focus shall be on defining the stress regime and pressure conditions prior and during CO₂ injection tests with their geomechanical consequences. Given the compartmentalized reservoir settings, modeling of impacts heterogeneities such as faults or fractures will be undertaken by UNOTT and CO2GeoNet-HWU. UNOTT will use INTERSECT™ next-generation reservoir simulator software, using unstructuring meshing, partitioned within a multi-million cell high resolution model of the overall reservoir. This activity will allow dynamic ranking of the different realizations, leading to improved understanding of the impact of heterogeneities and movement (with potential redirection) of the injected plume. It will be enabled by parallel processing using UNOTT's High Power Computing facility. CO2GeoNet-HWU will work on a fault upscaling approach, testing different physical representations of the faults and implementing various scenarios from the geological model developed in T.1.1.1. This will allow Geogreen to update the geological model with detailed knowledge on fault behavior.

Outcomes

Design and execution of cost-effective and innovative CO₂ injection strategies (pulse, cold, ...), associated modelling and history matching activities, linked with Pressure management and site conformance, under real-life conditions.

Demonstration of safe and environmentally sound CO₂ storage

Task 1.2 Induced seismicity: monitoring, control and hazard mitigation (TNO, CIUDEN, BRGM, CO2GeoNet-IGME)

State of the art

Induced seismicity risk in connection with subsurface fluid injection and production has recently become an increasingly important concern. For instance, observations of induced seismicity related to conventional gas production, gas storage, shale gas production, waste water injection, and geothermal activities have demonstrated that there is a need to improve our ability to reduce the uncertainty in seismic hazard assessment and investigate mitigation options. For onshore CO₂ storage in populated areas, induced seismicity is a major public concern and therefore a critical project and safety risk. Until now, CO₂ storage operations have resulted in very few recordings of induced earthquakes (IEAGHG report 2013/09, 2013). However, detailed monitoring studies of induced seismicity are scarce and cannot be generalized into a standard practice approach. In induced seismicity risk management so-called traffic-light systems are common in geothermal and O&G. However, these approaches, that prescribe measures to be taken if the seismicity observed exceeds a threshold, are highly qualitative and have not been tested widely under a wide variety of conditions. At present, the protocol that has been developed in the context of geothermal energy production in the EU FP7 Geiser project is the most advanced and detailed and no such protocol exists for CO₂ storage.

Progress beyond the state of the art

The objective of the work proposed in Task 1.2. is to develop and validate methods for generating input for risk management and control systems. This includes improvements on the physical modelling of seismic wave propagation to optimize monitoring systems and development of innovative approaches that combine physical modelling and statistical data to update the seismicity risk model as more observations and operational data become available.

The activities in Task 1.2 are grouped into three subtasks that are strongly linked but each focus on a different aspect of induced seismicity risk management.

Task 1.2.1. Baseline and background of the fault activity (CO2GeoNet-IGME, CIUDEN)

The aim of this sub-task is to determine the recent seismic activity around Hontomín site and its possible change caused by the injection. This will establish the Hontomín seismological baseline, which is needed to provide the initial risk assessment and interpretation of seismicity observed at the site. The seismic behaviour of a fault depends on the stress and strength fields. Existing characterization activities provided by CIUDEN will be extended by CO2GeoNet-IGME for the Hontomin site with a detailed analysis of the following aspects:

- Structural Analysis. Fault population analysis defines stress and strength trajectories.
- Analysis of natural seismicity into the area. Palaeoseismic recognition of active faulting, tectonic geomorphology and archaeoseismology.
- Analysis of induced seismicity: time-series analysis of triggered earthquakes. Estimation of short-term and long-term behavior.

These activities will be performed in different level of detail for three zones of interest: the storage complex, an intermediate area (25km range from the injection site) and on a regional scale (100 km).

Task 1.2.2 Demonstration of (Passive) Seismic Monitoring Network reliability (TNO, CIUDEN)

The aim of this task is to test the reliability of the existing seismic monitoring network at Hontomin and optimize it, in terms of reliability, accuracy, and sensitivity. This will lead to increased safety during operation, thus promoting confidence in CO2 storage.

Part of the activities will be devoted to execute a detailed performance assessment methodology for the existing micro-seismic monitoring network at Hontomin. This activity will be done in two phases, first conducting a conventional calibration analysis of the seismic instruments, using correlation analysis of recorded micro-seismic events to improve the sensitivity and using progressive propagation model updates to improve localisation of the events. A parallel simulation process using detailed 3D finite element with SPECFEM3D will be done, which will provide the simulated data that can be compared with actual observations using advanced Full Waveform Inversion techniques, providing improved understanding and ultimately better predictive capabilities of the seismic response to the injection. Once a detailed model for the seismic response is available, a Value of Information (VOI) analysis will be performed. This analysis will not only provide an evaluation of the performance of the existing monitoring network but also considers alternative monitoring layouts, focusing on the trade-offs between initial and operational costs and reliability, accuracy and sensitivity of the network and instruments. The results of this analysis will be used to develop effective and validated monitoring strategies for induced seismicity risk management in onshore CO2 storage projects.

Task 1.2.3. Implementation of risk control activities (BRGM, CIUDEN)

Approaches for time-dependent seismic hazard estimates will be developed, using an advanced traffic light system, aiming to mitigate seismicity through real-time adaptation of injection strategy. Traffic light risk management systems require (near)-real time detection, localization, and (preferably) characterization of induced seismic events. The Hontomin site fulfils the needs with the monitoring network and characterization and monitoring data, providing a unique opportunity to develop the workflows to generate the information needed to execute a seismicity risk management protocol.

Existing guidelines have been formulated in the context of geothermal energy development. In this task this protocol will be evaluated and adapted for application in a CO2 context. In particular, a mitigation strategy will be developed that is based on control of injection rates to keep seismic hazard below a pre-defined level; thus linked with T.1.1 on operation aspects of CO2 injection.

This task will include a validation of each step of the methodology against observations from Hontomin operations. In particular, the simulated seismicity catalogues will be compared to observations and a calibration of free parameters in the approach to be developed. Specifically, the ground-motion models proposed for geothermally-induced seismicity will be compared with available ground-motion records. Potentially, simulations will be conducted for validation using the spectral-element codes (EFISPEC3D by Florent De Martin), where possible building on the spectral element simulations performed in Task 1.2.

Outcomes

Methods for reducing uncertainty and producing reliable and transparent induced seismicity hazard estimates under real-life conditions, using experiences and observations from Hontomín to validate the methods developed.

Demonstration of best practices for effective monitoring and risk assessment related to induced seismicity control allowing optimising the safe operation of storage sites.

Demonstration of mitigation techniques, to keep induced seismicity risks below an acceptable threshold

Providing input for a sustained engagement of local communities by a dedicated explanation of the risk management activities, in close collaboration with WP5 effort.

References:

IEAGHG (2013) Induced Seismicity and its Implication for CO₂ Storage Risk, 2013/09, June 2013.

Task 1.3 Monitoring safe underground storage behaviour (CIUDEN, BRGM, BGR, OGS, Silixa, UNIROMA1, Flodim) State of the art

Monitoring technologies are expected to be improved for reliable control of CO₂ storage. Many of the tools and techniques in use at the existing sites, such as Sleipner, come from Oil&Gas sector. The costs for deploying such techniques however need to be optimized and other techniques coming from other sectors still need to be adapted and demonstrated for CO₂ storage purposes. Geochemical monitoring through deep sampling is mainly performed with permanently installed U-tube system, which has been tested in key onshore CO₂ storage sites such as Frio Brine (US), Otway (AUS), Ketzin (GER) and Hontomin (ES).

Some tools as the Distributed Acoustic Sensor (iDAS) already installed at Hontomin in well H-I has been utilised for VSP surveys (this tool was developed through deployment at Hontomin, Otway (AUS), Ketzin (GER), or AQUISTORE (CAN))

Regarding soil gas monitoring stations, both BGR and UNIROMA1 stations were tested at different pilot and naturally leaking sites.

The aim of this task is to test different technologies under real-life conditions, each measuring different useful parameters that, when integrated, will contribute to understand what is occurring in the reservoir and the overburden, which is key for the demonstration of safe and environmentally sound CO₂ storage and for providing the needed information in T.1.4 for risk management.

Progress beyond the state of the art

Monitoring techniques for demonstrating site conformance using different monitoring techniques will be validated. For geochemical monitoring, a deep sampler will be tested at larger depths in the observation well (H-A) under harsh saline environments, supported by the knowledge acquired from the U-tube system at the injection well, H-I. Sampling fluids that are representative of in-situ conditions is still a challenge in particular for removable tools that can resist downhole pressure temperature and salinity. Improvement of active and passive seismic methods will be done, taking advantage of the existing settings in Hontomin (see. T.1.3.2), this will include testing the use of the Silixa IDAS cable for monitoring purposes other than VSP. This will allow acquiring precise data from the storage complex while validating monitoring techniques that can represent a cost effective solution when compared to well-known geophysical techniques common for Oil&Gas. In addition, different soil gas monitoring stations will be installed in Hontomin, pursuing a continuous control of the values in surface that will allow a TRL progress and a more complete monitoring plan at Hontomin. The combination of continuously measured soil gas composition data with CO₂ flux surveys will allow interpreting thresholds representing an irregularity.

Task 1.3.1 Alternative deep geochemical monitoring solutions (BRGM, CIUDEN, Flodim)

The overall aim of this task is to demonstrate tools for reservoir water and/or gas sampling and to validate the contribution geochemical monitoring can provide to the monitoring and management of CO₂ Storage.

BRGM will work on further developments of its deep sampler (patent FR-1259214), which will allow getting representative samples of water and/or gases existing at depth. The proposed monitoring strategy is oriented towards a system that is both retrievable and can be left in place in monitoring boreholes to get samples. Until now, the device has only been deployed at shallower depth and in freshwater environment (1035 m in the Aquitaine basin in France). This will allow evaluating potential adverse effects linked to saline environments, such as corrosion. Three sampling campaigns are budgeted in the proposal (2016, 2017 and 2018). Flodim will test its new Bottom Hole Sampling system, where the sampling chamber is also a transport container and a PVT cell and its High Temperature Geochemical instrument (P, T, GR, CCL, pH, Redox potential, Conductivity and dissolved O₂).

Gas and water samples will be acquired at Hontomin and processed at BRGM's laboratory in order to get major and trace element analyses. This will bring information on the remobilization of trace metal elements in water, and hence understanding processes that may lead to such remobilization in a carbonated aquifer.

Using the initial composition of the formation water from Hontomin characterization phase, from the existing U-tube sampler located at the Injection well and from flodim probe, the geochemical evolution of the reservoir will be evaluated. A reactive transport model will be developed that will be based on calibration laboratory experiments. Because of the relatively high salinity in the Hontomin reservoir, geochemical modeling will be made using the Pitzer formalism,

suitable for high salinity solutions and enabling to test it on real case. Such a modeling will also give the opportunity to implement the Pitzer approach for the Fe(II)/Fe(III) redox couple and to validate it versus natural brines at the reservoir scale.

Task 1.3.2 Innovative geophysical monitoring (OGS, Silixa, BRGM, CIUDEN)

The scope of this activity is to provide geophysical data in relevant time (i.e. useful to take decisions) for the integrated risk management approach in T.1.4. There are techniques that offer opportunities in terms of integration, usability and cost reduction, which are going to be demonstrated under real conditions in ENOS.

OGS and Silixa will perform 2 surveys (2016, 2018) using a surface seismic vibrator source, and recording data at the existing iDAS in H-I (injection well) and hydrophones in H-A (observation well). Results will be confronted by OGS with already existing 3D seismic information for improving the subsurface imaging, and the definition of the fractured blocks within the reservoir and for CO₂ plume tracking. The iDAS dense spatial sampling offers the opportunity to extensively apply to 3D VSP the innovative dual-field separation method, without need of detailed signal picking. Associated numerical modeling including attenuation and ray tracing, using existing information of the subsurface and near-surface Hontomin 3D seismic model, will verify downhole illumination zone, estimate resolution, and provide sensitivity analysis (see also Task 1.4.1).

Moreover, OGS will use a slim sparker borehole source to acquire crosswell and single-well acoustic signals with higher frequency and without the overburden effects, immediately after the 3D VSP surveys in 2016 and 2018, to improve the resolution and sensitivity of the seismic results to be used for the subsequent integration with downhole resistivity (ERT) data from permanent borehole electrodes installed in H-I and H-A that will be acquired by CIUDEN, and local calibration of the areal 3D VSPs from surface sources.

The application of seismic interferometry (SI) techniques to borehole data with active (seismic vibrator) and passive sources (injection noise) will make possible to obtain signals redatumed at depth without the overburden effects, and to remove the source effects in the time lapse applications. This approach will create signals from virtual sources, which will be compared with the sparker crosswell acoustic results. SI will be based on cross-correlation and, thanks to dense iDAS sampling, multidimensional deconvolution method to remove the virtual source's point spread function. To extend the stationary coverage condition with partial illumination OGS will use the tangent-phase method proposed by Poletto et al. (2013, and see Bibliography for OGS in Section 4).

From operational point of view, crosswell acoustic and SI by active surface sources represent quick methods, with respect to 3D VSP, to monitor the local CO₂ plume evolution between virtual source and receivers in the borehole.

Another approach from BRGM relates to seismic noise correlation. This method for CO₂ storage monitoring has undergone a first test on the Ketzin injection site. This test showed that this method offers room for improvement to get a better insight at the reservoir level and thus offers a competitive and continuous alternative to the current 4D time lapse seismic surveys. BRGM will reprocess the data from the surface seismological network and transpose new developed algorithms, to extract speed variations at the reservoir level and thus highlight changes in the reservoir induced by CO₂ presence or fracturation.

Task 1.3.3 Determination of action levels by soil gas monitoring (BGR, CIUDEN, UNIROMA1)

The aim of this activity is to progress the TRL of permanently acquired soil gas concentration data from monitoring stations developed by BGR and UNIROMA1. These will be located at key sites at Hontomin, close to the injection area and near existing faults. Both monitoring stations will provide accurate data during the operation of the facility. These data will be permanently cross-referenced to a "reference site" station, which is mandatory to acquire accurate natural background (annual, inter-annual or daily variations) and threshold data. This subtask will take advantage of the existing baseline CO₂ fluxes and data from the existing meteorological station acquired by CIUDEN, and further CO₂ fluxes surveys are also expected in order to correlate them with the data acquired by the soil gas monitoring stations equipped with a commercial flux measurement device. By combining continuously measured data and spatial data threshold can be defined that could represent an irregularity. These thresholds will be inputs to the risk management procedure developed in T1.4. This activity will complement the BGR soil gas monitoring activities in Task 3.3.2 where leakage will occur for sure.

Outcomes

Extension of the deep sampling capacities for CO₂ storage, key for improving knowledge on reservoir behaviour, geochemical response, and a better understanding on the processes in the reservoir.

Benchmarking of different samplers (Utube, BGRM's and Flodim's)

Demonstration of best practices for monitoring of CO₂ storage, providing accurate data on the behaviour of the storage complex during the operation of a CO₂ storage site. Progress TRL monitoring tools validated at real-life conditions.

Building public awareness by facilitating data and "visible in surface" monitoring stations.

References:

Poletto F., B. Farina, and G. Böhm, 2013. Tangent-Phase Interferometry, Time Lapse Application and Sensitivity Analysis: 75th EAGE Conference & Exhibition incorporating SPE EUROPEC, Extended Abstract.

Task 1.4 Demonstrating operational risk management (BRGM, CIUDEN, CIEMAT, GGR, PLC-3, OGS, TNO)

State of the art

Some form of operational risk management were already performed in previous injection sites but in most of them used an ad hoc methodology. In some cases, no clear workflow or procedure is apparent (Sleipner, Chadwick et al. 2008; In Salah, Ringrose et al. 2012; Ketzin, Wurdemann et al. 2011, Martens et al. 2014). Those references often mention updates of either the main models or the risk assessments but not in a clearly defined way, such as what is required from the EU directive and the accompanying guidance documents. In North America, more robust risk management methods were used (at Weyburn, Bowden et al. 2013, or at Decatur, Hnottavange-Telleen, 2014) but how monitoring is used to update the risk assessment is less clear. An operational automated system for monitoring was developed for the Decatur site (Picard et al. 2011) but again, the link with risk assessment is not clear.

The ROAD project in the Netherlands, developed risk management plans in accordance with the requirements of the EU directive but is still in the pre-injection phase (Steeghs et al. 2014).

There also exist various published (but still untested on real sites) methods regarding links between the risk management plans and how to set thresholds: Setting up a Monitoring plan: Bourne et al. 2014; Having probabilistic thresholds in the monitoring plan: Jenkins, 2013; Using a traffic light system for dealing with the offset between models and measurements: Kronimus et al. 2013; Using Key Performance indicators for linking observation and risk assessments: Pearce et al. (2013).

Progress beyond the state of the art

The task will seek to make progress on the following points:

- Integration of different monitoring techniques in order to derive more meaningful indicators
- Robust link between risk assessment updates and observations through the use of clearly defined thresholds
- Use of probabilistic risk models
- Integrated workflow for operational risk management including monitoring, modelling and risk communication.

The activities in Task 1.4 are grouped into three subtasks: the first two are demonstration of best practices at the Hontomin site, while the third will deal with more general aspects:

- In Task 1.4.1 the measurements from different monitoring techniques (geophysical and geochemical) are integrated in order to obtain more meaningful information related to the actual risk;
- Task 1.4.2 will update of the risk models following the observations made during operations;
- Task 1.4.3 will be dedicated to the methodological aspects and to the extrapolation of results for future storage sites.

Task 1.4.1. Integration of monitoring data (OGS, BRGM, CIUDEN)

Integration of monitoring data is needed as part of an operational risk management procedure for several reasons: 1/ some monitoring techniques such as geophysical techniques can reduce the uncertainty on their measurements when combined with other, complementary measurements; and 2/ reasoning on risks is more practical with meaningful indicators (such as localisation of CO₂ front) rather than on raw measurements, but such indicators can be computed using different information sources.

OGS will coordinate the integration and evaluation of the geophysical data, including correlation of the recorded microseismicity (including waveforms) with CO₂ injection activities, seismic and electromagnetic sensitivity analysis, poro-visco-elastic modeling and data inversion (including multi-phase fluid geophysical characterization). BRGM will contribute by integrating the geochemical data and surface measurements of gases. CIUDEN, as operator of the site, will gather all possible data, including data from the shallow hydrogeological monitoring network. During a previous baseline campaign at Hontomin, BRGM acquired a spatially dense CSEM dataset with an innovative/efficient source type, the surface LEMAM setup combining surface electrodes and one borehole casing. Integrated with the previously mentioned monitoring techniques, these data can bring complementary information at storage complex scale, thus reducing uncertainties on measurements and facilitating interpretation. In order to do this, a 3D resistivity map will be inverted from the baseline data (i.e. apparent resistivity maps) using a modular parallel frequency-domain CSEM inversion code.

Task 1.4.2 Update of risk assessment (CIEMAT, CIUDEN)

A key issue in CO₂ storage activities is that the knowledge on the risks is evolving along the life of the project as new information is derived from the monitoring system, and thus requiring a regular update of the risk assessment. As an objective of the task is to progress on the development of a risk management procedure for a potential automated alert system (subtask 1.4.3), a key aspect in this subtask will be to develop a clear, robust and repeatable workflow for updating the risk models.

In the current collaboration between CIUDEN and CIEMAT, a methodology for estimating the probability of risk of leakage has been developed for the Hontomin Technology Development Plant site and an ad hoc model has been implemented on a probabilistic simulation object-oriented framework. This model yields quantitative risk probability functions of the total CO₂ storage system and of each one of their subsystems as well as the stochastic time evolution of the CO₂ plume during the injection period, the stochastic time evolution of the drying front, the probabilistic evolution of the pressure front, and the leakage probability functions through major leakage risk elements (fractures / faults and wells / deep boreholes (Hurtado et al. 2014)).

In Task 1.4.2, CIEMAT proposes to validate that risk model using as input data those variables from the monitoring process related to the temporal evolution of the CO₂ plume and the drying front. As a result of the validation process, the probabilistic model will be modified as to reflect the singularities of the Hontomin site.

Task 1.4.3. Technical Guidelines for operational risk management (BRGM, CIEMAT, CIUDEN, PLC-3, GGR, OGS, TNO)

This subtask will have two main purposes: the first is to guide the methodological developments needed in the other subtasks. The other is to extract the lessons learned in the whole task and to extrapolate them for future storage sites.

Using the existing Risk Assessment and the latest data produced by the monitoring infrastructure at Hontomin, a list of the Key Performance Indicators (KPI) of the site will be defined, as well as how they will be computed in subtask 1.4.1, and used in task 1.4.2.

Then thresholds based on those KPI will be set in coherency with the traffic-light system developed by TNO in the FP7 CO₂CARE project. Thresholds on the KPI will allow triggering additional monitoring or corrective measures. There is also a need for a threshold related to the offset between models and observations that, when overpassed, would require the model to be modified.

Those developments will allow having a full operating workflow, linking risk assessment, the monitoring system and corrective measures. The partners will provide a first version of the workflow in the beginning of the project and will then improve it as more data and experience are gathered during the project. One goal of this task is to draft the specifications for a future integrated and automated alert system. The integration of the storage component in the whole CCS system, and the potential effect on operations in the whole chain (incl. capture and transport) will also be assessed.

BRGM will lead the task. All partners will contribute to the methodological developments through dedicated meetings. CIUDEN and PLC-3 will work on the specifications of the alert system for its integration on an industrial full chain project.

Outcomes

Demonstration of an integrated workflow of risk management, providing a strong basis for communication of risks with various stakeholders, including authorities and the general public.

Initial design stage of an integrated alert system, providing provide a strong methodological framework for future operators and regulators of storage sites and will be consistent with the guidance of the EU directive.

References:

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Interaction with other WPS

A strong interaction with other WP in the project is assured, especially with WP3 on demonstration that there is no leakage. WP1 will focus on monitoring to verify deep processes which control the security of storage and technologies used to demonstrate that the CO2 is contained within the storage complex. WP3 will focus on verifying the effectiveness of selected shallow and surface monitoring technologies and techniques advanced through the ENOS project that will be utilised alongside improved understanding of major leakage pathways (faults and boreholes) and the outcomes of WP1 to advance monitoring protocols.

With WP5 where coordination with local population includes the explanation of the activities at Hontomin.

In WP7, the development and dissemination of best practices will use conclusions from WP1. Knowledge sharing and international cooperation in WP6 will be based on WP1 activities for Hontomin site twining with site projects outside Europe, as Otway (AUS), and Battelle (US) ones.

Participation per Partner

Partner number and short name	WP1 effort
1 - BRGM	45.00
2 - BGR	10.00
5 - CIEMAT	6.00
6 - CIUDEN	102.00
7 - flodim	4.00
8 - GGR	11.40
12 - OGS	40.00
13 - PLC-3	0.00
IPF	2.50
ENAGAS	1.50
15 - SILIXA	4.50
17 - TNO	16.00
18 - UNIROMA1	1.00
19 - UNOTT	8.00
20 - CO2GeoNet	0.00
HWU	4.00
IGME	20.20
Total	276.10

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D1.1	Design of CO ₂ injection tests	6 - CIUDEN	Report	Confidential, only for members of the consortium (including the Commission Services)	6
D1.2	Report on installation, with constantly updated data and threshold assessments	2 - BGR	Report	Public	14
D1.3	Dynamic ranking of the impact of heterogeneities on plume movement	19 - UNOTT	Report	Confidential, only for members of the consortium (including the Commission Services)	25
D1.4	Benchmarking studies on deep sampling	1 - BRGM	Report	Public	25
D1.5	Design & optimization of seismic monitoring network for induced seismicity management	17 - TNO	Report	Public	25
D1.6	Report on fault activity	20 - CO ₂ GeoNet	Report	Confidential, only for members of the consortium (including the Commission Services)	32
D1.7	Interpretation and history matching on CO ₂ injection activities	8 - GGR	Report	Confidential, only for members of the consortium (including the Commission Services)	37
D1.8	Risk model updated	5 - CIEMAT	Report	Confidential, only for members of the consortium (including the Commission Services)	37
D1.9	Benchmarking on different geophysical techniques	12 - OGS	Report	Public	37

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D1.10	Assessment of KPI from measurements	12 - OGS	Report	Confidential, only for members of the consortium (including the Commission Services)	38
D1.11	Specifications for future integrated and automated system	6 - CIUDEN	Report	Public	39
D1.12	Lessons learned on Geochemical modelling and sampling activities	1 - BRGM	Report	Public	39
D1.13	Results of induced seismic risk control activities	1 - BRGM	Report	Public	42
D1.14	integrated workflow for operational risk management	1 - BRGM	Report	Public	44

Description of deliverables

Task 1.1

D1.1 Design of CO2 injection tests. M6. CIUDEN (GGR)

D1.3 Dynamic ranking of the impact of heterogeneities on plume movement, M25, UNOTT (CO2GeoNet-HWU)

D1.7 Interpretation and history matching on CO2 injection activities, M37, GGR, (CIUDEN, UNOTT, CO2GeoNet-HWU)

Task 1.2

D1.6 Report on fault activity, M32, CO2GeoNet-IGME (CIUDEN)

D1.5 Design & optimization of seismic monitoring network for induced seismicity management, M25, TNO (CIUDEN)

D1.13 Results of induced seismic risk control activities, M42. BRGM (CIUDEN)

Task 1.3

D1.4 Benchmarking studies on deep sampling, M25, BRGM (CIUDEN,Flodim)

D1.12 Lessons learned on Geochemical modelling and sampling activities, M39, BRGM (CIUDEN,Flodim)

D1.9 Benchmarking on different geophysical techniques, M37. OGS (CIUDEN, SILIXA, BRGM).

D1.2 Report on installation, with constantly updated data and threshold assessments, M8, BGR (CIUDEN)

Task 1.4

D1.8 Risk model updated M37. CIEMAT (CIUDEN)

D1.10 Assessment of KPI from measurements, M 38. OGS (BRGM, CIUDEN)

D1.14 Integrated workflow for operational risk management, M44. BRGM (TNO, PLC-3, CIUDEN)

D1.11 Specifications for future integrated and automated system, M39. CIUDEN (BRGM, TNO, PLC-3)

D1.1 : Design of CO2 injection tests [6]

The aim of this deliverable is to define a methodology involving field tests and operation procedures for its development at Hontomín Technology Development Plant, according planned activities to be performed in the project scope.

Following tasks are related with D1.1: Tasks 1.1, 1.2, 1.3 and 1.4

D1.2 : Report on installation, with constantly updated data and threshold assessments [14]

Two monitoring stations will be installed at key sites in Hontomin (close to observation wells), a third as reference site. Data will be cross-referenced against each other. Based on the detected annual/diurnal/other natural variations at the reference site, site specific threshold values of soil gas concentration changes will be defined and reported.

D1.3 : Dynamic ranking of the impact of heterogeneities on plume movement [25]

Task 1.1 The impact of heterogeneities (e.g. faults) on plume behaviour will be determined using INTERSECT high resolution reservoir tool. The resulting impact will be dynamically ranked according to fault characteristics.

D1.4 : Benchmarking studies on deep sampling [25]

Task 1.3 - A report presenting the different geochemical monitoring techniques implemented at Hontomin to control the safety of CO₂ storage

D1.5 : Design & optimization of seismic monitoring network for induced seismicity management [25]

The report describes the reliability, accuracy and sensitivity of the existing seismic monitoring network at Hontomin based on a detailed performance assessment, which will be performed in Task 1.2.2 of WP1 (TNO and CIUDEN).

The assessment consists of two stages: conventional calibration using the recorded microseismic events and a detailed finite element data simulation enabling comparison with the actual data. A subsequent Value-of-Information analysis will provide the comparison of different monitoring layouts and recommendations for future monitoring strategies.

D1.6 : Report on fault activity [32]

Task 1.2 Report will include fault population, natural seismicity and induced seismicity analysis in the Hontomín area in order to estimate short-term and long-term behavior

D1.7 : Interpretation and history matching on CO₂ injection activities [37]

Task 1.1.2: Report presenting the Performed history matching of injection tests. It will present the conclusions on: Assessing the geomechanical impacts, and the influence of heterogeneities and uncertainties on the CO₂ plume development. It will propose alternative fault models into the geological model, if adequate.

D1.8 : Risk model updated [37]

Task 1.4 Global quantitative risk probability function at Hontomin TDP site after up to 10 kton of CO₂ injection tests, based on monitoring observations during the operation. Leakage probability functions through major leakage risk elements such as fractures / faults and wells / deep boreholes.

D1.9 : Benchmarking on different geophysical techniques [37]

This deliverable is related to task T 1.3.2 and consists of reporting on innovative geophysical monitoring of safe underground storage behaviour. This activity will perform a benchmarking on geophysical techniques, by evaluating their effectiveness for the integrated risk management approach of task T 1.4.

D1.10 : Assessment of KPI from measurements [38]

This deliverable is related to tasks T 1.4.1 and also T 1.4.3, and consists of reporting on integration and evaluation of monitoring data, which are needed as part of an operational risk management procedure. This activity will provide information useful to determine the Key Performance Indicators (KPI) for the purposes of the operational risk management of task T 1.4.3.

D1.11 : Specifications for future integrated and automated system [39]

Task 1.4 The deliverable will present the specifications on the specifications of the alert system for its integration on an industrial full chain project. It will reflect the needs from operators for the full chain.

D1.12 : Lessons learned on Geochemical modelling and sampling activities [39]

Task 1.3 - A report presenting the results of the deep sampling campaigns, the analysis of the gas and water sampled at underground conditions and the evaluation of the geochemical evolution of the reservoir by numerical simulations

D1.13 : Results of induced seismic risk control activities [42]

Task 1.2 - A report presenting the result for the seismic risk control activities as tested on the Hontomin site. The chosen approach consists in adapting advanced mitigation protocols developed for geothermal energy projects, and will combine the observations with short term predictions (combining physical and statistical models) of the seismicity.

D1.14 : integrated workflow for operational risk management [44]

Task 1.4 - A report describing the risk management workflow as created in the project, tested on the Hontomin site and further refined. The aim of the workflow is to provide consistent links between risk assessment update,

monitoring, and corrective measures. An important aspect is to extrapolate the main lessons from the application in order to be useful for other sites.

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS3	Hontomin 3D Geological model	6 - CIUDEN	3	Data available
MS4	International collaboration input to Work programme planned	1 - BRGM	3	D6.1
MS7	Hontomin 3D dynamic model	6 - CIUDEN	6	Data available
MS8	first geochemical investigation in Hontomin	1 - BRGM	6	Samples acquired
MS9	Soil Gas Monitoring installed in Hontomin	2 - BGR	6	Data acquired
MS11	Start of injection in Hontomin	6 - CIUDEN	7	First tonnes injected
MS13	Input from End-User Committee 1	10 - IRIS	11	Key outcomes from meeting
MS15	Definition of KPI and preliminary thresholds	1 - BRGM	12	Validation by partners
MS18	second geochemical investigation on site	1 - BRGM	18	Samples acquired
MS22	Feedback to CO2 injection operations in Hontomin	6 - CIUDEN	21	Data available
MS23	Input from End-User Committee 2	10 - IRIS	23	Key outcomes from meeting
MS28	Last geochemical investigation at hontomin	1 - BRGM	30	Samples acquired
MS29	End of injection in Hontomin	6 - CIUDEN	31	Injection stopped
MS32	Input from End-User Committee 3	10 - IRIS	35	Key outcomes from meeting
MS33	Update of thresholds	1 - BRGM	36	Validation by Partners
MS34	Advisory board input 2	1 - BRGM	36	report and note on impact on ENOS
MS35	End of all field activity	1 - BRGM	36	End of CO2 injection and ENOS data acquisition

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS36	Input from End-User Committee 4	10 - IRIS	47	Key outcomes from meeting

Work package number ⁹	WP2	Lead beneficiary ¹⁰	1 - BRGM
Work package title	Ensuring storage capacities and cost-effective site characterisation		
Start month	1	End month	48

Objectives

While offshore storage in Europe will certainly occur underneath the North Sea in large CO₂ storage units collecting CO₂ through long distance transport infrastructure, onshore CO₂ storage in Europe will probably be distributed in many low to medium storage capacity sites close to CO₂ emitters. Unless uncertainty on storage capacities onshore is significantly decreased, the cost for site selection reduced and early characterization improved, onshore CCS will not happen. Operators can only engage minimum funds in site investigation before FID (Final Investment Decision) is taken. However as for all underground related activities, perceived uncertainties are high and the way to reduce them is often expensive: e.g. drilling and seismic acquisition. For new storage projects to be developed and therefore for CCS to be deployed widely, the future site operators need to be able to assess the financial and operational risk taken and therefore need to be able to streamline procedures and reduce the cost whilst improving the reliability of the capacity estimates and the potential cost for reducing uncertainties (exploration). More research is needed to de-risk site characterisation in order to provide bankable capacity assessments that can satisfy stakeholders and investors. To reach this goal, working on datasets from real sites is essential.

This work package aims to:

- Further investigate potentialities of next-generation 'high resolution' reservoir modelling to assess impact of heterogeneities on CO₂ storage capacities;
- Quantify the reliability of storage capacities estimates;
- Lower characterisation costs through (i) the validation of methodology to optimize exploration program, and (ii) the development of front-end engineering study for low cost drilling.

Description of work and role of partners

WP2 - Ensuring storage capacities and cost-effective site characterisation [Months: 1-48]

BRGM, BGS, CIUDEN, PLC-3, SOTACARBO, UNOTT, CO₂GeoNet

Task 2.1 Quantify reliability of storage capacities estimates (BRGM, CO₂GeoNet-HWU, BGS, UNOTT, CIUDEN)

A more realistic estimate of storage capacities implies: (1) to optimize computing performance for dynamic modelling of heterogeneous and complex reservoirs and (2) to account for the multiple sources of uncertainty (geological heterogeneities, model parameters, choice in the physical laws, etc.). By doing so, quantification of the reliability of capacity volumes can be provided.

State of the art

Dynamic capacity assessment relies strongly on modelling capabilities. Schlumberger ECLIPSE has been a benchmark reservoir simulation tool for the past 25 years to deal with increased complexities in oil fields, as well as alternative hydrocarbons and CO₂ geological storage. Then next-generation reservoir models (e.g. INTERSECT, simulation code developed by Schlumberger), which will also be applied to study injectivity in T1.1, include scalable parallel processing capability for dramatic decrease in run-times on multi-million segment grids, advanced gridding techniques for accurate representation of heterogeneities (DeBaun et al., 2005; Dogru et al., 2009). INTERSECT was used in a recent case study, for the Australian Gorgon Project, taking advantage of its high performance with parallel processing (Edwards et al., 2012). However, these capabilities have not been used to assess the impact of heterogeneities such as permeable faults and (low permeability) granulation seams on plume migration and 'bankable' storage capacity estimates in faulted and complex reservoirs targeted for CO₂ storage.

Within the flow modelling workflow for dynamic capacity estimates, uncertainties are introduced from a range of sources, for example uncertainties in geological characteristics and limitations of modeling input and software. Uncertainty can take several forms. A first category referred to as parametric stems from difficulty in estimating the input parameters (in a broad sense) of models/analysis due to the limited number, poor representativeness (caused by time, space and financial limitations), and imprecision of observations/data. Examples are model spatially homogeneous parameters like multiphase flow properties of a given rock formation and geological heterogeneities related to spatial variability (e.g., heterogeneous reservoir permeability field). A second category referred to as modelling uncertainty is related to the assumptions underlying the construction of the model. Examples in the domain of CO₂ storage modeling are the inclusion of the capillary processes, the size of the grid mesh and the choices of boundary conditions. This last

category also includes modelling errors, which can be defined by the discrepancy between the simulation code and the actual physical system (e.g., Kennedy & O'Hagan, 2001).

Any efficient management of storage site (e.g., site selection, injection operations, etc.) should then rely on a “good picture” of what is unknown: this is the purpose of Uncertainty Quantification (UQ). Standards for reliability of reserves in the domain of O&G typically rely on quantiles P10, P50, P90 to do so (Px is a statistical confidence level for an estimate, when probabilistic Monte Carlo type evaluations are adopted. Px is defined as x% of estimates exceed the Px estimate. P90 and P10 are low and high estimates respectively).

Progress beyond the state of the art

INTERSECT will be used to investigate the impact of fracture networks and granulation seams on capacity evaluation. Detailed analysis of these features, using down-hole characterisation data from the GeoEnergy Test Bed. Also, follow-on activities from the INTERSECT simulations of injectivity in T1.1 (Hontomin test site) will investigate the role of fractures on capacity evaluation in fractured carbonate reservoirs. These studies will improve our understanding of storage capacity estimates in complex reservoirs.

UQ of storage capacities can rely on several approaches. Meta-Models (i.e., response surface based on Design of Experiments as traditionally used in O&G) have proved to be powerful since they allow reducing the required computational costs to perform a full UQ study into manageable level (Manceau and Rohmer, 2014, Petvipusit et al., 2014). Yet, several deficiencies still require to be addressed for direct use for UQ of capacity estimates:

Def.1. meta-modelling can be severely hindered by the large number of uncertain parameters (>10);

Def.2. modelling uncertainty related to the necessary assumptions on flow modelling (e.g., boundary conditions) are rarely placed on the same footing for comparison with parametric uncertainties;

Def.3. UQ based on meta-models should also include the influence of complex geological heterogeneities (spatial uncertainty) together with model and parametric uncertainties;

Def.4. current implementation of these techniques rarely accounts for modelling errors which can be significant.

Task 2.1.1 High resolution Dynamic modelling of heterogeneous Reservoirs

UNOTT will provide high-resolution scalable reservoir simulation for representative modeling of geology and wells, along with field management and planning for the CO₂ injection. This will involve using the ‘INTERSECT’ High-Resolution Reservoir Simulator. This tool will enable detailed reservoir characterization of the GeoEnergy Test Bed and Hontomin sites by taking into account the heterogeneous lithologies and well network coupling with minimal or no upscaling. For this purpose the extensive data generated by down-hole imaging at the GeoEnergy Test Bed will be made available for use in this project, and will allow the inclusion of accurate and detailed modeling of the faults and other features. Large field simulations of up to billion grid blocks are possible in conjunction with UNOTT’s High Performance Computing (HPC) facility. Efficient solver technology delivers results in a fraction of the time required by existing simulators. This will be used to simulate the impact of heterogeneities (at reservoir scale) on the storage of CO₂ and the potential redirection of the injected plume. This will be modelled in a single, unified simulation incorporating dual and single porosity and permeability.

Task 2.1.2 Uncertainty quantification and sensitivity analysis

Step 1: “Developments”

BRGM and CO₂GeoNet-HWU will lead on assessing the impact of uncertainty on modeling parameters. The first step will focus on addressing each deficiency in turn and on developing appropriate tools using synthetic but realistic cases. Combining response surfaces with global sensitivity analysis can be a powerful approach even for a high number of uncertain parameters (>20; Def.1). This can for instance be tackled within the formal setting of High Dimensional Model Representation (HDMR) (e.g., Petvipusit et al., 2014). This setting is generic enough to include different types of uncertainties. Regarding parametric uncertainty (like uncertainty in the value of permeability, porosity, etc.), continuous variables can classically be used. BGS will provide realistic ranges for key geological parameters (e.g. permeability, injectivity) where site data are not available using the state-of-the-art CO₂Stored database for input into the models being built by CO₂GeoNet-HWU and BRGM. The CO₂Stored database contains a wealth of data compiled for potential geological storage sites for the UK. Regarding modelling uncertainties (Def.2), discrete (categorical) variables can be defined to point to each plausible scenario (for instance each plausible model assumption like the choice for a physical law, mesh grid size, boundary conditions, etc.). This was recently tested by Manceau and Rohmer (2014) using ACOSSO-type meta-models. Treating spatial uncertainty (Def.3) can be envisaged in a similar manner in the HMDR setting using ACOSSO-type response surfaces as shown by Rohmer (2014): BRGM will propose an approach for treating simultaneously modelling and spatial uncertainties. This could be combined with advanced techniques like adaptive sparse grid methods (Elsheikh et al., 2014) to improve and optimise computation time cost, which will be set-up by CO₂GeoNet-HWU.

In parallel, CO₂GeoNet-HWU will develop an approach to make use of any sources of modelling information. Capacity estimates can typically rely on a large variety of models with different levels of details. A multi-model (i.e. hierarchy of

models) approach can then be proposed to combine information from static models, dynamic models with full physics and reduced order dynamic models (i.e. Vertical Equilibrium). Given this toolbox of different models (static, full physics and VE), an optimal combination of model runs (number and input parameters for each run) can be sought to efficiently estimate the capacity of a specific site. Finally, modelling errors (Def.4) can be addressed making use of any observed data using Gaussian process (kriging) meta-models in the Bayesian calibration framework proposed by Kennedy & O'Hagan (2001). Recently, Josset et al. (2015) built an error model using a mapping between a detailed physic model (multi-phase flow) and an approximate physic model (single phase flow model) for immiscible two phase flow problem. The purpose of that work was to accelerate model calibration using MCMC (i.e. history matching). The same approach will be used for uncertainty quantification and modelling error estimation.

Step 2: "Unified framework and application on real cases"

Based on step 1, a coherent framework will be defined by CO2GeoNet-HWU and BRGM supported by other partners incorporating the best of the developed approaches. This will be conducted via working sessions among partners based on cross-comparison and benchmarking using shared dataset of simulations. More specifically, the question of meta-model errors (the uncertainty related to use of meta-models instead of the "true" flow simulators) will be carefully tackled through validation on independent dataset of simulations (i.e. set of simulations not used for constructing the response surfaces). Once validated, the applicability and extrapolation of the proposed UQ framework will be tested with the geological characteristics from the different ENOS sites with the view which will enable consideration of a wide range of different geological settings.

The a priori selected sites for sub-tasks 2.1.1 and 2.1.2 are the same as those studied in task 2.2: Hontomin, Spain (fractured carbonate aquifer), and GeoEnergy Test Bed, UK (faulted Permo-Triassic sandstone aquifer). For this benchmark, base data from the sites could include geological facies, basic core data, geophysical well log data, seismic data, geological samples, water samples, published maps and papers. Use of existing models will be made where appropriate. For the Hontomin site, CIUDEN will develop a model using a free code and provide with dynamic simulations based on different input data sets defined by BRGM and its expertise on geology and properties of target formations. Final decisions on sites to be worked on will be taken at the beginning of the project after detailed assessment of the available data in the different cases (Milestone 2.1)

Outcomes

Modelling techniques for high resolution simulation of fractured reservoirs and an understanding of the effect of fractures on storage estimates

Methods and a modelling strategy (framework) for tackling the different uncertainty sources (parametric, modelling, spatial uncertainty, and model errors) for capacity estimates.

P10, P50, P90 estimates (similar to the widely used reserve estimation techniques in the O&G) of the expected capacities of at least two sites of ENOS project fields.

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Task 2.2 Smart Characterization (CO2GeoNet-HWU, BGS)

State of the art

Studies have been performed to address site characterization for geological CO₂ storage (CO₂CRC, 2008; DNV, 2009; NETL, 2010; SiteChar, 2013; Bachu, 2015; Heidug, 2013). This is a data, cost and time intensive process. The initial steps is to collect all available data followed by screening, and detailed modeling using both static and dynamic models. For a depleted hydrocarbon site, large amount of data is usually available to the field owner including well logs, seismic surveys and historical production data. On the contrary, deep saline storage sites characterization will involve active data collection by drilling wells or performing new seismic surveys. Site characterisation heavily relies on building a static model describing the structural and stratigraphic geology of the reservoir and the cap rock as well as populating this model with properties from available data. Decision on actual project development is based on assessing storage site uncertainties and reducing these uncertainties corresponds to active collection of new data.

Progress beyond the state of the art

This task will develop methodologies to optimise the data gathering and interpretation process to balance the acquisition costs with the insights this data provides. Statistical experimental design provides rules for resource allocation for information gathering. An experimental design approach for agile site characterization, where the process is continuously assessed and revised as the data being collected will be tested. For the highly nonlinear process of CO₂ injection, optimal designs generally depend on the true values of the model parameters and since the data has not been collected yet, the model parameter values are not known. Bayesian methodologies for optimal experimental design (Huan & Marzouk, 2013) provide an elegant solution to this problem where prior distributions of the unknown parameters are postulated during the formulation of the experimental design problem. Solving the Bayesian optimal design involved maximizing the expected utility function over the different options of data collection with respect to the future observed data and model parameters. Two approaches are proposed:

1. Nested Sampling algorithm (Skilling 2006, Elsheikh et al. 2014) for performing the high dimensional integration of the expected utility function for solving the optimal experimental design problem.
2. meta-modeling techniques (Elsheikh et al. 2014, Petvipusit et al. 2014, Rohmer, 2014) for efficient solution of the optimal experimental design problem.

Description of work

Step 1: "Methodology Developments"

CO₂GeoNet-HWU will investigate the application of Bayesian experimental design techniques on synthetic but realistic cases mimicking the Hontomin CO₂ storage site. Various algorithms for evaluating the high-dimensional integral of the expected utility function (i.e. Monte-Carlo, Nested Sampling and Important Sampling) will be evaluated. Additionally, meta-modeling techniques developed in Task 2.1.2 will be used to replace the full dynamic simulator with approximate proxy functions for rapid solution of the optimal experimental design problem. BGS will contribute to new frameworks for streamlined smart characterization. BGS will also provide feedback on sensitivity of geological parameters relevant to CO₂ storage based on the CO₂Stored database (where the most sensitive parameters affecting storage capacity were indicated to be permeability, pressure response and injectivity).

Step 2: "Application to real cases"

Based on the developed methodologies in Step 1, a framework for optimal data gathering will be developed. This task will be led by CO₂GeoNet-HWU. This framework will be systematically streamlined to evaluate the impacts of data variability and applied to two onshore CO₂ injection sites, anticipated to be the Hontomin site (carbonate aquifer) and the GeoEnergy test bed in the UK (sandstone shallow aquifer). The sites to be included will be confirmed at the beginning of the project after detailed assessment of the available data in the different cases (Milestone 2.1). The available data will be divided into base-case data which is needed to build a base case model for each site. Each additional data that is not included in the base-case data set will be plugged into the Bayesian experimental design to obtain the optimal data gathering schedule. BGS will provide at least one geological model (depending on work carried outside of ENOS) and data relating to the GeoEnergy Test Bed and will provide feedback on the geological models generated by CO₂GeoNet-HWU which have been built using the ENOS smart data gathering workflow to assess the optimal solution balancing the requirements of low cost and producing a reliable geological model.

Outcomes

Methods and a modelling strategy (framework) on how to prioritize data collection, summarized in a report detailing the general procedure for smart site characterization and accompanied by a set of computer script (i.e. wrappers) utilizing commercial simulation tool. The streamlining framework of data use and acquisition will contribute to cost efficient characterization.

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Task 2.3 Low Cost Drilling (CIUDEN, SOTACARBO, PLC-3)

State of the art

Drilling boreholes using O&G industry standard rigs is expensive, which reduces the number of wells drilled during exploration and therefore reduce the amount of data available for reservoir characterization. Drilling using light equipment technology (adapted from the mining industry) presents a distinct advantage in offering the ability to obtain fully cored wells that cost less than wells drilled with hydrocarbon rigs. This is of high interest for CO2 storage and site characterization. The technology however has only been tested at depths of up to 1500m at Hontomin Technology Development Plant. The original plan at Hontomin was to use conventional O&G drilling techniques but finally light drilling was selected and saved up to 60% of the original planned budget. The resulting well has a smaller diameter than O&G standards. The implications of this for CO2 storage site operation need to be studied and consideration of how drilling techniques can be optimized need to be investigated through discussion between the drill rig operators and geoscientists who will use the core for experimentations to characterise reservoir and seal.

Although there are experiences in the light drilling for other activities such as mining and shale gas exploration especially in the USA, experiences at CO2 storage are limited to the Hontomin case. Deeper reservoirs are usually reached using oil and gas machinery, with higher cost and low flexibility.

Progress beyond the state of the art

A study will be carried out on developing the drilling rig and its associated equipment in order to reach depths of up to 2,500 m and to integrate different services, namely drilling, well completion and well logging, leading to cost savings and reducing the contracts for well services for the execution of exploratory, injection or monitoring wells.

Description of work

CIUDEN will work with PLC-3 for acquiring the required data to design the rig machinery and all the associated engineering studies in order to provide a cost effective solution to support the development of drilling activities within the Palencia-3 characterization process, that will likely be deployed during the ENOS timeframe, using the solution provided by the project. It is therefore expected that the FEED (Front-End Engineering Design) study developed will be tested in 2017 as part of the committed tasks of the exploratory permit Palencia 3, using funds outside of ENOS. The results from this engineering design and test will be used for potential implementation at the Sulcis site, by SOTACARBO. Implication of the diameter of the drilled well for its use as future monitoring or injection well will be studied with input from BRGM.

Outcomes

Demonstration of cost effective solutions to execute key characterization activities such as the drilling of wells to have a precise description of the reservoir and caprock. The engineering works will be applied to Palencia-3 site to demonstrate its effectiveness. PLC-3 will use their own resources to execute this drilling at the site These light drilling activities will provide significant cost savings in the characterization phase of this demo site and other future sites onshore in Europe.

Task 2.4 Technical guidelines on storage capacities estimates and cost-effective site characterisation (BRGM, BGS, CIUDEN, PLC-3, CO2GeoNet-HWU, SOTACARBO, UNOTT)

This task aims at synthesizing all the results of WP2 into technical guidelines regarding:

- the impact of heterogeneities (faults and granulation seams) on storage capacities
- the quantification of reliability of dynamic capacities including the large variety of different uncertainty sources (geological, model, parametric, etc.
- smart characterization
- light-equipment and low-cost drilling

BRGM will lead the task. Partners contributing to the tasks 2.1 to 2.3 will provide the description of technical or numerical tools, methodologies or workflow developed during the WP, highlighting their novelty compared to the state of the art. These results will be assessed by Sotacarbo and PLC-3 considering their use and applicability in their own workflow at the Sulcis and Palencia 3 sites. These guidelines will be presented into a comprehensive approach so that they could be useful for industrials or investors and be applied for future storage sites.

Interaction with other WPS

Results from WP2 will feed WP7 for the development and dissemination of best practices. It is also closely linked to WP5 that will link the technical WPs 1 to 4 with the societal context.

Knowledge sharing between partners will be assured through integration of results and with external stakeholders through input to WP6, 7 and 8.

Participation per Partner

Partner number and short name	WP2 effort
1 - BRGM	15.00
3 - BGS	6.20
6 - CIUDEN	17.00
13 - PLC-3	0.00
IPF	1.50
ENAGAS	4.30
16 - SOTACARBO	3.00
19 - UNOTT	12.00
20 - CO2GeoNet	0.00
HWU	26.00
Total	85.00

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D2.1	Report on FEED study on light drilling	6 - CIUDEN	Demonstrator	Confidential, only for members of the consortium (including the Commission Services)	15
D2.2	Uncertainty Quantification of capacity estimates: coherent	1 - BRGM	Report	Public	22

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
	framework & applications				
D2.3	High resolution simulation to determine heterogeneity effects on storage estimates in fractured reservoirs	19 - UNOTT	Report	Public	25
D2.4	Smart Characterization	20 - CO2GeoNet	Report	Public	28
D2.5	Report on drilling activities for extension to other sites	6 - CIUDEN	Report	Confidential, only for members of the consortium (including the Commission Services)	38
D2.6	Technical Guidelines on storage capacities estimates and cost-effective site characterisation	1 - BRGM	Report	Public	42

Description of deliverables

Task 2.1

D 2.2 : Report on Uncertainty Quantification of capacity estimates: coherent framework & applications – M22 – BRGM, CO2GeoNet-HWU, BGS

D 2.3: Report on High resolution simulation to determine heterogeneity effects on storage estimates in fractured reservoirs – M25 – UNOTT

Task 2.2

D 2.4: Report on Smart Characterisation and computer scripts developed – M28 – CO2GeoNet-HWU, BGS

Task 2.3

D 2.1: Report on FEED study for light drilling – M15 – CIUDEN, PLC-3

D 2.5: Report on drilling activities for extension to other sites – M38 – CIUDEN, Sotacarbo, PLC-3, BRGM

Task 2.4

D 2.6: Technical Guidelines on storage capacities estimates and cost-effective site characterisation – M42 – BRGM, BGS, CIUDEN, PLC-3, SOTACARBO, UNOTT, CO2GEONET-HWU

D2.1 : Report on FEED study on light drilling [15]

Regarding CIUDEN experiences from well drilling works at Hontomín site, required data and engineering studies to design a light drilling rig will be performed, in order to provide a cost effective solution for the exploration phase of other sites involved in ENOS. Following tasks are related with D2.1: Tasks 2.3 and 2.4

D2.2 : Uncertainty Quantification of capacity estimates: coherent framework & applications [22]

Task 2.1 - Description of methods and a modelling strategy (framework) for uncertainty characterization (ranking of the different uncertainty sources (parametric, modelling, spatial uncertainty, and model errors) and quantification regarding capacity estimates. This will be supported by application on reservoir cases.

D2.3 : High resolution simulation to determine heterogeneity effects on storage estimates in fractured reservoirs [25]

Task 2.1 The impact of permeable faults and (impermeable) granulation seams on reliable CO₂ storage capacity estimates in faulted and complex reservoirs will be determined using INTERSECT high resolution reservoir tool.

D2.4 : Smart Characterization [28]

Task 2.2 Summary of efficient techniques for optimal data gathering for site characterisation with links to open source repository of computer scripts demonstrating the methodology

D2.5 : Report on drilling activities for extension to other sites [38]

Light drilling equipment design will be implemented under boundary conditions determined by the singularities from other sites . Particularly, geological and geomechanical characteristics from Palencia 3 and Sulcis sites involved in ENOS will be the reference for this design. Following tasks are related with D2.5: Tasks 2.3 and 2.4

D2.6 : Technical Guidelines on storage capacities estimates and cost-effective site characterisation [42]

Technical guidelines for integrating the results of ENOS with existing state of the art tools in the context of full scale storage (uses inputs from all tasks in WP2)

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS1	Decision on sites and modelled to be used in task 2.1 and 2.2	1 - BRGM	3	Minutes of data evaluation meeting
MS4	International collaboration input to Work programme planned	1 - BRGM	3	D6.1
MS13	Input from End-User Committee 1	10 - IRIS	11	Key outcomes from meeting
MS23	Input from End-User Committee 2	10 - IRIS	23	Key outcomes from meeting
MS25	Drill experiment based on ENOS FEED study performed by PLC-3 (external event)	6 - CIUDEN	24	Report from operator
MS32	Input from End-User Committee 3	10 - IRIS	35	Key outcomes from meeting
MS34	Advisory board input 2	1 - BRGM	36	report and note on impact on ENOS
MS35	End of all field activity	1 - BRGM	36	End of CO ₂ injection and ENOS data acquisition
MS36	Input from End-User Committee 4	10 - IRIS	47	Key outcomes from meeting

Work package number ⁹	WP3	Lead beneficiary ¹⁰	3 - BGS
Work package title	Managing leakage risks for protection of the environment and groundwater		
Start month	1	End month	48

Objectives

WP3 will focus on monitoring leakage risks for protection of the environment and groundwater, including identifying and quantifying any CO₂ emissions into the atmosphere, using practical experience from real-life sites. Injection tests will be performed at a range of sites, each offering unique geological characteristics adapted to address specific issues: Sulcis Fault Lab for injection near faults; GeoEnergy Test Bed (GTB) for groundwater impact and LBr-1 field site for risks relating to boreholes and faults. The resulting understanding of leakage and its potential impact will be used to enhance development of monitoring technologies.

Targeted monitoring technologies for leakage detection and quantification will be advanced at real-life sites progressing them from TRL 4-5 to TRL 6 or 7. The tools developed in WP3 will meet the monitoring requirements of the EU Directives and supporting documents and be applicable over the full storage lifecycle. Furthermore, the different tools will be integrated into a comprehensive monitoring solution with consideration of other state-of-the-art tools available outside of the project and in the context of full scale storage site operation.

WP3 will use innovative CO₂ injection tests, experiments carried out under realistic storage site conditions and advanced modeling techniques to develop technical guidelines and feed into WP7 Best Practices.

Description of work and role of partners

WP3 - Managing leakage risks for protection of the environment and groundwater [Months: 1-48]

BGS, BRGM, BGR, CGS, CIUDEN, IDIL, IRIS, NHAZCA, OGS, PLC-3, SILIXA, SOTACARBO, TNO, UNIROMA1, UNOTT, CO2GeoNet

Task 3.1 Groundwater protection: Geochemical and geophysical monitoring and potential impact of leakage on potable aquifers (BRGM, BGS, IDIL, IRIS, UNOTT, UNIROMA1, Silixa)

State of the art:

In the FP7 RISCS project, and other recent reviews, the potential geochemical risks to drinking water aquifers related to CO₂ leakage out of the storage complex were identified. Geochemical surveying at Hontomin demonstrates current commercially available tools for geochemical monitoring of groundwater quality in an extensive network of monitoring wells. Shallow groundwater monitoring in a few <100 m deep well near the injection site at Otway in Australia highlighted the importance of baseline measurements to remove seasonal and local effects. There remains scope for improvement through further technological development and validation for monitoring potable groundwater.

Progress beyond the state of the art:

The aim is to build on previous groundwater modelling and monitoring work on the impact of CO₂ on underground drinking water so as to demonstrate the efficacy and increase the TRL of these techniques and technologies. There are geochemical and geophysical based numerous tools for detecting the first arrival of CO₂, the TRL of tools suitable for use in potable water supply areas will be advanced in this task. The work in ENOS will advance beyond state of the art as the tests at the GTB and Sulcis Fault Lab will be carried out at greater depths than previous groundwater assessments. Effective monitoring deployment strategies to locate leakage will be developed, the most sensitive parameters highlighted, sensitivity of tools improved and low cost solutions capable of long term deployment developed.

3.1.1 Understanding potential leakage impacts and developing a groundwater monitoring strategy

The impact of CO₂ on groundwater will be tested at controlled leakage sites. Baseline data will be obtained and early warning signs for CO₂ intrusion will be detected through tests at two field sites; Sulcis Fault Lab and the GTB where CO₂ will be injected at 100-300m depth over the time-scale of months to 1-2 years. Basic mineralogical testing and groundwater baseline data will be obtained from Sulcis (by UNIROMA1) and the GTB (by BGS and UNOTT) to inform the modelling work and provided. In order to be able to develop a monitoring strategy, a good understanding of the impact of CO₂ arrival in the aquifer and of the fate of the CO₂ must be developed. A tool-box, based on water-gas-rock interaction on the potential reactivity of CO₂ within a potable aquifer, will be tested by BRGM on these sites. The effectiveness of this tool will be validated in the field. It will identify the geochemical changes to be expected and therefore steer the definition of the groundwater geochemical monitoring strategy by highlighting the most sensitive parameters to monitor and appropriate deployment of monitoring tools. The modelling will be verified (history matched) using the field site data.

3.1.2 Increasing the TRL of groundwater quality monitoring tools in boreholes

Innovative monitoring tools suitable for deployment in boreholes in potable aquifers will be tested during ENOS. These tools have been selected to fill gaps identified in the currently available suite of tools for CO₂ site monitoring. The effectiveness of the tools developed through ENOS will be compared to commercial probes at the Sulcis Fault Lab to assess the sensitivity, accuracy and reliability of each technique and technology, thereby increasing the TRL level of these novel technologies to at least TRL6:

- An optical fibre tool for dissolved CO₂ detection through changes in pH is developed by BGS. This tool requires field testing (and further laboratory based calibration) to move the tool from TRL 4 to TRL6. The aim is to develop a low cost, almost 'disposable' monitoring technique that can be deployed in many boreholes. This tool will be deployed at the GeoEnergy Test Bed and/or the Sulcis Fault Lab.
- An innovative optical fibre tool, transparent in the mid-infrared, detecting gaseous CO₂, has been developed by BRGM and IDIL. This tool will be calibrated in the laboratory then field tested and the results compared with the BGS optic fibre tool at the Sulcis Fault Lab and/or GeoEnergy Test Bed sites. This will move the tool from TRL 5-6 to TRL 7. The sensitivity, reproducibility and detection limits of the tool will be compared with the results of standard CO₂ detection sensors.
- Cost-effective tools developed by UNIROMA1 (that measure CO₂, CH₄, pH, P, T) will be deployed at the Sulcis Fault Lab site. The probe has been tested to a limited extent in groundwater wells, but will be demonstrated more extensively here. UNIROMA1 will improve the response time of the pCO₂ tool. In addition, other sensors will be added to the system, such as Eh and conductivity, to give a more complete and detailed assessment of water quality and breakthrough times of leakage related parameters. The tool will hereby be brought to TRL7.
- A hybrid cable with more sensitive acoustic detection thresholds than currently commercially available seismic sensors and with temperature change detection capability is being developed by Silixa and will be tested at the Sulcis Fault Lab for application to leakage detection and groundwater monitoring and will be compared with other commercially available tools (which will be installed at the site through the national programme). The seismic survey will provide a better characterization of the faults. Moreover Distributed Temperature Sensor measurements during the injection phase will contribute to the leak detection and characterization. TRL of this application will be brought to 7 through testing in wells in the freshwater zone.
- IRIS will further develop and test a biosensor technology based on DNA recognition to monitor changes in microbial communities in groundwater caused by CO₂ leakage. Key advantage of specific microbial changes is that it allows the leakage detection a posteriori, even after chemicals may no longer be detectable. The method may also detect low-level leaks at, or below, rates detectable by chemical methods developed in parallel, possibly enhancing sensitivity and greatly increasing overall detection reliability by combining methods with different detection principles. This biotechnology will be field tested at the GeoEnergy Test Bed and Sulcis Fault Lab sites to move this technology to TRL6.

Outcomes

- Tool-box to assess the geochemical reactivity of CO₂ leakage within groundwater and define key parameters to monitor for early leakage detection.
- Five Monitoring tools demonstrated at pilot scale with sensitivity and cost optimised so that they are ready for use at demonstration/flagship sites (at least TRL6). These tools will be included in the integrated monitoring solution to be prepared under Task 3.4

Task 3.2 Understanding risk of CO₂ migration through faults and boreholes for effective monitoring (UNIROMA1, IRIS, CGS, BRGM, OGS, SILIXA, BGS, NHAZCA, CO₂GeoNet-HWU, CO₂GeoNet-GeoEcoMar)

State of the art:

Faults and boreholes are the most likely major potential leakage pathways at storage sites. The possible expression and rates of leakage along these pathways during and post-injection need to be understood to feed into risk-led site characterisation (e.g. as described in the SiteChar project) and inform monitoring strategies throughout the site lifecycle. Few field data are available on CO₂ migration through faults in sedimentary basin regions or on borehole leakage other than from major blowout events. Studies of leakage at natural analogue sites were undertaken in the FP7 RISCs project and indicated that further study on the expression of leakage at the surface (vent or diffuse, continuous or sporadic) were required. Borehole leakage through cement and/or casing defects is mainly limited to model studies with virtually no direct field experience. Damaged cement can increase the risk of leakage.

It is known that injection of fluids in the subsurface can induce surface deformation, however few studies have addressed the correlation between gas leakage through faults and boreholes and the resulting surface displacement patterns. Satellite Interferometry is presently used to quantify and map surface ground deformation, nevertheless there are still limitations for its application to small scale storage fields with vegetative cover.

Progress beyond the state of the art:

The Sulcis Fault Lab, where CO₂ will be injected near a fault, offers a rare opportunity to advance understanding of technologies for monitoring CO₂ leakage through faults beyond the state of the art. The activities carried out through

ENOS will complement the Sulcis Fault Lab programme funded by the Sardinia Region and Ministry of Economic Development which includes high resolution seismic surveys, soil gas surveys, seismic monitoring, acquisition of core samples and fracture modeling of the seal. If faults are present at the GTB, this may also allow insights to be gained should they provide pathways for fluid migration. A key milestone for WP3 will be establishing early in the project if CO₂ is migrating through faults at the test injection sites to surface and if not, alternative sites to carry out field activities will be selected. This sub-task will generate valuable information for development of the most effective surface monitoring strategy for sites where faults are identified.

Task 3.2.1: Assessing what makes a fault likely to leak

The geochemical (including mineralogy) and physical properties increasing the risk of fault leakage will be assessed using the Sulcis Fault Lab site, GTB and knowledge from natural analogue(s) where leakage of CO₂ and other substances is occurring. These sites will be assessed by BGS and UNIROMA1 to understand what characteristics of these faults permit leakage and what characteristics prevent leakage of CO₂ and other fluids by taking a number of samples along the faults.

The geomechanical aspects of leakage from a fault need to be considered as highly dense CO₂ is being injected under pressure and will induce stresses, potentially re-opening fault planes and opening new fractures. Based on real-life data from the Sulcis Fault Lab and the fault stability analysis at LBr-1 from the REPP-CO₂ project in the Czech Republic, provided by CGS, IRIS will perform a transient analysis of the expected pressure changes if the faults were to leak. Transient analysis requires fewer data than full numerical simulation and can therefore be implemented at early site characterisation stage. The results of this analytical modelling will be useful as a benchmark for later numerical modelling (to be completed outside of the ENOS project).

Using data from Sulcis Fault Lab, UNIROMA1 will model the gas migration pathway through and along a fault using appropriate software to reconstruct the geometry of the fault and the potential stress pattern produced during injection. This will be compared with real-life data to establish the effectiveness of the modeling technique, taking advantage of the opportunity to utilise primary data at the Sulcis Fault Lab.

Both work will link with WP1, where appropriate, to consider the risk of induced seismicity (note that the stress regime will be different at the field sites utilised by WP3 compared to WP1 as the zone of investigation is shallower).

Upscaling of the fault zone will be undertaken in order to reduce complexity and save on computational cost and increases efficiency for subsequent risk analysis/uncertainty runs. CO₂GeoNet-HWU will consider how to apply analytical upscaling techniques for fault zones to be imbedded in CO₂ simulators to account for sub-grid features. These upscaling techniques will be calibrated using real data from the Sulcis Fault Lab and if appropriate the GTB and results from the other teams in the task.

Task 3.2.2: Monitoring CO₂ migration through fault planes in the sub-surface

At the Sulcis Fault Lab, OGS will undertake geophysical measurements using downhole tools and surface techniques, to examine if the migration of CO₂ along the fault and its proximity can be tracked. Seismic techniques will include borehole measurements using wireline and SILIXA DAS-VSPTM, cross well applications and seismic interferometry (in surface-borehole and cross-well geometry). These will be integrated and compared with other geophysical and well results, such as electric and electromagnetic logs and surveys to demonstrate the most effective integrated geophysical approaches for monitoring migration of CO₂ in the near sub-surface in and around faults. Sensitivity analyses will be performed for both the seismic and electric methods based on detailed investigation of the area including comparison against time lapse surface and well geochemical data to determine if the signal is absent or below the geophysical detection threshold. The time-lapse data will use accurate modelling and sensitivity analysis for CO₂ injection in the area of investigation, to obtain the best acquisition parameters, and support interpretation of the results. The numerical modelling will also make use of existing geological and geophysical data acquired with national funding. The results of Task 3.3.3 will be incorporated into the integrated monitoring solution to be prepared in Task 3.4.

An innovative technique, based on state of the art remote sensing techniques will be adopted by NHAZCA to monitor the surface deformation pattern on a range of time scales (from baseline through injection phase to a few months after the injection phase) and geometric scales (from local to regional scale). The collected data will be used to derive detailed information about CO₂ leakage at Sulcis Fault Lab on the basis of the induced surface ground deformation. The technique combines corner reflectors installed on a regular grid, a photogrammetric RPAS used to refine the interferometric analysis and continuous topographic monitoring of targets to validate data collected by both RPAS and Satellite InSAR.

Task 3.2.3: Characterising expression of leakage through faults at/near the surface to improve monitoring strategies

Leakage through faults will be characterized (discrete vents vs. diffuse leakage at the surface, continuous vs. intermittent). In particular, the expression of CO₂ leakage through faults at the surface will be assessed with general conclusions drawn for application at storage sites (BGS and UNIROMA1) Geochemical survey data at the Sulcis Fault Lab site (and possibly GTB) will be used. These data will be supplemented by investigation at natural analogue site

in San Vittorino, Italy where leakage has been occurring for an extended time. This sub-task will generate valuable information for development of the most effective surface monitoring strategy for sites where faults are identified.

Task 3.2.4: Assessing risks presented by boreholes

At the LBr-1 site, there are a number of abandoned wells which are now being recompleted to mitigate the risk of leakage of hydrocarbons and CO₂. Using the site as a case study, CGS and IRIS will assess potential pathways, extent and impacts of leakage through boreholes on shallow groundwater using innovative dynamic modelling of leakage scenarios – the aim will be full 3D coupled flow, geochemical modelling and detailed representation of well and annuli flow. This will build on the results of the FP7 RISCs and CO₂ CARE projects. CGS will provide static geological models (horizon topography) and field data from the site. IRIS will perform flow-path simulations and model a range of borehole conditions including detailed modelling on tubular and annuli conditions appropriate for the LBr-1 site to quantify (temporally and spatially) the potential leakage through abandoned wells. This modelling will assess the short-term risk presented by boreholes during the operational lifetime of the storage site.

Boreholes can represent a leakage risk if improperly completed or if the CO₂ affects the sealing ability of the borehole materials. A risk assessment of leakage from abandoned wells & recompletion procedures using LBr-1 as a case study will be performed to feed technical guidelines and the best practice recommendations of WP7. CGS and IRIS will perform a risk-based assessment of old abandoned wells on the site (led by IRIS) to identify the main risks and to generate a best-practice report with recommendations for safely assessing and mitigating the risks presented by old boreholes for future storage sites. State of the art data from the Getica site on the risk assessment of existing wells (carried out for a completed feasibility study) will be provided by CO₂GeoNet-GeoEcoMar who will thus support the assessment of leakage risk through boreholes at LBr-1. BGS will provide data from laboratory experiments carried out for previous projects on cement carbonation as an in-kind contribution

Outcomes

- Improved understanding of the risk posed by faults utilising unique new field data to understand what geochemical and geomechanical properties make faults more likely to leak and how this leakage will present at surface/in the shallow fault plane to improve the effectiveness of the monitoring programme. Technical guidelines for mitigating risk of leakage through based on data from real-life case studies.
- Data to feed into technical guidelines on mitigation of risks through intelligent site design and monitoring strategies based on risk assessment of boreholes and faults

Task 3.3: Development of surface monitoring tools towards quantification of CO₂ emissions from a leaking CO₂ storage site (BGR, BGS, UNIROMA1, UNOTT, OGS, CGS, TNO, CO₂GeoNet-HWU and CO₂GeoNet-GeoEcoMar)

State of the art:

One of the recognised challenges of surface monitoring is finding potentially small leaks (metres to tens of metres across) over the comparatively large storage footprint (100 km² +). The aim of wide-area coverage technologies is to survey a large area rapidly to locate possible leakage that would then be verified by detailed ground investigation. Techniques have been trialed at natural CO₂ leakage and storage sites. However, they all have drawbacks in terms of sensitivity, false positives and areal coverage. This has highlighted the need for additional development. Continuous monitoring generating point data has also been tested at a small number of sites but still has scope for technology development and more widespread deployment. Soil gas monitoring is a well-recognised technique that is often the first technique applied when leakage is suspected, however, experience at industrial CCS sites has shown there can be challenges in discriminating between background biogenic and injected CO₂. Earlier work at the CO₂FieldLab and for RISCs indicated diffuse leakage of injected CO₂ can occur when concentrations and fluxes are within baseline values but the extent and importance of this for overall emissions has yet to be established. There has been little progress in practical demonstration of quantification of CO₂ emissions from storage.

Progress beyond the state of the art:

Partners are developing a range of tools to address the above issues that will be advanced during ENOS. Wide-area coverage tools for leakage detection, continuous monitoring and emission quantification tools/techniques will be advanced. Technologies applicable to onshore storage will be taken to at least TRL6 during ENOS. These tools have been developed in previous projects and specific field demonstration is required to improve them. The importance of diffuse leakage (often below the detection threshold for standard tools) will be assessed to determine if this should be considered in all storage site monitoring plans.

Task 3.3.1: Wide-area coverage tools for leakage detection

The trade-offs between wide areal coverage, cost and the need for more sensitive sensors will be examined. All techniques will be benchmarked against established tools with more limited areal capability. These techniques will be used to demonstrate the effectiveness of monitoring for CO₂ leakage at various heights above the ground.

UNIROMA1 will improve the sensitivity and response time of the ground CO₂ mapper and integrate it with an autonomous robot to continuously map CO₂ concentrations over a specified area. This unit detects CO₂ close to the ground and will be tested both at natural CO₂ leakage sites and during CO₂ injection tests at the Sulcis Fault Lab.

The possibility of using an Unmanned Aerial Vehicle (UAV) as a mobile platform for leakage detection using direct absorption spectra and temperature difference techniques will be investigated using repeated surveys at one or more site. This low cost OGS drone can carry a selection of tools including CO₂ probe, a thermal camera and/or a HD video camera. The UAV can record CO₂ concentrations both along transects and vertical profiles (hovering mode) to map and study CO₂ dispersion rates in the air.

BGS will test a new more sensitive multispectral thermal sensor detector for its ability to detect leakage in the thermal region of the electromagnetic spectrum using pre-dawn flights at the GTB using a plane available to NERC.

Task 3.3.2: Advanced soil gas monitoring

Soil gas monitoring is one of the main techniques used for leakage detection. However, uncertainties in identifying leakage remain due to the high variation of natural background levels. Therefore a better understanding of these variations will improve the operator's ability to demonstrate that the soil gas measurements indicate no leakage without frequent recourse to additional analyses to prove this to be the case. These new soil gas tools will be compared against each other and commercially available tools and will be used to examine the efficacy of the wide-area coverage tools in T3.3.1.

The newly developed BGR monitoring devices for measuring CO₂ concentrations at the internal boundary layer (constant flux layer) will be enhanced. Preliminary tests during a controlled CO₂ release at the Ketzin Pilot Site have shown promising results. Further developments will move this approach from TRL 4 to 6. This new probe will examine the migration of CO₂ from the shallow sub-surface into the atmosphere immediately above the ground to evaluate CO₂ migration into the atmosphere at selected points at the GeoEnergy Test Bed. Water table changes occurring in the vadose zone affect soil gas readings and better understanding of this will increase confidence in soil gas results. Metre-scale test bed experiments and modelling studies by BGR will assess migration effectiveness of CO₂ and CH₄ gas (potentially resulting from bio reduction of CO₂) at the saturated/vadose zone interface. Comparative measurements of CO₂ in the vadose zone and in the groundwater simultaneously will validate the applied models and increase the TRL to 6.

The UNIROMA1 GasPro system, able to continuously measure CO₂ concentration, P and T in the unsaturated soil horizon has been tested in small numbers at several natural and experimental sites. UNIROMA1 will extend the capability of the system by further reducing production costs and by conducting a "mass" deployment of 50 probes at the Sulcis Fault Lab, bringing the technology to TRL7. It will show how multiple unit deployment improves the chances of detecting spatially localized leakage and the definition of variability in time and different controlling conditions (e.g., soil type, topography, water content, seasonal changes etc.) at a given site.

Diffuse leakage detection presents severe monitoring challenges for storage sites: detection threshold and differentiation from naturally produced CO₂ in the shallow environment. BGS will investigate if significant low concentration diffuse leakage of CO₂ occurs in injection tests and at natural analogue sites, well characterized in previous projects (e.g. S Vittorino), using the stable C isotopic signature of leaking CO₂ compared to shallow biogenic CO₂. This activity will move this monitoring technique for diffuse leakage forward to TRL6. The identification of the CO₂ source (shallow natural production vs. injected CO₂) in soil gas will benefit from a new combination of techniques that focuses on the processes of CO₂ formation. The formation temperature of CO₂ determines the abundance of rare CO₂ isotopologues (abundance of ¹³C and ¹⁸O bonds in CO₂). TNO will undertake measurements for a number of selected samples at San Vittorino where CO₂ is leaking from depth to test the method. Soil gas samples will further be analysed for CO₂, N, O, CH₄ and C₂-C₅ hydrocarbon concentrations and isotopes to evaluate the new method against previous approaches to define the source of CO₂ and to further evaluate the significance of diffuse low-level leakage.

Task 3.3.3: Emission quantification

A new open path laser CO₂ detection tool is under development in a separate project by Rutherford Appleton Laboratory, working with BGS and Shell, performing laboratory and prototype field testing. A reflector array is used to detect and quantify leakage in the atmosphere using tomographic reconstruction. The applicability to onshore storage will be tested at one of the field sites. This will advance the technique towards the market through field demonstration.

In addition, UNIROMA1 will establish an empirical relationship between the ground CO₂ mapper results from subtask 3.3.1 and direct soil gas flux measurements to extend the mapper's capability to emission quantification.

Outcomes

- Demonstration of techniques for effective surface monitoring which will fill identified gaps in current techniques including wide-area coverage tools for rapid location of potential leakage sites (e.g. UAV, autonomous ground mapper robot) and complementary advanced ground truthing techniques (e.g. soil gas).
- Improved detection threshold and origin discrimination for CO₂ in soil gas monitoring tools, and related increase in TRL.

- Tested CO2 leakage/emission quantification techniques

Task 3.4: Integrated monitoring solution for leakage detection and quantification (BGS, all WP partners)

Established tools are not sufficient to ensure efficient leakage monitoring of a storage site. Their different capabilities must be considered in light of the site risk assessment and this should be integrated into a monitoring strategy. The innovative tools advanced through ENOS need to be integrated into a comprehensive monitoring solution alongside current state of the art tools to provide technical guidelines on appropriate monitoring solutions for onshore site operators. The technical guidelines developed here will feed into best practice recommendations made by WP7.

BGS will lead this task with strong support by BGR, a partner in the MONACO project, which developed an integrative hierarchical assurance monitoring concept, and all ENOS WP3 partners. In particular, CIUDEN, UNIROMA1, Sotacarbo and PLC-3 will provide expertise based on their real-life experience at large storage and industrial sites. This will ensure that the technical guidelines from WP3 are practicable. The report will include an assessment of the upscaling of techniques to large scale demonstration, as undertaken by Sotacarbo with support from CIUDEN and other partners. PLC-3 with support from all partners will consider how technologies and techniques tested in WP3 could be integrated into a monitoring plan for the PLC-3 site. This will provide a real-life assessment of their potential benefits and will include a cost estimation of their deployment. The outcome will be a site monitoring plan improved with the technologies and monitoring tools developed through WP3. This task will also receive input from WP5 on societal requirements based on specific sites in ENOS and consider how these views fit into technical guidelines for storage site operation.

Outcomes

Technical Guidelines for an integrated onshore monitoring solution, including ENOS and other cutting edge tools to detect and quantify CO2 leakage.

Interaction with other WPs

Data from tools in T3.2.1 and 3.3.2 and from integration in T3.4 will be shared with WP1 as required, in particular the recommendations will also be fed into the Task 1.4 on integration of deep monitoring data. Through WP7, the leakage monitoring technical guidelines will be assessed to ensure it is fit for a wide range of technical stakeholders with particular focus on (potential) site operators and technical guidelines from WP3 will feed into best practice documents. Knowledge sharing between partners will be assured through integration of results and with external stakeholders through input to WP6, 7 and 8. In particular, activities in WP3 will be the basis for international cooperation in the leakage simulation alliance in WP6. Societal requirements highlighted by WP5 will feed into WP3 where practicable. Information will be provided to WP5 for presentation to the local population near pilot injection sites in Spain, the Czech republic and Italy.

Participation per Partner

Partner number and short name	WP3 effort
1 - BRGM	12.00
2 - BGR	32.00
3 - BGS	30.60
4 - CGS	8.50
6 - CIUDEN	1.00
9 - IDIL	4.00
10 - IRIS	8.00
11 - NHAZCA	6.00
12 - OGS	40.00
13 - PLC-3	0.00
IPF	2.00
ENAGAS	2.30

Partner number and short name	WP3 effort
15 - SILIXA	3.00
16 - SOTACARBO	5.00
17 - TNO	5.00
18 - UNIROMA1	57.00
19 - UNOTT	4.50
20 - CO2GeoNet	0.00
HWU	16.00
GEOECOMAR	2.50
Total	239.40

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D3.1	Report on leakage through faults (T3.2.1 & 3.2.2)	18 - UNIROMA1	Report	Public	23
D3.2	Assessment of leakage risk presented by old boreholes at onshore site (case study report) (T3.2.4)	20 - CO2GeoNet	Report	Public	26
D3.3	BGS optic fibre tool (T3.1.1)	3 - BGS	Demonstrator	Confidential, only for members of the consortium (including the Commission Services)	32
D3.4	BRGM-IDIL optic fibre tool (T3.1.1)	1 - BRGM	Demonstrator	Confidential, only for members of the consortium (including the Commission Services)	32
D3.5	UNIROMA1 probes (T3.1.1)	18 - UNIROMA1	Demonstrator	Confidential, only for members of the consortium (including the Commission Services)	32
D3.6	Silixa hybrid cable (T3.1.1)	15 - SILIXA	Demonstrator	Confidential, only for members of the consortium (including the	32

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
				Commission Services)	
D3.7	IRIS biosensors (T3.1.1)	10 - IRIS	Report	Confidential, only for members of the consortium (including the Commission Services)	32
D3.8	OGS UAV drone (T3.3.1)	12 - OGS	Demonstrator	Confidential, only for members of the consortium (including the Commission Services)	33
D3.9	Report on field tests and modelling of impact of CO2 leakage on freshwater aquifers (T3.1.1)	1 - BRGM	Report	Public	33
D3.10	Report on Improvement in advanced soil gas monitoring techniques and assessment of CO2 source (T3.3.2)	2 - BGR	Report	Public	37
D3.11	UNIROMA1 GasPro system (3.3.2)	18 - UNIROMA1	Demonstrator	Confidential, only for members of the consortium (including the Commission Services)	33
D3.12	UNIROMA1 ground mapper robot (T3.3.1)	18 - UNIROMA1	Demonstrator	Confidential, only for members of the consortium (including the Commission Services)	33
D3.13	Report on leakage detection and quantification tools (T3.3.3)	3 - BGS	Report	Confidential, only for members of the consortium (including the Commission Services)	37
D3.14	Report on the development of wide-area surface coverage tools	18 - UNIROMA1	Report	Public	37

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
	and their efficacy) (T3.3.1)				
D3.15	Report on monitoring techniques which can detect CO2 migrating through fault planes (T3.2.2)	12 - OGS	Report	Public	35
D3.16	Technical guidelines for CO2 leakage detection and quantification: integration of monitoring tools developed through ENOS with existing state of the art tools in the context of full scale storage site operation (T3.4)	3 - BGS	Report	Public	40

Description of deliverables

Task 3.1

D3.9 Report on field tests and modelling of impact of CO2 leakage on freshwater aquifers (T3.1.1), M 33, BRGM (BGS, UNIROMA1, UNOTT, Silixa, IRIS) [including tools applicable to potable groundwater sites tested]

D3.3 BGS optic fibre tool (T3.1.1) M32

D3.4 BRGM-IDIL optic fibre tool (T3.1.1) M32

D3.5 UNIROMA1 probe (T3.1.1) M32

D3.6 Silixa hybrid cable (T3.1.1) M32

D3.7 IRIS biosensors (T3.1.1) M32

Task 3.2

D3.1 Report on leakage through faults and tools tested in T3.2, M23, UNIROMA1 (BGS, CGS, IRIS, NHAZCA)

D3.15 Report on monitoring techniques which can detect CO2 migrating along fault planes, (T3.2.2) M 37, OGS

D3.2 Assessment of leakage risk presented by old boreholes at onshore site (case study report), (T3.2.4) M26, CO2GeoNet-HWU (CGS, BRGM, CO2GeoNet-GeoEcoMar)

Task 3.3

D3.14 Report on the development of wide-area surface coverage tools and their efficacy, M35, UNIROMA1 (OGS, BGS)

D3.12 UNIROMA1 ground mapper robot (T3.3.1) M33 [including tools tested in T3.3.1]

D3.8 OGS UAV drone (T3.3.1) M33

D3.10 Report on Improvement in advanced soil gas monitoring techniques and assessment of CO2 source, M37, BGR (UNIROMA1, TNO, BGS) [including tools tested in T3.3.2]

D3.11 UNIROMA1 GasPro system (3.3.2) M33

D3.13 Report on leakage detection and quantification tools, (T3.3.3) M35, BGS (UNIROMA1)

Task 3.4

D3.16 Technical guidelines for CO2 leakage detection and quantification: integration of monitoring tools developed through ENOS with existing state of the art tools in the context of full scale storage site operation, M40 BGS (all WP partners)

D3.1 : Report on leakage through faults (T3.2.1 & 3.2.2) [23]

Task 3.2 This report will describe the results obtained by the numerical modelling of leakage mechanisms and pressures through a fault. It will Summarise of what makes a fault likely to leak and what form the leakage is likely to take based on ENOS field studies and outcomes of testing tools for effective monitoring around faults It will include data from Uniroma1 and Iris work.

D3.2 : Assessment of leakage risk presented by old boreholes at onshore site (case study report) (T3.2.4) [26]

Task 3.2.4 Summary of what risks old boreholes present for unwanted CO2 migration/leakage through integration of modelling and field data for two sites

D3.3 : BGS optic fibre tool (T3.1.1) [32]

Task 3.1 - A cost effective downhole optical fibre tool for detecting dissolved CO2 by testing for changes in pH tested in the field

D3.4 : BRGM-IDIL optic fibre tool (T3.1.1) [32]

Task 3.1 - Calibrated optic fibre tool for detecting gaseous CO2 demonstrated in the field

D3.5 : UNIROMA1 probes (T3.1.1) [32]

Task 3.1 - validated UNIROMA1 pCO2 probe, describing the results of the experiments and the deployments that moved the technology from TRL5 to TRL7.

D3.6 : Silixa hybrid cable (T3.1.1) [32]

Task 3.1 - Field demonstration of hybrid cable with more sensitive acoustic detection thresholds than currently commercially available with temperature change detection capability

D3.7 : IRIS biosensors (T3.1.1) [32]

Task 3.1 - report on potential bacterial strains that could be used as markers to detect and identify CO2 leakage into groundwater. Special focus should be on detecting low level concentrations.

D3.8 : OGS UAV drone (T3.3.1) [33]

Task 3.3.1 Tested UAV drone to monitor CO2 leakages. Innovative instruments and methodologies will be described.

D3.9 : Report on field tests and modelling of impact of CO2 leakage on freshwater aquifers (T3.1.1) [33]

Task 3.1.1 Summary of findings on the impact of CO2 on potable groundwater and the tools tested in the field (uses outputs from T3.1.1, 3.1.2)

D3.10 : Report on Improvement in advanced soil gas monitoring techniques and assessment of CO2 source (T3.3.2) [37]

Task 3.3 - Different techniques for effective surface monitoring will be tested against each other and gaps in current techniques will be identified. Included are results of wide-area coverage tools for location of potential leakage sites (e.g. UAV, autonomous ground mapper robot) and complementary advanced ground truthing techniques (e.g. soil gas) and techniques for origin discrimination for CO2.

D3.11 : UNIROMA1 GasPro system (3.3.2) [33]

Task 3.3 - Technical development and testing of the UNIROMA1 GasPro system, describing the integration of additional sensors (like conductivity) into the existing prototype and the results of experiments.

D3.12 : UNIROMA1 ground mapper robot (T3.3.1) [33]

Task 3.3 - Technical development and testing of the ground mapper robot, results of experiments and possible deployments.

D3.13 : Report on leakage detection and quantification tools (T3.3.3) [37]

Report on Field tests of new tool for CO2 leakage quantification in the air above a leakage zone

D3.14 : Report on the development of wide-area surface coverage tools and their efficacy) (T3.3.1) [37]

Task 3.3 - This report will detail the technical solution adopted, the deployments and the results obtained during the monitoring activities and experiments performed at the Sulcis fault Lab.

D3.15 : Report on monitoring techniques which can detect CO2 migrating through fault planes (T3.2.2) [35]

This deliverable is related to task T 3.2.2. and reports the monitoring of CO2 Migration through fault plane in the sub-surface at the Sulcis Fault Lab by geophysical measurements using downhole tools, surface and also satellite techniques. The results will be incorporated in the integrated monitoring solution of Task 3.4.

