Annex A Project Description

Project Structure

The project consists of six work packages, which are divided into subtasks led by designated partners. These subtasks are specific, time constraints, and responsibilities are clearly assigned with an objective to simplify the project management and to prevent unnecessary discrepancies and delays.

These WPs are the following:

- WP1 – Systems study – FC in the mobility sector
- WP2 – Vehicle development
- WP3 – Fuel cell design
- WP4 – Fuel cell system development
- WP5 – Powertrain
- WP6 – Evaluation

The WPs are not necessarily followed by the numbers, they are intended to run in parallel, e.g., the WP2 is not finished before WP3, WP4, and WP5, as these are closely connected, and technically some of their parts are components of one another. Lead partners of particular Tasks of WPs reflects the main competencies within the project with Czech partners more focused on vehicle design and construction and German partners more heavily concentrated on FC technology. These core competencies are reflected in the entire project for which success is necessary in this international collaboration. A similar benefit is expected in the market application where implementation is expected earlier in Germany, as there is a more widespread infrastructure for hydrogen vehicles.

WP1 Task 1 – Deep study of SOTA of FC(s) and FCEV

Lead: ČVUT

Participants: FH IWU, ÚJV Řež, 1to1design

This study will provide deep information about state-of-art of fuel cells and FC technologies available with a focus on mobility applications. Already published concepts and market-available devices will be assessed and based on that unique selling points (compared to other drive concepts) will be defined. This task is therefore closely connected to WP1 T2 where the requirements (customer's expectations and needs) will be defined.

WP1 Task 2 – Market study: need/benefit of the project/vehicle (product)
Lead: 1to1design
Participants: ÚJV Řež, ČVUT
The output of this task is definition of the requirements of the product necessary to be attractive to the customers/end users. It will also take into account competition, products, target markets, and intended use of the vehicle. ČVUT will provide its capacity in evaluating proposed solutions from a technical point of view, particularly possibilities (and limits) concerning two-wheeler vehicle package design.

WP1 Task 3 – Legislative framework for fuel cells in mobility
Lead: FH IWU
Participants: 1to1design, ČVUT, ÚJV Řež
The result should be a detailed breakdown of national and international laws, standards, and guidelines (plant, storage, and operational safety, legislative framework for approval of drive concepts with alternative fuels) that must be observed when using hydrogen or fuel cells in mobility. In addition, skills for implementation should be acquired.

WP1 Task 4 – Legislative framework for motorcycles
Lead: ČVUT
Participants: 1to1design
The output of this task is a detailed legislative framework for two-wheeled vehicle: different vehicle classes, and requirements for homologation. Based on decisions made in WP2 T1 (total dimensions, power, and weight of vehicle), the class of the vehicle will be established and necessary components (lights, horn, design constraints) will be defined for WP2 T3 and WP2 T5.
The ČVUT team has experience with homologation requirements for two-wheeled vehicles (EV, ICE). That serial of technical requirements will correspond with FCEV; however, details and differences will be defined in WP1 T3.

WP2 Task 1 – Package Study: research and definition of vehicle parameters & specifications
Lead: ČVUT
Participants: 1to1design, Wätas, FH IWU
This task will research and define vehicle parameters and required specifications from the technical point of view, with respect to requirements defined in WP1 T2 and technical possibilities, particularly limitations of package design. The output will be required maximal power, required top speed, required range and time needed to refill, required trunk space, and preferred design (type) of the vehicle. Technical limits are expected to be hydrogen tank capacity, maximal FC power output (limited by cooling capabilities), and weight. Each chosen motorcycle component also has space requirement which determines the package design of the whole two-wheeler.

WP2 Task 2 – Technical concept study: hybridization of the vehicle
Lead: ÚJV Řež
Participants: 1to1design, ČVUT
Fuel cell vehicles are essentially EVs with an electric power source that charges the buffer battery used for propulsion. Therefore, the combination of electric motor requirements, FC power output and battery capacity, and charging/discharging parameters must be adjusted. This is essential for the design of efficient and cost-effective powertrain. The other part of this task is also definition of the rider HMI, particularly seat height and position related to handlebars and footpegs, but also topics like thermal comfort of the rider (determines the location and maximal capacity of FC coolers). ČVUT has experience with different motorcycle designs focused on rider performance as well as comfort.

WP2 Task 3 – Design concept study
Lead: 1to1design
Participants: ČVUT
The goal of this task is to define vehicle design and driving behavior parameters, which is determined mostly by geometry of the frame, motorcycle fork angle and design and rider position. Esthetics of vehicle design are key requirement to create attractive product and greatly increases interest in the motorcycle. Body design (fairing), materials and 3D focal points will be defined, resulting to manufacturing documentation and further optimization using tools such as FEM. ČVUT subtask is mostly assessment of vehicle geometry and optimization calculations and technical comments on design.