D3.16 : Technical guidelines for CO2 leakage detection and quantification: integration of monitoring tools developed through ENOS with existing state of the art tools in the context of full scale storage site operation (T3.4) [40]

Technical guidelines for integrating the tools advanced through ENOS with existing state of the art tools in the context of full scale storage (uses inputs from all tasks in WP3)

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS4	International collaboration input to Work programme planned	1 - BRGM	3	D6.1
MS13	Input from End-User Committee 1	10 - IRIS	11	Key outcomes from meeting
MS17	Start of field activities in GeoEnergy test bed	3 - BGS	17	Staff at field
MS23	Input from End-User Committee 2	10 - IRIS	23	Key outcomes from meeting
MS30	End of field activities in GeoEnergy test bed	3 - BGS	31	no more staff at field
MS31	End of field activities in Sulcis Fault lab	16 - SOTACARBO	31	no more staff at field
MS32	Input from End-User Committee 3	10 - IRIS	35	Key outcomes from meeting
MS34	Advisory board input 2	1 - BRGM	36	report and note on impact on ENOS
MS35	End of all field activity	1 - BRGM	36	End of CO2 injection and ENOS data acquisition
MS36	Input from End-User Committee 4	10 - IRIS	47	Key outcomes from meeting

Work package number ⁹	WP4	Lead beneficiary ¹⁰	17 - TNO
Work package title	Integration of CO2 storage with local economic activities		
Start month	1	End month	48

Objectives

CO2 storage, especially onshore is facing resistance as its added value is not easily recognized by the general public and local communities. At the same time early movers find great difficulties in financing their CCS projects. Integration of CO2 storage combined with other (economic) activities, will increase societal and political acceptance and improve the business case for CCS projects.

The objective of WP4 is to evaluate and develop demonstration of CO2 storage integrated in other economic activities, e.g. enhanced hydrocarbon production, CO2 buffering for different types of utilization and CO2 buffering as part of a CO2 (shipping) terminal, prior to transport and large-scale storage. Work will be done at 2 sites:

- LBr-1: an oil field in the Czech Republic to demonstrate integration of safe and permanent CO2 storage in combination with Enhanced Hydrocarbon Recovery (EHR);

- Q16-Maas: a gas-condensate field in The Netherlands to demonstrate safe and permanent CO2 storage in combination with CO2 buffering and delivery for different types of utilization. Furthermore the Q16-Maas field can be integrated as a buffer location for a CO2 shipping terminal in the Port of Rotterdam. The data from a different gasfield offshore the Netherlands, K12 B, will be used as an analogue to provide information on the composition of the back produced CO2.

The evaluation and development will focus on technical, economic and regulatory aspects. Developing these projects will contribute to the higher goal of accelerating the development and deployment of CCS in Europe and will improve the competitiveness and growth of companies in the energy and food sectors and will positively impact employment and decrease the carbon footprint (see also WP6).

Description of work and role of partners

WP4 - Integration of CO2 storage with local economic activities [Months: 1-48]

TNO, CGS, GGR, IRIS, SGIDS, CO2GeoNet

Task 4.1 CO2 buffering and re-production for greenhouse horticulture (TNO, GGR)

State of the art

A wealth of experience is already available on the storage and production of natural CO2, natural gas and other hydrocarbons, as well as on CO2 storage. In contrast, studies on integrated gas production and seasonal and permanent CO2 storage activities are rare. In general just 25% of CO2 used for EHR is permanently stored (North America). Main reason for this is that the CO2 EOR project is not designed for permanent storage. The Q16-Maas field will be designed in order to store > 80% of the CO2 injected. This means a closed loop system needs to be designed and monitored. Furthermore the short- and long-term geochemical impact of CO2 injection and storage has been assessed for depleted natural gas fields in different geological contexts (Chiquet et al., 2013; Girard et al., 2013; Snippe et al., 2012). However, most projects were focusing on CO2 storage procedures and prediction of fluid flow (Tambach et al., 2015) or on chemical effects (Waldmann et al., 2014), rather than on modeling the approach for a combined project on CO2 buffering and permanent storage. Different forms of CO2 utilization (CCU) are developing rapidly and can accelerate the development of CCS by adding value to the business case of individual projects. In practice there can be a mismatch between demand and supply. Temporal oversupply or shortage can be compensated for by buffer storage. From a legal perspective CO2 storage or buffering can be permitted, however it is not yet possible to gain EU-ETS credits for the CO2 stored for a combined operation.

References:

Chiquet P, Thibau S, Lescanne M, Prinnet C.(2013) Geochemical Assessment of the Injection of CO2 into Rousse Depleted Gas Reservoir Part II: Geochemical Impact of the CO2 Injection. Energy Procedia, 37, 6383-6394.

Girard, J. P., Chiquet, P., Thibau, S., Lescanne, M., & Prinnet, C. (2013). Geochemical Assessment of the Injection of CO2 into Rousse Depleted Gas Reservoir. Part I: Initial Mineralogical and Geochemical Conditions in the Mano Reservoir. Energy Procedia, 37, 6395-6401.

Snippe, J., Wei, L., Lovelock, C., et al. (2012). Reactive Transport Modeling for CO2 Storage in a Depleted North Sea Gas Field. In: Third EAGE CO2 Geological Storage Workshop.

Tambach, T. J., Koenen, M., Wasch, L. J., & van Bergen, F. (2015). Geochemical evaluation of CO2 injection and containment in a depleted gas field. International Journal of Greenhouse Gas Control, 32, 61-80.

Waldmann, S., Busch, A., van Ojik, K., Gaupp, R. (2014). Importance of mineral surface areas in Rotliegend sandstones for modeling CO₂-water-rock interactions. *Chemical Geology*, 378-379, 89-109.

Progress beyond the state of the art

The ENOS project will advance the understanding of integrating CO₂ seasonal storage with back-production and permanent storage of CO₂. The mass balance of the whole system will be a key issue: what and how much CO₂ comes in, goes out, or stays in the system and how can the CO₂ be monitored in order to meet legal requirements and gain ETS credits for the CO₂ stored. The regulatory requirements on CO₂ for these integrated activities will be investigated. This task will demonstrate if CO₂ from industrial sources can be buffered and reproduced in sufficient quantities, with the proper gas composition specifications for different uses including the greenhouse horticulture. Understanding of the gas purity is crucial for different forms of use. The composition of the produced gas and requirements for gas treatment before it can be delivered to customers like the greenhouses will be investigated in detail. A novel approach in developing the integration of spatial irreducible formation water and minerals in geochemical models will be developed.

The overall technical feasibility of combined CO₂ buffering and permanent storage in the Q16-Maas gas field, will be evaluated: Quantification of mass balance, quality of the required and delivered end-products and embedding in regulation. Furthermore an adequate monitoring system, meeting the regulatory requirements will be designed.

Task 4.1.1 Modelling of CO₂ quality during temporary buffering and permanent storage in Q16-Maas (TNO)

In terms of CO₂ injection and storage, geochemical fluid-rock interactions are important site-specific issues playing a role in the short- and long term during the buffer and storage phases. These processes will be assessed with geochemical modeling tools to identify the most significant chemical reactions. For these purposes, kinetic mineral dissolution and precipitation reactions will be taken into account, using data from a real-life gas field Q16-Maas. The relatively low water saturation, compared to aquifers, of the porous medium has a major influence on the accurate prediction of fluid-rock interactions. The spatial distribution of and local equilibria between water and mineral(s) will be evaluated, included in geochemical models and compared to an average whole rock compositions generally used for such models. Whole rock mineralogy and chemistry as well as the type and chemical composition of the clay fraction will be analyzed (e.g. X ray diffraction, X ray fluorescence, and electron microprobe analysis) to define input parameters. The spatial distribution of minerals will be assessed on thin-section scale (e.g. Qemscan). Additional data and parameters, like reservoir temperature, as well as gas and water composition, will be provided by the Q16-Maas site operator.

An integrated geological model will be built based upon existing models. The injection/production stream composition will be evaluated using a 3-D coupled compositional multiphase flow - geochemistry model of the storage. The key geochemical interactions and parameters will be identified by geochemical models and used in the 3-D storage model to compute the evolution of CO₂ inventory throughout the commercial life of the gas field and beyond for permanent storage.

Task 4.1.2 Integrating and optimizing suitable separation methods to meet requirements for end users (TNO)

Different forms of CO₂ utilization are under development in the larger Rotterdam area. In order to meet the requirements or CO₂ specifications for the different forms of use, the CO₂ must be purified, using technologies designed to capture CO₂ from flue gasses (CO₂ concentrations typically from 5 – 15%). The CO₂ concentrations of the re-produced gas / CO₂ are much higher (40% K12B, > 90% in Q16-Maas). The cost of CO₂ separation can be an economical showstopper to developing a buffer project. Therefore existing separation technologies need to be optimized in order to meet the requirements in a cost effective way. This task will focus on a review of existing separation technologies and how these can be optimized for this purpose. The results of task 4.1.1. will be used. Depending on the gas composition produced from the Q16-Maas field, it may or may not be viable to extract methane for sale. Different technology options can be deployed to obtain sales gas. Significant amounts of condensates and/or heavies can represent an important revenue stream. Recommendation will be made on how these components can be extracted and/or whether an existing gas separating unit can be used directly or after modifications.

Furthermore, significant amounts of components such as propane and butane may occur. Alternatively, the gas stream may contain impurities such as benzene, toluene, and xylene (BTX) that need to be removed from the stream. Recommendation will be made on how the gas should be treated to obtain or remove these components.

Task 4.1.3 Removing regulatory barriers

The injection of anthropogenic CO₂ into the Dutch subsurface either for enhanced hydrocarbon recovery, buffering (temporary storage), or permanent storage, has yet to take place. The current legal framework for CO₂ storage in the EU, specifically the EU Directive on the geological storage of CO₂, and the amendments allowing CO₂ storage as a permitted mitigation activity under the EU ETS, does not prohibit the combination of CO₂ storage with enhanced hydrocarbon recovery and/or buffering of CO₂. Despite this, certain Member States, for instance the Netherlands, have enacted legislation that prevents operators holding a license for both permanent CO₂ storage and CO₂ EHR or buffering. In addition, the permitting process for regulating a CO₂ storage site, where a small percentage of the storage volume

may act as a CO₂ buffer, has yet to be approached by any European Member State. In the current regulatory system it is not possible to gain credits for CO₂ storage during hydrocarbon production and/or buffering.

This task will primarily be focused on the Dutch legislative and regulatory framework, however brief comparative assessments of the regulation of combined CO₂/EHR activities in the Member States of the United Kingdom and Denmark will be completed. The deliverables of Task 4.1.3 will be completed through specific legal/regulations research in combination with interviews with regulators and industry stakeholders.

The purpose of Task 4.1.3 is to describe the legality of combining the activities of CO₂ buffering, permanent CO₂ storage, and enhanced hydrocarbon recovery. A legal assessment, including permitting steps, will be conducted for three different scenarios:

1. CO₂ injection, buffering and permanent storage
2. CO₂ injection for the purposes of EHR
3. CO₂ buffering with simultaneous EHR

Task 4.1.4 Monitoring

An accurate knowledge of the volume of CO₂ in the reservoir and of the total volumes injected and produced is a first priority in regulations that would accept combined buffering and storage activities. This activity prepares for such future regulations by designing a monitoring system for accounting purposes in a scenario in which part of the CO₂ is to remain permanently in storage. The approach in this activity will be to combine existing techniques to design a system that produces the necessary information. While the focus will be on designing a system for the Q16-Maas field, more generally applicable guidelines will be defined on the design of a monitoring system for combined projects. A key part of this evaluation will be an investigation of the role monitoring and associated requirements on monitoring as part of the regulatory framework. In particular, considerations with regard to monitoring and measurement for accounting purposes will be taken into account in a scenario in which part of the CO₂ is to remain permanently in storage.

Outcomes

- Technical feasibility of combined CO₂ buffering and permanent storage activity.
- Quantification of mass balance and quality of the delivered end-products (back-produced CO₂), including a description of additional separation methods.
- Potential solution for adapting current regulatory regime to accept the combination of buffering and enhanced production activities.
- Detailed description of an adequate monitoring system that suits the regulatory requirements.

Task 4.2 CO₂ storage and oil production (IRIS, CGS, CO₂GeoNet-METU-PAL& TNO)

State of the art

CO₂ EOR has been applied extensively for over 3 decades, predominately in the USA and Canada but also in Hungary, Croatia and Turkey. Most of the CO₂ used in these operations is from natural sources: it is produced from CO₂ reservoir and transported to the oil fields, where it is sold to operators. As the CO₂ is rather an expensive commodity, the amount used for the EOR process is minimized, while the oil production is maximized. This is done by alternating CO₂ injection with as much water as possible (Water Alternating Gas process). Furthermore, a final water flood is often conducted at the end of the oil production to sweep and reproduce as much CO₂ as possible for reuse in adjacent oil fields. The US CO₂ EOR situation is described in a number of papers, e.g. Mungan (1981) and ARI Inc. (2005). The Weyburn field in Canada is a prime example of CO₂ EOR.

References:

Mungan N. (1981) CO₂ flooding - fundamentals-The journal of Canadian Petroleum Technology 81-01-03:87-92.
ARI Inc. (2005) Basin oriented strategies for CO₂ Enhanced oil recovery: California. DOE report.

Progress beyond the state of the art

For the European CCUS (Carbon Capture Utilisation and Storage) projects, the ambition is two-fold: maximizing total oil production and making optimal use of the gradually depleting reservoir for storing CO₂. In terms of volumes of CO₂ injected such projects have opposite objectives to American analogues. Together with boosting oil production, opportunities for reduction of CO₂ back production and increase in volumes of CO₂ injected towards the end of field lifetime will be screened. Physical forces controlling both EOR, (e.g. miscibility with oil), and storage (e.g. solubility in water or mineralogical reactions) will be screened, evaluated and accounted for. The simulation work will be based on both available data (static geological model, samples crude oil, cores etc.) and the lab tests results obtained in this project (miscibility, impact of CO₂ on crude etc.). The optimization will be based not only on the volumes of CO₂ stored and oil produced, but also on economical screening of different scenarios. An economic assessment tool will optimize the objective function with costs/benefits values of the injected fluids (CO₂ and water) and the produced crude oil. This means that these assigned costs will have an impact on the way the injection process is designed. Recent studies have shown that this combined approach is capable of increasing the net use of CO₂ by 25 and 40% for immiscible

and miscible CO₂, respectively, without compromising crude oil production. These optimized simulations will result in recommendations for a future pilot test in the oil field or a similar field nearby. The Czech LBr-1 site, will be used as an example for developing technical-economical evaluations of the CCUS concept in Task 4.3. LBr-1 is close to the Czech-Slovakian border and future injection of CO₂ may lead to trans-boundary issues. Those will be tackled with support of the Slovak partner SGIDS, and possible regulatory solutions will be proposed.

A CCUS solution (combining CO₂-EOR with CCS) is one of the best ways to mitigate reservoir pressure and, at the same time, recover hydrocarbons in order to generate revenue to cover some of the storage expenses. CCUS projects, however, have their own peculiarities and challenges, that would be addressed in this task. Task leader will be IRIS, with CGS, TNO, CO₂GeoNet-METU-PAL and SGIDS contribution. International collaboration on novel EOR concepts will be developed with the Kansas Geological Survey, through WP6 twinning with LBr-1.

Task 4.2.1 Design of novel EOR-concept

The CCUS concept has key differences from both pure utilization and pure storage projects that require significant design and planning changes. The aim is to increase oil recovery and at the same time increase volume of CO₂ stored during the process and after field-end-of-life. Both subsurface reservoir conditions and required infrastructure for increasing oil production and CO₂ injection during the different phases of the project lifetime will be taken into account. Different options for the design of wells will be considered: cheap and flexible ones that could easily be converted from hydrocarbon production to CO₂ injectors and monitoring wells in the CO₂ storage phase. The development of novel concepts for EOR will start from a thorough review of the literature in the US, Canada and Europe.

Task 4.2.2 Reservoir modelling of designed concepts

Based on the available geological architecture and properties, and a history matched dynamic model of the LBr-1 field a number of production and storage scenarios will be screened. Reservoir simulation coupled with screening of risk, uncertainties and costs would provide a reasonable evaluation of several design concepts. An assessment of the volatility in demand and supply of CO₂ will be performed. The simulation work will be backed up with lab test work (slim tube and contact tests) on the basis of analogue reservoir core material.

Task 4.2.3 Study on trans-boundary storage site issues and regulation

The national transpositions of the EU CCS Directive doesn't fully tackle trans-boundary issues, which creates hurdles for utilization of promising storage sites situated on or near Member States boundaries. LBr-1, situated close to the Czech-Slovak border, will be studied from the trans-boundary point of view, including items such as national legislations, definition of the storage complex, assessment of CO₂ storage pressure footprint, risk management and proposals for possible regulatory solutions. CGS, SGIDS and IRIS will perform a practical study based on the LBr-1 site case. Regulatory solutions of the trans-boundary storage issues will be provided and recommendations for EU regulation will be defined.

Task 4.2.4 Design of CO₂-EOR pilot

Based on the proposed designs and simulations carried out a detailed plan for the field-scale CCUS pilot at LBr-1 field will be prepared. The plan will include subsurface configuration, injection/production schedule and a required infrastructure. The design will be fitted to local condition and a draft of local community involvement will be prepared, taking into account WP5 outcomes.

Outcomes

A developed approach combining EOR and storage aspects based on both technical economical and regulatory factors for the LBr-1 field. While the end-result would be field specific, the developed approach will lay a basis for the roadmap to be developed in Task 6.5 and for a guidance document (best practice) in Task 7.3.

Task 4.3 Building the socio-economic case (CO₂GeoNet-GSB-RBINS, IRIS, TNO)

State of the art

The economic evaluation of projects in which CO₂ geological storage forms an important element, is currently based on relatively straightforward, often even generic schemes. In a generic scheme, such a system can be pictured as a single chain, with generally CO₂ being passed on from source to geological reservoir. Economic evaluations calculate costs and benefits of capturing, transporting and storing based on realistic average values for the different techniques (e.g. van den Broek, 2010). Such an approach ignores essential uncertainties regarding geological context, problems of project flexibility due to high upfront investment costs, or uncertain socio-economic outlooks including forecasted CO₂-ETS costs and economic boundary conditions. An example of such difference between theory and practice are the economic evaluations of CO₂-EOR in the North-Sea Basin (e.g. Klock et al., 2010). These unanimously indicate an important increase in return compared to primary oil production, but in reality such projects appear much less evident to realize (none have been realized yet).

With the exception of the work in the recent years of the CO₂GeoNet-GSB-RBINS (Piessens et al., 2012; Welkenhuysen et al., 2013), this is the end-point for CCS related assessments. Analogue problems arise wherever geological data is

an important factor in calculating the value of a project, e.g. in determining the price of licenses for natural resources (hydrocarbons, ores, e.g. Moel & Tufano, 2000), or when comparing the costs of remediation technologies (Compernelle et al., 2014). The central methodology proposed for such situations is Real Option Analysis (ROA; Dixit & Pindyck, 1994), able to meaningfully deal with very large uncertainties, including those of geological nature. Although the first public studies proposing ROA as the proper methodology date back to 1985 (Brennan & Schwartz, 1985), it is not commonly applied (e.g. also not for assessing CCS projects). Reasons seem to be mainly practical: combination in one team of geological, economic and mathematical expertise, the potential complexity of ROA decision criteria, and potential long calculation times of stochastic results.

References:

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- Piessens K, Welkenhuysen K, Laenen B, Ferket H, Nijs W, Duerinck J, Cochez E, Mathieu Ph, Valentiny D, Baele J-M, Dupont N & Hendriks Ch, 2012. Policy Support System for Carbon Capture and Storage and Collaboration between Belgium-the Netherlands “PSS-CCS”, Final report. Belgian Science Policy Office, Research Programme Science for a Sustainable Development contracts SD/CP/04a,b& SD/CP/803, 335p
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- Welkenhuysen, K., Ramírez, A., Swennen, R., Piessens, K., 2013. Strategy for ranking potential CO2 storage reservoirs: a case study for Belgium. *International Journal of Greenhouse Gas Control*, 17, p.431-449.

Progress beyond the state of the art

The major challenge is to include essential additional factors that come into play in real world projects, which may importantly improve or weaken the economic case: geological uncertainty and infrastructure costs. Uncertainty usually affects project decisions, because higher uncertainty on return requires a higher expected return. Positive FIDs are therefore less likely to be taken. Geologic uncertainty is distinct from technological or economic uncertainties. Estimating the level of this uncertainty often requires in-depth regional (per country or basin) expertise. It will not resolve gradually over time, as is the case for most technical or socio-economic parameters, but requires a significant upfront investment for additional exploration. Reservoirs are also complex natural systems, and the residual uncertainty after exploration and pilot testing may remain relatively large. The other essential factor to be captured is project flexibility: the capacity to adjust to some extent a project as uncertainty is increasingly resolved in the course of an actual project with a positive or negative impact on the project.

When uncertainties are taken into account, project outlooks will generally be less favourable. When project flexibility is not taken into account, then the rigid theoretical outlooks will be pessimistic compared to projects in the real world. ROA meets those needs but has only rarely been used for assessing projects involving CO2 geological storage, and, not to the topic of temporary storage of CO2 or onshore EOR. Previous studies on offshore EOR were performed at a much more generic level than this proposed task.

One of the intentions of putting projects in a realistic socio-economic context is to demonstrate how CCS and CCUS can be a positive and non-intrusive element in sustainable economic and industrial development. A transparent economic case will facilitate valuating the importance of innovative (CO2 based) industry, as well as make CO2 geological storage more acceptable and appealing to a local population.

For the two storage schemes that will be scrutinized, comparable subtasks are required, each however taking into account the peculiarities of the specific project. Results will be used directly for evaluating the economic viability of a proposed project, to pinpoint weaknesses and strengths from the investors point of view, and to evaluate the required context for these specific CCS projects, which will allow ENOS to assess how generally they can be applied in Europe. Since CCS is being placed as accurately as possible in a regional context in WP6, the results are particularly relevant also to policy makers when rolling out socio-economic policy in a climate and resource constraint Europe.

Task 4.3.1 Outlining the optional project development scheme

Integrating flexibility in the simulation of the project execution, starts with a tree-like mapping out of the different evaluations and decisions that can be taken in function of the outcome of a project from start to end (Real Options Scheme). A straightforward example is the outcome of exploration activities, after which the Final Investment Decision for the full scale project may be taken. Only decision points that have an important impact, also referred to as 'Option Value', on the overall NPV calculation will be integrated and these will be different for a temporary gas storage or EOR project.

Task 4.3.2 Assessing the stochastic ranges/distributions of the input data

In the stochastic calculations, different decisions at option points will be taken because of the stochastic nature of input values. Particular focus will be on the realistic translation of geological uncertainty, but also on techno-economic parameters. In order to obtain meaningful results, the number of stochastic parameters is best limited to 4 or 5. Close collaboration is needed between the reservoir modelers of the gas storage and EOR projects, in order to realistically represent the uncertainty and variability of the geological and simulation input data to the economic evaluations.

Assessing the general economic or policy related parameters, such as CO₂-ETS price, will be discussed within WP4, based on the background assumptions proposed in Tasks 4.1 and 4.2, and on proposed ranges by the techno-economic sub-task group (4.3). These uncertainties will be caught at the scenario level. A minimum number of scenarios will be used, mainly to address the issue of the highly volatile energy and CO₂ ETS prices.

Task 4.3.3 Determination of the project value

The actual value of the two projects will be calculated by using the PSS (Policy Support System) simulator directly or indirectly with the help of a spreadsheet environment. The ROA schemes will be calculated using a Monte-Carlo approach, and the outcome will be evaluated both in terms of the average and variance of the project value, the different options, and the sensitivity to each of the stochastic parameters.

Outcomes

The market potential, economic viability, physical planning with synergies and conflicts, and legal and regulatory aspects specific to the identified integrated chains including CO₂ storage will be evaluated (see also Task 6.3). The business cases for the identified chains will be elaborated so that they can be used as a basis for investment decision making. Relevant stakeholders will be engaged in this process; participation of the local inhabitants will be enabled via WP5. Interaction with other WPs Results from WP4 will feed the work in task 6.5 Roadmap for upscaling identified synergies of CO₂ storage with CO₂ utilisation. WP4 and 5 will cooperate on the definition of the work with the local community. Furthermore WP4 will deliver building blocks for best practice documents in WP7 and will contribute to the curriculum of the training sessions in WP8.

Participation per Partner

Partner number and short name	WP4 effort
4 - CGS	9.00
8 - GGR	3.50
10 - IRIS	10.00
14 - SGIDS	3.00
17 - TNO	30.00
20 - CO ₂ GeoNet	0.00
METU	6.00
GSB-RBINS	24.00
Total	85.50

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D4.1	Novel Concepts for EOR with permanent storage of CO ₂	10 - IRIS	Report	Confidential, only for members of the consortium (including the Commission Services)	13
D4.2	Progress report on the economic evaluation on the project value of the geo-technical uncertainties related to CO ₂ buffering and re-production for greenhouse horticulture, and to onshore CO ₂ storage and oil production	20 - CO ₂ GeoNet	Report	Confidential, only for members of the consortium (including the Commission Services)	20
D4.3	Progress report on identified key chemical processes	17 - TNO	Report	Confidential, only for members of the consortium (including the Commission Services)	22
D4.4	Summary report with gas stream scenarios and user specifications	17 - TNO	Report	Confidential, only for members of the consortium (including the Commission Services)	25
D4.5	Reservoir models of novel CO ₂ -EOR concepts at LBr-1	10 - IRIS	Report	Confidential, only for members of the consortium (including the Commission Services)	30
D4.6	Assessment of transboundary effects at LBr-1 and regulatory solutions	4 - CGS	Report	Public	37
D4.7	Approaches to regulating CO ₂ with EHR in selected Member States	17 - TNO	Report	Public	37

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D4.8	Economic evaluation on the project value of the geo-technical uncertainties related to CO2 buffering and re-production for greenhouse horticulture, and to onshore CO2 storage and oil production	20 - CO2GeoNet	Report	Public	37
D4.9	Report on separation technology options and recommendation for the gas stream scenarios	17 - TNO	Report	Confidential, only for members of the consortium (including the Commission Services)	38
D4.10	Design of a CO2-EOR pilot	10 - IRIS	Report	Confidential, only for members of the consortium (including the Commission Services)	38
D4.11	Monitoring system for an integrated CO2 buffer and permanent CO2 storage project	17 - TNO	Report	Public	39
D4.12	Final report on gas phase quality assessment during CO2-EHR, buffering and storage	17 - TNO	Report	Confidential, only for members of the consortium (including the Commission Services)	40

Description of deliverables

Task 4.1
D4.3 Progress report on identified key chemical processes (M 22; TNO)
D4.4 Summary report with gas stream scenarios and user specifications (M 25; TNO)
D4.7 Approaches to regulating CO2 with EHR in selected Member States (M 37; TNO)
D4.9 Report on separation technology options and recommendation for the gas stream scenarios (M 38; TNO)
D4.11 Monitoring system for an integrated CO2 buffer and permanent CO2 storage project (M 39; TNO)
D4.12 Final report on gas phase quality assessment during CO2-EHR, buffering and storage (M 40; TNO)

Task 4.2
D4.1 Novel Concepts for EOR with permanent storage of CO2 (M 13; IRIS)
D4.5 Reservoir models of novel CO2-EOR concepts at LBr-1 (M 30; IRIS)
D4.6 Assessment of trans-boundary effects at LBr-1 and regulatory solutions (M 37; CGS)

D4.10 Design of CO₂-EOR pilot (M38; IRIS)

Task4.3

D4.2 Progress report on the economic evaluation on the project value of the geo-technical uncertainties related to CO₂ buffering and re-production for greenhouse horticulture, and to onshore CO₂ storage and oil production (M20; CO₂GeoNet-RBINS-GSB)

D4.8 Economic evaluation on the project value of the geo-technical uncertainties related to CO₂ buffering and re-production for greenhouse horticulture, and to onshore CO₂ storage and oil production (M 37; CO₂GeoNet-RBINS-GSB)

D4.1 : Novel Concepts for EOR with permanent storage of CO₂ [13]

Task 4.2 - Report on Novel Concepts for EOR with permanent storage. The report should describe differences from "conventional" storage and EOR projects in a form of maximising both hydrocarbon production and volumes of CO₂ stored on site. An optimisation methodology would be developed and concept suggested based on LBr-1 site.

D4.2 : Progress report on the economic evaluation on the project value of the geo-technical uncertainties related to CO₂ buffering and re-production for greenhouse horticulture, and to onshore CO₂ storage and oil production [20]

This intermediary WP4.3 report will outline the geo-techno-economic methodology and implementation that has been developed, including first test results based either on preliminary actual input or dummy data, depending on the progress in the largely parallel tasks WP4.1 and WP4.2. Additional topics at this stage will likely include a stochastic sensitivity analysis, important for understanding the importance of the uncertainty on key-parameters.

D4.3 : Progress report on identified key chemical processes [22]

The progress report describes the first results of Task 4.1.1 in WP4. The chemical interaction processes, which are key to the understanding of the chemical composition of the gas stream produced from the Q16-Maas field will be elucidated.

D4.4 : Summary report with gas stream scenarios and user specifications [25]

The second interim report in Task 4.1.1 describes various scenarios of the composition of the gas stream produced during subsequent stages of gas production and CO₂ injection at the Q16-Maas field, and specifications of the gas stream composition required by different users.

D4.5 : Reservoir models of novel CO₂-EOR concepts at LBr-1 [30]

Task 4.2 - A reservoir model showing optimised scenario of maximising recovery and storage volumes (based on concept from delivery 4.1) would be prepared and delivered. The model would optimise for well location and injection rates

D4.6 : Assessment of transboundary effects at LBr-1 and regulatory solutions [37]

Task 4.2 Study on trans-boundary issues of the LBr-1 site, which is situated close to the Czech-Slovak border. It will include items such as national legislations, definition of the storage complex, assessment of CO₂ storage pressure footprint, risk management and proposals for possible regulatory solutions. Regulatory solutions of the trans-boundary storage issues will be provided and recommendations for EU regulation will be defined.

D4.7 : Approaches to regulating CO₂ with EHR in selected Member States [37]

The report includes the results of Task 4.1.3 in WP4 and is directed to the regulatory assessment of several combinations of injection, buffering and HC production for the Netherlands, the UK and Denmark. The report will conclude with recommendations for removing existing regulatory barriers.

D4.8 : Economic evaluation on the project value of the geo-technical uncertainties related to CO₂ buffering and re-production for greenhouse horticulture, and to onshore CO₂ storage and oil production [37]

This WP4.3 report will detail how the schemes and data from WP 4.1 and WP4.2 were translated in a geo-techno-economic model, and how the economic, technical and geological maturation outlooks are for the respective CO₂ utilization cases. This report is scheduled near the end of the project to allow for maximum adoption of data and proposed operational schemes from WP4.1 and WP4.2, and is as such dependend on the (expected) pre-reporting availability of final views from these tasks (e.g. the design of the CO₂-EOR project).

D4.9 : Report on separation technology options and recommendation for the gas stream scenarios [38]

The report deals with available separation options to purify the produced gas stream according to existing specifications for the users of hydrocarbons or CO₂ (Task 4.1.2 in WP4). Recommendations for the most cost-effective solutions will be made.

D4.10 : Design of a CO₂-EOR pilot [38]

Task 4.2 - A report with the design of the CO₂-EOR pilot for LBr-1 (number and position of wells, operational conditions) based on the simulation results in delivery 4.5.

D4.11 : Monitoring system for an integrated CO₂ buffer and permanent CO₂ storage project [39]

The report describes the results of Task 4.1.4 in WP4 on the design of a monitoring system for the mass balance of injected and produced CO₂ streams, and permanently stored CO₂ according to regulation for CO₂ accounting.

D4.12 : Final report on gas phase quality assessment during CO₂-EHR, buffering and storage [40]

The final report of Task 4.1.1 (TNO & GGR) provides a full account of the assessment of the gas quality during the stages of EHR, CO₂ buffering and storage at the Q16-Maas field. The assessment is based on results of geochemical modelling of fluid-rock interactions, lab analysis of the chemical composition and spatial distribution of minerals and 3-D coupled compositional multiphase flow - geochemistry simulations.

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS4	International collaboration input to Work programme planned	1 - BRGM	3	D6.1
MS13	Input from End-User Committee 1	10 - IRIS	11	Key outcomes from meeting
MS14	Draft Real Option Schemes for CO ₂ buffer and CO ₂ -EOR	20 - CO ₂ GeoNet	12	Discussed and validated schemes by partners of Tasks 4.1, 4.2 and 4.3
MS16	Identification of main geochemical processes	17 - TNO	14	Geochemical model outcome supplied to partner in Task 4.1.1
MS21	Decision on designs for considered separation processes	17 - TNO	18	Approved list of process designs by partners in Tasks 4.1.1 and 4.1.2
MS23	Input from End-User Committee 2	10 - IRIS	23	Key outcomes from meeting
MS24	Selection of production scenario(s)	17 - TNO	24	Definition of scenario supplied to partner in Task 4.1.2
MS27	Transfer of data, pending potential updates, of Tasks 4.1 and 4.2 to Task 4.3	17 - TNO	30	Notes with data from Tasks 4.1 and 4.2 in agreement with needs in 4.3
MS32	Input from End-User Committee 3	10 - IRIS	35	Key outcomes from meeting
MS34	Advisory board input 2	1 - BRGM	36	report and note on impact on ENOS
MS35	End of all field activity	1 - BRGM	36	End of CO ₂ injection and ENOS data acquisition
MS36	Input from End-User Committee 4	10 - IRIS	47	Key outcomes from meeting

Work package number ⁹	WP5	Lead beneficiary ¹⁰	18 - UNIROMA1
Work package title	Coordination with local communities		
Start month	1	End month	48

Objectives

By linking the work of the technical WPs to the perspective of the local population, ENOS will develop a unique body of knowledge about how technical aspects of CO₂ storage can be synchronized with societal needs. Evaluation of the technology's societal implications and identification of possible solutions together with local populations will be the focus of the WP5. The main objectives will be:

- To gain the involvement of the local population in the development of best practices by organizing collaborative research processes between lay citizens and experts
- To support the ENOS project in developing best practices which are proven for societal aspects, in particular with regard to safety and potential impacts
- To provide a methodology to link the scientific and technical development of the best practices with societal concerns and implementation issues at local level
- To develop an online public information tool based on input and feed-back from the local population
- To verify how the integration of societal input in CO₂ storage research and implementation can increase awareness about storage processes and confidence in how they are being developed and implemented

Description of work and role of partners

WP5 - Coordination with local communities [Months: 1-48]

UNIROMA1, BRGM, BGR, CGS, CIUDEN, OGS, PLC-3, SOTACARBO, TNO, UNOTT, CO₂GeoNet

Storage projects will need to be implemented in such a way that is felt to be safe by the local population. This will not only require the projects to be compliant with technical best practices but also to ensure that what they do is recognized by the population as following safe state of the art practices. In other words, it is not sufficient that the site obeys regulations, it is also necessary that it is perceived as such. WP5 will undertake activities with the goal of developing knowledge and tools that can fill the gap between the technical and the societal level of perception on CCS. To achieve this, WP5 will create conditions for the establishment of a long term relationship with a group of public's representatives, within which research and technological issues will be discussed with two main objectives: (i) to gain input from the population to make sure that the best practices developed by the ENOS project don't neglect reasonable societal concerns and integrate the point of view of the population; (ii) to produce a public information tool specific for CO₂ storage sites that enables people to understand and follow site development and operation. The two objectives are closely related, through the relationship with the population, ENOS will coordinate the scientific and technological aspects with the social and societal ones. The outcomes will be directed to satisfy the authorities and the operators, through the contribution to ENOS final best practice documents and to engage the general public and other societal stakeholders, through the production of a dedicated public information tool.

Task 5.1 – Knowledge development and integration in a societal perspective (UniRoma1, all WP partners)

State of the art

Discussion at societal level on technical topics requires support of the technical community and suitable supporting material. There are existing examples of researchers working together to integrate their knowledge from different disciplines related to storage and making the effort of expressing it in lay terms, which have produced a variety of materials for communication with the public. The most notable one is CO₂GeoNet brochure "What does the geological storage of CO₂ really mean?", now available in 27 languages, which some of the ENOS partners have contributed to. However these are one way communication materials, produced for general engagement purposes, without direct input or verification by the population.

Progress beyond the state of the art

To allow participation and discussion with civil society on technical topics and integration of public concerns in research and implementation projects a common language, terminology and understanding of concepts is required. ENOS will work with researchers and the population alike to find satisfactory formulations that facilitate reciprocal input and pave the way for correct but accessible communication between the technical researchers and the local community.

Activities: Work will be performed in interaction with WPs1-4 to define the key steps of the technological development being undertaken in easy-to-understand, communication-prone materials which will provide the basis for exchange

on technical issues with the local community. Task 5.1 will be performed by means of desktop work, email and teleconference exchange plus six two-day workshops with WPs1-5 researchers. During the later stages of ENOS WP5 will provide input to WP7 research integration activities. During the first part of the project the materials for exchange will be prepared (Task 5.1); subsequently the work with the researchers will focus on the discussion of the input coming from the population and how it can be taken into account in the development of the research work (Task 5.2).

Task 5.1.1 Description and definition of technical themes and technologies that ENOS aims to develop, through exchange among researchers and agreement on lay formulations, including provisional description of the topics' relevance for the local community (developed with the community itself in task 5.2). Main areas of work following the technological challenges tackled in WP1 to 4:

Advanced methods for risk management, injection strategies and monitoring at injection site (WP1)

Risk and mitigation techniques (WP1&3)

Understanding of capacity issues (WP2)

Protection of water resources (WP3)

Monitoring plans (WP1&3)

Synergies of CO₂ geological storage with CO₂ utilisation (WP4)

The materials produced will be translated (in the languages of the communities involved, by site partners) and used for the group work with the local population and once verified and updated also for general communication purposes.

Task 5.1.2 Integration of the population's input in the research process, in implementation process of pilots and in the development of the best practice manuals at the end of the project.

The work with the population will highlight what is regarded as most important in public perception terms; based on this, researchers will discuss how to integrate public input in the ENOS research to addresses public values. Wherever possible researchers will look for technically and socially sound solutions. The interplay between researchers' analysis and the input gained through the representatives of the public involved, will help finding appropriate formulations of the final best practice report to ensure both technical and societal relevance and comprehensibility.

Outcomes:

WP5 provide input into best practice documents (in WP7) that take into account and integrate the perspective of the population, these will be an important tool to help operators and the authorities develop storage projects with greater awareness of what needs to be considered, not only in a technical perspective but also in a societal perspective. Another important outcome relates to the influence that the process established in this task will have on research development: Researchers that will be more aware of societal requirements will develop tools, models and techniques that better serve both industrial and societal demands.

Task 5.2 – Work with the local communities (UniRoma1, SOTACARBO, TNO, CIUDEN, UNOTT)

State of the art

Interaction with the population on technical issues and the establishment of a collaborative research process is not new in other sectors. For instance the application of methodologies that seek to include social and societal aspects into what is commonly referred to as 'technical' challenges has largely taken place in formerly technical issues such as water and soil management. This approach is only just starting in the field of CCS. An example is a German study on participative modelling for CO₂ storage characterization by Class et al. However, these studies usually involve technical stakeholders or civil society organisations, rather than the local population living near an existing or potential storage site - the stakeholder most affected by technical choices made by scientists and operators.

Progress beyond state of the art

ENOS will expand work for participative research and operation processes, by covering a range of storage topics, which are of direct interest for the population and by involving and prioritizing lay citizens living near the storage pilot areas. This will be an important step towards a methodology for a community centred exchange between scientists, operators, local authorities and the local population. Progress will also be made on how to facilitate successful societal exchange on storage themes and on the advantages of an organized and long term joint effort, which could be replicated by future storage operators, with respect to more focused and short term activities. Additionally this task will progress our knowledge on the potential for integration of different methodologies to work with the population. The project will therefore advance state of the art knowledge providing insight on how researchers, the population and local authorities can work together to build safety conditions and best practice protocols.

Activities:

Task 5.2 focuses on the interaction with the local communities on the thematic areas covered by the technical WPs. Four sites/areas will be covered presenting different kinds and stages of storage plans: Sulcis, Hontomin, GeoEnergy TestBed, Rotterdam area.

Task 5.2.1: Coordination and elaboration of the work with the local communities (UniRoma1, SOTACARBO, TNO, CIUDEN, UNOTT):

The partners will define together the approach to the work with the local community, by sharing methodologies and experience and, building a common understanding about the development of the relationship with the local communities. Different methodologies for establishing a collaborative relationship with the population will be used by the partners, ranging from psychoanalytic based (Vercelli et al., 2014) to political science based approaches (Duijn, M., Laws D.W., 2005; Ehrmann, J.R., Stinson B.L., 1999).

Task 5.2.2: Joint work with citizens and stakeholders (UniRoma1, SOTACARBO, TNO, CIUDEN, UNOTT)

The activities in this task will be carried on at the level of the individual sites.

Preparatory phase: The partners will further develop existing contacts with the local authorities and relevant stakeholders in order to establish the framework conditions for working with citizens living in the area, including making public presentations of the project, its aims and objectives and launching social media activities or other forms of involvement of the community to communicate about the work being done and its outcomes. This preliminary phase to collect and apply knowledge on the appropriate conditions for the research work with the citizens will pave the way for the collaborative research process at the selected locations.

Group work: Groups of 12-15 citizens (reflecting proportions of gender, age, education etc.) and stakeholders will be formed for interaction on the different thematic areas identified in task 5.1 and exploration of the different perspectives on the technological issues under study. The groups will meet for a cycle of regular meetings of 2-3 hours to address the need of dedicated space and sufficient time for people to understand, reflect, formulate requests and look together for solutions (Vercelli et al. 2015). The group work with the participants will focus on three distinct areas and phases of work:

- 1) introduction and understanding of the technological aspects;
- 2) discussion and evaluation of societal implications, critical aspects, etc.;
- 3) development of solutions or improvements that are acceptable from a research/industrial/societal point of view

The four sites represent different social, geographical, economic and industrial realities and different stages of development of the pilot/ projects; they will bring a variety of perspectives which will make the final best practice guidelines more reliable.

The Hontomin site (CIUDEN): the pilot is in operation and the relationship with the population is already well advanced; the perspectives brought in the group work by citizens will reflect their experience with having an operating site in their area. After the preliminary organizing and communication activities, a group of citizens will be established for 15 meetings. The group work will have a focus on operational issues, so it will be shaped in order to improve communication activities with local society on safe storage operation and promote transparency of the activities ongoing in the area. This exchange will provide the base for the public information tool to be developed in task 5.3.

The Sulcis site (UNIROMA1, SOTACARBO): the pilot project is in the stage of completing the characterization phase, a limited number of public communication activities has taken place up to now and the community is in a phase of increasing interest for the project. Activities will be performed at the Sulcis pilot site to encompass all the main sectors of the local society and explore the advantages of a full coverage and more articulated work with the community. After the preparatory phase three long term groups (for a minimum of 15 meetings) will be established involving 1) a random sample of lay citizens; 2) local industrial, commercial and civil society stakeholders; 3) regional and local policy makers. The group work will focus on understanding how the topics defined in task 5.1 are relevant for the local context and how research can better be directed in synergy with other contextual elements and societal requirements. To this end collaboration with Regional authorities will be enhanced and collaboration with civil society organisations present in the areas will be established.

The GeoEnergy TestBed (UNOTT): This is a test injection site on University owned land and the local population are accustomed to research activities. Starting with the preparatory phase, the established GERC website will be updated to inform the public about ENOS activities. Relationships with the local authority, the British Army Royal Engineers (UK armed forces national borehole capability located in Nottingham), the national regulators (Environment Agency), and the local population (Parish Councils) already exist. Within this framework the ENOS project will provide the opportunity for a more technical and long term exchange with a group of citizens which will meet for 15 meetings. In addition UNOTT will facilitate links with the UNOTT China campus (Ningbo), and gain input to the collaborative research process through colleagues at the Ningbo campus and UNOTT's partnership with CO2 storage site owners at the China University of Mining and Technology.

The Rotterdam area (TNO): the Rotterdam area has an interesting potential for both capture and storage of CO2, due to the presence of intensive industrial activities, gas fields and geological formations suitable for storage. This region has also previously been involved in proposed CO2 storage projects that have raised controversial discussions, as was the

case for Barendrecht. The ENOS project will undertake activities with a group of representatives of the lay public to share and explore the potential for storage and the conditions that would make its implementation of interest for the local population. Results of this consultation will be brought to the attention of different stakeholder groups in the area, such as industry/entrepreneurs, local citizens, NGOs and politicians and policy professionals. First, a panel group formed by a random sample of citizens will meet for about 15 meetings. This exploration will deliver insights into the key factors that characterize the disposition of citizens towards these types of project. Second, the input from the citizens will be shared in 3 workshops with representatives of all stakeholder groups in the area facilitating a dialogue approach to explore new possibilities for CO₂ storage. This will create a better understanding of the potential synergies of temporary CO₂ storage with economic activities like greenhouse horticulture and energy storage, which can bring additional benefits to the local population. The different technological challenges tackled in WP1-4 will be explored with a focus on the design of a participatory monitoring system for the different phases of project development; decision-making, construction and operation (e.g. what items should be monitored? From what perspectives? Which data is needed? Which data is already available, from whom? Which data needs to be collected, by whom? Etc.).

Task 5.2.3 – Verification and feed-back from the population (TNO, UniRoma1, SOTACARBO, CIUDEN, UNOTT)
During the last phase of ENOS, verification will be performed through interviews and a questionnaire on the level of satisfaction of involved citizens and stakeholders, about the process of exchange and the way the input has been taken into account by the researchers. This will also contribute to collecting feed-back on the innovative process for integrating the community input into best practices for technology implementation.

Outcomes: The experience of a collaborative research process for producing indications for guidelines, best practices and a public information tool for storage sites, tested by societal stakeholders and lay citizens, will contribute in creating an important reference on the possibility of working together with the population to solve storage implementation challenges. Onshore storage needs to be well understood in its potential impacts and benefits by society as a whole; by enabling technical discussions with the population, ENOS will set an example of collaboration across stakeholders and will increase trust in guidelines appropriate for the population.

Task 5.3 – Development of a Public Information Tool for CO₂ storage sites (CIUDEN, UNIROMA1, SOTACARBO, TNO, UNOTT)

In this task the partners will apply the knowledge gained through the relationship with the local communities to develop a dynamic and interactive online Public Information Tool of an active CO₂ storage site (Hontomin). The work in this task builds on the recognition that people living near a storage site have the right to access information about site operations and that trust and feelings of safety will be positively influenced by facilities that enable people to follow the work. The challenge is to structure the information tool so that people can quickly and easily understand how to use it. Close collaboration will be necessary with members of the public to ensure the ENOS tool answers these requirements. The application will be developed during the first two years of the project and will be tested during the third year. A smartphone enabled application will be developed to explain key project data and interesting facts for all stakeholders. It will be a web-based application that can follow the progress of the implementation process of an active CO₂ storage site. It will be developed for Hontomin and the platform will offer the option for addition of other sites. In this way in the future the end user will be able to connect and get information from one or more storage sites. Content will be defined by the interaction with the local population and other stakeholders like journalists, local and regional politicians and regulators conducted as part of Task 5.2.2. It will be updated at regular intervals with information such as the amount of CO₂ injected,, results from recent surveys performed at the site, news from the project and CCS in general The contents would be updated in two languages, English and Spanish (for ease of reading for the local population).

Outcomes: The Public Information Tool which will give access to storage sites development in a manner comprehensible to all, supporting further interaction between the technical and the local communities.

Interactions with other WPs

WP5 work will proceed in close collaboration with the technical WPs 1 to 4 (Task 5.1), will provide input to WP7 for the inclusion of societal aspects in Best Practice documents and WP8 for e-learning and educational activities and for collaborating to media events. Concerning WP6 it will contribute to Experience sharing focus groups and defining storage sites' follow up activities.

References:

Class, H. et al., (2015), Combined Natural and Social Science Approach for Regional-Scale Characterisation of CO₂ Storage Formations and Brine Migration Risks (CO₂BRIM) in Liebscher, A., Münch, U., Geological Storage of CO₂ – Long Term Security Aspects Advanced Technologies in Earth Sciences, Springer.

Duijn, M., D.W. Laws (2005). Facilitating network (inter-organizational) learning: a relativist - pragmatist perspective on participatory policy analysis, Proceedings of the OLKC-conference, Cambridge/MA.

Ehrmann, J.R., B.L. Stinson (1999). Joint Fact-Finding and the Use of Technical Experts, in: The Consensus Building Handbook, L.E. Susskind, S. McKernan, J. Thomas-Larmer, (eds.), SAGE Publications.

Vercelli et.al., (2014), Dialogue and Mutual Learning towards a Low Carbon Society – Experiences from 10 Countries Across Europe, Energy Procedia, Volume 58, Pages 30-35.

Vercelli et al. (2015), The Geological Storage of CO₂: and what do you think? – Findings from the ECO2 project about the public perception of CO₂ geological storage. Lay report D6.4, April 2015, 24 pages.

Participation per Partner

Partner number and short name	WP5 effort
1 - BRGM	4.00
2 - BGR	2.00
4 - CGS	4.00
6 - CIUDEN	21.00
12 - OGS	2.00
13 - PLC-3	0.00
IPF	1.00
16 - SOTACARBO	8.00
17 - TNO	14.00
18 - UNIROMA1	39.00
19 - UNOTT	9.00
20 - CO2GeoNet	0.00
GBA	4.00
HWU	3.00
IGME	2.00
GEOECOMAR	4.00
TTUGI	2.30
Total	119.30

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D5.1	Presentation of the project's technical content in lay terms	18 - UNIROMA1	Report	Public	13
D5.2	Public Information Tool upgraded and ready for application to other CO ₂ storage sites	6 - CIUDEN	Other	Public	34

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D5.3	CO2 Storage Best practice indications from the Hontomin site community	6 - CIUDEN	Report	Public	35
D5.4	CO2 Storage Best practice indications from the Rotterdam area community	17 - TNO	Report	Public	37
D5.5	CO2 Storage Best practice indications from the GeoEnergy TestBed site community	19 - UNOTT	Report	Public	38
D5.6	CO2 Storage Best practice indications from the Sulcis site community	18 - UNIROMA1	Report	Public	40
D5.7	Guidelines for coordinating the development of CO2 storage projects with local communities	18 - UNIROMA1	Report	Public	44
D5.8	Report on feed-back from citizens on ENOS activities	17 - TNO	Report	Public	45
D5.9	Report on the process of integration of indications coming from site communities in ENOS research and CO2 storage Best Practices	18 - UNIROMA1	Report	Public	46

Description of deliverables

Task 5.1

D5.1 Presentation of the project's technical content in lay terms (Collection of lay terms text and ppt presentations for each of the technologies or set of technologies being developed) (M 13)(UNIROMA1)

Task 5.2

D5.3 CO2 Storage Best practice indications from the Hontomin site community (M 35)(CIUDEN)

D5.4 CO2 Storage Best practice indications from the Rotterdam area community (M 37) (TNO)

D5.5 CO2 Storage Best practice indications from the GeoEnergy TestBed site community (M 38) (UNOTT)

D5.6 CO2 Storage Best practice indications from the Sulcis site community (M 40) (UNIRMA1)

D5.7 Guidelines for coordinating the development of CO2 storage projects with local communities (M 44)

D5.8 Report on feed-back from citizens on ENOS activities (M 45)

D5.9 Report on the process of integration of indications coming from site communities in ENOS research and CO2 storage Best Practices (M 46) (UNIROMA1)

Task5.3

D5.2 Public Information Tool upgraded and ready for application to other CO2 storage sites (M 34) (CIUDEN)

D5.1 : Presentation of the project's technical content in lay terms [13]

This deliverable relates to task 5.1.1. It will consist of a report or alternatively of another suitable instrument (for instance fact sheets, posters or a video) that allows facilitated communication of the scientific content of the project. It will illustrate the technical themes and technologies that ENOS aims to develop in terms as much as possible understandable for local population participants and in a form that is functional for the activities to be undertaken with them in task 2.

D5.2 : Public Information Tool upgraded and ready for application to other CO2 storage sites [34]

The aim of this deliverable is to develop a dynamic and interactive on line tool for public information in Hontomín as operation site. Partners will apply the knowledge gained through relationship with local populations. The platform will offer the option for addition of other sites. Following tasks are related with D5.2: Tasks 5.1, 5.2 and 5.3

D5.3 : CO2 Storage Best practice indications from the Hontomin site community [35]

Experiences and lessons learned corresponding to the works performed with Hontomín local community will produce indications for development of best practise guidelines, in order to solve onshore storage implementation challenges. Following tasks are related with D5.3: Tasks 5.1, 5.2 and 5.3

D5.4 : CO2 Storage Best practice indications from Rotterdam area community [37]

The report describes the results of the interaction with stakeholders in the Rotterdam area in Task 5.2.2 of WP5. The interaction follows two stages: in the first stage a panel of citizens will interact on the type of projects considered and in the 2nd stage stakeholders will repond to the input from the citizens. The possibilities for participatory monitoring will be explored.

D5.5 : CO2 Storage Best practice indications from the GeoEnergy TestBed site community [38]

This report will illustrate the outcomes of the group work undertaken with local stakeholders and citizens of the GeoEnergy TestBed site. It will highlight their meaning for the development of CO2 Storage best practices (task 5.2.2)

D5.6 : CO2 Storage Best practice indications from the Sulcis site community [40]

This report will illustrate the outcomes of the group work undertaken with local stakeholders and citizens of the Sulcis site. It will highlight their meaning for the development of CO2 Storage best practices (task 5.2.2)

D5.7 : Guidelines for coordinating the developmentof of CO2 storage projects with local communities [44]

This report will draw conclusions from the overall experience conducted with the four site communities. It will further develop the indications coming from deliverables 5.3 to 5.6, to formulate general guidelines for the stakeholders on how, based on the project's experience, the development of CO2 storage sites can be coordinated with the local communities (task 5.2.1)

D5.8 : Report on feed-back from citizens on ENOS activities [45]

The report entails the feedback from citizens on the process followed in ENOS and on the way the results have been used. The reported work inlcudes all activities of Task 5.2.3 in WP5.

D5.9 : Report on the process of integration of indications coming from site communities in ENOS research and CO2 storage Best Practices [46]

This report will illustrate the process followed in the project for integrating the input received from local communities in ENOS research and in the final ENOS CO2 storage guidelines. It will explain if and how the observations and suggestions coming from the population have informed the research activities and the formulation of the guidelines (task 5.1.2)

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS4	International collaboration input to Work programme planned	1 - BRGM	3	D6.1
MS5	Start of field activities in Sulcis Fault lab	16 - SOTACARBO	5	Staff at field
MS13	Input from End-User Committee 1	10 - IRIS	11	Key outcomes from meeting
MS20	Start of group meetings with citizens	18 - UNIROMA1	18	First meeting documents
MS23	Input from End-User Committee 2	10 - IRIS	23	Key outcomes from meeting
MS26	Launch of the Public Information tool	6 - CIUDEN	24	First version available online
MS32	Input from End-User Committee 3	10 - IRIS	35	Key outcomes from meeting
MS34	Advisory board input 2	1 - BRGM	36	report and note on impact on ENOS
MS35	End of all field activity	1 - BRGM	36	End of CO2 injection and ENOS data acquisition
MS36	Input from End-User Committee 4	10 - IRIS	47	Key outcomes from meeting

Work package number ⁹	WP6	Lead beneficiary ¹⁰	4 - CGS
Work package title	International Cooperation & seeding pilots and demos in Europe		
Start month	1	End month	48

Objectives

In order to successfully deploy commercial CCS with onshore storage across Europe, a series of pilot projects needs to be developed and realized, preferably in a variety of geographical and geological settings across the continent, followed by larger-scope demonstration projects. Additionally, the experience gained from existing pilots needs to be maximised through knowledge sharing and identifying analogous sites where the lessons learned can be most effectively applied to catalyse the next generation of successful onshore storage projects.

The objective of WP6 is to facilitate such development by:

- Establishing partnerships and sharing experience and knowledge with groups and entities executing CO2 storage pilots, demonstration projects and leakage simulation tests worldwide;
- Liaising and exchanging knowledge with other pilot and demonstration projects in Europe across the full pilot/demonstration lifecycle (planned-operational-closed);
- Identifying success criteria that can be applied to create a catalogue of potential situations where new storage sites might be successful;
- Paving the way for pilot sites in the ENOS project portfolio to further develop beyond the end of the project through planning of follow-up stages of their development and/or upscaling to a larger amount of stored CO2;
- Preparing a Roadmap for upscaling identified synergies of CO2 storage with CO2 utilisation

Description of work and role of partners

WP6 - International Cooperation & seeding pilots and demos in Europe [Months: 1-48]

CGS, BRGM, BGR, BGS, CIUDEN, IRIS, OGS, PLC-3, SGIDS, SOTACARBO, TNO, UNIROMA1, UNOTT, CO2GeoNet

Task 6.1 International cooperation (BRGM, CGS, CIUDEN, BGS, UNOTT, UNIROMA1, OGS, IRIS, CO2GeoNet-GeoEcoMar, Sotacarbo, PLC-3)

Context

Europe is lagging behind North America and other parts of the world in deployment of CO2 storage onshore. The European experience is limited to a few pilot sites (e.g. Ketzin, Lacq-Rousse, Hontomin), which makes sharing experience and knowledge with other onshore storage sites outside Europe (e.g., in U.S.A., Canada or Australia) imperative. ENOS can learn the most from sites which represent similar types of storage to those in the ENOS project, with respect to geological setting, reservoir type, storage strategy. The proposed work in this task will provide a framework for sharing and mutual learning with international sites, who provided letter of intent to participate in this task see Section 4.

Activity

Task 6.1.1 Storage Site twinning programme

A twinning programme, aimed at creating a durable close working relationship between onshore site owners, will be set up. It will consist of mutual visits, regular exchanges of information and data, discussions on real-life issues encountered by the twinned sites operations and where possible identification of collaborative actions to address those issues through research alignment and cooperation. Activities will take advantage of modern communication and data sharing tools to maximize collaboration opportunities.

The proposed twinings are: Sulcis-Janggi (Korea)-South Africa Pilot CO2 Storage Project / Hontomin- Batelle site in Michigan Basin (USA)-Otway(Australia) / LBr1-Kansas Wellington Field.

A detailed plan of international collaboration activities will be drafted within the first 3 months of the project (D6.1). Two joint reports with international site owners will be produced at the end of Year 2 (D6.2) and Year 4 (D6.11), describing results of the Twinning Programme, including common issues identified and mutual learning.

BRGM will be responsible for this sub-task and will facilitate exchanges in the twinning groups.

Task 6.1.2 Leakage simulation alliance

Worldwide there are several sites planning to study CO2 leakage in different environments and conditions through real-life field injection experiments. The alliance will foster cooperation and allow comparison and generalization of results. The sites proposed for the alliance are the GeoEnergy Test Bed (UK) and the Sulcis fault (Italy) sites from ENOS, as

well as the Carbon Management Canada (CMC), South Korean K-COSEM and South African Bongwana Fault (natural analogue) site. If possible other sites will be added during the course of the project.

Activities will consist of site visits, workshops, data exchange and joint reports/publications. It is proposed that one workshop will be held in Canada in conjunction with the annual CMC workshop to allow attendance at both events and a visit to the CMC Field Research Station.

Visits will explore the possibility of collaborative working across the sites through separate funding mechanisms. This sub-task will build on an existing project funded by the UK CCS Research Centre project involving visits by BGS and UNOTT to forge collaborative links between the GeoEnergy Test Bed and the sites in South Korea, South Africa and Canada.

The activities of the alliance led by BGS and will be summarised in a report (D6.5)

Task 6.1.3 Experience sharing Focus groups

ENOS will create a small number of experience sharing groups, which will each target a specific issue that is relevant to all sites.. The work will rely on each participant's own research activities with the aim of sharing experience (both successes and failures), exchanging datasets where relevant, and identifying the necessary developments of technologies and methodologies. In contrast to the activities of the twinning program, the focus groups will be open to many sites and research teams and focused on a single issue. European sites approached in task 6.2 will be invited to join.

Anticipated topics for the focus groups are: site characterisation, CO₂ injection management, site monitoring strategy or relation with the local population. The final decision on the topics will be taken at the beginning of the project in accordance with the site owners'/operators' updated needs.

Activities will consist of webinars (no less than 8 webinars are planned during the project duration), preferably in cooperation with the European CCS Demonstration Project Network, and two workshops aligned with the CO₂GeoNet Open Forums. These activities will be organised in close cooperation with Task 6.2 that will link ENOS to further European projects and activities).

BRGM will be responsible for this task and will facilitate exchanges in the groups as well as producing reports on the meetings and workshops. BGS will be responsible for sub-task 6.1.2. Representatives of the individual sites in the ENOS portfolio will be involved in this task. OGS will (with the external support of the Global CCS Institute, currently running the Secretariat of the European CCS Demonstration Project) organise of the webinars.

The activities of the Focus groups will be described in a report that will also include recommendations resulting from experience sharing (D6.9).

Impact

Enhancing experience sharing amongst pilot sites and field experiments worldwide and providing opportunities for research alignment will leverage research investments made at each of the different sites as well as in previous and current research projects. The activity will also increase the visibility of activities performed as part of ENOS and of the sites within the ENOS portfolio.

Task 6.2 European liaison and knowledge exchange (CO₂GeoNet-GeoEcoMar, CGS, CO₂GeoNet-TTUGI, PLC-3, CIUDEN, CO₂GeoNet-IGME, BRGM, BGS, UNOTT, CO₂GeoNet-UNIZG-RGNF)

Context

In addition to the international cooperation and exchange identified in Task 6.1, it is also important to establish and strengthen links between the ENOS sites and the European activities in the area of onshore storage. These include both the existing pilot storage sites and the association and networks active within this field.

Activity

Discussion and experience exchange with other onshore pilot and demonstration projects in Europe that are in various project lifecycle stages (planned, ongoing and completed – e.g., Ketzin, Lacq-Rousse, Heletz, CarbFix, Longyearbyen, GETICA CCS) will be strengthened or newly established in order to include these projects in the international cooperation organised by ENOS. In addition, ENOS will actively cooperate with the European CCS Demonstration Project Network, using the support of GCCSI. Hontomin TDP, the BGS Hydrothermal Laboratory, BGS Near Surface Gas Monitoring Facility and the Sulcis Fault Lab and OGS aircraft are all part of the European Carbon Dioxide Capture and Storage Laboratory Infrastructure (ECCSEL) and these links will be exploited by the partners of ENOS.

Cooperation with ECCSEL on support and development of CO₂ storage pilots will be ensured through those partners (BGS, BRGM, CIUDEN, OGS, Sotacarbo, TNO) already active in ECCSEL and working in ENOS. Support for ETP ZEP on demonstrations will be fostered through active participation of ENOS project partners in ZEP activities, building on the success of the ZEP/CGS Europe 'State of play' report. ENOS will liaise with the EURELECTRIC CCS taskforce and with national CO₂ Clubs existing in several countries across Europe.

ENOS partners will use the knowledge obtained through ENOS to contribute directly to the development of the EERA CCS JP research activities. This will be achieved through partner s' attendance at an EERA research workshop which

will review the state of the art and identify future European research priorities. In addition ENOS partners will produce a report for EERA summarising the conclusions of the discussions (D6.4).

ENOS will liaise with the Baltic Sea Region CCS network recently established by BASREC (Baltic Sea Region Energy Cooperation) to support cooperation and exchange of knowledge between ENOS project and regional CCS activities in the Baltic Sea Region as well as possible newly organised onshore pilots and some ongoing onshore EOR-CCS activities in the EU countries not participating in ENOS (Poland, Sweden, Latvia, Lithuania). A joint workshop will be organised in Tallinn.

All activities performed in Task 6.2 will be summarised in two periodic reports at the mid-term (D6.3) and at the end (D6.12) of the project.

Impact

Liaising with European projects and other activities is necessary in order to strengthen the position of ENOS-supported sites in the European CCS context, to share knowledge and experience within the European CCS community and to exchange achievements with other onshore storage sites in Europe. These outputs will inform European research priorities, via direct support to ECCSEL and the EERA CCS JP.

Task 6.3 Supporting new pilot and demonstration opportunities (CO2GeoNet-UNIZG-RGNF, BGS, CGS, CO2GeoNet-IGME, CO2GeoNet-TTUGI, CO2GeoNet-GeoEcoMar, PLC-3)

Context

Existing pilot and demonstration sites enhance confidence in the ability of geological formations to safely store CO2 on a regional basis and local demonstration of CCS technology will encourage further project development. So far, onshore storage has been tested and demonstrated only at a few pilot sites in Europe (i.e. Ketzin, Lacq-Rousse, and recently Hontomin), which is deemed insufficient. A ZEP/CGS Europe study identified several promising opportunities for possible onshore storage pilots across Europe, based on proposals by partners with 19 potential onshore locations for pilot projects. There was a limited assessment of the probability of these pilot sites moving forward and as the CCS landscape changes rapidly. This could now be updated and the assessment of the likelihood of these storage pilots moving forward enhanced by considering a wider range of factors including regional circumstances and potential impact, variability of geological settings, comparison with successful projects etc.

Activity

A study focusing on onshore pilot/demonstration project opportunities across Europe (D6.8) will be prepared, delivering on a diverse portfolio of geological settings (covered / not covered so far) and regions with little CCS activity to date. The study will identify factors that have helped lead to a successful pilot or demonstration site and look for other sites where there is a good chance that success could be replicated. The aim is to seek out areas where the geological setting and other technical factors (e.g. CO2 sources, infrastructures etc.) are similar to existing successful pilot projects in order to identify regions likely to be favourable for future pilot projects or regions with potential to scale up to demonstration scale. This task will use data from existing pilot sites, key recommendations from other research projects (inter alia EU GeoCapacity, SiteChar, RISCS, CO2CARE, etc.) and build on the CGS Europe 'State of Play of CCS' report and the CGS Europe/ZEP report on potential pilot projects in Europe. A catalogue of the most prospective candidates for second generation pilots will be developed for a few regions that offer the greatest potential. These regions will be selected to provide representative and concise case studies to illustrate the possibilities. Direct links will be established with the ECCSEL Research Infrastructure, to whom ENOS will provide a written recommendation on future opportunities for second generation pilots.

Impact

Task 6.3 will provide recommendations regarding future developments of onshore CO2 storage in Europe, including promising opportunities for future pilot/demo sites, and the identification of unused or underused geological settings in Europe with significant storage potential.

Task 6.4 Preparation of follow-up stages for ENOS pilot sites (CGS, UNOTT, BGS, CIUDEN, OGS, UNIROMA1, TNO, IRIS, CO2GeoNet-TTUGI, CO2GeoNet-UNIZG-RGNF, BGR, CO2GeoNet-GEOINZ, Sotacarbo, CO2GeoNet-GBA, SGIDS)

Context

Real-life experimental sites, even if of different scale all require high up-front investment. The value obtained for such investment should be maximised in time by ensuring that the sites will continue to operate and provide benefit to the scientific community and other CCS stakeholders after ENOS. To support the continuation of activities at the sites and maximize the value of their contribution to the development of onshore CO2 storage in Europe, ENOS will prepare internally reviewed plans for further development of the sites and their utilization.

Activity

An action plan for continuation of storage pilot projects and injection test sites in the ENOS portfolio will be prepared (D6.10). For sites that achieve more advanced stages of development during the project (Hontomin, Sulcis fault injection, GeoEnergy Test Bed), plans will be prepared to increase the value of the sites and the knowledge gained. Challenges, remaining after ENOS, will be identified and a set of recommendations will be established for future activities. For example, it is intended to expand the scope of the GeoEnergy Test Bed site to act as a research hub to draw CO₂ storage researchers and industrial stakeholders together as a component of ECCSEL. Future planning to expand the scope of the site to satisfy these stakeholders will need to build on the knowledge gained during ENOS with input from the project stakeholder workshops. UNOTT and BGS will host an ENOS scoping workshop and monitoring technology demonstration at the GeoEnergy Test Bed site inviting consortium members to explore future opportunities for expanding and enhancing the site and its capabilities as a collaborative research facility.

For projects in early stage of development (e.g., LBr-1), items such as preparatory work for the storage permit (including the definition of lacking pieces of information and data), drilling plans, CO₂ delivery, injection strategy etc. will be included.

For the Sulcis Fault Lab, after the deliberate CO₂ injection and drilling of the deeper characterisation well (with national funding), supported by ENOS, the injection test area and infrastructure (injection and monitoring wells) will constitute a permanent Field Experimental Lab, able to host researchers after the end of ENOS, to test and calibrate monitoring systems (geochemical and geophysical), to verify models and to plan new injection test experiments.

The site development plans will also be reviewed by partners not directly involved in site activities to ensure an independent view and that the European dimension, complementarity and research potential of the pilot sites development is taken into account.

Impact The plans for further development of storage and injection test sites of the ENOS portfolio will be important for sustaining the impetus derived from ENOS. This will pave the way for further development of the sites and help the site owners to adjust their site-related plans according to the needs of the European and international context.

Task 6.5 Roadmap for upscaling identified synergies of CO₂ storage with CO₂ utilisation (TNO, CGS, IRIS, CO₂GeoNet-GBA, SGIDS)

Context

To move CO₂ storage and utilisation projects beyond the research and demonstration phase, business cases have to be identified and developed, which involve the exploration of additional factors beyond technical feasibility alone. Roadmaps can be used to identify individual engineering, economic, environmental, regulatory and societal factors that must be addressed to allow projects to move forward.

Activity

Roadmaps will be developed for both the CO₂ EOR and CO₂ Buffering concepts, which will include the technical, economic and regulatory outputs from WP4.

CO₂-Buffering in the Dutch greenhouse sector to 2030

Sufficient warmth, light and enhanced CO₂ levels in a greenhouse are essential for creating the optimal growing conditions for all commercial crops. The combustion of natural gas in combined heat and power (CHP) installations is the most common route to create such an environment. The majority of growers use purified exhaust streams from such installations as the primary source of CO₂, which is also the primary source of CO₂ emissions from the sector. Many stakeholders are looking to reduce the reliance on CHP installations, looking towards more sustainable sources of heat from geothermal installations and industrial waste heat. However, without access to secure and affordable CO₂, CHP installations will continue to be used.

A Roadmap for CO₂ re-use will cover the expected demand by greenhouses in the south-western part of the Netherlands to 2030. The roadmap (D6.7) will clearly outline the necessary technical and organisational milestones, expected duration, potential challenges and solutions associated with realising the CO₂ buffering concept.

Towards a strategic development plan for CO₂ EOR in the Vienna Basin

Leading from the exploratory work completed for the Czech LBr-1 CO₂ EOR pilot site, an assessment will be made of the EOR potential in the oil fields of the Vienna Basin. Initial studies have been completed on using various techniques to maximise the production of individual mature oil fields of the Vienna Basin spread across Austria, the Czech Republic, and Slovakia, information has been published within European projects (Sliupa 2013, EU Geocapacity 2008), and by commercial parties (Potsch 2004). From this information it is clear that potential exists for enhancing oil recovery in the region through CO₂ injection, however commercial projects have yet to take place. A strategic, regional dialogue, involving both emitters, potential storage operators and governing bodies, on the potential for CO₂ EOR and storage synergies can have considerable value for understanding the barriers and drivers for moving this concept forward.

The objective of this task is to explore the potential drivers and barriers to the development of CO₂ EOR in the region of Austria, the Czech Republic, and Slovakia. Based on existing data, estimates will be made on both the economic and environmental benefits the developing a regional plan for accelerated deployment of CO₂ EOR projects. Existing CO₂ sources and transportation routes to specific EOR fields will be identified. Potential operators will be approached to

build an initial representation of the conditions necessary to realise a business case for a project in the region. This task will result in a report (D6.8) providing the foundations for a strategic development plan for CO₂ EOR in the region.

References:

Šliaupa, S et al., 2013. CO₂ storage potential of sedimentary basins of Slovakia, the Czech Republic, Poland and the Baltic States. Geological Quarterly, 2013, 57 (2): 219–232

EU GeoCapacity, 2008. Economic uses of CO₂. WP3 Report, D22.

Potsch, K. 2004. Enhanced oil recovery of OMV in the Vienna Basin.

Impact

Both the Roadmap for the CO₂ buffering project in the Netherlands, and the report on CO₂ EOR potential in the Vienna Basin, are intended to raise awareness, stimulate dialogue and aid decision making both by businesses and policy makers, regarding the potential synergies of combining CO₂ storage with other economic activities, both to the benefit of society and the environment. The reports will include consistent approaches to stakeholder and economic analysis, and the identification of engineering milestones for CO₂ storage projects, which may be transferable to similar concepts in other regions.

Participation per Partner

Partner number and short name	WP6 effort
1 - BRGM	5.00
2 - BGR	1.00
3 - BGS	7.20
4 - CGS	17.00
6 - CIUDEN	8.00
10 - IRIS	3.50
12 - OGS	6.00
13 - PLC-3	0.00
IPF	2.40
14 - SGIDS	5.00
16 - SOTACARBO	5.00
17 - TNO	8.00
18 - UNIROMA1	4.00
19 - UNOTT	6.00
20 - CO ₂ GeoNet	0.00
GBA	7.00
UNIZG-RGNF	7.30
IGME	2.00
GEOECOMAR	6.20
TTUGI	5.90
GEOINZ	1.00
Total	107.50

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D6.1	Detailed plan of international collaboration activities	1 - BRGM	Report	Confidential, only for members of the consortium (including the Commission Services)	3
D6.2	1st report on Twinning Programme	1 - BRGM	Report	Confidential, only for members of the consortium (including the Commission Services)	25
D6.3	1st report on European links, liaison and knowledge exchange	20 - CO2GeoNet	Report	Public	25
D6.4	State-of-the-art report identifying current lessons learned and future research priorities for EERA	3 - BGS	Report	Public	40
D6.5	Summary report on activities of the Leakage simulation alliance	3 - BGS	Report	Public	42
D6.6	Roadmap for CO2-Buffering in the Dutch greenhouse sector to 2030	17 - TNO	Report	Public	42
D6.7	Towards a strategic development plan for CO2 EOR in the Vienna Basin	17 - TNO	Report	Public	42
D6.8	Study on new pilot and demonstration project opportunities in Europe	20 - CO2GeoNet	Report	Public	42
D6.9	Report on the focus group activities and recommendations	1 - BRGM	Report	Public	46
D6.10	Follow-up plan for continuation of ENOS pilot projects	4 - CGS	Report	Confidential, only for members of the consortium (including the	46

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
				Commission Services)	
D6.11	2nd report on Twinning Programme	1 - BRGM	Report	Confidential, only for members of the consortium (including the Commission Services)	48
D6.12	2nd report on European links, liaison and knowledge exchange	20 - CO2GeoNet	Report	Public	48

Description of deliverables

Task6.1

D6.1 Detailed plan of international collaboration activities (BRGM, M3)

D6.2 1st report on Twinning Programme (BRGM, M25)

D6.5 Summary report on activities of the Leakage simulation alliance (BGS, M42)

D6.9 Report on the focus group activities and recommendations (BRGM, M46)

D6.11 2nd report on Twinning Programme (BRGM, M48)

Task 6.2

D6.3 1st report on European links, liaison and knowledge exchange (CO2GeoNet-GeoEcoMar, M25)

D6.4 State-of-the-art report on current lessons learned and future research priorities for EERA (BGS, M40)

D6.12 2nd report on European links, liaison and knowledge exchange (CO2GeoNet-GeoEcoMar, M48)

Task 6.3

D6.8 Study on new pilot and demonstration project opportunities in Europe (CO2GeoNet-UNIZG-RGNF, M42)

Task 6.4

D6.10 Follow-up plan for continuation of ENOS pilot projects (CGS, M46)

Task 6.5

D6.6 Roadmap for CO2-Buffering in the Dutch greenhouse sector to 2030 (TNO, M42)

D6.7 Report: Towards a strategic development plan for CO2 EOR in the Vienna Basin (TNO, M42)

D6.1 : Detailed plan of international collaboration activities [3]

Task 6.1 Plans for international collaboration, with confirmed partners for the three sub tasks 6.1.1, 6.1.2, 6.1.3. It will include planned activities, travels, data exchanges.

D6.2 : 1st report on Twinning Programme [25]

Task 6.1.1 Report presenting the site twinning activities taken place in the first half of the project

D6.3 : 1st report on European links, liaison and knowledge exchange [25]

Task 5.2 - The report will present the international cooperation and knowledge exchange activities undertaken within the ENOS project during the first project period (months 0-24).

D6.4 : State-of-the-art report identifying current lessons learned and future research priorities for EERA [40]

Task 6.2 - ENOS partners will attend an EERA research workshop to review the state of the art and identify future European research priorities. ENOS partners will produce a report (coordinated by BGS) for EERA summarising the conclusions of the discussions (D6.4).

D6.5 : Summary report on activities of the Leakage simulation alliance [42]

Task 6.1.2 The activities of the leakage simulation alliance will be summarised in a report (D6.5). This report will describe activities such as site visits, workshops, data exchange and joint reports/publications to highlight new and strengthened collaboration achieved through ENOS

D6.6 : Roadmap for CO2-Buffering in the Dutch greenhouse sector to 2030 [42]

The report describes a roadmap for developing CO2 buffering in the Dutch greenhouse sector up to 2030 (part of Task 6.5 in WP6). The roadmap will clearly outline the necessary technical and organisational milestones, expected duration, potential challenges and solutions associated with realising the CO2 buffering concept.

D6.7 : Towards a strategic development plan for CO2 EOR in the Vienna Basin [42]

The report describes a strategic implementation plan for CO2 EOR in the Vienna Basin (part of Task 6.5 in WP6). The potential drivers and barriers to the development of CO2 EOR in the region of Austria, the Czech Republic, and Slovakia will be evaluated. Based on existing data, estimates will be made on both the economic and environmental benefits for the region.

D6.8 : Study on new pilot and demonstration project opportunities in Europe [42]

Task 6.3 - The study will contain description of a diverse portfolio of geological settings and EU regions with little CCS activity to date. Emphasis will be given to factors that have lead to a successful pilot or demonstration sites elsewhere, trying to explain why and where that success could be replicated. The most important factors are the geological setting and surface conditions such as vicinity/properties of CO2 sources, infrastructure etc.

D6.9 : Report on the focus group activities and recommendations [46]

Task 6.1.3 Report presenting the outcomes of the different focus groups and the resulting recommendations for the future. The report will include the presentation of the different activities conducted during the project. A general conclusion of task 6.1.3 will also be included.

D6.10 : Follow-up plan for continuation of ENOS pilot projects [46]

Task 6.4 Plans for further development of storage and injection test sites of the ENOS portfolio - they will be important for sustaining the impetus derived from ENOS, paving the way for further development of the sites and helping the site owners to adjust their site-related plans according to the needs of the European and international context.

D6.11 : 2nd report on Twinning Programme [48]

Task 6.1.1 Report presenting the site twinning activities taken place in the second half of the project

D6.12 : 2nd report on European links, liaison and knowledge exchange [48]

Task 5.2 The report will present the international cooperation and knowledge exchange activities undertaken within the ENOS project during the second project period (months 24 - 48).

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS4	International collaboration input to Work programme planned	1 - BRGM	3	D6.1
MS13	Input from End-User Committee 1	10 - IRIS	11	Key outcomes from meeting
MS23	Input from End-User Committee 2	10 - IRIS	23	Key outcomes from meeting
MS32	Input from End-User Committee 3	10 - IRIS	35	Key outcomes from meeting
MS34	Advisory board input 2	1 - BRGM	36	report and note on impact on ENOS

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS35	End of all field activity	1 - BRGM	36	End of CO2 injection and ENOS data acquisition
MS36	Input from End-User Committee 4	10 - IRIS	47	Key outcomes from meeting

Work package number ⁹	WP7	Lead beneficiary ¹⁰	10 - IRIS
Work package title	Spreading innovation		
Start month	1	End month	48

Objectives

WP7 will communicate R&D results between work packages, present the ENOS project results and deliver TRL improvements externally to the R&D, engineering, business, operational industrial and regulatory communities. This WP will enhance the results of the project and maximize its impact by bringing the technology towards the market through publications, best practices and patents, as appropriate. Furthermore, WP7 will help deliver cross-disciplinary integration of the research and researchers. The core group of WP7 will be the Scientific Editor Committee that will gather, analyse, and steward the knowledge developed in WPs 1-5 by promoting collaboration, encouraging and supervising publication, aiding in organising workshops and knowledge exchange with research industrial and policy making communities. One of the key instruments will be a plan for dissemination and exploitation of the innovative ENOS results (task 7.3.1). The Scientific Editor committee will be also responsible for contents of the ENOS newsletter (task 7.3.2) and website. The Scientific Editors will work in close cooperation with WP leaders and will also be responsible for bringing attention to important breakthroughs and updates from WPs 1-5 to WP 6 and -8.

Key objectives are:

- To facilitate research integration and dissemination across the WPs
- To author best practice guidance documents specifically aimed at industrial sector and policy makers to favour market uptake of the research results
- To promote exploitation of project results among the research community

Description of work and role of partners

WP7 - Spreading innovation [Months: 1-48]

IRIS , BRGM, BGR, BGS, CGS, CIEMAT, CIUDEN , flodim, GGR, IDIL, NHAZCA, OGS, PLC-3, SGIDS, SILIXA, SOTACARBO, TNO, UNIROMA1, UNOTT, CO2GeoNet

Task 7.1 Research integration (IRIS, all partners)

The task objective is to facilitate and boost cross-disciplinary collaboration and integration of results between WPs 1-5, by establishing board of Scientific Editors and providing a reliable and convenient web platform.

7.1.1 Knowledge integration workshops (IRIS, all partners)

ENOS will tackle different field of science covering a broad spectrum of geosciences metrology, economics and social sciences. Outcomes from each field need to be seen in light of each other. Only through such integration can CO2 storage gain the required level of confidence from all stakeholders and progress to implementation at large scale. Integration of the ENOS research will be achieved through Knowledge Integration Workshops, that will address cross cutting issues and leave ample time for discussion and group work. The key goal of the workshops is to allow participating ENOS researchers to reflect on the implications of their results for storage as a whole, which will support the development of best practice documents and other communications outputs. The Workshops will be organized at least annually in conjunction with other events. The work in this task will serve as a bridge between WPs 1-5 and provide ground material for WP 6 and WP 8 by defining cross-cutting and common issues in the storage lifecycle, e.g. risk management, economics. These will be defined during the first year of the project and will contribute both to the identification of the dissemination materials and to the creation of fit-for-purpose best practice documents.

7.1.2 Web site and Knowledge-Sharing Platform (OGS)

The web site and knowledge-sharing platform will be established within the first 6 months. The key goals for the website are to provide i) a collaborative internal area open only to project partners and ii) a public area . The website will be based on the technologies developed by OGS and used for the established CO2GeoNet website. Easy-to-use technology for tracking the project status, exchanging draft documents and for publishing results will facilitate information sharing and collaboration across the whole ENOS team. The open access area of the website will provide information for interested parties outside the project, such as industry, decision makers and regulators. The ENOS website will be easy to navigate and be useful for both scientifically-literate people as well as the interested general public.

Sub task 7.1.2 will persist for the whole ENOS project duration and comprises technical support and maintenance as well as technology updates of the website.

Impact

This task should provide facilities in the form of website and workshops in order to facilitate, information flow and co-operation between the ENOS partners across WPs 1-5. The impact should be in increased knowledge building, aligned research efforts and better handling of project and R&D bottlenecks.

Task 7.2 Best practices (CO2GeoNet-GEOINZ, all partners)

Objective:

A significant amount of data and knowledge has been produced across the CC(U)S community in different countries. This knowledge covers most of the CC(U)S value chain, however, rather limited efforts to optimize, connect and standardise the data and approaches have been made so far. The key objective of this task is to create a set of best practices- and guidance documents based on the research findings in WPs 1-5. The best practices and guidelines should form a set of short, down to the point documents aimed at particular target groups, such as decision makers, risk managers, financial officers and regulators in order to streamline the development of storage projects as well as to reduce costs associated with planning and design.

Planned activities: The Scientific Editors together with WP leaders shall identify technologies reaching TRL 6 and summarize the essential results ready to be included in the best practice documents. The best practices would be created based on the detailed technical guidance documents from WPs 1-5. The four best practices to be produced are short and focused documents aimed at Research and Development, Business and Industry, Government and Regulators and NGOs and General Public communities. The aim is to design and develop a useful and informative document for each target group that would boost market uptake and brief each of the target groups in best available solutions and practices through the whole CCUS value chain. Representatives from target groups will be invited to form an End-User Committee to provide input and feed-back to these guidance documents. The End-User Committee meetings will be held at least on an annual basis and will provide a platform for open cooperation and integration between research, industrial and regulatory actors.

Impact:

The current state-of-the-art data and the advancements achieved in WPs 1-5 will be collated and analysed and the increase in the TRL-level will be evaluated. A set of best practices will be created. The resulting document package will help to reduce the costs, to confine uncertainties and to streamline the development of CCS projects. Collaboration with the end-user committee which includes representatives from industry actors and regulators shall draw together the research and industry sectors to ensure WP7 outputs are suitable for targeted end users.

Task 7.3 Promoting exploitation of ENOS results (TNO, CO2GeoNet-TTUGI, CGS, IRIS, CO2GeoNet-GeoEcoMar, CO2GeoNet-GEOINZ, CIUDEN)

Objectives:

The task objective is to develop and update an innovation management strategy with plans for dissemination, exploitation and communication of ENOS results and actions, the first drafts of which have been outlined in Section 2.2. The planning will include goals and criteria for publications and patents and identification of target groups and their primary interests. Coordination of workshops and forums spanning across ENOS organised for outside communities will also be part of the task 7.3. Moreover, preparation, publication and distribution of ENOS newsletters are planned. Task 7.3 comprises the following sub-tasks.

ENOS will contribute, upon invitation by the INEA, to common information and dissemination activities to increase the visibility and synergies between H2020 supported actions.

Task 7.3.1 Plans for dissemination and exploitation of results

This subtask will coordinate, update and follow-up the dissemination and exploitation of the project results, presented in Section 2.2. The Scientific Editors together with the work package leaders will be responsible for identifying and facilitating the opportunities for bringing to the market the main outcomes and messages of the project, through publications and communications, contacts with end users and patents where relevant. The plan for dissemination and exploitation of results will include an end user communication plan with events and conferences to be organised, strategic external events to be attended, a publication strategy and IPR management for near market results. The plan will be regularly updated during the project, i.e. at the start of the project, mid-term and in the final stage of the project.

Task 7.3.2 Scientific dissemination

Every publication and conference-participation related to ENOS activities will be coordinated and supported by the scientific editors and WP leaders through WP7. Scientific editors will also bring attention to material that is ready for publication and encourage dissemination of results. Participation in large strategic events will be coordinated and partially financed through WP7. The key event organised by ENOS for presenting its results will be the Open Forum annually hosted by CO2GeoNet in Venice. Workshops and/or training sessions spanning across WPs would be organized at least annually in conjunction with the Open Forum, to meet the dissemination, engagement and education aims of ENOS.

Task 7.3.3 Promoting utilisation of ENOS results

An annual newsletter will promote ENOS' progress among the technical community but also to policy makers, regulators and the public. The newsletter will be made available in both an electronic format on ENOS website and in printed form to be distributed at special events. All ENOS members participating in scientific and general meetings as well as professional and social media will be asked to advertise, promote and distribute the project newsletter. Newsletters editor CO2GeoNet-TTUGI will have the editorial responsibility for the newsletter and the publishing commitment. The contents, structure and format of the newsletter will be developed jointly with the Scientific Editors.

Starting from the plans built in Subtask 7.3.1, this subtask will generate and provide information to the ENOS partners in order to facilitate knowledge transfer to local target groups. A seminar format (including a platform for webinars) will be designed in order to address industry, regulators and operators and allow to follow up on their response.

The webinars should also allow engagement of a broader audience by providing a simple and cost-free (no travels, no participation fee) platform for knowledge sharing across Europe (including SMEs) and to the rest of the world.

CO2GeoNet-TTUGI is responsible for the Task 7.3.3

Impact

Aligned dissemination of results and tighter interaction with target groups should allow the development of stronger and consistent messages and, boost market uptake and utilisation of ENOS results beyond the involved ENOS partners. Interaction with other WPs: WP7 will be very strongly linked with all other WPs as it will gather and integrate results from WP1-5 and help define the content of the activities in WP6 and 8.

Participation per Partner

Partner number and short name	WP7 effort
1 - BRGM	6.00
2 - BGR	3.00
3 - BGS	5.40
4 - CGS	15.00
5 - CIEMAT	1.00
6 - CIUDEN	3.00
7 - flodim	1.00
8 - GGR	0.50
9 - IDIL	1.00
10 - IRIS	14.00
11 - NHAZCA	1.00
12 - OGS	14.00
13 - PLC-3	0.00
IPF	2.00
ENAGAS	3.50
14 - SGIDS	1.00
15 - SILIXA	1.00
16 - SOTACARBO	1.00
17 - TNO	10.00
18 - UNIROMA1	4.00
19 - UNOTT	1.00
20 - CO2GeoNet	0.00

Partner number and short name	WP7 effort
METU	1.00
GBA	3.00
HWU	1.00
UNIZG-RGNF	1.00
GEUS	3.00
IGME	3.40
GEOECOMAR	7.30
TTUGI	11.30
GSB-RBINS	1.00
GEOINZ	7.00
Total	127.40

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D7.1	Plan for dissemination and exploitation of results	17 - TNO	Report	Confidential, only for members of the consortium (including the Commission Services)	6
D7.2	Web-platform	12 - OGS	Websites, patents filling, etc.	Public	7
D7.3	Results of OpenForum n°1	12 - OGS	Websites, patents filling, etc.	Public	7
D7.4	Newsletter 1	20 - CO2GeoNet	Websites, patents filling, etc.	Public	10
D7.5	Annual publication summary report n°1	10 - IRIS	Report	Public	13
D7.6	Results of OpenForum n°2	12 - OGS	Websites, patents filling, etc.	Public	19
D7.7	Short note summarizing knowledge integration workshop n°1	10 - IRIS	Report	Public	19

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D7.8	Newsletter 2	20 - CO2GeoNet	Websites, patents filling, etc.	Public	22
D7.9	Updated plan for dissemination and exploitation of results	17 - TNO	Report	Confidential, only for members of the consortium (including the Commission Services)	25
D7.10	Annual publication summary report n°2	10 - IRIS	Report	Public	25
D7.11	Results of OpenForum n°3	12 - OGS	Websites, patents filling, etc.	Public	31
D7.12	Short note summarizing knowledge integration workshop n°2	10 - IRIS	Report	Public	31
D7.13	Newsletter 3	20 - CO2GeoNet	Websites, patents filling, etc.	Public	34
D7.14	Best practice documents	20 - CO2GeoNet	Report	Public	40
D7.15	Annual publication summary report n°3	10 - IRIS	Report	Public	40
D7.16	Short note summarizing knowledge integration workshop n°3	10 - IRIS	Report	Public	43
D7.17	Newsletter 4	20 - CO2GeoNet	Websites, patents filling, etc.	Public	43
D7.18	Final plan for exploitation of results	17 - TNO	Report	Public	45

Description of deliverables

Task 7.1
D7.2 Web-platform (OGS, Month 7)
D7.7,D7.12, D7.16 Short notes summarizing knowledge integration workshop (Month19,31, 43)
Task 7.2
D7.14 Best practice documents (CO2GeoNet- GEOINZ, Month 44)

Task 7.3

D7.1 Plan for dissemination and exploitation of results (TNO, Month 6)

D7.9 Updated plan for dissemination and exploitation of results (TNO, Month 25)

D7.4, D7.8, D7.13 Newsletters (CO2geoNet-TTUGI, Month 10, 22, 34)

D7.5, D7.10, D7.15 Annual publication summary report (IRIS, Month 13, 25, 40)

D7.3, D7.6, D7.11 Results of Open Forum (OGS, Month 7, 19, 31)

D7.17 Final plan for exploitation of results (TNO, Month 45)

D7.1 : Plan for dissemination and exploitation of results [6]

The plan for dissemination and exploitation of results describes the actions to bring to the market the main outcomes and messages of the project, through publications and communications, contacts with end users and patents where relevant. The plan will include an end user communication plan with events and conferences to be organised, strategic external events to be attended, a publication strategy and IPR management for near market results (Task 7.3.1 in WP7)

D7.2 : Web-platform [7]

The web platform including both internal (aimed at data and knowledge exchange for project partners) and external (aimed at dissemination and general public) should be established and filled in with general project information

D7.3 : Results of OpenForum n°1 [7]

The report from the 2016 open forum would be made available on specialised and ENOS web site as soon as the web platform is established.

D7.4 : Newsletter 1 [10]

An annual newsletter will promote ENOS' progress (task 7.3.3) among the technical community, policy makers, regulators and the public. The newsletter will be made available in both an electronic format on ENOS website and in printed form to be distributed at special events. The contents, structure and format of the newsletter will be developed by the newsletters editor CO2GeoNet-TTUGI jointly with the Scientific Editors.

D7.5 : Annual publication summary report n°1 [13]

Task 7.3 A report summarising all publications by the project partners would be prepared and delivered every 12 months starting from the project start up date. The report should include references and a short summary of all publications. The report would be publically available on the ENOS project web site.

D7.6 : Results of OpenForum n°2 [19]

This deliverable is related to task T 7.3.2. The most important results of the annual Open Forum will be reported, distributed as a pdf file to all the Open Forum attendees and made available through the project website in the form of an interactive e-brochure.

D7.7 : Short note summarizing knowledge integration workshop n°1 [19]

Each knowledge integration workshop would be summarised with a short note presenting main theme, workshop participants and key outcomes. The workshops summary notes would be made available on the project website.

D7.8 : Newsletter 2 [22]

An annual newsletter will promote ENOS' progress (task 7.3.3) among the technical community, policy makers, regulators and the public. The newsletter will be made available in both an electronic format on ENOS website and in printed form to be distributed at special events. The contents, structure and format of the newsletter will be developed by the newsletters editor CO2GeoNet-TTUGI jointly with the Scientific Editors.

D7.9 : Updated plan for dissemination and exploitation of results [25]

The plan for dissemination and exploitation of results will be updated on the basis of feedback from project partners and external stakeholders (Task 7.3.1 in WP7).

D7.10 : Annual publication summary report n°2 [25]

Task 7.3 A report summarising all publications by the project partners would be prepared and delivered every 12 months starting from the project start up date. The report should include references and a short summary of all publications. The report would be publically available on the ENOS project web site.

D7.11 : Results of OpenForum n°3 [31]

Task 8.3 - Report on the preparation for university cooperation to set the basis for a coordinated Master and post-graduate Master programmes on CO2 storage (development of a network of institutions and laboratories, and educational modules/lectures)

D7.12 : Short note summarizing knowledge integration workshop n°2 [31]

Each knowledge integration workshop would be summarised with a short note presenting main theme, workshop participants and key outcomes. The workshops summary notes would be made available on the project website.

D7.13 : Newsletter 3 [34]

An annual newsletter will promote ENOS' progress (task 7.3.3) among the technical community, policy makers, regulators and the public. The newsletter will be made available in both an electronic format on ENOS website and in printed form to be distributed at special events. The contents, structure and format of the newsletter will be developed by the newsletters editor CO2GeoNet-TTUGI jointly with the Scientific Editors.

D7.14 : Best practice documents [40]

Task 7.2 Integration of research outcomes from WPs1-5 and set-up of short, down to the point documents aimed at particular target groups in order to streamline the developments of the project

D7.15 : Annual publication summary report n°3 [40]

Task 7.3 A report summarising all publications by the project partners would be prepared and delivered every 12 months starting from the project start up date. The report should include references and a short summary of all publications. The report would be publically available on the ENOS project web site.

D7.16 : Short note summarizing knowledge integration workshop n°3 [43]

Each knowledge integration workshop would be summarised with a short note presenting main theme, workshop participants and key outcomes. The workshops summary notes would be made available on the project website.

D7.17 : Newsletter 4 [43]

An annual newsletter will promote ENOS' progress (task 7.3.3) among the technical community, policy makers, regulators and the public. The newsletter will be made available in both an electronic format on ENOS website and in printed form to be distributed at special events. The contents, structure and format of the newsletter will be developed by the newsletters editor CO2GeoNet-TTUGI jointly with the Scientific Editors.

D7.18 : Final plan for exploitation of results [45]

The final update of the plan for dissemination and exploitation of ENOS results will focus on follow-up activities after the end of the project, based on the main outcomes and messages from the project (Task 7.3.1 in WP7).

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS2	Establishment of scientific editor committee	10 - IRIS	3	First meeting of Scientific Editor Committee
MS6	update of plan for dissemination and exploitation of results	10 - IRIS	7	Dissemination plan delivered to all partners
MS10	Establishing of the web-platform	12 - OGS	7	Web-site available for ENOS partners and general public
MS13	Input from End-User Committee 1	10 - IRIS	11	Key outcomes from meeting
MS23	Input from End-User Committee 2	10 - IRIS	23	Key outcomes from meeting

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS32	Input from End-User Committee 3	10 - IRIS	35	Key outcomes from meeting
MS34	Advisory board input 2	1 - BRGM	36	report and note on impact on ENOS
MS35	End of all field activity	1 - BRGM	36	End of CO2 injection and ENOS data acquisition
MS36	Input from End-User Committee 4	10 - IRIS	47	Key outcomes from meeting

Work package number ⁹	WP8	Lead beneficiary ¹⁰	20 - CO2GeoNet
Work package title	Promoting CCS through Training and education		
Start month	1	End month	48

Objectives

In WP8, ENOS will address the need for training of young scientists to build the skill-base necessary for large scale development of CO2 storage in Europe. The objective of WP8 is to provide the upcoming generation of scientists with up-to-date CCS skills and therefore to support objectives of the SET-Plan on European Energy Education and Training Initiative (2012). Valuable input will also be provided by WP5 on communication. In particular WP8 will aim to:

- Develop intensive training weeks, for young scientists, dedicated to Onshore CO2 geological storage and the implementation of the EU- Directive and will be based on latest research results and real-life experience.
- Build awareness on climate change and opportunities for mitigation action utilising CCS through building e-learning courses
- Initiate a university cooperation on CO2 storage education and a coordinated Master and post-graduate Master programmes through the development of a network of institutions and laboratories, and the development of educational modules
- Provide short courses for journalists and media to raise awareness on CCS and enhance communication between scientists and journalists.

Description of work and role of partners

WP8 - Promoting CCS through Training and education [Months: 1-48]

CO2GeoNet, BRGM, BGR, BGS, CGS, CIUDEN, OGS, TNO, UNIROMA1, UNOTT

Task 8.1 Education and training for the European research community (CO2GeoNet-GEUS, BRGM, BGS, CGS, CIUDEN, UNIROMA1 and CO2GeoNet-GeoEcoMar)

Context:

Five successful CCS schools were held during the COACH and CGS Europe projects giving a well-established concept to build on. Furthermore CO2GeoNet was involved in the organisation of and presented at previous IEAGHG summer schools and the EAGE European lecture tour.

The purpose of the CGS Europe Spring School on CO2 Geological Storage was to offer an advanced course on geological storage of carbon dioxide, allowing for knowledge sharing and learning about near zero-emission power generation delivered by CGS Europe and CO2GeoNet researchers and scientists. The evaluations of the two sessions held were very positive and showed that there is a high level of satisfaction with the content, and coherency of the sessions. It is proposed that this success should be captured and continued by the development of topical CO2 storage schools.

Description of work:

Topical CO2 storage Schools will be prepared and organized (i.e. one week intensive schools for young researchers (MSc and PhD students, post-graduate students, early-career researchers). The CO2 storage school course material will be further developed and updated with the most recent results from the storage pilots on site assessment, characterisation and risk management. The preparation of the courses will take advantage of the interaction between project partners and the cross-disciplinary environment in ENOS.

Three intensive schools on CO2 Geological storage are planned for countries with planned storage sites used by the ENOS project (Czech Republic, Italy and Spain). Each school will cover 7 days of lectures and exercises and will target young researchers. The overall objective is to communicate knowledge and understanding of CO2 geological storage from real-life experience at ENOS pilot sites including monitoring, modelling and verification (and an introduction to capture and transport for context) in order to enthuse and engage the next generation of scientists.

Impact:

Promoting CCS by teaching real-life experience from the ENOS storage sites will foster interest in the upcoming generation, fill the expected skill gap identified by the SET-plan and initiate knowledge transfer and capacity building, needed for the widespread deployment of the technology. In addition, the schools and lecture tours will help to create international networking opportunities to the next generation of scientists.

Task 8.2 Developing and providing an e-learning course (BGR, BGS, CGS, CO2GeoNet-GeoEcoMar, OGS, CO2GeoNet-GEUS, CO2GeoNet-HWU, CO2GeoNet-TTUGI, CO2GeoNet-UNIZG-RGNF, UNOTT, UNIROMA1)

Context:

E-learning and blended learning are common, up-to-date education tools used at modern universities. A variety of tools and platforms are available for these purposes. E-learning is a flexible and convenient educational method, providing a wider community of users with learning materials. It can be accessed at any time and any place allowing users to learn at their own pace. ENOS will provide and promote multi-media information and e-lectures on the web-site. The utilisation of e-learning and training for the broader community will help to grow public awareness on climate change and mitigation action utilising CCS.

Description of work:

WP8 will organise e-learning: internet based training on CCS, reaching out to a broad audience. Therefore, ENOS will develop 10 e-lectures on various aspects of CCS, containing generic knowledge (aimed at the general public) and as well specific technical knowledge on CO₂ storage, based on state-of-the-art understanding from comprehensive ongoing R&D efforts (aimed at students or stakeholders).

The 10 e-lectures will be grouped into three e-learning series covering the following topics:

- Climate change and importance of CCS technology for decarbonisation of energy and industry
- Geosciences applied to geological storage of CO₂
- Regulatory and social aspects of CCS technology

Each e-learning series will be published as an e-book.

The planned activities of this task are:

- a) internal workshop for the development of a curriculum
- b) agreement on e-learning tools, platform and on common design and layout templates
- c) preparation of lecture material
- d) internal workshop for first presentation and discussion of lecture drafts
- e) improvements and adaptations of e-lectures
- f) internal workshop for final discussions of e-lectures
- g) publication of e-lectures/e-books on the project web-site or/and a suitable external platform

Impact:

E-learning will provide training and dissemination of the cutting edge research results to a much wider audience. The specific technical content of the e-lectures will contribute to the dissemination of ENOS research results while the generic content will help raising public awareness on CCS.

Task 8.3 CCS educational programme (UNIROMA1, CO₂GeoNet-GEUS, CO₂GeoNet-HWU, CO₂GeoNet-TTUGI, CO₂GeoNet-UNIZG-RGNF, UNOTT)

Context:

A non-exhaustive mapping of EU universities, research centres and laboratories with expertise and competences in CCS was collected in the SET Plan Energy Education & Training Report Carbon Capture and Storage, assessment report (2012) and a list of courses covering the CCS chain was compiled. The outcome showed needs and highlighted possible gaps in E&T in the CCS chain. If Europe is to deploy CCS, the manpower needed for storage (site characterisation + monitoring) is slightly higher than required for capture whereas the needs are about equal for the rest of the World. However, in the next 15 years, the need in manpower in Europe will be much higher for storage than for capture. Degree courses including CO₂ storage study are therefore necessary to support long term deployment. ENOS will foster such capacity building, by developing cooperation between participating universities.

Some universities in Europe already have a programme for harmonising higher education, establishing international curricula or for completion of the Double Degree requirements (120 ECTS), where two separate diplomas are conferred to the student according to the local regulations. Other universities are part of an international group called 'Universitas 21,' where they exchange students on their undergraduate programmes for entire semesters, offering the chance to study abroad. UNIROMA1 and UNOTT are already partner in the Erasmus Mundus Program, which supports teaching activities shared for a total of 120 ECTS over a two year course. Other exchange programmes are already active between the University partners in ENOS, which can facilitate the the transfer of grades from the host institute to the home institute.

Description of work:

The internationalization of higher education as well as the international mobility of students, contributes to the development of a European generation which share needs and objectives. University networks, supported by research institutes and the other partners of ENOS will build a framework for a Master-level course that specifically addresses CO₂ storage practise and techniques, starting from site characterization to monitoring techniques, in order to produce a new professional training, specifically preparing to manage CCS techniques and solve specific problems. Existing schemes, programmes and curricula in the courses given by university partner will be improved and focused on CCS activities, following the industry needs and, while at the same time retaining the necessary broad knowledge basis to

offer flexible curricula responsive to the market needs of the low carbon economy. This task will focus on education for the future and will provide a plan to meet the needs and fill the gaps within CCS Education and Training in Europe in order to support the objectives of the SET-Plan on European Energy Education and Training Initiative (2012). During the first 12 months, a plan for joint MSc and PhD programme will be designed. A possible framework for such programme will be investigated as well as the different role of ENOS partners, i.e. the Universities, institutions and industry. Led by the university partners, the ENOS project will prepare a possible structure.

For the following 24 months, 5 students, one in each of the partners CO2GeoNet-HWU, CO2GeoNet-TTUGI, CO2GeoNet-UNIZG-RGNF, UNOTT, UNIROMA1 shall be offered support to attend courses at the other partner institutes. At the end of the project an evaluation report on the experience of the students and institutes to ensure lessons learned will be available to support future activities.

Impact:

This task aims to enable long term impacts from ENOS by fostering enhanced collaboration between universities at the forefront of CCS research and by providing the basis for sound CO2 storage education for the upcoming generation of scientists

Task 8.4 Raising awareness by training workshops for journalists and media (CO2GeoNet-IGME, BRGM, BGS, CGS, CIUDEN, CO2GeoNet-GEOINZ, TNO, UNOTT, UNIROMA1)

Context:

Interaction with the media is regarded as a major channel for effective dissemination to the general public and an effective way of promoting CCS. Scientific matters can however be difficult to communicate, and the media has a role to clear misconceptions and provide impartial information. During the CGS Europe project period, focus on organisation of opportunities for direct interaction between researchers and journalists resulted in a more in-depth learning about the technology and an improved communication between researchers and journalists. Other key events were the CO2GeoNet Open Forum and workshops with science journalists. The participation of science journalists to events such as the annual CO2GeoNet Open Forum was an excellent opportunity for supporting a thorough understanding of the technology, and the journalists had the opportunity of information exchange with some of the most prominent researchers in the field and thus access to verified scientific information.

Description of work:

The ENOS project will continue the action that was started by the CGS Europe project and further develop interaction with media through direct interaction with science journalists as well as local journalists near the project pilot sites (Italy, Czech Republic, Spain). Direct exchange with media professionals and press releases can be the best channel for the dissemination of complex technical and scientific knowledge, such as the multidisciplinary research area of the geological storage of CO2.

Participation of science journalists to events planned in connection with the annual CO2GeoNet Open Forum, where the latest research developments are presented, will be an excellent opportunity to promote CCS by providing an understanding of the technology, greater than what can be achieved through reading documents or internet resources.

In the backyard of the pilot projects, i.e. in the local community, WP8 in coordination with WP5 will arrange events, where journalists and targeted local stakeholders will have the opportunity for face-to-face exchanges with some of the most prominent researchers in the field, offering accurate, cutting edge and direct access to verified scientific information. In this context, important issues to be communicated are safety, monitoring and site management. Activities will be co-organised with European Union of Science Journalists' Associations, CSLF and IEAGH whenever possible.

Impact:

By creating a lasting relationship with journalists and supporting in depth understanding of the CO2 geological storage technology, ENOS will participate in the raising awareness on CCS. This will also enable debates of CCS on a sound scientific basis.

Interaction with other WPs WP8 will benefit from the knowledge integration and results exploitation plan developed in WP7 to identify topics that should be included in the different training activities and in the interaction with the media. Particular interaction will be with WP5 coordination with local population, where communication activities towards the general public will also be undertaken.

Participation per Partner

Partner number and short name	WP8 effort
1 - BRGM	2.50

Partner number and short name	WP8 effort
2 - BGR	3.00
3 - BGS	2.80
4 - CGS	3.00
6 - CIUDEN	2.00
12 - OGS	1.00
17 - TNO	1.00
18 - UNIROMA1	5.50
19 - UNOTT	3.50
20 - CO2GeoNet	0.00
HWU	3.30
UNIZG-RGNF	3.20
GEUS	8.00
IGME	4.20
GEOECOMAR	3.00
TTUGI	3.80
GEOINZ	1.00
Total	50.80

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D8.1	E-book: Climate change and importance of CCS technology for decarbonisation of energy and industry	2 - BGR	Websites, patents filling, etc.	Public	10
D8.2	Joint education activities – Report 1, including outcome of internal workshop for the development of the joint curriculum	18 - UNIROMA1	Report	Confidential, only for members of the consortium (including the Commission Services)	10
D8.3	Report on awareness raising course for journalists workshop and interactions with	20 - CO2GeoNet	Report	Public	13

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
	media – months 1-12				
D8.4	E-book: Geoscience applied to geological storage of CO ₂	2 - BGR	Websites, patents filling, etc.	Public	14
D8.5	ENOS Spring School 1 on CO ₂ storage	20 - CO ₂ GeoNet	Websites, patents filling, etc.	Public	17
D8.6	E-book: Regulatory and social aspects of CCS technology	2 - BGR	Websites, patents filling, etc.	Public	22
D8.7	Report on awareness raising course for journalists workshop and interactions with media – months 13-24	20 - CO ₂ GeoNet	Report	Public	25
D8.8	ENOS Spring School 2 on CO ₂ storage	20 - CO ₂ GeoNet	Websites, patents filling, etc.	Public	29
D8.9	Report on awareness raising course for journalists workshop and interactions with media – months 25-36	20 - CO ₂ GeoNet	Report	Public	37
D8.10	Evaluation of joint Master and post-graduate Master educational programme based on first experience	18 - UNIROMA1	Report	Public	37
D8.11	Outcome of building and providing an e-learning course	2 - BGR	Report	Public	38
D8.12	Outcome of WP8 - Promoting CCS through Training and education	20 - CO ₂ GeoNet	Report	Public	39

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D8.13	ENOS Spring School 3 on CO2 storage	20 - CO2GeoNet	Websites, patents filling, etc.	Public	40
D8.14	Report on interactions with media and journalist final report 37-45	20 - CO2GeoNet	Report	Public	45

Description of deliverables

Task8.1
D8.5, D8.8 D8.13 reports on each ENOS Schools CO2GeoNet-GEUS, M17,29,40

Task 8.2
D8.1 - E-book: Climate change and importance of CCS technology for decarbonisation of energy and industry, BGR (M10)
D8.4 -E-book: Geoscience applied to geological storage of CO2, BGR, (M14)
D8.6 - E-book: Regulatory and social aspects of CCS technology , BGR (M22)
D8.11 - Outcome of building and providing an e-learning course, BGR (M38)

Task 8.3
D8.2 - Joint education activities – Report 1, including outcome of internal workshop for the development of the joint curriculum, UNIROMA1 (M10)
D8.10 - Evaluation of joint Master and post-graduate Master educational programme based on first experience, UNIROMA1 (M37)

Task 8.4
D8.3 D8.7 D8.9 D8.14 - Report on awareness raising course for journalists workshop and interactions with media year 1, 2,3,4 CO2GeoNet-IGME (M13, 25, 37 and 48)
D8.12 Outcome of WP8 - Promoting CCS through Training and education, CO2GeoNet-GEUS (M39)

D8.1 : E-book: Climate change and importance of CCS technology for decarbonisation of energy and industry [10]
Task 8.2 - Report on the first experiences on e-learning course for students and the civil society, and provision of e-learning materials on a web platform

D8.2 : Joint education activities – Report 1, including outcome of internal workshop for the development of the joint curriculum [10]

Task 8.3 - Report on the preparation for university cooperation to set the basis for a coordinated Master and post-graduate Master programmes on CO2 storage (development of a network of institutions and laboratories, and educational modules/lectures)

D8.3 : Report on awareness raising course for journalists workshop and interactions with media – months 1-12 [13]
Task 8.4 - Report on short courses for journalists and media, an on enhancing scientist-journalist communication, leason learnt

D8.4 : E-book: Geoscience applied to geological storage of CO2 [14]
Task 8.2 - Report on the experiences on e-learning course for students and the civil society, leasons learnt, and provision of e-learning materials on a web platform

D8.5 : ENOS Spring School 1 on CO2 storage [17]
Task 8.1 - Report on the training courses for young scientists on onshore CO2 geological storage and latest research, leasons learnt

D8.6 : E-book: Regulatory and social aspects of CCS technology [22]

Task 8.2 - Report on the experiences on e-learning courses for students and the civil society, lessons learnt, and provision of e-learning materials on a web platform

D8.7 : Report on awareness raising course for journalists workshop and interactions with media – months 13-24 [25]

Task 8.4 - Report on short courses for journalists and media, and on enhancing scientist-journalist communication, lessons learnt

D8.8 : ENOS Spring School 2 on CO2 storage [29]

Task 8.1 - Report on the training courses for young scientists on onshore CO2 geological storage and latest research, lessons learnt

D8.9 : Report on awareness raising course for journalists workshop and interactions with media – months 25-36 [37]

Task 8.4 - Report on short courses for journalists and media, and on enhancing scientist-journalist communication, lessons learnt

D8.10 : Evaluation of joint Master and post-graduate Master educational programme based on first experience [37]

Task 8.3 - Outcome of the cooperation between universities on a coordinated Master and post-graduate Master programmes, lessons learnt, recommendations

D8.11 : Outcome of building and providing an e-learning course [38]

Task 8.2 - Outcome of the e-learning course for students and for the civil society, lessons learnt, recommendations

D8.12 : Outcome of WP8 - Promoting CCS through Training and education [39]

Task 8.4 - Report on the experiences from the different training activities, e-learning, intensive schools, cooperation between universities on a coordinated Master and post-graduate Master programmes, and on interaction with media and journalists, synthesis report

D8.13 : ENOS Spring School 3 on CO2 storage [40]

Task 8.1 - Report on the promoting of onshore CO2 geological storage through intensive training courses for young scientists, lessons learnt from all 3 schools

D8.14 : Report on interactions with media and journalist final report 37-45 [45]

Task 8.4 - Report on the interaction with journalists and media, and on enhancing scientist-journalist communication, lessons learnt

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS12	plans for WP8 education activities	20 - CO2GeoNet	10	Report on workshop
MS13	Input from End-User Committee 1	10 - IRIS	11	Key outcomes from meeting
MS23	Input from End-User Committee 2	10 - IRIS	23	Key outcomes from meeting
MS32	Input from End-User Committee 3	10 - IRIS	35	Key outcomes from meeting
MS34	Advisory board input 2	1 - BRGM	36	report and note on impact on ENOS
MS35	End of all field activity	1 - BRGM	36	End of CO2 injection and ENOS data acquisition
MS36	Input from End-User Committee 4	10 - IRIS	47	Key outcomes from meeting

Work package number ⁹	WP9	Lead beneficiary ¹⁰	1 - BRGM
Work package title	Management		
Start month	1	End month	48

Objectives

- To execute smoothly and efficiently the operational, legal, financial and administrative management of the ENOS project and consortium.
- To manage site operations

Description of work and role of partners

WP9 - Management [Months: 1-48]

BRGM, BGS, CGS, CIUDEN , IRIS , PLC-3, SOTACARBO, TNO, UNIROMA1, UNOTT, CO2GeoNet

Task 9.1 Communication with the EC and contractual reporting (BRGM)

- Communication with the EC and the consortium participants for all contractual, legal, financial and administrative issues
- Submission of deliverables to the EC in due time
- Supporting Partners in issues with H2020 framework

Task 9.2 Operational management of the project by the Management Board (BRGM, CIUDEN, BGS, TNO, UNIROMA1, CGS, IRIS, CO2GeoNet-GEUS)

- Hold and attend Management Board meetings every two months (mainly webconferences) to discuss the overall progress of the project, address arising difficulties, discuss emerging ideas or opportunities, take specific decisions;
- Monitor the progress of ENOS
- Prepare the annual General Assembly meetings, where strategic decisions will be taken;
- Organise the consultation with the Advisory Body;

Task 9.3 Site activities management (CIUDEN, BGS, Sotacarbo or UNIROMA1,TNO, CGS)

Practical site operations are always subject to uncertainties related to operational and legal issues that have to be taken into account while building and managing a project.

At the beginning of the project, precise plans for each site will be prepared. The plan will include:

- Necessary data to be exchanged – management of potential IPR issues
- Detailed timing of the different activities
- Necessary logistics
- Staff to be involved from each institute
- Risks and mitigation plan
- Management of datasets produced and open access

Plans will be regularly updated and deviations will be explained. No major field activities will be planned in the last year of the project, in order to be able to buffer any unplanned minor delays.

Participation per Partner

Partner number and short name	WP9 effort
1 - BRGM	23.00
3 - BGS	10.90
4 - CGS	8.00
6 - CIUDEN	11.00
10 - IRIS	5.00
13 - PLC-3	0.00
IPF	1.00

Partner number and short name	WP9 effort
16 - SOTACARBO	4.00
17 - TNO	5.00
18 - UNIROMA1	5.00
19 - UNOTT	3.00
20 - CO2GeoNet	0.00
GEUS	8.00
Total	83.90

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D9.1	Plan for site activities	6 - CIUDEN	Report	Confidential, only for members of the consortium (including the Commission Services)	4
D9.2	Minutes of Management Board and General Assembly meetings for Year 1	1 - BRGM	Report	Confidential, only for members of the consortium (including the Commission Services)	13
D9.3	Updates to site activity plans 1	6 - CIUDEN	Report	Confidential, only for members of the consortium (including the Commission Services)	16
D9.4	Minutes of Management Board and General Assembly meetings for Year 2	1 - BRGM	Report	Confidential, only for members of the consortium (including the Commission Services)	25
D9.5	Updates to site activity plans 2	6 - CIUDEN	Report	Confidential, only for members of the consortium (including the Commission Services)	28
D9.6	Minutes of Management Board and General Assembly meetings for Year 3	1 - BRGM	Report	Confidential, only for members of the consortium (including the	37

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
				Commission Services)	
D9.7	Updates to site activity plans 3	6 - CIUDEN	Report	Confidential, only for members of the consortium (including the Commission Services)	40
D9.8	Minutes of Management Board and General Assembly meetings for Year 4	1 - BRGM	Report	Confidential, only for members of the consortium (including the Commission Services)	48
D9.9	detailed Project Management Plan	1 - BRGM	Report	Confidential, only for members of the consortium (including the Commission Services)	3
D9.10	Update of detailed Project Management Plan 1	1 - BRGM	Report	Confidential, only for members of the consortium (including the Commission Services)	16
D9.11	Update of detailed Project Management Plan 2	1 - BRGM	Report	Confidential, only for members of the consortium (including the Commission Services)	28
D9.12	Update of detailed Project Management Plan 3	1 - BRGM	Report	Confidential, only for members of the consortium (including the Commission Services)	40

Description of deliverables

Task 9.2
D9.2 D9.4 D9.6 D9.8 Minutes of Management Board and General Assembly meetings for Year 1, 2,3 and 4; M 13, 25, 37, 48 BRGM

Task 9.3
D9.1 Plan for site activities , M 4,CIUDEN (BGS,CGS, Sotacarbo, TNO, UNOTT)
D9.3 D9.5 D9.7 Updates to site activity plans, M 16, 28 and 40 CIUDEN(BGS,CGS, Sotacarbo, TNO, UNOTT)
D9.1 : Plan for site activities [4]

Task 9.3 Specific planning for the activities to be conducted on each site within project scope, including data to be shared, logistics, staff, activity schedule, risks/mitigation plan and dataset management .

D9.2 : Minutes of Management Board and General Assembly meetings for Year 1 [13]

Task 9.2 Compilation of the minutes of the management Board meetings and of the annual Genral assembly in year 1

D9.3 : Updates to site activity plans 1 [16]

Task 9.3 Update of D9.1

D9.4 : Minutes of Management Board and General Assembly meetings for Year 2 [25]

Task 9.2 Compilation of the minutes of the management Board meetings and of the annual Genral assembly in year 2

D9.5 : Updates to site activity plans 2 [28]

Task 9.3 Update of D9.1

D9.6 : Minutes of Management Board and General Assembly meetings for Year 3 [37]

Task 9.2 Compilation of the minutes of the management Board meetings and of the annual Genral assembly in year 3

D9.7 : Updates to site activity plans 3 [40]

Task 9.3 Update of D9.1

D9.8 : Minutes of Management Board and General Assembly meetings for Year 4 [48]

Task 9.2 Compilation of the minutes of the management Board meetings and of the annual Genral assembly in year 4

D9.9 : detailed Project Management Plan [3]

Task 9.2 A detailed Project Management Plan with a Gantt chart and a Work Breakdown Structure (WBS), a schedule per task, responsible partner related subtasks, related deliverables, and dependencies to other tasks.

D9.10 : Update of detailed Project Management Plan 1 [16]

Task 9.2 Update of project management Plan. (D9.9)

D9.11 : Update of detailed Project Management Plan 2 [28]

Task 9.2 Update of project management Plan. (D9.9)

D9.12 : Update of detailed Project Management Plan 3 [40]

Task 9.2 Update of project management Plan. (D9.9)

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS19	Advisory board input 1	1 - BRGM	18	Advisory body report and note on impact on the project
MS34	Advisory board input 2	1 - BRGM	36	report and note on impact on ENOS
MS35	End of all field activity	1 - BRGM	36	End of CO2 injection and ENOS data acquisition

1.3.4. WT4 List of milestones

Milestone number ¹⁸	Milestone title	WP number ⁹	Lead beneficiary	Due Date (in months) ¹⁷	Means of verification
MS1	Decision on sites and modelled to be used in task 2.1 and 2.2	WP2	1 - BRGM	3	Minutes of data evaluation meeting
MS2	Establishment of scientific editor committee	WP7	10 - IRIS	3	First meeting of Scientific Editor Committee
MS3	Hontomin 3D Geological model	WP1	6 - CIUDEN	3	Data available
MS4	International collaboration input to Work programme planned	WP1, WP2, WP3, WP4, WP5, WP6	1 - BRGM	3	D6.1
MS5	Start of field activities in Sulcis Fault lab	WP5	16 - SOTACARBO	5	Staff at field
MS6	update of plan for dissemination and exploitation of results	WP7	10 - IRIS	7	Dissemination plan delivered to all partners
MS7	Hontomin 3D dynamic model	WP1	6 - CIUDEN	6	Data available
MS8	first geochemical investigation in Hontomin	WP1	1 - BRGM	6	Samples acquired
MS9	Soil Gas Monitoring installed in Hontomin	WP1	2 - BGR	6	Data acquired
MS10	Establishing of the web-platform	WP7	12 - OGS	7	Web-site available for ENOS partners and general public
MS11	Start of injection in Hontomin	WP1	6 - CIUDEN	7	First tonnes injected
MS12	plans for WP8 education activities	WP8	20 - CO2GeoNet	10	Report on workshop
MS13	Input from End-User Committee 1	WP1, WP2, WP3, WP4, WP5, WP6, WP7, WP8	10 - IRIS	11	Key outcomes from meeting
MS14	Draft Real Option Schemes for CO2 buffer and CO2-EOR	WP4	20 - CO2GeoNet	12	Discussed and validated schemes by partners of Tasks 4.1, 4.2 and 4.3

Milestone number ¹⁸	Milestone title	WP number ⁹	Lead beneficiary	Due Date (in months) ¹⁷	Means of verification
MS15	Definition of KPI and preliminary thresholds	WP1	1 - BRGM	12	Validation by partners
MS16	Identification of main geochemical processes	WP4	17 - TNO	14	Geochemical model outcome supplied to partner in Task 4.1.1
MS17	Start of field activities in GeoEnergy test bed	WP3	3 - BGS	17	Staff at field
MS18	second geochemical investigation on site	WP1	1 - BRGM	18	Samples acquired
MS19	Advisory board input 1	WP9	1 - BRGM	18	Advisory body report and note on impact on the project
MS20	Start of group meetings with citizens	WP5	18 - UNIROMA1	18	First meeting documents
MS21	Decision on designs for considered separation processes	WP4	17 - TNO	18	Approved list of process designs by partners in Tasks 4.1.1 and 4.1.2
MS22	Feedback to CO2 injection operations in Hontomin	WP1	6 - CIUDEN	21	Data available
MS23	Input from End-User Committee 2	WP1, WP2, WP3, WP4, WP5, WP6, WP7, WP8	10 - IRIS	23	Key outcomes from meeting
MS24	Selection of production scenario(s)	WP4	17 - TNO	24	Definition of scenario supplied to partner in Task 4.1.2
MS25	Drill experiment based on ENOS FEED study performed by PLC-3 (external event)	WP2	6 - CIUDEN	24	Report from operator
MS26	Launch of the Public Information tool	WP5	6 - CIUDEN	24	First version available online
MS27	Transfer of data, pending potential updates, of Tasks	WP4	17 - TNO	30	Notes with data from Tasks 4.1 and 4.2 in agreement with needs in 4.3

Milestone number ¹⁸	Milestone title	WP number ⁹	Lead beneficiary	Due Date (in months) ¹⁷	Means of verification
	4.1 and 4.2 to Task 4.3				
MS28	Last geochemical investigation at hontomin	WP1	1 - BRGM	30	Samples acquired
MS29	End of injection in Hontomin	WP1	6 - CIUDEN	31	Injection stopped
MS30	End of field activities in GeoEnergy test bed	WP3	3 - BGS	31	no more staff at field
MS31	End of field activities in Sulcis Fault lab	WP3	16 - SOTACARBO	31	no more staff at field
MS32	Input from End-User Committee 3	WP1, WP2, WP3, WP4, WP5, WP6, WP7, WP8	10 - IRIS	35	Key outcomes from meeting
MS33	Update of thresholds	WP1	1 - BRGM	36	Validation by Partners
MS34	Advisory board input 2	WP1, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9	1 - BRGM	36	report and note on impact on ENOS
MS35	End of all field activity	WP1, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9	1 - BRGM	36	End of CO2 injection and ENOS data acquisition
MS36	Input from End-User Committee 4	WP1, WP2, WP3, WP4, WP5, WP6, WP7, WP8	10 - IRIS	47	Key outcomes from meeting

1.3.5. WT5 Critical Implementation risks and mitigation actions

Risk number	Description of risk	WP Number	Proposed risk-mitigation measures
1	Staff availability: in time, staff leaving partner's staff	WP9	The WP leaders will regularly monitor staff availability with involved partners in order to ensure availability and continuity in case of staff changes in the team. This may also concern key personnel e.g. WP leaders or the coordinator. The use of the project platform, gathering all key materials for the project will provide a sound basis for ensuring continuity. The involvement of high level staff in the General Assembly will ensure potential issues are taken into account by partners head offices.
2	Delays in the execution of tasks	WP9	Work package leaders are requested to deliver a WP status report every 4 months. This guarantees a continuous monitoring of the execution of tasks within the WPs and early warning will allow to mitigate potential delays and manage their impacts. No major research activity is planned during the last year of the project.
3	Partners new to EU projects	WP9	The coordinator will support partners without sufficient experience with the execution of EU projects whenever necessary. 4 partners in the consortium have no experience in FP6 or 7 projects
4	Lack of communication and information exchange between partners	WP7, WP9	In order to ensure an efficient and effective execution of the project, partners on all project levels need to communicate regularly and in an expedient way. The coordinator and the WP and task leaders are specifically responsible to stimulate communication and collaboration between all those involved. In particular WP7, aiming at integrating the knowledge created by the project, will collect information from all WPs, provide an overview to all participants and organize events to share knowledge. The availability of electronic communication is advantageous for regular and uncomplicated interaction between partners. WP7 will build a web-based platform to ensure easy exchange of information, results and documents.
5	Risk of scarce collaboration from societal stakeholders	WP5	Particular emphasis will be given in the preparation phase to set the right conditions for collaboration in the different societal contexts involved and for peer support between project partners to overcome bottlenecks.
6	Limited injection at hontomin. Site operations always entail a risk. CO2 Injection could be either delayed or very limited due to either surface or	WP1, WP6, WP7	Experience gathered during hydraulic characterization phase and operation start-up provide solutions for avoiding problems. Equipment breakdown is solved storing spare parts on site, even of the main components. Delay in supply of CO2 is mitigated using 3 CO2

Risk number	Description of risk	WP Number	Proposed risk-mitigation measures
	subsurface problems. Operation injections in Hontomin already started and 2000t of CO ₂ were already injected. Therefore the probability of failure is low.		tanks installed on site. Issues related to reservoir injectivity would bring new insights on pressure / flow management.
7	Risk of limited or no activity possible at the GeoEnergy test bed or sulcis Fault lab. Both site are under construction and there are risks of delay and potentially not to be able to inject CO ₂ . In that case the activities in WP3 would be strongly impacted. Both sites already have their financing secured from national funds. The probability of both sites failing is low.	WP3, WP7	The advance of the preparation of the sites will be monitored carefully by the management team. In case one of the sites is not available in time, deployment of the monitoring technologies at the other site will be considered, as well as using ECCSEL infrastructures and/or the sites from the international collaboration (in Canada, Australia or South africa) In case of delay, some buffer time in the last year of the project has been planned.
8	Problems in getting access to background data related to sites. Background data is usually sensitive data. Exchange of data is however necessary for the work to be undertaken in ENOS. This risk is the highest for Q16Maas site, where exploitation data from a gas field is to be dealt with.	WP1, WP2, WP3, WP4, WP6	At project proposal stage, Site owners provided to the consortium commitment letters detailing pre-existing data that will be provided to participants. What data will be necessary has therefore been clearly identified and data to be provided from outside of ENOS funding outlined to ensure it will be available where needed for ENOS activities. The management of issues arising will be dealt in the management WP in the site operation plans. For Q16maas : timely arrangement are made with the site owner to get access to site-specific data. The FID related to the use of Q16-Maas as a storage location for the ROAD project is expected to be taken in Q4 2016. After FID, there will be more clarity about the status of the field and the availability of data and support for the study from the stakeholders involved.

1.3.6. WT6 Summary of project effort in person-months

	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	WP9	Total Person/Months per Participant
1 - BRGM	45	15	12	0	4	5	6	2.50	23	112.50
2 - BGR	10	0	32	0	2	1	3	3	0	51
3 - BGS	0	6.20	30.60	0	0	7.20	5.40	2.80	10.90	63.10
4 - CGS	0	0	8.50	9	4	17	15	3	8	64.50
5 - CIEMAT	6	0	0	0	0	0	1	0	0	7
6 - CIUDEN	102	17	1	0	21	8	3	2	11	165
7 - flodim	4	0	0	0	0	0	1	0	0	5
8 - GGR	11.40	0	0	3.50	0	0	0.50	0	0	15.40
9 - IDIL	0	0	4	0	0	0	1	0	0	5
10 - IRIS	0	0	8	10	0	3.50	14	0	5	40.50
11 - NHAZCA	0	0	6	0	0	0	1	0	0	7
12 - OGS	40	0	40	0	2	6	14	1	0	103
13 - PLC-3	0	0	0	0	0	0	0	0	0	0
· IPF	2.50	1.50	2	0	1	2.40	2	0	1	12.40
· ENAGAS	1.50	4.30	2.30	0	0	0	3.50	0	0	11.60
14 - SGIDS	0	0	0	3	0	5	1	0	0	9
15 - SILIXA	4.50	0	3	0	0	0	1	0	0	8.50
16 - SOTACARBO	0	3	5	0	8	5	1	0	4	26
17 - TNO	16	0	5	30	14	8	10	1	5	89
18 - UNIROMA1	1	0	57	0	39	4	4	5.50	5	115.50
19 - UNOTT	8	12	4.50	0	9	6	1	3.50	3	47
20 - CO2GeoNet	0	0	0	0	0	0	0	0	0	0
· METU	0	0	0	6	0	0	1	0	0	7

	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	WP9	Total Person/Months per Participant
· GBA	0	0	0	0	4	7	3	0	0	14
· HWU	4	26	16	0	3	0	1	3.30	0	53.30
· UNIZG-RGNF	0	0	0	0	0	7.30	1	3.20	0	11.50
· GEUS	0	0	0	0	0	0	3	8	8	19
· IGME	20.20	0	0	0	2	2	3.40	4.20	0	31.80
· GEOECOMAR	0	0	2.50	0	4	6.20	7.30	3	0	23
· TTUGI	0	0	0	0	2.30	5.90	11.30	3.80	0	23.30
· GSB-RBINS	0	0	0	24	0	0	1	0	0	25
· GEOINZ	0	0	0	0	0	1	7	1	0	9
Total Person/Months	276.10	85	239.40	85.50	119.30	107.50	127.40	50.80	83.90	1174.90

1.3.7. WT7 Tentative schedule of project reviews

Review number ¹⁹	Tentative timing	Planned venue of review	Comments, if any
RV1	20	Brussels	
RV2	34	Brussels	
RV3	48	Brussels	

1. Project number

The project number has been assigned by the Commission as the unique identifier for your project. It cannot be changed. The project number **should appear on each page of the grant agreement preparation documents (part A and part B)** to prevent errors during its handling.

2. Project acronym

Use the project acronym as given in the submitted proposal. It can generally not be changed. The same acronym **should appear on each page of the grant agreement preparation documents (part A and part B)** to prevent errors during its handling.

3. Project title

Use the title (preferably no longer than 200 characters) as indicated in the submitted proposal. Minor corrections are possible if agreed during the preparation of the grant agreement.

4. Starting date

Unless a specific (fixed) starting date is duly justified and agreed upon during the preparation of the Grant Agreement, the project will start on the first day of the month following the entry into force of the Grant Agreement (NB : entry into force = signature by the Commission). Please note that if a fixed starting date is used, you will be required to provide a written justification.

5. Duration

Insert the duration of the project in full months.

6. Call (part) identifier

The Call (part) identifier is the reference number given in the call or part of the call you were addressing, as indicated in the publication of the call in the Official Journal of the European Union. You have to use the identifier given by the Commission in the letter inviting to prepare the grant agreement.

7. Abstract

8. Project Entry Month

The month at which the participant joined the consortium, month 1 marking the start date of the project, and all other start dates being relative to this start date.

9. Work Package number

Work package number: WP1, WP2, WP3, ..., WPn

10. Lead beneficiary

This must be one of the beneficiaries in the grant (not a third party) - Number of the beneficiary leading the work in this work package

11. Person-months per work package

The total number of person-months allocated to each work package.

12. Start month

Relative start date for the work in the specific work packages, month 1 marking the start date of the project, and all other start dates being relative to this start date.

13. End month

Relative end date, month 1 marking the start date of the project, and all end dates being relative to this start date.

14. Deliverable number

Deliverable numbers: D1 - Dn

15. Type

Please indicate the type of the deliverable using one of the following codes:

- R Document, report
- DEM Demonstrator, pilot, prototype
- DEC Websites, patent filings, videos, etc.
- OTHER
- ETHICS Ethics requirement

16. Dissemination level

Please indicate the dissemination level using one of the following codes:

PU Public
CO Confidential, only for members of the consortium (including the Commission Services)
EU-RES Classified Information: RESTREINT UE (Commission Decision 2005/444/EC)
EU-CON Classified Information: CONFIDENTIEL UE (Commission Decision 2005/444/EC)
EU-SEC Classified Information: SECRET UE (Commission Decision 2005/444/EC)

17. Delivery date for Deliverable

Month in which the deliverables will be available, month 1 marking the start date of the project, and all delivery dates being relative to this start date.

18. Milestone number

Milestone number: MS1, MS2, ..., MSn

19. Review number

Review number: RV1, RV2, ..., RVn

20. Installation Number

Number progressively the installations of a same infrastructure. An installation is a part of an infrastructure that could be used independently from the rest.

21. Installation country

Code of the country where the installation is located or IO if the access provider (the beneficiary or linked third party) is an international organization, an ERIC or a similar legal entity.

22. Type of access

VA if virtual access,
TA-uc if trans-national access with access costs declared on the basis of unit cost,
TA-ac if trans-national access with access costs declared as actual costs, and
TA-cb if trans-national access with access costs declared as a combination of actual costs and costs on the basis of unit cost.

23. Access costs

Cost of the access provided under the project. For virtual access fill only the second column. For trans-national access fill one of the two columns or both according to the way access costs are declared. Trans-national access costs on the basis of unit cost will result from the unit cost by the quantity of access to be provided.



Table of history of changes

Section	Change	justification
Measures to maximise impact	Added general IPR description for the results of the project	Requested from evaluation
Milestone 12	Title changed from WP8 workshop on planning WP8 education To Plans for WP8 Education	clarification
Milestone 17 30 31	Related WP was 2 changed to 3	Correction of typo
WP7	Added sentence on communication	Requested
WP3 task 3.2	Silixa added to list of partners	Correction of missing data (no additional cost incurred)
WP7 Deliverable	Added one missing deliverable: last issue of the newsletter D7.17	Missing data
WP7 Task	CO2GeoNetTTUGI clearly responsible for task 7.3.3	
Deliverable list	All deliverables with dissemination level RE have been put as CO (RE is not an option any more)	Those deliverables are internal ones: plans for international collaboration etc
Deliverable WP3	Adaptation of delivery time for D3.10 from 33 to 36 D3.13 from 34 to 36 D3.14 from 35 to 36 D3.15 from 36 to 35	To take into account the shifted start of the project and the fact that some field activities depend on seasons and take into account better task dependency
Deliverables WP1	Delivery time for 1.2 from month 8 to 14	If the project will start in late autumn we will have problems with the installation which is roughly scheduled for project month 3. Installation during winter times is difficult and we would like to shift this by a couple of months to early spring. This will result

		in a delay of the delivery date as we ideally need reference data of 1 year for the threshold assessment.
Section 4.2	Added info on subcontracts Ciuden: part of the sub contracts have been moved to contract BGS: info added Uniroma: The planned subcontracting has been moved to contracts. However part of personnel costs have been moved to sub contract (see justification) CO2GeoNEt: info added	-Ciuden requalification of contract cf H2020 rules -BGS: info requested - uniroma: The costs for personnel for these two tasks have been moved from direct costs to subcontracting following the recent (October 2015) EC interpretation of the eligible costs in H2020 (see List of issues applicable to particular countries), since personnel costs that according to the Italian national legislation (law 240/2010) “assegni di ricerca” and “collaborazioni” are considered as staff personnel (in-house consultant), have now been classified as subcontracting/services. The amount (70k€) allocated as subcontract refers to personnel costs related to “assegni di ricerca” which have been reclassified as subcontract in compliance with EC indications. The work in these two tasks concerns the activities of guidance for the integration of the input from the local communities in the research process and the work for coordination and elaboration of the work with the local communities and relates to D5.9 and D5.7.
Section 4.2	Remove table on CO2GEONet staff effort	Already included in part A
Section 3.4	Removed LRI costs from TNO	As the EC did not accept the requested compensation for the LRI, the LRI access costs have been set to zero, consequently leading to a lowering of the total eligible costs.
Section1.2	Added table on site status	To answer comment from evaluation
1.2 and 4.1	Duero site removed	ENDESA withdrawal
Section 3.3	Endesa removed from consortium description	ENDESA withdrawal
Deliverable D1.11	Responsible from ENDESA to CIUDEN	ENDESA withdrawal
Budget	Endesa Budget and staff effort passed to Palencia 3 and CIUDEN	ENDESA withdrawal
Budget	TNO changes of budget and staff effort	<i>Changes in person months:</i> Swap between WP3 and 4: the equivalent of 2 person months was shifted from WP4 to WP3 to compensate workload in WP3. WP7: As the preparation and updating of the

		dissemination plan and accompanying dissemination activities requires more work, 5 person months have been added. WP8: 3 person months have been added to have a more balanced representation of TNO's technological achievement in the training programme. These changes did not lead to an increase in the personnel costs for TNO. <i>Change in travelling costs:</i> WP8: A more balanced contribution from TNO in the training activities has resulted in a modest increase of the travelling costs with 2250 Euro.
Section 3.4	Adjusted travel costs for BRG and Silixa Added sentence clarifying the meaning of CFS and GA	
Section 4.2	Re inserted able on CO2GEoNet and Palencia 3 staff effort and corrected figures (no ore rounded figures)	As requested and correction in the figures to fix the incoherences.
Section 3.4	"The beneficiaries will base their contracts and subcontracts on the 'best value-for-money...' " added	<i>Upon request</i>
Section 3.4	"All equipment and other items that will be claimed 100% as cost of the project will be exclusively used for the activities in the project; as a consequence, if the equipment is also used for other activities outside the project, only part of its cost (corresponding to the percent of use within the project) will be charged." Added	<i>Has been added for clarification for each partner that will sign.</i>

Table 3.4a	TNO other costs corrected	<i>Requested change</i>
Table 3.4a	HWU high computing details added	<i>Requested change</i>
Section1.2 table 1.2	Site status table corrected to add sulcis pilot	<i>Was missing</i>
Table 3.4a	Correction of bgs travel details	<i>Typo on the cost for WP3 travel</i>
Table 3.4a	CIUDEN correction of typo: Equipment → other costs and services	<i>Mistake on the title of the line.</i>
Section 3.2	Changes in MB members (names)	<i>Due to staff changes in CIUDEN and BRGM the WP leaders and therefore members of the MB have changed</i>
Staff effort WP 1 4 7 for GGR	Changes in staff effort	<i>Due to salary raises.</i>
Table 3.4a	CIUDEN	<i>Added justification for costs calculations</i>
Budget	Correction of max grant for Ciuden	<i>I made a miscalculation: ciuden claims the initial amount from proposal stage (2 685 225.00) + additional money for taking over 1 endesa task: 4525</i>
WP2 task 2.1.2	Clarification of task for CIUDEN (words in blue added): For the Hontomin site, CIUDEN will develop a model using a free code and provide with dynamic simulations based	<i>Request from partner as they don 't have a model available at hand to perform the work.</i>
Deliverable	Correction of name of D2.1	<i>Coherence with WP2 deliverable list</i>
Deliverable	Correction of name of D5.2	<i>Coherence with WP5 deliverable list</i>
WP6 description	Correction of deliverable number in the text of task 6.3	
WP1 description	Adding GGR to task 1.4 partners	<i>Was missing : they were already listed in 1.4.3</i>
WP1 description	GEogreenn→ GGR	
WP3 description	Correction of delivery month in the text of D3.13	<i>Coherence</i>
Staff effort for BGS	Correction of staff effort	<i>Change of position (and therefore salary) of key staff involved</i>

Table 3.4a	Added information on intercontinental travels in BRGM other costs	<i>Requested</i>
Section 3.4	<i>and avoiding any conflict of interest. Added</i>	<i>Requested</i>
WP3 description	<i>Adding silixa in the fooling sentence</i> Task 3.2.2: Monitoring CO2 migration through fault planes in the sub-surface At the Sulcis Fault Lab, OGS will undertake geophysical measurements using downhole tools and surface techniques, to examine if the migration of CO2 along the fault and its proximity can be tracked. Seismic techniques will include borehole measurements using wireline and Silixa DAS-VSPTM, cross well applications and seismic interferometry (in surface-borehole and cross-well geometry).	<i>Upon partner request. To avoid ambiguity</i>
Deliverable	<i>Postponing deliverable in August to September (M12 → 13, 24 → 25, 36 → 37</i> <i>Consequently moved D4.10 from M38 to M 39</i>	<i>To take into account the summer break</i>
Risks	<i>R8 added mention of ECCSEL infrastructures in mitigation</i>	
Risks	<i>R6 and R10 removed</i>	<i>Requested. Was duplicated</i>
Section 3.1	<i>Update of the GANTT chart</i>	<i>For coherence with other changes</i>
Table 3.4	<i>Removal of SDG and updating budget for IPF and ENAGAS</i>	<i>SDG withdrawal from project</i>

Section4.1 13.	<i>Removing staff is provided by SDG, removing mention of SDG in efforts and staf</i>	<i>SDG withdrawal from project</i>
Section4.2	<i>Update of palncia 3 third parties staff effort</i>	<i>SDG withdrawal from project</i>
WP5 satff effort	<i>Removed BGS</i>	<i>I don t know why it was there. Not involved in the WP</i>

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1. Excellence

1.1 Objectives

Context of the project

Currently, the few large-scale CO₂ Capture and Storage (CCS) demonstration projects in Europe that are in operation or preparation are storing CO₂ in deep geological formations offshore, (e.g. Sleipner and Snøhvit - NO, ROAD - NL, Peterhead and White Rose - UK). The onshore large-scale integrated CCS demonstration projects that were in preparation under the EEPR¹ and NER300² schemes have largely been either cancelled or suspended (e.g. Janschwalde - DE, Belchatow - PL, Florange - FR, Getica - RO, Compostilla-Duero - ES). Although there are general financial and economic constraints involved in getting large-scale integrated projects off the ground, the challenges are much greater when the storage site is onshore. This is because local communities, and other stakeholders, have more immediate concerns as to whether the storage will be safe and environmentally sound, and as to whether local socio-economic benefits will emerge from this approach to climate and energy issues, such as the creation or preservation of local jobs. However, in order to reach the EU's ambitious goal of an 80% reduction in greenhouse gas emissions by 2050, while ensuring the security, flexibility and competitiveness of energy supply, deployment of onshore CO₂ storage will be crucial. Therefore, ENOS will focus on onshore storage, with the demonstration of best practices through pilot-scale projects and field laboratories, integration of CO₂ storage in local economic activities and creating a favourable environment for CCS onshore through public engagement, knowledge sharing and training.

The ENOS project is an initiative of CO₂GeoNet, the European Network of Excellence on the geological storage of CO₂, and a result of its recognition of the need to support onshore storage as a priority in today's context. CO₂GeoNet is committed to facing the technical and societal challenges for CCS through coordinated research and the global dissemination of scientific knowledge on CO₂ storage.

Objectives of the project

The objective of the project is to enable the development of CO₂ storage onshore in Europe by:

1) Developing, testing and demonstrating in the field, under “real-life conditions”, key technologies specifically adapted to onshore contexts.

Research and Development (R&D) at pilot sites and experiments under real-life conditions will allow demonstration of technologies for safe and environmentally sound storage in relevant environments. The portfolio of field sites in ENOS will also provide great opportunities for on-site training and dialogue with local authorities and civil society.

2) Contributing to the creation of a favourable environment for onshore storage across Europe, by i) supporting knowledge sharing to maximise the benefits of demonstration from each site, ii) integrating research results and setting out best practices on key topics based on the findings from real-life experiments, iii) supporting the preparation of new pilot projects and upscaling from pilot to demonstration, iv) bringing innovation to society through dialogue and communication and v) promoting CCS through training and education.

Involvement of a range of stakeholders and the general public in the development of best practices will enable the project partners to discuss, test and include wider requirements for CO₂ storage implementation. This will produce well integrated research outcomes and, at the same time, increase understanding by stakeholders, including the public, of the necessity for wide implementation of CO₂ storage. In this framework of improved understanding, the project will support the preparation of new onshore pilots and demonstration projects in various countries and

¹ European Energy Programme for Recovery

² Financing instrument funded from the sale of 300 million emission allowances from the New Entrants' Reserve of the EU Emissions Trading System

geological settings in Europe, also taking into account the specific socio-economic context of the territories concerned and local benefits such as job creation or preservation.

Although the project is designed to address concerns specific to onshore storage, a number of outcomes from onshore pilots and field experiments will be also useful for offshore storage development. In particular, it is easier and cheaper to test certain storage technologies onshore rather than offshore. This will be highlighted in the best practices that will be produced by ENOS.

1.2 Relation to the work programme topic LCE 15 2015

In order for the EU to reach its commitment of an overall reduction of greenhouse gas emissions of at least 80% by 2050, CCS needs to be deployed widely and applied to power plants and key industries by then. This means storing 3 to 13 billion³ tonnes of CO₂ across Europe by 2050. In light of these figures, Europe cannot rely solely on the North Sea, despite its great and readily available storage potential; CO₂ geological storage also needs to be deployed onshore. Developing onshore storage, relatively near the emission points, will contribute to reducing the costs of CCS, enable territories to manage their CO₂ emissions locally, and build lasting public confidence in CCS as a mitigation option that can also contribute to local economic development. By developing technologies to enable onshore geological storage and demonstrating best practices, ENOS will contribute to the deployment of a key technology for CO₂ emission reduction by 2050. In addition, through reciprocal knowledge-sharing activities with storage pilot and demonstration sites outside of Europe, ENOS will ensure that advancements are truly moving beyond global state of the art and that the value of the European sites in ENOS is maximised. Onshore sites also offer a relatively cheap option to develop CCS technologies and strategies that can then be adapted for offshore as needed, thus ENOS will also contribute to the wider CCS community.

Progressing technologies from TRL 4-5 to TRL 6

ENOS will focus on progressing technologies that have already reached Technology Readiness Level (TRL) 4 (validated in laboratory) or TRL5 (validated in relevant environment, i.e. in the field, occasionally/with small equipment) with the aim of bringing them to TRL6 (demonstrated in relevant environment, i.e. in the field, over long periods with adapted equipment) by the end of the project. The technologies considered will be those most needed to enable onshore CO₂ storage, advancing site characterisation operation, risk assessment, monitoring and management of leakage risks. These are necessary to answer specific onshore storage concerns, such as:

- a. Increased data availability for improved site characterisation, through low cost and smart drilling adapted to onshore context;
- b. Improved site characterisation enabling a better assessment of storage capacity and performance, particularly for onshore deep saline aquifers;
- c. Adapted and specific monitoring technologies and strategies for onshore settings;
- d. Preservation of groundwater used for human consumption;
- e. Preservation of onshore terrestrial and aquatic ecosystems, to protect the environment and human health;
- f. Detection and quantification of any CO₂ leakage (emissions) at ground surface;
- g. Increased understanding and prevention of induced seismicity, crucial to onshore context;
- h. Management of multiple uses of the subsurface;
- i. Integration of onshore CO₂ storage with local economic activities.

Real-life conditions

Real-life conditions are critical to the objectives of the Work Programme. ENOS has therefore built a comprehensive portfolio of sites, representing a variety of geological and socio-economic contexts and different stages of the storage lifecycle. This set of sites, with a good range of onshore contexts in various Member States, will allow technologies already at levels TRL4-5 to be tested and increased to TRL6, while favouring CO₂ storage development across Europe. All the proposed sites have either already benefited or shall benefit from funding outside the present call (industrial, national, European or own funding) and their operational plans extend beyond the scope of the ENOS project. The activities proposed in ENOS are complementary to those already funded and will enable additional research on these sites, liaising with other sites and comparison of results and experience, therefore maximising knowledge sharing in Europe and smart alignment of financial resources from various European stakeholders. The sites can be divided into three categories: operational storage pilot, field laboratories

³ *Energy Roadmap 2050 - Impact assessment and scenario analysis*

for leakage simulation and storage sites in the planning and characterisation phase. *Table 1.1* summarises the sites operated by ENOS partners and the issues related to onshore storage that they will be used to address.

Operational storage pilot site:

Hontomin – ES: The Spanish CO₂ storage technology development site, where injection at 1 500 m depth in a fractured carbonate reservoir in an anticlinal domal structure began in 2014. The site has been developed and equipped through the EEPR scheme and national funding and has been recognised by the European Parliament⁴ as a key test facility for onshore CO₂ storage. The site will allow acquisition of experience in a complex setting on issues that a future CO₂ storage operator might face, e.g. pressure management, low matrix permeability, impact of fractures or control of induced seismicity. A significant budget (2M€) from ENOS will be dedicated to buying and injecting 10ktonnes of additional CO₂ in order to work in real-life conditions. At Hontomin ENOS will a) test safe injection and innovative monitoring tools, b) develop a protocol for safe management of the site including induced seismicity control c) underpin the importance of local community engagement during the operational phase.

Field laboratories for leakage simulation:

CO₂ will be injected at two sites in order to simulate unwanted migration and leakage of CO₂, and advance our ability to detect and quantify CO₂ leakage onshore. The experiments will enable a better understanding of the processes involved in CO₂ migration within overburden, provide critical field data on CO₂ migration in a faulted context and reactivity in an aquifer and offer the opportunity to test cutting-edge monitoring technologies.

Sulcis Fault Lab - IT: As part of the 10 year Italian R&D program for CCS demonstration in Sardinia, an experimental open research platform is being created to study CO₂ flow along faults. CO₂ will be injected near a fault at 200-300 m depth from 2017 onwards. Wells will enable monitoring of the CO₂ behaviour underground.

GeoEnergy TestBed (GTB) - UK: GeoEnergy Research Centre, GERC (a UNOTT and BGS joint venture) owns and funds a site that will enable fully-monitored injection and migration of CO₂ into the Sherwood Sandstone (an important UK resource for CO₂ storage, oil & gas extraction, and a major onshore aquifer) at depths of up to 250 m. It will enable the study of a heterogeneous mudstone caprock, injection into a shallow near-surface control aquifer (~25 m depth), and research into leakage migration along localised natural faults. Site characterisation is underway, with the first borehole planned for summer 2015, and CO₂ injection will start end 2016.

Storage sites in the planning and characterisation phase:

LBr-1 - CZ: LBr-1 is a depleted oil field in the Czech Republic where a small-scale storage pilot is in preparation through the REPP-CO₂ project (see page 7). The reservoir, Miocene sandstones at ~1100 m depth hydraulically connected to an aquifer, is a typical example of a hydrocarbon-bearing structure in the Vienna Basin, one of the oldest hydrocarbon provinces in Europe. The site will be used to i) assess the potential for unwanted migration and/or leakage through abandoned boreholes and faults and ii) investigate reservoir behaviour in the presence of CO₂ and hydrocarbons, including possible mobilisation of hydrocarbons and use of CO₂ for Enhanced Oil Recovery (EOR).

Q16-Maas site - NL: The Dutch gas field Q16 Maas with onshore surface installations is currently under consideration, as part of a Dutch programme (see page 6) for the development of a CO₂ buffer for CO₂ utilisation. The 2 800 m deep Triassic sandstones of the gas reservoir have an estimated storage capacity of about 1.8 Mt CO₂. This large buffer will offer storage for industrially produced CO₂ in the wintertime and back production in summertime for greenhouse horticulture companies and thus guarantee the security of supply with increasing demand for CO₂, which is commonly used in greenhouses to enhance plant growth. Underground buffering is the only solution considering the scale of the buffer capacity needed. Such buffer storage could also be necessary for other uses of CO₂ and for collecting emissions before sending them to larger storage sites, including offshore. Site specific data will be used to study the conditions of back production of CO₂ (for use or transfer) and to assess the economic viability of implementing such facilities.

Sulcis pilot - IT: As part of the 10 year Italian R&D programme for CCS demonstration in Sardinia, a full chain pilot project is under preparation. The target reservoir is a limestone aquifer at a depth of about 1 300 m. The initial 3 year programme (2014-2017) is funding activities ranging from site characterisation to test injection, in addition to the fault test infrastructure mentioned above. It includes i) geological and geochemical studies; ii) seismic survey, geological and geophysical modeling and exploration; iii) experimental injection of CO₂. In ENOS, this site

⁴ European Parliament Resolution P7_TA(2014)0009 Bullet 17

will allow analysis on applicability of low cost drilling technology and possibly implementation of smart characterisation tools.

Palencia 3 exploration permit – ES: An exploration permit for CO₂ storage In Northern Spain has been awarded to PLC-3. Exploration will be completed by the end of 2017 and data will be provided to ENOS in order to develop the light drilling technology that will then be tested on the site. Funds for performing the drilling will be provided by PLC-3.

More details on the different sites are given in the Section 4.1 ‘Participants’ under ‘Infrastructure proposed by the partners - test sites’.

Country	Site	Type of storage	Depth	Reservoir	Phase	Issues related to onshore storage addressed
Spain	Hontomin	Deep saline aquifer	1500 m	carbonate	injection	b. Site characterisation techniques enabling a better assessment of storage capacity and performance c. Onshore adapted and specific monitoring technologies and strategies d. Preservation of groundwater used for human consumption e. Preservation of onshore ecosystems, to protect the environment and human health f. Localisation and quantification of any CO ₂ leakage at ground surface g. Increased understanding and prevention of induced seismicity
UK	GeoEnergy Test bed (GTB)	Injection site into shallow aquifer with caprock	250 m	sandstone	characterisation and injection	c. Onshore adapted and specific monitoring technologies and strategies d. Preservation of groundwater used for human consumption e. Preservation of onshore ecosystems, to protect the environment and human health f. Localisation and quantification of any CO ₂ leakage at ground surface
Italy	Sulcis Fault Lab	Injection tests through faults	250 m	fault through volcanic rock, clay s, limestones	characterisation and injection	c. Onshore adapted and specific monitoring technologies and strategies d. Preservation of groundwater used for human consumption e. Preservation of onshore ecosystems, to protect the environment and human health f. Localisation and quantification of any CO ₂ leakage at ground surface
Czech Rep.	LBr-1	Depleted oil field	1100 m	sandstone	characterisation	d. Preservation of groundwater used for human consumption i. Integration of onshore CO ₂ storage with local economic activities f. Localisation and quantification of any CO ₂ leakage at ground surface h. Management of the multiple uses of the subsurface
Netherlands	Q16Maas	Buffer storage in depleted O&G fields	2800 m	sandstone	characterisation	i. Integration of onshore CO ₂ storage with local economic activities h. Management of the multiple uses of the subsurface
Italy	Sulcis pilot	Deep saline aquifer	1500 m	limestone	characterisation	a. Low cost and smart drilling to increase data availability for improved site characterisation b. Site characterisation techniques enabling a better assessment of storage capacity and performance
Spain	PALENCIA 3	Deep saline aquifer (exploration permit)	2000 m	Sandstone and carbonates	Characterisation	a. Low cost and smart drilling to increase data availability for improved site characterization b. Site characterization techniques enabling a better assessment of storage capacity and performance

Table 1.1: Site portfolio for ENOS and issues these sites will help to address

Site	Country	Type of site	Status as of April 2016	Operations for ENOS
Hontomin	Spain	Storage reservoir	Operating. 2000 t of CO ₂ injected	CO ₂ injection and monitoring
Geo Energy Testbed	UK	Leakage simulation	under construction (drilling) expected start of operations: 2017	Simulation of leakage and deployment of monitoring methods in aquifer environment in WP3
Sulcis Fault lab	Italy	Leakage simulation	Under characterisation Expected start of operations: 2018	Simulation of leakage and deployment of monitoring methods in fault environment in WP3
Sulcis Pilot	Italy	Exploration permit	Exploration permit has been granted and exploration has started	The site will be used as test site for feasibility of the guidance documents from WP2 and 3
LBr-1	Czech Republic	Storage reservoir	Site characterisation and risk assessment are being performed in REPP-CO ₂ project (Czech-Norwegian project) which will finish in November 2016	Studies to assess the potential for unwanted migration and/or leakage through abandoned boreholes and faults and investigate reservoir behaviour in the presence of CO ₂ and hydrocarbons, Combination of CO ₂ storage with possible Enhanced Oil Recovery in terrestrial conditions of the Vienna Basin. Study on trans-boundary issues. No field activities planned.
Q16-Maas	Netherlands	Storage reservoir; Depleted wet gas field	Production of wet gas (gas with condensate)	Study on using the reservoir for buffer storage; no field activities planned
Palencia 3	Spain	Exploration permit	Exploration permit has been granted and exploration has started	The site will be used as test site for feasibility of the guidance documents from WP2 and 3

Table 1.2: Site portfolio status as of April 2016

Local community engagement

Onshore CO₂ geological storage is highly reliant on the confidence the local authorities and population will place in the technologies and the storage projects. ENOS will undertake innovative work to involve the local population with the research teams and create a space for dialogue to encourage a favourable environment where storage can be implemented. This work will be undertaken at sites in the planning and injection stages.

Knowledge sharing in Europe and globally

Building on experience and initiatives from CO₂GeoNet, an ambitious programme of knowledge sharing and dissemination will be undertaken in order to maximise the impact of ENOS and other CCS projects. The aim is to pass on the experience gained from onshore experimental sites within the ENOS portfolio and worldwide to projects under creation in Europe and thus improve their chances of coming to fruition. The resulting knowledge will also be passed on to the next generation of scientists, through dedicated training sessions, and integration of specific modules into academic curricula. Knowledge-sharing activities to be undertaken in collaboration with operators of international sites outside of Europe are described in WP6.

1.3 Concept and approach

Overall concept

The main objective of ENOS is to help to remove the immediate hurdles to onshore CCS deployment by further developing key technologies and preparing a favourable (societal, regulatory and technological) environment.

The main challenge facing onshore CCS is to gain the confidence of the public, but also of operators, emitters, investors, policy-makers, and regulators. This incorporates:

- Demonstrating through practical experience that injection operations can be run safely and efficiently onshore, which is key for optimizing operations and to enable a positive regulatory environment;
- Ensuring that estimated matched storage capacities are sufficiently reliable and also affordable to verify, which is needed to enable investment in projects and therefore the deployment of CCS;
- Demonstrating our capacity to understand, detect and manage potential leakage risks, which is key for regulatory issues and to demonstrate storage is environmentally sound and safe for human health;
- Integrating CO₂ storage into the local economic activities so that the benefits are also reflected at the local scale, which is vital to enable the deployment of CCS;
- Engaging the local population in the storage projects, without which project development is impossible.

The experience acquired on these issues at the various sites will be compared with other experiences worldwide, and then integrated into protocols, proposed standards and best practices. This knowledge will be made available to operators, regulators and scientists through the ENOS innovation management strategy and education and training. Involvement of industrial partners and input from external stakeholders will ensure that the deliverables are fit for purpose.

Project position in R&I

ENOS will focus on validating onshore CO₂ geological storage, as a whole, through action at pilot scale (TRL6) such that it is ready for moving to large-scale integrated CCS demonstration projects (TRL7), by:

- advancing innovative technologies already tested at lab or smaller scales (TRL4-5) to TRL6 by validating them in relevant real-world environments;
- improving the range, sensitivity, response time and/or portability of existing technologies;
- adapting existing technologies used in other domains by applying them to CO₂ storage;
- integrating single technologies into a coherent system and validating it with large-scale site operators;;
- improving existing methodologies by applying them to real-life data from sites in the injection or characterisation phase.

Work Programme

The ENOS work programme will be organised into 9 work packages (WP) as follows. A first group of WPs (1 to 4) will focus on demonstrating technologies able to tackle key issues for onshore CO₂ storage in close connection with the local communities (WP5). The 4 key issues identified are: ensuring safe storage operations (WP1), ensuring robust storage capacities and cost-effective characterisation (WP2), managing leakage risks for protection of the environment and groundwater (WP3) and integrating CO₂ storage with local economic activities (WP4). WP5 will aim to establish a collaborative relationship between research teams and the local communities, focussing around new/future pilot sites. It will bring research outcomes and their impacts on society to the population and bring concerns and societal challenges to the researchers.

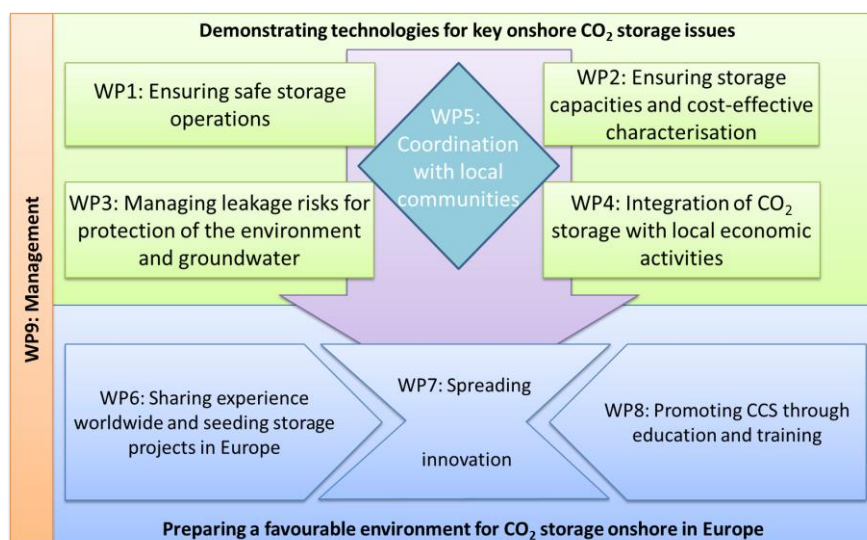


Figure 1: ENOS Work Package (WP) structure

The second group of WPs (6 to 8) will prepare a favourable environment for CCS onshore in Europe. Relying on the results from WP1-5, they will maximise the impact and innovation potential of ENOS. WP6 aims to share experience with other onshore projects in the world, and drawing on all past experiences, to support the preparation of new pilot and demonstration projects in Europe. By integrating research outcomes and bringing them to stakeholders and the market, WP7 will allow the spreading of innovation achieved in ENOS, mainly through best practices and identification and protection of project intellectual property. WP8 will address training and capacity building needs for a new generation of scientists. Lastly, WP9 will be dedicated to project management.

Figure 1 illustrates the ENOS project structure. More details on objectives, progress beyond the state of the art and the innovation potential of each WP are given in section “1.4 Ambition”.

Link to national and international research and innovation activities

International cooperation with onshore pilots and demonstration projects across the world will be set up through a programme including storage site twinning, focus groups centred around operative issues and the creation of a leakage simulation alliance. Fostering experience sharing and research alignment between existing sites is key to maximize the investment made at individual sites and to support the large scale deployment of CCS. The collaboration through ENOS will ensure greater reliability and visibility of results. In addition, it will help promote European expertise around the World. The partners that will participate in the collaboration programme (see intention letter in Section 4) are:

- Batelle in the USA, running an EOR-storage large-scale test in the oil-bearing carbonate reefs of the Michigan Basin,
- CO2CRC running the Otway site in Australia
- Kansas Geological Survey, preparing to inject CO₂ at a pilot scale in Wellington Field in Sumner County, in the USA.
- KIGAM in South Korea running an onshore pilot Janggi
- K-COSEM Leakage simulation site, Environmental Impact Test (EIT) facility at Eumseong
- SACCCS in South Africa, currently preparing a pilot as part of the South African CCS road Map
- CMC in Canada setting up a leakage simulation site, where CO₂ will be released at 300-500m depth

Detailed Framework for the international collaboration is described in WP6.

ENOS has been endorsed by the CCS Joint Programme of the European Energy Research Alliance (EERA) of the SET-Plan, thanks to the proposed work programme that addresses the alliance research priorities – see letter in Section 4. Several partners of ENOS are members of EERA, this will ensure a close relationship all along the project for mutual benefit.

Several partners (BGS, BRGM, CIUDEN, OGS, Sotacarbo, TNO) are members of ECCSEL, the European distributed, integrated Research Infrastructure, drawing together Centres of Excellence on CCS research from 10 countries across Europe.

ENOS will take advantage of different national initiatives in Europe and proposes to extend the activities already included in national projects. Such initiatives include:

- REPP-CO₂ project in the Czech Republic: Funded by a Norway grant of 2.2M € complemented by 0.6M€ partners' contribution, REPP-CO₂ aims to characterise the LBr-1 site as a potential storage site. The project (led by CGS with IRIS participation), embracing site characterisation, geological modelling, basic risk assessment and plans for site monitoring is being carried out from January 2015 to April 2016. Site-specific activities planned within ENOS will be a direct follow-up to the outcomes of this 1st-phase.
- The Italian government has decided to back a 10-year research programme dedicated to CCS in Sardinia. The programme will be financed by the Regional Government of Sardinia and the Ministry of Economic Development. The site development and operations will be managed by Sotacarbo. Along with capture technology development, the Sulcis initiative includes the realization of a CO₂ storage small scale pilot which aims to characterise the storage area, and to test and demonstrate the storage potential in deep underground aquifers and in unmined coal seams in the Sulcis area. An experimental open research platform is also being created to study CO₂ flow along faults (Sulcis Fault Lab). ENOS will use this facility and test tools for characterising the pilot site.
- A Dutch national research project with a budget of about 250 k€ is being developed for the Netherlands Energy Innovation Programme. Site-specific data from the Q16-Maas gas field will be made available to the ENOS project, for studying CO₂ Utilisation concept related to buffer storage and economic impacts.
- In the UK, the GeoEnergy Test Bed (GTB) will benefit from direct investment from the site owners (BGS and UNOTT) worth £3.5M, with additional direct investment from the £60M Phase 1 UK Government support for the GeoEnergy Research Accelerator (G-ERA) – forming part of the UK Midlands Energy Research Accelerator (ERA) - and with proposed additional investment from the £190M Phase 2 support is being sought. The GTB will be extensively used by ENOS to demonstrate leakage risk management.

In addition, the project will also benefit from all the national R&D programmes in which the participants are involved. These programmes are listed in the consortium description in Section 3.3.

1.4 Ambition

Progress beyond the state of the art

Progress on CCS in Europe has slowed down recently. There are currently only two commercial-scale operations in Europe (Sleipner and Snøhvit both in offshore Norway), and despite policy and financial drivers, no new major CO₂ storage project has been sanctioned onshore. This slow development is partly due to the lack of sufficient financial incentives but also, importantly, to a lack of feed-back on the regulatory framework for CO₂ transport and storage, operational experience, cost visibility and public acceptance. Overcoming those issues is ENOS ambitious target.

Significant investment in research has been made by the EC through FP6 and FP7. The knowledge acquired through these earlier projects will serve as the basis for ENOS but will be further validated and integrated as required in order to be instrumental in CO₂ storage deployment. The consortium has extensive expertise and will rely on field work to address the most urgent issues preventing the wide deployment of onshore storage. Based on practical experience, WPs 1 to 5 will undertake applied R&I to provide solutions for the identified barriers to implementing safe and environmentally sound storage. For this purpose, ENOS address a variety of issues by gaining experience from different sites across Europe, and will tackle different challenges from a broad spectrum of disciplines: geosciences and metrology, economics and social sciences. Outcomes from each discipline will be seen from the perspectives of the other disciplines. Only with this integration of knowledge can CO₂ storage significantly progress and build the vital level of confidence for all stakeholders. A less ambitious programme focusing on merely one or two issues, while helping, would fail to deliver the expected impacts.

For WPs 1-5, aiming at demonstrating key technologies, the state of the art and the progress by ENOS beyond this state of the art are presented in each WP description in Chapter 3. A summary of the ambitious tangible outcomes brought by each of these technical WPs is given in Table 1.2.

WP	Objective	Tangible outcomes
1	Demonstrate safe and environmentally sound injection management:	Demonstration of:
	- Test injection strategies	• History matching for site conformance
	- Provide tools for injection and reservoir monitoring	• Cost-effective injection strategies in a tight fractured reservoir
		• Mitigation techniques and reduction of uncertainties for induced seismicity
		• Reservoir monitoring tools for site conformance at pilot scale, ready for use at demonstration/flagship sites:
		○ Validation of Silixa's IDAS as part of a 3D seismic survey

- Provide monitoring data integration solutions and alert systems	- o Extension of the range of application for the removable deep fluid sampler - o Validation of Flodim sampler and probe • Smart Monitoring integrated approach • Development of Workflow to integrate operation, monitoring and modelling data into risk management and alert system
2 Provide bankable capacity assessment convincing to stakeholders and operators by: - Quantifying the reliability of estimates - Lowering the cost for characterisation	Development and validation of • A reliability index for capacity assessment, therefore improving capacity assessment TRL • A smart characterisation methodology to optimise exploration costs based on existing data • FEED study for low cost smart drilling, that will be tested outside ENOS
3 Demonstrate safe storage through effectiveness of leakage monitoring techniques and strategies: - Demonstrate ability to monitor groundwater - Demonstrate ability to monitor leakage pathways (faults and boreholes) up to the surface Provide integrated monitoring solution	Demonstration of: • Monitoring strategies to demonstrate there is no unwanted migration or leakage of CO₂ at storage sites, including diffuse leakage and leakage through faults and boreholes; • Tool-box of techniques to assess the geochemical reactivity of groundwater and definition of key parameters to monitor for early leakage detection. • Monitoring at pilot scale ready for use at demonstration sites. Tools and techniques will include: - o Innovative optic fibre tools for groundwater monitoring (TRL4,5 to 6,7) - o GASPro-MS Multi sensor probe (TRL6 to 7) - o Biosensor tools, adapted for CO₂ application (TRL5 to 6) - o DAS for leakage pathway characterisation using iCABLE, (TRL6 to 7) - o Tool measuring CO₂ flux from saturated to vadose zone (TRL5 to 6) - o Low cost GasPro-CO₂ probe network (TRL 6 to 7) - o Diffuse leakage detector (TRL 5 to 6) - o Soil gas techniques with improved sensitivity and discrimination of the CO₂ source (from TRL4,5 to 6,7) - o Including discrimination of the CO₂ source (from TRL4 to 6) - o Ground CO₂ mapper – autonomous robot (from TRL5 to 6) - o Multispectral thermal airborne detector (from TRL 5 to 6) - o UAV for CO₂ air concentration mapping (TRL 5 to 6) - o Tool for leakage quantification (TRL4 to 6) These tools will address both the need for wide-areal techniques to identify leakage and for detailed point data to confirm and quantify leakage.
4 Integrate the CO₂ storage concept into given economic activities by tackling technical, economic and regulatory issues.	• Technical feasibility of combined condensate production, CO₂ buffering and permanent storage in the Q16 Maas gas field, the Netherlands • EOR and storage coupling based on both technical and economic factors for LBr-1 field. Assessment of the market potential and economic viability of CCS taking into account synergies and conflicts, legal and regulatory aspects.
5 Engage the local population Develop best practices integrative of societal aspects Verify how the integration of societal input can increase awareness and confidence	• A methodology to link the scientific and technical development of the best practices with societal concerns and implementation issues at local level • Developed relationship between R&D community and local population • Online public information tool, providing information relevant to the population based on their input and feed-back • Enhanced relationship between the ENOS pilot sites and the local populations

Table 1.2 summary of the objectives and tangible outcomes of the technical WPs

Innovation potential

ENOS has been designed to produce innovations that are fit for purpose and near to market, so as to be instrumental in CO₂ storage deployment. Overall, the WPs are directed at advancing to the next step in the innovation cycle: through rigorous field testing, a wide variety of methods and tools will be developed and/or adapted to reach at least TRL6. A number of the products that result from the work programme are or will be of commercial interest and of value to both storage operators (e.g. light drilling, injection strategies etc.) and regulators (e.g. ground water protection guidelines, microseismicity mitigation techniques). WP7 will develop an innovation management strategy and identify the opportunities for bringing to market the main outcomes of the project, through ongoing evaluation and protection of arising project intellectual property, discussion with industry and end-users, publications and communiqués. For each activity in the detailed WP description, precise progress beyond the state of the art is described as well as the outcomes to be produced by the ENOS project.

2. Impact

2.1 Expected impacts

ENOS, the aim of which is to enable onshore CO₂ storage in Europe, will have the following needed impacts:

Demonstration of safe and environmentally sound storage - ENOS will participate in the CO₂ injection activities at Hontomin and deploy modelling and monitoring techniques that will further demonstrate the concept of environmentally sound storage. Fieldwork at leakage simulation sites will prove our ability to understand leakage risks and thereby to mitigate them. In particular, improved understanding of fault behaviour will shed light on one of the last major unknowns for the safety of storage. If unforeseen leakage did occur, then new monitoring methods will ensure it is more likely to be detected early and that possible emissions to the atmosphere can be quantified with greater precision. Early leakage detection will permit rapid response, thereby limiting the amount and impact of any leakage.

Optimising safe operations and fine tuning of regulatory issues - Integrated workflows validated in ENOS with a clear link to Risk Management will allow regulators to have a better overview of site behaviour, thus offering a collaborative link between site operators and regulatory authorities. The development of a protocol for daily management of injection and an alert system will allow integration of monitoring data and thereby optimisation of injection and storage while ensuring safety. Through consultation with representatives of regulatory authorities, ENOS will develop best practices targeted to support them. ENOS will rely on and further develop the current involvement of the CO₂GeoNet association in actions such as the ISO TC265 standard definition and the review of the European CO₂ Storage Directive, as well as the established relationships between CO₂GeoNet Members and regulating bodies in several countries. The End-User Committee, in WP7, will include representatives of regulatory bodies in different Member States. This engagement with policy makers and regulators will support fine tuning of regulatory issues based on the latest research outcomes and strong integrated expertise offered by the consortium.

Increased confidence of the local population - The demonstration of safe and environmentally sound storage is key to building confidence in the local population. This includes demonstration of the ability to manage and mitigate leakage risks and to ensure the protection of groundwater resources. This will be achieved by the validation of monitoring tools for leakage detection and their integration into a comprehensive and effective monitoring programme. Most importantly, an innovative and cooperative process will be developed to involve the local population in ENOS and to integrate their concern into the research agenda as far as practicable with the aim of increasing the confidence of the local population and the general public in the long term. An on-line communication tool, providing real-time information on site operations will be created, based on the needs expressed by the local community.

Increased confidence of operators, emitters and investors - Site operators, emitters and investors need greater visibility on the implications of CCS project developments and their economic potential to advance CCS as a favourable option. In addition to providing key technologies, sensors and protocols adapted to their needs, ENOS will improve the reliability of capacity estimates, participate in de-risking early site characterisation and outline methods for clearly communicating storage capacity and uncertainties to these end users. In order to improve the business case for CCS, ENOS will investigate opportunities to integrate CO₂ storage in the economic development of a region.

Public awareness - ENOS will publish documents that are complementary to existing material, for civil society and industry, to explain the CO₂ storage technology. Online dissemination materials will be made globally and openly accessible through the project and partner websites. Work with the media will be undertaken, in particular in relation to the experimental and pilot sites, in collaboration with site operators.

Enhanced and effective cooperation between key stakeholders and Member States - The ENOS project is building on the pan-European coverage and expertise of CO₂GeoNet. The portfolio gathers sites in several Member

States and ENOS will ensure maximum cooperation between these sites. Testing technologies in real-life conditions up to TRL6 requires field work that is costly, both in terms of capital costs and operational costs. Therefore, the ENOS project has chosen to work on sites that already benefit or have benefitted from other funding from national and European sources. The added value of the ENOS project working closely with existing operational/field test sites will be to enable i) additional testing of innovative technologies at these sites, ii) longer test periods, and iii) a site portfolio approach necessary to demonstrate technologies across the storage cycle and in a wide range of geological, socio-economic and national contexts. This is a cost-effective way to advance onshore CO₂ storage development onshore across Europe. The knowledge-sharing activities will also foster collaboration outside of the ENOS consortium between a wide range of stakeholders (European and national policymakers, regulators, emitters from power and industry, transport and/or storage operators etc.) across Member States and globally. This enhanced and effective cooperation is essential for achieving the objectives of the project, i.e. enabling the development of CO₂ storage onshore in Europe by demonstrating technologies and preparing a favourable environment across Europe.