WP2 Task 4 – Application Requirements
Lead: ČVUT
Participants: 1to1design
This task technically integrates the requirements from WP1 T2 and WP2 T1 into the design of the vehicle with focus on rider comfort and cargo (trunk space) demands. Size of trunk and loading will be designed, rider protection against weather will be assessed and optimized, FC waste heat will be concerned (negative for comfort in hot weather, possibility of warming the rider in cold weather).

WP3 Task 1 – FC Stack design
Lead: Wätas
Participants: FH IWU, ČVUT, ÚJV Řež
This task deals with FC stack design for motorcycle use case – parameters and production of individual components and stack, integration of sensors and measurements/characterization of the stack. ČVUT competencies in this task are mostly based on experience with battery-electric drivetrain in motorcycle.

WP3 Task 2 – FC end plate and bracing system
Lead: Wätas
Participants: FH IWU, ÚJV Řež
Appropriate end plate and bracing system for the FC will be selected based on comparison of the options. Interface design for the installation will be also chosen, function model will be researched and characterized. Parts of this task are closely related to WP2 T1 and WP2 T5.

WP3 Task 3 – FC housing
Lead: Wätas
Participants: FH IWU, ÚJV Řež
Housing for the FC will be developed in this task. That concerns mainly design and media routing as well as vibration decoupling/resistance of the stack, thermal management (and measurement, limits defined in WP2 T2 and WP2 T4), safety requirements according to WP1 T3 and WP1 T4 and production of functional models.

WP4 Task 1 – FC operating conditions definition
Lead: Wätas
Participants: FH IWU
Based on parameters and behavior of FC system designed in WP3 T1, requirements and conditions needed for FC operation will be clarified. Output: user manual, requirements for FC package (WP2 T1)

WP4 Task 2 – Development of fuel cell subsystems
Lead: FH IWU
Participants: Wätas, ÚJV Řež
In constant exchange with the vehicle and fuel cell development teams (WP2, WP3), the work package focuses on the design of various parts of the two-wheel drive train. The work is essentially divided into three areas: mechanical design (hydrogen, air and cooling supply), electrical design (compatibility between electrical components of the FCS and the vehicle's on-board network) and their control and regulation.

WP4 Task 3 – Component procurement
Lead: FH IWU
Participants: Wätas, ÚJV Řež
During the whole development of functional sample there are many components which require the “make-or-buy” decision. The development and manufacture on parts should be focused on prototype/experimental parts. Procurement of stock parts (e.g., parts of FC(S) as well as other parts such as shock absorbers, footpegs, brakes, parts of handlebars, lights etc.) is to be done in this task.

WP4 Task 4 – Mechanical structure of FC
Lead: FH IWU
Participants: Wätas, 1to1design
The task includes the structure of the fuel cell system and validates the transferability of theoretical 3D models to reality. The accuracy of fit and compliance with the installation space specifications are checked, cable guides are added, and the ease of assembly is assessed. It is also possible to implement optimization approaches from Tasks 4.5 and 5.1.

WP4 Task 5 – Testing
Lead: FH IWU
Participants: Wätas, ÚJV Řež, 1to1design, ČVUT
Complex task dealing with testing on different levels of detail:

- Individual components testing
- Functional group testing
- Subsystem testing
- FC system testing
- Motorcycle testing (assessment of passive safety and impact safety on other road users depending on the targeted environment, i.e., roads, pedestrian pavements, cycling roads, etc.)

During this task, all parts will be tested, firstly as itself and gradually as a part of more complex systems. Finally, the functional sample of the motorcycle will be tested (and optimized in WP5 T1).

WP5 Task 1 – Vehicle handling behavior
Lead: ČVUT
Participants: 1to1design, FH IWU
The functional sample will be subjected to various tests focused on HMI and UX. It will be tested in a closed safe environment by an experienced rider. Monitored parameters will be handling (cornering, braking) and UX components (starting and shutting down procedures, noise levels). ČVUT uses methodology for two-wheeler assessment based on subjective (driver's) perspective and opinions as well as objective analysis based on numerous parameters measured on bike (from accelerometers and other proprietary developed devices). The goal of this task is to tune motorcycle behavior, shock absorbers and springs parameters, braking behavior etc. to fine-tune the ride quality. Furthermore, if case such systems will be used on vehicle, it will be possible to measure performance of ADAS.