Accelerating demonstration - All the impacts described above will contribute to this broad impact: they will all help accelerate demonstration of CCS. In addition, WPs 6-8 dedicated to creating a favourable environment for CO₂ storage onshore in Europe will allow the acceleration of demonstration by:

- Better identifying storage project opportunities across Europe and providing a stepping stone for new onshore storage pilots and demonstrations to develop;
- Enhancing knowledge transfer from existing sites worldwide to catalyse new projects;
- Bringing key technologies, developed in ENOS and necessary for CCS deployment onshore, to operators and engineers;
- Building a roadmap for upscaling identified synergies of CO₂ storage with CO₂ utilisation;
- Training and educating scientists and engineers to face the challenges of CCS.

Improving innovation capacity and integration of new knowledge

ENOS will produce innovations that are adapted to the needs of implementing CO₂ storage and facilitate uptake by the market. Through a broad communication strategy, ENOS will aim to expand understanding in potential end-user sectors in order to increase the number of players in the potential supply-demand chain for CCS thereby expanding the potential market for CCS in Europe. The participation of industrial representatives from different sectors and input from the advisory body will ensure alignment of ENOS outcomes with needs. 4 SMEs are involved in the consortium and will use ENOS as an opportunity to expand their area of service/expertise by validating technologies and thereby strengthening their competitiveness. A number of activities in the work programme are dedicated to lowering the cost of storage, ensuring revenue for storage (by addressing Storage and Utilisation coupling issues) and de-risking the investment decision for storage. All this will contribute to making CCS a real possibility for companies to consider in order to lower their emissions while not jeopardizing their competitiveness and balance sheet. A number of outcomes (e.g. monitoring tools) from ENOS will also be applicable to offshore storage sites.

By demonstrating/ validating technologies for safe and efficient storage, ENOS will help the growth of an industry sector dedicated to CCS. However this sector will only develop if there is a strong political will for implementing CCS and if incentives (or penalties) are established for storing (or emitting) CO₂.

Many technologies developed in ENOS can also be extended for other uses of the underground (such as energy storage, oil and gas, geothermal energy, groundwater management etc.) and therefore be of interest for a broader spectrum of companies in Europe. Such opportunities will be identified in the exploitation of results plan.

2.2 Measures to maximise impact

The structure of ENOS has been designed in order to maximize the impact of the research results, and more precisely to maximize the uptake of knowledge by industry, government and regulators, society and the scientific community. The Consortium also strives for a maximum disclosure of the project results while carefully screening to what extent the knowledge of individual partners needs to be protected (see 'IPR management and open access'). The Management Board will systematically and transparently decide if and how knowledge needs to be protected and subsequently what can be disseminated. Dissemination and exploitation of project results will play a significant role in the ENOS project. While the first five WPs are dedicated to significantly advancing technologies and knowledge for enabling onshore CO₂ storage, WPs 6, 7 and 8 aim to develop, integrate and disseminate these advances and therefore ensuring ENOS will positively impact the deployment of CCS in Europe. WP7 will integrate all the research outcomes into best practices and plan the exploitation and dissemination of results. WP6 will liaise with other pilot projects and identify opportunities to develop new storage sites or to up-scale pilots. Finally WP8 will disseminate the results both towards the new generation of scientists through education and

training and towards the general public through interaction with the media. Dissemination of knowledge to the public living near envisaged storage projects and to engage them in the decision making, is considered to be of crucial importance for turning onshore storage projects into a success; public participation is central to WP5.

WP	Expected impacts	Measures to maximise impact
6	- Leverage research investments - Support research alignment between site operators - Enhance knowledge and experience sharing within the European CCS community - contribute to the acceleration of CCS development onshore, - Increase the worldwide visibility of ENOS activities and site portfolio	- Establishing durable close partnerships between CO₂ storage pilots and demonstration projects in Europe and worldwide: setting up site twinning partnerships, a leakage simulation site alliance and focus groups; - Preparing further development of ENOS sites to maximise the full value of the pilot projects for research and for upscaling to higher TRL levels leading to market uptake - Identification of promising opportunities for future pilot/demo sites, and geological settings in Europe with significant untapped storage potential. - Producing a roadmap for upscaling identified synergies of CO₂ storage with CO₂ utilisation
7	- Demonstration of safe and environmentally sound storage - Contribute to the acceleration of CCS development onshore, - Spreading innovation to end-users	- Organisation of internal knowledge integration workshops - Set up of scientific editor committee to coordinate research integration, plan for dissemination , and support exploitation of ENOS results - Production of concise best practices tailored to stakeholders needs - Set up of knowledge-sharing platform - Set up of ENOS website
8	- Educate the next generation through capacity building to meet the future needs inherent to CO₂ storage deployment - Set the basis for CCS education - Favour debates around CCS on a sound and scientific basis	- Providing intensive training courses, for young scientists, on onshore CO₂ geological storage outlining latest research - Enhancing university cooperation to set the basis for a coordinated Master and post-graduate Master programmes on CO₂ storage through the development of : - a network of institutions and laboratories - educational modules/lectures - Providing e-learning course for students allowing wider access to research results and for the civil society - Providing short courses for journalists and media, enhancing scientist-journalist communication

Table 2.1: Expected impacts and measures to maximise them

a) Dissemination and exploitation of results

The dissemination and exploitation of results plan will include:

- Innovation management strategy with plans for the main outcomes of the project. The aim is to bring the results nearer to the market and make sure they are useable by stakeholders;
- End-use communication plan (see section below), with events and conferences to be organized;
- Input to training and education, identifying which research results should be included in training and education and how;
- Strategic events to be attended to promote ENOS results.

The plan will take into account the different target groups for the dissemination of results:

- The scientific community in particular through publication and promotion of open-access to data sets produced in ENOS.
- Industry, through the consultation with end-user representatives, the production of fit for purpose best practices and organisation of workshops and conferences to promote the near market outcomes of ENOS.
- Governments to support development or adjustment of their CCS enabling policies through provision of scientific advice
- Regulators and environmental agencies by providing guidelines on safe storage for policy fine tuning
- International and European standardisation organisations to evaluate existing standards and develop new standards

- Students and young scientists by providing training and education, using the cutting edge ENOS results and state of the art background.
- Environmental NGOs to provide them with independent balanced information on CO₂ storage
- General Public through media by creating a trust based exchange relationship with journalists to provide them with impartial scientific input on CO₂ Geological Storage.

For all the target groups CO₂GeoNet is excellently positioned as the association already has extensive experience in spreading research results to the wider community including the target audiences mentioned above. The Association has representatives in 19 European countries and liaises with the main entities dealing with CCS in Europe including the EC, ZEP, EERA CCS JP and ECCSEL and globally including GCCSI, CSLF, IEA-GHG and UNFCCC.

ENOS, in WP6, will enhance knowledge and experience sharing with other EU projects and with onshore pilot sites in the World. This will allow to compare and to validate ENOS outcomes with results from other sites and research results globally and will also offer a worldwide visibility amongst the main actors of CCS in the World. ENOS will direct particular attention to ‘real- life’ dissemination and exploitation of results to and with stakeholders engaged with the storage projects in the ENOS portfolio and to targeted dissemination related to new developments in CCS policy and roadmaps during the lifetime of the ENOS project. The preliminary plan for dissemination of the project results is delineated in Table 2.2. Target audiences will be asked for feedback so that follow-up actions for research or market-uptake can be better defined.

ENOS has been endorsed by the European Energy Research Alliance CCS Joint Programme (EERA CCS JP) of the SET-Plan, thanks to the proposed work programme that aligns the major research performing organisations in the framework of EERA and the SET Plan. Outputs from ENOS will inform the EERA CCS JP research priorities. Many ENOS partners are also participants in the EERA CCS JP.

The dissemination and exploitation of results from ENOS will be coordinated by WP7. A summary of preliminary dissemination and exploitation plans of the ENOS results is given in Tables 2.2 and 2.3 respectively. These plans will be regularly updated based on integration of the research activities and through the work of the scientific editors who will be responsible for identifying and facilitating the opportunities for bringing to the market the main outcomes and messages of the project, through publications and communications, contacts with end users and patents where relevant. In addition representatives of the end-users will be sitting on the Advisory Body (cf Section 3.2) and will thus be regularly consulted.

Target	Dissemination tool	Specific dissemination action	Project management steering
Project consortium	Annual meeting and workshops	Presentation and discussion of project results	Identify project results and assign presentation tasks
	ENOS knowledge-sharing platformer	Archiving of ENOS intermediate and final results	Maintenance and update of archive
External stakeholders	Annual CO ₂ GeoNet Forum in Venice	Session dedicated to ENOS results	Identify project key results
Media journalists	Press release	Provide updates on the project and CCS in general	Identify key outcomes and opportunities for exchange
	Short courses	Establish relationships with media	
industry ZEP	Workshop	Involvement in end user committee	Establishing and maintaining contacts with end-users
EERA CCS JP	Workshop and position paper	Joint organisation of dissemination event	Provide timely input Identify joint actions
Scientific community	Scientific journals	Publications of ENOS results	Identification of publishable results
Young professionals	CO ₂ storage school	Promotion in doctoral schools, research institutes and potential operators or site owners	Identification of key knowledge to transfer
Students	E learning CCS educational programme	Promotion of education opportunities in partner universities	Identification of key knowledge to transfer to student
EC DGs	Lunch tables	Presentation of the impact of the ENOS outcomes for CCS deployment	Establishing contact with DGs Identification of key messages
Local	Online info-tool	Organisation of the interaction	Develop local contacts

communities around sites	Workshops, local media	between scientists and local communities	Identification of understandable message
Public at large	Website	Publish documents and video with information about CCS and ENOS easily understandable	Key message identification and vulgarisation

Table 2.2 Preliminary dissemination plan

Target user	Description of project result and use
R&D community	Advance in the state of the art Datasets acquired at the field sites to use for further study
Potential site operator	Roadmap with input for business plan Best practices for business and industry Technical guidelines for capacity estimates, smart site characterisation, monitoring site conformance and for planning and implementing storage sites Technologies ready for use at demonstration scale (see table 2.1)
Geo-engineering industry	Technologies validated at pilot scale that can be applied for other underground uses, such as light drilling, sensors and samplers.
Standardisation organisation	Best Practice and standard development
Policy maker	Roadmap for the region deployment of CCS with economical impact, to be used for assessing potential policies Best practices for government and regulators
Regulator	Technical guidelines on monitoring and site conformance Best practices for regulators, to be used for implementing the EU CCS directive and for interaction with the local population Technologies ready for use at demonstration scale (see table 2.1)
NGO and local community	Easily understandable and scientifically sound information , in particular : Best practices on what makes a sound CO ₂ Storage project Online information tool

Table 2.3: Provisional exploitation plan

IPR management and Open access

Knowledge generated and used within the project will be properly managed, with any arising IP protected and exploited effectively while allowing for open access publications and the transfer of data generated to open repositories for training and/or dissemination as appropriate. Knowledge management will be based on the legal requirements defined in the official documentation published by the European Commission: ‘*H2020 Rules for Participation*’, and will be conducted by following the definitions and statements in the Consortium Agreement.

Generated knowledge of commercial interest will be safeguarded and protected for exploitation by the owner (s) in accordance with the terms negotiated and outlined within the Consortium Agreement. The consortium agreement will be based on usual DESCA model and provisions. The Intellectual property of produced results in ENOS will be shared between the participants in the task. Partners in the project will have the right to use the results for non-commercial purposes. Co-owners of a result shall ask permission to other coowners before granting an exploitation license.

An exploitation plan will be developed between consortia partners in the course of the project, coordinated by the Scientific Editors in collaboration with the relevant partners. Both documents will seek to ensure that IP exploitation is undertaken by the partners best positioned to do so with apportionment of fair reward to all contributing parties.

The WP7 coordinator will take on the role of Project Dissemination and Exploitation Manager and will manage the knowledge generated in terms of dissemination and exploitation. In this role, he will report to the General Assembly, which has overall responsibility and decision making authority. Throughout the duration of the project, the Scientific Editors will review a list of IP to be protected, agree a timetable for filing protection activities and establishing other protections as relevant. They will actively seek professional advice in making decisions concerning IP, including whether research output dissemination needs to be delayed to allow for appropriate IP protection. This strategy for using and disseminating the knowledge during the lifetime of the project and beyond will be considered at each General Assembly. Where appropriate, IPR review and proposed protection will be supported by IP teams from relevant institutions, guiding on appropriate ownership, protection and exploitation

models available to the consortia to ensure that all new knowledge generated through the project is protected and/or exploited as appropriate and in line with the objectives of the funding stream.

ENOS will strive to provide open access to as much of its data as possible. Data acquired at sites through ENOS will be made available for further research by the scientific community on an open access policy. For data where strategic interest might be impacted, open access will be delayed for a determined time not exceeding 2 years (embargo time). The data will be gathered by site owners and stored and maintained on the already existing UK Research Council-funded CCS Knowledge Hub, which has been designed for the purpose of gathering and giving access to public domain documents and data from all UK CCS RC-funded research projects and other projects willing to grant access to their public datasets. For LBr-1, data are already gathered in a different database, which will be used to provide open-access. The ENOS website will serve as a gateway, presenting the different datasets available data and providing links. The process for third parties to get access to the data will also be clearly presented. Data produced in ENOS will mainly be measurements related to site operations in Hontomin, leakage simulation experiments at GTB and Sulcis Fault Lab, project deliverables will also be stored for long term availability in the UKCCSRC data hub for access after ENOS. Each site operator will be responsible for gathering and integrating the collected data.

b) Communication activities

The dissemination and exploitation of *results* plan is an important part of the larger detailed communication plan of the ENOS project. The project will perform dedicated communication to highlight the *actions* in the project which will be closely related and complementary to dissemination and exploitation. Key communication activities that will be undertaken by ENOS, include:

- Organisation of the annual Open Forum in Venice,
- Biannual newsletter sent to relevant stakeholders,
- Public pages of the ENOS Website, integrating social media such as Twitter, linkedIn and Facebook, and providing access to open data.
- Promotion of training and education programme, using the existing networks,
- Participation at key events, not only strictly CCS events (COPs etc.),
- Organisation of workshops with journalists.
- Press releases at start and end of project and important milestones achieved at the sites

3. Implementation

3.1 Work plan — Work packages, deliverables and milestones

The ENOS work programme will be organised into 9 work packages (WP) as depicted in figure 1. A first group of WPs (1 to 4) will focus on demonstrating technologies able to tackle key issues for onshore CO₂ storage in close connection with the local communities (WP5). A second group of WPs (6 to 8) will prepare a favourable environment for CO₂ storage onshore in Europe. Relying on the results from the previous WPs, they will maximise the impact and innovation potential of ENOS. The timing of the different activities is presented in figure 2. All field activities and main research tasks will be performed in the first 3 years of the project in order to leave time for development and further integration of results, and to allow interaction with stakeholders during the finalisation of best practice documents.

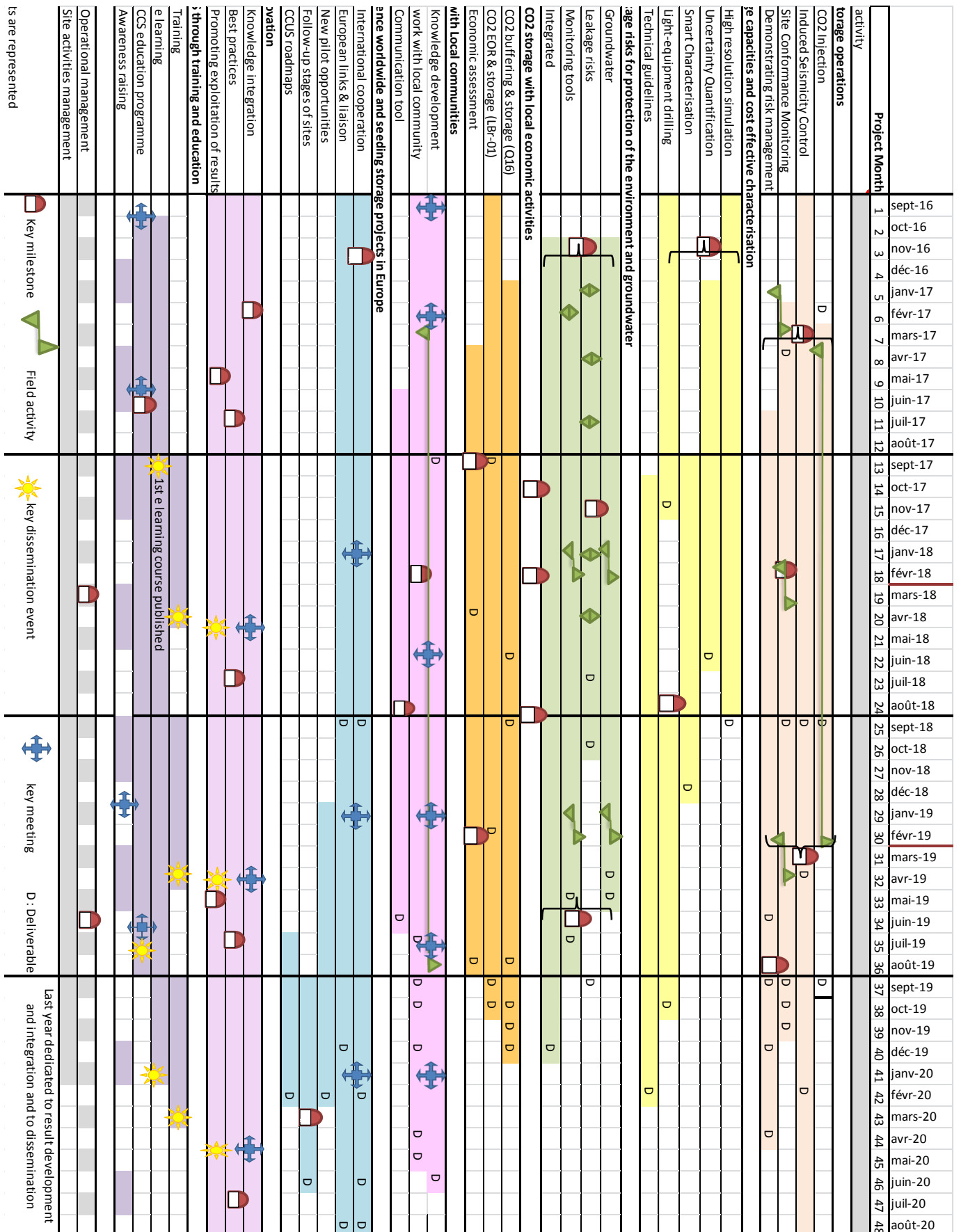


Figure 2: ENOS GANTT chart over the 4 years

3.2 Management structure and procedures

Organisational structure and decision making

The consortium is well aware of the ambitious and specific nature of this Research and Innovation action, such as:

- coordination of field activities, each with its own uncertainties and risks;
- High ambitions in the number of issues addressed and the resulting high number of WP
- 20 participants, representing 33 partners when one counts the 10 Members of the CO₂GeoNet Association participating as third parties and the 3 third parties in PLC-3;
- Many different nationalities, languages, cultural backgrounds and habits.

Consequently, the participants of the consortium have jointly decided how to best match the organisation and management of ENOS to these challenges, according to the following principles:

- The proposed organisational structure is relatively simple with bodies and formal duties clearly identified so as to assure high-level commitment of the participants, efficient operational management
- The work plan is structured into nine work packages of manageable size, each with clear descriptions of objectives, tasks, deliverables and time planning.
- Designated responsibilities for each of the work packages, tasks and deliverables from the very beginning. This means that all participants have a clear understanding of their expected contribution and commitment, which makes delivery of the project's results more efficient and reliable.
- Most work package leaders are also involved in the site activities (as owner, co-owner or as major actor).

Project Management

The Project Management will be carried out under the legal umbrella of the EC H2020 contract and a Consortium Agreement signed by the Participants. In addition, CO₂GeoNet members are bound by the Association's statutes and the CO₂GeoNet Consortium Agreement. A dedicated work package is devoted to the project management (WP9'Management'). The work is carried out by the Coordinator in conjunction with the Management Board.

BRGM, member of CO₂GeoNet, is the Coordinator. BRGM i) has significant experience in coordinating European projects (e.g. Ultimate CO₂), ii) hosts the head office of the CO₂GeoNet association, iii) was CO₂GeoNet Network Manager during the FP6 CO₂GeoNet project, iv) was coordinator of the FP7 CGS Europe project, a pan-European Coordination Action on CO₂ Geological Storage that pooled together the expertise of 34 key research institutes across 28 European countries, with CO₂GeoNet acting as a nucleus, and v) has much experience in CCS networking activities in Europe and globally.

The coordinating person is Marie Gastine from BRGM. She is an experienced and fully trained project manager. She will be supported by a nominated deputy from BRGM for the daily tasks and by the contractual, financial and legal divisions of BRGM as support services. As Coordinator, BRGM will be responsible for:

- Communication with the EC and the consortium participants for all contractual, legal, financial and administrative issues
- Submission of deliverables to the EC in due time
- Coordinating the work of the Management Board
- Monitoring the progress of the project in order to ensure ENOS will deliver the expected outcomes in a timely manner.

The operational management of the project will be carried out by the Management Board, comprising the coordinator and the work package leaders. It will be the responsibility of the MB members to:

- Hold and attend Management Board meetings every two months (mainly web/phone-conferences) to discuss the overall progress of the project, address arising difficulties, discuss emerging ideas or opportunities, take specific decisions;
- Prepare the General Assembly meetings, where strategic decisions will be taken;
- Organise consultation with the Advisory Body;
- Organise and support the contractual reporting to the EC at mid-term (18 months) and at the end of the project period (36 months).

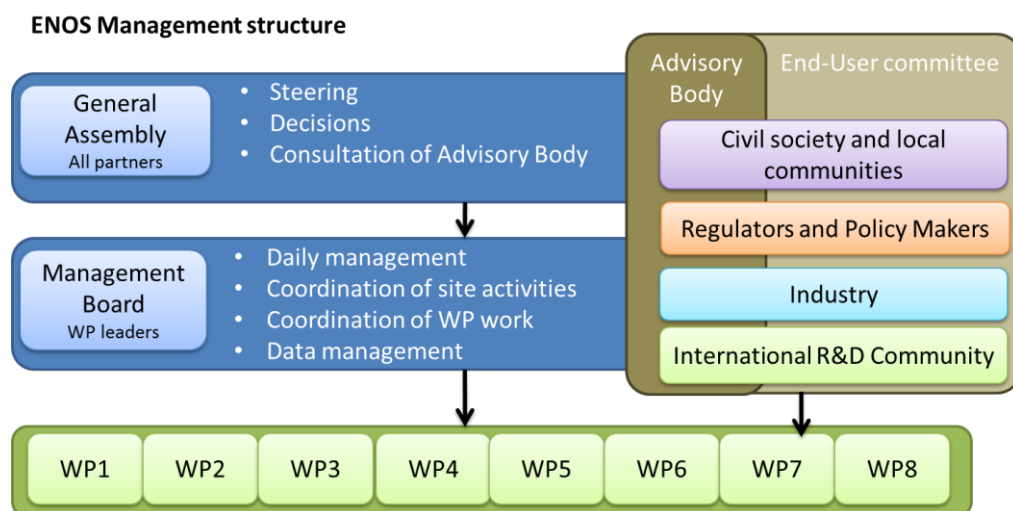


Figure 3: ENOS Management Structure

Organisational structure

The organisational structure is designed to guarantee clear responsibilities, close coordination and effective communication within the ENOS consortium and towards external stakeholders. This will facilitate successful project management and will ensure the delivery of the results and impacts envisaged.

The organisational structure of the project will comprise:

- General Assembly

The General Assembly (governing body) is formed of high-level representatives of the participant organisations, having the necessary authority for making commitments. The main responsibilities of the General Assembly are to:

- steer the project
- take advice from the Advisory Body
- make decisions on issues raised by the Management Board
- discuss and approve strategic project issues

The General Assembly meets once a year, next to an ENOS event, to reduce expenses. If necessary an exceptional General Assembly will be called by the coordinator. The Coordinator convenes and chairs the General Assembly meetings, and is in charge of recording the minutes and the actions/decisions taken during the session. The assembly will be chaired by Isabelle Czernichowski-Lauriol. One or more representatives of the European Commission can be invited to attend the General Assembly meetings during its deliberations related to the contract, as observers with speaking rights.

- Advisory Body

The Advisory Body is composed of external persons representing End-Users of the outcomes of ENOS and international R&D community. The anticipated members will be key representatives of Industry, Regulatory bodies, NGO/civil society, Partners from international collaboration, the Global CCS Institute.

The exact composition of the Advisory Body and the names of the selected persons will be decided at the 1st General Assembly meeting. The role of the Advisory Body will be to give advice to the General Assembly on:

- the relevance of ENOS activities with recommendations for the actions to come
- the innovation management plans and draft best practices
- the effectiveness of intermediate and final results
- dissemination and use of the project results

Three Advisory Body meetings will be held during the course of the project and will be scheduled next to key project events for convenience (workshops or General Assembly meetings). The Advisory Body will elect a Chairperson during its first meeting who will be responsible for steering the meeting and providing a written report to the General Assembly. Interaction with the Advisory Body will also occur on an informal and ad-hoc basis during the course of the project in the case of specific emerging issues.

- Management Board

The Management Board (operational body) is composed of:

- Marie Gastine, BRGM, project Coordinator and WP9 leader
- Lionel Loubeau Gavilanes, CIUDEN, WP1 leader
- Pascal Audigane, BRGM, WP2 leader

- Ceri Vincent, BGS, WP3 leader
- Ton Wildenborg, TNO, WP4 leader
- Samuela Vercelli, UNIROMA1, WP5 leader
- Vit Hladik, CGS, WP6 leader
- Roman Berenblyum, IRIS, WP7 leader
- Niels Poulsen, CO₂GeoNet-GEUS, WP8 leader

The combination of key actors of CO₂ geological storage research, through their insight and experience in multi-partner project management and coordination activities at national and EU project level, forms the optimum operational setting for the efficient management of the consortium. The good balance on geographical origin, gender and age is an additional strength for achieving the project's results.

The Management Board will be responsible for:

- Preparing logistics and content of the General Assembly meetings, including list of decisions to be taken;
- Making sure that the points raised and decisions made by the General Assembly are correctly addressed
- Organising the meetings of the Advisory Body;
- Ensuring good coordination between the project work packages;
- Organising and supporting the contractual reporting to the EC.

The Management Board will meet at least every two months, mainly in connection with ENOS events or through webconferences. Meetings will be chaired by the Coordinator who will also prepare the minutes.

- **Work Package Leaders**

Each work package Leader is responsible for the tasks and deliverables under his/her work package. He/she will liaise with the task leaders and their teams and meet with them as appropriate. Each work package Leader has a seat in the Management Board. WP leaders will organise ad hoc meetings to coordinate the WP activities. Such meetings will be conducted either through phone conferences or in conjunction with other ENOS events in order to save on travel expenses.

Contact with the European Commission

The coordinator will act as the intermediary between all participants and the Commission's services. The DG Research scientific officer in charge of the project will be invited to key ENOS events.

Decision-making mechanisms

Key decisions within the project will be the remit of the General Assembly. Decisions by the General Assembly will preferably be taken on a consensus basis, but when this is not possible, by vote. Voting rights of participants and third parties and mechanisms for decision-making, will be detailed in the Consortium Agreement, prepared during the negotiation phase of the contract. Decisions of the General Assembly requiring the agreement of the European Commission will be submitted by the Coordinator for approval and will only be executed once agreement has been obtained. Minor decisions on operative issues can be taken by the Management Board, which will give the flexibility needed for an effective day-to-day operational management, taking into account the constraints and opportunities that may arise. These decisions will be reported to the General Assembly, which may overrule Management Board decisions.

Innovation management

Innovation management will be dealt within WP7 and will be the basis for the development of the dissemination and exploitation of the results plan. Scientific Editors, in coordination with WP leaders, will be responsible for this, as described in WP7 description (Section 3) and 'measures to maximize impacts' set out in Section 2.2.

Risks related to project implementation

The ENOS work programme is based on real-life experiments. Such activities entail high uncertainty and therefore present risks for the project in addition to the risks inherent in research. ENOS will set up the appropriate measures to mitigate those risks, as described in Part A.

3.3 Consortium as a whole

ENOS is an initiative of CO₂GeoNet, the European Network of Excellence on the geological storage of CO₂, created in 2004 through a FP6 project and now a non-profit scientific Association since 2008, active on both the EU and global scene to help enable efficient and safe CO₂ storage. Current membership is 26 research institutes spanning 19 European countries. ENOS builds on CO₂GeoNet's strength, expertise and added value: a reputed, independent, multidisciplinary, pan-European scientific body with established links to key initiatives and stakeholders at an international level (GCCSI, CSLF, ISO TC265, IEAGHG, UNFCCC), experienced in research, training, scientific advice and various forms of dissemination activities with stakeholders. The European coverage

of CO₂GeoNet combined with the international collaboration set up in ENOS will allow community-based research integration, verification of best practices and cross-disciplinary communication. This will ensure excellence in science and completeness in addressing the multidisciplinary challenges of implementing CO₂ storage.

The consortium is composed of most of the members of CO₂GeoNet and completed by CIEMAT, SGIDS and University of Nottingham and several industrial companies: Geogreen, Silixa (SME), IDIL (SME), Flodim (SME), NHAZCA (SME) PLC-3 and Sotacarbo. For the purpose of enabling onshore CO₂ storage in Europe, the consortium has the necessary pan-European coverage (17 countries are involved), gathers the required high level of expertise in CO₂ geological storage from research institutes and academia, complemented by experience and know-how from site owners and technology providers. Industry partners in the consortium will ensure that the technologies validated in ENOS are relevant for their activities and can be deployed in the near term. The consortium has the necessary links with national, European and international networks to maximise the impact of ENOS and to spread innovation, for example, the GCCSI will support the project and have a strong leveraging effect in knowledge sharing, disseminating and creating favourable conditions to implement CO₂ storage in Europe and around the world. The members of CO₂GeoNet are involved either as full partners or as third parties in the consortium, depending on their involvement in the project.

Together the participants bring an extensive and unique experience in CO₂ geological storage, demonstrated by a wide range of European and national projects, which will feed into the work carried out under ENOS. Key projects that ENOS partners participated in that provide a strong foundation for the proposed work programme include:

- FP6 CO₂GeoNet, CASTOR, CO₂ReMoVe, EU GeoCapacity, ULCOS, INCA-CO₂, GRASP, INTAS;
- FP7 CGS Europe, CO₂CARE, ULTime-CO₂, SITECHAR, ECO₂, RISCS, R&Dialogue, IMPACTS, ECCSEL PPI and PPII, STRACO₂, COMET;
- French ANR and ADEME projects such as EM-Hontomín, CIPRES, H-CUBE, CO₂-Dissolved, FISIC, MANAUS, COPTIK, France Nord, ULCOS-TGRBF, AMIRAL, IMPACTS-CO₂, MOME CO₂;
- EUROGIA+ CO₂FieldLab
- UK projects ASGARD, CASSEM, ETI UK SAP; Dutch CATO programs; German Federal Ministry of Education and Research projects CLEAN & MONACO
- EEPR-funded projects: OXY-CFB-300 Compostilla – (Duero/Hontomín sites).

Industry involvement

The consortium includes 6 industrial partners. They represent different segments of the potential CCS business:

. PLC-3 is a permit holder for underground exploration. On the other side Geogreen, is an engineering company dedicated to CO₂ storage, which could in the future propose storage solutions to emitters. Technology providers are represented in ENOS through innovative SME's: SILIXA Flodim, NHAZCA and IDIL. All have interest in the results of the project and will provide their expertise but also express the end- user view on the ENOS innovation. The participation of the SMEs is limited (in relation to the total amount of the project), but this corresponds to their research investment capacities. They are nonetheless important actors in the consortium and they will be involved in the integration of results as much as possible.

Sotacarbo is a research company, tightly involved with industry partners.

ENOS investor Club

ENOS will create an investor club that will gather financial contribution from European industry sector interested in supporting the deployment of CCS onshore and in the outcomes the project will create. The members of the club will get early access to the results of the project. They will also provide input, as interested end-users, to ENOS General Assembly and to the innovation management through the advisory body. This will ensure that a wider view of the industrial needs and expectations are taken into account. As of the time of submission, EDF declared its intention to join the investor club (see intention letter in Section 4.3). Further efforts are on-going to gain support from more partners.

The sponsorship gathered through the investor club will serve to fund additional activities, not covered by this Work Programme, such as a particular research task if a need or opportunity emerge, a dissemination task, buying some extra CO₂, etc.

3.4 Resources to be committed

Justification of major other direct cost

The table below presents the justification for the travel and other costs for all partners and third parties. Travel cost estimation are done on an average costs basis and will be subject to changes according to destination and duration. The number of travels, in particular in communication and dissemination may vary from predicted according to opportunities arising during the project.

The beneficiaries will base their contracts and subcontracts on the 'best value-for-money' considering the quality of the service proposed (also called 'best price-quality ratio') or on the lowest price and avoiding any conflict of interest. Beneficiaries that are 'contracting authorities' or 'contracting entities' (within the meaning of the EU public procurement Directives 2004/18/EC and 2004/17/EC — or any EU legislation that replaces these Directives) must moreover comply with the applicable national law on public procurement. These rules normally provide for a special procurement procedure for the types of contracts they cover.

All equipment and other items that will be claimed 100% as cost of the project will be exclusively used for the activities in the project; as a consequence, if the equipment is also used for other activities outside the project, only part of its cost (corresponding to the percent of use within the project) will be charged.

Note in the following table CFS: stands for Certificate on Financial Statements and GA for General Assembly

1/ BRGM	Cost (k€)	Justification
Travel	69.4	Field activities: WP1: - 3 sampling campaigns for geochemical monitoring: 3x3.5k€ - 3 geophysics field activities 10.5k€ ; WP3: - Field campaigns to test optic fibre tool 3x6k€ Attending WP Meetings: WP1 6k€; WP2 3k€; WP3 2k€ ; WP9 5k€ Attending Workshops: WP5 2k€; WP7 2.4k€; WP8 5k€ (CO ₂ storage schools) International collaboration: WP6 5k€
Other goods and services	132	4k€ for CFS ; 50k€ for Advisory Body travel task 9.2, (about intercontinental travels: 3 meetings and 2 or 3 members coming from overseas) 50k€ for international collaboration partner travel to ENOS sites task 6.1: collaboration with USA (2 entities) ,Canada, South Korea (2 entities), South Africa and Australia Support one or 2 visits from each entity: about 10 intercontinental travels 20k€ for General Assembly organisation (4); 8k€ for fluid sample analysis in WP1.
Total	201.4	
2/BGR		
Travel	48.9	Field activities: 24.9k€: 6 x (2 Persons, 4 days) to Hontomin (WP1) and 6 x (2 Persons, 4 days) to the Geoenergy testbed (WP3) WP 1 & 3: annual WP meetings, ENOS GA (2 Persons 2 days twice per project year) 10k€, two conferences in Europe (e.g. EGU): 6k€, WP 6.4: 4 Travels (1 person 2-3 days) to Q16-Maas site in order to review the site development plans and one WP meeting : 2k€, WP 8: Travel to three WP8 workshops preparing CO ₂ storage school e-lectures: 3 x 1 Person three days 2k€, Conference and General Assembly attendances 3 x 1 Person for 2-3 days including conference fees 4k€,
Equipment	23.5	WP 1 (14.1k€) and WP 3 (9.4€). to refurbish parts of monitoring stations and/or replace devices during the continuous 3-year monitoring program for a minimum of 5 complete stations operated (3 x Hontomin, 2 x Geoenergy Test Bed) 10k€ for 5 data loggers (Gantner e-reader or similar); 4.5k€ for 5 new IR-CO ₂ -Sensor for low concentrations; 4.5k€ replacement of the 5 soil humidity sensors (TDR Pico Prime); 4.5k€ for new Router/Modem (UTM capability) devices with faster data transmission for the 5 considered stations .

Other goods and services	23.4	WP 1 (11k€) and WP 3 (8.4€). to refurbish parts of monitoring stations and/or replace devices during the continuous 3-year monitoring program for a minimum of 5 complete stations (3 at Hontomin, 2 at the Geoenergy Testbed): 3.1k€ for 26 test gases cans with different concentrations; 4k€ for 30 tanks of ultrapure methanol for fuel cells; 5.7€ for 12 Nafion-Tubes for soil gas drying purpose and 18 small membrane pumps ; 2.7k€ for 8 solar panels and 16 replacement batteries for short power failures; 4.5k€ for Router/Modem (UTM capability) and real time data transmission via UMTS network to a central data server. 4k€ for CFS
Total	95.8	
3/BGS		
Travel	95.9	Majority is costs for travel and subsistence for field activities at Sulcis Fault Lab and San Vittorino site. Funds will also be spent on travel and subsistence for attending key ENOS meetings, workshops and events, internal project activities (hereafter referred to as 'ENOS meetings' to reduce text length) and promoting ENOS results through presentations at external conferences. WP2 – 3k€ for travel and subsistence (T&S), attendance of 1 person to 3 ENOS meetings and 1 conference (5 days per meeting). WP3 – Field work T&S and local travel to GTB, 151 days in the field 43.2 k€; ENOS meetings (attendance at 13 meetings of 5 days each), 13.9 k€; Conference attendance (3 people) 5.6 k€. WP6 – Attendance at 7 ENOS meetings (1 person, 5 days per meeting) 9.6 k€; Attendance at conference and side event 2 k€ (1 person, 5 days); room hire for side event 5 k€; attendance at 1 ECCSEL event 1 k€ (1 person, 5 days). WP7 – Attendance at 5 ENOS meetings (1 person, 5 days per meeting) 6.8 k€. WP8 – Attendance at 3 ENOS summer schools (1 person, 5 days per school) 4 k€; attendance at 1 ENOS meeting (1 person, 5 days) 1 k€
Services	49.2	5k€ for CFS. WP3 – Shipping/transporting equipment to and from field sites 4.2 k€; Consumables for field and laboratory experiments 4.1k€; flight hire 6.9 k€; purchase optic fibre 22 k€; groundwater equipment 4.2 k€; lab costs and sample analyses 2.8k€;
Total	145.1	
4/CGS		
Travel	37.3	5k€ - WP4 –WP and Task meetings and events for dissemination 3k€ - WP5 –WP workshops (6 workshops * 500€) 16 k€ WP6 - Task 6.1 – international cooperation – twinning visit in the USA, participation in workshops; Task 6.2 – European links & liaison; Task 6.3 meetings with stakeholders in the region 6,5 k€ - WP 7 –knowledge integration workshops, 4 Open Forum, dissemination events 1,8 k€ - WP8 –CO ₂ Storage School in the Czech Republic , short course for journalists 5 k€ - WP9 –General Assembly and Management Board meetings
Other goods and services	7	software for 3D geological data management, software for geochemical analyses and modelling, software for well data management, consumables
Total	44.3	
5/CIEMAT		
Travel	4.5	WP meetings and/or ENOS GA (2 persons, 4 GA or WP1)
Equipment	0	
Other goods and services	0	
Total	4.5	
6/CIUDEN		
Travel	30.3	- Travel cost for attending General Assembly, networking trips, conference attendance , EC reviews, workshops: 11k€ - Travel cost for attending Field activities:14.3k€ - Travel cost for attending Task 6.1 International cooperation: 5k€
Other goods and services	1291	- CO ₂ : 1030.75K€ (for maximum of 10kton CO ₂ for test injection). the planned quantity of CO ₂ is 10.000 tons, and the current best market price is

		103,075 €/ton - N₂: 0.93K€ (according to the flow of CO₂ injected and current price) - Propane: 24.80K€ (according to the flow of CO₂ injected and another Technology development Platform (TDP) needs and current price: to inject 10.000 tons of CO₂, we need 41.330 kg of propane, and the current best market price is 0,6 €/kg. - Salt: 36.68K€ (according to the flow of CO₂ injected and current price) In order to inject 10.000 tons of CO₂, we need 447,33 tons of salt and the current best market price is 82 €/ton. - Diesel Oil: 28.84€ (according to the flow of CO₂ injected and another TDP needs and current diesel price. Energy is produced by a diesel generator). In order to inject 10.000 tons of CO₂, we need 68.670 l of diesel oil and the current best market price (0,42 €/l) - TDP facilities maintenance: 58.50K€ (electric and mechanic maintenance and spare parts, for instance diesel generator, pumps, air compressor, fridge machines, heater and so on, as well as communications network maintenance, and passive seismic grid maintenance). - Well maintenance: 80 k€ (it will be workover operations on wells which are necessary to change some items from the well completions after the injection tests and before the introduce the geophysics devices. The slick line service used for this job is one of them). - Maintenance and spare parts of the lab: 2.56k€ (it is necessary to check using our Lab facilities the composition of the fluid from the reservoir in order to know if the chemical composition have the expected values). - Works and services related to improve local communities public perception, to develop workshops, scientific and general meetings and training sessions to accomplish the dissemination, engagement and education aims of ENOS (catering, bus, coffee break, brochures, lectures's subsistence allowance, etc): 22.54k€ - Audit certificate on the Financial Statements: 5.4K€ (3 audit for the 3 reporting periods).
Total	1321.3	
7/Flodim		
Travel	9	Hontomin Field activities in WP1 (3 surveys)
Services	5	Shipping of material to Hontomin for field activities WP1
Total	14	
8/GGR		
Travel	7.5	WP1: 3.5k€ as 1 GA attendance 0.5k€+ 4 Technical meetings (Hontomin) 4*0.75k€ WP4: 2k€ as 1 GA attendance 0.5k€+ 3 Technical meetings (Utretch) 3*0.5k€ WP7: 2k€ as 2 GA attendance 2*0.5k€+ 2 Technical meetings (Utretch) 2*0.5k€
Equipment		
Other goods and services	71.4	WP1&4: 3 rental periods of 4 months for fluid flow and geomechanics/geochemistry software (GEM) 3*23.8k€
Total	78.9	
9/IDIL		
Travel	2.5	Participation to 4 GAs
Equipment	-	
Other goods and services	-	
Total	2.5	
10/IRIS		
Travel	32.5	WP3: 8 k€ to be used for field trips, WP and task meetings. Corresponding approximately to 8 travels for 1 person for 3 days.

		WP4: 11 k€ to be used for WP and task meetings. Corresponding approximately to 11 travels for 1 person for 3 days. WP7: 8.5 k€ to be used for trips to open forum, WP and scientific committee meeting. Corresponding approximately to 8 travels for 1 person for 3 days. WP9: 5 k€ to be used for project management and GA meetings. Corresponding approximately to 5 travels for 1 person for 3 days.
Equipment		
Other goods and services	32	WP3: 8 k€ would be used for DNA sequencing and identification WP7: 20 k€ would be used for developing design of the website and promotion materials WP9: 4 k€ to be used for CFS
Total	64.5	
11/NHAZCA		
Travel	9.5	Field activities (WP3): 7.5 k€ (3 persons x 10 days to Sulcis) WP meetings and ENOS GA: 2 k€ (1 person attending 4 GA meetings)
Equipment	2	WP 3: 2k€ (optical camera and lenses for RPAS system)
Other goods and services	4	WP3: 4k€ (corner reflectors for Radar, optical prisms for total station, optical target for RPAS, rental of RPAS systems supporting apparatus)
Total	15.5	
12/ OGS		
Travel	77.6	Field activities: WP1 28 k€: Field activities in Spain Hontomin of personnel (Geophysicists, Field Engineers and technicians) for scouting and at least-two acquisitions, to perform time-lapse borehole geophysical acquisition, including mobilization, demobilization and in-field QC; WP3 22 k€: Field activities in Italy Sulcis of personnel (Geophysicists, Experts of Remote sensing, Field Engineers and technicians) for scouting and at least-two acquisitions, to perform plume monitoring surface and borehole geophysical acquisition, including installation assistance, mobilization, demobilization and in-field QC, and UAV drone operations. Project meetings, conferences/workshops, travels for international collaborations : WP1 8 k€: averaged 900 € x 3 Meetings at Hontomin in Spain and in Europe x 2 persons (coordinator, acquisition and different key experts involved in data analysis and integration) = 5.4 k€, 2.6 k support for 2 persons/European conference or workshop; WP3 5 k€: 1000 € 2 meetings x 1 person in Europe, 500 € x 2 Persons x 3 Meetings at Sulcis, focused on borehole instrumentation, geophysical monitoring and remote sensing; WP5 3k €: 1000 € x 1 persons x 1 meeting in Hontomin, 500 € x 2 persons x 2 meetings at Sulcis, for contacts with the local population regarding geophysical monitoring and remote sensing techniques; WP6 3.3 k€: 1650 € x 1 person x 2 international meetings for set-up collaborative actions between storage sites; WP7 6.5 k€: 400 € x 2 persons x 4 meetings for the organization and support during the Open Forums; 500 € x 2 persons x 2 meetings in Europe for knowledge integration workshops; 325 € x 1 person x 4 meetings for definition, realization and further development of the web site and knowledge sharing platform; WP8 1.8 k€: 900 € x 1 person x 2 meetings in Europe with partners for setting and preparing contents for e.learning courses.

Other goods and services	54	20 k€ for consumables for and during the Hontomin surveys (freight cost, gasoline and car rental) in WP1; 30 k€ for consumables for and during the Sulcis surveys (freight cost, gasoline and car rental)WP3; 2 k€ WP6 consumables (software tools for webinars); 2 k€ WP8 consumables (software tool for e-learning).
Total	131.6	
13/PLC-3		ENAGAS
Travel	6.39	WP1 meeting:450€ (1 meeting) WP2 meetings : 2040€ (5 meetings) WP3 meetings 2400€ (5 meetings) WP7: 1500€ Participation for 1 person to 4 GA
Equipment	-	
Other goods and services	-	
Total	4.95	
13/PLC-3		IPF
Travel	7.9	WP1 meeting:1600€ (3 meeting) WP2 meeting 600€ (2 meetings) WP3 meetings 1200€ (2 meeting) WP5 meetings : 1000€ (2 meetings) WP6 meetings : 2000€ (4 meetings) WP7: 1500€ Participation for 1 person to 4 GA
Equipment	-	
Other goods and services	-	
Total	6.3	
14/SGUDS		
Travel	4	WP4: 1k€ for WP meetings WP6: 1k€ for WP meetings WP7: 2k€ for 4 GA
Equipment	-	
Other goods and services	-	
Total	4	
15 / Silixa		
Travel	20.9	Field activities: 2x(2 Persons, 12 days) to Hontomin , 4x(1 Person, 4 days) to Sulcis 2 500€ for project meetings
Equipment	45.8	WP1: 27k€ iDAS components (triggering mechanism, GPS Antenna, external data storage Raid, additional data storage hard drives, acquisition cards) additional parts and/or replace components during the continuous 2-year monitoring program for the seismic surveys at the Hontomin site. WP 3: 18.8k€, to purchase, splice and terminate the icable for the seismic surveys at the Sulcis site: 17.5k€ hybrid fibre optic cable (iCable) and 1.3k€ cable terminations (U-bend and E2000 connectors)
Services	9	handling and logistics for field activities (shipping costs x 5)
Total	75.7	
16/SOTAC ARBO		
Travel	15	1000 € for participating in 4 GAs

		1500 € for participating in WP2 and WP3 meetings 12.500 € for international collaboration: - visit to South African CO₂ storage site (2 persons, 2x2500 €); - visit to Korean CO₂ storage site (2 persons, 2x2500 €); - visit to Australian CO₂ storage site (1 person, 2500 €).
Equipment	-	
Other goods and services	-	
Total	15	
18 / TNO		
Travel	48.1	WP1 Travelling and subsistence for two field visits of 2 persons to Hontomin site during 3 days: 2*2*900 € = 3.6 k€; travelling and subsistence for 2 person to 3 technical meetings during 2 days: 3 * 1.4 k€ = 4.2 k€; 2 presentations at conferences for one person during 3 days: 2 * 950 € = 1.9 k€; total 9.7 k€ WP3 Travelling and subsistence for visits to the UK field experiment for 2 persons during 4 days: 4*725 € = 2.9k€, one person to two conferences during 3 days: 2*950 € = 1.9k€; one person for travelling and subsistence to 1 technical meeting during 2 days: 700 €; total 5.5 k€ WP4 Travelling and subsistence for one person at 4 conferences during 3 days: 4*950€ = 3.8 k€; attendance of 6 technical meetings by one person for two days: 6*700 € = 4.2 k€; 2 visits of 3 days to EOR site in Czech Republic for 2 persons: 2*1.4 k€ = 2.8 k€; 3 visits to buffer site in the NL by two persons: 3*200 € = 600 €; organisation of stakeholder meeting: 600 €; total : 12 k€ WP5 Organisation of 4 workshops with stakeholders in Rotterdam area: 4*575 € = 2.3 k€; attendance of 3 technical meetings for 2 persons during 2 days: 3*1.2 = 3.6 k€; conference for one person: 400 €; total 6.3 k€ WP6 Travelling and subsistence for one person for two 3-day conference: 0,8 k€; travelling and subsistence for technical/stakeholder meetings by one person: 2.2 k€; organisation of stakeholder meetings: 1 k€; total 4 k€ WP7 Attendance of 4 dissemination events/knowledge integration workshops by one person for 2 days: 4*700 € = 2.8 k€, 1 conference by 1 person for 3 days: 1000 € = 1k€; workshop organisation costs: 1000 €; total 4.8 k€ WP8 Training during CO ₂ storage schools: Training during CO ₂ storage schools: travelling and subsistence for 1 persons for one event during 3 days: 0.8 k€; total 0.8 k€ WP9 Management board meetings: Travelling and subsistence for 2 persons in 2 meetings during 2 days (incl. travelling): 2*1.450 k€ = 2.9 k€; travelling and subsistence for 1 person in 3 meetings during 2 days: 3 * 700 € = 2.1 k; total 5 k€
Equipment	19	WP3: 10 k€ Soil gas measuring equipment. WP4: 9 k€ Laboratory analysis and fluid chemistry.
Other goods and services	7.5	WP9: 7.5 k€ Certificate financial statement at the end of the project.
Total	74.6	
18/UNIROMA1		
Travel	80	Field activities (WP1, WP3 and WP5) 51 k€ : 2 persons x 6 days to Hontomin 5K€, 3 persons x 70 days to Sulcis 46 k€ WP meetings (WP5, WP3, WP6, WP8): 10-12 trips for 1 person destination tbd 10k€ International collaboration trips (WP6) 1 person to Korea and 1 to South Africa for one week (7,5 k€) Knowledge integration workshops or other dissemination events (WP7) destination tbd, 2 trips of 2-3 days for 1 person (2,5 k€) Organisation of educational activities (WP8) 3-4 trips to the partner universities for 1 person (4k€) Meetings of the management board and ENOS GA (WP9) destination tbd, 4-5 trips

		for 1 person (5k€)
Equipment	62	WP1 (2k€) and WP3 (60k€). Material for construction and maintenance of: - minimum of 5 complete stations at Sulcis site for water monitoring 10K€; - 50 GasPro-pCO2 at the Sulcis site; 2 GasPro-CO2 at Hontomin 50K€; - the autonomous robot to continuously map CO2 concentrations 2K€;
Other goods and services	75	WP5 Support for activities with the population: contract to a market research firm for the selection of random sample participants' (5K€); for organisational support to group activities with the population (including organisations and management of appointments, catering, incentives to the participants, recording, transcriptions of meeting recordings) for 50 meetings (60K€); transcription of final interviews (5K€). WP8 Support of 1 student for attending activities at partner universities (task 8.3) 5k€
Total	217	
19/UNOTT		
Travel	20.7	Meetings and workshop attendance: WP2 3k€ ; WP5 4k€ ; WP7 2.5k€ (4GA) ; WP8 3.2k€ International cooperation on field sites: WP6 8k€
Equipment		
Other goods and services	32.7	Support for modelling simulations and data analysis: WP1 8.2k€ WP2 7k€; WP3 8k€ WP9 4.5k€ CFS and auditing costs; WP8 5k€ training materials
Total	53.4	
20/CO2GE ONET		
Travel	6	WP5: Participation of task 5.1 workshop: 2 k€: 1 person x 2 days; WP6: Participation at task 6.5 meeting; 1,5 k€: 1 person x 1,5 days WP7: Participation at Knowledge Integration workshop (task 7.1): 2,5 k€: 1 Person x 2,5 days
Equipment		
Other goods and services		
Total	6	
20/CO2GE ONET		
Travel	14.9	WP3 (2 k€) 1 person X 2 technical meetings WP5 (2 k€) 1 person X 2 technical meetings/workshops WP6 (4 k€) 1 person X 4 international collaboration/ project meetings WP7 (3 k€) 1 person X 3 dissemination events/ knowledge integration workshops WP8 (3.9 k€) Teacher mobility for the CO2 storage schools (1 person X 3 schools)
Equipment		
Other goods and services	1	WP3 (1 k€) consumables
Total	15.9	
20/CO2GE ONET		
Travel	5.1	WP Meetings and ENOS GA: 4 meetings x 1 person x 0,600 k€ = 2,8 k€; WP6 workshops and working meetings: 1 meetings x 1 person x 0,6k€ = 0,6 k€ WP7 workshops and working meetings: 2 meetings x 1 person x 0,6k€ = 1,2 k€ WP8 workshops and working meetings: 1 meetings x 1 person x 0,5k€ = 0,5 k€
Equipment		
Other goods and services		

Total	5.1	
20/CO2GE ONET		GEUS
Travel	8.6	travel and accommodation costs as teacher on 3 schools (WP8.1) (3 x 1,5k€), Travel cost related to 3 workshops in WP8.2 (3x0,5k€), 3 workshops in WP8.3 (3x0.5k€), and travel related to WP9, management(1.1k€) This is student travel and accommodation support related to the planned 3 intensive schools
Equipment		
Other goods and services	36	Travel and accommodation funds for students for the 3 schools (3*12*1k€)
Total	44.6	
20/CO2GE ONET		GSB-RBINS
Travel	4.5	3 k€ - WP4: GA (1 person * 4 meetings * 300€), WP (1 person * 3 meetings * 300€) and Task meetings (1 person * 2 meetings * 300€) and events for specific dissemination (1 person * 1 meeting * 300€) 1.5 k€ - WP 7: knowledge integration workshops (1 person * 1 meeting * 300€), Open Forum (1 person * 3 meetings * 300€), general dissemination events (1 person * 1 meeting * 300€) It is foreseen to combine site visits and one-on-one ad-hoc (technical) discussions, necessary for especially WP4, with WP or task meetings. If respecting the timeline of WP7 requires additional visits, then these will be planned accordingly
Equipment	5	5 k€ - WP4 - high-end CPU hardware costs: The geo-economic evaluations that will be made, are extremely computing intensive, and hardware needs to be updated frequently since calculation time forms an important practical limit for the multi-nested Monte-Carlo simulations. This sum is based on replacing/upgrading our two 6-core machines. Software costs are limited, since our simulator is in-house developed, but may include GIS licences if the need for such package would arise.
Other goods and services		
Total	9.5	
20/CO2GE ONET		HWU
Travel	9.3	9.3 k€ Project meetings, national and international conferences/workshops (WP2 2*1.5 k€; WP5 2 k€ ; WP7 2*0.75 k€; WP8 2*1.4 k€)
Equipment	19	19k€ High performance computing -- Three high performance computing (HPC) nodes with parallel processing capabilities necessary to perform multi-phase flow simulations listed in WP2 and WP3. -- Two workstation computing machines equipped with powerful graphics processing units (GPUs) for visualization of the CO2 flow simulation results.
Other goods and services	1	1k€ External audit certificate
Total	29.3	
20/CO2GE ONET		IGME
Travel	11.8	Field activities: WP1 (2k€ = 2 persons x 10 days to Hontomín) + WP5 (2k€ workshops with researchers) + 2k€ for project meetings and GA Cooperation and education activities: WP6 (1.5 k€ = 750 € for the EERA CCS research workshop + 750 € for project meetings) + WP7 (2.9 k€ = 1.5 k€ for knowledge integration workshops and 1.4 k€ for scientific editors and project meetings) + WP8 (1.4 k€ awareness raising workshops)

Equipment		
Other goods and services	12	12 k€ for organization of 6 awareness raising workshops x 2 k€ (rental of rooms, catering, invited speakers...)
Total	23.8	
20/CO2GE ONET		METU PAL
Travel	3.5	WP4 : WP meetings 1k€ (1 persons for 2 meetings) WP7: General Assembly 2.5k€ (1 person for 4 meetings)
Equipment		
Other goods and services		
Total	3.5	
20/CO2GE ONET		TTUGI
Travel	8	WP5 (1 k€) 1 person attending 2-days local workshop = 1000€. WP6 (3 k€) 2 person attending 2 knowledge exchange workshops = 4*750€. WP7 (2 k€) 1 person attending 2 GA meetings= 2*1000€. WP8 (2 k€) 1 person attending 2 internal workshops= 2*1000€.
Equipment		
Other goods and services	6.5	WP6 (1.5 k€) organization of common workshop with Baltic Sea Region CCS Network (BASRECCS) WP7 (5 k€) for printing and distribution of annual ENOS Newsletter to the special events
Total	14.5	
20/CO2GE ONET		UNIZG-RGNF
Travel	5.8	WP6 EERA research workshop, 1 person*€600 ENOS- Baltic Sea Region CCS network joint workshop, 1 person*€600 ENOS scoping workshop and monitoring technology demonstration, 1 person*€600 WP7 1 st knowledge integration workshop, 1 person*€500 2 nd knowledge integration workshop, 1 person*€500 3 rd knowledge integration workshop, 1 person*€500 Kick-off meeting, 1 person*€500 Final GA meetings (other GA meetings in conjunction with other events), 1 person*€500 WP8 Internal workshop for development of curriculum, 1 person*€500 ; Internal workshop for first presentation, 1 person*€500 Internal workshop for final discussions, 1 person*€500
Equipment		
Other goods and services	5	WP8 Student support for attending courses at other partner institutes
Total	10.8	

4.1. Participants

1. Bureau de Recherches Géologiques et Minières (BRGM)

Description of the entity:

BRGM, France's leading public institution in the Earth Science field, has three main activities: scientific research, support for government policy, and international cooperation and development assistance. BRGM has been among the pioneers in research on CO₂ geological storage, participating from 1993 in the first European research project (Joule II) and in the first pilots worldwide (Sleipner, Weyburn, In Salah, Nagaoka, Ketzin, Lacq-Rousse, Hontomín, etc.). BRGM is also carrying out research activities at natural CO₂ fields, such as Montmiral in France, and at natural CO₂ seepage areas in Italy, Germany and France. Its fields of expertise are site selection and characterisation, predictive modelling, risk analysis, monitoring and safety management, thus addressing a wide range of the issues related to CO₂ geological storage. BRGM was strongly involved in the tentatives to set up a demonstration project for CO₂ storage in France (Ademe France Nord and TGR BF). BRGM has been manager of the CO₂GeoNet European Network of Excellence on the geological storage of CO₂, initiated in 2004 through an EC FP6 contract, now a legally registered Association under French law. BRGM was President of the CO₂GeoNet Association from 2011 to March 2015. Recently, BRGM was the coordinator of the FP7 CGS Europe project (2010-2013), a Pan-European Coordination Action on CO₂ Geological Storage involving 34 research institutes over 28 countries, including the CO₂GeoNet Association. BRGM is currently coordinating the FP7 ULTimate CO₂ project (2011-2015) dedicated to the understanding of the long term fate of geologically stored CO₂ and is involved in the ECCSEL H2020 INFRADEV-3 project on CCS Research Infrastructure that will start mid 2015 after two ECCSEL Preparatory Projects Phase I and Phase II carried out in FP7. BRGM is also a member of ZEP, EERA CCS, French Club CO₂ and is representing France in CSLF and ISO TC265 on CCS.

Contribution to the Work Plan and expertise brought to ENOS:

BRGM will coordinate the proposal and therefore be in charge of the WP management. BRGM will also coordinate the WP2 ensuring storage capacities and cost-efficient characterization. Given its wide expertise, BRGM will be involved in a wide range of activities in ENOS.

On the technical level, BRGM contribution will consist mainly in:

- Validation of monitoring techniques at Hontomin (WP1)
- Integration of monitoring measurements (WP1)
- Development of methodologies for assessing reliability of capacity estimates (WP2)
- Validation of smart characterization methodologies (WP2)
- Validation of groundwater monitoring and of downhole gas sensor using fiber optics (WP3)

BRGM will strongly participate to the dissemination and innovation development, the preparation of best practices (WP7), the international collaboration (task leader) and training (WP8)

BRGM is involved in:

- 3 of the 4 tasks in **WP1** Ensuring safe storage operations (Task 1.2 Induced seismicity: monitoring, control and hazard mitigation; Task 1.3 Monitoring safe underground storage behavior; Task 1.4 Demonstrating operational risk management)
- 2 of the 4 tasks in **WP2** Ensuring storage capacities and cost-effective site characterization (WP Leader): (Task 2.1 Quantify reliability of storage capacities estimates; Task 2.4 Technical guidelines on storage capacities estimates and cost-effective site characterisation)
- 2 of the 4 tasks in **WP3** Managing leakage risks for protection of the environment and groundwater
- **WP5** Coordination with local communities (Task 5.1 Knowledge development and integration in a societal perspective)

- **WP6** International Cooperation & seeding pilots and demos in Europe (Task 6.1 International cooperation; Task 6.2 European links, liaison and knowledge exchange)
- **WP7** Spreading innovation for Research integration and Best practices
- **WP8** Promoting CCS through training and education (Task 8.1 Education and training for the European research community; Task 8.4 Raising awareness by training workshops for journalists and media)
- **WP9** Management (WP Leader)

Staff

Coordinator: Marie GASTINE obtained an environmental engineering degree from Politecnico di Milano and an engineering degree from Ecole Centrale Paris. She joined BRGM in 2007 and has since been working on CO₂ Geological storage flow modeling, including work on the ADEME demonstrator projects (France Nord and TGR BF). She has been deeply involved in several European projects, such as CO₂GeoNet, CGS Europe, *COMET, *R&Dialogue, ECCSEL PPI and * ECCSEL PPII (*as BRGM project manager). She was WP leader in COMET and assisted the coordinator –her colleague I. CZERNICHOWSKI-LAURIOL - in CGS Europe. She has therefore the necessary experience in managing large European projects. From 2013 she overviewed CCS activities in the Water Environment and Eco-technology division of BRGM and participates regularly in national and European networks focused on CO₂ Storage: French Club CO₂, EERA-CCS and ZEP. She will be Coordinator of ENOS, overseeing the smooth running of the programme of activities and consortium management.

Isabelle CZERNICHOWSKI-LAURIOL will chair the General Assembly. She will advise Marie GASTINE and the Management Board in management and strategic issues. She will review deliverables of WP6 and WP7, mainly those dealing with future plans for research and CO₂ storage pilots and demonstration projects in Europe, international and European collaboration, best practice documents. She holds an Engineering degree in geology (ENSG Nancy, 1984) and PhD in geosciences (INPL, 1988). She joined BRGM in 1988, has been involved in CO₂ storage since 1993, was President of CO₂GeoNet from July 2011 to March 2015, Coordinator of FP7 CGS Europe project (2010-2013), CCS Programme Officer at the French National Research Agency from February 2010 to Feb. 2014 (part-time secondment), and is presently Programme Officer on Geo-Energy (CO₂ and energy storage, geothermal energy) at BRGM's Division of Research and Development.

The technical work will be mainly performed by the following staff:

Sandrine GRATALOUP is a geologist engineer. She graduated from Ecole du Pétrole et des Moteurs (IFP School) with an engineer degree in Exploration Geology in 2002 and from the Paris National School of Mines with an international Post-Master degree in Engineer and Environmental Geology in 2005. She worked in 2003-2004 at ANDRA, the French National Agency for Radioactive Waste Management, as a geologist for geological and hydrogeological modeling. She joined BRGM in 2006 and works in the Geology Department. She is involved in several national and international projects for geological storage of CO₂. Her main activities are focused on geological characterisation and modelling of underground formations. In ENOS, she will be in charge of WP2 management.

Julie LIONS is a hydrogeochemist. In 2004, she obtained a PhD in hydrochemistry and hydrogeology. Since 2005, she joined BRGM to become involved in projects concerning groundwater hydrochemistry and CO₂ geological storage. She focuses on geochemical and long term reactive transport modelling with respect to safety aspects of geological CO₂ storage and impacts on groundwater quality. She is also deeply involved in experimental works and field investigations for water-rock interactions in shallow groundwater. In ENOS, she will be in charge of task 3.1

Thomas LE GUENAN joined BRGM in January 2008 to work on safety issues for geologic storage of CO₂ under the Risks and CO₂ storage Safety department. He is now in charge of the safety criteria and impacts of CO₂ storage programme, which comprises around 20 BRGM projects on the subject. He holds a multidisciplinary master level degree from the Ecole Centrale Paris, a French non-specialized engineering school, and a Master of Science degree in environmental and land planning engineering from the Politecnico di Milano University. He was involved in the EUROGIA+ CO₂FieldLab and ANR SENTINELLE projects on monitoring protocols issues, and on the FP7 CO₂CARE project on risk management issues. He is main author of the preliminary risk assessment performed for the ADEME TGR-BF project. In ENOS, he will be in charge of Task 1.4

Publications

- 2014, Manceau J.C., Rohmer J. Ranking importance of uncertainties for the assessment of residual and dissolution trapping of CO₂ on a large-scale storage site. *Energy Procedia*, Volume 63, pp 3658-3664.
- 2014, Bader A.G., Thibeau S., Vincké O., Delprat Jannaud F., Saysset S., Joffre G.H., Giger F.M., David M., Gimenez M., A. Dieulin A., Copin D. CO₂ Storage Capacity Evaluation in Deep Saline Aquifers for an Industrial Pilot Selection. Methodology and Results of the France Nord Project. *Energy Procedia*, Volume 63, pp 2779-2788.
- Lions, J., Devau, N., de Lary, L., Dupraz, S., Parmentier, M., Gombert, P., and Dictor, M.-C., 2014. Potential impacts of leakage from CO₂ geological storage on geochemical processes controlling fresh groundwater quality: A review. *International Journal of Greenhouse Gas Control* 22, 165-175.
- Lions, J., Humez, P., Pauwels, H., Kloppmann, W., and Czernichowski-Lauriol, I., 2014. Tracking leakage from a natural CO₂ reservoir (Montmiral, France) through the chemistry and isotope signatures of shallow groundwater. *Greenhouse Gases: Science and Technology*. 4, 225–243.
- Lary, L. D., Manceau, J. C., Loschetter, A., Rohmer, J., Bouc, O., Gravaud, I., Chiaberge, C., Willaume, P. & Yalamas, T. (2014). Quantitative risk assessment in the early stages of a CO₂ geological storage project: implementation of a practical approach in an uncertain context. *Greenhouse Gases: Science and Technology*.

Past experience

ADEME –TGR- BF: The TGR-BF project was carried out within the framework of the second phase of the ULCOS European Program, the aim of which was to search for breakthrough process routes in order to reduce for CO₂ emissions within steel production. The project aimed at demonstrating the feasibility of the Top Gas Recycling Blast Furnace (TGR-BF) technology at an industrial site, namely Florange in Lorraine, France. One of the blasts was to be adapted to implement the TGR-BF technology and then integrate this in a CO₂ Capture, Transport and Storage chain. A nearby deep saline aquifer was considered for the CO₂ storage.

This project is coordinated by ArcelorMittal and funded by ADEME, the French Environment and Energy Management Agency. It should initially have covered the feasibility and exploration phase before a further operational phase during which 100 000 t of CO₂ were expected to be injected.

However, at the end of 2012, ArcelorMittal announced the withdrawal of its carbon capture project from the European Commission funding program call, which would have funded the operational phase following the TGR-BF project. This withdrawal interrupted at the same time TGR-BF studies with, for example, cancellation of geophysical and geological exploration of the potential storage area (seismic acquisition, drillings and associated analyses).

BRGM was the reference institute of the project for geoscience research studies. It was in charge of research activities for the geological storage feasibility: identification of the geological site location, its characterization before injection (geology, hydrogeology...), the evaluation of CO₂ injection impacts and risk analysis and monitoring.

EC FP7 - CGS Europe: BRGM was Coordinator of CGS Europe, a 3-year Coordination Action on CO₂ Geological Storage funded by the EC 7th Framework Programme (2010-2013). BRGM managed the large Consortium (34 key research institutes across 28 countries (24 MS and 4 AC)) and supervised the progress of the

work programme in accordance with the contract with the EC. Activities included i) Integration and networking amongst the partners and externally with stakeholders, ii) Developing a knowledge repository containing key data accessible via the Web, iii) Knowledge development and sharing and iv) knowledge dissemination, through the website, workshops, brochures, interaction with media, etc. The main objective was to develop a credible, independent and representative pan-European scientific body of expertise on CO₂ geological storage. This was achieved through expansion of the CO₂GeoNet Association.

ULTimateCO₂ (<http://www.ultimateco2.eu/>): BRGM is currently coordinator of this four-year FP7 project

CO₂Field Lab (<https://www.sintef.no/projectweb/co2fieldlab/>): BRGM is involved in monitoring, modelling, dissemination activities and coordinates the French part

2. Bundesanstalt für Geowissenschaften und Rohstoffe - The Federal Institute for Geosciences and Natural Resources (BGR)

Description of the entity:

The Federal Institute for Geosciences and Natural Resources (BGR) is the central geoscientific authority providing advice to the German Federal Government in all geo-relevant questions. It is subordinate to the Federal Ministry for Economic Affairs and Energy (BMWi). BGR's main scientific areas are: Energy resources, mineral resources, groundwater, soil, final disposal of radioactive waste, deep subsurface use & geological CO₂ storage, geoscientific information and fundamentals, control of nuclear weapons test ban, and geo-hazard assessment.

Contribution to the Work Plan and expertise brought to ENOS:

BGR provides their soil gas monitoring stations, mobile and/or continuous flux chambers for a three year period of monitoring at Hontomin and the GeoEnergy test bed site. BGR will offer certain lab capacity to other partner with respect to gas analysis (compositional and isotope analysis). Building on experience in training and dissemination activities, BGR will help to promote information and knowledge sharing regarding CCS.

BGR is involved in:

- **WP1.** Ensuring safe storage operations (Task 1.3 Monitoring safe underground storage behaviour)
- 2 of the 4 tasks in **WP3.** Managing leakage risks for protection of the environment and groundwater (Task 3.3 Development of surface monitoring tools (Task Leader) and; Task 3.4 Integrated monitoring solution)
- **WP5** Coordination with local communities (Task 5.1 Knowledge development and integration in a societal perspective)
- **WP6.** International Cooperation & seeding pilots and demos in Europe (Task 6.4 Knowledge development and integration in a societal perspective)
- **WP7** Spreading innovation for Research integration and Best practices
- **WP8** Promoting CCS through training and education (Task 8.2 Building and providing an e-learning course (Task leader))

Staff

Dr. Stefan Schlömer will serve as a contact person/coordinator for BGR's activities in ENOS and is taskleader of WP3.3 Stefan Schlömer is a trained mineralogist and holds a Ph.D. in Applied Geology. After his Ph.D. he has been working for AGIP/EniTechnology in Milan before joining BGR in 2002. Since then he is working in the division "Geochemistry of Energy Resources and Gas Monitoring" and was involved in various national and international CCS projects (CO₂REMOVE, CLEAN, MONACO) and is coordinating the gas and isotope laboratory of the division.

Stefan Knopf holds an MSc in Earth Sciences. His research has covered petroleum geology, regional geology of Germany and especially various aspects regarding geological CO₂ storage. One main focus is to evaluate CO₂ storage potentials in Germany, which involves the development of capacity estimation methodologies. He has managed CCS projects regarding potential conflicts of use between CO₂ storage and geothermal energy use ("Geothermie-Atlas") and brine migration risks ("CO₂BRIM"). His work includes activities as a guest lecturer on CCS at the University of Hannover. Furthermore, he was a lecturer for two CGS Europe Spring Schools on CO₂ geological storage. He will serve as leader of Task 8.2 (Building and providing an e-learning course) in the proposed project.

Dr. Franz May has been involved in research projects on CCS projects and natural analogues since 25 years. He is head of the unit CO₂ storage processes and technologies

Publications

- Schlömer, S., Furche, M., Dumke, I., Poggenburg, J., Bahr, A., Seeger, C., Vidal, A. & Faber, E. (2013): A review of continuous soil gas monitoring related to CCS - Technical advances and lessons learned. – Applied Geochemistry, 30, 148-160
- Schlömer, S., Möller, I. & Furche, M. (2014): Baseline soil gas measurements as part of a monitoring concept above a projected CO₂ injection formation: a case study from Northern German. – International Journal of Greenhouse Gas Control, 20, 57-72
- Castillo, S. Knopf, C. Kervévan, F. May, CO₂-DISSOLVED: a Novel Concept Coupling Geological Storage of Dissolved CO₂ and Geothermal Heat Recovery – Part 2: Assessment of the Potential Industrial Applicability in France, Germany, and the U.S.A, Energy Procedia, Volume 63, 2014, Pages 4519-4535, ISSN 1876-6102
- Franz May, Stefan Knopf, Christian Müller, and Peer Hoth: CO₂ Storage Options in Germany. AAPG studies in geology ; 59, pp 35-45
- Sauer, U., Schütze, C., Leven, C., Schloemer, S. & Dietrich, P. (2013): An Integrative Hierarchical Monitoring Approach for Detecting and Characterizing CO₂ Releases. – Energy Procedia, 37, 4257-4267

Past experience

The Federal Institute for Geosciences and Natural Resources (BGR) is the central geoscientific authority in Germany providing neutral and independent information and advice to the German Federal Government. It is subordinate to the Federal Ministry for Economic Affairs and Energy and has a staff of around 700 people. BGR was one of the founding members of CO₂GeoNet at the time of the EC contract and is now a cooperating partner of the CO₂GeoNet Association as defined by a cooperation agreement signed between the CO₂GeoNet Association and BGR. Since 2000, BGR has been examining various aspects of the geological storage of CO₂ in various locations and regions inside and outside Germany, partnered by national and foreign research institutions, geological surveys, and industry players. BGR is one of the competent authorities in Germany according to the German CCS law and is committed in relevant international committees, such as ISO TC 265, IEA-GHG. BGR is involved in international capacity building and exchange on CO₂ storage with developing countries.

Research activities currently focus on the following topics:

Storage options (e.g., projects: Storage Catalogue of Germany, GESTCO, GEOCAPACITY, CO₂STORE).

Subsurface processes (by laboratory experiments, natural analogue studies & geochemical simulations (e.g., projects: COORAL, CLEAN, DYNAMIS; CSEGR).

Development of Safety and Monitoring concepts and guidelines (e.g., project STABILITY).

Field testing of gas-geochemical monitoring methods (e.g., projects CASTOR, CLEAN) and tool development for sub-aquatic and microbiological monitoring (e.g., projects CO₂ReMoVe, CLEAN)

Impact of CO₂ on the environment (e.g., projects RISCS, NASCENT, CO₂GeoNet).

3. Natural Environment Research Council (NERC) as represented by the British Geological Survey (BGS)

Description of the entity:

The British Geological Survey is a component organization of the Natural Environment Research Council (NERC), which is the UK's leading body for basic, strategic and applied research and monitoring in the environmental sciences. The British Geological Survey (BGS) itself was founded in 1835 and is the world's longest established national geological survey. BGS carries out strategically important research including in the energy and natural resources sectors and assessing vulnerability to environmental change and hazards, often in collaboration with the national and international scientific academic community. BGS seeks to advance the understanding of the structure, properties and processes of the solid Earth system through interdisciplinary surveys, monitoring and research for the benefit of society. BGS is a public sector organization responsible for advising the UK government on all aspects of geosciences, as well as providing impartial geological advice to industry, academia and the public. It is the UK's premier provider of objective and authoritative geoscientific data, information and knowledge for sustainable use of natural resources, reducing risk and living with the impacts of environmental change. NERC has the UK's largest academic CO₂ storage research group. ENOS will be staffed by the CO₂ Storage Research Team within the BGS Energy Programme. BGS is an ISO 9001:2000 accredited organization (cert. FS 71346), with independently provided certification of its management systems.

BGS is a leading player in the field of underground CO₂ storage. We have a leading research role in a number of major EU/industry and government funded projects. Over the last few years BGS have carried out more than 40 CO₂ storage projects for the EU, industry and the UK and overseas governments, with a current annual CCS budget of over 2 million Euros. The BGS CO₂ storage team comprises 25 researchers with expertise in a wide variety of fields including advanced seismic monitoring, reservoir modelling, leakage detection, monitoring planning, technical risk assessments

Contribution to the Work Plan and expertise brought to ENOS:

BGS will be work package leader of WP3 (Managing leakage risks for protection of the environment and groundwater) and will also contribute strongly to WP2 bringing expertise in understanding storage site behaviour and assuring storage capacity. BGS will contribute to WP6 through established links with other CO₂ storage pilot and test injection sites worldwide. BGS will contribute to WP7 and 8 utilising its extensive experience in capacity building, knowledge sharing and communicating on geological storage of CO₂ to a wide range of audiences both in the UK and internationally.

BGS is involved in:

- Task 2.1 and 2.2 in **WP2** to provide expertise on geological factors relating to smart site characterisation and uncertainty in capacity estimates
- all tasks in **WP3** to undertake fieldwork to advance monitoring technologies and techniques and to improve understanding of the risks presented by faults. BGS is leading WP3 and leading on Task T3.4 (Integration into monitoring solution).
- Tasks 6.1 – 6.4 in **WP6** as leader of the 'leakage simulation alliance' and supporting the task to identify opportunities for new pilots/upscaling of pilots
- Tasks 7.1 and 7.2 in **WP7** as part of the Scientific Editor Committee and to provide input to best practice and dissemination outputs.
- Tasks 8.1, 8.2 and 8.4 in **WP8** to present at the training courses, support preparation of e-learning materials and to support the tasks for communication with journalists.
- in **WP9** Management as WP leader on the MB and as Site Contact (GeoEnergy Test Bed)

Staff

Ceri Vincent has geological CO₂ storage expertise with 15 years' experience working on or managing projects. She has supported experts in South Africa and China in assessing CO₂ storage options. Ceri coordinated the South Africa-EU Cooperation on CCS (SAfECCS) project. She was a significant contributor to the BGS report for [653718 – ENOS – PART B - 44]

DECC (UK Government) on the shale gas potential of the UK in 2013. Current research interests include undertaking CO₂ storage assessments for the UK, South Africa and China. She co-wrote a 2014 paper on "Assessment of storage capacity for CO₂ in saline aquifers near hydrocarbon fields, northern Songliao Basin, China." Greenhouse gases: science and technology. From April 2015, she will be the Chair of the Executive Committee for the CO₂GeoNet Association - the European Network of Excellence on the Geological storage of CO₂.

Dr. David Jones is a project leader/principal geochemist responsible for leading BGS surface gas monitoring for CCS projects. Involved in research on many CO₂ Storage projects since 2001 including Weyburn, In Salah, CO₂GeoNet (originally an EU FP6 funded project) and the EU FP6 CO₂ReMoVe, he has also led large projects including the EU FP7 RISCS project (Research Into Impacts and Safety in CO₂ Storage: www.riscs-co2.eu), the UK Energy Technology Institute's (ETI) Measurement Monitoring and Verification UK Requirements study and BGS' input for the CO₂ Field Lab project in Norway (<http://www.sintef.com/Projectweb/co2fieldlab>). David is an investigator on a Science and Technology Facilities Council grant on 2D CO₂ Flux mapping; is BGS lead for the follow on ETI-MMV study and for the UKCCSRC co-funded proposal on generating links between test injection sites in the UK, Canada, South Korea and Australia.

Dr. Christopher Rochelle is a senior geochemist with extensive experience in fluid-rock interaction processes over a wide range of pressures and temperatures and one of his main research areas is underground CO₂ storage. Chris has extensive experience designing, constructing, operating and interpreting laboratory experimental investigations into fluid-rock interactions over a wide range of temperatures and pressures; experience in the rates and magnitudes of geochemical reaction processes. His research interests include geochemical reactivity of gases in the subsurface and the impacts of supercritical CO₂ and CO₂ rich fluids on host rocks, caprocks and borehole materials under deep basinal conditions.

Jonathan Pearce is a principal geoscientist and sediment geochemist specialising in geological CO₂ storage, fluid rock interactions, fracture leakage mechanisms, long-term geochemical interactions in reservoir and cap rocks, practical and technical implementation of CO₂ storage regulations with a focus on monitoring storage operations; assessing risks and storage permit applications. He is leader of the CO₂ Storage Team at BGS; Deputy Director GeoEnergy Research Centre (GERC) and heavily involved in the development of the GeoEnergy Test Bed. Jonathan is Storage Coordinator for the CCS Joint Programme of the European Energy Research Alliance (EERA) and was Editor of the Guide to Assessment of Impacts from Potential Leakage from CO₂ Storage for the RISCS Project. He was project leader of the CO₂ storage tasks for Near Zero Emissions Coal (NZEC) and played a significant part in the official team advising DECC on the UK CCS competition for the first demonstration.

Michelle Bentham is a senior geoscientist and carbon dioxide storage expert at BGS. She is a UKCCSRC Research Area Champion for regulation and site leasing; on the expert working group for site selection of CO₂ storage sites for ISO T265; a member of the taskforce for the application of United Nations Framework Classification for Fossil Energy and Mineral Resources, UNFC 2009, to injection projects and was the BGS lead in the CO₂stored project for the ETI and the Crown Estate. She is highly skilled in assessing CO₂ storage potential and methodologies; CCS capacity building; CCS monitoring and verification and CCS storage site characterisation.

Luke Bateson is a senior geoscientist with expertise in the application of remote sensing techniques to monitoring CO₂ storage sites. He has experience in 3D visualisation of large datasets, optical remote sensing techniques and image processing and interpretation.

Maxine Akhurst is an experienced project leader with expertise in regulatory issues relating to geological storage of CO₂. Maxine was project leader for the CO₂ MultiStore project where she led and managed research activities to reduce the risks to the economic and business case. She was also WP leader for the SiteChar project where she led appraisal and characterisation for an offshore storage site including preparation of 3D geological models of aquifer and hydrocarbon fields.

Helen Taylor is a senior geochemist responsible for key inputs to the ULTimate CO₂ project which will assess the long term fate of CO₂ in the reservoir. Helen is leading the Communication and Networking WP for ECCSEL (European Carbon Dioxide Capture and Storage Laboratory Infrastructure) where she will coordinate activities to

develop the communication strategy and outreach plan and engage with stakeholders ahead of implementation in 2015.

Publications

- Bateson, L., Vellico, M., Beaubien, S.E., Pearce, J.M., Annunziatellis, A., Ciotoli, G., Coren, F., Lombardi, S., Marsh, S., 2008. The application of remote-sensing techniques to monitor CO₂-storage sites for surface leakage: Method development and testing at LATERA (Italy) where naturally produced CO₂ is leaking to the atmosphere. *Int. J. Greenhouse Gas Control* 2, 388-400
- Jones, D.G., Barkwith, A.K.A.P., Hannis, S., Lister, T.R., Gal, F., Graziani, S., Beaubien, S.E., Widory, D., 2014. Monitoring of near surface gas seepage from a shallow injection experiment at the CO₂ Field Lab, Norway. *Int. J. Greenhouse Gas Control* 28, 300-317
- Jones, D.G., Beaubien, S.E., Barlow, T.S., Barkwith, A.K.A.P., Hannis, S.D., Lister, T.R., Strutt, M.H., Bellomo, T., Annunziatellis, A., Graziani, S., Lombardi, S., Ruggiero, L., Braibant, G., Gal, F., Joubin, F., Michel, K., 2014. Baseline variability in onshore near surface gases and implications for monitoring at CO₂ storage sites. *Energy Procedia* 63, 4155-4162
- Jones, D.G., Barlow, T., Beaubien, S.E., Ciotoli, G., Lister, T.R., Lombardi, S., May, F., Möller, I., Pearce, J.M., Shaw, R.A., 2009. New and established techniques for surface gas monitoring at onshore CO₂ storage sites. *Energy Procedia* 1, 2127-2134
- Rushton, J.C., Wagner, D., Purser, G., Pearce, J.M., Rochelle, C.A. 2013. Green River CO₂ natural analogue, Utah: insights into Fe mobilisation from jarosite fracture mineralisation. *Mineralogical Magazine* 77(5):2102 doi:10.1180/minmag.2013.077.5.18

Past experience

BGS has experience in developing monitoring programmes for a variety of proposed and active storage sites. BGS developed and maintains the [IEAGHG web-based site monitoring selection tool](#). Through projects such as EU FP7 [RISCS](#), [QICS](#) and [ECO2](#), BGS have demonstrated their field expertise in monitoring CO₂ storage sites. Through the EU FP7 [SiteChar](#) project, BGS demonstrated how risk assessment is critical to development of an effective and efficient storage site monitoring programme. Working with the UK Crown Estate, as Development Manager for the online [CO₂ Stored database](#), BGS is currently working optimisation of storage resource on the UK Continental Shelf. Other recent projects include Weyburn monitoring; EU FP7 [CO₂ReMoVe](#); Otway Basin and Gorgon reviews; UKCCSRC [CASSEM](#); EU FP7 funded [CO₂CARE](#); the joint industry project [CO₂MultiStore](#); EU FP7 funded [ULTimateCO₂](#). We have also carried out a major study for the IEAGHG/GCCSI on managing storage resources. BGS have participated in capacity building activities such as supporting national experts in assessing geological storage potential in South Africa ([SAFECCS](#)) and China ([UK NZEC](#); [COACH](#)) and have presented in training courses on geological storage in the UK, South Africa, China and South Korea. BGS also participated in the COACH and [CGS-Europe](#) CCS schools.

Infrastructure/ major equipment provided to ENOS

GeoEnergy TestBed - More detail is provided in the section 'Infrastructure proposed by the partners – test sites'

4. Czech Geological Survey (CGS)

Description of the entity:

Czech Geological Survey (CGS / Czech Republic) is the leading geological research institution in the Czech Republic. It is a state research institute supervised by the Ministry of Environment. Its staff counts about 300 people, round 200 of them being university graduates.

Geo-energy related activities of CGS have developed a significant knowledge in the field of CO₂ geological storage, monitoring of CO₂ and methane migration, formation water geochemistry, mineralogical, optical and geochemical characterisation of the reservoir rocks and seals.

CGS has rich experience with participation in international research projects in many areas of geoscience, including European Framework Programmes (FP6, FP7, Horizon 2020) and other types of multilateral cooperation. CGS is member of EuroGeoSurveys and the Czech national country representative in ENeRG (European Network for Research in Geo-Energy). Since 2013 CGS has been a member of CO₂GeoNet.

Contribution to the Work Plan and expertise brought to ENOS:

CGS is currently leading a Czech-Norwegian research project focusing on screening an assessment of the LBr-1 depleted oilfield as potential site for a pilot CO₂ storage project in the Czech Republic. Results and achievements of this project will be provided to ENOS as input information for further research work, especially in WP3 and WP4. Moreover, CGS' project management skills and experience in co-ordination of activities at international level will be used in WPs 6-9.

In ENOS, CGS will lead WP6 and will be responsible for liaising project activities with the LBr-1 pilot site in the Czech Republic.

CGS is involved in:

- 3 of the 4 tasks in **WP3** Managing leakage risks for protection of the environment and groundwater
- **WP4**. Integration of CO₂ storage with local economic activities (Task 4.2 CO₂ storage and oil production)
- **WP5**. Coordination with local communities (Task 5.1 Knowledge development and integration in a societal perspective)
- All tasks in **WP6** International Cooperation & seeding pilots and demos in Europe (WP leader) and leader for Task 6.4 Preparation of follow-up stages for ENOS pilot sites
- All tasks in **WP7** Spreading innovation
- 3 of the 4 tasks in **WP8** Promoting CCS through training and education (Task 8.1 Education and training for the European research community; Task 8.2 Building and providing an e-learning course; Task 8.4 Raising awareness by training workshops for journalists and media)
- in **WP 9** Management as WP leader on the MB and as LBr-1 Site Contact

Staff

Vit Hladik is research coordinator for Environmental and Geo-Energy Technologies at Czech Geological Survey. His professional focus is research and project management in the field of CO₂ geological storage, incl. rich experience with participation in international projects. He acted as project coordinator of the FP6 CO₂NET EAST project (CO₂ capture and storage networking extension to new Member States) and TOGEOS (Towards geological storage of CO₂ in the Czech Republic), a Czech-Norwegian R&D project funded by EEA/Norway Grants, and was Management Board member of the FP7 CGS Europe project. At present, he coordinates REPP-CO₂ – a Czech-Norwegian project funded by Norway Grants, aiming at preparation of a research CO₂-storage pilot project in Czechia. Vit is the Czech national representative in European Network for Research in Geo-Energy (ENeRG), member of two Task Forces of the European Technology Platform on Zero-Emission Fossil Fuel Power Plants (ETP ZEP), member of EuroGeoSurveys Task Force on CCS, and CGS representative in the CO₂GeoNet network. Vit possesses MSc degree in applied geophysics from Charles University in Prague, and MBA from Nottingham Trent University / Brno Business School. He will lead WP6 of ENOS, and will be responsible for local coordination related to the LBr-1 project site.

Juraj Francu is a senior researcher at Czech Geological Survey. His primary focus includes gas and petroleum geochemistry and basin modeling. His experience embraces field and laboratory measurements of gases and rocks in deeper and shallow subsurface, research on microbial reduction of CO₂ to methane at depth of about 1000 m and microbial oxidation of methane to CO₂ in the shallower horizons, genetic relationships among gases occurring in different horizons above natural gas accumulations and gas storages up to the soil pore system, pore water chemistry and associated gases in the oil and gas bearing basins in the Czech Republic and the Caspian region. Juraj also participated in the TOGEOS Czech-Norwegian R&D project, contributing with the basin thermal model and geochemistry.

Juraj finished his MSc. and PhD. at the Comenius University in Bratislava and at the Slovak Academy of Sciences in Bratislava, Slovakia. He worked as visiting scientist at the Institute of Organic and Petroleum Geochemistry, Forschungszentrum Juelich, Germany, University of Missouri-Columbia, University of Utah, USA, and RWTH University in Aachen, Germany.

Publications

- Hladík, V. - Kolejka, V. - Lojka, R. - Fott, P. - Vácha, D. (2009): CO₂ emissions and geological storage possibilities in the Czech Republic. – Slovak Geological Magazine, February 2009,, 29-41. ISSN 1335-096X
- Hatzignatiou, D. - Riis, F. - Berenblyum, R. - Hladík, V. - Lojka, R. - Francu, J. (2011): Screening and evaluation of a saline aquifer for CO₂ storage: Central Bohemian Basin, Czech Republic. – International Journal of Greenhouse Gas Control 5, 6, 1429-1442. ISSN 1750-5836. DOI 10.1016/j.ijggc.2011.07.013
- Šliaupa, S. – Lojka, R. – Tasáryová, Z. – Kolejka, V. – Hladík, V. – Kotulová, J. – Kucharič, L. – Fejdi, V. – Wojcicki, A. – Tarkowski, R. – Uliasz-Misiak, B. – Šliaupienė, R. – Nulle, I. – Pomeranceva, R. – Ivanova, O. – Šogenova, A. – Šogenov, K. (2013): CO₂ storage potential of sedimentary basins of Slovakia, the Czech Republic, Poland and the Baltic States. – Geological Quarterly 57, 2, 219-232. ISSN 1641-7291. DOI 10.7306/gq.1088

Past experience

- partner in EU GeoCapacity (FP6, Assessing European Capacity for Geological Storage of Carbon Dioxide);
- coordinator of CO₂NET EAST (FP6, focused on CCS knowledge transfer and awareness raising in new EU Member States and Candidate Countries;
- coordinator of TOGEOS (Towards geological storage of CO₂ in the Czech Republic), Czech-Norwegian project funded by EEA/Norway Grants;
- partner and Management Board member in CGS Europe (FP7, Pan-European coordination action on CO₂ Geological Storage);
- provider of CO₂ geological storage –related expertise and consultancy services to Czech regulators, especially the Ministry of Environment, incl. advice on implementation of the European CCS Directive in the Czech national law.

Infrastructure/ major equipment provided to ENOS

LBr-1 - More detail is provided in the section ‘Infrastructure proposed by the partners – test sites’

5. Energy, Environment and Technology Research Center (CIEMAT)

Description of the entity:

CIEMAT is a public research body that reports to the Ministry of Economy and Competitiveness and whose activities are carried out in the areas of Energy, Environment and Technology in the framework of the National Plan for Scientific Research, Development and Technological Innovation ; in EU R&D Programmes, and cooperating with the Autonomous Communities, universities, and enterprises, as well as with intergovernmental bodies and R&D centers from other countries, with special attention to Latin America and the Mediterranean.

Contribution to the Work Plan and expertise brought to ENOS:

CIEMAT will be contributing to ENOS in WP1, Ensuring safe storage operations, Task 1.4 Integrated alert system, Subtask 1.4.2 Update and validation of the risk model. CIEMAT, in collaboration with CIUDEN developed a probabilistic methodology for estimating geological storage risks for the Hontomin Technology Development Plant site. The ad hoc model implemented on a probabilistic simulation object-oriented framework will be a basic tool for the validation of Task 1.4 risk model.

CIEMAT is involved in:

WP1. Ensuring safe storage operations:

- Task 1.4 Demonstrating operational risk management

* Subtask 1.4.2 Update of risk assessment (Subtask leader)

* Subtask 1.4.3. Technical Guidelines for operational risk management

Staff

Antonio Hurtado Bezos. PhD. Mining Engineer. Scientist of CIEMAT has over 15 years of experience in risk management and assessment in both the industrial sector and scientific research in the area of the geological environment altered by human activity. Currently working on the development of methodologies for risk assessment of geological sites for both CO₂ geological storage and unconventional hydrocarbon exploitation, and previously in the selection, characterization, capacity estimation and determination of uncertainties associated with geological storage of CO₂.

Sonsoles Eguilior Díaz. PhD. in Physics. Scientist working in the CIEMAT, with more than 15 years of experience, where has worked in the areas of safety and risk assessment and the development of transport models in inhomogeneous media under advective-diffusive processes. Currently her main line of work is the development of global models for evaluation of risks associated with geological storage of CO₂ and uncertainty treatment associated with long-term risks.

Fernando Recreo Jiménez. Degree in Geology .Master in Hydrogeology, More than 20 years of experience in nuclear waste repositories performance assessment. Currently is Head of the CO₂ Geological Storage Programme of CIEMAT.

Julio Rodrigo Naharro. PhD. Mining Engineer. Scientist of CIEMAT with 10 years of experience in CCS technologies, the last five in relation to the CO₂ Geological Storage, particularly in the study of natural analogues of CO₂ Storage and leakage. Currently he is working on the geochemical risks related to the CO₂ injection using the TOUGHREACT and PetraSim codes.

María del Rocío Maldonado Pérez. Geological Engineer. Master in Cartographic Geotechnologies in Engineering and Architecture with 2 years of experience in assessing of geomechanical risks associated with geological storage of CO₂. Currently she is doing a PhD about this line of work, studying the impact of geomechanical processes during CO₂ injection, to be included into the global model of probabilistic risk evaluation being developed by CIEMAT.

Publications

- Methodological development of a probabilistic model for CO₂ geological storage safety assessment. A. Hurtado , S.Eguilior , F.Recreo. Int J Energy Environ Eng (2014)

- Desarrollo Metodológico del Modelo Probabilista de Evaluación de Seguridad de la Planta de Desarrollo Tecnológico de Hontomin .A.Hurtado, S.Eguilior, F.Recreo. In. Técnicos Ciemat #1230, 2011
- Implementación del Modelo Estocástico de Evaluación de Seguridad de la PDT. Modelo de Pluma. A. Hurtado, S. Eguilior, F. Recreo. Inf. Técnicos Ciemat #1343. 2015
- Modelo Probabilista de Evaluación Integrada del Comportamiento de la Planta de Desarrollo Tecnológico de Hontomin. Versión 2. A. Hurtado, S. Eguilior, F.Recreo. Inf. Técnicos Ciemat #1346, 2015.
- Diffuse soil CO₂ flux to assess the reliability of CO₂ storage in the Mazarrón–Gañuelas Tertiary Basin (Spain). Rodrigo-Naharro, J., Nisi, B., Vaselli, O., Lelli, M., Saldaña, R., Clemente-Jul, C., Pérez del Villar, L. Fuel 114, 162-171 (2013).

Past experience

The CIEMAT research team has an experience of more than 20 years in performance assessment and risk analysis of deep geological repositories for high activity radioactive wastes. Since 2007, activities were devoted on CO₂ geological storage performance assessment and risk analysis. As a collaborator of CIUDEN it has developed a probabilistic methodology for risk analysis for the Hontomin Technology Development Plant site.

6. Fundación Ciudad de la Energía (CIUDEN)

Description of the entity:

The Fundación Ciudad de la Energía (CIUDEN) is a public law body created by the Spanish Government in 2006 to support and promote international cooperation to enhance European competitiveness through strategic research partnerships with industry, SMEs, Universities and research institutions. The scope of CIUDEN's Clean Coal Technologies Programme is the development of efficient, cost effective and reliable CCS technologies. In this sense, CIUDEN is involved in the development of several Research Infrastructures, as the Technology Development Plant on CO₂ Storage in Hontomín. Furthermore, CIUDEN has experience in several EU projects, as the so-called OXYCFB300 Compostilla Project funded under the European Energy Programme for Recovery (EEPR), ECCSEL Preparatory Phases, R&Dialogue or IMPACTS. Networking and knowledge sharing expertise comes from the active participation of Ciuden in taskforces within EU Knowledge Sharing CCS Network, CO₂Geonet and Global CCS Institute activities. In addition, Ciuden has experience in arranging training activities, as the courses performed with national universities.

Contribution to the Work Plan and expertise brought to ENOS:

With the aim of providing the needed commitments for the correct development of the ENOS proposal, Ciuden is showing the activities and background information that will enable the project to achieve the expected outcomes; these are the following:

- CO₂ and brine injection strategies. These are included as the core part of T.1.1. and will take advantage of the experiences acquired until now, which includes the CO₂ and brine injection tests that have already been done, in order to better define the more innovative approaches, as explained in the proposal.
- Data acquisition and interpretation of the 30 passive microseismic monitoring stations located all around the Hontomin site for induced seismicity risk management purposes (T.1.2) in the vicinity of the CO₂ injection activities. These data will also be used as part of the integration activities that will be located at T.1.4. The geophones are divided in 2 types, both of 3 components, 20 of them were provided by Sara Electronics with a frequency of 4,5Hz, whereas the other 10 were provided by Lennartz with frequency of 0,5Hz. The existing data will also be available if needed, to establish the baseline for a better understanding of the initial conditions. The passive seismic network is in operation since 2011.
- Reservoir geochemical monitoring. Apart from the deep sampler which is going to be developed in T.1.3, and all its associated activities in lab and simulation, according to project needs, Ciuden will provide data from the sampling to be performed at Hontomin H-I Injection well using the U-tube tool, and will give access to data from former sampling surveys.
- Geophysical monitoring. Several activities will take place in the frame of ENOS, mainly at T.1.3 (3D VSPs, crosshole seismic, seismic noise correlation or seismic interferometry...), Ciuden wants to highlight that data from former VSPs surveys will be available for the partners, if needed, to provide input in the definition of the surveys to be done during the project. In addition, data acquired using iDAS, the retrievable set of hydrophones in the monitoring well H-A and the crosshole data collected from electrodes installed in both wells (HI and HA) will be also available for the partners to accomplish the activities explained in T.1.4.
- Soil gas monitoring. Ciuden will provide the existing data from natural flow emissions acquired during the characterization phase at Hontomin, as well as the data from the meteorological station which is in operation since June 2010 providing data of different nature (temperature, moisture, solar radiation, wind speed and direction, pluviometry...). These data will allow a better definition of the threshold values in T.1.3.
- Shallow groundwater monitoring. A monitoring network was established in 2012 at Hontomin, consisting of 3 new Wells in the surroundings of H-I and H-A Wells, measuring piezometric levels (m), temperature (°C), pH, ORP (mV) and LDO (mg/l); and 5 existing ones that provide piezometric levels. The necessary data will be

available for the ENOS partners and will allow a complete definition of the monitoring input that is going to allow the risk model to be updated.

- Monitoring data in the Wells. Pressure and temperature in the wellhead and at different depths all along the wells, up to 1,500m will be available according to the project goals.

- CO₂ injection will be carried out with controlled pressure, temperature and flow rates, thus different phases will be tested. The facility also offers the possibility of co-injecting brine and CO₂, with or without tracers. The data will be provided during operations in order to better define the simulation and history matching activities within ENOS.

Furthermore, CIUDEN will also provide to the involved partners in ENOS activities all the needed information for accomplishing the satisfactory execution of the committed Works, that may include existing models and data from surveys already performed, establishing the confidentiality agreements when needed.

CIUDEN is involved in:

- all tasks of **WP1** Ensuring safe storage operations (WP leader)

- 3 of the 4 tasks in **WP2**. Ensuring storage capacities and cost-effective site characterisation (A minor contribution in Task 2.1 for exchange of information on modelling data; Task 2.3 Low Cost Drilling (task leader) and Task 2.4 Technical guidelines on storage capacities estimates and cost-effective site characterisation).

- **WP3**. Managing leakage risks for protection of the environment and groundwater (Task 3.4 Integrated monitoring solution)

- all tasks in **WP5** Coordination with local communities, and Leader of Task 5.3 Development of a Public Information Tool for CO₂ storage sites

- 3 of the 5 tasks in **WP6** International Cooperation & seeding pilots and demos in Europe (Task 6.1 International cooperation; Task 6.2 European links, liaison and knowledge exchange; Task 6.4 Preparation of follow-up stages for ENOS pilot sites)

- all tasks in **WP7** Spreading innovation

- 2 of the 4 tasks in WP8 Promoting CCS through training and education (Task 8.1 Education and training for the European research community; Task 8.4 Raising awareness by training workshops for journalists and media)

- in **WP9** Management as WP Leader in the MB and as Hontomin Site Contact

Staff

1. **José Carlos de Dios** (Male) is Low Carbon Technologies Manager at Fundación Ciudad de la Energía (CIUDEN), entity attached to the Spanish Ministry of Industry, and Director for the exploration and operation activities at the CO₂ Geological Storage Pilot Plant in Hontomín (Spain).

Education

- M.Sc.Mining Engineer. Technical University of Madrid
- Master in Business and Administration (MBA Executive)

Professional Experience

Long experience in energy, mining and environmental sustainability projects for 27 years, occupying the position of technical manager and CEO in several companies, related with the industrial processing and technological development. Actually working as technological manager and responsible for the Spanish Pilot Plants of CO₂ Capture, Transport and Storage attached to CIUDEN. He is responsible in particular for front end engineering design (FEED), construction, commissioning and operation of the Storage Pilot Plant, the design and supervision of the site geological characterization, modeling and monitoring of the injection strategies, including the safety

supervision for the operational phase and the public engagement activities. Long experience in the performance of relationship with industry, research centers and academia in the international framework, R+D projects leadership and the European institutional relationship. Particularly on CCS activities, occupying the following positions:

- Project Manager on CO₂ storage activities within OXYCFB300 Project (EEPR and Spanish Government)
- Member of the Steering Board in IMPACTS Project
- Member of the Executive Board and General Assembly in ECCSEL Infradev Project
- Member of CCS EU Network

2. **Juan Andrés Marín Vidal.** (Male), PhD. Mining Engineer by the University of Oviedo, Master in Labour Risks Prevention (Safety, Hygiene and Ergonomics) by UPM. Head of Ciuden's Technical Development Plant for Geological Storage of CO₂ at Hontomin. He has worked in mining and construction industries for more than 10 years related with engineering and R+D projects, at the positions of the design, development and commissioning. Before his current position in Ciuden, he worked as a Head of the Underground Construction Area of FSB, a public foundation focused on the promotion and development of R+D projects in the areas of energy, mining and environment.

3. **Lionel Loubeau Gavilanes** (Male), Industrial Engineer by the "Universidad Pontificia de Comillas", Master in Environmental Technology by the University of Vigo. He works for CIUDEN since 2006, starting as Project Manager during the engineering phase, construction and commissioning of the Flue Gas Cleaning System of the Capture and Transport Technology Development Centre located in Cubillos del Sil (Spain), continuing as Purchasing Director of CIUDEN. Currently working as New Markets Responsible at the Business Development Unit on issues related to CO₂ Capture and Storage, new developments and Public Perception. He was involved in the Research and Dialogue Project, covering management, technical, public engagement and knowledge sharing issues. He has worked in energy and construction industries for more than 15 years related with engineering and R+D projects, at the positions of the design, development and commissioning. Author of over 10 publications (conferences, deliverables and books included).

4. **Miguel Angel Delgado Calvo** (Male), R&D Project Manager at Fundación Ciudad de la Energía (CIUDEN). He received his Master's Degree in Chemical Engineering by the University of Salamanca (2004). In 2006, he got a Master in Industrial Safety whereas in 2014 he finished an Executive MBA (European Business School, EEN). His main activities cover following areas: Development, innovation and deployment of gasification processes; CCUS; energy system integration aspects; European Union policies relating to carbon capture and storage and engineering, economic and quantitative analysis regarding advanced energy production. Author of over 30 publications (peer-review articles, conferences, deliverables and books included).

5. **Juan Ignacio Salvador Parrilla** (Male), Hontomin Plant systems responsible at CIUDEN. Industrial Engineer. (UPM, ETSII Madrid). Microsoft Certified Engineer in Databases and Networks. 30 years IT experience, developing projects related to control process, networks and communications, databases, logistic, BI and data mining between others, always related to power production or green industries.

Publications

- Alcalde, J., Martí, D., Calahorrano, A., Marzan, I., Ayarza, P., Carbonell, R., Juhlin, C., Pérez-Estaún, A. (2013). Active seismic characterization experiments of the Hontomín research facility for geological storage of CO₂, Spain. International Journal of Greenhouse Gas Control 19, 785-795.
- Alcalde, J.; Ignacio Marzán, Eduard Saura, David Martí, Puy Ayarza, Christopher Juhlin, Andrés Pérez-Estaún, Ramon Carbonell (2014). 3D geological characterization of the Hontomín CO₂ storage site, Spain:

Multidisciplinary approach from seismic, well-log and regional data. Tectonophysics, In Press, Corrected Proof, Available online.

- Lupion, M.; Perez, A.; Torrecilla, F.; Merino, B. (2013). Lessons learned from the public perception and engagement strategy – Experiences in CIUDEN’s CCS facilities in Spain. Energy Procedia 31, 7369-7379.
- Pool, M., Carrera, J., Vilarrasa, V., Silva, O., Ayora, C. (2013). Dynamics and design of systems for geological storage of dissolved CO₂. Advances in Water Resources 62, Part C, p. 533-542.
- Vilarrasa, Víctor, Silva, Orlando, Carrera, Jesús, Olivella, Sebastià (2013). Liquid CO₂ injection for geological storage in deep saline aquifers. International Journal of Greenhouse Gas Control, 14, p.84-96.

Past experience

EU funded projects: IMPACTS; OXY-CFB-300 EEPR; R&Dialogue; BRISK; MACPLUS; FLEXIBURN; RELCOM; O2GEN; EM-Hontomin ;

National projects and other large initiatives: CIUDEN-ULe Project, FPA041 GCCSI Contract

Infrastructure/ major equipment provided to ENOS

Hontomin - More detail is provided in the section ‘Infrastructure proposed by the partners – test sites’

7. Flodim (Flodim)

Description of the entity:

Flodim is a cavity Survey and Well Logging Services Company with operations in all of Europe and in South America.

Flodim is also a Company with significant Research & Development capabilities dedicated to downhole technologies, such as Solution Mining, some O&G specific subjects and all of the new underground projects : deep Geothermy, Energy Storage, H2 storage and of course CO₂ storage.

Contribution to the Work Plan and expertise brought to ENOS:

- New Bottom Hole Sampling system (Sampling chamber is also a transport container and a PVT cell)
- High Temperature Geochemical instrument (P, T, GR, CCL, pH, Redox potential, Conductivity and dissolved O₂), versus depth or versus time.
- Potentially specific Video instruments and generally any Cased Hole instrument that can give information on an existing well together with a self-sufficient lightweight logging unit (up to 2000m).

Flodim is involved in:

WP1 – task 1.3 Monitoring safe underground storage behavior and more specifically, 1.3.1. Alternative deep geochemical monitoring

WP7 - Spreading innovation for Research integration and Best practices

Staff

Jean-Paul CRABEIL, manager, founder of Flodim, HEI, Schlumberger 6 years, Geostock 9 years
 Karl ANTIER, Engineer EOST, Operation manager in charge of field Services organization
 Emilien BELLE, Earth Sciences and Environment Doctor, Survey specialist, in charge of new Domains
 Fabien ESPEUT, R&D manager, Polytechnic Nice, CGG field and development engineer

Publications

September 2014 Electrochemical Casing Cutter patent
 October 2014 SMRI Conference of Groningen (NL), EZ Cutter
 December 2014 New Bottom Hole Sampling System patent
 April 2015 SMRI Conference of Groningen (US), EZ Cutter

Past experience

- Cavity Survey: Sonar, Laser-Image, Interface measurement
- Geothermy: ELS representative in the FONGEOSEC and in the COGEWI projects
- New R&D projects : Cavity suite (Sonar, Casing Cutter, EZ blanket), Deep Geothermal projects (HT color video, HT BHS system), Oil & Gas (EZC 2", EZ level, EZ com).
- Collaborations: Eurostar project, 'Pole Mer' and Idronaut (I)
 French cluster, Fongeosec Deep Geothermy project
- Partners: Multiline (D), Robertson (UK), Century WL (USA), Ground Search (Aus)

8. Geogreen (GGR)

Description of the entity:

Geogreen (www.geogreen.eu) is an international company offering engineering services dedicated to the transport and geological storage of CO₂, and consulting services on the CCS chain (including all economic aspects).

Geogreen results from a joint venture by three leading French players in the field: IFP Energies nouvelles, Géostock (underground storage of hydrocarbons), and BRGM (Bureau de Recherche Géologique et Minière), which are pooling their respective expertise in order to position themselves in the world market for the geological storage of CO₂ and thereby contribute to reducing emissions of greenhouse gases.

The perfect technical complementarity of its experts enables Geogreen to provide the industries concerned with a comprehensive range of services, covering the whole chain from the transport of CO₂ to its geological storage, from upstream expertise to engineering and project development. In the longer term, Geogreen will offer injection site operation assistance, inspection and maintenance services, and monitoring services related to post-injection control of storage sites

Geogreen has developed a portfolio of projects ranging from pre-feasibility studies for a given CCS project (capture orientation, transport pre-routing and design, storage site selection) to site pre-selection. On top of technical design, Geogreen has also developed a strong expertise in economical evaluation of solutions.

Contribution to the Work Plan and expertise brought to ENOS:

Geogreen contribution will mainly be on site modeling (WP1 and WP4) both geological and dynamical. For the two sites, earth model will be elaborated at the early stage of the project to ensure a consistent data set for the subsequent modeling tasks.

The contribution to WP1 will be mainly on the design of the injection test based upon the different scenario modelled for Hontomin to ensure the operational success. The dynamic modeling shall particularly focus on the mechanical impact of the storage due to CO₂ injection. The monitoring data acquired along the project will be integrated on a regular basis to analyze deviations and ensure consistency of the model with the on-going operations. Towards, the end of the project, the static and dynamic models will be updated with the modeling and monitoring work performed in ENOS. Based upon its industrial experience on hydrocarbon storage, Geogreen will contribute to the establishment of the Technical Guidelines

The contribution to WP1 will be mainly on the assessment of the geochemical impact and CO₂ quality changes during the buffering in the Q16 Maas gas field. The dynamic modeling shall particularly focus on the geochemical impact of the storage during to CO₂ production.

Geogreen is involved in:

WP1 Ensuring safe storage operations

- Task 1.1 Reliable CO₂ injection procedures
- Task 1.4 Demonstrating operational risk management

WP4 Integration of CO₂ storage with local economic activities

- Task 4.1 CO₂ buffering and re-production for greenhouse horticulture

WP7 Spreading innovation for Research integration and Best practices

Staff

Dr. Yann LE GALLO is a CO₂ storage expert and serves as the project director for all projects related to risk assessment and reservoir simulation. To that extent, he acts as project coordinator for the Manaus Risk assessment project and he manages Geogreen contribution in European projects such as UltimateCO₂. He is a regular reviewer for several journals (IJGGC, SPE, OGST, IECR) and is part of the Technical Committee for definition of standard on risk assessment of geological storage of CO₂ (ISO/TC-265). He was formerly an assistant professor at Institut Français du Pétrole (now IFPEN). He holds both a doctorate and master's degree in chemical engineering from the Illinois Institute of Technology in the US and an engineering degree (Diplôme d'Ingénieur) from Ecole Supérieure de Chimie Industrielle de Lyon in France (now ESCPE Lyon). He was involved in nearly all of IFP CO₂ storage projects between 2000 and 2007 such as CO₂REMOVE, DYNAMIS, & GEOCAPACITY. In addition, he taught reservoir simulation courses for the IFP School and initiated the Reactive Modeling Course for CO₂GeoNet. He is a member of SPE.

Gilles MUNIER, Geogreen CEO graduated from Paris National School of Mines in 1981 in the field of geosciences. He joined the underground hydrocarbon storage industry in 2001 and began managing CCS-related projects after he joined Geostock in 2006 (PICOREF, INJECTIVITE, INTEGRITE, and METSTOR projects). As Geogreen CEO, Gilles has increased the company's global presence, operating budget, and project portfolio - with clients/contacts and various levels of activity taking place in Europe, North and South America, and the Middle East, as well as international clients such as the IEA-GHG, GCCSI, and UNIDO. Beyond his work as CEO, Gilles brings specialized knowledge in geosciences, economic analysis, corporate strategy, and financial forecasting to the Geogreen shareholders and engineering team. He served as project director for the CCS roadmap elaboration for Saudi Arabia, as a speaker on CCS-related topics for numerous events across the world including the World Energy Dialogue in Riyadh in November 2011, some ANR-Ademe events from 2007 to 2013. As industry stakeholder representative, Gilles MUNIER was co-chairman during the CCS summit in France in October 2007, and also speaker at a workshop organized by SPE in Dubrovnik in May 2008, and co-chaired SPE CCS workshop held in Cadiz in august 2009 and in Beijing in august 2010. He was also a speaker during the CO₂Geonet meeting held in Bucharest in September 2008, and also speaker during different sessions of European Commission meetings between 2009 and 2013. He is Geogreen Representative at the Club CO₂ both in France and in Romania. He is a member of SPE

Publications

- Y. Le Gallo Quantitative assessments of CO₂ injection risks for onshore large scale CO₂ storage. Proceedings of the 14th Annual CCUS conference, Pittsburgh, April 2015
- J. Rohmer, A. Loschetter, D. Raucoules, M. de Michele, Y. Le Gallo, D. Raffard "Improving Persistent Scatterers Interferometry (PSI) analysis in highly vegetal / agricultural areas for long term CO₂ storage monitoring" Proceedings of International Conference on Greenhouse Gas Control Technologies 12th, Energy Procedia, 2014, 63, 4019-4026
- B. Issautier, S. Fillacier, Y. Le Gallo, P. Audigane, Ch. Chiaberge, S. Viseur "Modelling of CO₂ Injection in Fluvial Sedimentary Heterogeneous Reservoirs to assess the impact of geological heterogeneities on CO₂ Storage Capacity and Performance" Proceedings of International Conference on Greenhouse Gas Control Technologies 11th, Energy Procedia 37, 5181-5190
- Laude, O. Ricci, G. Bureau-Cauchois, J. Royer-Adnot, A. Fabbri. CO₂ capture and storage from a bioethanol plant: carbon and energy footprint and economic assessment. international journal of Greenhouse Gas Control, 2011, 5, 1220-1231.
- "Carbon capture and storage: technologies, policies, economics, and implementation strategies" CRC Press, 2011

Past experience

Framework for Carbon Capture and Sequestration Program in the Kingdom of Saudi Arabia

Geogreen Scope of Work: (1) evaluation of CO₂ sources, (2) pooling strategy, (3) transport conceptual design, (4) source / sink matching strategy elaboration, (5) GIS building, (6) writing of a book on all worldwide CCS issues including technical, regulatory, development, financing, (7) strategic advices for future CCS development (R&D and operation, (8) training on Carbon Capture, CCS economics, CDM implementation at King Abdullah Petroleum Studies And Research Center

ULTIMATECO₂ FP7 project: Long-term fate of CO₂ in geological storage

Geogreen Scope of Work: 3D geological modeling, Hydrodynamic simulations of injections of CO₂, and uncertainty assessment with geochemistry and geomechanical modeling at local and regional scales.

COCATE FP7 project: Large scale CCS transportation Infrastructure in Europe

Geogreen Scope of Work : Flue gas pooling network and main pipeline transport design - Optimization of pipeline and boat transport for sink in North Sea, network management, metering philosophy, basic design of transport pipelines, project development design, economics and real option analysis for newcomers

Services for CO₂-EOR design

Geogreen Scope of Work : Phase 1: Site selection and detailed studies for CO₂ reinjection and EOR (Venezuela) - Onshore oil fields, capacity assessment, 3D injection reservoir modeling, risk assessment, transport system design, Project development design, Phase 2: Detailed CO₂-EOR assessment including 3D modeling and simulation, well analysis, conceptual design for transport, qualitative and quantitative risk analysis, monitoring and development plans and economic assessments.

Owner's engineering for development of storage in aquifer ULCOS-BF Project

Geogreen Scope of Work : 3D geological modeling, Petrophysical interpretation, Hydrodynamic simulations of injections of CO₂, Construction of the storage complex, Analysis of risks, Design of wells, including well logs, administrative engineering, pipeline transport basic design, Seismic works declaration and danger study

GCCSI/IEA GHG Review for Policy makers of CCS deployment worldwide

Geogreen Scope of Work : Regional analysis of storage suitability, capacity assessment, planning of deployment, onshore and offshore statistical cost models, GIS and database implementation, identification of gaps and short term candidates

9. IDIL Fibres Optiques (IDIL)

Description of the entity:

IDIL Fibres Optiques is a French company specify in the conception and fabrication of optical fibers systems.

Contribution to the Work Plan and expertise brought to ENOS:

Validation of CO₂ optical measurement technology at GGeoENergy test bed.

IDIL is involved in:

- **WP3.** Managing leakage risks for protection of the environment and groundwater (Task 3.1 Groundwater protection: Geochemical monitoring and potential impact of leakage on potable aquifers, and more specifically, the subtask Increasing the TRL of groundwater quality monitoring tools)
- **WP7** Spreading innovation for Research integration and Best practices

Staff

Lionel Quétel Project manager

He received a Master in Optical-Electrical engineering in 1994 from Rennes I University and Ph. D. degrees in optical engineering in 1997 From Lilles University.

From 1998 to 2003, he was Fiber Bragg Grating project manager in Highwave Optical Technologies (France).

Since 2004, he is the Optical Component manager in IDIL Fibres Optiques (France).

Publications

- OFC 2015 “Reliable Expanded Beam Connector Compliant with Single-mode Fiber Transmission at 10 Gbit/s” Sy Dat Le, Michel Gadonna, Monique Thual, Lionel Quétel, Jean-Francois Riboulet, Vincent Metzger, Douglas Parker, Alain Philippe, and Sebastien Claudio

Past experience

2014/2016 French National Project COPTIK Co2 sensor development

2013-2015 RLDO project: Optical passive component development

2010-2012 DECIDII project: Bridge monitoring with FBG sensors

10. International Research Institute of Stavanger (IRIS)

Description of the entity:

IRIS AS - International Research Institute of Stavanger - is a recognized research institute with high focus on applied research, equally owned by the University of Stavanger and the regional foundation Rogaland Research. Rogaland Research was established in 1973, and because of a technical re-structuring of its ownership, IRIS was established in 2006. The continuation of Rogaland Research's activities provides IRIS with a long and proud history right from the start. Research activities started in the area of social science, but quickly developed to include petroleum. Today IRIS remains an independent research institute with research and research-related activities in petroleum, new energy, marine environment, biotechnology, social science and business development.

Contribution to the Work Plan and expertise brought to ENOS:

IRIS has a long experience in IOR/EOR methods including, but not limited to CO₂ EOR. In the project IRIS would contribute with its broad simulation experience. Another contribution is within biological environmental monitoring. IRIS is also involved as a work package leader in WP7.

IRIS is involved in:

- **WP3.** Managing leakage risks for protection of the environment and groundwater (Task 3.1 Groundwater protection: Geochemical monitoring and potential impact of leakage on potable aquifers and Task 3.1 Groundwater protection: Geochemical monitoring and potential impact of leakage on potable aquifers)
- **WP4.** Integration of CO₂ storage with local economic activities (Task 4.2 CO₂ storage and oil production and 4.3 Building the socio-economic case)
- In 3 of the 5 tasks of **WP6** International Cooperation & seeding pilots and demos in Europe (Task 6.1 International cooperation; Task 6.4 Preparation of follow-up stages for ENOS pilot sites; Task 6.5 Roadmap for upscaling identified synergies of CO₂ storage with CO₂ utilisation)
- All tasks in **WP7** Spreading innovation (WP Leader)
- As WP leader on the MB in **WP9** Management

Staff

Roman Berenblyum holds chemical engineer degree from University of Chemical Technology in Moscow, followed by PhD from Danish Technical University. Dr. Berenblyum has joined IRIS in 2006 and currently holds position of Research Director on Field Studies and New Recovery Technology. Roman's research interests are within simulation of IOR / EOR processes including gas and water based methods, in-situ mobility control, PVT modelling, CO₂ utilisation and storage and analytical reservoir models. Roman Berenblyum has been involved in both research and engineering projects with among others for Statoil, ConocoPhillips, TNK-BP, ADNOC, PetroEcuador, PDVSA. Dr. Berenblyum is coordinating IRIS Energy activities within Norwegian and international networks such as EERA CCS and Shalegas and CO₂GeoNet. Roman participated in a number of training courses and workshops organised both by IRIS and other parties. Roman Berenblyum is an active member of SPE serving in journal and conference reviewing committees.

Astri JS Kvassnes has an MSc in geology from University of Bergen, and a PhD from Massachusetts Institute of Technology/Woods Hole Oceanographic Joint Program in Marine Geology, specializing in hard-rock geochemistry. She has experience as a Post Doc at IfM Geomar in Kiel, Germany and five years as a research scientist at the Norwegian Institute for Water Research in Bergen and Oslo. She has held a position at IRIS as a Senior Research Scientist and business developer for Carbon-dioxide Capture and Storage since 2013. She bridges the gap between marine ecology, geology, geochemistry and modeling so that Carbon Capture and Storage (CCS) can help the petroleum industry prevent climate change in a sustainable manner. She has been a member of the Task force for CO₂GeoNet since 2014.

Catherine Boccadoro holds a Molecular Genetics Master from Paris University followed by a PhD from Cambridge University, UK in Microbial Ecology and Microbial Biosensors for the detection of pollutants in the environment. She has joined IRIS in 2007 leading and taking part in projects related to bioremediation, microbiology and environmental response to pollutants in the environment, development of biosensors and microbial and molecular tools for environmental monitoring. She is leading the Biotechnology research group in the Environment Department at IRIS, which works in close collaboration with the Energy Department on problematics related to the O&G industry including environmental monitoring, oil spill biotechnology, reservoir microbiology and CO₂ utilisation and storage.

Publications

- Screening and Evaluation of a Saline Aquifer for CO₂ Storage - Central Bohemian Basin, Czech Republic. J. of Greenhouse Gas Control 5(6),pp. 1429-1442.
- Second EAGE CO₂ storage workshop. Physical phenomena during CO₂ injection: from lab to field.2010.
- Implementation of the EU CCS directive in Europe: Results and development in 2013. Shogenova, A. and others (including Kvassnes). <http://dx.doi.org/10.1016/j.egypro.2014.11.700>
- Microbial response and molecular marker target species for CO₂ exposure in the marine environment. Boccadoro, K. ; Ramanand, S. ; Maeland, M. ; Internal report 2015 (article in prep).
- Quantitative analyses of hydrocarbon-degrading bacteria in the marine environment for the development of markers of petroleum pollution. 15th International Symposium on Microbial Ecology. 24-29 August 2014. Seol, South-Korea

Past experience

- Tjelbergodden value chain: CO₂ EOR
- CO₂ EOR for Ekofisk field
- Evaluation of CO₂ injectivity and storage at Tubaen formation, Snohvit
- Screening of CO₂ storage in Czech Republic
- Microbial response and molecular marker target species for CO₂ exposure in the marine environment.
- Microbial community changes following petroleum exposure in the marine environment.
- Development of molecular microbial markers for the detection of Petroleum exposure in the marine environment.

11. Natural HAZards Control and Assessment (NHAZCA)

Description of the entity:

NHAZCA (Natural HAZards Control and Assessment) is a Spin-off Company of "Sapienza" University of Rome, international leader in the analysis and monitoring of natural hazards and large infrastructures for the management and mitigation of risks.

NHAZCA provides specialized consultancies in the geological, geotechnical and civil engineering fields through innovative remote sensing techniques, developed also through the collaboration with CERI (Research Centre of "Sapienza" University of Rome), IMG S.r.l. (promoting partner) and prestigious entities such as the European Space Agency (ESA).

NHAZCA is a reference partner for entities and companies in charge of land and urban planning, civil protection, oil & gas, mining, large infrastructures and conservation of the architectural and monumental heritage.

Our main solutions are:

- Risk Assessment
- Geotechnical Monitoring
- Structural Health Monitoring
- Early Warning Systems
- Geological Design
- Engineering Design

Contribution to the Work Plan and expertise brought to ENOS:

NHAZCA is involved in:

WP3 Managing leakage risks for protection of the environment and groundwater

- Task 3.2 Understanding risk of CO₂ migration through faults and boreholes for effective monitoring.
- **WP7** Spreading innovation for Research integration and Best practices

Specifically, NHAZCA aims to provide an analysis of the ground deformations induced by the activities for the storage of carbon dioxide, by a pioneering integration of space, aerial and ground-based remote sensing technologies. By the achieved results, it will be possible to identify pros and cons of the different technologies and to design a suitable technical protocol (in terms of costs and benefits) to be adopted in similar applications.

Interferometric analyses will be performed by high resolution satellite SAR images (available from the Space Agencies archives) in order to investigate both the historical ground deformation (i.e. 2010-2015) of the test site area and those deriving from the storage activity in the near future (both in uplift and subsidence) with millimetric accuracy. Specifically, for a comprehensive characterization of the phenomenon during injection phases, corner reflectors (i.e. passive devices allowing the optimal backscatter of the radar signal emitted by the satellite) will be installed in the test area on a regular grid in order to achieve high resolution displacement information. RPAS (Remotely Piloted Aircraft Systems) surveys will be also performed for the acquisition of an accurate DEM (Digital Elevation Model), suitable for both the refinement of the interferometric analyses and, eventually, to perform multi-temporal digital image correlation for the detection of ground deformation. Such integration represents the most relevant improvement respect to the state of art in the field of remote sensing techniques applied to Oil&Gas issues.

During the storage operation, a continuous topographic monitoring by automatic total station will be also performed in order to correlate the ground deformation to the injection activities.

Such integrated approach represents an accurate and comprehensive control system of the CO₂ injections both at local and regional (some km²) scale, thus fitting with the main objectives of the project (i.e. developing, testing and demonstrating in the field, under “real-life conditions”, key technologies specifically adapted to onshore contexts).

Staff

Paolo Mazzanti, PhD, co-founder and CEO of NHAZCA S.r.l. and lecturer of Remote Sensing at “Sapienza” University of Rome.

Paolo is PhD in Earth Sciences and is the organizer of the International Course on Geotechnical and Structural Monitoring (directed by Dr. John Dunncliff). He is also lecturer at several master degree courses on natural hazards and at national and international professional courses.

On September 2011 receives the first award at the FMGM (Field Measurement in GeoMechanics) Symposium and in 2012 receive the award for Young GIN Engineer.

He is invited lecturer at several conventions and international research centres and is author of more than 60 scientific papers inherent the following main thematic: a) terrain deformation monitoring by remote sensing techniques; b) Terrestrial and Satellite SAR Interferometry; c) geological and geomorphological characterization of sub aerial, subaqueous and coastal landslides; d) numerical modelling of quick landslides and snow avalanches; e) landslides forecasting analysis; f) thermal behaviour of rock masses.

Alfredo Rocca, PhD, Project Manager and head of InSAR division at NHAZCA S.r.l.

Alfredo is PhD in Earth Sciences with a strong expertise on ground deformation analysis and monitoring. In 2011 attended a 6 months long stage at the European Space Research Institute (ESRIN) of the European Space Agency (ESA) in Frascati (Rome) in the frame of the Earth Observation Program. On 2012 was visiting Researcher at the Institute of Space and Earth Information Science (Chinese University of Hong Kong). He is co-author of several scientific papers and conferences proceedings of national and international relevance.

Alfredo is co-organizer of the course titled “Satellite SAR Interferometry for Geologists and Engineers”.

His main skills and interests are: a) numerical modeling for the stress-strain analysis by finite difference methods; b) analysis of satellite SAR data by DInSAR techniques; c) study of deformation processes by ADInSAR techniques (processing and interpretation by stacking interferometry methods such as Persistent Scatterers and SBAS); d) landslides monitoring.

Dr. Alessandro Brunetti, Project Manager at NHAZCA S.r.l.

Alessandro is graduated in Engineering Geology and is expert geologist in remote sensing for the mitigation of natural and anthropic risks. He was involved in the MODE TInSAR Incubation Project with ESA (European Space Agency) for the development of new solutions for the application of TInSAR technique to geotechnical and structural monitoring. He was also promoter of some national research and development programs like: “Promotori Tecnologici III Edizione” (by the Province of Rome) and “PRO.DI.GIO” (by the Lazio Region).

His main skills and interests are: a) processing and interpretation of ground-based InSAR data for geotechnical and structural monitoring; b) projects management; c) geological, geomechanical and geostructural surveys, also by innovative remote sensing techniques; d) landslide monitoring.

Prof. Francesca Bozzano, co-founder and President of NHAZCA S.r.l.

Francesca is Full Professor of Engineering Geology at “Sapienza” University of Rome and Director of CERI - Research Centre on Prediction, Prevention and Mitigation of Geological Risks.

She is author and co-author of more than 90 scientific papers published on international magazines and national and international conference proceedings.

She is referee of some national and international scientific magazines.

She has been involved in the following research activities:

a) analysis of the evolution processes of slopes affected by erosive processes, mainly performed in the frame of PhD activities; b) landslides phenomena triggered by rainfalls and earthquakes, with the recent implementation of monitoring activities; c) geotechnical and compositional characteristics of fine-grained sediments for large spectrum applications; d) technical geology of Rome subsoil, with recent applications to urban cavities; e) geotechnical analysis in the frame of seismic micro-zoning in some urban areas of Central Italy; f) geotechnical support in the frame of in situ experimental activities for the development of new techniques for the remediation of polluted aquifers.

Publications

- Gandolfo L., Brunetti A., Bozzano F., Bratus A., Busnardo E., Floris M., Genevois R., Mazzanti P., Saporito F., 2015. The Ligosullo (UD, Italy) Landslide, Revisiting of Past Data and Prospects from Monitoring Activities. G. Lollino et al. (eds.), Engineering Geology for Society and Territory, Volume 5, Springer International Publishing, Switzerland, 171-175.
- Rocca A., Mazzanti P., Bozzano F., Perissin D., 2015. Advanced Characterization of a Landslide-Prone Area by Satellite a-DInSAR. G. Lollino et al. (eds.), Engineering Geology for Society and Territory, Volume 5, Springer International Publishing, Switzerland, 177-181.
- Bozzano F., Esposito C., Franchi S., Mazzanti P., Perissin D., Rocca A., Romano E., 2015. Analysis of a Subsidence Process by Integrating Geological and Hydrogeological Modelling with Satellite InSAR Data. G. Lollino et al. (eds.), Engineering Geology for Society and Territory, Volume 5, Springer International Publishing, Switzerland, 155-159.
- Rocca A., Mazzanti P., Perissin D., Bozzano F., 2014. Detection of past slope activity in a desert area using multi-temporal DInSAR with Alos Palsar data. Italian Journal of Engineering Geology and Environment, Casa Editrice Università La Sapienza, Rome, Italy, DOI: 10.4408/IJEGE.2014-01.O-03
- Mazzanti P., 2012. Remote monitoring of deformation. An overview of the seven methods described in previous GINs. Geotechnical Instrumentation News, Dicembre 2012, pp. 24-29.

Past experience

Over the last 5 years NHAZCA provided several consultancies and services to more than 20 national and international clients, including international Firms and Public Entities.

Among the most relevant which NHAZCA was involved in it is worth to mention the monitoring by Satellite InSAR of moraines and glaciers deposits in Antarctica, of the ground deformation of unstable slopes in the Sultanate of Oman and several landslide and artificial dams in Italy.

Furthermore, NHAZCA recently performed an analysis of ground instability processes in order to investigate the relationship with gas extraction and storage over the last 20 years in a site in Central Italy.

NHAZCA was promoter of “MODE TInSAR” (Monitoring Deformation by Terrestrial SAR Interferometry), an incubation project by ESA (European Space Agency) aiming at the development of TInSAR applications for the monitoring of natural and structural instability problems.

In the last two years NHAZCA provided highly professional courses to more than 100 Firms and Public Entities coming from more than 30 countries, thus providing to end-users the necessary background about the recent innovations in the field of geotechnical and structural monitoring and in the analysis of natural hazards for risk mitigation purposes.

12. National Institute of Oceanography and Experimental Geophysics (OGS)

Description of the entity:

The mission of OGS, a national Italian institute under the control of the Ministry of University and Research, is to promote, coordinate and perform studies and research on the Earth and its resources, more specifically, applied geophysical and environmental disciplines, marine sciences, seismicity, hydrodynamic and geodynamic phenomena, in collaboration with other national, international, and European institutions. The institute, located in Trieste and Udine, has a staff of about 270 units (about 100 on temporary contracts), and a long tradition in (on and offshore) geophysical exploration, physical oceanography, marine biology and Earth observation. OGS coordinated or participated in more than 70 EU-funded research and demonstration projects in the fields of Energy, Environment and Marine Sciences. OGS has built solid networks and partnerships in Europe, in developing countries and in transition-economies' countries. Moreover, due to its long-term collaboration with the industry of the energy sector, OGS has developed high-technology competence and skills, to manage the acquisition of onshore (surface and borehole) and offshore geophysical and oceanographic data, as well as data processing and interpretation.

Contribution to the Work Plan and expertise brought to ENOS:

OGS is involved in:

WP1: Ensuring safe storage operations (2 of the 4 tasks)

Task 1.3 Monitoring safe underground storage behaviour - 1.3.2 Innovative geophysical monitoring

Task 1.4 Demonstrating operational risk management - 1.4.1 Integration of monitoring data, 1.4.3 Technical Guidelines for operational risk management.

WP3: Managing leakage risks for protection of the environment and groundwater (3 of the 4 tasks)

Task 3.2 Understanding risk of CO₂ migration through faults and boreholes for effective monitoring - 3.2.2 Monitoring CO₂ migration through fault planes in the sub-surface

Task 3.3 Development of monitoring tools

Task 3.4 Integrated monitoring solution

WP5: Coordination with local communities (one of the 3 tasks)

Task 5.1 Knowledge development and integration in a societal perspective

WP6: International Cooperation & seeding pilots and demos in Europe (3 of the 5 tasks)

Task 6.1 International cooperation - 6.1.3 Experience sharing Focus groups

Task 6.2 European links, liaison and knowledge exchange

Task 6.4 Preparation of follow-up stages for ENOS pilot sites

WP7: Spreading innovation (one of the 3 tasks)

Task 7.1 Research integration - 7.1.2 Web site and Knowledge Sharing Platform

WP8: Promoting CCS through Training and education (one of the 4 tasks)

Task 8.2 Building and providing an e-learning course

OGS can provide seismic vibrator source, borehole seismic tools, multichannel recording system and drone equipped with high tech remote sensing instruments.

Staff

Flavio POLETTTO has the degree “Dottore in Fisica” (Trieste University). He is a senior geophysicist (Director of Research) coordinator of the OGS Borehole Geophysics Group. He was awarded two Honourable mentions for the Best papers in Geophysics (2001, 2002), a Best Paper by ASCE Earth & Space Exploration and Utilization of Extraterrestrial Bodies (paper “MOONBIT SWD laboratory testing with lunar regolith simulant”, ESA project, 2010), and “Legends of SWD Award” (Joint SEG/SPE SWD Workshop Galveston, TX, 2013). He was scientific and technical coordinator of many projects with EU and Oil industry (Eni and other Oil industries) focused on borehole seismic and geosteering research, acquisition and data processing. He is inventor of patents on SWD and Tunnel SWD methods, published about 50 journal articles, and is author of many international conference’s presentations on borehole seismics (VSP, crosswell), acoustic, seismic wave propagation and seismic interferometry with applications to oil and geothermal exploration. He is the scientific coordinator of the OGS Instrumented-well Test Site (PITOP). He is author of the book “Seismic While Drilling – Fundamentals of drill bit seismic for exploration”, Poletto and Miranda (2004, see OGS bibliography). His expertise and research activity include new variants and innovative methods for SI wavefield representation, borehole instrument calibration (including DAS), source emission analysis by ground-force monitoring, and joint use of borehole EM and seismic methods.

José M. CARCIONE has a degree in “Licenciado in Ciencias Físicas” (Buenos Aires University), a degree “Dottore in Fisica” (Milan University), and a Ph.D. in Geophysics (Tel-Aviv University). From 1978 to 1980 he worked at the “Comisión Nacional de Energía Atómica” at Buenos Aires. From 1981 to 1987 he was employed as a research geophysicist at YPF (national oil company of Argentina). Presently, he is Director of Research at OGS. He was awarded the Alexander von Humboldt scholarship for a post-doc at Hamburg University (1987-1989). In 2007, he received the Anstey award at EAGE in London. He published more than 200 journal articles on acoustic and electromagnetic numerical modeling, with applications to oil exploration and environmental geophysics. He is the author of the book “Wave fields in Real Media – Theory and numerical simulation of wave propagation in anisotropic, anelastic, porous and electromagnetic media” (see the OGS bibliography). He has been editor of “Geophysics” since 1999. He has coordinated many projects funded by the EU and private companies.

Stefano PICOTTI has a degree in Physics, and a Ph.D. in Polar Sciences. As researcher at OGS, he has developed particular expertise in the field of seismic tomography, non-conventional processing, seismic modeling and calculation of physical properties of rocks and fluids. He participated and coordinated projects focusing on reservoir characterization and geological sequestration of CO₂. He developed algorithms for the evaluation of seismic attenuation (quality factor), and for the estimation of the petrophysical characteristics of reservoirs, including seismic anisotropy. He developed algorithms to build realistic reservoir models, and applied modelling techniques to the evaluation of the sensitivity of the seismic and EM methods to the changes in the rock properties during and after the CO₂ injection, in particular for the detection of possible CO₂ leakages. He applied the tomographic technique on the optimization of the site monitoring during and after the CO₂ injection. He published 34 articles on national and international journals.

Enrico PRIOLO is senior researcher at OGS. He has experience in numerical modeling of seismic wave propagation and earthquake simulation, seismic site response estimation, as well as seismic monitoring. He was a director of the OGS Seismological Department in 2003-2008. At present, he is responsible of the Collalto Seismic Network, which is the first Italian seismic network, managed by a public institute, devoted to monitoring the activity of gas storage in an underground depleted gas reservoir.

Andrea SCHLEIFER is a senior electronic engineer, coordinator of the acquisition activity in the Borehole Geophysics Group of the OGS Geophysical Section. He has been manager of the acquisition-system and borehole-instrumentation development, preparation and utilization activity in more than 35 field surveys of borehole geophysics (including seismic, distributed acoustic DAS by fiber optic sensors and EM applications), for downhole and joint surface-borehole innovative instrumentation testing and experimental monitoring purposes. Since 2009 he is the technical coordinator of the geophysical-experimental PITOP infrastructure with instrumented wells (OGS Test Site of Piana di Toppo in Italy).

Gualtiero BÖHM holds a MSc in Geological sciences. He is senior researcher at OGS, with over 25 years deep experience in seismic methods, in particular in the development of new algorithms for seismic tomography. He is the responsible of the CAT3D project, that develops the software tomographic package CAT3D, own by OGS. This software has been and is being applied for hydrocarbons and gas-hydrates search, seismotectonic studies, near surface applications, civil engineering studies, and monitoring underground CO₂ storage. He was involved in many projects for oil companies (Eni-Agip, Norsk Hydro, Fina, Elf, OMV, Saudi Aramco and Enterprise), concerning tomographic inversion and processing of real data; he participated in numerous national and European projects, and for some of them acted as scientific responsible for OGS, as the Wise research project of the Italian national research program in Antarctica and the European projects on CCS in Coal beds (MoVeCBM), and on CO₂ Site Closure Assessment (Co2Care). He published over 50 papers in international journals and almost 100 works in international conference proceedings.

Michela VELLICO is an environmental engineer, with a Ph.D. in Applied Geophysics and Hydraulics. Her main technical expertise is in remote sensing techniques, particularly their applications for CCS studies. In this field, she has been involved in the following EC projects: CO₂ GeoNet (testing the use of remote sensing methodologies in the leaking sites of Latera and the Laacher See), Geocapacity and CO₂StoP (providing datasets to the European WebGIS of storage sites, and storage capacity calculation), ECCSEL PPI and ECCSEL PPII. She has also contributed to national projects related to CCS (for ENEL and Cesi Ricerca), and has been actively involved in all the studies performed by the OGS Research aircraft equipped with high-tech remote sensing instruments.

Publications

- Carcione, J. M., 2015, Wave Fields in Real Media. Theory and numerical simulation of wave propagation in anisotropic, anelastic, porous and electromagnetic media, 3rd edition, Elsevier.
- Picotti, S., Grünhut, V., Osella, A., Gei, D., Carcione, J. M., 2013, Sensitivity analysis from single-well ERT simulations to image CO₂ migrations along wellbores, The Leading Edge 32(5), 504-512. DOI: 10.1190/tle32050504.1.
- Poletto F., B. Farina, G. Böhm, and K. Wapenaar, 2014. Seismic interferometry by tangent-phase correction: Geophysical Prospecting. DOI: 10.1111/1365-2478.12209.
- Poletto F., and F. Miranda, 2004. Seismic-While-Drilling. Fundamentals of Drill-Bit Seismic for Exploration: Handbook of Geophysical Exploration, Seismic Exploration. Vol. 35. Elsevier, Amsterdam. Release Date: 30 Jun 2004, Imprint: Pergamon, eBook ISBN: 9780080474342, Print Book ISBN: 9780080439280, Pages: 546.
- Priolo, E., M. Romanelli, M. P. Plasencia Linares, M. Garbin, L. Peruzza, M. A. Romano, P. Marotta, P. Bernardi, L. Moratto, D. Zuliani, and P. Fabris (2015). Seismic monitoring of an underground natural gas storage facility: The Collalto Seismic Network, Seismol. Res. Lett. 86, no. 1, 109--123, doi: 10.1785/0220140087.

Past experience

Past OGS research on CCS has been focused on: storage sites identification and characterization, subsurface imaging by geophysical methodologies, on-shore and off-shore storage sites monitoring, remote sensing, impact assessment on marine ecosystem, and development of advanced monitoring techniques for data acquisition, processing and modelling. In particular, OGS has been involved in the following European projects on the geological storage of CO₂: CO₂-NET2, CASTOR, INCA-CO₂, CO₂GeoNet, GeoCapacity, CO₂ReMoVe, MOVE-[653718 – ENOS – PART B - 67]

CBM, RISCS, ECO₂, SiteChar, CGS Europe, CO₂CARE, and ECCSEL. OGS is Secretary General of CO₂GeoNet (the European Network of Excellence on the Geological Storage of CO₂) and coordinator of the EERA Joint Program on CO₂ Geological Storage.

Relevant borehole activities have been performed at the OGS instrumented Test Site Piana di Toppo (PITOP, Italy), in particular for acoustic calibration of iDAS by co-located geophones in borehole and surface trenches. These activities include crosswell investigations (CO₂Monitor project), with evaluation of borehole seismic, resistivity and EM methods.

Thanks also to a fruitful collaboration with other CO₂GeoNet members, OGS has tested and implemented some innovative remote sensing techniques to indirectly monitor CO₂ leakages through joint interpretation of data acquired by instruments mounted on board of aircrafts, helicopters or drones.

Finally, worthy to be mention is the collaboration of OGS with the Italian Economic Development Ministry (MISE), for the definition of methodologies and operational monitoring protocols to ensure safe injection/extraction operations. In this ongoing collaboration, OGS have already given a substantial contribution to write the Italian national guidelines for geophysical monitoring of oil & gas exploitation activities.

13. Palencia 3, Investigación, Desarrollo y Explotación, S.L. (PLC-3)

Description of the entity:

Palencia 3, Investigación, Desarrollo y Explotación, S.L. (Palencia 3) was born on July of 2010 with the purpose of analysing the viability for CO₂ storage of *Almacén 3*, located in Palencia, Spain.

The society has the following owning companies: Gas Natural SDG (Palencia3-Gas Natural), ENAGAS (Palencia 3-Enagas) and Fundación Instituto Petrofísico (Palencia 3-IPf).

Palencia 3 faced to the challenge of CO₂ storage carried out by an important part of the electrical sector of Spain (Gas Natural-Fenosa) and the Technical manager of the Spanish gas system, also certified as independent TSO European Union (ENAGAS).

On 22nd of December, 2010, *Almacén 3* was declared Provisional Reserve of State, and the development of the Research Plan for this Reserve, in accordance to the Law 40/2010, was commissioned to Palencia 3.

Palencia 3 has developed the two first steps of the Research Plan outlined in Law 40/2010 (formation characterization and CO₂ storage capacity of Campillo 1 closed structure) and currently the dynamic model of the storage is under way.

The staff from Palencia 3 is provided by ENAGAS and IPF. These will therefore be third parties in performing the work planned

Contribution to the Work Plan and expertise brought to ENOS:

PLC-3 is involved in:

WP1: *Palencia 3-Enagas*. For providing industrial view on the risk management work flow and alert system (task 1.4)

WP2: *Palencia 3-IPF* and *Palencia 3-Enagas*. Working with CIUDEN on the light drilling (task 2.3) and provide industrial view on the outcomes of the WP

WP3: *Palencia 3-Enagas*. Providing industrial point of view on monitoring technical guidelines (task 3.4)

WP6: *Palencia 3-IPf*. Participating in international collaboration focus groups (task 6.1.3)

WP7: *Palencia 3-IPF* and *Palencia 3-Enagas*. Providing industrial view on the best practices, participate in workshops and Project meetings.

WP9: *Palencia 3-IPf*. Managing data sharing relayed to the Palencia 3 (task 2.3) and Site Contact

Staff

The staff from Palencia 3 is provided by ENAGAS and IPF. These will therefore be third parties in performing the work planned

Palencia 3-ENAGAS

Rafael Moreno García - Mining Engineer by Polytechnic University of Madrid, since 1.981, specialized in Energy and Fuels. He was working in Repsol Exploracion S.A. in Reservoir, Exploration Dept. After 7 years change his activity working as Mechanical Maintenance Chief in petrochemical Repsol Quimica, S.A. Since 1.993, his activity passing to ENAGAS S.A. as Maintenance Chief of transmission/piping area. In 2.006, arrived to Enagas' Projects Dept. as Project Manager, for piping and compression station Projects. He becomes as Underground Gas Storage Project Manager, since last 2.012 year.

Patricia Suarez Cienfuegos is the principal Geosciences Engineer at the Underground Gas Storage Project Management in Enagas. She is Mining Engineer specialized in Geology and Geophysics by University of Oviedo. She has been working for several Exploration and Development UGS projects. During the last years she is focused on the UGS monitoring with different technologies and contributes on the traffic light system for alerts while operation. She is an Enagas team member for CCS projects as well as for the Evaluation of the EU's Carbon Capture Directive.

Palencia 3-IPf

Emilio Carro Puente - Mining Engineer. 33 years of experience in Exploration & Production activities of Repsol and Hispanoil.

Laura M Valle Falcones - Mining and Energy Engineer, Politechnical University of Madrid. Master on Prevention of Industrial Hazards and Health. Master on Reservoir Engineering. Institut Français du Pétrole. Responsible for the Petrophysical Laboratory of IPF. Scientific researcher in CO₂ geological storage and thermodynamic of the injection and transport process. Developer of technology, with patent pending, for CO₂ trap mechanisms in saline aquifers and hydrocarbon reservoir characterization. PhD: “Sensitivity Study of the main petrophysical parameters for the CO₂ storage capacity estimation in deep saline aquifers”. Research on well cements for PDT Hontomín: “Cements of improved sealing capacity in CO₂ geological storage”. E. Estévez, L. Valle, D. del Barrio, G. Blázquez, T. Kovács, V. Blázquez. 2014. Peer review of *Journal of Canadian Petroleum Technology*

Raúl Rodríguez Martín

BSc in Geology. MSc in Environmental Geology and geological resources. PhD Programme Petrophysics: CO₂ storage characterization. Study and evaluation of “Zonas de reserva a favor del Estado” related to underground structures capable to storage CO₂. Carrying out the report to request the Provisional Reserve Statement for the reserve zone “Palencia 3” and afterwards, the request for the research permit, following the law 40/2010 of December 29th, for geologic storage of CO₂. Petrophysics and geomechanic characterization of the reservoir formation in Palencia 3 zone Petrophysics and geomechanic characterization of all the formations involved in the CCS research project of CIUDEN, in Hontomín. Geophysics interpretation of the seismic data available for Palencia 3 project. Develop of the 3D geological static model. Supervision of the geophysics interpretations of the 3D seismic cube for Hontomín project (CIUDEN). Quality check of the 3D static geological modeling process and results. Petrophysics interpretation of the logs available in the wells present in Palencia 3 zone in order to calculate porosity, permeability, fluid saturations and water salinity in the geological formations involved in the storage. Petrophysics interpretation of the logs available in the wells present in Hontomín project (CIUDEN) in order to calculate porosity, permeability, fluid saturations and water salinity in the geological formations involved in the storage.

Infrastructure/ major equipment provided to ENOS

Palencia 3 - More detail is provided in the section ‘Infrastructure proposed by the partners – test sites’

14. State Geological Institute of Dionyz Stur (SGIDS)

Description of the entity:

The State Geological Institute of Dionyz Stur (SGIDS) is a state contributory organization acting as Slovak Geological Survey supervised by the Ministry of Environment of the Slovak Republic. The activities are focused in the solutions of the geological research and exploration projects, creation and application of the information system in geology, registration, collection, evidence and making accessible the results of geological works carried out at the territory of the Slovak Republic and overseas. The particular engagement is linked with the geological mapping, mineral resources, processing of mineral resources, hydro-geological survey, engineering geological survey, environment, facilities for the storing of gas, liquids and wastes, extraction of raw minerals, reference laboratory services etc.

Contribution to the Work Plan and expertise brought to ENOS:

Engagement within WP4 lead by TNO and the activity focusing on the cross-border impact study of the prospective Czech pilot LBr-1.

WP6 because of the activities linked with the depleted gas deposit in Brodske (Slovak Republic) and the managing leakage risks and protecting groundwater.

Provision of both geological and hydro-geological expertise meeting the expected selected tasks of the ENOS project.

SGIDS is involved in:

- **WP6.** International Cooperation & seeding pilots and demos in Europe (Task 6.4 Preparation of follow-up stages for ENOS pilot sites; Task 6.5 Roadmap for upscaling identified synergies of CO₂ storage with CO₂ utilisation)
- **WP7** Spreading innovation for Research integration and Best practices

Staff

Dr. Ludovit Kucharic, PhD

Comenius University, Bratislava 1965-1968 Slovakia

Charles University Prague 1968 – 1971 Czech

Diploma: geology, specialization applied geophysics

Comenius University Bratislava 1981-1986 Slovakia PhD (CSc) Thesis: A reflection of geological phenomena in geophysical fields in the Spissko - gemerske Ore Mts. (in Slovak). Awarded 1986

KEY QUALIFICATIONS

Long term experience with geological and geophysical data interpretation

Geological mapping

Evaluator of project regarding geology and environment for INTAS, EC Brussels, Hungary Academy of Science

Orientation in the international environment regarding impacts of energy production

Global overview on European necessities and problems from environmental, raw material and energy point of views

Presentation of achieved results on the conferences and workshops in the Europe, some presentation concerning to CO₂ storage and connected problems have been on call: Petten 2006, Zagreb, 2007, Bratislava, 2009, 2010, Fontainebleau (France) 2009, Prague, 2010, Venice 2010, 2011, 2012, Trondheim (Norway) 2010.

Contributor to the EC Directive creation regarding geological storage of CO₂; member of Slovakian group creating the National law on this issue

Holistic approach to cycle raw materials exploitation, utilisation and storage by surviving principle of sustainable development.

Publication activity – more than 125 (papers, posters, presentations - (selected publications see www.researchgate.net/), above 60 reports (manuscripts).

MSc. Michal Jankulár, PhD.

Comenius University in Bratislava, Slovakia 2003 – 2005 Faculty of Natural Sciences, Master of Science degree in Environmental geochemistry,
Comenius University in Bratislava, Slovakia, Faculty of Natural Sciences 2005 – 2012 PhD. study in Environmental geochemistry.

MAIN ACTIVITIES AND RESPONSIBILITIES

State monitoring program of selected old environmental loads in Slovak republic – *member of work team - responsibility for part of the project*

Research on vulnerability of groundwater for management of sustainable exploiting of groundwater in Bratislava municipality (existing and potential contamination sources for groundwater, sensitivity of aquifers, statistics, GIS) – *member of work team*

Publications

- Potential, Capacities Estimation, and Legislation for CO₂ storage in the Geological Formations of the Slovak Republic. Slovak Geological Magazine. / Ľudovít Kucharič, Ľubomír Tuček, Dušan Bodiš, Martin Radvanec, Ján Wallner, Katarína Čechovská, Zoltán Németh, Ivan Baráth, Alexander Nagy, Ján Derco, Boris Antal, Vladimír Bezák, Pavol Šesták - In: (2013), - 142 s.
- CO₂ storage potential of sedimentary basins of Slovakia, the Czech Republic, Poland and the Baltic States. / Saulius Šliaupa, Richard Lojka, Zuzana Tasáryová, Vladimír Kolečka, Vít Hladík, Júlia Kotulová, Ľudovít Kucharič, Vladimír Fejdi, Adam Wójcicki, Radosław Tarkowski, Barbara Uliasz-Misiak, Rasa Šliaupienė, Inara Nulle, Raisa Pomeranceva, Olga Ivanova, Alla Shogenova, Kazbulat Shogenov - In: Geological Quarterly. - ISSN 1641-7291 - Vol. 57, Issue 2(2013), - S. 219-232.
- Case for CO₂ geological storage-site Bzovík central Slovakia volcanic area. / Ľudovít Kucharič - In: Slovak Geological Magazine. - č. 2008(2009), - s. 73-80.
- CO₂ storage opportunities in the Central-NE Europe. / G. V. Georgiev, M. Larsen, N. Christensen, P. Scholtz, G. Falus, V. Hladik, L. Kolečka, Júlia Kotulová, Ľudovít Kucharič, A. Wojcinski, B. Saftic, B. Goricnik, M. Car, C. S. Sava, M. Bentham, N. Smith - In: Natural Cataclysms and Global problems of the Modern Civilization. Special edition of Transaction of the International Academy of Science. Baku, Azerbaidzhan, September, 24-27th 2007. - Baku-Innsbruck: H&E, ICSD/IAS, 2007. - s. 736-741.
- Preliminary results of the Slovakian national project regarding carbon dioxide storage in underground spaces. / Ľudovít Kucharič, Martin Radvanec, Ľubomír Tuček, Zoltán Németh, Dušan Bodiš, Katarína Čechovská, Ján Derco, Juraj Michalko, Ján Wallner, Peter Liška, Boris Antal - In: Energy Procedia. 10th International Conference on Greenhouse Gas Control Technologies. Amsterdam, The Netherlands, 19-23 September 2010. - Vol. 4, (2011), - s. 4921-4929.

Past experience

6thFP CO₂ Net East

6thFP Geocapacity – Estimation of Europe for CO₂ storage

CGS Europe - Pan-European Coordination action on CO₂ Geological Storage

CO₂STOP – European Atlas on Suitable Geological Structures for CO₂ Storage

15. Silixa (Silixa)

Description of the entity:

Silixa manufactures the world's highest performance distributed fibre optic sensors for temperature and acoustic monitoring. Ultima™ DTS offers the best spatial resolution available on the market for continuous temperature measurements along the FO cable. iDAS™ enables the user to listen in to digital-quality sound at every point along the cable. Both systems have been used successfully in the oil & gas, industrial and environmental sector.

A hybrid cable with more sensitive acoustic detection thresholds than currently commercially available and temperature change detection capability is being developed by Silixa and will be tested at the Sulcis fault laboratory and compared with other commercially available tools (which will be installed at the site through the national programme). This cable detects the arrival of CO₂ based on the differing physical properties of the CO₂ plume compared with the native groundwater. It utilises advanced silica engineering to optimise the interaction between the acoustic signal with the backscattered light. Through careful tuning of the iCable optoacoustic characteristics, Silixa can achieve a 15dB to 30dB improvement in the acoustic Signal to Noise Ratio compared to the use of standard cable. This breakthrough performance allows the iDAS to detect passive signals orders of magnitude lower than previously possible, or in the case of active seismic mode, to enable the operator to use significantly fewer repeat seismic shots or lower source effort. The seismic survey will provide a better characterization of the faults and leakages into borehole. Moreover Distributed Temperature Sensor measurements during the injection phase will contribute to the leak detection and characterization. TRL of this application will be brought to 7 through testing in wells in the freshwater zone

Contribution to the Work Plan and expertise brought to ENOS:

Silixa will be responsible for the iDAS data acquisition as part of the two 3D seismic surveys, in the Hontomin site. Silixa will also contribute to groundwater monitoring using innovative tools in the Sulcis site. These tools include an intelligent fibre optic cable (iCable) for enhanced seismic and temperature measurements for a better characterization of the faults and leakages in the Sulcis site.

Silixa will be mainly involved in the definition of the activities in Hontomin and Sulcis areas (WP1 and WP3) and in the definition of the best practices and innovative techniques (WP7).

Silixa is involved in:

WP1 Ensuring safe storage operations

- Task 1.3 Monitoring safe underground storage behaviour (Subtask 1.3.2 Innovative geophysical monitoring)

WP3 Managing leakage risks for protection of the environment and groundwater

- Task 3.1 Groundwater protection: Geochemical monitoring and potential impact of leakage on potable aquifers)

WP7 Spreading innovation for Research integration and Best practices

Staff

Dr Tom Parker, co-designer of Silixa's iDAS and ULTIMA units, is Silixa's Chief Technical Officer and has extensive expertise in fibre optic monitoring. Leading Silixa's R&D programmes he brings a clear direction of technical leadership to the company and is a world authority in distributed temperature, strain and acoustic sensing. Tom holds a PhD in Solid State Physics from Imperial College London and a first class degree in Physics from University College London. He is co-author on eight sensing patents, and has numerous international publications. Tom won a Metrology for World Class Manufacturing Award and British Telecom Technological Innovation Award for an extremely fine-resolution optical wavelength meter that he co-invented with Mahmoud Farhadiroushan, CEO of Silixa Ltd.

Dr Michael Mondanos, Silixa's VP of Industrial Applications, has over 15 years' experience in fiber optic monitoring. Holding a PhD in Optical Fibre Sensing from Imperial College, University of London he has not only

an in-depth technical knowledge of the fibre optic monitoring systems, but also a significant expertise in operations, project management, and strategic planning. He authored several international publications and he is a widely acknowledged expert in the energy industry.

Dr. Athena Chalari, Silixa's Environmental Engineer since 2012, has considerable experience in fibre optic monitoring for environmental applications. Athena holds a PhD in Marine Geosciences from University of Patras, Geology Department. She has field experience and expertise in data processing and geological interpretation. She has several international publications and has providing training in several distributed fibre optic workshops.

Dr Freifeld has been collaborating with Silixa as an external consultant. His research interests focus primarily on geologic sequestration of CO₂ in which Dr Freifeld has gained significant experience and track record through field installation and demonstrations in saline and depleted gas aquifers. Other research projects include understanding thermal and hydrologic conditions in arctic regions and monitoring geothermal systems. Currently he is the Principal Investigator at Lawrence Berkeley National Laboratory for a demonstration of coupled carbon sequestration and geothermal energy production. Dr Freifeld leads Berkeley Laboratory's collaborations with the Australian CO₂CRC Otway Project and the EU funded CO₂SINK program in Ketzin, Germany. He has over 100 publications and has received 7 awards in reservoir management and downhole techniques.

Publications

- Mondanos, M., Farhadiroushan, M. and Parker, T. (2007) Sensing System using optical fiber suited to high temperatures. International Patent: WO/2007/066146.
- Mondanos, M., Giles, I., Weir, K. (2005) Fibre optic polarimetric temperature sensor using low coherence source employing intensity and wavelength compensation. Proc. SPIE 5855, 17th International Conference on Optical Fibre Sensors, 647 (August 30, 2005); doi:10.1117/12.623280.
- Chalari A. , Mondanos M. , Finfer D. , Christodoulou D., Kordella S., Papatheodorou G., Geraga M., Ferentinos G. 2012. Short-term monitoring of a gas seep field in the Katakolo bay (Western Greece) using Raman spectra DTS and DAS fibre-optic methods. AGU Fall Meeting 3-7 December 2012.
- Ethan Castongia, Dante Fratta, Herb Wang, Michael Mondanos, Athena Chalari 2013. An initial test of an Intelligent Distributed Acoustic Sensing (iDAS) in the ice in Lake Mendota. AGU Fall Meeting 9-13 December 2013.
- Coleman, T., A. Chalari, B. Parker, J. Munn, and M. Mondanos. Accepted. Monitoring Borehole Flow Dynamics Using Heated Fiber Optic DTS in a Fractured Rock Aquifer. EGU General Assembly 2014, April 27-May 02, 2014, Vienna, Austria.

Past experience

Silixa is developing complementary signal processing techniques and application-customisation to form the base iDAS model into a number of specific tools: for example, flow meter, security sensor or seismic sensor. These projects involve seeking to resolve further specific technological uncertainties which fall within the definition of qualifying R&D for these purposes.

Previous experience includes participation in ZONeSEC programme under FP7 (call: SEC-2013.1.6-3) for pipeline surveillance and INTERFACES programme under Marie Curie Initial Training Networks (ITN) (Call: FP7-PEOPLE-2013-ITN). Moreover, Silixa in collaboration with the Fundación Ciudad de la Energía (CIUDEN) had performed iDAS seismic surveys and DTS trials in the Hontomin site for the development of a Deep-Well Heat Pulse Monitoring system for CO₂ sequestration. Silixa have also performed DTS trials in collaboration with CSIRO and the Australian National University (ANU) for CO₂ sequestration and iDAS seismic surveys in collaboration with Lawrence Berkeley National Laboratory at several CO₂ sequestration sites as the Australian CO₂CRC Otway Project, the Canadian Aquistore project and the US EPRI Energy Technology Assessment Center.

16. Società Tecnologie Avanzate Carbone S.p.A. (Sotacarbo)

Description of the entity:

Sotacarbo is a research and development company (shareholders: ENEA – the Italian National Agency for New Technologies, Energy and Sustainable Economic Development – and Sardinian Regional Administration) on clean energy and CCS.

Recently, Sotacarbo has been designed by the Sardinian Regional Government as the Centre of Excellence on Clean Energy, i.e. the regional and national reference for the development of the technologies for the sustainable use of fossil fuels (coal in particular) and clean energy (including carbon capture and storage), with the aim to collect knowledge and infrastructures in order to back and also to boost Italy's energy policy.

The activities programme of the Centre of Excellence includes theoretical and experimental studies on “zero emissions” technologies for power generation, production of energy carriers from coal, biomass and CO₂, pre-, post- and oxy-combustion carbon capture CCS and CO₂ geological storage.

Since 1988, Sotacarbo represents Italy in the International Energy Agency – Clean Coal Centre.

Contribution to the Work Plan and expertise brought to ENOS:

As the Sulcis (South-West Sardinia, Italy) site owner, Sotacarbo will coordinate all the activities carried out in such a site. Most of these activities will use the infrastructures (currently under development with Italian national funding) for site characterization and small-scale carbon dioxide injection to analyze CO₂ leakage in the faults.

In this context, Sotacarbo will be mainly involved in the definition of the experimental activities in Sulcis area (WP2 and WP3), in the work with Southern Sardinian local communities (WP5), in the activities to promote international cooperation (WP6), in the definition of the best practices (WP7) and in knowledge sharing and education activities (WP8).

Finally, Sotacarbo will also contribute to ENOS project through the organization of the following annual editions of the International Sulcis CCS Summer School, organized (together with the International Energy Agency – Clean Coal Centre, ENEA, the University of Cagliari and CO₂GeoNet) every July in its Research Centre in Carbonia, Italy. The school does not involve extra costs for ENOS, being funded through the national program.

Sotacarbo is involved in:

- **WP2** Ensuring storage capacities and cost-effective site characterisation (Task 2.3 Low Cost Drilling; Task 2.4 Technical guidelines on storage capacities estimates and cost-effective site characterisation)
- **WP3.** Managing leakage risks for protection of the environment and groundwater (Task 3.4 Integrated monitoring solution)
- all tasks in **WP5** Coordination with local communities (Task 5.1 Knowledge development and integration in a societal perspective; Task 5.2 Work with the local communities; Task 5.3 Development of a Public Information Tool for CO₂ storage sites)
- **WP6** International Cooperation & seeding pilots and demos in Europe (Task 6.1 International cooperation; Task 6.4 Preparation of follow-up stages for ENOS pilot sites)
- **WP7** Spreading innovation for Research integration and Best practices
- **WP9** Management as the Sulcis Site Owner

Staff

Mr. Giuseppe Girardi Age: 64 (male)

Profession: Graduated (cum laude) in Mechanical Engineering from University of Rome, he joined ENEA since 1978. He has directed the Diagnostic & Control Section of the Engineering Division, operating in basic and industrial oriented research activities. He has been involved in R&D programs on combustion and power plants, managing several projects and then playing the role of vice director of the Engineering Division. During the last decade he has directed the Energy Plants and Processes Division – operating in the fields of advanced power plants, low and zero emissions technologies, hydrogen technologies, decentralized power generation - and manager of Clean Coal/Zero Emission Project at ENEA. Now he's responsible of sustainable fossil fuels and CCS programs at ENEA, and Vice-president of Sotacarbo, giving advising and support to government both in technology innovation and energy strategies. He's also: President of Italian section of International Flame Research Foundation; Italian technical delegate in European Energy Research Alliance; Italian representative in the CCS-European Industrial Initiative of SET Plan; Italian delegate in the technical group of CSLF; member of Task Force "Technology" of ZEP European technological platform; Italian representative in Working Party Fossil Fuels.

Dr. Alberto Pettinau Age: 39 (male)

Profession: Dr. Pettinau is graduated in Mechanical Engineering and Ph.D. and he is currently Technical Manager of Sotacarbo. Dr. Pettinau is engaged, since 2004, in several research and development programs. He worked as Chief Scientist and Project Manager in several national and international research projects (including the project "Centre of Excellence on Clean Energy", funded with 8.4 M€ by the Sardinian Regional Government). His research is mainly focused on conventional and advanced gasification processes, oxyfuel combustion, carbon capture and storage and coal/biomass/CO₂ to liquids. He is the scientific coordinator of the Annual International Sulcis CCS Summer School (organized by Sotacarbo with Enea, University of Cagliari and International Energy Agency – Clean Coal Centre) and author of 50 publications (in international journals, books and conference proceedings) and a number of technical reports. He also cooperates as reviewer with several international journals.

Mr. Enrico Maggio Age: 47 (male)

Profession: Enrico Maggio is graduated in Mechanical Engineering at the University of Cagliari. He works in Sotacarbo since 1999 and he is currently Technical Manager. His main research activities are focused on coal and biomass gasification, advanced clean coal technologies, renewable sources, energy efficiency, carbon capture and storage, and experimental data processing. Mr. Maggio worked as Project Manager in several national and international research projects (including the project "Research on Electric System", funded with 3 M€/year by the Italian Ministry of Economic Development). He is also author of some publications on coal gasification and carbon capture and storage.

Mr. Alberto Plaisant Age: 41 (male)

Profession: Alberto Plaisant is graduated in Geological Science and he obtained a Master Degree in "Remote sensing and Geographic Information System (GIS)" in 2003. He works in Sotacarbo since 2005, where he is currently chief of the CO₂ Storage Team and vice chief of the Advanced Diagnostic Team. His research activities are mainly focused on CO₂ geological storage and site characterization. He has gained a 15-years experience and a wide knowledge on the Sulcis site from the geological and environmental points of view. He also has experience on laboratory-scale characterization of coal and biomass, gas analysis, CO₂ capture processes. Finally, Alberto Plaisant is co-author of several technical and scientific publications.

Publications

- V. Tola, A. Pettinau. Power generation plants with carbon capture and storage: a techno economic comparison between coal combustion and gasification technologies. Applied Energy, 2014;113:1461-1474.

- G. Girardi, E. Maggio, A. Pettinau, A. Plaisant, P. Deiana. Italian technology centre on CCS and clean energy: activities and international cooperation. Proceedings of the Asia Clean Energy Foru, 2014, Manila, Philippines, June 16-20, 2014.
- Plaisant, P. Deiana, G. Girardi, E. Maggio, A. Pettinau. Centre of Excellence on Clean Energy: Characterization of Sulcis coal basin for CO₂ geological storage. Proceedings of the 9th CO₂GeoNet Open forum, Venice, May 20-21, 2014.
- Pettinau, F. Ferrara, C. Amorino. Techno-economic comparison between different technologies for a CCS power generation plant integrated with a sub-bituminous coal mine in Italy. Applied Energy 2013;99:32-39.

Past experience

- Coordinator of the “Centre of Excellence on Clean Energy” Project, on carbon capture technologies by pre-, post- and oxy-combustion approaches and CO₂ geological sequestration.

Overall cost: 8.4 M€, funded by Sardinian Regional Government (2014-2016).

- Coordinator of the “Electric System Research” Project, on carbon capture technologies, power generation from biomass and energy efficiency.

Overall cost: 30 M€, funded by the Italian Ministry of Economic Development (2013-2023).

- Partner of the “Carbomicrogen” Project, on zero-emissions distributed power generation from coal.

Overall cost: 1.3 M€, funded by the Italian Ministry of Education and Research (2006-2010).

- Partner of the “COCACORK” Project on rotary kiln gasification for CO₂-free power generation.

Overall cost: 2.2 M€, funded by the European Commission’s Research Fund for Coal and Steel (2007-2010).

- Coordinator of the “COHYGEN” Project, on a gasification pilot platform for CO₂-free hydrogen production from coal.

Overall cost: 12 M€, funded by Italian Ministry of Education and Research (2003-2008).

Infrastructure/ major equipment provided to ENOS

Sulcis (fault lab and pilot) - More detail is provided in the section ‘Infrastructure proposed by the partners – test sites’.

17. Netherlands Organisation for Applied Scientific Research (TNO)

Description of the entity:

TNO is the largest fully independent Research, Development and Consultancy organisation in the Netherlands with a staff of about 5,400 and a total annual turnover of about 515 million Euros. Its primary tasks are to support and assist trade and industry including SME's, governments and others in technological innovation and in solving problems by rendering services and transferring knowledge and expertise. TNO provides contract research and specialist consultancy, as well as grant licenses for patents and specialist software. Also TNO tests and certifies products and services, and issues an independent evaluation of quality

Contribution to the Work Plan and expertise brought to ENOS:

TNO will bring in its expertise on monitoring subsurface CO₂ storage and its impacts (induced seismicity) and knowledge on developing practical technical guidelines for storage site operators. Geochemical modelling knowledge in TNO will be used to evaluate the impact of fluid-rock interactions on the purity of reproduced CO₂ gas streams. Engineering expertise on gas separation at TNO is central in developing the required separation techniques. Reservoir engineering expertise will be used to develop novel approaches for enhancing oil production and simultaneous CO₂ storage. Stakeholder analysis and techniques for engagement will be deployed to come to an active participation role of the stakeholders including the public. Regulatory hurdles in simultaneous oil production and CO₂ storage will be investigated and possible solutions will be defined. TNO will develop a plan for dissemination of project results to various stakeholder groups in industry, government, NGOs and the public at large.

TNO is involved in:

- **WP1.** Ensuring safe storage operations (Task 1.2 Induced seismicity: monitoring, control and hazard mitigation; Task 1.4 Demonstrating operational risk management)
- **WP3.** Managing leakage risks for protection of the environment and groundwater (Task 3.3 Development of monitoring tools; Task 3.4 Integrated monitoring solution)
- all tasks in **WP4.** Integration of CO₂ storage with local economic activities (WP Leader) and leader of Task 4.1 CO₂ buffering and re-production for greenhouse horticulture
- all tasks in **WP5** Coordination with local communities
- **WP6.** International Cooperation & seeding pilots and demos in Europe (Task 6.4 Preparation of follow-up stages for ENOS pilot sites; Task 6.5 Roadmap for upscaling identified synergies of CO₂ storage with CO₂ utilisation (Leader))
- all tasks of **WP7** Spreading innovation
- **WP8.** Promoting CCS through training and education (Task 8.4 Raising awareness by training workshops for journalists and media)
- **WP9** Management as WP Leader in the MB and as Q16 Maas Site Contact

Staff

Dr. Filip Neele is has a PhD in geophysics and holds a position as senior scientist and project manager in the field of CCS. Since 2006 he has been involved in a range of CCS projects: seismic monitoring, (geological) site characterisation, CCS chain integration and economical assessment. His special interest concerns the analysis and optimisation of the carbon capture, transport and storage chain. He coordinated the EU FP7 CO₂Europipe project, on the development of large-scale CCS infrastructure in Europe. He is also coordinating the MiReCOL project on the Mitigation and Remediation of CO₂ Leakage.

Dr. Ir. Cor Hofstee holds a PhD in the field of fluid flow through porous media. He worked in several countries (Australia, Niger, USA, Germany and the Netherlands) and for several research institutes and universities. Since

2001, he has been working for TNO, where he is currently active as a senior reservoir engineer. As such, he was involved in numerous oil and gas projects for a variety of operators. Furthermore, he managed in a number of screening and technical feasibility studies concerning CCS. He is currently involved in a number of EC projects including CO₂Geonet, IMAGE and MiReCOL.

Tom Mikunda is energy policy consultant at TNO. With a background in environmental science, environmental policy and economics, his work focuses primarily on policy and regulatory issues concerned with carbon capture and storage technologies. He has over 5 years experience in many aspects of European and international climate policy, closely observing the development of global climate negotiations under the UNFCCC. Between 2010 and 2014, he led the regulatory component of the €60 million Dutch national CCS research programme, CATO2. He has also advised and informed industrial and governmental stakeholders on issues such as transboundary CO₂ transport, CO₂ stream compositions and the long-term liability of storage sites, and has also partaken in CCS capacity building missions in developing countries including Brazil, Indonesia, Mexico, Mozambique and South Africa.

Dr Ton Wildenborg is a senior geoscientist and project manager at TNO, who has over 30 years of experience in projects dealing with waste management, CO₂ storage, performing risk assessment in CO₂ storage projects and developing regulations for CO₂ storage. He received his Master's Degree in Earth Sciences at Utrecht University in 1982. In the same year he started a PhD research project which was successfully defended in 1990. He was one of the lead authors of the IPCC Special report on CO₂ Capture and Storage and he facilitated the process of developing the OSPAR Framework for Risk Assessment and Management (FRAM). Ton was also engaged in studies supporting the development of the EU Storage Directive (analysis of storage scenarios and input for guidelines for CO₂ storage) and he advised the North Sea Basin Task Force in the development of guidelines for Monitoring, Verification, Accounting and Reporting of CO₂ storage. He was manager of the finalized EU project CO₂ReMoVe, which developed the technological basis for monitoring and verification of CO₂ storage and provided recommendations for monitoring and verification guidelines. Recently he is engaged in developing practicable approaches for regulatory requirements during the closure and post-closure phases of a storage site and the evaluation of the CCS Directive and CCS enabling policies. Ton has been elected as president of the CO₂GeoNet Association.

Publications

- Nepveu, M., Neele, F., Delprat-Jannaud, F., Akhurst, M., Vincké, O., Volpi, V., Lothe, A., Brunsting, S., Pearce, J., Battani, A., Baroni, A., Garcia, B., Hofstee, C., Wollenweber, J. (2014). CO₂ Storage Feasibility: A Workflow for Site Characterisation. Oil & Gas Science and Technology – Rev. IFP Energies nouvelles, DOI: 10.2516/ogst/2014034
- Wildenborg, T., de Bruin, G., Kronimus A., Neele, F., Wollenweber, J., Chadwick, A. Transferring responsibility of CO₂ storage sites to the competent authority following site closure.). Proceedings of the 12th International Conference on Greenhouse Gas Control Technologies (GHGT-12), Austin, USA, Energy Procedia 63 (2014) 6705 – 6716
- M. Kühn, M. Wipki, S. Durucan, A. Korre, J.-P. Deflandre, H. Boulharts, S. Lüth, P. Frykman, J. Wollenweber, A. Kronimus, A. Chadwick, G. Böhm (2013). Key site abandonment steps in CO₂ storage. Proceedings of the 11th International Conference on Greenhouse Gas Control Technologies (GHGT-11), Kyoto (Japan), Energy Procedia, Volume 37, 2013, Pages 4731-4740

Past experience

TNO is the leading research institute in the Netherlands on CCS with involvement in many international projects for almost two decades, including the coordination of EU research programs for subsurface CO₂ storage in aquifers, gas, oil, and coalbed reservoirs. Recently, TNO has performed national and international contract work for site specific evaluations of CCS projects. TNO has expertise over the entire chain from capture to transport to storage of CO₂ and TNO is the leading organization for the CATO project, the Dutch €80 million national program on CCS with more than 40 partners from industry, academia and research organisations. On an international scale, TNO is

active in the oil and gas industry, e.g. well and pipeline flow assurance, sensor development, basin modelling, geological modelling, seismic interpretations, reservoir engineering, prospect evaluation and production forecasting to portfolio management.