WP5 Task 2 – System intelligence
Lead: ÚJV Řež
Participants: FH IWU, ČVUT
This task is focused on the optimization of FC – buffer battery (and its BMS) interaction – communication between the systems and the most efficient operation of this part of the powertrain. Safety aspects of the use of fuel cells, batteries, and their operating conditions will be part of the analysis and design of control systems. HMI aspects will also be taken into account.

WP6 Task 1 – Economic parameters of the product
Lead: 1to1design
Participants: FH IWU, ČVUT, ÚJV Řež, Wätas
Based on the functional sample and all previous WPs, the manufacturing cost forecast at launch will be established. This cost will be dependent on scale, homologation requirements defined in WP1 T3 and WP1 T4, and also on commercialization method and expected financial return.

WP6 Task 2 – Sustainability
Lead: 1to1design
Participants: FH IWU, ČVUT, ÚJV Řež, Wätas
All partners are committed to maximum sustainability and ecological consideration during this project. The design of the vehicle takes into account the lowest possible ecological footprint, the use of recycled and recyclable materials as well as other DFE and DFS principles. Although the vehicle itself has zero local emissions (except for water), from a life-cycle point of view, an overall consideration of production, operation, maintenance, and recycling at the end of the life cycle is important.

Gantt Chart – WP and Tasks Break Down

		I. 24	II. 24	III. 24	IV. 24	V. 24	VI. 24	VII. 24	VIII. 24	IX. 24	X. 24	XI. 24	XII. 24	I. 25	II. 25	III. 25	IV. 25	V. 25	VI. 25	VII. 25	VIII. 25	IX. 25	X. 25	XI. 25	XII. 25
WP1 – Systems study – FC in mobility sector	T1																								
	T2																								
	T3																								
	T4																								
WP2 – Vehicle development	T1																								
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	T5																								
WP5 – Powertrain	T1																								
	T2																								
WP6 – Evaluation	T1																								
	T2																								

Gantt Chart – Lead Partners

		I. 24	II. 24	III. 24	IV. 24	V. 24	VI. 24	VII. 24	VIII. 24	IX. 24	X. 24	XI. 24	XII. 24	I. 25	II. 25	III. 25	IV. 25	V. 25	VI. 25	VII. 25	VIII. 25	IX. 25	X. 25	XI. 25	XII. 25
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	T2																								

1to1design
FH IWS
Wätas
ČVUT
ÚJV Řež

a) Roles of Each Main Applicant / Lead Organization and Project Partners

In a tabular form, provide a list of activities each organization intends to perform.

Roles of the partners in work packages/tasks which they are leading. Cooperation on other WPs will take place (and is planned), and the scope of work will correspond to the competencies of the partner in the project.

Role of 1to1design (main applicant Czech side)

Task no	Task Name	Description	Results
1.2	Market study: need/benefit of the project/vehicle (product)	Output of this task is definition of requirements of the product necessary to be attractive to the customers/end users. It will also take into account competition, their products, target markets and intended use of the vehicle. ČVUT will provide its capacity in evaluating proposed solutions from technical point of view, particularly possibilities (and limits) concerning two vehicle package design.	Market study
2.3	Design concept study	The goal of this task is to define vehicle design and driving behavior parameters, which is determined mostly by geometry of the frame, motorcycle fork angle and design and rider position. Esthetics of vehicle design are key requirement to create attractive product and greatly increases interest in the motorcycle. Body design (fairing), materials and 3D focal points will be defined, resulting to manufacturing documentation and further	Input for vehicle design

		optimization using tools such as FEM. ČVUT subtask is mostly assessment of vehicle geometry and optimization calculations and technical comments on design.	
6.1.	Economic parameters of the product	Based on the functional sample and all previous WPs, the manufacturing cost forecast at launch will be established. This cost will be dependent on scale, homologation requirements defined in WP1 T3 and WP1 T4, and also on commercialization method and expected financial return.	Economic evaluation
6.2	Sustainability	All partners are committed to maximum sustainability and ecological consideration during this project. The design of the vehicle takes into account the lowest possible ecological footprint, use of recycled and recyclable materials as well as other DFE and DFS principles. Although the vehicle itself has zero local emissions (except for water), from a life-cycle point of view, an overall consideration of production, operation, maintenance and recycling at the end of the life cycle is important.	Life-cycle study

Role of Czech Technical University in Prague (project partner Czech side)