Infrastructure/ major equipment provided to ENOS

Q16 Maas buffer project - More detail is provided in the section ‘Infrastructure proposed by the partners – test sites’

18. Sapienza University of Rome – CERI Research Centre (UniRoma1)

Description of the entity:

With 21 faculties and over 4500 teaching and research staff, Sapienza University of Rome is an internationally recognised centre of excellence for education and cutting edge research. The Fluid Chemistry Group, Department of Earth Sciences, affiliated with the CERI Research Centre on Geological Risks, represents the university in this proposal. It has specialised in near-surface gas and water geochemistry since 1980, using it as a tool in such topics as basic geology (tectonics, fault mapping, volcanic processes), resource exploration (geothermal, oil and gas, mineral), pollution mapping (garbage dumps, gasoline spills), and geological disposal (nuclear, CO₂). Due to the high social relevance of the issues addressed, since 1999 an interdisciplinary collaboration with social science researchers has been started and is now consolidated into a team work approach to science dissemination and public perception issues. With the addition of social scientists to the group, we have worked to take our knowledge and experience beyond the boundaries of the research laboratory, increasing our involvement at societal level, experimenting innovative approaches to science and society dialogue and researching the perception of technological innovation.

Contribution to the Work Plan and expertise brought to ENOS:

UniRoma1 will act in WP3 coordinating the activities for understanding risk of CO₂ migration through faults and boreholes for effective monitoring. Work will be performed at the Sulcis site, an area where we first conducted baseline monitoring in 2009 and where we are presently involved with other Italian research partners in site characterisation work for the proposed CCS pilot. We will be responsible for coordinating a CO₂ injection test at 200 m depth into a fault; we have already performed three shallow (>20m) injection tests in previous EC funded projects, including one at the Latera site during the NASCENT CCS project. Related to the injection test, within WP3, we will: conduct groundwater and near-surface gas geochemistry monitoring using methods proven within the RISCs project; further develop, test, and deploy innovative monitoring tools (GasPro, GasMapper) that we initially studied at lower Technology Readiness Levels in RISCs and CO₂GeoNet; and perform detailed fault analyses and 3D modelling of CO₂ gas movement using industry standard software like Petrel, Move 2011, and Comsol Multiphysics based on our experience in CO₂GeoNet and industry funded projects. In addition we will collaborate with monitoring at the Hontomin (WP1) site.

In WP5 UniRoma1 will lead the work with local populations for the integration of technical, scientific and societal aspects in the definition of guidelines for CO₂ storage implementation and for providing access to CO₂ storage sites' implementation processes to the public at large. UniRoma1 will bring to the project previous experiences in the study of public perception processes related to the geological storage of CO₂ and dissemination and communication activities carried on in several EC-funded projects like CO₂GeoNet, CGS Europe, ECO₂ and R&Dialogue. In particular UniRoma1 will build on the experience with long term group work with members of the lay public performed within the ECO₂ project; the management of complex societal dialogue processes within the R&Dialogue project and on a variety of experiences in developing CO storage communication tools by working with multidisciplinary teams, from CO₂GeoNet brochures to ECO₂ video for the young generation "CCS a bridging technology for the energy of the future" to the lay report on public perception "The geological storage of CO₂: and what do you think?".

As a centre of education excellence, we will be very active in the training activities of WP8, particularly as the task leader on the CCS education programme.

UniRoma1 is involved in

- **WP1.** Ensuring safe storage operations (Task 1.3 Monitoring safe underground storage behaviour)
- all 4 tasks in **WP3.** Managing leakage risks for protection of the environment and groundwater (WP3. Managing leakage risks for protection of the environment and groundwater; Task 3.2 Understanding risk of CO₂ migration through faults and boreholes for effective monitoring (Leader); Task 3.3 Development of monitoring tools; Task 3.4 Integrated monitoring solution)
- all tasks in **WP5.** Coordination with local communities (WP Leader) and task leader for Tasks 5.1 Knowledge development and integration in a societal perspective and 5.2 Work with the local communities
- 2 of the 5 tasks in **WP6.** International Cooperation & seeding pilots and demos in Europe (Task 6.1 International cooperation; Task 6.4 Preparation of follow-up stages for ENOS pilot sites)
- **WP7** Spreading innovation for Research integration and Best practices
- all tasks in **WP8.** Promoting CCS through training and education, and Leader of Task 8.3 CCS educational programme

Staff

Salvatore Lombardi. Professor of Hydrocarbon Geology, as Head of the Fluid Chemistry Laboratory has spent more than 30 years researching many aspects of gas and water distribution - migration in various geological environments, risk monitoring and the study of natural systems. He has acted as project leader and/or partner principle investigator in more than 20 EC-funded projects, as well as managing a large number of national and industry-funded projects.

Sabina Bigi (PhD). Assistant Professor in Structural Geology at the Department of Earth Sciences since 1996. Her main research interest is focused on brittle deformation, consisting of the reconstruction and description of faults and fracture networks, thrust tectonics and the interplay between fluids and faults. From 2006 she has been involved in numerous EC projects, working on the migration of fluids through faults and fractures. She is a Member of the Executive Committee of CO₂GeoNet, the European Network of Excellence.

Samuela Vercelli (MAS). Contract researcher in psychosocial processes related to the communication and implementation of innovative energy technologies. Previous Chair and Member of the Executive Committee of CO₂GeoNet European Network of Excellence, she has been involved, as work package or task leader, in several European projects on CO₂ Geological Storage communication, public perception and wider societal dialogue on energy technology innovation (CO₂GeoNet, RISCS, CGS Europe, SiteChar, ECO₂, R&Dialogue).

Stan Beaubien (PhD). Contract researcher in geochemistry at the Department of Earth Sciences since 1996. He specialises in the study of gas migration in the near surface environment, focussing on the controlling chemical-physical processes and using this information to improve innovative site monitoring technologies. He has been involved in 17 EC-funded projects, 9 of which focused on the geological storage of CO₂ (CCS).

Stefano Graziani (MEng). Contract researcher in electronic engineering at the Department of Earth Sciences since 2004. Specialized in visual guidance of robots emulated on FPGA, software and hardware development for remote control and telemetry, and most recently the development, construction, testing, and deployment of systems for environmental monitoring. Currently engaged in the development of low-cost sensors for the measurement of gaseous and dissolved CO₂ within the framework of several European projects on carbon capture and storage of CO₂.

Publications

- Graziani, S., Beaubien, S.E., Bigi, S., Lombardi, S., 2014. Spatial and Temporal p CO₂ Marine Monitoring Near Panarea Island (Italy) Using Multiple Low-Cost GasPro Sensors. *Environmental Science & Technology* 48, 12126-12133, doi:10.1021/es500666u.
- Beaubien, S.E., Jones, D.G., Gal, F., Barkwith, A.K.A.P., Braibant, G., Baubron, J.C., Ciotoli, G., Graziani, S., Lister, T.R., Lombardi, S., Michel, K., Quattrocchi, F., Strutt, M.H., 2013. Monitoring of near-surface gas geochemistry at the Weyburn, Canada, CO₂-EOR site, 2001-2011. *Int. J. of Greenhouse Gas Control* 16, Supplement 1, S236-S262, doi:10.1016/j.ijggc.2013.01.013.
- Bigi, S., Battaglia, M., Alemanni, A., Lombardi, S., Campana, A., Borisova, E., Loizzo, M., 2013. CO₂ flow through a fractured rock volume: Insights from field data, 3D fractures representation and fluid flow modeling. *Int. J. of Greenhouse Gas Control* 18, 183-199, doi:10.1016/j.ijggc.2013.07.011.
- Vercelli, S., Lombardi, S. 2009. CCS as part of a global cultural development for environmentally sustainable energy production. *Energy Procedia* 1, 4835-4841.
- Ciotoli, G., Etiope, G., Guerra, M., Lombardi, S., Duddridge, G., Grainger, P., 2005. Migration of gas injected into a fault in low-permeability ground. *Quarterly Journal of Engineering Geology and Hydrogeology* 38, 305-320, doi:10.1144/1470-9236/03-058.

Past experience

Since 1989 the Fluid Chemistry Group, Earth Sciences Department at Sapienza University of Rome has been involved in more than 20 European-Community-funded research projects, including 3 as Project Leader. While the earlier projects were concentrated on the geological storage of nuclear waste, more recently our work has focused on CCS research projects (Nascent, Weyburn, CO₂GeoNet, CO₂ReMoVe, MoveCBM, RISCS, CGS Europe, SiteChar, ECO₂) as well as environmental studies in marine (CRIMEA), lacustrine (APELIK), and waste (Intailrisk) systems. Within the CCS projects we have established ourselves as experts in the use of natural, leaking-CO₂ test sites to better understand gas migration pathways, to study CO₂ reaction/dispersion mechanisms, and to develop and test various monitoring technologies (including continuous monitoring stations, and geochemical, geophysical, geological, biological, and remote sensing techniques), to study ecosystem impacts. We have worked extensively on industrial sites to define baseline trends and monitor for leaks. In addition, we have developed expertise in the dissemination of scientific information, research into public perception of CCS and societal dialogue on energy technology innovation issues (CO₂GeoNet, CGS Europe, SiteChar, RISCS, ECO₂ R&Dialogue). UniRoma1 is one of the founding members of CO₂GeoNet and has been highly active in conducting and facilitating joint research and integration through management of the Network's natural test site at Latera, Italy. URS has also been active in the administration of this Network of Excellence, coordinating Spreading of Excellence Activities and continuing in its present form as a scientific Association, by serving on its Executive Committee.

19. University of Nottingham (UNOTT)

Description of the entity:

The University of Nottingham's position as a world-class University is confirmed by its ranking in the global top 100 league table. We were ranked 8th in the UK for research in the 2014 Research Excellence Framework (REF2014), and are ranked in the top 1 per cent of all universities worldwide. We have 2 nobel laureates including Sir Peter Mansfield who pioneered the invention of Magnetic Resonance Imaging (MRI). We maintain leading expertise in advanced imaging techniques through the Peter Mansfield MRI Centre and the Hounsfield X-ray CT Centre. The University also has a strong record in applied geomechanics research for the mining and minerals sector. Over the last 30 years it has produced some 40 PhDs on geomechanics topics.

Contribution to the Work Plan and expertise brought to ENOS:

UNOTT is involved in:

- **WP1.** Ensuring safe storage operations (Task 1.1 Reliable CO₂ injection procedures)
- 2 of the 4 tasks in **WP2.** Ensuring storage capacities and cost-effective site characterisation (Task 2.1 Quantify reliability of storage capacities estimates; Task 2.4 Technical guidelines on storage capacities estimates and cost-effective site characterisation)
- 3 of the 4 tasks in **WP3.** Managing leakage risks for protection of the environment and groundwater (Task 3.1 Groundwater protection: Geochemical monitoring and potential impact of leakage on potable aquifers; Task 3.3 Development of monitoring tools; Task 3.4 Integrated monitoring solution)
- all 3 tasks of **WP5.** Coordination with local communities (Task 5.1 Knowledge development and integration in a societal perspective; Task 5.2 Work with the local communities; Task 5.3 Development of a Public Information Tool for CO₂ storage sites)
- 3 of the 5 tasks in **WP6.** International Cooperation & seeding pilots and demos in Europe (Task 6.1 International cooperation; Task 6.2 European links, liaison and knowledge exchange; Task 6.4 Preparation of follow-up stages for ENOS pilot sites)
- **WP7** Spreading innovation for Research integration and Best practices
- 3 of the 4 tasks in **WP8.** Promoting CCS through training and education (Task 8.2 Building and providing an e-learning course; Task 8.3 CCS educational programme; Task 8.4 Raising awareness by training workshops for journalists and media)
- **WP9** Management as GeoEnergy Test Bed Site Contact

Staff

Dr Matthew Hall is an Associate Professor of Materials Engineering with over 14 years' experience. In 2013 he became Director of the GeoEnergy Research Centre (GERC); a £3M joint initiative between the British Geological Survey and the University of Nottingham. In 2014 he was awarded the Royal Academy of Engineering Senior Research Fellowship in CO₂ storage and alternative hydrocarbons, sponsored by British Geological Survey. He is a Chartered Scientist (CSci), a Chartered Engineer (CEng), a Member of the Institute of Physics (MInstP), and a Fellow of the Institute of Materials, Minerals & Mining (FIMMM), who in 2007 awarded him the prestigious Silver Medal in recognition of "...outstanding contributions and promotion of the field of materials science, engineering and technology at an international level". His research activities focus on porous materials and he has expertise in micro/ macro-structural characterization techniques of porosity and transport properties including X-ray CT, electron microscopy, gas physisorption, Hg porosimetry, thermophysical properties, and numerical modeling. His interests are in transport phenomena including heat and fluid transport, hygrothermal behavior, physisorption, capillarity, permeability, evaporative drying, ion diffusion, and carbonation. His work focusses on cement and concrete, soils, rocks, clays, and zeolites.

Dr Sean Rigby is Associate Professor and Reader at the Chemical & Environmental Engineering Department, University of Nottingham. His specialist fields include characterisation of porous media, transport in porous media, Enhanced Oil Recovery (EOR), MFX imaging and NMR studies of controlled drug release, synthesis and characterisation of highly-ordered porous solids, rock core and porous media characterisation, flow and permeation in porous solids, enhanced oil recovery, catalysis

Publications

- Hall MR, Mooney SJ, Sturrock C, Matelloni P, Rigby SP. Characterisation of multi-scale pore geometry and correlation with moisture storage function and sorptivity in cement-stabilised soils. *Acta Geotechnica* 8 1 67-79 (2012)
- Hall MR, Tsang SCE, Casey SP, Khan MA, Yang H. Synthesis, characterisation and hygrothermal behaviour of mesoporous silica high-performance desiccants for relative humidity buffering in closed environments. *Acta Materialia* 60 89-101 (2012)
- Rigby, S.P., Chigada, P.I., Interpretation of integrated gas sorption and mercury porosimetry studies of adsorption in disordered networks using mean-field DFT, *Adsorption* **2009**, 15, 31-41.
- Shah, A., Fishwick, R., Wood, J., Leeke, G., Rigby, S., Greaves M., A review of novel techniques for heavy oil and bitumen extraction and upgrading, *Energy & Environmental Science* **2010**, 3, 700-714.
- Sanna A, Hall MR, Maroto-Valer M. Recent development towards mineral carbonation costs reduction: Post-processing pathways. *Energy and Environmental Science* 5 7781-96 (2012)

Past experience

Major Research Grants and Contracts

Royal Academy of Engineering, Senior Research Fellowship ‘Rock-Fluid Interactions in Carbon Capture and Storage and Alternative Hydrocarbons’ sponsored by the British Geological Survey (2014 – 2019), PI £415k

EPSRC (EP/M000567/1), Gas Adsorption Analysis Suite (GAAS) – Strategic Equipment Grant, 2014 – 2017, PI £522k, with Co-I Prof M Schröder, Prof S Tendler, Prof R Mokaya, Prof G Walker, Dr SP Rigby, Dr S Yang

Energy Technologies Institute (ETI), ‘Carbon Capture and Storage by Mineralisation: Analysis of UK Opportunities’, May 2010 – Nov 2012, £340k (out of total £1.3m), Co-I in collaboration with M Maroto-Valer and M Clifford (UNOTT), A Zimmerman (Caterpillar), M Styles (British Geological Survey)

EPSRC (EP/E059430/1) 3 Yr, In-situ catalytic upgrading of heavy crude and bitumen: Optimisation of novel CAPRI reactor, July 2007, Prof. M. Greaves (PI), S. Rigby (CI) £298,436. Since Prof. Greaves is emeritus I was lead supervisor to the PDRA and PhD on the project and managed it day-to-day

EPSRC (EP/J008753/1) 3 Yr, Towards Realisation of Untapped Oil Resources via Enhanced THAI-CAPRI Process Using Novel Catalysts, October 2011, S. Rigby (PI) £252,860 (incl. PDRA)

Infrastructure/ major equipment provided to ENOS

GeoEnergy Test Bed (GTB) - More detail is provided in the section ‘Infrastructure proposed by the partners – test sites’

20. The European Network of Excellence on the geological storage of CO₂ (CO₂GEOINET)

Description of the entity:

CO₂GeoNet is a non-profit Scientific Association comprising a large and growing independent group of leading research institutions in the field of CO₂ storage, unmatched anywhere else in the World. CO₂GeoNet is the only integrated scientific community with comprehensive multidisciplinary expertise, focused on CO₂ storage that is independent of political, industrial or societal pressures. With activities encompassing joint research, training, scientific advice, information and communication, CO₂GeoNet has a valuable and independent role to play in enabling the efficient and safe geological storage of CO₂. CO₂GeoNet was created in 2004 as a Network of Excellence under the EC 6th Framework Programme and lasted for 5 years. In 2008, the Network became a non-profit Association under French law in order to continue after the end of the project. The CO₂GeoNet Network of Excellence has recently expanded its membership, and many partners from the now completed CGS Europe project have become. CO₂GeoNet now comprises 26 partners from 19 European countries and involves more than 300 researchers with the multidisciplinary expertise needed to address every facet of CO₂ geological storage

Contribution to the Work Plan and expertise brought to ENOS:

See the details described for each third party

Staff

See the details described for each third party

A summary of staff effort for the third parties under CO₂GeoNet is given below

CO ₂ GeoNet third parties	WP 1	WP2	WP3	WP4	WP5	WP6	WP7	WP 8	WP 9	Total Person/Months per Participant
CO ₂ GEOINET-GBA	0	0	0	0	4	7	3	0	0	14
CO ₂ GEOINET-GEOCOMAR	0	0	3	0	4	6	7	3	0	23
CO ₂ GEOINET-GEOINZ	0	0	0	0	0	1	7	1	0	9
CO ₂ GEOINET-GEUS	0	0	0	0	0	0	3	8	8	19
CO ₂ GEOINET- GSB-RBINS-	0	0	0	24	0	0	1	0	0	25
CO ₂ GEOINET-HWU	4	26	16	0	3	0	1	3	0	53
CO ₂ GEOINET-IGME	20	0	0	0	2	2	3	4	0	32
CO ₂ GEOINET-METU-PAL	0	0	0	6	0	0	1	0	0	7
CO ₂ GEOINET-TTUGI	0	0	0	0	2	6	11	4	0	23
CO ₂ GEOINET-UNIZG-RGNF	0	0	0	0	0	7	1	3	0	11
Total p.m	24	26	19	30	15	29	39	27	8	217

Publications

See the details described for each third party

Past experience

FP6 CO₂GeoNet project (2004-2009) The work programme was structured around three types of activity: Integrating activities, Joint research, and Spreading of excellence. The consortium comprised 13 founding members across 7 European countries.

FP7 CGS Europe project (2010-2013) the "Pan-European coordination action on CO₂ Geological Storage". The objective was to establish a credible, independent, long-lasting and representative pan-European scientific body of expertise on CO₂ geological storage. The consortium comprised 24 Participants, including the entire CO₂GeoNet Association (11 members as third parties) and 23 partners from the existing CO₂NET EAST and ENeRG networks, EuroGeoSurveys, etc. Together, the partners formed a network of 34 institutes specialized in CO₂ storage matters and offering a wide European coverage across 24 EU Member States and 4 Associated Countries.

CO₂GeoNet also has much experience in networking and collaboration with national, European and international bodies, such as the **ZEP** technology platform, the **EERA** CCS Joint Programme, **CCS Demo Project Network**, **GCCSI**, **IEAGHG**, **CSLF**, etc. CO₂GeoNet has responded to consultations and invitations from the EC and Parliament, is a member of the **ISO CCS Technical Committee**, and is a recognized Observer Organisation (Research NGO) at **UNFCCC**.

1. Geological Survey of Austria (CO₂GeoNet-GBA)

Description of the entity:

The Geological Survey of Austria, established in 1849, collects and interprets geoscientific information in Austria, lays the foundation for the sustainable use of the geogenic potential and provides them to the public in a systematic manner. In addition, the Geological Survey of Austria operates a geological information service and acts as a service for the public administration. In that context, the Geological Survey of Austria represents the national interests on the international geoscience, especially at European level.

The department of Applied Geosciences elaborates profound datasets dedicated to the exploration of mineral deposits, groundwater, natural hazards and geothermal energy for Austria. It also participates actively in international research projects, in particular with neighboring countries. Since 2004, the Geoenergy Working group (Geothermal Energy, CO₂-Storage and Hydrocarbon Exploitation) at the department of Applied Geosciences is dedicated to the assessment and visualization of potentials and conflicts associated to the extraction and storage of energy (including heat) at the underground. It operates both on national as well as on international level focusing on national and trans-boundary resources. Since 2013, GBA is a member of the CO₂GeoNet association.

Contribution to the Work Plan and expertise brought to ENOS:

WP6, Task 6.4 (Preparation of follow-up stages for ENOS pilot sites): GBA will contribute to the pilot site LBR-1 based on information and knowledge gained from analogues at the Austrian part of the Vienna Basin.

WP6, Task 6.5 (Roadmap for upscaling identified synergies of CO₂ storage with CO₂ utilisation): GBA will be responsible for all activities concerning the Austrian part of the Vienna Basin including stakeholder interaction.

WP7, Task 7.1 (Research integration): GBA will represent the scientific community of Austria at the knowledge integration workshops

WP7, Task 7.2 (Best practices): GBA will actively contribute to the elaboration and review of the best practice guidance documents

CO₂GeoNet-GBA is involved in:

- 2 of the 5 tasks in **WP6** International Cooperation & seeding pilots and demos in Europe (Task 6.4 Preparation of follow-up stages for ENOS pilot sites; Task 6.5 Roadmap for upscaling identified synergies of CO₂ storage with CO₂ utilisation)

- **WP7** Spreading innovation for Research integration and Best practices

Staff

Gregor GOETZL (Age: 39)

Profession: Geophysicist, MSc

Current position: Team leader of Geoenergy working group at the department of Hydrogeology and Geothermics

Professional experience in the topic of the project: Since 2004, Gregor Goetzl is involved at various national as well as international studies on geothermal utilization. From 2010 until 2013, Gregor Goetzl has also coordinated the activities of GBA at the projects CGS-Europe and CO₂Stop, which have been dealing with aspects of geological CO₂ storage. Currently Gregor Goetzl is extending his scientific portfolio coordinating a national study on the potential of shale gas exploitation in Austria. Gregor Goetzl is experienced in numerical modelling, resource assessment as well as economic analyses in the fields of geothermal utilization and geological CO₂ storage. Furthermore he has several years experience in project management and scientific communication.

Anna Katharina BRUESTLE (Age: 31)

Profession: Geophysicist, MSc.

Current position: Scientific assistens of Geoenergy working group at the department of Hydrogeology and Geothermics

Professional experience in the topic of the project: Since 2006, Anna Katharina Bruestle is involved in various national and international studies on geothermal utilization and has also been participating in the projects CGS-Europe and CO₂Stop, which have been dealing with geological storage of CO₂. The project CGS-Europe offered staff exchange to promote cooperation between partners and to enhance knowledge sharing on the topic, which Anna Katharina Bruestle used to work with the colleagues from the Geological survey of Belgium (RBINS) on CCS potential in Austria. During this side project, the technical, economic and geological data of potential CO₂-storage reservoirs in Austria were collected and used to assess the matched capacity and the development probability for the reservoirs (based on the PSS II Simulator developed by Piessens K. and Welkenhuysen K).

Anna Katharina Bruestle is experienced in data acquisition, data processing and numerical modelling for geothermal problems and problems related to geological storage of CO₂.

Publications

Welkenhuysen, K., Brüstle, A., Bottig, M., Ramirez, A., Swennen, R., & Piessens, K. (in preparation). A techno-economic approach towards capacity assessment and ranking of potential targets for geological storage of CO₂ in Austria.

Past experience (since 2010)

- GeoMol (2012 – 2015): Assessment of subsurface potentials in the northern Alpine Molasse basin (EU, Alpine Space).
- CGS Europe (2010 – 2013)
- Transenergy (2010 – 2013): Transboundary assessment of hydrogeothermal resources at the western Pannonian basin and its surrounding (EU, Central Europe).
- CO₂StoP (2012)
- Solcav (2014-2015): Seasonal storage of excess solar energy in subsurface caverns (Bilateral cooperation Austria – Czech Republic).

2. National Institute for Research and Development of Marine Geology and Geoecology (CO₂GeoNet-GeoEcoMar)

Description of the entity:

National Institute for Research and Development of Marine Geology and Geoecology - GeoEcoMar, established in 1993, represents the focal point of national excellence in research and consultancy on marine, coastal, river and lacustrine geology, geophysics and CO₂ storage. Concerns relating to the CO₂ geological storage began with the affiliation of the institute to ENERG in 2001 and continued with participation in national and international projects related to CCS, culminating in becoming a member of the Global CCS Institute in 2010. GeoEcoMar is also the founder member of CO₂ Club in Romania (2007).

Contribution to the Work Plan and expertise brought to ENOS:

CO₂GeoNet-GeoEcoMar is involved in:

- 3 of the 4 tasks in **WP3** Managing leakage risks for protection of the environment and groundwater (Task 3.2 Understanding risk of CO₂ migration through faults and boreholes for effective monitoring; Task 3.3 Development of monitoring tools; Task 3.4 Integrated monitoring solution)

- **WP5**. Coordination with local communities (Task 5.1 Knowledge development and integration in a societal perspective)

2 of the 5 tasks in **WP6**. International Cooperation & seeding pilots and demos in Europe (Task 6.2 European links, liaison and knowledge exchange; Task 6.3 Supporting new pilot and demonstration opportunities)

- all of the tasks in **WP7** Spreading innovation

2 of the 4 tasks in **WP8**. Promoting CCS through training and education (Task 8.1 Education and training for the European research community; Task 8.2 Building and providing an e-learning course)

Staff

Constantin-Stefan SAVA

- Senior Scientist within INCD GeoEcoMar, PhD in Geological Sciences, Phare expert in geophysics and geodesy, coordinator on behalf of GeoEcoMar in national and international projects related to CCS, Coordinator of the Storage Section of the Feasibility Study for GETICA CCS Demonstrative Project, "Impact of communication"-FENCO-ERA project, CO₂ Net East and EU GeoCapacity - FP6 projects, CGS Europe and CO₂ Stop - project FP 7, The National Program for Carbon Capture and Storage.
- The "Gheorghe Murgoci" award of the Romanian Academy, National representative in the Governmental Group of ETP-ZEP, Current president of ENERG.

Alexandra-Constanța DUDU

- Geophysical engineer, scientist within INCD GeoEcoMar, PhD student in CO₂ geological storage, active participation in national and international projects: "Impact of communication" - FENCO-ERA project, CO₂ Net East and EU GeoCapacity - FP6 projects, CGS Europe and CO₂ Stop - FP 7 projects, The National Program for Carbon Capture and Storage, Feasibility Study for the Demonstrative Project GETICA CCS;
- Teacher at the CGS Europe Spring School on CO₂ geological storage, Award for the best paper written by a young author entitled "Monitoring CO₂ geological storage sites", paper presented within the section "Clean and Efficient Technologies for Energy Production, FOREN 2012, Member of the Romanian Society of Geophysics.

Sorin ANGHEL

- Geophysical engineer, Senior scientist within INCD GeoEcoMar, PhD in Geological Sciences, specialization Near Surface Geophysics, Project management course organized by the Academy of Economic Studies, Active participation as project officer in CCS national and international projects: "Impact of communication" - FENCO-ERA project, CO₂ Net East and EU GeoCapacity - FP6 projects, CGS Europe and CO₂ Stop - FP7 projects, The National Program for Carbon Capture and Storage, Feasibility Study for the Demonstrative Project GETICA CCS;
- Member of Geophysical Society of Romania and Society of Exploration Geophysicists.

Publications

- Dudu A., “Monitoring CO₂ geological storage sites ”, paper presented within the section “Clean and Efficient Technologies for Energy Production (based on coal and other primary sources of energy)”, FOREN 2012, June 21th 12, published in the conference volume.
- Katja Pietzner, Diana Schumann,, Sturle D. Tvedt, Hans Y. Torvatn, Robert Næss, David M. Reiner, Sorin Anghel, Diana Cismaru, Carmencita Constantin, Dancker D. L. Daamen, Alexandra Dudu, Andrea Esken, Vassiliki Gemeni, Loredana Ivan, Nikolaos Koukoulzas, Glenn Kristiansen, Angelos Markos, Emma ter Mors, Oana C. Nihfidov, John Papadimitriou, Irene R. Samoila, Constantin S. Sava, Bart W. Terwel, Claudia E. Tomescu& Fotini Ziogou, Public awareness and perceptions of carbon dioxide capture and storage (CCS): Insights from surveys administered to representative samples in six European countries (Results from over 6000 respondents), INTERNATIONAL JOURNAL OF GREENHOUSE GAS CONTROL, Volume 18, 2013, Pages 256-263, ISSN 1750-5836
- Sava C.S., Carmencita Constantin, S. Anghel, A. Proca, Claudia Tomescu, Alexandra Dudu, Irene Samoila, State of the CCS Activities in Romania, AAPG/SEG/SPE Hedberg Conference - Geological Carbon Sequestration - Prediction and Verification, August 16-19, 2009, Vancouver, BC, Canada.
- Sava C.S., Constantin C., Proca A., Georgescu C., Tomescu C., Dudu A., 2009, Industrial CO₂ Emissions and Storage Possibilities in Romania, Paper presented at CO₂Net Seminar, 1-19 March 2009, Trondheim, Norway.
- Alla Shogenova, Kris Piessens, Jüri Ivask, Kazbulat Shogenov, Roberto Martínez, Kristin M. Flornes, Niels E. Poulsen, Adam Wójcicki, Saulius Sliupa, Ludovít Kucharič, Alexandra Dudu, Sergio Persoglia, Sam Holloway, Bruno Saftic. 2012 “CCS Directive Transposition into National Laws in Europe: Progress and Problems by the End of 2011”, abstract presented at GHGT 11, November 20th 2012, Kyoto, to be published in Energy Procedia 2013

Past experience

- FP 7 CO₂ STOP - Map and assess the capacity of all the possible CO₂ geological storage reservoir formation from Romania in order to be included in an European Storage Atlas.
- EU GEOCAPACITY- Assessing European capacity for geological storage of carbon dioxide. Within this large project, the institute mapped the CO₂ emission sources and CO₂ storage solutions, providing also the first theoretical assessment of the storage capacity of Romania.
- FENCO ERA NET “Scrutinizing the impact of CCS communication on the general and local public.
- Feasibility study (Storage section) for the first CCS Demonstration Project of Romania - GETICA CCS.

3. GEOINŽENIRING d.o.o. Geoinz (CO₂GeoNet-GEOINZ)

Description of the entity:

Geoinženiring, a research SME is engaged in geological engineering and is one of the leading companies of its kind in Slovenia. It was established in 1998 as a limited liability company. Prior to that, it has a noteworthy tradition, which had started in 1946 with its legal predecessors (1946 – 1954 Geological Institute of Slovenia, 1954 – 1991 Geological Institute Ljubljana, 1991 – 1998 Institute for Geology, Geotechnics and Geophysics).

The company's main activities comprise investigations, project designing and consulting in the areas of soil and rock mechanics, engineering geology and engineering geophysics. The co-ordination of these activities allows the firm to provide complete, cost-effective and environmental friendly solutions. The modern measuring and laboratory equipment and extensive data bases enable professional staff to perform wide range of services, such as projects for infrastructure and power plants, geological and environmental hazard, water and mineral resources. GEOINZ has developed a significant knowledge in geo-energy related activities and in particular in CO₂ geological storage and acts as the principal research body in the country.

Contribution to the Work Plan and expertise brought to ENOS:

CO₂GeoNet-GEOINZ is involved in:

- WP6. International Cooperation & seeding pilots and demos in Europe (Task 6.4 Preparation of follow-up stages for ENOS pilot sites)
- all tasks in WP7 Spreading innovation (Task 7.1 Research integration; Task 7.2 Best practices (Task Leader); Task 7.3 Promoting exploitation of ENOS results)
- WP8. Promoting CCS through training and education (Task 8.4 Raising awareness by training workshops for journalists and media)

Staff

Marjeta Car is a senior expert at Geoinženiring. She has more than thirty years of experiences in various applied geophysical fields. Her main expertise related to CCS lies in storage site characterization, capacity estimation, the interpretation of geophysical monitoring datasets and regulatory issues related to geological storage of CO₂. Since 1997 she is the head of Engineering Geophysical Department. She is a national representative in European Network for Research in Geo-Energy (ENeRG) and a member of CO₂GeoNet Association. In 2015 she has been appointed as a national expert in Panel of Experts on CO₂ geological storage at European Federation of Geologists.

Publications

- Car, M., 2009. Reduction of emissions of greenhouse gases by storing CO₂ underground. 1st International Conference Energy Technology and Climate Changes, Velenje, 2009.
- Car, M., 2011. Geological storage of CO₂ – where is Europe? Treaties, Reports, 20th Meeting of Slovenian Geologists, Ljubljana.
- Bavec, M., Car, M., Stopar, R., Jamšek Rupnik, P., Gosar, A., 2012. Geophysical evidence of recent activity of the Idrija fault, Kanomlja, NW Slovenia = Geofizikalni dokazi za recentno aktivnost Idrijskega preloma v dolini Kanomlje. *RMZ - Materials and geoenvironment*, ISSN 1408-7073, Vol. 59, No. 2/3, p. 247-256.
- Delprat-Jannaud, F., Korre, A., Shi, J.Q., McConnell, B., Arvanitis, A., Boavida, D., Car, M., Gastine, M., Grunnaleite, I., Bateman, K., Poulsen, N., Sinayuc, C., Vähäkuopus, T., Vercelli, S. and Wójcicki, A. 2013. State-of-the-art review of CO₂ Storage Site Selection and Characterisation Methods. CGS Europe report No. D3.3, In: Korre, A., McConnell, B. and Delprat-Jannaud, F. (Eds.), September 2013, 116p.
- Korre, A., Delprat-Jannaud, F., Welkenhuysen, K., Piessens, K., Falus, G., Vähäkuopus, T., Poulsen, N., Wickström, L., Alexandra, D., Vincent, C.J., Car, M., Wójcicki, A., Arts, R., Vit, H., Martinez, R., Komatina,

S., Akervoll, I., Brüstle, A.K., Götzl, G., Brikmane, B. and Hatzignatiou, D. 2014. State-of-the-art of directives and regulatory regimes related to operational and safety risks. CGS Europe report No. D3.5. In Korre, A. and Delprat-Jannaud F. (Eds.), February 2014, 125 p.

Past experience

Geoinženiring has actively participated in previous international CCS related projects:

- EU Geocapacity (EU FP6, 2004 – 2006, partner)
- CO₂NET EAST (EU Coordination Action, 2006 – 2009, associated partner)
- CO₂SToP (EU Contract No. ENER/C1/154-2011-SI2.611598, partner)
- CGS Europe (EU FP7, 2010 – 2013, partner)

and acts as a leading knowledge transfer body for geological storage of CO₂ in the country. CO₂ storage, monitoring and verification, utilization of the deep subsurface is of its particular interest.

4. Geological Survey of Denmark and Greenland (CO₂GeoNet-GEUS)

Description of the entity:

Geological Survey of Denmark and Greenland (GEUS), established in 1888, is a research and advisory institute under the Danish Ministry for Environment and Energy. The main mission of GEUS comprises provision of R&D and advisory services for government agencies, local authorities and private enterprises in Denmark as well as internationally. Key scientific areas include: ground water and surface water resources, petroleum resources and subsurface energy storage/disposal, raw materials and minerals resources, geological mapping of Denmark, Greenland and the Faeroe Islands, marine geology, environmental impacts assessment, and physical & electronic data storage for the Kingdom. The activities are organised within five programme areas:

1. Data banks, information technology, and information to the general public; 2. Water resources; 3. Energy resources; 4. Mineral resources and Greenland mapping; 5. Nature and environment.

Current staff is about 333, with some 200 holding academic degrees. Annual turnover is about DKK 338 million (c. 45 million Euro).

Contribution to the Work Plan and expertise brought to ENOS:

GEUS has conducted research pertaining to geological storage of CO₂ since 1993, being one of the European pioneers in this area. GEUS will mainly contribute to the dissemination and innovation development, the preparation of best practices (WP7), international collaboration on training and capacity building, coordination and teaching for spring schools, for development of e-learning and for a European educational programme (WP8).

CO₂GeoNet-GEUS is involved in:

WP7 Spreading innovation for Research integration and Best practices

WP8 Promoting CCS through training and education as WP Leader and in the tasks

- Task 8.1 Education and training for the European research community
- Task 8.2 Building and providing an e-learning course
- Task 8.3 CCS educational programme

WP9 Management as WP Leader in the MB

Staff

Dr. Niels E. Poulsen is senior scientist at GEUS. He holds an MSc and a PhD degree in geology from the University of Copenhagen. For many years he has worked as a scientist with focus on stratigraphy of the latest Triassic to earliest Cretaceous succession and Neogene deposits in Denmark and northern Europe. Niels became part of the CCS team at GEUS in 2008, and has participated in projects such as the COACH (WP3 leader), CO₂ReMoVe, Mapping of the storage potential of CO₂ in the eastern North Sea, Skagerrak, Kattegat and onshore Denmark, CGS Europe and SiteChar projects. He was coordinator for the CO₂StoP project. He participates now in the TOPS project as WP and task leader. Niels is GEUS-representative in the CO₂GeoNet executive committee now serving as Treasurer.

He participated in the COACH capacity building as teacher during two one-week long Schools; one in April 2009 in Hangzhou and the other in October 2009 in Beijing. These two schools working with methodology, policy and safety attracted in total 80 Chinese students and 30 European students at PhD or post doc level. Niels participated in the EAGE EU 2010-11 Student Lecture Tour on CO₂ geological storage teaching at universities in Denmark, Finland and Sweden. He participated in CGS Europe Spring School on CO₂ storage as teacher and task leader.

Publications

- Anthonsen, K.L., Aagaard, P., Bergmo, P.E.S., Erlström, M., Faleide, J.I., Gislason, S.R., Mortensen, G. M. & Snæbjörnsdóttir, S.Ó., 2013: CO₂ storage potential in the Nordic region. *Energy Procedia* 37 5080-5092.
- Poulsen, N.E., Chen, W., Dai, S., Ding, G., Li M., Vincent, C.J., and Zeng R., 2011: Geological assessment for CO₂ storage in the Bohaiwan Basin, East China. GHGT-10. *Energy Procedia* 4: 5990–98.
- Shogenova, A., Piessens, K., Holloway, S., Bentham, M., Martínez, R., Flornes, K.M., Poulsen, N.E., Wójcicki, A., Sliupa, S., Kucharič, L., Dudu, A., Persoglia, S., Hladik, V.m, Saftic, B., Kvassnes, A.m, Shogenov, K., Ivask, J., Suárez, I., Sava, C., Sorin A. and Chikkatur, A., 2014: Implementation of the EU CCS directive in Europe: Results and development in 2013. *Energy Procedia* 63 (2014) 6662 – 6670

Past experience

GEUS has conducted research pertaining to geological storage of CO₂ since 1993, being one of the European pioneers in this area. GEUS has lead or contributed to a number of RTD projects, including; SACS Phases Zero, 1 and 2, GESTCO (project manager), CO₂NET 1 & 2 (initiator and co-ordinator of RTD strategy activity), Weyburn (Canadian CO₂ EOR), CCP (sub-project on aquifer storage) and CO₂Store (coordinator of 4 onshore site-specific activities), CO₂GeoNet, EU GeoCapacity (project manager) (2006-2008), DYNAMIS (2006–2009), CO₂ReMoVe (monitoring and leader of regulatory work), CASTOR (leads activity on geological storage potential assessment) (2004–2009), CO₂SINK (2004–2010), COACH (work package leader) (2006–2009), ECCO (2008–2011), BIGCCS - International CCS Research Centre (2008-16), AQUA DK - EFP07- II (project manager) (2009-2013), CGS Europe (2010-2013), CO₂CARE ((2010-2013), SiteChar (2011-2013), UltimateCO₂ (2011-2014), CO₂StoP (coordinator) (2011-2013), as well as industrial CCS projects with Vattenfall and DONG. National funding for research in geochemical reactions and EOR with CO₂ is currently active, National project financed by the "High Technology Fund "(on-going). In addition GEUS is engaged in projects for the Norwegian Petroleum Directorate, the University of Oslo and GEO/MOGAS (ongoing).

GEUS is actively engaged involved as member in a series of international networks on CCS including: the Executive Committee if CO₂GeoNet Association (European Network of Excellence focussing on geological storage of CO₂), CO₂NET (Network of CCS stakeholders across Europe), president for ENeRG (European Network for Research in Geo-Energy), EERA (European Energy Research Alliance), EuroGeoSurveys (GEUS participate in the Task Force on CO₂) and European Strategic Energy Technology Plan (SET-plan).

5. *Royal Belgian Institute of Natural Sciences (CO₂GeoNet-GSB-RBINS)*

Description of the entity:

The Geological Survey of Belgium (GSB), department of the Royal Belgian Institute of Natural Sciences (RBINS), is a geo-scientific documentation centre and is a central player in national and international research and development projects. The GeoEnergy group of the Geological Survey of Belgium originated with the exploration campaigns for coal in the Flanders and the Walloon region. The expertise was extended with projects including exploration for hydrocarbons, geothermal energy, heat-cold storage, subsoil gasification of coal, storage of natural gas and reutilizing mining infrastructure. From 2000 on, research is performed on the possibilities of geological storage of CO₂ for national and international projects. This includes coordination of the PSS-CCS projects (Policy Support System for Carbon Capture and Storage; Piessens et al., 2009; Piessens et al., 2012), which were the national umbrella projects on CCS in Belgium, and participation in several other international CCS related projects. The GSB is member of the CO₂GeoNet network of excellence, the European Technology Platform for Zero Emission Fossil Fuel Power Plants, the EuroGeoSurveys expert group on CO₂ geological storage, and the European Federation on Geologists expert panel on geological storage of CO₂.

Contribution to the Work Plan and expertise brought to ENOS:

The GSB-RBINS will contribute mainly to WP4, more precisely on task 4.3, where it will use its expertise on geo-techno-economic assessments of projects with a high geological uncertainty to make a detailed assessment of the two detail case studies (buffer and EOR) to determine their economic value, serving as basis for the further evaluation of socio-economic benefits of integrated CO₂ storage projects.

CO₂GeoNet – GSB-RBINS will be involved in:

WP4. Integration of CO₂ storage with local economic activities (Leader of Task 4.3 Evaluation of impacts on the economics)

WP7 Spreading innovation for Research integration and Best practices

Staff

Kris Piessens graduated as a structural geologist in 1996 at the Katholieke Universiteit Leuven (Belgium), where he obtained his PhD in mineralogy and geochemistry in 2001. After obtaining the title of doctor in geosciences, Kris Piessens was offered a position at the Geological Survey of Belgium (Royal Belgian Institute of Natural Sciences) in 2002. He played a central role in the development of the PSS simulator, which is an ad-hoc economic-environmental tool that provides in-depth insights in national and international CCS implementation, including EOR. He feels well at ease wandering of from the beaten tracks of geosciences towards topics such as sink uncertainty, pipeline transport systems, real options economic analysis, raster routing, and Monte-Carlo analysis.

Kris Welkenhuysen obtained his Master in geology in 2006 from the Katholieke University Leuven (Belgium). He started his career at the Geological Survey of Belgium in 2007 in Cenozoic stratigraphy, after which he got involved in the national CCS projects “PSS-CCS”. As part of the GeoEnergy group at the GSB, he took part in several (inter)national projects relating to CO₂ geological storage. Since 2011, he is working on a PhD research on embedding geo-uncertainties in techno-economic CCS simulations and recently CO₂-enhanced oil recovery (CO₂-EOR) was added as a research subject.

Publications

- Welkenhuysen, K., Ramirez, A., Swennen, R. & Piessens, K., 2013. Ranking potential CO₂ storage reservoirs: an exploration priority list for Belgium. International Journal of Greenhouse Gas Control, 17, p. 431-449.
<http://www.sciencedirect.com/science/article/pii/S1750583613002417>
- Welkenhuysen, K., Compennolle, T., Piessens, K., Ramírez, A., Rupert, J. & Swennen, R., 2014. Geological uncertainty and investment risk in CO₂-enhanced oil recovery. Energy Procedia, 63, p. 7878-7883.
<http://www.sciencedirect.com/science/article/pii/S1876610214026381>
- Welkenhuysen, K., 2012. The cost of CO₂ geological storage is more than a number. European Geologist, 33, p.9-13. ISSN 1028-267X
http://www.eurogeologists.de/images/content/efg_magazine/egm33_web_small.pdf
- Nesladek, M., Helsen, S., Piessens, K., Van Passel, S., Gaydardzhiev, S., Kryukova, V., Myngheer, S., Janssens, R., Welkenhuysen, K., Compennolle, T., Mathieu, P. & Duser, M., 2013. Final ACCESS report – Clean Coal Technologies and Carbon Capture and Storage in Kazakhstan: Reflections and ACCESS project results. Myngheer, S., Janssens, R., Welkenhuysen, K. & Compennolle, T. (Eds.), 72p. ISBN 978-90-8913-025-9
- Piessens, K., Welkenhuysen K., Laenen, B., Ferket, H., Nijs, W., Duerinck, J., Cochez, E., Mathieu, Ph., Valentiny, D., Baele, J.-M., Dupont, N. & Hendriks, Ch., 2012. Policy Support System for Carbon Capture and Storage and Collaboration between Belgium-the Netherlands “PSS-CCS”, Final report. Belgian Science Policy Office, Research Programme Science for a Sustainable Development contracts SD/CP/04a,b & SD/CP/803, 335p. http://www.belspo.be/belspo/ssd/science/Reports/PSS-CCS_FinRep_AD.2.pdf

Past experience

Gestco

PSS-CCS projects: PSS-CCS phase I (Belspo, 2005-2007), PSS-CCS phase II (Belspo, 2009-2011), PSS-CCS BeNe (Belspo, 2009-2010)

ACCESS (EU Europe-Aid 2010-2012)

CGS Europe (EU FP7 2010-2013)

CO₂StoP (EU 2012-2013)

6. Institute of Petroleum Engineering, Heriot Watt University (CO₂GeoNet-HWU)

Description of the entity:

The Institute of Petroleum Engineering (IPE) at Heriot-Watt University (HWU) has been ranked as world-leading in the latest U.K. wide research assessment exercise. It is a member of two major joint research institutes of the Edinburgh Research Partnership in Engineering and Mathematics (<http://www.erp.ac.uk>), the Maxwell Institute of Mathematical Sciences and the Edinburgh Collaboration of Subsurface Science and Engineering (ECOSSE). Both are part of the EUR 26M funding initiative of the Scottish Funding Council to foster interdisciplinary research in mathematics and engineering across Edinburgh. IPE is also renowned for its world-leading joint academic-industrial research, which provides the opportunity to leverage the outcomes of the proposed network through new industrial collaboration. In addition, IPE is the largest non-commercial user of industry-leading simulation software and value of the annual software donations provided by companies such as Schlumberger, Computer Modeling Group, Weatherford and others exceeds multiple million pounds each year. The value of these donations is substantial in more than purely financial terms. For example, the IPE has more than 160 concurrent licenses for each of the ECLIPSE, CMG, and VIP reservoir simulators - significantly higher than any other university worldwide - enabling research studies beyond the reach of many oil companies. The IPE further owns several clusters and some 100+ workstations for students.

Contribution to the Work Plan and expertise brought to ENOS:

CO₂GeoNet-HWU is involved in:

- **WP1.** Ensuring safe storage operations (Task 1.1 Reliable CO₂ injection procedures)
- 3 of the 4 tasks in **WP2.** Ensuring storage capacities and cost-effective site characterisation (Task 2.1 Quantify reliability of storage capacities estimates; Task 2.2 Smart Characterization (Task Leader); Task 2.4 Technical guidelines on storage capacities estimates and cost-effective site characterisation)
- 3 of the 4 tasks in **WP3.** Managing leakage risks for protection of the environment and groundwater (Task 3.2 Understanding risk of CO₂ migration through faults and boreholes for effective monitoring; Task 3.3 Development of monitoring tools; Task 3.4 Integrated monitoring solution)
- **WP5.** Coordination with local communities (Task 5.1 Knowledge development and integration in a societal perspective)
- WP7** Spreading innovation for Research integration and Best practices
- 2 of the 4 tasks in **WP8.** Promoting CCS through training and education (Task 8.2 Building and providing an e-learning course; Task 8.3 CCS educational programme)

Staff

Florian Doster is Global Platform for Research Leaders Assistant Professor for Multi-Scale Multi-Phase Flow Modeling in the Institute of Petroleum Engineering at Heriot-Watt University since January 2014. Previously he has been working at the Department of Civil and Environmental Engineering at Princeton University (2011-2013) and the Department of Mathematics at University of Bergen (2011-2013). He received his PhD in 2011 in physics from University of Stuttgart at the Institute of Computational Physics. His research interests include the study of multi-phase flow phenomena in porous media and the proper physical and mathematical description across scales. He has published 13 peer-reviewed journal articles, 1 book and 1 book chapter and one conference proceeding. He has given 7 invited talks and more than 50 contributed oral and poster presentations at international workshops and conferences. He has also organized 1 workshop as well as 4 sessions and mini-symposia at conferences and serves as reviewer for WRR, TiPM, AIChE, CaVS, AdWR, JFM, CompGeo, VZJ.

Ahmed ElSheikh is an Assistant Professor in Predictive modeling and Uncertainty quantification of subsurface reservoirs at the Institute of Petroleum Engineering, Heriot-Watt University. Previously he has been working at the Center for Subsurface Modeling at the University of Texas at Austin (2012-2013) and the Department of Earth Science and Engineering at Imperial College London (2010-2012). He received his PhD in 2007 from McMaster University, Canada. His research interest is focused on uncertainty quantification of CO₂ sequestration models and optimization of CO₂ injection strategies. He has published 25 peer-reviewed journal articles and organized 5 workshops/mini-symposia at international scientific conferences.

Eric Mackay holds the Foundation CMG Chair in Reactive Flow Simulation in the Institute of Petroleum Engineering at Heriot-Watt University, where he has worked since 1990. His research interests include the study of fluid flow in porous media, such as the flow of oil, gas and water in subsurface geological formations. He has over 150 publications related to predicting and managing oilfield scale and to modelling carbon storage. He delivered a keynote presentation at the SPE International Symposium on Oilfield Scale in 2004, was appointed SPE Distinguished Lecturer on the topic of oilfield scale during 2007-2008, and co-delivers an SPE Short Course on Oilfield Scale Management.

Gillian Pickup is an Assistant Professor in the Institute of Petroleum Engineering at Heriot-Watt University. She holds a BSc degree (first class honours) in Astrophysics from the University of Edinburgh and a PhD in Astrophysics, also from University of Edinburgh. She joined Heriot-Watt University in 1990, initially as a Research Associate, then as a Senior Research Associate and a Research Fellow, before becoming a Lecturer in 2010. Gillian's research interests include geological modelling, flow through porous media and upscaling of small-scale effects for use in larger-scale models. In 2009, she was given an award by SPE Aberdeen for contribution to industry. Since 2005, she has been applying skills acquired in reservoir engineering to the problem of CO₂ storage in deep saline aquifers. Over the past few years she has participated in several multi-disciplinary collaborative projects to evaluate CO₂ storage potential for the UK. She has co-authored a number of papers on the numerical simulation of CO₂ storage, including six in the International Journal of Greenhouse Gas Control.

Publications

- Tavakoli, Yoon, Delshad, Elsheikh, Wheeler, Arnold: Comparison of ensemble filtering algorithms and null space Monte Carlo for parameter estimation and uncertainty quantification using CO₂ sequestration data, WRR, 49, 2013
- Petvipusit, Elsheikh, Laforce, King, Blunt: Robust optimisation of CO₂ sequestration strategies under geological uncertainty using adaptive sparse grid surrogates, Comp. Geo., 18, 2014
- Kang, Nordbotten, Doster, Celia: Analytical solutions for two- phase subsurface flow to a leaky fault considering vertical flow effects and fault properties, WRR, 50, 2014
- Doster, Nordbotten & Celia: Impact of capillary hysteresis and trapping on vertically integrated models for CO₂ storage, Adv. in Wat. Res., 62, 465-474, 2013
- Jin, Pickup, Mackay et al: "Static and Dynamic Estimates of CO₂ Storage Capacity in Two Saline Formations in the UK" (2012) SPE J. 17(4), 1108-1118.

Past experience

- Project DE-FOA-0001037 "Multiscale Modeling of CO₂ Migration and Trapping in Fractured Reservoirs with Validation by Model Comparison and Real-Site Applications" Dep. Of Energy, US call Research for Safe and Permanent Geologic Storage of CO₂, 2014-2017 (with Princeton University and Lawrence Berkley National Lab).
- "Reservoir Simulation of CO₂ Injection in the Forties Aquifer", 2013-2015, in collaboration with University of Durham, sponsored by The Crown Estate.
- "Modelling of CO₂-EOR", 2013-2014, sponsored by the Scottish Government, 2Co, Shell and Nexen.

- Energy Technologies Institute UK Storage Appraisal Project (ETI UK SAP) – 2010-2012. Project partners : Senergy Alternative Energy Ltd, BGS, the Scottish Centre for Carbon Storage (University of Edinburgh, Heriot-Watt University), Durham University, GeoPressure Technology Ltd, Geospatial Research Ltd, Imperial College London, RPS Energy and Element Energy Ltd.
- CASSEM – CO₂ Aquifer Storage Site Evaluation and Monitoring, 2008-2010, funded by TSB and EPSRC. Project partners included AMEC, BGS, UoE, HWU, Marathon, Schlumberger, Scottish Power, Scottish and Southern Energy and the Tyndall Centre.

7. Instituto Geológico y Minero de España (CO₂GeoNet-IGME)

Description of the entity:

IGME is the Spanish Geological Survey, recognized as a Public Research Organization. IGME is in charge of the creation and sustainability of the national knowledge infrastructure in Earth Sciences. IGME develops activity in several fields as Geology, Hydrogeology, Mineral Resources, Environmental Geology or Geophysics. IGME staff reaches 375 workers, including over 200 university graduates

Contribution to the Work Plan and expertise brought to ENOS:

IGME will bring to the consortium expertise in induced seismicity studies, coming from previous works related to the Castor Natural Gas Storage studies, and faults natural activity, based on works developed in several active areas of Spain (Lorca and Ossa de Montiel recent earthquakes f.e.) IGME will also provide previous experience acquired in CGS Europe Project and others regarding workshops organization, participation in other networks and will keep on working in the development of new pilot opportunities.

CO₂GeoNet-IGME is involved in:

WP1 Ensuring safe storage operations (Task 1.2 Induced seismicity: monitoring, control and hazard mitigation, and is Leader of the Subtask 1.2.1. Baseline and background of the fault activity)

WP5 Coordination with local communities (Task 5.1 Knowledge development and integration in a societal perspective)

WP6 International Cooperation & seeding pilots and demos in Europe (Task 6.2 European links, liaison and knowledge exchange; Task 6.3 Supporting new pilot and demonstration opportunities)

WP7 Spreading innovation for Research integration and Best practices

WP8 Promoting CCS through training and education (Task 8.4 Raising awareness by training workshops for journalists and media)

Staff

Roberto Martínez is a Mining Engineer graduated at the Polytechnic University of Madrid. Since 2002, first at the Madrid School of Mines and later in the Department of Research in Geological Resources at IGME, he is doing research in Coalbed Methane (CBM) resources and geological storage of CO₂. In this field, he is actively involved in major projects in Spain, such as CENIT CO₂ project. Its activity has been also at a European level through Geocapacity, COMET or CGS Europe Projects. He has developed skills in project coordination, field geology, drilling and logging. At the present moment, he is the Deputy Director of the Department of Research in Geological Resources.

Alicia Arenillas is a Mining Engineer graduated at the Polytechnic University of Madrid. Her expertise is in the field of geological modelling and process simulations and in the last years she has developed deep knowledge about CCS European and National legislation.

José Francisco Mediato M.Sc. in Geology. Fourteen years of experience in basin analysis of Mesozoics, Tertiary and Quaternary deposit. An extensive and well-rounded academic and industry background in geology, seismic interpretation, geochemistry and structural geology with specialization in sequence stratigraphy, reservoir characterization, basin analysis, modelling and sedimentology. The last five years concentrated on the construction of 3D geological and geophysical models for CO₂ storage.

Dr. Raúl Pérez Near twenty years of experience in geology of earthquakes, geomorphology tectonic and palaeoseismology. Currently, leader in a project for the use of thermos-gaseous precursor in earthquake

occurrence. Numerous oral and poster presentations at technical conferences. Also, an experienced technical writer with several publications in geologic journals and reports.

Publications

- Júlio Carneiro, Roberto Martinez, Isabel Suárez, Yassine Zarhloule, Abdelkrim Rimi. **Injection rates and cost estimates for CO₂ storage in the West Mediterranean region.** Environmental Earth Sciences 01/2015
- Alla Shogenova, Kris Piessens, Jüri Ivask, Kazbulat Shogenov, Roberto Martínez, Kristin M. Flornes, Niels E. Poulsen, Adam Wójcicki, Saulius Sliupa, Ludovít Kucharič, Alexandra Dudu, Sergio Persoglia, Sam Holloway, Bruno Saftic. **CCS Directive transposition into national laws in Europe.** Energy Proceedia 01/2013
- Amit Kanudia, Niels Berghout, Dulce Boavida, Machteld van den Broek, Helena Cabal, Júlio Carneiro, Patricia Fortes, Maurizio Gargiulo, João Pedro Gouveia, Maryse Labriet, Yolanda Lechón, Roberto Martinez, Paulo Mesquita, Abdelkrim Rimi, Júlia Seixas, Giancarlo Tosato. **CCS infrastructure development scenarios for the integrated Iberian Peninsula and Morocco energy system.** Energy Proceedia 01/2013
- Suárez, M. A. Zapatero, R. Martínez, M. Marina. **Synthesis of the exploration of formations with a potential for CO₂ storage: Intermediate Depression and Madrid Basin.** Energy Proceedia 02/2009
- R. Martínez, I. Suárez, M. A. Zapatero, B. Saftic, I. Kolenkovic. **The EU Geocapacity Project – Saline aquifers storage capacity in Group South countries.** Energy Proceedia 02/2009

Past experience

IGME has been a very active actor regarding identification and evaluation of CO₂ storage sites in Spain. Briefly, IGME has leaded geological storage work packages in **CENIT CO₂** and **PSE CO₂** Projects, funded by the Spanish Plans of Research. IGME has been a partner in **Geocapacity** Project (6th Framework Programme) and Work Package Leader in **COMET** and **CGS Europe** Projects (7th Framework Programme)

8. Middle East Technical University - Petroleum Research Center (CO₂GeoNet-METU-PAL)

Description of the entity:

Petroleum Research Center (PAL) is established in 1991. Routine fuel quality control analyses are performed in the laboratories of the center for gasoline, diesel, biodiesel, fuel oil, LPG and natural gas. A proficiency testing program in Turkey is also conducted by PAL since 2005. Center is also conducting researches related to oil/gas and geothermal reservoir evaluations, natural gas and carbon dioxide storage.

Contribution to the Work Plan and expertise brought to ENOS:

CO₂GeoNet-METU-PAL is involved in:

- **WP4** Performing Slim-Tube Tests in order to back up the simulation work using reservoir core material and doing a thorough literature survey on the novel concepts for EOR in the US, Canada and Europe
- **WP7** Spreading innovation for Research integration and Best practices

Staff

Dr. Çağlar Sinayuc is an assistant professor in METU Petroleum and Natural Gas Engineering Department. Before joining the department he worked for Imperial College London for more than 3 years. He has contributed to the short term modelling studies performed for EU FP 6 CO₂ReMoVe Project. He has performed the modelling studies of Insalah, Snohvit and Sleipner CO₂ storage fields. He is specialized in CO₂ flow modelling, geomechanical effects of CO₂ injection and enhanced CBM recovery. Geothermal reservoir evaluations, natural gas hydrate production technologies and hydraulic fracturing of shale gas reservoirs are the topics of the studies he is currently working and supervising.

Dr. Ender Okandan, has a BSc degree from METU and MSc and PhD with a minor in Chemical Engineering from Stanford University all on Petroleum Engineering. She is an academic member of the Petroleum and Natural Gas Engineering Department and specialises in oil/gas and geothermal reservoir engineering and enhanced oil recovery. She was the leader of the CO₂ storage capacity project in Turkey. She is also the country coordinator of EU FP 7 project, CGS Europe 256725.

Dr. Mahmut Parlaktuna is a Professor and senior expert at Petroleum Research Center - PAL. His expertise is on petroleum, natural gas and geothermal reservoir engineering as well as natural gas hydrates. He was project coordinator or researcher on numerous projects concerning reservoir engineering. Recently, he participated in a CCS project aiming as an EOR application in Turkey.

Publications

- Ors, O. and Sinayuc, C. An experimental study on the CO₂-CH₄ swap process between gaseous CO₂ and CH₄ hydrate in porous media, Journal of Petroleum Science and Engineering 119 (2014) 156-162.
- Shi, Ji-Quan, Sinayuc, C., Durucan, S., Korre, A. Assessment of carbon dioxide plume behavior within the storage reservoir and the lower caprock around the KB-502 injection well at In Salah. International Journal of Greenhouse Gas Control 7 (2012) 115-126.
- Okandan, E. et al. Assessment of CO₂ storage potential in Turkey, modeling and a prefeasibility study for injection into an oil field. Energy Procedia 4 (2011) 4849-4856.
- Sinayuc, C., Shi, Ji-Quan, Imrie C. E., Syed, A., Korre, A., Durucan, S. Implementation of horizontal well CBM/ECBM technology and the assessment of effective CO₂ storage capacity in a Scottish coalfield. Energy Procedia 4 (2011) 2150-2156.
- Dalkhaa, C., Okandan, E. Sayindere cap rock integrity during possible CO₂ sequestration in Turkey. Energy Procedia 4 (2011) 5350-5357.

Past experience

International Projects

- CGS Europe "Pan-European coordination action on CO₂ Geological Storage" funded within the 7th Framework Programme of the European Community for research.
- Contracted research: "Matin Oil Field: Reservoir Analysis" performed for Matin JV Kazakhstan. The aim was to conduct a reservoir engineering study and predict the effect of water flooding in Matin Oil Field.

National Projects

- TUBITAK KAMAG project completed in 2009, supported by Technological Research Council of Turkey (TUBITAK), which is carried out by METU PAL and Turkish Petroleum Cooperation (TPAO). The project focused on the determination of the amount of CO₂ emissions from industrial facilities such as thermal power plants, steel industry, cement factories and refineries in Turkey, selection of potential storage sites, modeling of storage in a chosen oil field and economical feasibility of transportation of CO₂ to the storage site.
- Kuzey Marmara Natural Gas Storage Field – Cushion Gas Analysis was performed for Turkish Petroleum Company aiming to review the gas reserves and determination of cushion gas required for the field.
- Evaluation of Kizildere Geothermal Field for Zorlu Enerji Project is performed to assess the heat capacity of the field.

9. Tallinna Tehnikaülikooli Geoloogia Instituut - Institute of Geology at Tallinn University of Technology (CO₂GeoNet-TTUGI)

Description of the entity:

Institute of Geology at Tallinn University of Technology (TTUGI) is a research and education institution. The **Institute of Geology** (former institute of the Estonian Academy of Sciences) is an independent research, development and teaching institution of the university. TTUGI is a pioneer in CO₂ storage research and education institution in Estonia, providing academic CO₂ storage course to international students. TTUGI participated in EU FP and EC projects (EU GeoCapacity, CO₂NetEAST, CGS Europe and CO₂Stop), made research and provides regular consultations to major national energy company Eesti Energia and to the Ministry of the Environment of Estonia. The main areas of expertise are EU CCS Legislation; CO₂ storage capacity, 3D geological, geochemical, petrophysical and geophysical modelling in the Baltic Sea Region, included in our publications and PhD research of Kazbulat Shogenov. TTUGI is a CO₂GeoNet member since 2014.

Contribution to the Work Plan and expertise brought to ENOS:

TTUGI will contribute to four work packages (WP5-WP8) through:

Knowledge development for local population in WP5 and its integration with knowledge dissemination in WP7

International cooperation and knowledge exchange with recently created Baltic CCS network

through organisation of common workshops with ENOS project in WP6,

Supporting a study focusing on pilot/demonstration project opportunities across Europe by planned and proposed national and regional projects in the Baltic Sea Region especially from countries not participating in ENOS (Finland, Latvia, Lithuania, Poland and Sweden)

Reviewing the follow-up stages of one of the ENOS pilot sites in WP6.4

Spreading innovation in all tasks of WP7, and being responsible for promoting ENOS results through annual ENOS Newsletter, being responsible for the Newsletter technical editing, production and printing in WP7.2.3

ENOS training and education activities within creating a program and lectures for e-learning course in WP 8.2 and teaching of ENOS students in a frame of CCS education programme in WP 8.4

CO₂GeoNet-TTUGI is involved in:

- **WP5** Coordination with local communities (Task 5.1 Knowledge development and integration in a societal perspective)
- 3 of the 5 tasks in **WP6** International Cooperation & seeding pilots and demos in Europe (Task 6.2 European links, liaison and knowledge exchange; Task 6.3 Supporting new pilot and demonstration opportunities; Task 6.4 Preparation of follow-up stages for ENOS pilot sites)
- all tasks in **WP7** Spreading innovation
- 2 of the 4 tasks in **WP8** Promoting CCS through training and education (Task 8.2 Building and providing an e-learning course; Task 8.3 CCS educational programme)

Staff

Dr. Alla Shogenova is a Senior Researcher in the Institute of Geology at Tallinn University of Technology, where she is working since 1989. She is PhD in Geology and Mineralogy since 1992. She was a Visiting Professor in CO₂ Geological Storage at Faculty of Geology, University of Warsaw supported by EU Project Modern University in 2013. From 1994 she is a leader of a number of Estonian and International research projects. A. Shogenova is an author and co-author of about 160 scientific publications including 30 publications and 12 reports in the field of CCS. She has wide research interests in the field of sedimentary geology including rock physics, petrophysics, geochemistry, mineralogy, oil-shale and phosphorite deposits and CO₂ geological storage. She was a leader of Estonian group in the projects FP6 EU GEOCAPACITY and CO₂NetEast, FP7 CGS Europe and CO₂Stop, and since 2007 she is raising public awareness in CCS through CO₂NetEast websites in Estonian and Russian languages. Being a member of the Taskforce Technology in the European Technology Platform for Zero Emission Fossil Fuel Power Plants (ZEP) and member of Scientific Advisory Board of CO₂GeoNet, a member of CO₂NET in 2006-2009 she was also an adviser in CCS for national legal authorities and energy companies in Estonia and Baltic Region since 2008. Dr. Shogenova was a president of the ENeRG (European Network for Research in GeoEnergy) in 2007 and represents Estonia in the ENeRG since 2004. Dr. Shogenova is a supervisor of the Ph.D. research and lecturer for M.S. and Ph.D. students in the field of CCS and CGS, petrophysics and geophysics. Shogenova was an organiser of six CGS Europe project Knowledge Sharing workshops. She cooperated with ICFI in the DG CLIMA contract "Implementation of Directive 2009/31/EC on the geological storage of carbon dioxide (CCS Directive) - support to the implementation report" on behalf of CO₂GeoNet.

Kazbulat Shogenov is a researcher in the Institute of Geology at Tallinn University of Technology, where he is working from 2003. In the 2008 he was graduated from Tallinn University of Technology as a Master of Science in Engineering with Master Thesis in Petrophysics. From 2009 he is a PhD student at TUT, Faculty of Science, in the field of Earth Sciences. His PhD research "Petrophysical models of CO₂ plume at the prospective storage sites in the Baltic Region" is planned for defence in June 2015. In 2012-2013 he was a researcher in OGS, Italy funded by Marie Curie Research Training Networks (EU FP7) - Quantitative Estimation of Earth's Seismic Sources and Structure – QUEST, making research on Seismic numerical modeling to monitor CO₂ storage in the Baltic Sea offshore structure.

K. Shogenov was a participant of the funded by EC FP6 projects EU GEOCAPACITY and CO₂NetEast and FP7 CGS Europe project and EC project CO₂ Stop. He is an author and co-author of number of scientific publications including 10 publications in the field of CO₂ capture and storage indexed by Thomson Reuters WOS. He has multidisciplinary research interests in CO₂ geological storage, rock physics, petrophysics, logging, geophysics, geochemistry and mineralogy, seismic modelling, 3D and 4D Geological modelling, GIS databases, websites design and management. He was/is a technical manager of the ENeRG website in 2008-2011 and of the GeoENeRGY newsletter in 2012-2015.

Jüri Ivask is a researcher in the Institute of Geology at Tallinn University of Technology, where he is working since 1988. He is a participant of several Estonian and International research projects in the field of Geosciences. Dr. Ivask has multidisciplinary research interests in the field of environmental geology including palaeoclimatology, geochemistry; chromatography including other related analytical methods and also CO₂ geological storage. He participated in EC FP6 CO₂NetEast and FP7 CGS Europe Project. He is a manager of the Estonian www site (www.gi.ee/co2net-east). He is also participating in the projects advising industrial companies (e.g. Eesti Energia - www.energia.ee) in the field of CO₂ geological storage (CGS). As a coauthor of the ordered by Eesti Energia research „CO₂ geological storage in Estonia and neighboring regions: analysis of options and storage recommendations" he presented its results on 12.10.2009 at the headquarters of Eesti Energia (www.energia.ee). Dr. Ivask has been an expert in CCS (CO₂ capture and storage) terminology to Ministry of Environment of the Estonian Republic. Dr. Ivask is an author of the Estonian version of the CO₂GeoNet brochure "What does CO₂ geological storage really mean?". He made number of presentations in Estonian to geoscientists and general public and gave several interviews to Estonian Press media about CCS in the Baltic Region. He is a co-author of number

of scientific publications on CCS in Estonian and English. He is also an Estonian representative in the Joint Committee of Antarctic Data Management. Dr. Ivask was graduated from the Tartu University in the field of analytical chemistry and has a PhD. degree in chemistry.

Publications

- Shogenova, A., Piessens, K., Holloway, S., Bentham, M., Martínez, R., Flornes, K.M., Poulsen, N.E., Wójcicki, A., Sliupa, S., Kucharič, L., Dudu, A., Persoglia, S., Hladik, V., Saftic, B., Kvassnes, A., Shogenov, K., Ivask, J., Suárez, I., Sava, C., Sorin, A., Chikkatur, A. 2014. Implementation of the EU CCS Directive in Europe: results and development in 2013 . Elsevier, The Netherlands. *Energy Procedia* 63, 6662-6670. | [DOI](#) |
- Shogenov, K., Shogenova, A., Vizika-Kavvadias, O. 2013. Petrophysical properties and capacity of prospective for CO₂ geological storage Baltic offshore and onshore structures . Elsevier. *Energy Procedia* 37, 5036-5045. | [DOI](#) |
- Shogenova, A., Piessens, K., Ivask, J., Shogenov, K., Martínez, R., Suárez, I., Flornes, K.M., Poulsen, N.E., Wójcicki, A., Sliupa, S., Kucharic, L., Dudu A., Persoglia, S., Holloway S. and Saftic, B. 2013. CCS Directive transposition into national laws in Europe: progress and problems by the end of 2011. Elsevier. *Energy Procedia* 37, 7723-7731. | [DOI](#) |
- Shogenova, A., Shogenov, K., Pomeranceva, R., Nulle, I., Neele, F. and Hendriks, C. 2011. Economic modelling of the capture–transport–sink scenario of industrial CO₂ emissions: the Estonian–Latvian cross-border case study. Elsevier, The Netherlands. *Energy Procedia* 4, 2385-2392. | [DOI](#) |
- Shogenova, A., Sliupa, S., Vaher, R., Shogenov, K., Pomeranceva, R. 2009. The Baltic Basin: structure, properties of reservoir rocks and capacity for geological storage of CO₂. Estonian Academy Publishers, Tallinn . *Estonian Journal of Earth Sciences* 58(4), 259-267. | [DOI](#) |

Past experience

1. FP 6 Projects EUGeoCapacity and CO₂NetEast. CO₂NetEast CCS Technology website is working since 2007 in 2 languages: Estonian and Russian, including English-Estonian and English-Russian CCS Dictionary and Glossary .
2. Advising to the Ministry of Environment of Estonia and national energy company Eesti Energia in the field of CCS
3. CO₂GeoNet brochure “What does CO₂ geological storage really mean?” was translated into Estonian and Russian and six Knowledge Sharing workshops were organised and reported to EC during FP7 CGS Europe Project.
4. CO₂ Geological Storage full term course was created and lectured to international students from 9 countries in Tallinn University of Technology in 2012 and in the University of Warsaw supported by EU Project Modern University in 2013.
5. Cooperation with ICFI in the DG CLIMA contract "Implementation of Directive 2009/31/EC on the geological storage of carbon dioxide (CCS Directive) - support to the implementation report" on behalf of CO₂GeoNet.

10. Sveučiliste u Zagrebu Rudarsko Geolosko Naftni Fakultet - University of Zagreb, Faculty of Mining, Geology and Petroleum Engineering (CO₂GeoNet - UNIZG-RGNF)

Description of the entity:

The Faculty is a part of the University of Zagreb and consists of several institutes – Mining Engineering, Geology, Geological Engineering and Petroleum Engineering. There are altogether 54 professors, 30 assistants and 26 other teaching collaborators. Apart from the primary activity in high education, they are usually engaged both in exploration and research activities and in various expert tasks.

This research covers a wide range of activities. Relevant to the ENOS project proposal are geology (subsurface geological mapping, petroleum geology, hydrogeology, geophysical prospecting) and petroleum engineering (drilling techniques, well fluids, reservoir development, production of HC's and geothermal water, gas management, safety techniques and protection of environment).

Contribution to the Work Plan and expertise brought to ENOS:

Being representatives of a university, all project participants will work in **WP6** where a study focusing on pilot/demonstration project opportunities across Europe will be prepared based on the results of ENOS pilots (Task 6.3 leader - Deliverable 6.6). In **WP7** there is a planned participation in the knowledge integration workshops and in contribution where appropriate to writing the best practices and guidelines for particular target groups in order to streamline the development of storage projects. Other concentration of involvement is going to be in **WP8** and that means taking part in spring schools & lecture tours, building an e-learning course, and particularly in preparation of a CCS education program, i.e. in making a curriculum of Master and post-graduate Master programs. Specific advantages are twofold. Our faculty has already implemented more than average number of e-courses compared to the Zagreb university level and further developments will give us additional experience before the starting of the ENOS project. Our faculty also has a limited experience in the international joint study programs (Joint PhD Study "Geo-engineering and Water Management" with TU Graz and other partners) and there is a formal procedure to make similar projects with the help of the International relations office of the university.

CO₂GeoNet-UNIZG-RGNF is involved in:

- **WP6** International Cooperation & seeding pilots and demos in Europe, leader of Task 6.3 Supporting new pilot and demonstration opportunities
- **WP7** Spreading innovation for Research integration and Best practices
- 2 of the 4 tasks in **WP8** Promoting CCS through training and education (Task 8.2 Building and providing an e-learning course; Task 8.3 CCS educational programme)

Staff

Domagoj Vulin (domagoj.vulin@rgn.hr), Assist. Prof. Petrol. Eng., Graduated petroleum engineer and specialized in reservoir engineering, he has defended the PhD Thesis "Modeling Thermodynamic and Petrophysical Parameters for Geological Storage of Carbon Dioxide" in 2010 and continued to study the sensisivity of parameters that are affecting petrophysical and thermodynamic properties related to CO₂ storage. He has been employed at the Faculty on scientific project sponsored by Croatian Ministry of Science, Education and Sports which was related to CO₂ Enhanced Oil Recovery. His fields of research are hydrocarbon thermodynamics (pVT), petrophysical modeling and reservoir characterization/simulation.

Bruno Saftić (bruno.saftic@rgn.hr), Assoc. Prof., Petrol. Geol., specialized in Geology of mineral resources and applied geophysics. After graduation in 1989 he is affiliated with the Faculty of Mining, Geology and Petroleum Engineering. He teaches various courses in the fields of petroleum geology, coal geology, seismic stratigraphy etc. In 1998 he defended PhD Thesis "Genetic Stratigraphic Sequence Analysis of the Pontian Sediments in the Western part of the Sava Basin". His research is in various field of petroleum geology, firstly mainly in the well log stratigraphy and subsurface mapping and later in regional analysis of the Neogene Pannonian basin system. Since 2005 he is involved in exploration of the regional CO₂ storage potential initiated by participation in several FP [653718 – ENOS – PART B - 108]

projects (CASTOR, EUGeoCapacity, CO₂NetEAST, ECCO, CGS Europe). He organized two national projects related to geological storage of CO₂, mentored or co-mentored 2 PhD Theses in the field (by D. Vulin and I. Kolenković), and also supervised altogether 5 undergraduate theses and 2 graduate theses with CO₂ geological storage exploration subjects at various geological study programs.

Iva Kolenković Močilac (iva.kolenkovic@rgn.hr), BSc Geol. (Hydrogeology), during the post-graduate study specialised in Petroleum geology, and defended in 2012 the PhD Thesis “Potential for Geological Storage of Carbon Dioxide in Upper Miocene Sandstones of the Western Part of Sava Depression”.

Željka Kurelec (zeljka.kurelec@rgn.hr), MA in English, affiliated with the Faculty in capacity of Chief administrator at the Office for postgraduate studies and international cooperation. Acting as the ENeRG secretary since October 2008, and also as the secretary of the CGS Europe FP7 project from 2010 to 2013, she is in charge of all the administration related to EU and other international projects.

Publications

- Vulin, D. (2010): Modeling Thermodynamic and Petrophysical Parameters for Geological Storage of Carbon Dioxide. PhD Thesis, University of Zagreb, Faculty of Mining, Geology and Petroleum Engineering, 138 p.
- Kolenković, I. (2012): Potential for Geological Storage of Carbon Dioxide in Upper Miocene Sandstones of the Western Part of Sava Depression. PhD Thesis, University of Zagreb, Faculty of Mining, Geology and Petroleum Engineering, 151 p.
- Saftić, B., Martinez, R., Donda, F., Car, M., Zapatero, M. A., Suarez, I., Vellico, M., Persoglia, S., Kolenković, I., Vulin, D. (2008): Geological Storage Options in Peri-Mediterranean Countries - Plans for Case Studies. First EAGE CO₂ Geological Storage Workshop - Extended Abstracts / Torp, Tore A. (ur.). Houten : European Association of Geoscientists and Engineers, 13-17.
- Vulin, D., Kurevija, T. & Kolenković, I. (2012): The effect of mechanical rock properties on CO₂ storage capacity. *Energy*, 45/1, 512-518.
- Kolenković, I. Saftić, B. & Perešin, D. (2013): Regional capacity estimates in deep saline aquifers – Upper Miocene sandstones in the SW part of Pannonian basin. *International Journal of Greenhouse Gas Control*, 16, 180-186.

Past experience

Faculty pioneered the CGS-related research in Croatia. As a research institution it is country representative in ENeRG (informal organisation – European Network for Research in Geo-Energy) and in CO₂GeoNet since 2013. Our researchers gained international experience in the two research projects: FP6 EUGeoCapacity (STREP) and FP7 ECCO (IP). The main activities included mapping of the regional CO₂ storage potential in various types of sinks, and mainly in transferring the Croatian experience in on-shore CO₂ injection pilot project.

In the coordinated actions FP6 CO₂NetEAST and FP7 CGSEurope, the Faculty has promoted the dissemination of the CCS-related research and knowledge in Croatia and other EE countries.

Infrastructure proposed by the partners - test sites

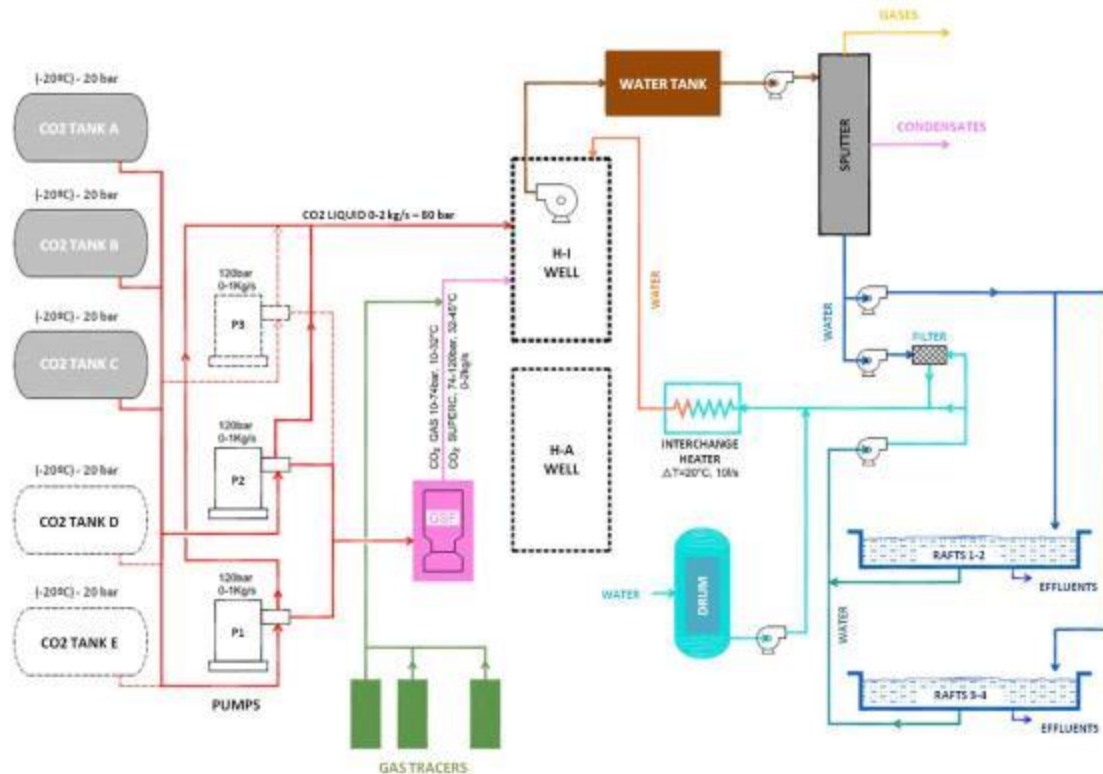
Hontomin, Spain (CIUDEN)



The Hontomín Technology Development Plant is located in Northern Spain, 30 km from the city of Burgos. The site includes one injection well and a monitoring well, both of them located at a depth close to 1580m. Both deep wells are fully instrumented and further monitoring capacities include a shallower hydrogeological monitoring network, and a set of surface tools, such as 30 microseismic stations. The carbonate reservoir forms a dome-like structure, with the presence of faults and fractures, making R&I activities on CO₂ storage easier when compared to ideal huge reservoirs. The Hontomin site offers high flexibility of CO₂ injection conditions being prepared for CO₂ injection in the liquid, gas and supercritical phases and thus is ideal for experimentation of different injection strategies. Its CO₂ injection plant counts on three cryogenic injection pumps allowing injection rates between 0,5 and 2 kg/s and pressures over 80 bar and three cryogenic CO₂ tanks of 50 ton capacity. The installation is complete with a gasifier to adjust the CO₂ temperature and a water injection plant, which plays a crucial role in the pressure control during injection and other operative phases. The water injection plant includes two ceramic plunger pumps capable of up to 125 bar pressure and 300 l/min flow injection each one, a 25 000 l capacity deposit for water mixture preparations and four 2500 m³ deposits for water storage besides the necessary water treatment equipment. The 1570 m deep injection and the monitoring wells are equipped with instrumentation ensuring the continuous monitoring of injection parameters, such as the U-tube deep fluid sampling system, ERT electrodes, DTS, P/T sensors or hydrophones, and a wide range of surface monitoring techniques that are being applied at the site for the controlling and monitoring of the injected CO₂ behaviour. This facility is owned by Ciuden, and its characterization, design and construction was part of the EEPR-funded OXY-CFB-300 Compostilla Project.

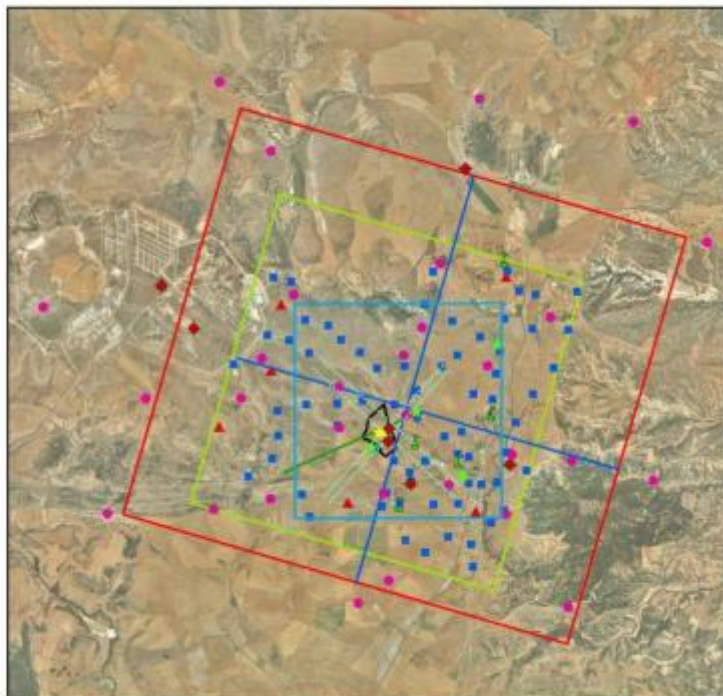
Extensive site characterisation – structural and baseline studies - of the Hontomin site occurred from 2009-2012. A 3-D geological characterization of the site suggests a complex fractured carbonate reservoir with permeability appearing to be lower than originally expected. Extensive hydraulic characterization tests have been performed in 2014 in order to refine CO₂ injection strategies, which will take place in the coming months.

Public engagement activities, including an educational programme on CCS, are being performed since early in the project at both the capture and storage areas, in close collaboration with local councils and promoting interaction with local communities.

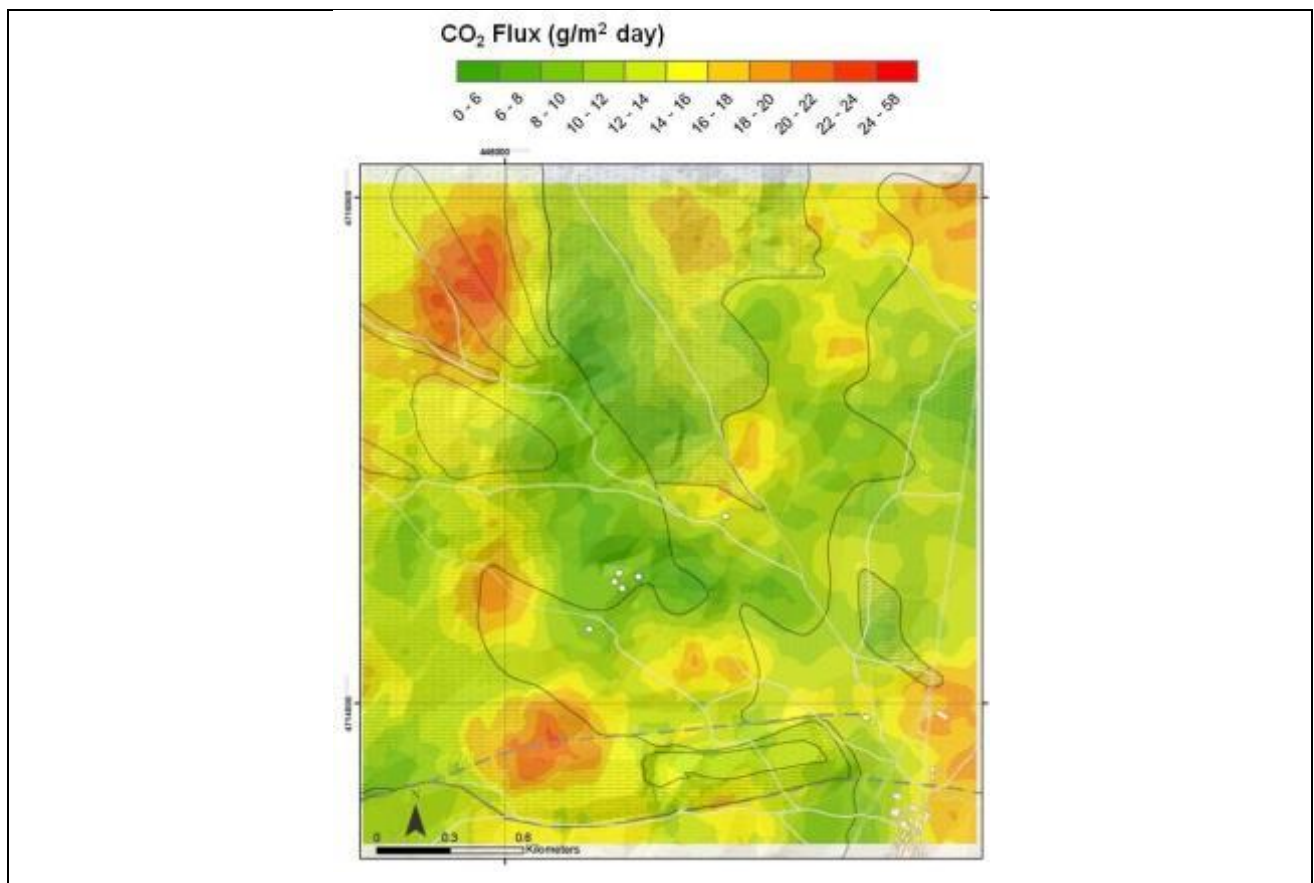
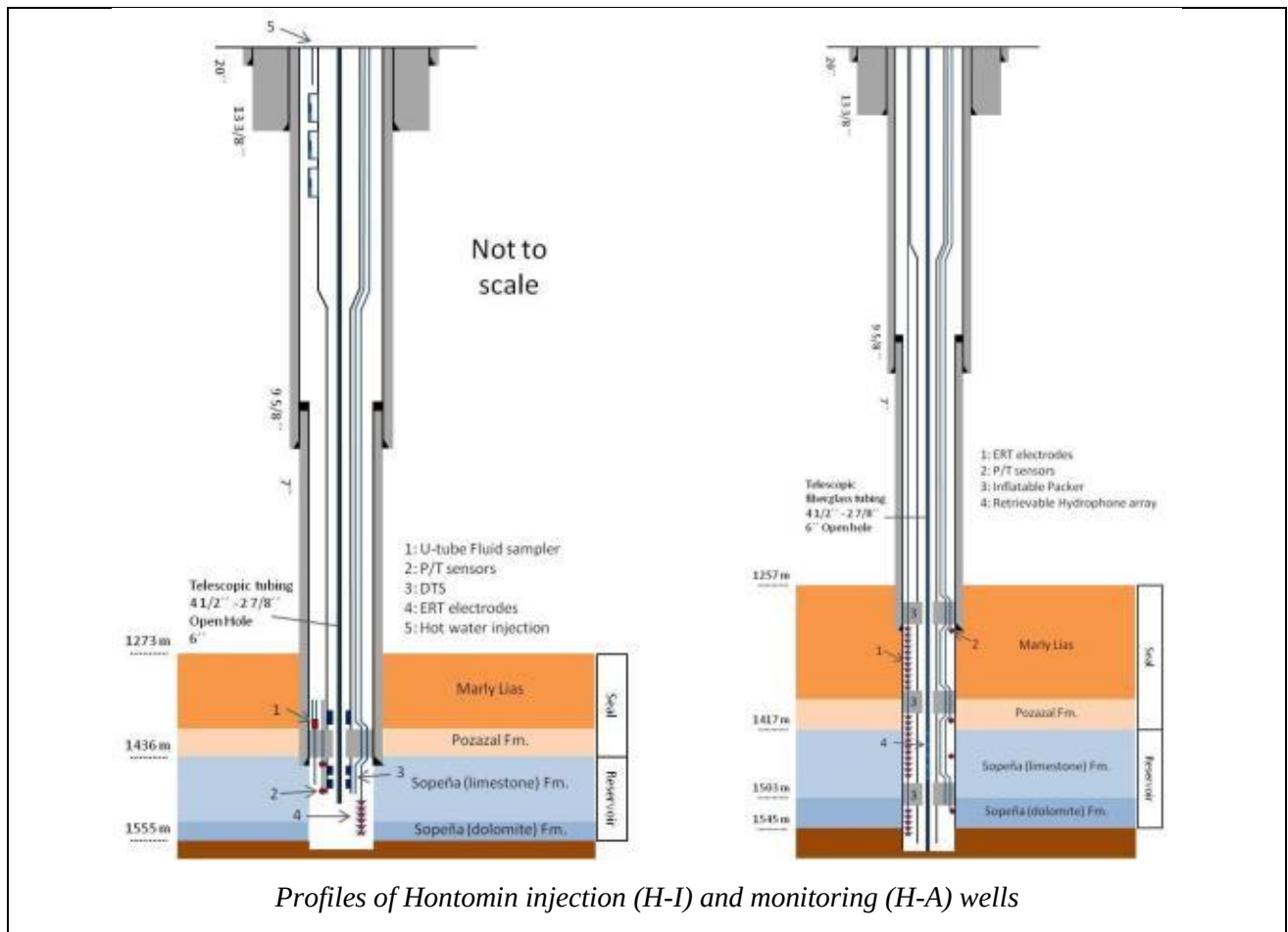


Process diagram of Hontomin TDP. Pressure, temperature and flowrate values included.

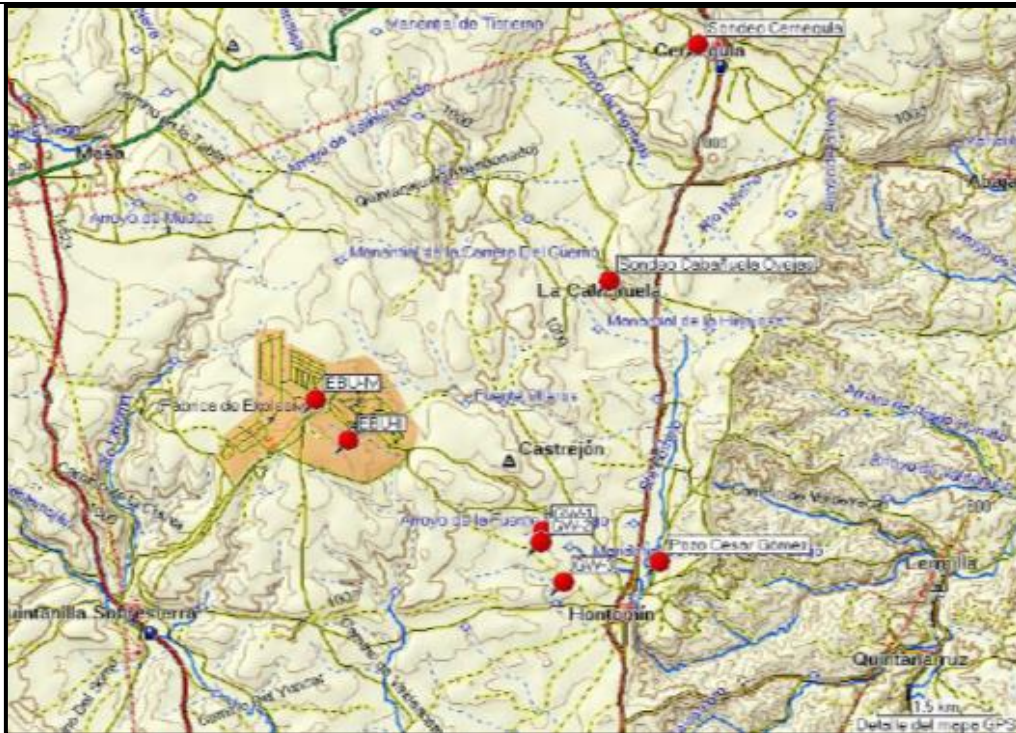
- Key**
- Hontomin TDP
 - Hontomin TDP Wells (H: 1, A)
 - Preexisting Wells (H: 1, 2, 3, 4)
- Monitoring Techniques**
- Seismics**
 - Microseismic Station
 - 2D-3C Seismic
 - 3D Seismics limits
 - Seismovle
 - Microgravimetry**
 - Gravimetry bases
 - Controlpoints
 - Microgravimetry limits
 - Electromagnetics**
 - Electromagnetics
 - Hydrogeology**
 - Hydrogeological Wells
 - Surface**
 - CO2 flux measurement limits
 - Surface water sampling



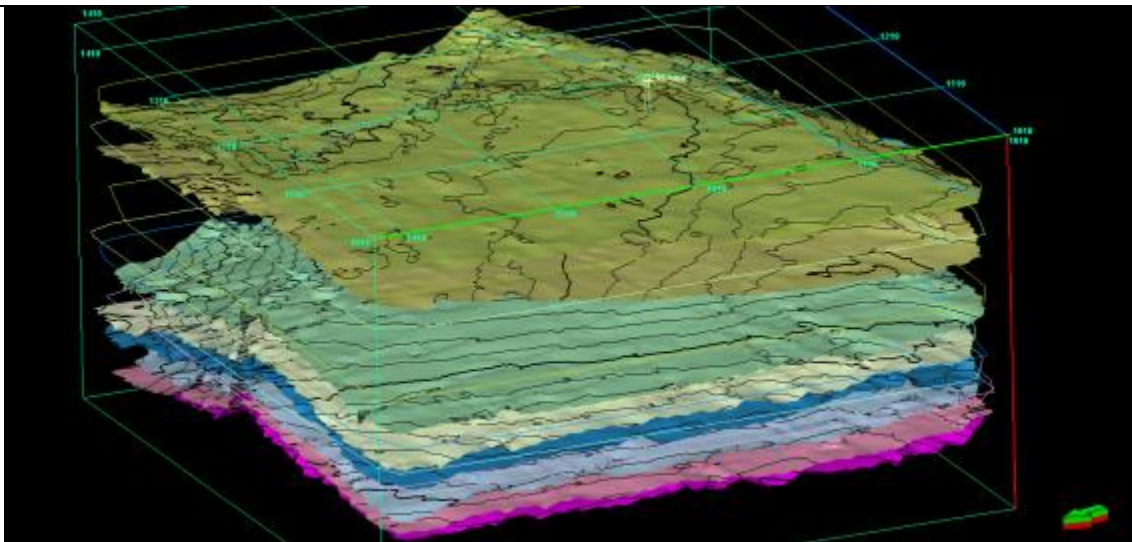
Map including the location of Hontomin TDP and the existing monitoring techniques that have been deployed during the characterization phase. Microseismic and hydrogeology monitoring points will also be included in ENOS



Baseline natural CO₂ flux map at Hontomin



Map including the location of the shallow hydrogeology monitoring points (red dots) at Hontomin



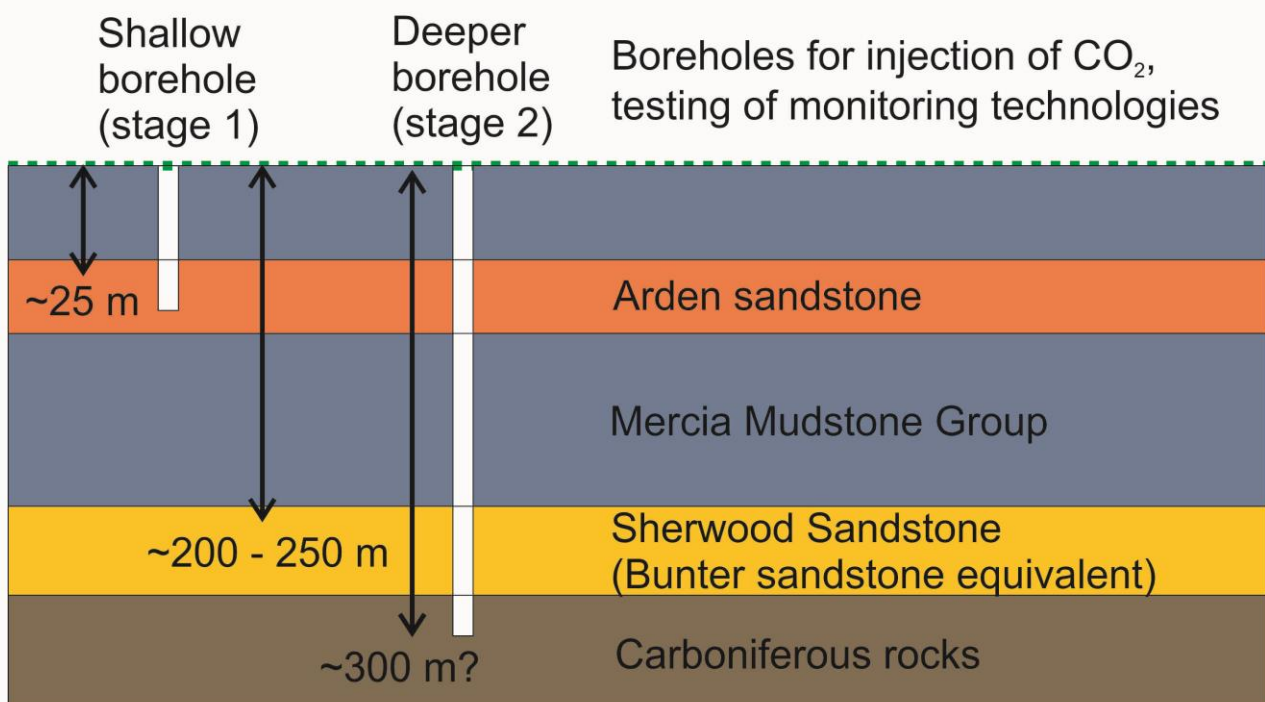
Sketch from 3D Geological model at Hontomin

GeoEnergy Test Bed, UK (BGS and UNOTT)

BGS and the University of Nottingham are working together on the GeoEnergy Test Bed (Located in the UK) which will be a shallow test injection/controlled leakage site, acting as a focal point for collaborative research with partners from Europe and beyond.

At this site, CO₂ will be injected into two shallow aquifer horizons (<300 m) beneath potential caprocks. This site will enable characterisation of shallow migration and leakage processes including studying natural attenuation and proactive remediation techniques for groundwater protection. A range of monitoring techniques will be deployed to establish their efficacy in detecting and tracking CO₂ movement. Geological site characterisation is currently underway. The number of wells to be drilled is not confirmed yet. The intention is to drill into the shallower Arden sandstone (~30 m) then the deeper Sherwood Sandstone Group (Bunter Sandstone Formation equivalent at ~200 – 250 m depth).

Schematic: Concept of GeoEnergy TestBed injection site



Sulcis - Fault Laboratory and Pilot, Italy (Sotacarbo)

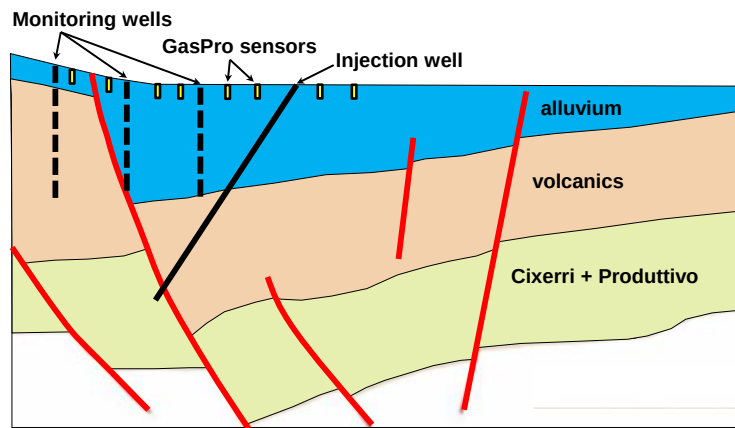
Introduction -context

The Eocene Sulcis Coal Basin, located in the south-western corner of the Island of Sardinia (Italy), hosts extensive sub-bituminous coal deposits that cover an area of approximately 800 km² and have reserves estimated to be of the order of 1.2 billion tons. To continue the use of this resource in an environmentally friendly way, an Italian law was recently passed (law No. 9 of 21 February 2014) that will subsidize the construction of a 350 MWe coal-fired power plant / CCS demonstration plant in the Sulcis area, with the eventual injection of the recovered CO₂ into a >1000-1500 m deep saline carbonate aquifer beneath the coal formation. Within this framework a three-year research program has been funded through Sotacarbo S.p.A. by the Region of Sardinia and the Italian Ministry of Economic Development to collect experimental data and information that will lead to the design and construction of the CCS pilot plant, covering the entire geological storage cycle under "real life" conditions. This will include site characterization, medium depth injection tests, and the eventual creation of a pilot site. The total national funding is of the order of 3-4 million Euros, and this is the first phase of a wider, 10-year 30 M€ R&D program. Three ENOS partners are involved in this national program, the research institutes UniRoma1 and OGS, as well as Sotacarbo S.p.A. (other Italian research groups involved in the national program include INGV, RSE, ENEA and the University of Cagliari).

Research performed and infrastructure created at the Sulcis site within the national program will form the backbone of the research planned within ENOS, providing a significant external contribution in terms of both site knowledge and monetary investment that will allow ENOS to achieve important scientific outcomes at a greatly reduced cost to the project. This nationally funded work will include research already performed in 2014 (fracture modelling of the seal and reservoir rock volumes, soil gas surveys at the regional scale to define the baseline and at the detailed scale across inferred faults to define potential gas migration pathways, continuous CO₂ monitoring at five wells, core analysis from two wells and passive seismic monitoring) as well as activities planned and funded for 2015-2016 (re-interpretation and re-processing of the available multichannel seismic lines, and acquisition, processing and interpretation of a new 2D seismic dataset, detailed soil gas surveys, a detailed hydrogeological study, a 2D/3D geoelectrical survey, re-definition of the 3D geological model, modelling of gas migration through faults, and extension of the continuous CO₂ monitoring network to the fault systems).

Sulcis Fault Laboratory

Sotacarbo, UniRoma1, and OGS are working together on the Sulcis Fault Laboratory (located near the SW coast of Sardinia, Italy), which will be designed to study gas migration processes in faults and to test a wide range of monitoring technologies proposed by all ENOS partners (see figure). Much of the infrastructure will be financed using external, national funds, whereas funding from ENOS will be used specifically to conduct and monitor the injection tests. The site will be fully equipped for medium depth CO₂ injection tests along a properly selected fault to better understand gas migration along such structures (via observations and associated fluid flow modelling), to improve monitoring technologies, and to develop a protocol to define permeability of the faults to the gas migration during site assessment work. This infrastructure will include a >200m deep inclined injection borehole, seven shallow piezometers / monitoring wells, one 200m deep vertical monitoring well, and the CO₂ to inject.



Schematic drawing of the Sulcis Fault Lab set-up, focused on injection of CO₂ into a fault at around 200m depth combined with geochemical, geophysical, and hydrogeological monitoring.

Sulcis Pilot

In addition, work will also be performed in the context of the eventual creation of a pilot-scale test site. Sotacarbo is the owner of the exploration permit in the area.

The characteristics of the Sulcis Pilot are:

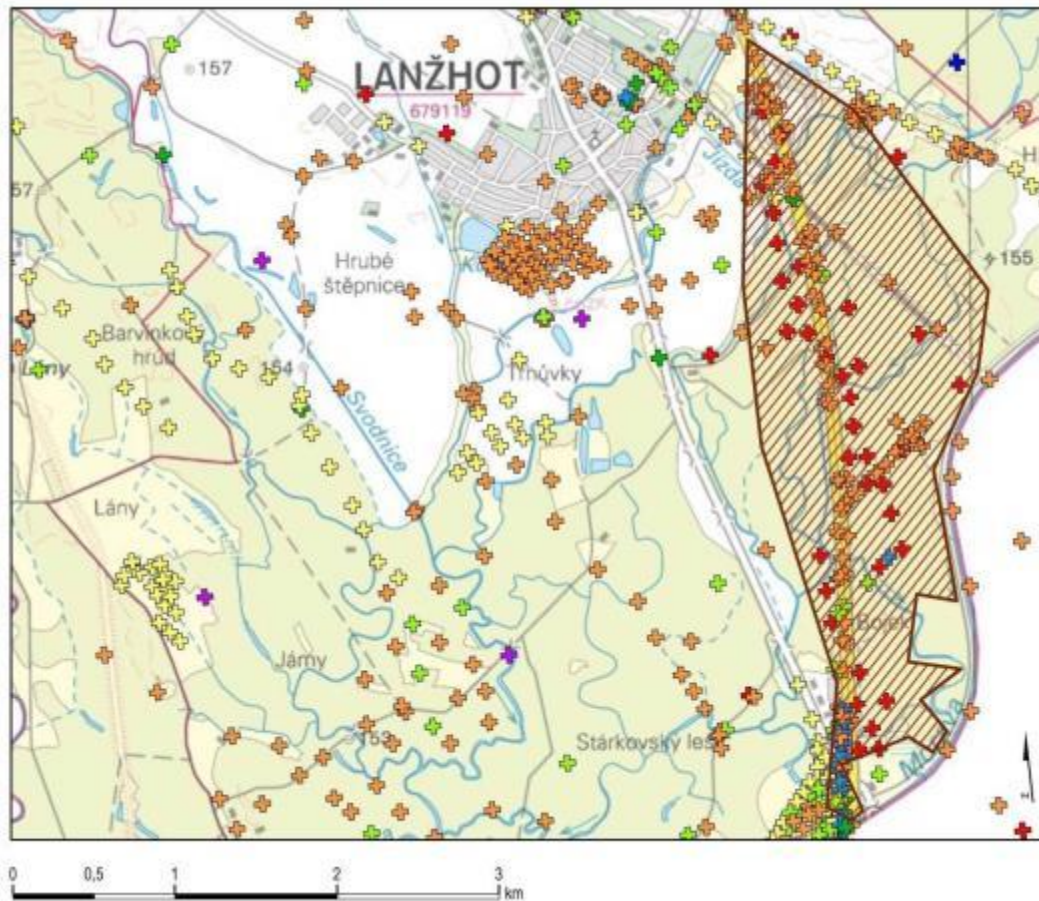
- a 350 MWe coal-fired power plant / CCS demonstration plant,
- injection of the recovered CO₂ into a >1000-1500 m deep saline fractured carbonate aquifer,
- caprock composed of volcanic rock, clays levels and coal bed limestones,

The ongoing national research program will provide surface and subsurface geological data, continuous monitoring data, a preliminary geological model of the area focused mainly on the localization and characterization of faults and their hydraulic behaviour (end of 2016), petrophysical characterization of the rock samples, results of the feasibility study, reprocessed seismic dataset (in progress). In terms of wells, the national program will provide the start of the injection well test for the end of the second year (2015) and of the pilot injection test for the end of 2016. There are some 40 existing wells of different depths (from 300 to 1000 m), meaning that stratigraphy and other well data are available, and an injection well test up to 100 m and a pilot injection test are planned.

LBr-1, Czech Republic (CGS)

LBr-1 is a depleted hydrocarbon field located in the South-Eastern part of the Czech Republic, close to the Czech – Slovak border. The LBr-1 field is the northern one of a pair of 2 neighbouring reservoirs, tectonically and hydrodynamically isolated. The northern reservoir (LBr-1) lies in the Czech Republic, while the southern one is in the territory of Slovakia.

From a geological point of view, the structure belongs to the Vienna Basin.



Map of the LBr-1 field with locations of historical wells (Source: CGS Geofond)

The main oil- and gas-bearing horizons are Middle Badenian sandstones (Lab horizon), especially the 12th, 13th and 14th Badenian, at a depth of ca. 950 m below sea level, i.e., ca. 1150 m below surface. The reservoir rock is medium-grained to fine-grained siliceous sand, with good porosity (up to 32 %) and permeability (locally up to 3,700 mD). In the southern part of the site, the whole Middle Badenian complex is up to 80 metres thick, its thickness gradually decreases in the northward direction, with some sands eventually wedging out at various places.

The productive area, delimited by the southern and northern wedge-outs, is approximately 3,000 metres long and up to 600 metres wide (counting the gas cap), with a total thickness of hydrocarbon-bearing horizons ca. 40 metres. The small size of the reservoir makes it a good candidate for a research CO₂ storage pilot project because it can be filled by a relatively small amount of injected CO₂, and all the processes related to a storage site reaching, or even exceeding its full storage capacity can be studied.

The caprock is mostly formed by Middle Badenian claystones, approximately 100 metres thick, gradually pinching out in the northward direction.

Faults play a significant role in the formation of sealed structures and reservoirs in the Vienna Basin. The southern boundary of the LBr-1 site structure is marked by the Farské faults. From the East, this fault system is

perpendicularly cut by the Brodské fault, running northwards with a westward dip and a downthrow of approximately 120 metres.

The estimated hydrocarbon reserves of LBr-1 (data from 1950s, probably too optimistic) were 300,000 tons of oil (OOIP) and 100 mil. m³ of natural gas (OGIP). The main exploitation phase of the field was in 1960s; the total production was ca. 65,000 tons of oil and 30 mil. m³ of natural gas. During production time, at least 26 production wells were in operation. The production stopped in mid-1970s; then the field was gradually abandoned. Nowadays, a re-abandonment project is ongoing, within which the old wells are being revisited and re-plugged. This brings a good opportunity to get fresh information about the status of old wells abandoned in the 1970s, including new well-log data.

In 2014, the Czech Geological Survey developed the idea of assessing the LBr-1 field as a potential research CO₂ storage site. A comprehensive project proposal aiming at the first, preparatory stage of such a pilot project was prepared and submitted to the CZ08 (CCS) programme of Norway Grants, and the project (titled REPP-CO₂) was, in the end, selected for funding. The Czech Geological Survey and IRIS (International Research Institute of Stavanger, member of CO₂GeoNet and ENOS proposal partner) form the core of the REPP-CO₂ consortium, which embraces five further Czech research-oriented institutions. The project with a total budget of ca. 2.8 mil. € is running from January 2015 till April 2016. Its main activities follow the workflow for developing a storage site according to the EU CCS Directive and include gathering of data for site characterisation, creation of a 3D geological model of the storage complex, numerical simulations of CO₂ injection in the reservoir and related dynamic modelling, risk assessment and development of a site monitoring plan.

LBr-1 site-related activities planned in ENOS are based on the expected outcomes of REPP-CO₂ and represent a direct continuation of work carried out in REPP-CO₂. This concerns the advanced assessment in leakage risks (including contamination of potable groundwater resources) through faults and legacy wells in WP3, appraisal of the possibility to combine CO₂ storage with Enhanced Oil Recovery and study of trans-border issues (Czech Republic-Slovakia) in WP4, as well as more regional and/or future-oriented studies in WP6. In general, ENOS activities related to LBr-1 will represent a significant step towards further development of the LBr-1 pilot project.

Q16 Maas Buffer project, The Netherlands (TNO)

The nearshore condensate gas field Q16 Maas with onshore surface installations – currently operated by ONE, is an attractive prospect for the development of a CO₂ buffer for greenhouse culture (and other forms of CO₂ utilisation; see figure below). It is located just offshore the Maasvlakte in the Rotterdam harbour area. The Ultimate Recovery is estimated at 0.8 billion Nm³, which is equal to a CO₂ storage capacity of about 2 Mt CO₂. The gas reservoir consists of Triassic sandstones in the Main Buntsandstein Subgroup of the Lower Germanic Trias Group at a depth of about 2800 metres.



Schematic of the existing infrastructure for delivery of CO₂ to the greenhouses and the planned additional infrastructure including the CO₂ buffer

The field was discovered in 2011, production started in April 2014 from the well Maasgeul-03X (MSG-03X) and is planned to cease by the end of 2020. The condensate-gas ratio of the produced gas is reported as about 410 m³/10⁶ Nm³ in the Winningsplan (Production plan to be found at www.nlog.nl). After production, the gas stream is processed in the Maas Treatment Installation from where the natural gas is transported via a pipeline to the GTS export network. The separated LPG and condensate will be transported by truck from the Maas gas treatment Installation.

To develop the gas field into a CO₂ buffer for the greenhouse horticulture, an additional pipeline and compressor are to be constructed and an expansion of the gas treatment installation will be necessary for the purification of the CO₂. Possibly also a new CO₂ injection well has to be drilled and completed.

Site-specific data of the Q16 Maas gas field will be made available for analysis in the ENOS project. A research project with a budget of about 250 k€ is being developed for the Netherlands energy innovation programme (TKI Gas).

Geographical and geological setting

The Q16-Maas gas field is located at the southwestern boundary of the West Netherlands basin about 2 km to the west of the Maasvlakte (province of Zuid-Holland). The most important reservoir units are the Solling and the Hardeggen sandstones sequences of the Main Buntsandstein Subgroup. These reservoirs are known for their good production properties in this part of the West Netherlands Basin. The top of the reservoir is bounded by claystones of Triassic and Jurassic age. The gas accumulated in northwest-southeast oriented structural trap. To the northeast it is bounded by faults and the trap is dipping to the southwest.

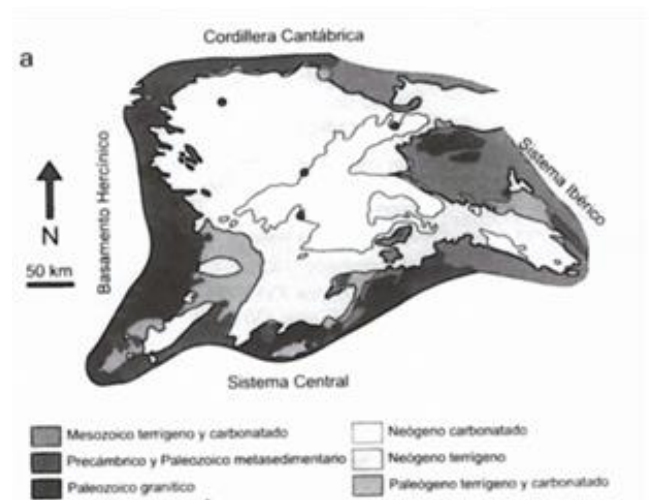
The well MSG-03X is deviating in northwestern direction. The surface location is on the Maasvlakte. The well reaches the top of the reservoir at a depth of 2845 m below sea level. The gas reservoir itself is located below the North Sea within the three-mile zone.

Palencia 3, Spain (PLC-3)

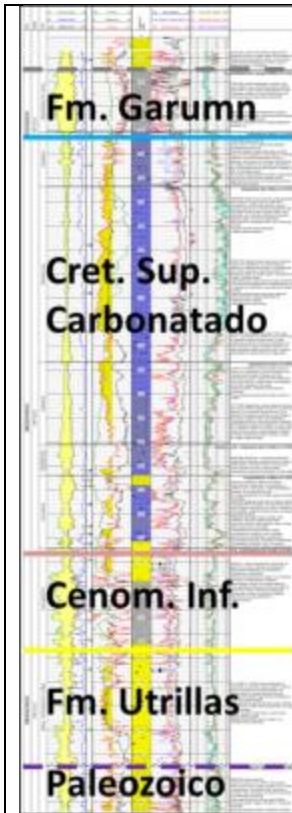
Palencia 3 is located in the north-eastern area of the Duero basin, a Cenozoic intraplate basin with a complex evolution that started to be defined during the Late Cretaceous, and where it is possible to distinguish different areas with their own tecto-sedimentary characteristics.

The area of study is located in the northern part of the Duero basin, which acted as a foreland basin, at least from the Eocene period, linked to the Cantabrian Mountain Range Alpine evolution. The response to the convergence between the Iberian and European plates, the collision between the Iberian and African plates and the regime change, from extensional during the Mesozoic period to compressional during Tertiary, produced the structuring and evolution of the mountain fronts that develop the basin borders and its dynamic and sedimentary history.

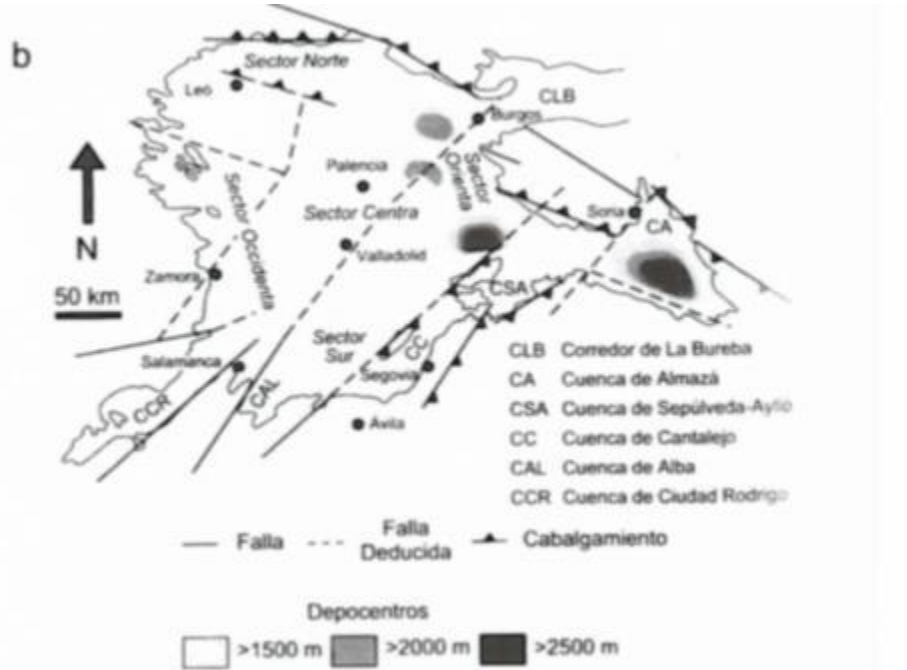
The source areas in the north-eastern sub basin are Paleozoic and Mesozoic carbonate and siliciclastic rocks. This lithological complexity controlled the composition and textural maturity of the sediments and the distribution of the deposits that developed the stratigraphic record. The main basin depocenters are related to the more active borders, such as the Cantabrian Mountains Range front and the Iberian System, where the thickness can exceed 2500 m.



Geological units of the Duero basin and neighbouring area



Composite log for Campillo-1 well.



Main lining directions and their relation with the maximum sediment deposit areas

Formations involved in the storage

Regionally, a reservoir with high matrix porosity can be found in the sandy Cretaceous materials (Fm. Utrillas). A secondary reservoir, with less petrophysical potential, is the carbonated Cretaceous materials, with fracture porosity.

Concerning the seals, a reliable regional seal is formed by the clayey and evaporitic materials of the Garumn facies. Locally, the lower Cenomanian acts as a seal over the Utrillas formation.

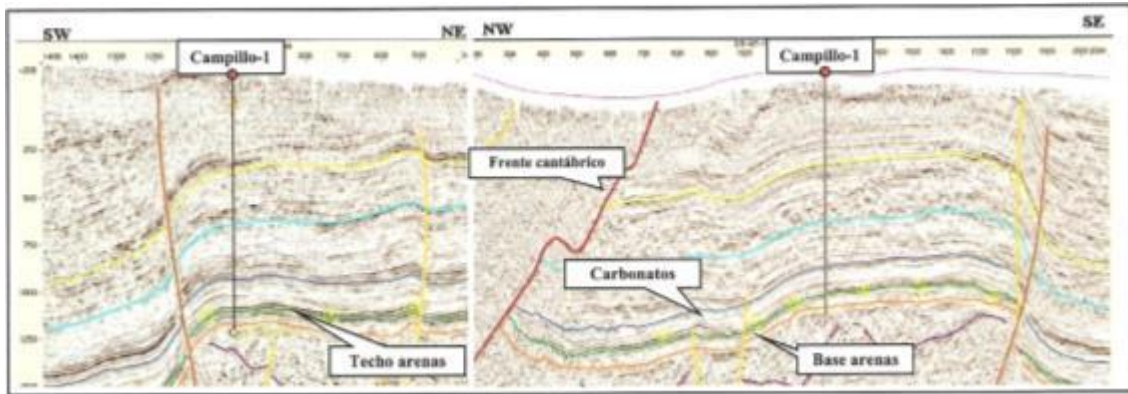
The area nearby Campillo-1 well shows very good conditions for a CCS project due to the presence of:

- A clear anticline closure in the base Tertiary and Cretaceous.
- A sandy Cretaceous with an excellent reservoir with porosity values around 20% in transgressive sands and very variable porosity values (10% - 20%) in the sequences 1, 2 and 3 of the Utrillas Fm. and Escucha and Weald formations.

This anticline shows:

- A four direction closure, independent from the inverse fault that generates it.
- A reliable closure without little faults that could be a risk for the vertical seal.

The next figure shows two seismic lines showing the tectonic structure that makes up the trap for CO₂ storage and the interpretation of the involved materials.



Cross sectional interpreted seismic lines.

Existing information and infrastructure:

Nearby Palencia 3, several wells have been drilled: León-1, León-1 bis, Campillo-1, Villameriel-1, San Pedro-1 a 3, Iglesias-1 a 4, Río franco-1 y Don Juan-1. Furthermore, some seismic surveys were carried out during the 1980's. The next figure shows the well and seismic situation.



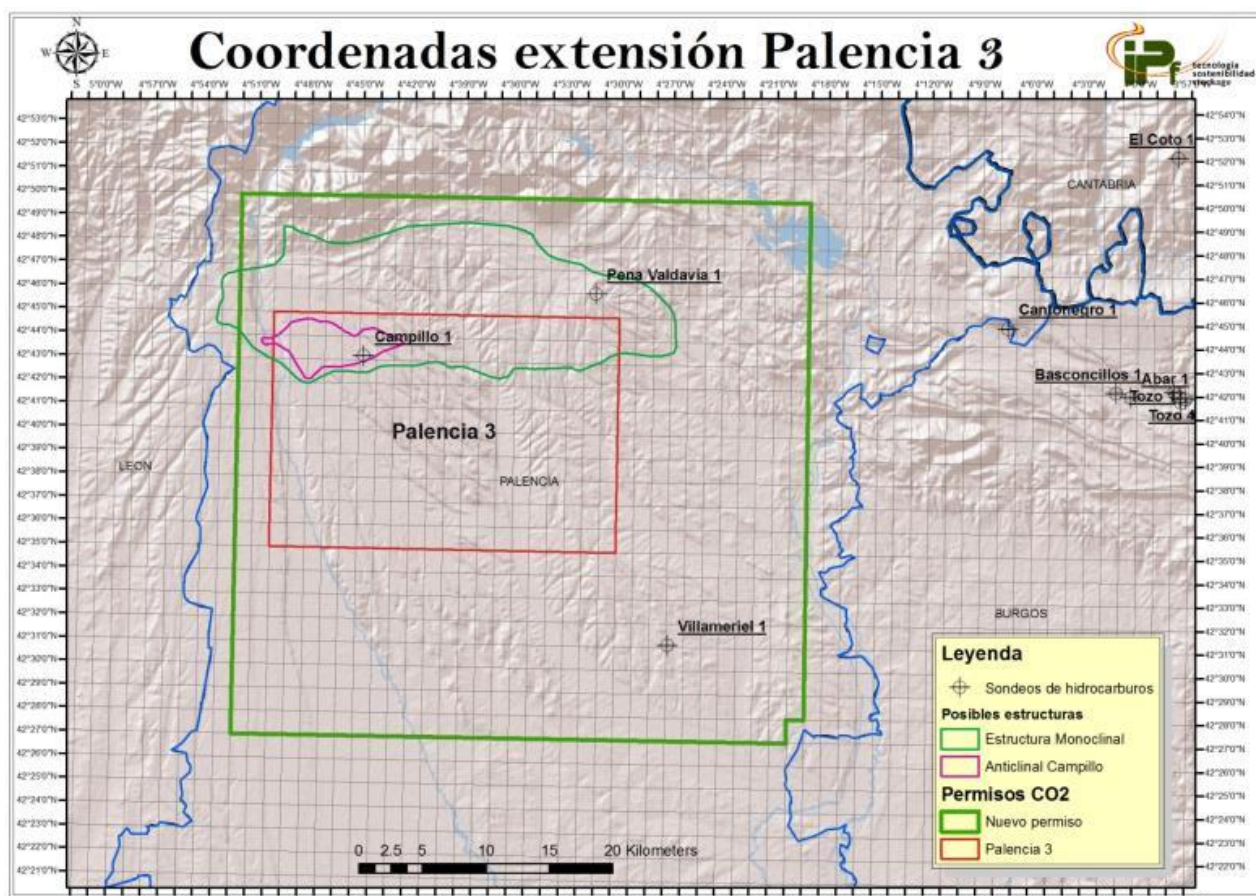
Map showing the situation of the different wells and the seismic cover.

A research permit for CCS has been commissioned to Palencia 3 the extension of which is delimited by the coordinates:

Vértex	Length	Latitude
1	4° 50'00" West	42° 45'00" North
2	4° 30'00" West	42° 45'00" North
3	4° 30'00" West	42° 35'00" North
4	4° 50'00" West	42° 35'00" North

Furthermore, a permit extension has been requested to the government, with the next coordinates:

Vértex	Length	Latitude
1	4° 52'00" West	42° 50'00" North
2	4° 52'00" West	42° 27'00" North
3	4° 19'00" West	42° 50'00" North
4	4° 19'00" West	42° 28'00" North
5	4° 20'00" West	42° 28'00" North
	4° 20'00" West	42° 27'00" North



Location map of the already commissioned Palencia 3 permit, its extension, and pending processing

4.2. Third parties involved in the project (including use of third party resources)

1. BRGM: No third parties/no subcontracting
2. BGR: No third parties/no subcontracting

3. BGS	
Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	YES
It is proposed to carry out a test of a new high precision open path laser system for emission quantification in Task 3.3.3 in WP3. -Scope: this instrument is being developed currently by the Rutherford Appleton Laboratory (RAL) of the Science and Technology Facilities Council (STFC) under a 2 year UK STFC project in collaboration with BGS and Shell. Since the Chirped Laser Dispersion Spectroscopy approach being used is unique to RAL we propose to test the equipment at one of the ENOS field sites through a subcontract to RAL, who will provide calibrated equipment and operators for the test and assist with data processing. The tool will most likely be tested at Sulcis field laboratory as this site is expected to show leakage at the surface, but could be deployed at the GeoEnergy Test Bed. - Cost estimate: A figure of up to 45,000 Euros is included for staff, travel and other costs related to the deployment (30k€ for 1.5 person months of staff time and 15k€ for travel/other costs related to the deployment). - Selection procedure: Only Rutherford are able to test this unique tool as it has been developed by Rutherford in collaboration with BGS and Shell.	
Does the participant envisage that part of its work is performed by linked third parties	NO
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	NO

4. CGS: No third parties/no subcontracting
5. CIEMAT: No third parties/no subcontracting

6. CIUDEN	
Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	YES
<i>Part of the work in task 5.3 will be subcontracted 25,000€</i> <u>Activitiy to be subcontracted</u> As exposed in the DOW, WP5 – Coordination with local population will create conditions for ensuring that CO2 storage activities in sites are recognized as a safe operation and for establishing long term relationships with stakeholders and local population. In this sense, intensive activity is requested in WP5 to engage effectively with stakeholders, to ensure understanding of the project and operational activities in site, and to work closely with the local communities. Following the guidance of the project, these actions will imply to carry out innovative activities	

aiming to develop knowledge and tools to bridge the gap between the technical side and the societal level of perception on CCS.

In this sense, and specifically stated in WP5 objectives and subsequently detailed in task 5.3, a public information tool for CO₂ storage site will be developed to enable people living near a storage site to understand and follow site development and operation. This tool will be also based on input and feedback from the local population and will offer the possibility of including experiences from other sites. Professional support in this area will be needed for the correct creation, development, implementation and update of the requested tool.

Consequently, subcontracting would be considered necessary in these regards in order to accomplish effectively the requested objectives of the project.

Expected cost:

Considering the committed tasks to be accomplished within WP5 (Task 5.3), an initial estimation of 25,000€ for subcontracting the development of a public information tool for CO₂ storage sites has been calculated considering hosting licenses, technical services, technological infrastructure and maintenance, if needed.

This estimation has been based on previous experiences and Spanish market prices for development of online tools.

Procedure

The subcontracts will be awarded ensuring the best value for money or, if appropriate, the lowest price following an open market consultation (a contract notice) allowing for a time-limit for receipt of tenders and always under an objective and non-discriminatory evaluation of the tenders.

Does the participant envisage that part of its work is performed by linked third parties	NO
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	NO

7. Flodim: No third parties/no subcontracting
8. Geogreen: No third parties/no subcontracting
9. IDIL: No third parties/no subcontracting
10. IRIS: No third parties/no subcontracting
11. NHAZCA: No third parties/no subcontracting
12. OGS: No third parties/no subcontracting

13. PLC-3

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	NO
Does the participant envisage that part of its work is performed by linked third parties	YES

As specified in the Palencia 3 description here above, Palencia 3 having no staff, the work will be performed by the three third parties.

	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	WP9	Total Person/ Months per Participant
PLC-3-ENAGAS	1.5	4.3	2.3	0.0	0.0	0.0	3.5	0.0	0.0	11.6
PLC-3-IPF	2.5	1.5	2.0	0.0	1.0	2.4	2.0	0.0	1.0	12.4
Total Person/Months	4.0	5.8	4.3	0.0	1.0	2.4	5.5	0.0	1.0	24.0

Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement) NO

14. SGIDS: No third parties/no subcontracting

15. Silixa: No third parties/no subcontracting

16. Sotacarbo: No third parties/no subcontracting

17. TNO: No third parties/no subcontracting

18. UniRoma1

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted) YES

WP5, Tasks 5.1.2 and 5.2.1 (70k€) The costs for personnel for these two tasks have been moved from direct costs to subcontracting following the recent (October 2015) EC interpretation of the eligible costs in H2020 (see List of issues applicable to particular countries), since personnel costs that according to the Italian national legislation (law 240/2010) “assegni di ricerca” and “collaborazioni” are considered as staff personnel (in-house consultant), have now been classified as subcontracting/services. The amount (70k€) allocated as subcontract refers to personnel costs related to “assegni di ricerca” which have been reclassified as subcontract in compliance with EC indications. The work in these two tasks concerns the activities of guidance for the integration of the input from the local communities in the research process and the work for coordination and elaboration of the work with the local communities and relates to D5.9 and D5.7.

Does the participant envisage that part of its work is performed by linked third parties NO

Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement) NO

19. UNOTT: No third parties/no subcontracting

20. CO₂GeoNet

10 third parties. Please see the details in the partner descriptions in 4.1

A summary of staff effort for the CO₂GeoNet third parties is given below

	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	WP9	Total Person/ Months per Participant
CO2GeoNet-GBA	0.0	0.0	0.0	0.0	4.0	7.0	3.0	0.0	0.0	14.0
CO2GeoNet-GeoEcoMar	0.0	0.0	2.5	0.0	4.0	6.2	7.3	3.0	0.0	23.0
CO2GeoNet-Geoinz	0.0	0.0	0.0	0.0	0.0	1.0	7.0	1.0	0.0	9.0
CO2GeoNet-GEUS	0.0	0.0	0.0	0.0	0.0	0.0	3.0	8.0	8.0	19.0
CO2GeoNet-GSB-RBINS	0.0	0.0	0.0	24.0	0.0	0.0	1.0	0.0	0.0	25.0
CO2GeoNet-HWU	4.0	26.0	16.0	0.0	3.0	0.0	1.0	3.3	0.0	53.3
CO2GeoNet-IGME	20.2	0.0	0.0	0.0	2.0	2.0	3.4	4.2	0.0	31.8
CO2GeoNet-METU PAL	0.0	0.0	0.0	6.0	0.0	0.0	1.0	0.0	0.0	7.0
CO2GeoNet-TTUGI	0.0	0.0	0.0	0.0	2.3	5.9	11.3	3.8	0.0	23.3
CO2GeoNet-UNIZG-RGNF	0.0	0.0	0.0	0.0	0.0	7.3	1.0	3.2	0.0	11.5
Total Person/Months	24.2	26.0	18.5	30.0	15.3	29.3	39.0	26.5	8.0	216.8

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)

YES

CO₂GeoNet-UNIZG 30 k€ subcontracting is planned.

Scope of the subcontract – Task 6.3 (D6.8) is aimed at finding the locations/regions likely to be favorable for future pilot or demonstration projects. This task will use data from existing pilot sites, key recommendations from previous and ongoing research projects. A catalogue of the most prospective candidates for second generation pilots will be developed. It is expected that some of them will be in countries not in ENOS consortium and therefore part of the work of task 6.8 will have to be subcontracted to a local entity having the necessary knowledge and expertise.

Based on the coordination through the work in Tasks 6.1 and 6.2 a plan will be made to contact the institutes from countries where the new pilots might be commenced and each of the selected institutes will be required to make a short report covering the subsurface data of the prospective site together with other surface and technical/legal conditions for a pilot study. Reports will have to be according to a specified structure (topics) and should not be more extensive than plan for a pre-feasibility study. Exact number of countries/locations will be determined during the first 2 years of ENOS in close cooperation with ECCSEL, ZEP etc., but the following countries are among candidates: Poland, Hungary, Lithuania, Latvia, Bulgaria, Finland and Sweden; in addition also Serbia and Bosnia and Herzegovina but this depends on the changes of their respective regulations. Altogether around 6 locations are to be chosen

Cost estimates – 6 subcontracts with the institutes that have the subsurface data (mostly geological surveys),

each can be up to EUR 5000. Selection procedure – due to the specific work and especially data needed it is most likely that only one entity per country (mostly the geological surveys or sometimes the university) could provide the needed information due to the required knowledge and data possession, therefore a negotiated procedure will be used to award the tenders.	
Does the participant envisage that part of its work is performed by linked third parties ⁵	YES
See details of the ten linked third parties in the partner descriptions in 4.1	
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	NO

⁵ A third party that is an affiliated entity or has a legal link to a participant implying a collaboration not limited to the action. (Article 14 of the Model Grant Agreement).

Section 5: Ethics and Security

5.1 Ethics

The only ethical issue raised by ENOS is on the collection of personal data related to the activities in WP5 Coordination with the local population.

Supporting information to Ethical issue 4: Personal data

ENOS will develop its activities within the framework of Responsible Research and Innovation – RRI, and will therefore take care to anticipate and assesses potential implications and societal expectations with regard to CO₂ storage research and innovation, with the aim of fostering the design of inclusive and sustainable research and innovation. In particular, in WP5, the societal actors (researchers, citizens, policy makers, business, third sector organisations, etc.) will work together during the research and innovation process in order to better align both the process and its outcomes with the values, needs and expectations of society. The partners will develop together a protocol on how to approach the work with the local communities (task 5.2.1), which will include discussion and definition of ethical aspects related to each site and, more generally, to the activities undertaken. Through a peer review process, comparing and cross checking, they will improve, when relevant, the forms or approaches of each institute.

Understanding fully how people feel about the innovations studied in ENOS and involving them in the process is of the utmost importance. Hence, the partners will aim to create conditions that maximise the potential for collaboration by, among other aspects, analysing the specific ethical issues that need consideration in a way that people will feel completely at ease with the process and confident about the use that will be made of their contribution.

The existing European and national legislation for personal data protection will be strictly followed, in Italy based on the Legislative Decree 30 June 2003, n.196 – Codex for the treatment of personal data, in the United Kingdom based on the Data Protection Act (1998) and comparable Acts in each country (underpinned by EU Directives) in which research activities involving members of the public are to be undertaken. Other relevant ethical codes and their provisions will be consulted and followed as appropriate. Key issues that will be treated concern a) the procedure for informed consent of participants, on the basis that they are aware of the research objectives, funder, context, methods to be employed and use of information gathered; b) the protection of all information collected and to ensure that it is carefully protected, that it is confidential and not released to a third party in a form that allows identification of particular individuals and that it is reported anonymously. It is also worth noting that the research institutes involved have previous experience of undertaking public engagement activities and are sensitive to the ethical issues that might be raised.

An example of an informed consent form is provided in the supporting documents. This form will be adapted according to the national constraints and activities.

5.2 Security

Please indicate if your project will involve:

- activities or results raising security issues: NO
- 'EU-classified information' as background or results: NO

ESTIMATED BUDGET FOR THE ACTION (page 1 of 3)

	Estimated eligible ¹ costs (per budget category)									EU contribution			Additional information		
	A. Direct personnel costs				B. Direct costs of subcontracting	[C. Direct costs of fin. support]	D. Other direct costs	E. Indirect costs ²	Total costs	Reimbursement rate %	Maximum EU contribution ³	Maximum grant amount ⁴	Information for indirect costs	Information for auditors	Other information:
	A.1 Employees (or equivalent) A.2 Natural persons under direct contract A.3 Seconded persons [A.6 Personnel for providing access to research infrastructure]		A.4 SME owners without salary A.5 Beneficiaries that are natural persons without salary				D.1 Travel D.2 Equipment D.3 Other goods and services D.4 Costs of large research infrastructure					Estimated costs of in-kind contributions not used on premises	Declaration of costs under Point D.4	Estimated costs of beneficiaries/ linked third parties not receiving EU funding	
Form of costs ⁶	Actual	Unit ⁷	Unit ⁸		Actual	Actual	Actual	Flat-rate ⁹							
								25%							
	(a)	Total (b)	No hours	Total (c)	(d)	(e)	(f)	(g)=0,25x ((a)+(b)+(c)+(f) +[(h1)+(h2)]-(m))	(i)=(a)+(b)+(c)+(d)+(e)+(f)+(g)+(h1)+(h2)+(h3)	(j)	(k)	(l)	(m)	Yes/No	
1. BRGM	0.00	838247.00	0	0.00	0.00	0.00	201400.00	259911.75	1299558.75	100.00	1299558.75	1299558.75	0.00	No	
2. BGR	312480.00	0.00	0	0.00	0.00	0.00	95802.00	102070.50	510352.50	100.00	510352.50	510352.50	0.00	No	
3. BGS	474195.00	0.00	0	0.00	45000.00	0.00	145146.00	154835.25	819176.25	100.00	819176.25	819176.25	0.00	No	
4. CGS	175307.00	0.00	0	0.00	0.00	0.00	44300.00	54901.75	274508.75	100.00	274508.75	274508.75	0.00	No	
5. CIEMAT	30702.00	0.00	0	0.00	0.00	0.00	4500.00	8800.50	44002.50	100.00	44002.50	44002.50	0.00	No	
6. CIUDEN	810500.00	0.00	0	0.00	25000.00	0.00	1321300.00	532950.00	2689750.00	100.00	2689750.00	2689750.00	0.00	No	
7. flodim	25000.00	0.00	0	0.00	0.00	0.00	14000.00	9750.00	48750.00	100.00	48750.00	48750.00	0.00	No	
8. GGR	262808.00	0.00	0	0.00	0.00	0.00	78900.00	85427.00	427135.00	100.00	427135.00	427135.00	0.00	No	
9. IDIL	25000.00	0.00	0	0.00	0.00	0.00	2500.00	6875.00	34375.00	100.00	34375.00	34375.00	0.00	No	
10. IRIS	538085.00	0.00	0	0.00	0.00	0.00	64500.00	150646.25	753231.25	100.00	753231.25	753231.25	0.00	No	
11. NHAZCA	25500.00	0.00	0	0.00	0.00	0.00	15500.00	10250.00	51250.00	100.00	51250.00	51250.00	0.00	No	
12. OGS	672565.00	0.00	0	0.00	0.00	0.00	131600.00	201041.25	1005206.25	100.00	1005206.25	1005206.25	0.00	No	
13. PLC-3 ¹³															0.00
- IPF ¹⁴	67000.00	0.00	0	0.00	0.00	0.00	7900.00	18725.00	93625.00	100.00	93625.00	93625.00	0.00	No	
- ENAGAS ¹⁴	81200.00	0.00	0	0.00	0.00	0.00	6390.00	21897.50	109487.50	100.00	109487.50	109487.50	0.00	No	
Total beneficiary 13	148200.00	0.00			0.00	0.00	14290.00	40622.50	203112.50		203112.50	203112.50	0.00		
14. SGIDS	28000.00	0.00	0	0.00	0.00	0.00	4000.00	8000.00	40000.00	100.00	40000.00	40000.00	0.00	No	
15. SILIXA	83195.00	0.00	0	0.00	0.00	0.00	75700.00	39723.75	198618.75	100.00	198618.75	198618.75	0.00	No	
16. SOTACARBO	112674.00	0.00	0	0.00	0.00	0.00	15000.00	31918.50	159592.50	100.00	159592.50	159592.50	0.00	No	
17. TNO	592213.00	0.00	0	0.00	0.00	0.00	74600.00	166703.25	833516.25	100.00	833516.25	833516.25	0.00	No	
18. UNIROMA1	515000.00	0.00	0	0.00	70000.00	0.00	217000.00	183000.00	985000.00	100.00	985000.00	985000.00	0.00	No	
19. UNOTT	357946.00	0.00	0	0.00	0.00	0.00	53400.00	102836.50	514182.50	100.00	514182.50	514182.50	0.00	No	
20. CO2GeoNet ¹³															0.00
- METU ¹⁴	29700.00	0.00	0	0.00	0.00	0.00	3500.00	8300.00	41500.00	100.00	41500.00	41500.00	0.00	No	
- GBA ¹⁴	63423.00	0.00	0	0.00	0.00	0.00	6000.00	17355.75	86778.75	100.00	86778.75	86778.75	0.00	No	
- HWU ¹⁴	300710.00	0.00	0	0.00	0.00	0.00	29300.00	82502.50	412512.50	100.00	412512.50	412512.50	0.00	No	
- UNIZG-RGNF ¹⁴	27000.00	0.00	0	0.00	30000.00	0.00	10800.00	9450.00	77250.00	100.00	77250.00	77250.00	0.00	No	

ESTIMATED BUDGET FOR THE ACTION (page 2 of 3)

	Estimated eligible ¹ costs (per budget category)									EU contribution			Additional information		
	A. Direct personnel costs				B. Direct costs of subcontracting	[C. Direct costs of fin. support]	D. Other direct costs	E. Indirect costs ²	Total costs	Reimbursement rate %	Maximum EU contribution ³	Maximum grant amount ⁴	Information for indirect costs	Information for auditors	Other information:
	A.1 Employees (or equivalent) A.2 Natural persons under direct contract A.3 Seconded persons [A.6 Personnel for providing access to research infrastructure]		A.4 SME owners without salary A.5 Beneficiaries that are natural persons without salary				D.1 Travel D.2 Equipment D.3 Other goods and services D.4 Costs of large research infrastructure						Estimated costs of in-kind contributions not used on premises	Declaration of costs under Point D.4	Estimated costs of beneficiaries/ linked third parties not receiving EU funding
Form of costs ⁶	Actual	Unit ⁷	Unit ⁸		Actual	Actual	Actual	Flat-rate ⁹							
								25%							
	(a)	Total (b)	No hours	Total (c)	(d)	(e)	(f)	(g)=0,25x ((a)+(b)+(c)+(f) +[(h1)+(h2)]-(m))	(i)= (a)+(b)+(c)+(d)+(e)+(f)+(g)+(h1)+(h2)+(h3)	(j)	(k)	(l)	(m)	Yes/No	
- GEUS ¹⁴	164277.00	0.00	0	0.00	0.00	0.00	44600.00	52219.25	261096.25	100.00	261096.25	261096.25	0.00	No	
- IGME ¹⁴	155041.00	0.00	0	0.00	0.00	0.00	23800.00	44710.25	223551.25	100.00	223551.25	223551.25	0.00	No	
- GEOECOMAR ¹⁴	118495.00	0.00	0	0.00	0.00	0.00	15900.00	33598.75	167993.75	100.00	167993.75	167993.75	0.00	No	
- TTUGI ¹⁴	81375.00	0.00	0	0.00	0.00	0.00	14500.00	23968.75	119843.75	100.00	119843.75	119843.75	0.00	No	
- GSB-RBINS ¹⁴	112000.00	0.00	0	0.00	0.00	0.00	9500.00	30375.00	151875.00	100.00	151875.00	151875.00	0.00	No	
- GEOINZ ¹⁴	36131.00	0.00	0	0.00	0.00	0.00	5100.00	10307.75	51538.75	100.00	51538.75	51538.75	0.00	No	
Total beneficiary 20	1088152.00	0.00			30000.00	0.00	163000.00	312788.00	1593940.00		1593940.00	1593940.00	0.00		
Total consortium	6277522.00	838247.00		0.00	170000.00	0.00	2736438.00	2463051.75	12485258.75		12485258.75	12485258.75	0.00		0.00

ESTIMATED BUDGET FOR THE ACTION (page 3 of 3)

- (1) See Article 6 for the eligibility conditions
- (2) The indirect costs covered by the operating grant (received under any EU or Euratom funding programme; see Article 6.5.(b)) are ineligible under the GA. Therefore, a beneficiary that receives an operating grant during the action's duration cannot declare indirect costs for the year(s)/reporting period(s) covered by the operating grant (see Article 6.2.E).
- (3) This is the theoretical amount of EU contribution that the system calculates automatically (by multiplying all the budgeted costs by the reimbursement rate). This theoretical amount is capped by the 'maximum grant amount' (that the Commission/Agency decided to grant for the action) (see Article 5.1).
- (4) The 'maximum grant amount' is the maximum grant amount decided by the Commission/Agency. It normally corresponds to the requested grant, but may be lower.
- (5) Depending on its type, this specific cost category will or will not cover indirect costs. Specific unit costs that include indirect costs are: costs for energy efficiency measures in buildings, access costs for providing trans-national access to research infrastructure and costs for clinical studies.
- (6) See Article 5 for the forms of costs
- (7) Unit : hours worked on the action; costs per unit (hourly rate) : calculated according to beneficiary's usual accounting practice
- (8) See Annex 2a 'Additional information on the estimated budget' for the details (costs per hour (hourly rate)).
- (9) Flat rate : 25% of eligible direct costs, from which are excluded: direct costs of subcontracting, costs of in-kind contributions not used on premises, direct costs of financial support, and unit costs declared under budget category F if they include indirect costs
- (10) See Annex 2a 'Additional information on the estimated budget' for the details (units, costs per unit).
- (11) See Annex 2a 'Additional information on the estimated budget' for the details (units, costs per unit, estimated number of units, etc)
- (12) Only specific unit costs that do not include indirect costs
- (13) See Article 9 for beneficiaries not receiving EU funding
- (14) Only for linked third parties that receive EU funding



ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

BUNDESANSTALT FUER GEOWISSENSCHAFTEN UND ROHSTOFFE (BGR), n.a., established in Stilleweg 2, HANNOVER 30655, Germany, DE811289832 ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become *beneficiary* No ('2')

in Grant Agreement No 653718 ('the Agreement')

between BUREAU DE RECHERCHES GEOLOGIQUES ET MINIERES **and** *the Innovation and Networks Executive Agency (INEA) ('the Agency'), under the power delegated by the European Commission ('the Commission'),*

for the action entitled 'ENabling Onshore CO2 Storage in Europe (ENOS)'.

and mandates

the *coordinator* to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Frank LICHTENBERG with ECAS id nlicfank signed in the Participant Portal on 13/09/2016 at 10:33:00 (transaction id SigId-74722-opQX7uy7APL9WtMKNspUEdMpbV38Z8B0etoDzWvzPkmsBWboLr91h0-qXnxCDPkbNq6PFRAowdydtUhlM8xOBgRs-Jj71zxYb8yrYiyGUQixsv0-raOhlwk02Bl8A52ztKQBle3HJ3U0KcOTq8mUgWWPhs). Timestamp by third party at Tue Sep 13 11:33:38 CEST 2016



ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

NATURAL ENVIRONMENT RESEARCH COUNCIL (BGS), RC000740, established in Polaris House, North Star Avenue, SWINDON WILTSHIRE SN2 1EU, United Kingdom, GB618367325 ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become *beneficiary* No ('3')

in Grant Agreement No 653718 ('the Agreement')

between BUREAU DE RECHERCHES GEOLOGIQUES ET MINIERES **and** *the Innovation and Networks Executive Agency (INEA) ('the Agency'), under the power delegated by the European Commission ('the Commission'),*

for the action entitled 'ENabling Onshore CO2 Storage in Europe (ENOS)'.

and mandates

the *coordinator* to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Christopher LUTON with ECAS id nlutonch signed in the Participant Portal on 07/09/2016 at 11:46:18 (transaction id SigId-30258-Sf3qbP5KqLpFkEeJY09Hp4zIzRraJZ8AMBXzbZFjXnFIIZgYsQWmceNxmfk72NHrkkKwr7hgetGoDoyrUWIFDwW-Jj71zxYb8yrYiyGUQlksv0-Rdzt9J2rQzq6UEnZ3M326zcxD6li3Npb5onnhhjQZpn4). Timestamp by third party at Wed Sep 07 12:46:53 CEST 2016



ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

CESKA GEOLOGICKA SLUZBA (CGS), N/A, established in Klarov 3/131, PRAGUE 1 11821, Czech Republic, 025798 ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become *beneficiary* No ('4')

in Grant Agreement No 653718 ('the Agreement')

between BUREAU DE RECHERCHES GEOLOGIQUES ET MINIERES **and** *the Innovation and Networks Executive Agency (INEA) ('the Agency'), under the power delegated by the European Commission ('the Commission'),*

for the action entitled 'ENabling Onshore CO2 Storage in Europe (ENOS)'.

and mandates

the *coordinator* to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Zdenek VENERA with ECAS id nvenerzd signed in the Participant Portal on 16/08/2016 at 13:26:10 (transaction id SigId-117394-ykzUH4TslUnpzwqy6JSEmHUuq3Vv7fEHbFBnIUH8sD5huel6BHNpP PF3OwQSmbx2KI0VpAP02ttl8xNii0SeEk-Jj71zxYb8yr5dzX2DFZb8K-DvdzVxx6FLnM416f90gQpcnssbxbn65bBDJPpxsMtDw). Timestamp by third party at Tue Aug 16 14:26:19 CEST 2016



ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

CENTRO DE INVESTIGACIONES ENERGETICAS, MEDIOAMBIENTALES Y TECNOLOGICAS-CIEMAT (CIEMAT), Q2820002J, established in Avenida Complutense 40, MADRID 28040, Spain, ESQ2820002J ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become *beneficiary* No ('5')

in Grant Agreement No 653718 ('the Agreement')

between BUREAU DE RECHERCHES GEOLOGIQUES ET MINIERES and *the Innovation and Networks Executive Agency (INEA) ('the Agency')*, under the power delegated by the European Commission ('the Commission'),

for the action entitled 'ENabling Onshore CO2 Storage in Europe (ENOS)'.

and mandates

the *coordinator* to submit and sign in its name and on its behalf any **amendments to the Agreement, in accordance with Article 55.**

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Cayetano LOPEZ with ECAS id nlopcaye signed in the Participant Portal on 09/08/2016 at 07:02:23 (transaction id SigId-68366-ziTnFqhQZpBGQMIXZPbYaCZyoZKjF3q6ubmFoxgfDe1ZA0W1ffnfyRI DmbR4UzjULIwYTZoXVqTIBP7EJ3LLzcG-Jj71zxYb8yr5dzX2DFZb8K-zzhIAUHpoBVEcAQ8pSAkiDYk4sxzodlvb6h548ASnQqu). Timestamp by third party at Tue Aug 09 08:02:34 CEST 2016



ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

FUNDACION CIUDAD DE LA ENERGIA (CIUDEN) ES3, 913, established in AVENIDA DEL PRESIDENTE RODRIGUEZ ZAPATERO SN, PONFERRADA 24492, Spain, ESG84737238 ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become *beneficiary* No ('6')

in Grant Agreement No 653718 ('the Agreement')

between BUREAU DE RECHERCHES GEOLOGIQUES ET MINIERES **and** *the Innovation and Networks Executive Agency (INEA) ('the Agency'), under the power delegated by the European Commission ('the Commission'),*

for the action entitled 'ENabling Onshore CO2 Storage in Europe (ENOS)'.

and mandates

the *coordinator* to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Castiñeiras CENAMOR with ECAS id ncenamca signed in the Participant Portal on 13/09/2016 at 10:55:48 (transaction id SigId-75245-zw4i7OwnDRRjn12JsKVihK78kzKJKVSjCgHfrrpQB8iEcIJEPLyPCUP24MN4dvo5683UaZ3aWAawhP3W9vVDnv-Jj71zxYb8yrYiyGUQlxsv0-zzL0HZzlkeptP3tCvimMIMbtJHsZI2NEum8i1ptLQ17W). Timestamp by third party at Tue Sep 13 11:56:32 CEST 2016



ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

FLODIM SARL (flodim) SARL, 399286020, established in 110 RUE DES RIZIERES
TECHNOPARC DES GRANDES TERRES, MANOSQUE 04100, France, FR28399286020 ('the
beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become *beneficiary* No ('7')

in Grant Agreement No 653718 ('the Agreement')

between BUREAU DE RECHERCHES GEOLOGIQUES ET MINIERES **and** *the Innovation and
Networks Executive Agency (INEA) ('the Agency'), under the power delegated by the European
Commission ('the Commission'),*

for the action entitled 'ENabling Onshore CO2 Storage in Europe (ENOS)'.

and mandates

the *coordinator* to submit and sign in its name and on its behalf any **amendments** to the Agreement,
in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant
in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Jean-Paul CRABEIL with ECAS id ncrabeje signed in the Participant
Portal on 09/08/2016 at 10:27:48 (transaction id SigId-71266-
oLVvFb4ZiNiLQa1bqzhzOu1U7pLqqilYeAPfbKUktmma5MNhcVRVK2A
52P5OdGd2nymnfaYHEr5Ezcof8x6pHp0-Jj71zxYb8yr5dzX2DFZb8K-
zl3WxWXbfE3xmJPVPw5zrJK5LiOg3SBOMgW2MI2oPpAG).
Timestamp by third party at
Tue Aug 09 11:27:57 CEST 2016



ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

GEOGREEN (GGR) FR39, 499 836 831 R.C.S NANTERRE , established in Rue Eugene et Armand Peugeot 7, RUEIL MALMAISON 92563 , France, FR18499836831 ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become *beneficiary* No ('8')

in Grant Agreement No 653718 ('the Agreement')

between BUREAU DE RECHERCHES GEOLOGIQUES ET MINIERES **and** *the Innovation and Networks Executive Agency (INEA) ('the Agency'), under the power delegated by the European Commission ('the Commission'),*

for the action entitled 'ENabling Onshore CO2 Storage in Europe (ENOS)'.

and mandates

the *coordinator* to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

gilles MUNIER with ECAS id nmungill signed in the Participant
Portal on 08/08/2016 at 13:42:03 (transaction id SigId-63351-
VBalvlhUCbiXWURgLCi6zy6BJ3YO6i3bsE8nllS13YszxzTnfrlFVlxf8
2oSWIbZXZ31JhlwaJzeX66MphzUjWM-Jj71zxYb8yr5dzX2DFZb8K-
4LDdi9chKkd55Qsls9NV0wIE3DFEaEBkOK6Ln5URkL0).
Timestamp by third party at
Mon Aug 08 14:42:11 CEST 2016



ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

I.D.I.L. SAS (INGENIERIE-DEVELOPPEMENT-INSTRUMENTATION-LASER) (IDIL)

SAS, 401282371, established in 21 RUE DE BROGLIE, LANNION 22300, France, FR10401282371 ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become *beneficiary* No ('9')

in Grant Agreement No 653718 ('the Agreement')

between BUREAU DE RECHERCHES GEOLOGIQUES ET MINIERES **and** *the Innovation and Networks Executive Agency (INEA) ('the Agency'), under the power delegated by the European Commission ('the Commission'),*

for the action entitled 'ENabling Onshore CO2 Storage in Europe (ENOS)'.

and mandates

the *coordinator* to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Lionel QUÉTEL with ECAS id nqueteli signed in the Participant Portal on 08/08/2016 at 14:41:24 (transaction id SigId-64555-54P7vEdL7EDrW97zNFdsGFeZgXZ6JrolyNuhQG144sT9R0izK3ahP0BJYL1dPdPJGeSQ90GvzaNKTOatZOzuQK0-Jj71zxYb8yr5dzX2DFZb8K-4DArW1rlbFp7sZUH29xSbCewitLiC2T0MEBXm8DKQQA). Timestamp by third party at Mon Aug 08 15:41:31 CEST 2016



ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

INTERNATIONAL RESEARCH INSTITUTE OF STAVANGER AS (IRIS) AS, 988944459, established in PROFESSOR OLAV HANSENS VEI 15, Stavanger 4068 , Norway, NO988944459MVA ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become *beneficiary* No ('10')

in Grant Agreement No 653718 ('the Agreement')

between BUREAU DE RECHERCHES GEOLOGIQUES ET MINIERES and *the Innovation and Networks Executive Agency (INEA) ('the Agency')*, under the power delegated by the European Commission ('the Commission'),

for the action entitled 'ENabling Onshore CO2 Storage in Europe (ENOS)'.

and mandates

the *coordinator* to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Kristin FLORNES with ECAS id nflornkr signed in the Participant Portal on 08/08/2016 at 13:39:47 (transaction id Sigld-63316-ncn4uOTzsoblybOvxGJwYiWifjnRCIWizsc0D0n4hBMvK3ebt4qfTBnzzN7htGguo2OpvOO6evCi5nm2YoTbSim-Jj71zxYb8yr5dzX2DFZb8K-Y5eMKnqWeMzuHLNMgwwFQHZD9ZoDFrEqAWBdrBqsoWk).
Timestamp by third party at
Mon Aug 08 14:39:54 CEST 2016



ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

NHAZCA SRL (NHAZCA) SRL, 1250972, established in VIA CORI S.N.C., ROMA 00177, Italy, IT10711191006 ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become *beneficiary* No ('11')

in Grant Agreement No 653718 ('the Agreement')

between BUREAU DE RECHERCHES GEOLOGIQUES ET MINIERES **and** *the Innovation and Networks Executive Agency (INEA) ('the Agency'), under the power delegated by the European Commission ('the Commission'),*

for the action entitled 'ENabling Onshore CO2 Storage in Europe (ENOS)'.

and mandates

the *coordinator* to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Paolo MAZZANTI with ECAS id nmzzanpa signed in the Participant Portal on 22/08/2016 at 15:31:36 (transaction id SigId-12061-JyiOEnwZtspVwMJaaCdnPNo2sF4dmNzODPKy8CsfNhgfc178wTm1xBC56WJiL1CTLPwEupQB3LzzbTCmehDzcm-Jj71zxYb8yrRavPD4Brza1-SfL6JKOvupSaitE0FUuPzljSMNvyC5b5kkyDoziRlnzm). Timestamp by third party at Mon Aug 22 16:31:44 CEST 2016



ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

ISTITUTO NAZIONALE DI OCEANOLOGRAFIA E DI GEOFISICA SPERIMENTALE (OGS), 58665, established in Borgo Grotta Gigante 42/C, SGONICO-TRIESTE 34010, Italy, IT00055590327 ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become *beneficiary* No ('12')

in Grant Agreement No 653718 ('the Agreement')

between BUREAU DE RECHERCHES GEOLOGIQUES ET MINIERES **and** *the Innovation and Networks Executive Agency (INEA) ('the Agency'), under the power delegated by the European Commission ('the Commission'),*

for the action entitled 'ENabling Onshore CO2 Storage in Europe (ENOS)'.

and mandates

the *coordinator* to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

maria cristina PEDICCHIO with ECAS id npediccm signed in the Participant Portal on 06/09/2016 at 15:35:29 (transaction id SigId-22276-jB4zKxdiOQW46SIPtAwzW0YAYuGWzObaOk3I9unjavuklITrTxxZCo5x4mZunYvpgFjppJXTCFuT1Tikumiaip0-Jj71zxYb8yrYiyGUQxsv0-idEUivWEeLmJZ6YT3taPPmsU50tH6jv0mxjiTcGGfsu). Timestamp by third party at Tue Sep 06 16:35:41 CEST 2016



ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

PALENCIA 3 INVESTIGACION DESARROLLO Y EXPLOTACION SL (PLC-3) SL, P6379, established in CALLE ERIC KANDEL 1, GETAFE 28906, Spain, ESB85971224 ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become *beneficiary* No ('13')

in Grant Agreement No 653718 ('the Agreement')

between BUREAU DE RECHERCHES GEOLOGIQUES ET MINIERES **and** *the Innovation and Networks Executive Agency (INEA) ('the Agency'), under the power delegated by the European Commission ('the Commission'),*

for the action entitled 'ENabling Onshore CO2 Storage in Europe (ENOS)'.

and mandates

the *coordinator* to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary



ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

STATNY GEOLOGICKY USTAV DIONYZA STURA (SGIDS), 31753604, established in MLYNSKA DOLINA 1, BRATISLAVA 81704, Slovakia, SK2020719646 ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become *beneficiary* No ('14')

in Grant Agreement No 653718 ('the Agreement')

between BUREAU DE RECHERCHES GEOLOGIQUES ET MINIERES **and** *the Innovation and Networks Executive Agency (INEA) ('the Agency'), under the power delegated by the European Commission ('the Commission'),*

for the action entitled 'ENabling Onshore CO2 Storage in Europe (ENOS)'.

and mandates

the *coordinator* to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Branislav ZEC with ECAS id nzechbran signed in the Participant Portal on 23/08/2016 at 16:04:51 (transaction id SigId-23594-PtYXX9Ailj4PhQvoozdPFWYbogUoLpd26j0NuWzWvi01aQbFXjUI6w78kzdo6BvRfc6cAwuDpjPW6vOZWncGWy0-Jj71zxYb8yrRavPD4Brza1-AWrirFNqSdl7YAxFzmSgF4fPjQFnFBqgGF8MdneJizm). Timestamp by third party at Tue Aug 23 17:05:01 CEST 2016



ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

SILIXA LTD (SILIXA), 06207412, established in CENTENNIAL AVENUE 230 CENTENNIAL, ELSTREE HERTFORDSHIRE WD6 3SN, United Kingdom, GB919322914 ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become *beneficiary* No ('15')

in Grant Agreement No 653718 ('the Agreement')

between BUREAU DE RECHERCHES GEOLOGIQUES ET MINIERES **and** *the Innovation and Networks Executive Agency (INEA) ('the Agency'), under the power delegated by the European Commission ('the Commission'),*

for the action entitled 'ENabling Onshore CO2 Storage in Europe (ENOS)'.

and mandates

the *coordinator* to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

RASHEED ABAYOMI with ECAS id nabayora signed in the Participant Portal on 18/08/2016 at 14:15:12 (transaction id SigId-1737-ROR332ezzkp1Zo6s9O8qPBcLa8CyVKRMEogEK3Q2frfM360Kk1Dw3Is6zdS5tj40KKRziEJEgC9eSmtR4gKcO-PHsiUMVSXYCs9DMKG9nW3i-gdAWn9VSWEfVC3NQ4Uf7eHizYYfdP5d4iamajfn4Vog). Timestamp by third party at Thu Aug 18 15:15:24 CEST 2016



ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

SOTACARBO - SOCIETA TECNOLOGIE AVANZATE CARBONE SPA. (SOTACARBO) SPA, CA-139833, established in C/O EX MINIERA DI SERBARIU, CARBONIA 09013, Italy, IT01714900923 ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become *beneficiary* No ('16')

in Grant Agreement No 653718 ('the Agreement')

between BUREAU DE RECHERCHES GEOLOGIQUES ET MINIERES **and** *the Innovation and Networks Executive Agency (INEA) ('the Agency'), under the power delegated by the European Commission ('the Commission'),*

for the action entitled 'ENabling Onshore CO2 Storage in Europe (ENOS)'.

and mandates

the *coordinator* to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Alberto PETTINAU with ECAS id npettalb signed in the Participant Portal on 08/08/2016 at 20:41:01 (transaction id SigId-67596-tJkm04uVZzh3eDeUypvicgjry9Zu0fVS9g7OHUQI7AIW94vrhZJQgxkx F6Vn5zSDWXYWM7dELrEktD5v0Q6i6-Jj71zxYb8yr5dzX2DFZb8K-9nKubAySPzI81iMx12Sf92l0nvqvc2CEEPGLZjgzUeW). Timestamp by third party at Mon Aug 08 21:41:11 CEST 2016



ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

NEDERLANDSE ORGANISATIE VOOR TOEGEPAST NATUURWETENSCHAPPELIJK ONDERZOEK TNO (TNO), 27376655, established in ANNA VAN BUERENPLEIN 1, DEN HAAG 2595 DA, Netherlands, NL002875718B01 ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become *beneficiary* No ('17')

in Grant Agreement No 653718 ('the Agreement')

between BUREAU DE RECHERCHES GEOLOGIQUES ET MINIERES **and** *the Innovation and Networks Executive Agency (INEA) ('the Agency'), under the power delegated by the European Commission ('the Commission'),*

for the action entitled 'ENabling Onshore CO2 Storage in Europe (ENOS)'.

and mandates

the *coordinator* to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Mart VAN BRACHT with ECAS id nvanbrmt signed in the Participant Portal on 10/08/2016 at 11:47:37 (transaction id SigId-84369-B2R13xAv0vyM0nPawFiNrUglGIPG7jxU2gukvrjaQjiPHoFzR4i3PKX4neHNKyBbqzJpS8znxFt0m7x01zSDAs4-Jj71zxYb8yr5dzX2DFZb8K-SOWBtiKelt5kgZPfv5DXfbVoelrI5DznrdADajyZjto). Timestamp by third party at Wed Aug 10 12:47:48 CEST 2016



ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

UNIVERSITA DEGLI STUDI DI ROMA LA SAPIENZA (UNIROMA1), 80209930587, established in Piazzale Aldo Moro 5, ROMA 00185, Italy, IT02133771002 ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become *beneficiary* No ('18')

in Grant Agreement No 653718 ('the Agreement')

between BUREAU DE RECHERCHES GEOLOGIQUES ET MINIERES **and** *the Innovation and Networks Executive Agency (INEA) ('the Agency'), under the power delegated by the European Commission ('the Commission'),*

for the action entitled 'ENabling Onshore CO2 Storage in Europe (ENOS)'.

and mandates

the *coordinator* to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Francesca BOZZANO with ECAS id nbozzanf signed in the Participant Portal on 09/08/2016 at 10:32:09 (transaction id SigId-71365-Mcs1NzvqcgVx81sy02PvVSXesiWaiRxp3eBUV68Ffa5ezfSzou1LzjM9zGRpCxlsfI0zh9nu12QpP2XYpUd4kpG-Jj71zxYb8yr5dzX2DFZb8K-fHapixMkCaLvQg9VTTJu7KwdAXMeW5QyGXBc9eZ92Ry).
Timestamp by third party at
Tue Aug 09 11:32:19 CEST 2016



ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

THE UNIVERSITY OF NOTTINGHAM (UNOTT), established in University Park, NOTTINGHAM NG7 2RD, United Kingdom, GB690391225 ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become *beneficiary* No ('19')

in Grant Agreement No 653718 ('the Agreement')

between BUREAU DE RECHERCHES GEOLOGIQUES ET MINIERES **and** *the Innovation and Networks Executive Agency (INEA) ('the Agency'), under the power delegated by the European Commission ('the Commission'),*

for the action entitled 'ENabling Onshore CO2 Storage in Europe (ENOS)'.

and mandates

the *coordinator* to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Ryan KEYWORTH with ECAS id nkeywory signed in the Participant Portal on 10/08/2016 at 09:09:15 (transaction id SigId-81368-zNLAQLwKIRJF5LRXIL3zQAjCCzzv7TQ174nqzjYblpnP6InzMfWMI5EA liBazt1hU5XamBSwkhUWbEurPxIHT5CG-Jj71zxYb8yr5dzX2DFZb8K-uOgM8STzNOUzrgXqMzimVuE75LLbXENzyNzmAzK8xbINW).
Timestamp by third party at
Wed Aug 10 10:09:25 CEST 2016



ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

CO2GEONET - RESEAU D'EXCELLENCE EUROPEEN SUR LE STOCKAGE GEOLOGIQUE DE CO2 (CO2GeoNet) FR3, 508292802, established in avenue Claude Guillemin 3, ORLEANS 45060 , France, FR06508292802 ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become *beneficiary* No ('20')

in Grant Agreement No 653718 ('the Agreement')

between BUREAU DE RECHERCHES GEOLOGIQUES ET MINIERES **and** *the Innovation and Networks Executive Agency (INEA) ('the Agency'), under the power delegated by the European Commission ('the Commission'),*

for the action entitled 'ENabling Onshore CO2 Storage in Europe (ENOS)'.

and mandates

the *coordinator* to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Car MARJETA with ECAS id nmarjcar signed in the Participant Portal on 22/08/2016 at 12:49:56 (transaction id SigId-9018-VRo4tbjGzPj59Xy3297YTPiDIFhxy8H3kGrzUjgo70TrMZi4CjfATJEOgeCzqb9saqdzzbssASdv4DV20tI0TGW-Jj71zxYb8yrRavPD4Brza1-GXqQvuqzHk3cHhHvriAtNqFsXKq968Eik2zIYc9Hpi9m). Timestamp by third party at Mon Aug 22 13:50:04 CEST 2016



ANNEX 3a

DECLARATION ON JOINT AND SEVERAL LIABILITY OF LINKED THIRD PARTIES

FUNDACION INSTITUTO PETROFISICO (IPF) ES3, 1117, established in C/ ALENZA 1, MADRID 28003, Spain, ESG85532927 ('the linked third party'), represented for the purpose of signing this Declaration on joint and several liability by its legal representative(s) [forename and surname, function of the legal representative(s) of the linked third party],

linked to beneficiary No 13 **PALENCIA 3 INVESTIGACION DESARROLLO Y EXPLOTACION SL (PLC-3)** SL, P6379, established in CALLE ERIC KANDEL 1, GETAFE 28906, Spain, ESB85971224 ('the beneficiary'),

hereby accepts joint and several liability with the beneficiary

for any amount owed to the *Agency* by the beneficiary under Grant Agreement No 653718 (ENOS), up to the maximum EU contribution indicated, for the linked third party, in the estimated budget (see Annex 2).

The linked third party irrevocably and unconditionally agrees to pay amounts requested under this Declaration to the *Agency*, immediately and at first demand.

For the linked third party
[forename/surname/function]

Done in English at [place], on [date]



ANNEX 3a

DECLARATION ON JOINT AND SEVERAL LIABILITY OF LINKED THIRD PARTIES

ENAGAS INTERNACIONAL SL (ENAGAS) SL, M538271, established in PASEO DE LOS OLMOS 19, MADRID 28005, Spain, ESB86466646 ('the linked third party'), represented for the purpose of signing this Declaration on joint and several liability by its legal representative(s) [forename and surname, function of the legal representative(s) of the linked third party],

linked to beneficiary No 13 **PALENCIA 3 INVESTIGACION DESARROLLO Y EXPLOTACION SL (PLC-3)** SL, P6379, established in CALLE ERIC KANDEL 1, GETAFE 28906, Spain, ESB85971224 ('the beneficiary'),

hereby accepts joint and several liability with the beneficiary

for any amount owed to the *Agency* by the beneficiary under Grant Agreement No 653718 (ENOS), up to the maximum EU contribution indicated, for the linked third party, in the estimated budget (see Annex 2).

The linked third party irrevocably and unconditionally agrees to pay amounts requested under this Declaration to the *Agency*, immediately and at first demand.

For the linked third party
[forename/surname/function]

Done in English at [place], on [date]



ANNEX 3a

DECLARATION ON JOINT AND SEVERAL LIABILITY OF LINKED THIRD PARTIES

MIDDLE EAST TECHNICAL UNIVERSITY (METU), 6887, established in DÜMLÜPINAR BULVARI 1, ANKARA 06800, Turkey, TR6320050974 ('the linked third party'), represented for the purpose of signing this Declaration on joint and several liability by its legal representative(s) [forename and surname, function of the legal representative(s) of the linked third party],

linked to beneficiary No 20 **CO2GEONET - RESEAU D'EXCELLENCE EUROPEEN SUR LE STOCKAGE GEOLOGIQUE DE CO2 (CO2GeoNet)** FR3, 508292802, established in avenue Claude Guillemin 3, ORLEANS 45060, France, FR06508292802 ('the beneficiary'),

hereby accepts joint and several liability with the beneficiary

for any amount owed to the *Agency* by the beneficiary under Grant Agreement No 653718 (ENOS), up to the maximum EU contribution indicated, for the linked third party, in the estimated budget (see Annex 2).

The linked third party irrevocably and unconditionally agrees to pay amounts requested under this Declaration to the *Agency*, immediately and at first demand.

For the linked third party
[forename/surname/function]

Done in English at [place], on [date]



ANNEX 3a

DECLARATION ON JOINT AND SEVERAL LIABILITY OF LINKED THIRD PARTIES

GEOLOGISCHE BUNDESANSTALT (GBA), established in NEULINGGASSE 38, WIEN 1030, Austria, ATU40330600 ('the linked third party'), represented for the purpose of signing this Declaration on joint and several liability by its legal representative(s) [forename and surname, function of the legal representative(s) of the linked third party],

linked to beneficiary No 20 **CO2GEONET - RESEAU D'EXCELLENCE EUROPEEN SUR LE STOCKAGE GEOLOGIQUE DE CO2 (CO2GeoNet)** FR3, 508292802, established in avenue Claude Guillemin 3, ORLEANS 45060, France, FR06508292802 ('the beneficiary'),

hereby accepts joint and several liability with the beneficiary

for any amount owed to the *Agency* by the beneficiary under Grant Agreement No 653718 (ENOS), up to the maximum EU contribution indicated, for the linked third party, in the estimated budget (see Annex 2).

The linked third party irrevocably and unconditionally agrees to pay amounts requested under this Declaration to the *Agency*, immediately and at first demand.

For the linked third party
[forename/surname/function]

Done in English at [place], on [date]



ANNEX 3a

DECLARATION ON JOINT AND SEVERAL LIABILITY OF LINKED THIRD PARTIES

HERIOT-WATT UNIVERSITY (HWU), 000216, established in Riccarton, EDINBURGH EH14 4AS, United Kingdom, GB270800579 ('the linked third party'), represented for the purpose of signing this Declaration on joint and several liability by its legal representative(s) [forename and surname, function of the legal representative(s) of the linked third party],

linked to beneficiary No 20 **CO2GEONET - RESEAU D'EXCELLENCE EUROPEEN SUR LE STOCKAGE GEOLOGIQUE DE CO2 (CO2GeoNet)** FR3, 508292802, established in avenue Claude Guillemin 3, ORLEANS 45060 , France, FR06508292802 ('the beneficiary'),

hereby accepts joint and several liability with the beneficiary

for any amount owed to the *Agency* by the beneficiary under Grant Agreement No 653718 (ENOS), up to the maximum EU contribution indicated, for the linked third party, in the estimated budget (see Annex 2).