Task no	Task Name	Description	Results
1.1	Deep study of SOTA of FC(s) and FCEV	Review of existing (and concept) vehicles using hydrogen FCs. Current SOTA of FCs will be assessed with focus on mobility application. With this knowledge, the USPs of FCEV in comparison to BEV will be defined.	Input for WP1 T2 and WP2 T1
1.4	Legislative framework for motorcycles	Safety and homologation requirements will be defined for the functional sample. The ideal target is for the vehicle to be roadworthy in the EU, even as a sample. If this target will not be applicable, it still needs to be safe to operate in controlled environment.	Requirements and limits for motorcycle design in WP2 T1, WP2 T3, WP3 T3, WP4 T3 and WP4 T5
2.1	Package Study: research and definition of vehicle parameters & specifications	Based on the customer requirements (from market research) and SOTA analysis in WP1 T1 the definition of vehicle parameters and therefore subsystems and their integration into vehicle (motorcycle frame) will be done.	Definition of the feasible vehicle requirements for the design phase (WP2 T3)
2.4	Application Requirements	This task is closely related to WP2 T3 with focus on rider comfort, HMI, and UX. During the functional sample design phase, objective of this task is to continuously pay attention to the usability of the motorcycle, particularly trunk space, rider ergonomics, rider protection from elements and heat management.	Inputs for WP2 T3 and WP4 T5
5.1	Vehicle handling behavior	Assessment of HMI of the motorcycle in static	Optimization and tuning of vehicle

		conditions and then testing of the handling on a closed circuit with the use of objective methods and data analysis. Optimization of UX and handling (tuning of the suspension, minor design changes to controls etc.)	handling and rider UX

Role of ÚJV Řež (project partner Czech side)

Task no	Task Name	Description	Results
2.2	Technical concept study: hybridization of the vehicle	Fuel cell vehicles are essentially EV with electric power source which charges the buffer battery used for propulsion. Therefore, the combination of electric motor requirements, FC power output and battery capacity and charging/discharging parameters must be adjusted. Part of this task is also definition of the rider HMI, particularly seat height and position related to handlebars and footpegs, but also topics like thermal comfort of the rider (determines the location and maximal capacity of FC coolers). ČVUT has experience with different motorcycle designs focused on rider performance as well as comfort.	FC system parameters, input for 3D concept
5.2	System intelligence	Optimization of two key FCEV powertrain components: fuel cell and buffer battery (and BMS). With data from WP5 T1 it	Output of this WP will be beneficial for further optimization and dimensioning of FCEV vehicles.

		will be possible to exactly define the minimal power output of FC needed and minimal capacity of the battery (and possibly optimal chemistry/type of the battery)	

Role of Wätas Waermetauscher Sachsen GmbH (main applicant Saxon side)

Task No	Task Name	Description	Results
3.1	Stack design	The development of the new fuel cell stack includes considering the use case motorcycle, integration of sensors, production of individual components and stack, measurement and characterization of stack)	Functional sample of a fuel cell stack adapted to the specifications of the motorcycle vehicle
3.2	End plate and clamping system	comparison of the options and selection of the appropriate system, interface design for installation, production of the research function model, characterization	Functional sample of the end and media modules with clamping system optimized in terms of weight saving, material saving and cost reduction
3.3	housing	Design of media feed-throughs and connections, shock resistance/vibration decoupling of the BZ stack, thermal measurement, safety	Guidelines for the functional design of housings for mobile applications Functional sample of a fuel cell stack integrated in a

		requirements, production of functional samples	housing for motorcycle vehicle applications
4.1	clarify operating conditions/requirements of the fuel cell	After the stack has been developed, its requirements and permissible operating parameters must be documented and coordinated with the fuel cell system and the application in the vehicle.	Operating instructions for vehicle integration

Role of Fraunhofer IWU (project partner Saxon side)

Task no	Task Name	Description	Results
4.2	Development of the (sub)system design	Conception of the supply systems for hydrogen, air/oxygen and cooling medium depending on the vehicle concept and the requirements for the operating conditions of the fuel cell	P&I flow chart and CAD model as the basis for construction; Development of optimization approaches to reduce costs, installation space, weight or the internal power requirements of the components used
4.4	Mechanical structure	In order to bring the packaging from theory into practice, the mechanical structure of the fuel cell system and then the integration into the vehicle must first be checked and, if necessary, revised.	functional demonstrator system, documentation of assembly as a guide to system design

4.5	Test phase	Beginning with functional tests of individual components, the test procedure is initially supplemented by functional groups, subsystems and the entire fuel cell system after successful completion. This includes the mechanical structure, the implementation of the power electronics and the design of the control and regulation, taking into account all safety requirements. The final test includes the implementation of the hybridization and the operation of the motorcycles	validation of the BZS concept; working prototype with data acquisition