The linked third party irrevocably and unconditionally agrees to pay amounts requested under this Declaration to the *Agency*, immediately and at first demand.

For the linked third party
[forename/surname/function]

Done in English at [place], on [date]



ANNEX 3a

DECLARATION ON JOINT AND SEVERAL LIABILITY OF LINKED THIRD PARTIES

SVEUCILISTE U ZAGREBU RUDARSKO-GEOLOSKO-NAFTNI FAKULTET (UNIZG-RGNF), 080159382, established in PIEROTTIJEVA 6, ZAGREB 10 000, Croatia, HR99534693762 ('the linked third party'), represented for the purpose of signing this Declaration on joint and several liability by its legal representative(s) [forename and surname, function of the legal representative(s) of the linked third party],

linked to beneficiary No 20 **CO2GEONET - RESEAU D'EXCELLENCE EUROPEEN SUR LE STOCKAGE GEOLOGIQUE DE CO2 (CO2GeoNet)** FR3, 508292802, established in avenue Claude Guillemin 3, ORLEANS 45060 , France, FR06508292802 ('the beneficiary'),

hereby accepts joint and several liability with the beneficiary

for any amount owed to the *Agency* by the beneficiary under Grant Agreement No 653718 (ENOS), up to the maximum EU contribution indicated, for the linked third party, in the estimated budget (see Annex 2).

The linked third party irrevocably and unconditionally agrees to pay amounts requested under this Declaration to the *Agency*, immediately and at first demand.

For the linked third party
[forename/surname/function]

Done in English at [place], on [date]



ANNEX 3a

DECLARATION ON JOINT AND SEVERAL LIABILITY OF LINKED THIRD PARTIES

Geological Survey of Denmark and Greenland (GEUS), 55145016, established in OSTER VOLDGADE 10, KOBENHAVN K 1350, Denmark, DK55145016 ('the linked third party'), represented for the purpose of signing this Declaration on joint and several liability by its legal representative(s) [forename and surname, function of the legal representative(s) of the linked third party],

linked to beneficiary No 20 **CO2GEONET - RESEAU D'EXCELLENCE EUROPEEN SUR LE STOCKAGE GEOLOGIQUE DE CO2 (CO2GeoNet)** FR3, 508292802, established in avenue Claude Guillemin 3, ORLEANS 45060 , France, FR06508292802 ('the beneficiary'),

hereby accepts joint and several liability with the beneficiary

for any amount owed to the *Agency* by the beneficiary under Grant Agreement No 653718 (ENOS), up to the maximum EU contribution indicated, for the linked third party, in the estimated budget (see Annex 2).

The linked third party irrevocably and unconditionally agrees to pay amounts requested under this Declaration to the *Agency*, immediately and at first demand.

For the linked third party
[forename/surname/function]

Done in English at [place], on [date]



ANNEX 3a

DECLARATION ON JOINT AND SEVERAL LIABILITY OF LINKED THIRD PARTIES

INSTITUTO GEOLÓGICO Y MINERO DE ESPAÑA (IGME), 1953/2000, established in RÍOS ROSAS 23, MADRID 28003, Spain, ESQ2820007I ('the linked third party'), represented for the purpose of signing this Declaration on joint and several liability by its legal representative(s) [forename and surname, function of the legal representative(s) of the linked third party],

linked to beneficiary No 20 **CO2GEONET - RESEAU D'EXCELLENCE EUROPEEN SUR LE STOCKAGE GEOLOGIQUE DE CO2 (CO2GeoNet)** FR3, 508292802, established in avenue Claude Guillemin 3, ORLEANS 45060 , France, FR06508292802 ('the beneficiary'),

hereby accepts joint and several liability with the beneficiary

for any amount owed to the *Agency* by the beneficiary under Grant Agreement No 653718 (ENOS), up to the maximum EU contribution indicated, for the linked third party, in the estimated budget (see Annex 2).

The linked third party irrevocably and unconditionally agrees to pay amounts requested under this Declaration to the *Agency*, immediately and at first demand.

For the linked third party
[forename/surname/function]

Done in English at [place], on [date]



ANNEX 3a

DECLARATION ON JOINT AND SEVERAL LIABILITY OF LINKED THIRD PARTIES

INSTITUTUL NATIONAL DE CERCETARE-DEZVOLTARE PENTRU GEOLOGIE SI GEOECOLOGIE MARINA-GEOECOMAR (GEOECOMAR), J40/1075/17.02.1997, established in DIMITRIE ONCIUL STREET 23-25, BUCHAREST 024053, Romania, RO5194978 ('the linked third party'), represented for the purpose of signing this Declaration on joint and several liability by its legal representative(s) [forename and surname, function of the legal representative(s) of the linked third party],

linked to beneficiary No 20 **CO2GEONET - RESEAU D'EXCELLENCE EUROPEEN SUR LE STOCKAGE GEOLOGIQUE DE CO2 (CO2GeoNet)** FR3, 508292802, established in avenue Claude Guillemin 3, ORLEANS 45060 , France, FR06508292802 ('the beneficiary'),

hereby accepts joint and several liability with the beneficiary

for any amount owed to the *Agency* by the beneficiary under Grant Agreement No 653718 (ENOS), up to the maximum EU contribution indicated, for the linked third party, in the estimated budget (see Annex 2).

The linked third party irrevocably and unconditionally agrees to pay amounts requested under this Declaration to the *Agency*, immediately and at first demand.

For the linked third party
[forename/surname/function]

Done in English at [place], on [date]



ANNEX 3a

DECLARATION ON JOINT AND SEVERAL LIABILITY OF LINKED THIRD PARTIES

TALLINNA TEHNIKAULIKOOL (TTUGI), 74000323, established in Ehitajate tee 5, TALLINN 19086, Estonia, EE100224841 ('the linked third party'), represented for the purpose of signing this Declaration on joint and several liability by its legal representative(s) [forename and surname, function of the legal representative(s) of the linked third party],

linked to beneficiary No 20 **CO2GEONET - RESEAU D'EXCELLENCE EUROPEEN SUR LE STOCKAGE GEOLOGIQUE DE CO2 (CO2GeoNet)** FR3, 508292802, established in avenue Claude Guillemin 3, ORLEANS 45060, France, FR06508292802 ('the beneficiary'),

hereby accepts joint and several liability with the beneficiary

for any amount owed to the *Agency* by the beneficiary under Grant Agreement No 653718 (ENOS), up to the maximum EU contribution indicated, for the linked third party, in the estimated budget (see Annex 2).

The linked third party irrevocably and unconditionally agrees to pay amounts requested under this Declaration to the *Agency*, immediately and at first demand.

For the linked third party
[forename/surname/function]

Done in English at [place], on [date]



ANNEX 3a

DECLARATION ON JOINT AND SEVERAL LIABILITY OF LINKED THIRD PARTIES

INSTITUT ROYAL DES SCIENCES NATURELLES DE BELGIQUE (GSB-RBINS), N/A, established in RUE VAUTIER 29, BRUXELLES 1000, Belgium, BE0353070496 ('the linked third party'), represented for the purpose of signing this Declaration on joint and several liability by its legal representative(s) [forename and surname, function of the legal representative(s) of the linked third party],

linked to beneficiary No 20 **CO2GEONET - RESEAU D'EXCELLENCE EUROPEEN SUR LE STOCKAGE GEOLOGIQUE DE CO2 (CO2GeoNet)** FR3, 508292802, established in avenue Claude Guillemin 3, ORLEANS 45060 , France, FR06508292802 ('the beneficiary'),

hereby accepts joint and several liability with the beneficiary

for any amount owed to the *Agency* by the beneficiary under Grant Agreement No 653718 (ENOS), up to the maximum EU contribution indicated, for the linked third party, in the estimated budget (see Annex 2).

The linked third party irrevocably and unconditionally agrees to pay amounts requested under this Declaration to the *Agency*, immediately and at first demand.

For the linked third party
[forename/surname/function]

Done in English at [place], on [date]



ANNEX 3a

DECLARATION ON JOINT AND SEVERAL LIABILITY OF LINKED THIRD PARTIES

GEOINZENIRING DRUZBA ZA GEOLOSKI INZENIRING DOO (GEOINZ) DOO, 1328484000, established in DIMICEVA ULICA 14, LJUBLJANA 1000, Slovenia, SI10467050 ('the linked third party'), represented for the purpose of signing this Declaration on joint and several liability by its legal representative(s) [forename and surname, function of the legal representative(s) of the linked third party],

linked to beneficiary No 20 **CO2GEONET - RESEAU D'EXCELLENCE EUROPEEN SUR LE STOCKAGE GEOLOGIQUE DE CO2 (CO2GeoNet)** FR3, 508292802, established in avenue Claude Guillemin 3, ORLEANS 45060 , France, FR06508292802 ('the beneficiary'),

hereby accepts joint and several liability with the beneficiary

for any amount owed to the *Agency* by the beneficiary under Grant Agreement No 653718 (ENOS), up to the maximum EU contribution indicated, for the linked third party, in the estimated budget (see Annex 2).

The linked third party irrevocably and unconditionally agrees to pay amounts requested under this Declaration to the *Agency*, immediately and at first demand.

For the linked third party
[forename/surname/function]

Done in English at [place], on [date]

🖨️ print format A4
landscape

MODEL ANNEX 4 FOR H2020 GENERAL MGA — MULTI

FINANCIAL STATEMENT FOR [BENEFICIARY [name]/ LINKED THIRD PARTY [name]] FOR REPORTING PERIOD [reporting period]

	Eligible ¹ costs (per budget category)												Receipts	EU contribution				Additional information
	A. Direct personnel costs				B. Direct costs of subcontracting	[C. Direct costs of fin. support]	D. Other direct costs		E. Indirect costs ²		[F. Costs of ...]		Total costs	Receipts	Reimbursement rate %	Maximum EU contribution ³	Requested EU contribution	Information for indirect costs : Costs of in-kind contributions not used on premises
	A.1 Employees (or equivalent)		A.4 SME owners without salary				D.1 Travel	[D.4 Costs of large research infrastructure]		[F.1 Costs of ...]			Receipts of the action, to be reported in the last reporting period, according to Article 5.3.3					
	A.2 Natural persons under direct contract		A.5 Beneficiaries that are natural persons without salary				D.2 Equipment											
	A.3 Seconded persons						D.3 Other goods and services											
[A.6 Personnel for providing access to research infrastructure]																		
Form of costs ⁴	Actual	Unit	Unit		Actual	Actual	Actual	Actual	Flat-rate ⁵	Unit		Unit						
									25%									
	a	Total b	No hours	Total c	d	[e]	f	[g]	h=0,25 x (a+b+c+f+[g] + [i1] ⁶ +[i2] ⁶ - o)	No units	Total [i1]	Total [i2]	j = a+b+c+d+[e] +f+[g] +h+[i1] +[i2]	k	l	m	n	o
[short name beneficiary/linked third party]																		

The beneficiary/linked third party hereby confirms that:
The information provided is complete, reliable and true.
The costs declared are eligible (see Article 6).
The costs can be substantiated by adequate records and supporting documentation that will be produced upon request or in the context of checks, reviews, audits and investigations (see Articles 17, 18 and 22).
For the last reporting period: that all the receipts have been declared (see Article 5.3.3).

📌 Please declare all eligible costs, even if they exceed the amounts indicated in the estimated budget (see Annex 2). Only amounts that were declared in your individual financial statements can be taken into account lateron, in order to replace other costs that are found to be ineligible.

¹ See Article 6 for the eligibility conditions

² The indirect costs claimed must be free of any amounts covered by an operating grant (received under any EU or Euratom funding programme; see Article 6.2.E). If you have received an operating grant during this reporting period, you cannot claim any indirect costs.

³ This is the *theoretical* amount of EU contribution that the system calculates automatically (by multiplying the reimbursement rate by the total costs declared). The amount you request (in the column 'requested EU contribution') may have to be less (e.g. if you and the other beneficiaries are above budget, if the 90% limit (see Article 21) is reached, etc).

⁴ See Article 5 for the form of costs

⁵ Flat rate : 25% of eligible direct costs, from which are excluded: direct costs of subcontracting, costs of in-kind contributions not used on premises, direct costs of financial support, and unit costs declared under budget category F if they include indirect costs (see Article 6.2.E)

⁶ Only specific unit costs that do not include indirect costs

H2020 Model Grant Agreements: H2020 General MGA — Multi: September 2014

ANNEX 5

MODEL FOR THE CERTIFICATE ON THE FINANCIAL STATEMENTS

- For options [*in italics in square brackets*]: choose the applicable option. Options not chosen should be deleted.
- For fields in [grey in square brackets]: enter the appropriate data

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H2020 Model Grant Agreements: H2020 General MGA — Multi: September 2014

Terms of Reference for an Independent Report of Factual Findings on costs declared under a Grant Agreement financed under the Horizon 2020 Research and Innovation Framework Programme

This document sets out the ‘**Terms of Reference (ToR)**’ under which

[OPTION 1: [insert name of the beneficiary] (*‘the Beneficiary’*)] [OPTION 2: [insert name of the linked third party] (*‘the Linked Third Party’*), third party linked to the Beneficiary [insert name of the beneficiary] (*‘the Beneficiary’*)]

agrees to engage

[insert legal name of the auditor] (*‘the Auditor’*)

to produce an independent report of factual findings (*‘the Report’*) concerning the Financial Statement(s)¹ drawn up by the [Beneficiary] [Linked Third Party] for the Horizon 2020 grant agreement [insert number of the grant agreement, title of the action, acronym and duration from/to] (*‘the Agreement’*), and

to issue a Certificate on the Financial Statements’ (*‘CFS’*) referred to in Article 20.4 of the Agreement based on the compulsory reporting template stipulated by the Commission.

The Agreement has been concluded under the Horizon 2020 Research and Innovation Framework Programme (H2020) between the Beneficiary and [OPTION 1: *the European Union, represented by the European Commission (‘the Commission’)*][OPTION 2: *the European Atomic Energy Community (Euratom,) represented by the European Commission (‘the Commission’)*][OPTION 3: *the [Research Executive Agency (REA)] [European Research Council Executive Agency (ERCEA)] [Innovation and Networks Executive Agency (INEA)] [Executive Agency for Small and Medium-sized Enterprises (EASME)] (‘the Agency’), under the powers delegated by the European Commission (‘the Commission’).*]

¹ By which costs under the Agreement are declared (see template ‘Model Financial Statements’ in Annex 4 to the Grant Agreement).

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The *[Commission]* *[Agency]* is mentioned as a signatory of the Agreement with the Beneficiary only.
The *[European Union]**[Euratom]**[Agency]* is not a party to this engagement.

1.1 Subject of the engagement

The coordinator must submit to the *[Commission]**[Agency]* the final report within 60 days following the end of the last reporting period which should include, amongst other documents, a CFS for each beneficiary and for each linked third party that requests a total contribution of EUR 325 000 or more, as reimbursement of actual costs and unit costs calculated on the basis of its usual cost accounting practices (see Article 20.4 of the Agreement). The CFS must cover all reporting periods of the beneficiary or linked third party indicated above.

The Beneficiary must submit to the coordinator the CFS for itself and for its linked third party(ies), if the CFS must be included in the final report according to Article 20.4 of the Agreement..

The CFS is composed of two separate documents:

- The Terms of Reference ('the ToR') to be signed by the *[Beneficiary]* *[Linked Third Party]* and the Auditor;
- The Auditor's Independent Report of Factual Findings ('the Report') to be issued on the Auditor's letterhead, dated, stamped and signed by the Auditor (or the competent public officer) which includes the agreed-upon procedures ('the Procedures') to be performed by the Auditor, and the standard factual findings ('the Findings') to be confirmed by the Auditor.

If the CFS must be included in the final report according to Article 20.4 of the Agreement, the request for payment of the balance relating to the Agreement cannot be made without the CFS. However, the payment for reimbursement of costs covered by the CFS does not preclude the *[Commission]*,*[Agency]*, the European Anti-Fraud Office and the European Court of Auditors from carrying out checks, reviews, audits and investigations in accordance with Article 22 of the Agreement.

1.2 Responsibilities

The *[Beneficiary]* *[Linked Third Party]*:

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- must draw up the Financial Statement(s) for the action financed by the Agreement in compliance with the obligations under the Agreement. The Financial Statement(s) must be drawn up according to the *[Beneficiary's] [Linked Third Party's]* accounting and book-keeping system and the underlying accounts and records;
- must send the Financial Statement(s) to the Auditor;
- is responsible and liable for the accuracy of the Financial Statement(s);
- is responsible for the completeness and accuracy of the information provided to enable the Auditor to carry out the Procedures. It must provide the Auditor with a written representation letter supporting these statements. The written representation letter must state the period covered by the statements and must be dated;
- accepts that the Auditor cannot carry out the Procedures unless it is given full access to the *[Beneficiary's] [Linked Third Party's]* staff and accounting as well as any other relevant records and documentation.

The Auditor:

- *[Option 1 by default: is qualified to carry out statutory audits of accounting documents in accordance with Directive 2006/43/EC of the European Parliament and of the Council of 17 May 2006 on statutory audits of annual accounts and consolidated accounts, amending Council Directives 78/660/EEC and 83/349/EEC and repealing Council Directive 84/253/EEC or similar national regulations].*
- *[Option 2 if the Beneficiary or Linked Third Party has an independent Public Officer: is a competent and independent Public Officer for which the relevant national authorities have established the legal capacity to audit the Beneficiary].*
- *[Option 3 if the Beneficiary or Linked Third Party is an international organisation: is an [internal] [external] auditor in accordance with the internal financial regulations and procedures of the international organisation].*

The Auditor:

- must be independent from the Beneficiary *[and the Linked Third Party]*, in particular, it must not have been involved in preparing the *[Beneficiary's] [Linked Third Party's]* Financial Statement(s);
- must plan work so that the Procedures may be carried out and the Findings may be assessed;
- must adhere to the Procedures laid down and the compulsory report format;
- must carry out the engagement in accordance with this ToR;
- must document matters which are important to support the Report;
- must base its Report on the evidence gathered;
- must submit the Report to the *[Beneficiary] [Linked Third Party]*.

The Commission sets out the Procedures to be carried out by the Auditor. The Auditor is not responsible for their suitability or pertinence. As this engagement is not an assurance engagement, the Auditor does not provide an audit opinion or a statement of assurance.

1.3 Applicable Standards

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The Auditor must comply with these Terms of Reference and with²:

- the International Standard on Related Services ('ISRS') 4400 *Engagements to perform Agreed-upon Procedures regarding Financial Information* as issued by the International Auditing and Assurance Standards Board (IAASB);
- the *Code of Ethics for Professional Accountants* issued by the International Ethics Standards Board for Accountants (IESBA). Although ISRS 4400 states that independence is not a requirement for engagements to carry out agreed-upon procedures, the [Commission][Agency] requires that the Auditor also complies with the Code's independence requirements.

The Auditor's Report must state that there is no conflict of interests in establishing this Report between the Auditor and the Beneficiary *[and the Linked Third Party]*, and must specify - if the service is invoiced - the total fee paid to the Auditor for providing the Report.

1.4 Reporting

The Report must be written in the language of the Agreement (see Article 20.7).

Under Article 22 of the Agreement, the [Commission] [Agency], the European Anti-Fraud Office and the Court of Auditors have the right to audit any work that is carried out under the action and for which costs are declared from [the European Union] [Euratom] budget. This includes work related to this engagement. The Auditor must provide access to all working papers (e.g. recalculation of hourly rates, verification of the time declared for the action) related to this assignment if the [Commission] [Agency], the European Anti-Fraud Office or the European Court of Auditors requests them.

1.5 Timing

The Report must be provided by [dd Month yyyy].

² Supreme Audit Institutions applying INTOSAI-standards may carry out the Procedures according to the corresponding International Standards of Supreme Audit Institutions and code of ethics issued by INTOSAI instead of the International Standard on Related Services ('ISRS') 4400 and the Code of Ethics for Professional Accountants issued by the IAASB and the IESBA.

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1.6 Other terms

[The [Beneficiary] [Linked Third Party] and the Auditor can use this section to agree other specific terms, such as the Auditor's fees, liability, applicable law, etc. Those specific terms must not contradict the terms specified above.]

[legal name of the Auditor]

[legal name of the [Beneficiary][Linked Third Party]]

[name & function of authorised representative] [name & function of authorised representative]

[dd Month yyyy]

[dd Month yyyy]

Signature of the Auditor

Signature of the [Beneficiary][Linked Third Party]

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**Independent Report of Factual Findings on costs declared under Horizon 2020 Research and
Innovation Framework Programme**

(To be printed on the Auditor's letterhead)

To

[name of contact person(s)], [Position]

[*Beneficiary's* *Linked Third Party's* name]

[Address]

[dd Month yyyy]

Dear [Name of contact person(s)],

As agreed under the terms of reference dated [dd Month yyyy]

with [OPTION 1: *insert name of the beneficiary*] ('the Beneficiary')] [OPTION 2: *insert name of the
linked third party*] ('the Linked Third Party'), third party linked to the Beneficiary [*insert name of the
beneficiary*] ('the Beneficiary'),

we

[name of the auditor] ('the Auditor'),

established at

[full address/city/state/province/country],

represented by

[name and function of an authorised representative],

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have carried out the procedures agreed with you regarding the costs declared in the Financial Statement(s)³ of the [Beneficiary] [Linked Third Party] concerning the grant agreement

[insert grant agreement reference: number, title of the action and acronym] ('the Agreement'),

with a total cost declared of

[total amount] EUR,

and a total of actual costs and 'direct personnel costs declared as unit costs calculated in accordance with the [Beneficiary's] [Linked Third Party's] usual cost accounting practices' declared of

[sum of total actual costs and total direct personnel costs declared as unit costs calculated in accordance with the [Beneficiary's] [Linked Third Party's] usual cost accounting practices] EUR

and **hereby provide our Independent Report of Factual Findings ('the Report')** using the compulsory report format agreed with you.

The Report

Our engagement was carried out in accordance with the terms of reference ('the ToR') appended to this Report. The Report includes the agreed-upon procedures ('the Procedures') carried out and the standard factual findings ('the Findings') examined.

The Procedures were carried out solely to assist the [Commission] [Agency] in evaluating whether the [Beneficiary's] [Linked Third Party's] costs in the accompanying Financial Statement(s) were declared in accordance with the Agreement. The [Commission] [Agency] draws its own conclusions from the Report and any additional information it may require.

³ By which the Beneficiary declares costs under the Agreement (see template 'Model Financial Statement' in Annex 4 to the Agreement).

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The scope of the Procedures was defined by the Commission. Therefore, the Auditor is not responsible for their suitability or pertinence. Since the Procedures carried out constitute neither an audit nor a review made in accordance with International Standards on Auditing or International Standards on Review Engagements, the Auditor does not give a statement of assurance on the Financial Statements.

Had the Auditor carried out additional procedures or an audit of the *[Beneficiary's] [Linked Third Party's]* Financial Statements in accordance with International Standards on Auditing or International Standards on Review Engagements, other matters might have come to its attention and would have been included in the Report.

Not applicable Findings

We examined the Financial Statement(s) stated above and considered the following Findings not applicable:

Explanation (to be removed from the Report):

If a Finding was not applicable, it must be marked as 'N.A.' ('Not applicable') in the corresponding row on the right-hand column of the table and means that the Finding did not have to be corroborated by the Auditor and the related Procedure(s) did not have to be carried out.

The reasons of the non-application of a certain Finding must be obvious i.e.

- i) if no cost was declared under a certain category then the related Finding(s) and Procedure(s) are not applicable;*
- ii) if the condition set to apply certain Procedure(s) are not met the related Finding(s) and those Procedure(s) are not applicable. For instance, for 'beneficiaries with accounts established in a currency other than euro' the Procedure and Finding related to 'beneficiaries with accounts established in euro' are not applicable. Similarly, if no additional remuneration is paid, the related Finding(s) and Procedure(s) for additional remuneration are not applicable.*

List here all Findings considered not applicable for the present engagement and explain the reasons of the non-applicability.

....

Exceptions

Apart from the exceptions listed below, the *[Beneficiary] [Linked Third Party]* provided the Auditor all the documentation and accounting information needed by the Auditor to carry out the requested Procedures and evaluate the Findings.

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Explanation (to be removed from the Report):

- If the Auditor was not able to successfully complete a procedure requested, it must be marked as 'E' ('Exception') in the corresponding row on the right-hand column of the table. The reason such as the inability to reconcile key information or the unavailability of data that prevents the Auditor from carrying out the Procedure must be indicated below.
- If the Auditor cannot corroborate a standard finding after having carried out the corresponding procedure, it must also be marked as 'E' ('Exception') and, where possible, the reasons why the Finding was not fulfilled and its possible impact must be explained here below.

List here any exceptions and add any information on the cause and possible consequences of each exception, if known. If the exception is quantifiable, include the corresponding amount.

....

Example (to be removed from the Report):

1. The Beneficiary was unable to substantiate the Finding number 1 on ... because
2. Finding number 30 was not fulfilled because the methodology used by the Beneficiary to calculate unit costs was different from the one approved by the Commission. The differences were as follows: ...
3. After carrying out the agreed procedures to confirm the Finding number 31, the Auditor found a difference of _____ EUR. The difference can be explained by ...

Further Remarks

In addition to reporting on the results of the specific procedures carried out, the Auditor would like to make the following general remarks:

Example (to be removed from the Report):

1. Regarding Finding number 8 the conditions for additional remuneration were considered as fulfilled because ...
2. In order to be able to confirm the Finding number 15 we carried out the following additional procedures:

Use of this Report

This Report may be used only for the purpose described in the above objective. It was prepared solely for the confidential use of the [Beneficiary] [Linked Third Party] and the [Commission] [Agency], and only to be submitted to the [Commission] [Agency] in connection with the requirements set out in Article 20.4 of the Agreement. The Report may not be used by the [Beneficiary] [Linked Third Party] or by the [Commission] [Agency] for any other purpose, nor may it

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be distributed to any other parties. The [Commission] [Agency] may only disclose the Report to authorised parties, in particular to the European Anti-Fraud Office (OLAF) and the European Court of Auditors.

This Report relates only to the Financial Statement(s) submitted to the [Commission] [Agency] by the [Beneficiary] [Linked Third Party] for the Agreement. Therefore, it does not extend to any other of the [Beneficiary's] [Linked Third Party's] Financial Statement(s).

There was no conflict of interest⁴ between the Auditor and the Beneficiary [and Linked Third Party] in establishing this Report. The total fee paid to the Auditor for providing the Report was EUR [] (including EUR [] of deductible VAT).

We look forward to discussing our Report with you and would be pleased to provide any further information or assistance.

[legal name of the Auditor]

[name and function of an authorised representative]

[dd Month yyyy]

Signature of the Auditor

⁴ A conflict of interest arises when the Auditor's objectivity to establish the certificate is compromised in fact or in appearance when the Auditor for instance:

- was involved in the preparation of the Financial Statements;
- stands to benefit directly should the certificate be accepted;
- has a close relationship with any person representing the beneficiary;
- is a director, trustee or partner of the beneficiary; or
- is in any other situation that compromises his or her independence or ability to establish the certificate impartially.

Agreed-upon procedures to be performed and standard factual findings to be confirmed by the Auditor

The European Commission reserves the right to i) provide the auditor with additional guidance regarding the procedures to be followed or the facts to be ascertained and the way in which to present them (this may include sample coverage and findings) or to ii) change the procedures, by notifying the Beneficiary in writing. The procedures carried out by the auditor to confirm the standard factual finding are listed in the table below.

If this certificate relates to a Linked Third Party, any reference here below to 'the Beneficiary' is to be considered as a reference to 'the Linked Third Party'.

The 'result' column has three different options: 'C', 'E' and 'N.A.':

- 'C' stands for 'confirmed' and means that the auditor can confirm the 'standard factual finding' and, therefore, there is no exception to be reported.
- 'E' stands for 'exception' and means that the Auditor carried out the procedures but cannot confirm the 'standard factual finding', or that the Auditor was not able to carry out a specific procedure (e.g. because it was impossible to reconcile key information or data were unavailable),
- 'N.A.' stands for 'not applicable' and means that the Finding did not have to be examined by the Auditor and the related Procedure(s) did not have to be carried out. The reasons of the non-application of a certain Finding must be obvious i.e. i) if no cost was declared under a certain category then the related Finding(s) and Procedure(s) are not applicable; ii) if the condition set to apply certain Procedure(s) are not met then the related Finding(s) and Procedure(s) are not applicable. For instance, for 'beneficiaries with accounts established in a currency other than the euro' the Procedure related to 'beneficiaries with accounts established in euro' is not applicable. Similarly, if no additional remuneration is paid, the related Finding(s) and Procedure(s) for additional remuneration are not applicable.

Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
A	ACTUAL PERSONNEL COSTS AND UNIT COSTS CALCULATED BY THE BENEFICIARY IN ACCORDANCE WITH ITS USUAL COST ACCOUNTING PRACTICE		

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Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
	The Auditor draws a sample of persons whose costs were declared in the Financial Statement(s) to carry out the procedures indicated in the consecutive points of this section A. <i>(The sample should be selected randomly so that it is representative. Full coverage is required if there are fewer than 10 people (including employees, natural persons working under a direct contract and personnel seconded by a third party), otherwise the sample should have a minimum of 10 people, or 10% of the total, whichever number is the highest)</i> The Auditor sampled [] people out of the total of [] people.		
A.1	PERSONNEL COSTS <u>For the persons included in the sample and working under an employment contract or equivalent act (general procedures for individual actual personnel costs and personnel costs declared as unit costs)</u> To confirm standard factual findings 1-5 listed in the next column, the Auditor reviewed following information/documents provided by the Beneficiary: ○ a list of the persons included in the sample indicating the period(s) during which they worked for the action, their position (classification or category) and type of contract; ○ the payslips of the employees included in the sample; ○ reconciliation of the personnel costs declared in the Financial Statement(s) with the accounting system (project accounting and general ledger) and payroll system; ○ information concerning the employment status and employment conditions of personnel included in the sample, in particular their employment contracts or equivalent;	1) The employees were i) directly hired by the Beneficiary in accordance with its national legislation, ii) under the Beneficiary's sole technical supervision and responsibility and iii) remunerated in accordance with the Beneficiary's usual practices.	
		2) Personnel costs were recorded in the Beneficiary's accounts/payroll system.	
		3) Costs were adequately supported and reconciled with the accounts and payroll	

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Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
	- the Beneficiary's usual policy regarding payroll matters (e.g. salary policy, overtime policy, variable pay); - applicable national law on taxes, labour and social security and - any other document that supports the personnel costs declared. The Auditor also verified the eligibility of all components of the retribution (see Article 6 GA) and recalculated the personnel costs for employees included in the sample.	records.	
		4) Personnel costs did not contain any ineligible elements.	
		5) There were no discrepancies between the personnel costs charged to the action and the costs recalculated by the Auditor.	
	<i>Further procedures if 'additional remuneration' is paid</i> To confirm standard factual findings 6-9 listed in the next column, the Auditor: - reviewed relevant documents provided by the Beneficiary (legal form, legal/statutory obligations, the Beneficiary's usual policy on additional remuneration, criteria used for its calculation...); - recalculated the amount of additional remuneration eligible for the action based on the supporting documents received (full-time or part-time work, exclusive or non-exclusive dedication to the action, etc.) to arrive at the applicable FTE/year and pro-rata rate (see data collected in the course of carrying out the procedures under A.2 'Productive hours' and A.4 'Time recording system').	6) The Beneficiary paying "additional remuneration" was a non-profit legal entity.	
		7) The amount of additional remuneration paid corresponded to the Beneficiary's usual remuneration practices and was consistently paid whenever the same kind of work or expertise was required.	

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Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
	<i>IF ANY PART OF THE REMUNERATION PAID TO THE EMPLOYEE IS NOT MANDATORY ACCORDING TO THE NATIONAL LAW OR THE EMPLOYMENT CONTRACT ("ADDITIONAL REMUNERATION") AND IS ELIGIBLE UNDER THE PROVISIONS OF ARTICLE 6.2.A.1, THIS CAN BE CHARGED AS ELIGIBLE COST TO THE ACTION UP TO THE FOLLOWING AMOUNT:</i> (A) <i>IF THE PERSON WORKS FULL TIME AND EXCLUSIVELY ON THE ACTION DURING THE FULL YEAR: UP TO EUR 8 000/YEAR;</i> (B) <i>IF THE PERSON WORKS EXCLUSIVELY ON THE ACTION BUT NOT FULL-TIME OR NOT FOR THE FULL YEAR: UP TO THE CORRESPONDING PRO-RATA AMOUNT OF EUR 8 000, OR</i> (C) <i>IF THE PERSON DOES NOT WORK EXCLUSIVELY ON THE ACTION: UP TO A PRO-RATA AMOUNT CALCULATED IN ACCORDANCE TO ARTICLE 6.2.A.1.</i>	8) The criteria used to calculate the additional remuneration were objective and generally applied by the Beneficiary regardless of the source of funding used.	
		9) The amount of additional remuneration included in the personnel costs charged to the action was capped at EUR 8,000 per FTE/year (up to the equivalent pro-rata amount if the person did not work on the action full-time during the year or did not work exclusively on the action).	
	<i>Additional procedures in case “unit costs calculated by the Beneficiary in accordance with its usual cost accounting practices” is applied:</i> Apart from carrying out the procedures indicated above to confirm standard factual findings 1-5 and, if applicable, also 6-9, the Auditor carried out following procedures to confirm standard factual findings 10-13 listed in the next column:	10) The personnel costs included in the Financial Statement were calculated in accordance with the Beneficiary's usual cost accounting practice. This methodology was consistently used in all H2020 actions.	

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Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
	- obtained a description of the Beneficiary's usual cost accounting practice to calculate unit costs; - reviewed whether the Beneficiary's usual cost accounting practice was applied for the Financial Statements subject of the present CFS; - verified the employees included in the sample were charged under the correct category (in accordance with the criteria used by the Beneficiary to establish personnel categories) by reviewing the contract/HR-record or analytical accounting records; - verified that there is no difference between the total amount of personnel costs used in calculating the cost per unit and the total amount of personnel costs recorded in the statutory accounts; - verified whether actual personnel costs were adjusted on the basis of budgeted or estimated elements and, if so, verified whether those elements used are actually relevant for the calculation, objective and supported by documents.	11) The employees were charged under the correct category.	
		12) Total personnel costs used in calculating the unit costs were consistent with the expenses recorded in the statutory accounts.	
		13) Any estimated or budgeted element used by the Beneficiary in its unit-cost calculation were relevant for calculating personnel costs and corresponded to objective and verifiable information.	
	<u>For natural persons included in the sample and working with the Beneficiary under a direct contract other than an employment contract, such as consultants (no subcontractors).</u> To confirm standard factual findings 14-18 listed in the next column the Auditor reviewed following information/documents provided by the Beneficiary: the contracts, especially the cost, contract duration, work description, place of work, ownership of the results and reporting obligations to the Beneficiary;	14) The natural persons reported to the Beneficiary (worked under the Beneficiary's instructions).	
		15) They worked on the Beneficiary's premises (unless otherwise agreed with the Beneficiary).	

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Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
	- the employment conditions of staff in the same category to compare costs and; - any other document that supports the costs declared and its registration (e.g. invoices, accounting records, etc.).	16) The results of work carried out belong to the Beneficiary.	
		17) Their costs were not significantly different from those for staff who performed similar tasks under an employment contract with the Beneficiary.	
		18) The costs were supported by audit evidence and registered in the accounts.	
	<u>For personnel seconded by a third party and included in the sample (not subcontractors)</u> To confirm standard factual findings 19-22 listed in the next column, the Auditor reviewed following information/documents provided by the Beneficiary: - their secondment contract(s) notably regarding costs, duration, work description, place of work and ownership of the results; - if there is reimbursement by the Beneficiary to the third party for the resource made available (in-kind contribution against payment): any documentation that supports the costs declared (e.g. contract, invoice, bank payment, and proof of registration in its accounting/payroll, etc.) and reconciliation of the Financial Statement(s) with the accounting system (project accounting and general ledger) as well as any proof that the amount invoiced by the third party did not include any profit;	19) Seconded personnel reported to the Beneficiary and worked on the Beneficiary's premises (unless otherwise agreed with the Beneficiary).	
		20) The results of work carried out belong to the Beneficiary.	
		<i>If personnel is seconded against payment:</i> 21) The costs declared were supported with documentation and recorded in the	

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Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
	○ if there is no reimbursement by the Beneficiary to the third party for the resource made available (in-kind contribution free of charge): a proof of the actual cost borne by the Third Party for the resource made available free of charge to the Beneficiary such as a statement of costs incurred by the Third Party and proof of the registration in the Third Party's accounting/payroll; ○ any other document that supports the costs declared (e.g. invoices, etc.).	Beneficiary's accounts. The third party did not include any profit. <i>If personnel is seconded free of charge:</i> 22) The costs declared did not exceed the third party's cost as recorded in the accounts of the third party and were supported with documentation.	
A.2	PRODUCTIVE HOURS To confirm standard factual findings 23-28 listed in the next column, the Auditor reviewed relevant documents, especially national legislation, labour agreements and contracts and time records of the persons included in the sample, to verify that: ○ the annual productive hours applied were calculated in accordance with one of the methods described below, ○ the full-time equivalent (FTEs) ratios for employees not working full-time were correctly calculated.	23) The Beneficiary applied method <i>[choose one option and delete the others]</i> [A: 1720 hours] [B: the 'total number of hours worked'] [C: 'annual productive hours' used correspond to usual accounting practices]	

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Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
	If the Beneficiary applied method B, the auditor verified that the correctness in which the total number of hours worked was calculated and that the contracts specified the annual workable hours. If the Beneficiary applied method C, the auditor verified that the ‘annual productive hours’ applied when calculating the hourly rate were equivalent to at least 90 % of the ‘standard annual workable hours’. The Auditor can only do this if the calculation of the standard annual workable hours can be supported by records, such as national legislation, labour agreements, and contracts. <i>BENEFICIARY’S PRODUCTIVE HOURS’ FOR PERSONS WORKING FULL TIME SHALL BE ONE OF THE FOLLOWING METHODS:</i> <i>A. 1720 ANNUAL PRODUCTIVE HOURS (PRO-RATA FOR PERSONS NOT WORKING FULL-TIME)</i> <i>B. THE TOTAL NUMBER OF HOURS WORKED BY THE PERSON FOR THE BENEFICIARY IN THE YEAR (THIS METHOD IS ALSO REFERRED TO AS ‘TOTAL NUMBER OF HOURS WORKED’ IN THE NEXT COLUMN). THE CALCULATION OF THE TOTAL NUMBER OF HOURS WORKED WAS DONE AS FOLLOWS: ANNUAL WORKABLE HOURS OF THE PERSON ACCORDING TO THE EMPLOYMENT CONTRACT, APPLICABLE LABOUR AGREEMENT OR NATIONAL LAW PLUS OVERTIME WORKED MINUS ABSENCES (SUCH AS SICK LEAVE OR SPECIAL LEAVE).</i>	24) Productive hours were calculated annually.	
		25) For employees not working full-time the full-time equivalent (FTE) ratio was correctly applied.	
		<i>If the Beneficiary applied method B.</i> 26) The calculation of the number of ‘annual workable hours’, overtime and absences was verifiable based on the documents provided by the Beneficiary.	
		<i>If the Beneficiary applied method C.</i> 27) The calculation of the number of ‘standard annual workable hours’ was verifiable based on the documents provided by the Beneficiary.	

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Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
	<i>C. THE STANDARD NUMBER OF ANNUAL HOURS GENERALLY APPLIED BY THE BENEFICIARY FOR ITS PERSONNEL IN ACCORDANCE WITH ITS USUAL COST ACCOUNTING PRACTICES (THIS METHOD IS ALSO REFERRED TO AS 'TOTAL ANNUAL PRODUCTIVE HOURS' IN THE NEXT COLUMN). THIS NUMBER MUST BE AT LEAST 90% OF THE STANDARD ANNUAL WORKABLE HOURS.</i> <i>'ANNUAL WORKABLE HOURS' MEANS THE PERIOD DURING WHICH THE PERSONNEL MUST BE WORKING, AT THE EMPLOYER'S DISPOSAL AND CARRYING OUT HIS/HER ACTIVITY OR DUTIES UNDER THE EMPLOYMENT CONTRACT, APPLICABLE COLLECTIVE LABOUR AGREEMENT OR NATIONAL WORKING TIME LEGISLATION.</i>	28) The 'annual productive hours' used for calculating the hourly rate were consistent with the usual cost accounting practices of the Beneficiary and were equivalent to at least 90 % of the 'annual workable hours'.	
A.3	HOURLY PERSONNEL RATES <u>I) For unit costs calculated in accordance to the Beneficiary's usual cost accounting practice (unit costs):</u> If the Beneficiary has a "Certificate on Methodology to calculate unit costs " (CoMUC) approved by the Commission, the Beneficiary provides the Auditor with a description of the approved methodology and the Commission's letter of acceptance. The Auditor verified that the Beneficiary has indeed used the methodology approved. If so, no further verification is necessary. If the Beneficiary does not have a "Certificate on Methodology" (CoMUC) approved by the	29) The Beneficiary applied [choose one option and delete the other]: [Option I: "Unit costs (hourly rates) were calculated in accordance with the Beneficiary's usual cost accounting practices"] [Option II: Individual hourly rates were applied]	

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Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
	Commission, or if the methodology approved was not applied, then the Auditor: ○ reviewed the documentation provided by the Beneficiary, including manuals and internal guidelines that explain how to calculate hourly rates; ○ recalculated the unit costs (hourly rates) of staff included in the sample following the results of the procedures carried out in A.1 and A.2. <u>II) For individual hourly rates:</u> The Auditor: ○ reviewed the documentation provided by the Beneficiary, including manuals and internal guidelines that explain how to calculate hourly rates; ○ recalculated the hourly rates of staff included in the sample following the results of the procedures carried out in A.1 and A.2.	<i>For option I concerning unit costs and if the Beneficiary applies the methodology approved by the Commission (CoMUC):</i> 30) The Beneficiary used the Commission-approved methodology to calculate hourly rates. It corresponded to the organisation's usual cost accounting practices and was applied consistently for all activities irrespective of the source of funding.	
	<u>“UNIT COSTS CALCULATED BY THE BENEFICIARY IN ACCORDANCE WITH ITS USUAL COST ACCOUNTING PRACTICES”:</u> <i>IT IS CALCULATED BY DIVIDING THE TOTAL AMOUNT OF PERSONNEL COSTS OF THE CATEGORY TO WHICH THE EMPLOYEE BELONGS VERIFIED IN LINE WITH PROCEDURE A.1 BY THE NUMBER OF FTE AND THE ANNUAL TOTAL PRODUCTIVE HOURS OF THE SAME CATEGORY CALCULATED BY THE BENEFICIARY IN ACCORDANCE WITH PROCEDURE A.2.</i> <u>HOURLY RATE FOR INDIVIDUAL ACTUAL PERSONAL COSTS:</u> <i>IT IS CALCULATED BY DIVIDING THE TOTAL AMOUNT OF PERSONNEL COSTS OF AN EMPLOYEE VERIFIED IN LINE WITH</i>	<i>For option I concerning unit costs and if the Beneficiary applies a methodology not approved by the Commission:</i> 31) The unit costs re-calculated by the Auditor were the same as the rates applied by the Beneficiary.	
		<i>For option II concerning individual hourly rates:</i>	

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Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
	<i>PROCEDURE A.1 BY THE NUMBER OF ANNUAL PRODUCTIVE HOURS VERIFIED IN LINE WITH PROCEDURE A.2.</i>	32) The individual rates re-calculated by the Auditor were the same as the rates applied by the Beneficiary.	
A.4	TIME RECORDING SYSTEM To verify that the time recording system ensures the fulfilment of all minimum requirements and that the hours declared for the action were correct, accurate and properly authorised and supported by documentation, the Auditor made the following checks for the persons included in the sample that declare time as worked for the action on the basis of time records: ○ description of the time recording system provided by the Beneficiary (registration, authorisation, processing in the HR-system); ○ its actual implementation; ○ time records were signed at least monthly by the employees (on paper or electronically) and authorised by the project manager or another manager; ○ the hours declared were worked within the project period; ○ there were no hours declared as worked for the action if HR-records showed absence due to holidays or sickness (further cross-checks with travels are carried out in B.1 below) ;	33) All persons recorded their time dedicated to the action on a daily/ weekly/ monthly basis using a paper/computer-based system. <i>(delete the answers that are not applicable)</i>	
		34) Their time-records were authorised at least monthly by the project manager or other superior.	
		35) Hours declared were worked within the project period and were consistent with the presences/absences recorded in HR-records.	

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Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
	the hours charged to the action matched those in the time recording system. <i>ONLY THE HOURS WORKED ON THE ACTION CAN BE CHARGED. ALL WORKING TIME TO BE CHARGED SHOULD BE RECORDED THROUGHOUT THE DURATION OF THE PROJECT, ADEQUATELY SUPPORTED BY EVIDENCE OF THEIR REALITY AND RELIABILITY (SEE SPECIFIC PROVISIONS BELOW FOR PERSONS WORKING EXCLUSIVELY FOR THE ACTION WITHOUT TIME RECORDS).</i>	36) There were no discrepancies between the number of hours charged to the action and the number of hours recorded.	
	<u>If the persons are working exclusively for the action and without time records</u> For the persons selected that worked exclusively for the action without time records, the Auditor verified evidence available demonstrating that they were in reality exclusively dedicated to the action and that the Beneficiary signed a declaration confirming that they have worked exclusively for the action.	37) The exclusive dedication is supported by a declaration signed by the Beneficiary's and by any other evidence gathered.	
B	COSTS OF SUBCONTRACTING		
B.1	The Auditor obtained the detail/breakdown of subcontracting costs and sampled [] cost items selected randomly (<i>full coverage is required if there are fewer than 10 items, otherwise the sample should have a minimum of 10 item, or 10% of the total, whichever number is highest</i>). To confirm standard factual findings 38-42 listed in the next column, the Auditor reviewed the	38) The use of claimed subcontracting costs was foreseen in Annex 1 and costs were declared in the Financial Statements under the subcontracting category.	

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Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
	following for the items included in the sample: - the use of subcontractors was foreseen in Annex 1; - subcontracting costs were declared in the subcontracting category of the Financial Statement; - supporting documents on the selection and award procedure were followed; - the Beneficiary ensured best value for money (key elements to appreciate the respect of this principle are the award of the subcontract to the bid offering best price-quality ratio, under conditions of transparency and equal treatment. In case an existing framework contract was used the Beneficiary ensured it was established on the basis of the principle of best value for money under conditions of transparency and equal treatment). In particular, - if the Beneficiary acted as a contracting authority within the meaning of Directive 2004/18/EC or of Directive 2004/17/EC, the Auditor verified that the applicable national law on public procurement was followed and that the subcontracting complied with the Terms and Conditions of the Agreement. - if the Beneficiary did not fall under the above-mentioned category the Auditor verified that the Beneficiary followed their usual procurement rules and respected the Terms and Conditions of the Agreement.. For the items included in the sample the Auditor also verified that: - the subcontracts were not awarded to other Beneficiaries in the consortium;	39) There were documents of requests to different providers, different offers and assessment of the offers before selection of the provider in line with internal procedures and procurement rules. Subcontracts were awarded in accordance with the principle of best value for money. <i>(When different offers were not collected the Auditor explains the reasons provided by the Beneficiary under the caption "Exceptions" of the Report. The Commission will analyse this information to evaluate whether these costs might be accepted as eligible)</i> 40) The subcontracts were not awarded to other Beneficiaries of the consortium.	

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	○ there were signed agreements between the Beneficiary and the subcontractor; ○ there was evidence that the services were provided by subcontractor;	41) All subcontracts were supported by signed agreements between the Beneficiary and the subcontractor.	
		42) There was evidence that the services were provided by the subcontractors.	
C	COSTS OF PROVIDING FINANCIAL SUPPORT TO THIRD PARTIES		
C.1	The Auditor obtained the detail/breakdown of the costs of providing financial support to third parties and sampled [] cost items selected randomly (<i>full coverage is required if there are fewer than 10 items, otherwise the sample should have a minimum of 10 item, or 10% of the total, whichever number is highest</i>). The Auditor verified that the following minimum conditions were met: a) the maximum amount of financial support for each third party did not exceed EUR 60 000, unless explicitly mentioned in Annex 1; b) the financial support to third parties was agreed in Annex 1 of the Agreement and the other provisions on financial support to third parties included in Annex 1 were	43) All minimum conditions were met	

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Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
	respected.		

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D	OTHER ACTUAL DIRECT COSTS		
D.1	COSTS OF TRAVEL AND RELATED SUBSISTENCE ALLOWANCES The Auditor sampled [] cost items selected randomly <i>(full coverage is required if there are fewer than 10 items, otherwise the sample should have a minimum of 10 item, or 10% of the total, whichever number is the highest).</i> The Auditor inspected the sample and verified that: ○ travel and subsistence costs were consistent with the Beneficiary's usual policy for travel. In this context, the Beneficiary provided evidence of its normal policy for travel costs (e.g. use of first class tickets, reimbursement by the Beneficiary on the basis of actual costs, a lump sum or per diem) to enable the Auditor to compare the travel costs charged with this policy; ○ travel costs are correctly identified and allocated to the action (e.g. trips are directly linked to the action) by reviewing relevant supporting documents such as minutes of meetings, workshops or conferences, their registration in the correct project account, their consistency with time records or with the dates/duration of the workshop/conference; ○ no ineligible costs or excessive or reckless expenditure was declared.	44) Costs were incurred, approved and reimbursed in line with the Beneficiary's usual policy for travels.	
		45) There was a link between the trip and the action.	
		46) The supporting documents were consistent with each other regarding subject of the trip, dates, duration and reconciled with time records and accounting.	
		47) No ineligible costs or excessive or reckless expenditure was declared.	
D.2	DEPRECIATION COSTS FOR EQUIPMENT, INFRASTRUCTURE OR OTHER ASSETS The Auditor sampled [] cost items selected randomly <i>(full coverage is required if there are fewer than 10 items, otherwise the sample should have a minimum of 10 item, or 10% of the total, whichever number is the highest).</i> For “equipment, infrastructure or other assets” [from now on called “asset(s)”] selected in the	48) Procurement rules, principles and guides were followed.	
		49) There was a link between the grant agreement and the asset charged to the action.	

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	sample the Auditor verified that: ○ the assets were acquired in conformity with the Beneficiary's internal guidelines and procedures; ○ they were correctly allocated to the action (with supporting documents such as delivery note invoice or any other proof demonstrating the link to the action) ○ they were entered in the accounting system; ○ the extent to which the assets were used for the action (as a percentage) was supported by reliable documentation (e.g. usage overview table); The Auditor recalculated the depreciation costs and verified that they were in line with the applicable rules in the Beneficiary's country and with the Beneficiary's usual accounting policy (e.g. depreciation calculated on the acquisition value). The Auditor verified that no ineligible costs such as deductible VAT, exchange rate losses, excessive or reckless expenditure were declared (see Article 6.5 GA).	50) The asset charged to the action was traceable to the accounting records and the underlying documents.	
		51) The depreciation method used to charge the asset to the action was in line with the applicable rules of the Beneficiary's country and the Beneficiary's usual accounting policy.	
		52) The amount charged corresponded to the actual usage for the action.	
		53) No ineligible costs or excessive or reckless expenditure were declared.	
D.3	COSTS OF OTHER GOODS AND SERVICES The Auditor sampled [] cost items selected randomly (<i>full coverage is required if there are fewer than 10 items, otherwise the sample should have a minimum of 10 item, or 10% of the total, whichever number is highest</i>). For the purchase of goods, works or services included in the sample the Auditor verified that: ○ the contracts did not cover tasks described in Annex 1;	54) Contracts for works or services did not cover tasks described in Annex 1.	
		55) Costs were allocated to the correct action and the goods were not placed in the inventory of durable equipment.	

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	○ they were correctly identified, allocated to the proper action, entered in the accounting system (traceable to underlying documents such as purchase orders, invoices and accounting); ○ the goods were not placed in the inventory of durable equipment; ○ the costs charged to the action were accounted in line with the Beneficiary's usual accounting practices; ○ no ineligible costs or excessive or reckless expenditure were declared (see Article 6 GA). In addition, the Auditor verified that these goods and services were acquired in conformity with the Beneficiary's internal guidelines and procedures, in particular: ○ if Beneficiary acted as a contracting authority within the meaning of Directive 2004/18/EC or of Directive 2004/17/EC, the Auditor verified that the applicable national law on public procurement was followed and that the procurement contract complied with the Terms and Conditions of the Agreement. ○ if the Beneficiary did not fall into the category above, the Auditor verified that the Beneficiary followed their usual procurement rules and respected the Terms and Conditions of the Agreement. For the items included in the sample the Auditor also verified that: ○ the Beneficiary ensured best value for money (key elements to appreciate the respect of this principle are the award of the contract to the bid offering best price-quality ratio, under conditions of transparency and equal treatment. In case an existing framework contract was used the Auditor also verified that the Beneficiary ensured it was established on the basis of the principle of best value for money under conditions of transparency and equal treatment); <i>SUCH GOODS AND SERVICES INCLUDE, FOR INSTANCE, CONSUMABLES AND SUPPLIES, DISSEMINATION (INCLUDING OPEN ACCESS), PROTECTION OF RESULTS, SPECIFIC EVALUATION OF THE ACTION IF IT IS REQUIRED BY THE</i>	56) The costs were charged in line with the Beneficiary's accounting policy and were adequately supported. 57) No ineligible costs or excessive or reckless expenditure were declared. For internal invoices/charges only the cost element was charged, without any mark-ups. 58) Procurement rules, principles and guides were followed. There were documents of requests to different providers, different offers and assessment of the offers before selection of the provider in line with internal procedures and procurement rules. The purchases were made in accordance with the principle of best value for money. <i>(When different offers were not collected the Auditor explains the reasons provided by the Beneficiary under the</i>	

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	AGREEMENT, CERTIFICATES ON THE FINANCIAL STATEMENTS IF THEY ARE REQUIRED BY THE AGREEMENT AND CERTIFICATES ON THE METHODOLOGY, TRANSLATIONS, REPRODUCTION.	<i>caption “Exceptions” of the Report. The Commission will analyse this information to evaluate whether these costs might be accepted as eligible)</i>	
D.4	AGGREGATED CAPITALISED AND OPERATING COSTS OF RESEARCH INFRASTRUCTURE The Auditor ensured the existence of a positive ex-ante assessment (issued by the EC Services) of the cost accounting methodology of the Beneficiary allowing it to apply the guidelines on direct costing for large research infrastructures in Horizon 2020. <i>In the cases that a positive ex-ante assessment has been issued (see the standard factual findings 59-60 on the next column),</i> The Auditor ensured that the beneficiary has applied consistently the methodology that is explained and approved in the positive ex ante assessment; <i>In the cases that a positive ex-ante assessment has NOT been issued (see the standard factual findings 61 on the next column),</i> The Auditor verified that no costs of Large Research Infrastructure have been charged as direct costs in any costs category;	59) The costs declared as direct costs for Large Research Infrastructures (in the appropriate line of the Financial Statement) comply with the methodology described in the positive ex-ante assessment report.	
		60) Any difference between the methodology applied and the one positively assessed was extensively described and adjusted accordingly.	
		61) The direct costs declared were free from any indirect costs items related to the Large Research Infrastructure.	

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	<i>In the cases that a draft ex-ante assessment report has been issued with recommendation for further changes (see the standard factual findings 61 on the next column),</i> The Auditor followed the same procedure as above (when a positive ex-ante assessment has NOT yet been issued) and paid particular attention (testing reinforced) to the cost items for which the draft ex-ante assessment either rejected the inclusion as direct costs for Large Research Infrastructures or issued recommendations.		
E	USE OF EXCHANGE RATES		
E.1	a) For Beneficiaries with accounts established in a currency other than euros The Auditor sampled [] cost items selected randomly and verified that the exchange rates used for converting other currencies into euros were in accordance with the following rules established in the Agreement (full coverage is required if there are fewer than 10 items, otherwise the sample should have a minimum of 10 item, or 10% of the total, whichever number is highest): <i>COSTS INCURRED IN ANOTHER CURRENCY SHALL BE CONVERTED INTO EURO AT THE AVERAGE OF THE DAILY EXCHANGE RATES PUBLISHED IN THE C SERIES OF OFFICIAL JOURNAL OF THE EUROPEAN UNION (https://www.ecb.int/stats/exchange/eurofxref/html/index.en.html), DETERMINED OVER THE CORRESPONDING REPORTING PERIOD.</i> <i>IF NO DAILY EURO EXCHANGE RATE IS PUBLISHED IN THE OFFICIAL JOURNAL OF THE EUROPEAN UNION FOR THE CURRENCY IN QUESTION, CONVERSION SHALL BE MADE AT THE AVERAGE OF THE MONTHLY ACCOUNTING RATES ESTABLISHED BY THE COMMISSION AND PUBLISHED ON ITS WEBSITE (http://ec.europa.eu/budget/contracts_grants/info_contracts/inforeuro/inforeuro_en.cfm),</i>	62) The exchange rates used to convert other currencies into Euros were in accordance with the rules established of the Grant Agreement and there was no difference in the final figures.	

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	DETERMINED OVER THE CORRESPONDING REPORTING PERIOD.		
	<u>b) For Beneficiaries with accounts established in euros</u> The Auditor sampled [] cost items selected randomly and verified that the exchange rates used for converting other currencies into euros were in accordance with the following rules established in the Agreement (full coverage is required if there are fewer than 10 items, otherwise the sample should have a minimum of 10 item, or 10% of the total, whichever number is highest): <i>COSTS INCURRED IN ANOTHER CURRENCY SHALL BE CONVERTED INTO EURO BY APPLYING THE BENEFICIARY'S USUAL ACCOUNTING PRACTICES.</i>	63) The Beneficiary applied its usual accounting practices.	

[legal name of the audit firm]**[name and function of an authorised representative]****[dd Month yyyy]****<Signature of the Auditor>**

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ANNEX 6

MODEL FOR THE CERTIFICATE ON THE METHODOLOGY

- For options [*in italics in square brackets*]: choose the applicable option. Options not chosen should be deleted.
- For fields in [grey in square brackets]: enter the appropriate data.

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Terms of reference for an audit engagement for a methodology certificate in connection with one or more grant agreements financed under the Horizon 2020 Research and Innovation Framework Programme

This document sets out the ‘**Terms of Reference (ToR)**’ under which

[OPTION 1: *[insert name of the beneficiary]* (‘the Beneficiary’)] [OPTION 2: *[insert name of the linked third party]* (‘the Linked Third Party’), third party linked to the Beneficiary *[insert name of the beneficiary]* (‘the Beneficiary’)]

agrees to engage

[insert legal name of the auditor] (‘the Auditor’)

to produce an independent report of factual findings (‘the Report’) concerning the *[Beneficiary’s]* *[Linked Third Party’s]* usual accounting practices for calculating and claiming direct personnel costs declared as unit costs (‘the Methodology’) in connection with grant agreements financed under the Horizon 2020 Research and Innovation Framework Programme.

The procedures to be carried out for the assessment of the methodology will be based on the grant agreement(s) detailed below:

[title and number of the grant agreement(s)] (‘the Agreement(s)’)

The Agreement(s) has(have) been concluded between the Beneficiary and [OPTION 1: *the European Union, represented by the European Commission* (‘the Commission’)] [OPTION 2: *the European Atomic Energy Community (Euratom), represented by the European Commission* (‘the Commission’)] [OPTION 3: *the [Research Executive Agency (REA)] [European Research Council Executive Agency (ERCEA)] [Innovation and Networks Executive Agency (INEA)] [Executive Agency for Small and Medium-sized Enterprises (EASME)]* (‘the Agency’), under the powers delegated by the European Commission (‘the Commission’)].

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The *[Commission] [Agency]* is mentioned as a signatory of the Agreement with the Beneficiary only.
The *[European Union] [Euratom] [Agency]* is not a party to this engagement.

1.1 Subject of the engagement

According to Article 18.1.2 of the Agreement, beneficiaries *[and linked third parties]* that declare direct personnel costs as unit costs calculated in accordance with their usual cost accounting practices may submit to the *[Commission] [Agency]*, for approval, a certificate on the methodology ('CoMUC') stating that there are adequate records and documentation to prove that their cost accounting practices used comply with the conditions set out in Point A of Article 6.2.

The subject of this engagement is the CoMUC which is composed of two separate documents:

- the Terms of Reference ('the ToR') to be signed by the *[Beneficiary] [Linked Third Party]* and the Auditor;
- the Auditor's Independent Report of Factual Findings ('the Report') issued on the Auditor's letterhead, dated, stamped and signed by the Auditor which includes; the standard statements ('the Statements') evaluated and signed by the *[Beneficiary] [Linked Third Party]*, the agreed-upon procedures ('the Procedures') performed by the Auditor and the standard factual findings ('the Findings') assessed by the Auditor. The Statements, Procedures and Findings are summarised in the table that forms part of the Report.

The information provided through the Statements, the Procedures and the Findings will enable the Commission to draw conclusions regarding the existence of the *[Beneficiary's] [Linked Third Party's]* usual cost accounting practice and its suitability to ensure that direct personnel costs claimed on that basis comply with the provisions of the Agreement. The Commission draws its own conclusions from the Report and any additional information it may require.

1.2 Responsibilities

The parties to this agreement are the *[Beneficiary] [Linked Third Party]* and the Auditor.

The *[Beneficiary] [Linked Third Party]*:

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- is responsible for preparing financial statements for the Agreement(s) ('the Financial Statements') in compliance with those Agreements;
- is responsible for providing the Financial Statement(s) to the Auditor and enabling the Auditor to reconcile them with the [Beneficiary's] [Linked Third Party's] accounting and bookkeeping system and the underlying accounts and records. The Financial Statement(s) will be used as a basis for the procedures which the Auditor will carry out under this ToR;
- is responsible for its Methodology and liable for the accuracy of the Financial Statement(s);
- is responsible for endorsing or refuting the Statements indicated under the heading 'Statements to be made by the Beneficiary/ Linked Third Party' in the first column of the table that forms part of the Report;
- must provide the Auditor with a signed and dated representation letter;
- accepts that the ability of the Auditor to carry out the Procedures effectively depends upon the [Beneficiary] [Linked Third Party] providing full and free access to the [Beneficiary's] [Linked Third Party's] staff and to its accounting and other relevant records.

The Auditor:

- *[Option 1 by default: is qualified to carry out statutory audits of accounting documents in accordance with Directive 2006/43/EC of the European Parliament and of the Council of 17 May 2006 on statutory audits of annual accounts and consolidated accounts, amending Council Directives 78/660/EEC and 83/349/EEC and repealing Council Directive 84/253/EEC or similar national regulations].*
- *[Option 2 if the Beneficiary or Linked Third Party has an independent Public Officer: is a competent and independent Public Officer for which the relevant national authorities have established the legal capacity to audit the Beneficiary].*
- *[Option 3 if the Beneficiary or Linked Third Party is an international organisation: is an [internal] [external] auditor in accordance with the internal financial regulations and procedures of the international organisation].*

The Auditor:

- must be independent from the Beneficiary *[and the Linked Third Party]*, in particular, it must not have been involved in preparing the Beneficiary's *[and Linked Third Party's]* Financial Statement(s);
- must plan work so that the Procedures may be carried out and the Findings may be assessed;
- must adhere to the Procedures laid down and the compulsory report format;
- must carry out the engagement in accordance with these ToR;
- must document matters which are important to support the Report;
- must base its Report on the evidence gathered;
- must submit the Report to the *[Beneficiary] [Linked Third Party]*.

The Commission sets out the Procedures to be carried out and the Findings to be endorsed by the Auditor. The Auditor is not responsible for their suitability or pertinence. As this engagement is not an assurance engagement the Auditor does not provide an audit opinion or a statement of assurance.

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1.3 Applicable Standards

The Auditor must comply with these Terms of Reference and with¹:

- the International Standard on Related Services ('ISRS') 4400 *Engagements to perform Agreed-upon Procedures regarding Financial Information* as issued by the International Auditing and Assurance Standards Board (IAASB);
- the *Code of Ethics for Professional Accountants* issued by the International Ethics Standards Board for Accountants (IESBA). Although ISRS 4400 states that independence is not a requirement for engagements to carry out agreed-upon procedures, the Commission requires that the Auditor also complies with the Code's independence requirements.

The Auditor's Report must state that there was no conflict of interests in establishing this Report between the Auditor and the Beneficiary [*and the Linked Third Party*] that could have a bearing on the Report, and must specify – if the service is invoiced - the total fee paid to the Auditor for providing the Report.

1.4 Reporting

The Report must be written in the language of the Agreement (see Article 20.7 of the Agreement).

Under Article 22 of the Agreement, the Commission, [*the Agency*], the European Anti-Fraud Office and the Court of Auditors have the right to audit any work that is carried out under the action and for which costs are claimed from [*the European Union*] [*Euratom*] budget. This includes work related to this engagement. The Auditor must provide access to all working papers related to this assignment if the Commission, [*the Agency*], the European Anti-Fraud Office or the European Court of Auditors requests them.

1.5 Timing

The Report must be provided by [dd Month yyyy].

¹ Supreme Audit Institutions applying INTOSAI-standards may carry out the Procedures according to the corresponding International Standards of Supreme Audit Institutions and code of ethics issued by INTOSAI instead of the International Standard on Related Services ('ISRS') 4400 and the Code of Ethics for Professional Accountants issued by the IAASB and the IESBA.

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1.6 Other Terms

[The [Beneficiary] [Linked Third Party] and the Auditor can use this section to agree other specific terms, such as the Auditor's fees, liability, applicable law, etc. Those specific terms must not contradict the terms specified above.]

[legal name of the Auditor]

[legal name of the [Beneficiary] [Linked Third Party]]

[name & title of authorised representative]

[name & title of authorised representative]

[dd Month yyyy]

[dd Month yyyy]

Signature of the Auditor Signature

Signature of the [Beneficiary] [Linked Third Party]

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Independent report of factual findings on the methodology concerning grant agreements financed under the Horizon 2020 Research and Innovation Framework Programme

(To be printed on letterhead paper of the auditor)

To

[name of contact person(s)], [Position]

[[Beneficiary's] [Linked Third Party's] name]

[Address]

[dd Month yyyy]

Dear [Name of contact person(s)],

As agreed under the terms of reference dated [dd Month yyyy]

with [OPTION 1: [insert name of the beneficiary] ('the Beneficiary')] [OPTION 2: [insert name of the linked third party] ('the Linked Third Party'), third party linked to the Beneficiary [insert name of the beneficiary] ('the Beneficiary')],

we

[name of the auditor] ('the Auditor'),

established at

[full address/city/state/province/country],

represented by

[name and function of an authorised representative],

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have carried out the agreed-upon procedures ('the Procedures') and provide hereby our Independent Report of Factual Findings ('the Report'), concerning the *[Beneficiary's] [Linked Third Party's]* usual accounting practices for calculating and declaring direct personnel costs declared as unit costs ('the Methodology').

You requested certain procedures to be carried out in connection with the grant(s)

[title and number of the grant agreement(s)] ('the Agreement(s)').

The Report

Our engagement was carried out in accordance with the terms of reference ('the ToR') appended to this Report. The Report includes: the standard statements ('the Statements') made by the *[Beneficiary] [Linked Third Party]*, the agreed-upon procedures ('the Procedures') carried out and the standard factual findings ('the Findings') confirmed by us.

The engagement involved carrying out the Procedures and assessing the Findings and the documentation requested appended to this Report, the results of which the Commission uses to draw conclusions regarding the acceptability of the Methodology applied by the *[Beneficiary] [Linked Third Party]*.

The Report covers the methodology used from [dd Month yyyy]. In the event that the *[Beneficiary] [Linked Third Party]* changes this methodology, the Report will not be applicable to any Financial Statement² submitted thereafter.

The scope of the Procedures and the definition of the standard statements and findings were determined solely by the Commission. Therefore, the Auditor is not responsible for their suitability or pertinence.

Since the Procedures carried out constitute neither an audit nor a review made in accordance with International Standards on Auditing or International Standards on Review Engagements, we do not

² Financial Statement in this context refers solely to Annex 4 of the Agreement by which the Beneficiary declares costs under the Agreement.

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give a statement of assurance on the costs declared on the basis of the *[Beneficiary's] [Linked Third Party's] Methodology*. Had we carried out additional procedures or had we performed an audit or review in accordance with these standards, other matters might have come to its attention and would have been included in the Report.

Exceptions

Apart from the exceptions listed below, the *[Beneficiary] [Linked Third Party]* agreed with the standard Statements and provided the Auditor all the documentation and accounting information needed by the Auditor to carry out the requested Procedures and corroborate the standard Findings.

List here any exception and add any information on the cause and possible consequences of each exception, if known. If the exception is quantifiable, also indicate the corresponding amount.

....

Explanation of possible exceptions in the form of examples (to be removed from the Report):

- i. the [Beneficiary] [Linked Third Party] did not agree with the standard Statement number ... because...;*
- ii. the Auditor could not carry out the procedure ... established because (e.g. due to the inability to reconcile key information or the unavailability or inconsistency of data);*
- iii. the Auditor could not confirm or corroborate the standard Finding number ... because*

Remarks

We would like to add the following remarks relevant for the proper understanding of the Methodology applied by the *[Beneficiary] [Linked Third Party]* or the results reported:

Example (to be removed from the Report):

Regarding the methodology applied to calculate hourly rates ...

Regarding standard Finding 15 it has to be noted that ...

The [Beneficiary] [Linked Third Party] explained the deviation from the benchmark statement XXIV concerning time recording for personnel with no exclusive dedication to the action in the following manner:

...

Annexes

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Please provide the following documents to the auditor and annex them to the report when submitting this CoMUC to the Commission:

1. Brief description of the methodology for calculating personnel costs, productive hours and hourly rates;
2. Brief description of the time recording system in place;
3. An example of the time records used by the [Beneficiary] [Linked Third Party];
4. Description of any budgeted or estimated elements applied, together with an explanation as to why they are relevant for calculating the personnel costs and how they are based on objective and verifiable information;
5. A summary sheet with the hourly rate for direct personnel declared by the [Beneficiary] [Linked Third Party] and recalculated by the Auditor for each staff member included in the sample (the names do not need to be reported);
6. A comparative table summarising for each person selected in the sample a) the time claimed by the [Beneficiary] [Linked Third Party] in the Financial Statement(s) and b) the time according to the time record verified by the Auditor;
7. A copy of the letter of representation provided to the Auditor.

Use of this Report

This Report has been drawn up solely for the purpose given under Point 1.1 Reasons for the engagement.

The Report:

- is confidential and is intended to be submitted to the Commission by the [Beneficiary] [Linked Third Party] in connection with Article 18.1.2 of the Agreement;
- may not be used by the [Beneficiary] [Linked Third Party] or by the Commission for any other purpose, nor distributed to any other parties;
- may be disclosed by the Commission only to authorised parties, in particular the European Anti-Fraud Office (OLAF) and the European Court of Auditors.
- relates only to the usual cost accounting practices specified above and does not constitute a report on the Financial Statements of the [Beneficiary] [Linked Third Party].

No conflict of interest³ exists between the Auditor and the Beneficiary [and the Linked Third Party] that could have a bearing on the Report. The total fee paid to the Auditor for producing the Report was EUR [] (including EUR [] of deductible VAT).

³ A conflict of interest arises when the Auditor's objectivity to establish the certificate is compromised in fact or in appearance when the Auditor for instance:

- was involved in the preparation of the Financial Statements;

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We look forward to discussing our Report with you and would be pleased to provide any further information or assistance which may be required.

Yours sincerely

[legal name of the Auditor]

[name and title of the authorised representative]

[dd Month yyyy]

Signature of the Auditor

-
- stands to benefit directly should the certificate be accepted;
 - has a close relationship with any person representing the beneficiary;
 - is a director, trustee or partner of the beneficiary; or
 - is in any other situation that compromises his or her independence or ability to establish the certificate impartially.

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Statements to be made by the Beneficiary/Linked Third Party ('the Statements') and Procedures to be carried out by the Auditor ('the Procedures') and standard factual findings ('the Findings') to be confirmed by the Auditor

The Commission reserves the right to provide the auditor with guidance regarding the Statements to be made, the Procedures to be carried out or the Findings to be ascertained and the way in which to present them. The Commission reserves the right to vary the Statements, Procedures or Findings by written notification to the Beneficiary/Linked Third Party to adapt the procedures to changes in the grant agreement(s) or to any other circumstances.

If this methodology certificate relates to the Linked Third Party's usual accounting practices for calculating and claiming direct personnel costs declared as unit costs any reference here below to 'the Beneficiary' is to be considered as a reference to 'the Linked Third Party'.

Please explain any discrepancies in the body of the Report.	
Statements to be made by Beneficiary	Procedures to be carried out and Findings to be confirmed by the Auditor
A. Use of the Methodology I. The cost accounting practice described below has been in use since [dd Month yyyy]. II. The next planned alteration to the methodology used by the Beneficiary will be from [dd Month yyyy].	Procedure: ✓ The Auditor checked these dates against the documentation the Beneficiary has provided. Factual finding: 1. The dates provided by the Beneficiary were consistent with the documentation.
B. Description of the Methodology III. The methodology to calculate unit costs is being used in a consistent manner and is reflected in the relevant procedures. <i>[Please describe the methodology your entity uses to calculate <u>personnel</u> costs, productive hours and hourly rates, present your description to the Auditor and annex it to this certificate]</i> <i>[If the statement of section "B. Description of the methodology" cannot be endorsed by the Beneficiary or there is no written methodology to calculate unit costs it should be listed here below and reported as exception by the Auditor in the main Report of</i>	Procedure: ✓ The Auditor reviewed the description, the relevant manuals and/or internal guidance documents describing the methodology. Factual finding: 2. The brief description was consistent with the relevant manuals, internal guidance and/or other documentary evidence the Auditor has reviewed. 3. The methodology was generally applied by the Beneficiary as part of its usual costs accounting practices.

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Please explain any discrepancies in the body of the Report.	
Statements to be made by Beneficiary	Procedures to be carried out and Findings to be confirmed by the Auditor
Factual Findings: - ...]	
C. Personnel costs <u>General</u> IV. The unit costs (hourly rates) are limited to salaries including during parental leave, social security contributions, taxes and other costs included in the remuneration required under national law and the employment contract or equivalent appointing act; V. Employees are hired directly by the Beneficiary in accordance with national law, and work under its sole supervision and responsibility; VI. The Beneficiary remunerates its employees in accordance with its usual practices. This means that personnel costs are charged in line with the Beneficiary's usual payroll policy (e.g. salary policy, overtime policy, variable pay) and no special conditions exist for employees assigned to tasks relating to the European Union or Euratom, unless explicitly provided for in the grant agreement(s); VII. The Beneficiary allocates its employees to the relevant group/category/cost centre for the purpose of the unit cost calculation in line with the usual cost accounting practice; VIII. Personnel costs are based on the payroll system and accounting system. IX. Any exceptional adjustments of actual personnel costs resulted from relevant budgeted or estimated elements and were based on objective and verifiable information. <i>[Please describe the 'budgeted or estimated elements' and their relevance to personnel costs, and explain how they were reasonable and based on objective and verifiable information, present your explanation to the Auditor and annex it to this certificate].</i> X. Personnel costs claimed do not contain any of the following ineligible costs: costs related to return on capital; debt and debt service charges; provisions for future losses	Procedure: <i>The Auditor draws a sample of employees to carry out the procedures indicated in this section C and the following sections D to F.</i> <i>[The Auditor has drawn a random sample of 10 full-time equivalents made up of employees assigned to the action(s). If fewer than 10 full-time equivalents are assigned to the action(s), the Auditor has selected a sample of 10 full-time equivalents consisting of all employees assigned to the action(s), complemented by other employees irrespective of their assignments.]. For this sample:</i> ✓ the Auditor reviewed all documents relating to personnel costs such as employment contracts, payslips, payroll policy (e.g. salary policy, overtime policy, variable pay policy), accounting and payroll records, applicable national tax, labour and social security law and any other documents corroborating the personnel costs claimed; ✓ in particular, the Auditor reviewed the employment contracts of the employees in the sample to verify that: i. they were employed directly by the Beneficiary in accordance with applicable national legislation; ii. they were working under the sole technical supervision and responsibility of the latter; iii. they were remunerated in accordance with the Beneficiary's usual practices; iv. they were allocated to the correct group/category/cost centre for the purposes of calculating the unit cost in line with the Beneficiary's usual cost accounting practices; ✓ the Auditor verified that any ineligible items or any costs claimed under other costs categories or costs covered by other types of grant or by other grants financed from the European Union budget have not been taken

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Please explain any discrepancies in the body of the Report.	
Statements to be made by Beneficiary	Procedures to be carried out and Findings to be confirmed by the Auditor
or debts; interest owed; doubtful debts; currency exchange losses; bank costs charged by the Beneficiary's bank for transfers from the Commission/Agency; excessive or reckless expenditure; deductible VAT or costs incurred during suspension of the implementation of the action. XI. Personnel costs were not declared under another EU or Euratom grant (including grants awarded by a Member State and financed by the EU budget and grants awarded by bodies other than the Commission/Agency for the purpose of implementing the EU budget). <u>If additional remuneration as referred to in the grant agreement(s) is paid</u> XII. The Beneficiary is a non-profit legal entity; XIII. The additional remuneration is part of the beneficiary's usual remuneration practices and paid consistently whenever the relevant work or expertise is required; XIV. The criteria used to calculate the additional remuneration are objective and generally applied regardless of the source of funding; XV. The additional remuneration included in the personnel costs used to calculate the hourly rates for the grant agreement(s) is capped at EUR 8 000 per full-time equivalent (reduced proportionately if the employee is not assigned exclusively to the action). <i>[If certain statement(s) of section "C. Personnel costs" cannot be endorsed by the Beneficiary they should be listed here below and reported as exception by the Auditor in the main Report of</i>	into account when calculating the personnel costs; ✓ the Auditor numerically reconciled the total amount of personnel costs used to calculate the unit cost with the total amount of personnel costs recorded in the statutory accounts and the payroll system. ✓ to the extent that actual personnel costs were adjusted on the basis of budgeted or estimated elements, the Auditor carefully examined those elements and checked the information source to confirm that they correspond to objective and verifiable information; ✓ if additional remuneration has been claimed, the Auditor verified that the Beneficiary was a non-profit legal entity, that the amount was capped at EUR 8000 per full-time equivalent and that it was reduced proportionately for employees not assigned exclusively to the action(s). ✓ the Auditor recalculated the personnel costs for the employees in the sample. Factual finding: 4. All the components of the remuneration that have been claimed as personnel costs are supported by underlying documentation. 5. The employees in the sample were employed directly by the Beneficiary in accordance with applicable national law and were working under its sole supervision and responsibility. 6. Their employment contracts were in line with the Beneficiary's usual policy; 7. Personnel costs were duly documented and consisted solely of salaries, social security contributions (pension contributions, health insurance, unemployment fund contributions, etc.), taxes and other statutory costs included in the remuneration (holiday pay, thirteenth month's pay, etc.); 8. The totals used to calculate the personnel unit costs are consistent with those registered in the payroll and accounting records; 9. To the extent that actual personnel costs were adjusted on the basis of budgeted or estimated elements, those elements were

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Please explain any discrepancies in the body of the Report.	
Statements to be made by Beneficiary	Procedures to be carried out and Findings to be confirmed by the Auditor
Factual Findings: - ...]	relevant for calculating the personnel costs and correspond to objective and verifiable information. The budgeted or estimated elements used are: — (indicate the elements and their values). 10. Personnel costs contained no ineligible elements; 11. Specific conditions for eligibility were fulfilled when additional remuneration was paid: a) the Beneficiary is registered in the grant agreements as a non-profit legal entity; b) it was paid according to objective criteria generally applied regardless of the source of funding used and c) remuneration was capped at EUR 8000 per full-time equivalent (or up to up to the equivalent pro-rata amount if the person did not work on the action full-time during the year or did not work exclusively on the action).
D. Productive hours XVI. The number of productive hours per full-time employee applied is <i>[delete as appropriate]</i>: A. 1720 productive hours per year for a person working full-time (corresponding pro-rata for persons not working full time). B. the total number of hours worked in the year by a person for the Beneficiary C. the standard number of annual hours generally applied by the beneficiary for its personnel in accordance with its usual cost accounting practices. This number must be at least 90% of the standard annual workable hours. <u>If method B is applied</u> XVII. The calculation of the total number of hours worked was done as follows: annual workable hours of the person according to the employment contract, applicable labour agreement or national law plus overtime worked minus absences (such as sick leave and special leave). XVIII. 'Annual workable hours' are hours	Procedure (same sample basis as for Section C: Personnel costs): ✓ The Auditor verified that the number of productive hours applied is in accordance with method A, B or C. ✓ The Auditor checked that the number of productive hours per full-time employee is correct and that it is reduced proportionately for employees not exclusively assigned to the action(s). ✓ If method B is applied the Auditor verified i) the manner in which the total number of hours worked was done and ii) that the contract specified the annual workable hours by inspecting all the relevant documents, national legislation, labour agreements and contracts. ✓ If method C is applied the Auditor reviewed the manner in which the standard number of working hours per year has been calculated by inspecting all the relevant documents, national legislation, labour agreements and contracts and verified that the number of productive hours per year used for these calculations was at least 90% of the standard number of working hours per year.

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Please explain any discrepancies in the body of the Report.	
Statements to be made by Beneficiary	Procedures to be carried out and Findings to be confirmed by the Auditor
during which the personnel must be working, at the employer's disposal and carrying out his/her activity or duties under the employment contract, applicable collective labour agreement or national working time legislation. XIX. The contract (applicable collective labour agreement or national working time legislation) do specify the working time enabling to calculate the annual workable hours. <u>If method C is applied</u> XX. The standard number of productive hours per year is that of a full-time equivalent; for employees not assigned exclusively to the action(s) this number is reduced proportionately. XXI. The number of productive hours per year on which the hourly rate is based i) corresponds to the Beneficiary's usual accounting practices; ii) is at least 90% of the standard number of workable (working) hours per year. XXII. Standard workable (working) hours are hours during which personnel are at the Beneficiary's disposal performing the duties described in the relevant employment contract, collective labour agreement or national labour legislation. The number of standard annual workable (working) hours that the Beneficiary claims is supported by labour contracts, national legislation and other documentary evidence. <i>[If certain statement(s) of section "D. Productive hours" cannot be endorsed by the Beneficiary they should be listed here below and reported as exception by the Auditor:</i> - ...]	Factual finding: <u>General</u> 12. The Beneficiary applied a number of productive hours consistent with method A, B or C detailed in the left-hand column. 13. The number of productive hours per year per full-time employee was accurate and was proportionately reduced for employees not working full-time or exclusively for the action. <u>If method B is applied</u> 14. The number of 'annual workable hours', overtime and absences was verifiable based on the documents provided by the Beneficiary and the calculation of the total number of hours worked was accurate. 15. The contract specified the working time enabling to calculate the annual workable hours. <u>If method C is applied</u> 16. The calculation of the number of productive hours per year corresponded to the usual costs accounting practice of the Beneficiary. 17. The calculation of the standard number of workable (working) hours per year was corroborated by the documents presented by the Beneficiary. 18. The number of productive hours per year used for the calculation of the hourly rate was at least 90% of the number of workable (working) hours per year.
E. Hourly rates The hourly rates are correct because: XXIII. Hourly rates are correctly calculated since they result from dividing annual personnel	Procedure ✓ The Auditor has obtained a list of all personnel rates calculated by the Beneficiary in accordance with the methodology used. ✓ The Auditor has obtained a list of all the relevant employees, based on which the

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Please explain any discrepancies in the body of the Report.	
Statements to be made by Beneficiary	Procedures to be carried out and Findings to be confirmed by the Auditor
costs by the productive hours of a given year and group (e.g. staff category or department or cost centre depending on the methodology applied) and they are in line with the statements made in section C. and D. above. <i>[If the statement of section 'E. Hourly rates' cannot be endorsed by the Beneficiary they should be listed here below and reported as exception by the Auditor:</i> - ...]	personnel rate(s) are calculated. For 10 full-time equivalent employees selected at random (same sample basis as Section C: Personnel costs): ✓ The Auditor recalculated the hourly rates. ✓ The Auditor verified that the methodology applied corresponds to the usual accounting practices of the organisation and is applied consistently for all activities of the organisation on the basis of objective criteria irrespective of the source of funding. Factual finding: 19. No differences arose from the recalculation of the hourly rate for the employees included in the sample.
F. Time recording XXIV. Time recording is in place for all persons with no exclusive dedication to one Horizon 2020 action. At least all hours worked in connection with the grant agreement(s) are registered on a daily/weekly/monthly basis <i>[delete as appropriate]</i> using a paper/computer-based system <i>[delete as appropriate]</i>; XXV. For persons exclusively assigned to one Horizon 2020 activity the Beneficiary has either signed a declaration to that effect or has put arrangements in place to record their working time; XXVI. Records of time worked have been signed by the person concerned (on paper or electronically) and approved by the action manager or line manager at least monthly; XXVII. Measures are in place to prevent staff from: i. recording the same hours twice, ii. recording working hours during absence periods (e.g. holidays, sick leave), iii. recording more than the number of productive hours per year used to calculate the hourly rates, and	Procedure ✓ The Auditor reviewed the brief description, all relevant manuals and/or internal guidance describing the methodology used to record time. The Auditor reviewed the time records of the random sample of 10 full-time equivalents referred to under Section C: Personnel costs, and verified in particular: ✓ that time records were available for all persons with not exclusive assignment to the action; ✓ that time records were available for persons working exclusively for a Horizon 2020 action, or, alternatively, that a declaration signed by the Beneficiary was available for them certifying that they were working exclusively for a Horizon 2020 action; ✓ that time records were signed and approved in due time and that all minimum requirements were fulfilled; ✓ that the persons worked for the action in the periods claimed; ✓ that no more hours were claimed than the productive hours used to calculate the hourly

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Please explain any discrepancies in the body of the Report.	
Statements to be made by Beneficiary	Procedures to be carried out and Findings to be confirmed by the Auditor
iv. recording hours worked outside the action period. XXVIII. No working time was recorded outside the action period; XXIX. No more hours were claimed than the productive hours used to calculate the hourly personnel rates. <i>[Please provide a brief description of the <u>time recording system</u> in place together with the measures applied to ensure its reliability to the Auditor and annex it to the present certificate⁴].</i> <i>[If certain statement(s) of section “F. Time recording” cannot be endorsed by the Beneficiary they should be listed here below and reported as exception by the Auditor:</i> - ...]	personnel rates; ✓ that internal controls were in place to prevent that time is recorded twice, during absences for holidays or sick leave; that more hours are claimed per person per year for Horizon 2020 actions than the number of productive hours per year used to calculate the hourly rates; that working time is recorded outside the action period; ✓ the Auditor cross-checked the information with human-resources records to verify consistency and to ensure that the internal controls have been effective. In addition, the Auditor has verified that no more hours were charged to Horizon 2020 actions per person per year than the number of productive hours per year used to calculate the hourly rates, and verified that no time worked outside the action period was charged to the action. Factual finding: 20. The brief description, manuals and/or internal guidance on time recording provided by the Beneficiary were consistent with management reports/records and other documents reviewed and were generally applied by the Beneficiary to produce the financial statements. 21. For the random sample time was recorded or, in the case of employees working exclusively for the action, either a signed declaration or time records were available; 22. For the random sample the time records were signed by the employee and the action manager/line manager, at least monthly. 23. Working time claimed for the action occurred in the periods claimed; 24. No more hours were claimed than the number productive hours used to calculate the hourly

⁴ The description of the time recording system must state among others information on the content of the time records, its coverage (full or action time-recording, for all personnel or only for personnel involved in H2020 actions), its degree of detail (whether there is a reference to the particular tasks accomplished), its form, periodicity of the time registration and authorisation (paper or a computer-based system; on a daily, weekly or monthly basis; signed and countersigned by whom), controls applied to prevent double-charging of time or ensure consistency with HR-records such as absences and travels as well as its information flow up to its use for the preparation of the Financial Statements.

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<i>Please explain any discrepancies in the body of the Report.</i>	
Statements to be made by Beneficiary	Procedures to be carried out and Findings to be confirmed by the Auditor
	personnel rates; 25. There is proof that the Beneficiary has checked that working time has not been claimed twice, that it is consistent with absence records and the number of productive hours per year, and that no working time has been claimed outside the action period. 26. Working time claimed is consistent with that on record at the human-resources department.

[official name of the [Beneficiary] [Linked Third Party]]

[official name of the Auditor]

[name and title of authorised representative]

[name and title of authorised representative]

[dd Month yyyy]

[dd Month yyyy]

<Signature of the [Beneficiary] [Linked Third Party]>

<Signature of the Auditor>



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