European Commission

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Title: Develop and demonstrate a 100 MW electrolyser upscaling the link between renewables and industrial applications

Type of action: innovation action

Specific challenge:

The European long term decarbonisation strategy “A Clean Planet for All” published by the European Commission in November 2018 refers to the potential key role of hydrogen in decarbonising hard-to-abate sectors, such as industry, cement, steel, and also contributing to decarbonisation of heavy duty and long distance transport. Hydrogen, if produced from renewable electricity through electrolysis, can also be a basis for Power to X (power to multiple end use applications), and Power to Liquids (synthetic and drop in fuels based on hydrogen).

Energy System Integration, as currently developed by the European Commission aims at reinforcing synergies between economy sectors to make them work more efficiently, reduce overall CO2 footprint and dependence on fossil fuels, and integrate renewables into the energy system, so as to contribute to achieve climate neutrality by 2050.

To contribute to the climate neutrality objective, hydrogen needs to be produced at large scale, mainly through electrolysis powered by renewable electricity. The LTS scenarios achieving climate neutrality envisage an installed electrolyser capacity ranging between 400 and 511 GW by 2050 in the EU. However today the technology is only available at multi-MW scale (a 20 MW electrolyser project is being implemented through the co-funding of the Fuel Cells and Hydrogen Joint Undertaking, under the call 2018).

In order to reach the GW scale, an important milestone would be the development and demonstration of a 100MW electrolyser.

The challenge for this topic is to develop modules of 4-5 MW (or larger) with reduced balance of plant, managing efficiently the input power, the output hydrogen and oxygen streams, as well as the heat flows, while ensuring the reliability of the system and reducing the footprint. It is expected that the development of bigger modules will help create economies of scale, thus leading to further cost reductions.

The modules will then be assembled into a 100MW electrolyser system, which will be tested and demonstrated in a real life conditions, operating flexibly to harvest maximum renewable power and provide grid-balancing services and supplying renewable hydrogen to a commercial/industrial application. The hydrogen purity should meet the hydrogen market requirements. The output pressure shall be designed to fulfil, when possible, the required pressure for the hydrogen application targeted - including buffer storage needs if any - and reduce as far as possible the need for dedicated hydrogen compression units downstream. The performance and the durability of the electrolyser operating dynamically need to be assessed and potential safety issued addressed.

The scope of this project is to operate and install a 100 MW electrolyser to produce renewable hydrogen, as energy carrier. Specific activities are:

- **The main activity will consist of** development, installation and operation a 100 MW electrolyser for managing and using efficiently power (electricity and heat), water, Hydrogen and Oxygen flows;
- Demonstrate the increased usage and economic impact of RES mix, addressing potential curtailment issues in Demand Response operation (if grid connected) or island mode functioning (if dedicated to hydrogen production);
- Operation of an electrolyser system in real life conditions in an industrial or port environment, for example feeding a mobility hub, a fertiliser production plant, a synthetic fuel production plant, a biorefinery or other industries injecting in NG transmission grid type of application.
- Investigate possibility to make use of rejected heat or vented Oxygen
- Operating pressure should be suitable for the application & any buffering / compression requirements

Other activities will consist of economic and environmental assessments:

- Demonstration of future economic viability of the technology depending on cost of electricity and hours of operation of electrolyser;
- Reduce footprint and address safety issues;

- Evaluation of the environmental performance of the system, notably in terms of GHG emissions reduction in line with the methodology of the Renewable Energy Directive II and in terms of water consumption;
- Evaluation of other ecological and societal benefits along the value chain;
  - Project should ensure European value chain by building on technology and business concepts developed by European companies.

- **Mandatory knowledge sharing activity:**
  Cross border dimension and knowledge sharing within Europe: as part of mandatory activities, organise 3 workshops, out of which 2 in European countries, outside of the beneficiary's main implantation, involving policy makers and energy stakeholders, to share knowledge on experience gathered and replication of experiences

The proposed topic of **the call for proposals is expected to have the following impacts**:

Technological impacts:

- Establish a European industry capable of developing novel hundreds of MW electrolysers using a European value chain, consisting of 4-5MW modules and a suitable balance of plant for managing power (electricity and heat), water, Hydrogen and Oxygen flows;
- Increase the efficiency of the electrolyser reaching an energy consumption of 49 (ALK) to 52 (PEM) kWh/kg H2 at nominal power;
- Increase the current density to 1A/cm2 (ALK) or 3A/cm2 (PEM) and delivery pressure to 30 bar. Power electronics should allow for dynamic operation of electrolyser from 25 to 100% in seconds (following the JRC harmonised testing protocols);
- Reduce the plant's footprint by 30% thanks to the larger modules and the plant layout as well as the higher current densities;
- Reduce the electrolyser CAPEX by 20% down to €480/kW and €700/kW for Alkaline and PEM electrolysers respectively, meeting the Fuel Cells and Hydrogen Joint Undertaking targets for 2024;
- Improve the maturity of technologies being tested through demonstrations in real life environment, taking into account constraints from real operations;
- Improving durability of the membranes and components.
- Improve the overall efficiency valorising also by-product heat (e.g. for space heating).

Operational and environmental impacts:

- Demonstrating feasible operation of 100MW-scale electrolysis and the use of the produced hydrogen in an application valorising the renewable character of the produced hydrogen;
- Assessment and operational experience, including safety, of the contractual and hardware arrangements required to distribute and supply hydrogen to the specific industrial and/or transport market;
- Assessment of feasibility to connect the electrolyser to a production site of renewable sources of energy such as offshore wind, or solar plants;
- Technical assessment of the suitability of the electrolyser equipment to operate in its expected environment and suggestion of best practices
- Evaluation of the environmental performance of the system (in alignment with RED II compliant methodologies) – with attention to the CO2 intensity of the hydrogen produced versus Natural Gas route, which should include an understanding of the CO2 impact of the grid services mode selected and CO2 footprint impact in the addressed hydrogen end-user markets.
- Evaluation of other ecological and societal benefits along the value chain.

Knowledge sharing within the EU and competitiveness impacts:

- through mandatory knowledge sharing activities, transfer of know-how, and spill over of knowledge at EU level, through workshops beyond industry players, involving European decision makers and energy stakeholders

Cost competitiveness impacts:

- Demonstrate a compelling economic and environmental case, including boundary conditions, for key applications such as transport, energy storage, raw material (hydrogen and oxygen) or heat and power production. For a LCOE of up to €40/MWh (renewable sources), achieve a cost of green H2 below €2.5/kg and aim for further reductions by generating income from the provision of electricity grid balancing services.

<u>Additional end study impacts addressed directly to the European Commission:</u>

- Assessment of the legislative and RCS implications of these systems and any issues identified in obtaining consents to operate the system
- Recommendations for policy makers and regulators on measures helping to maximise the value of renewable energy and stimulate the market for renewables-electrolyser systems.

Co- Funding

EC support would amount to EUR XX million while a total budget of EUR XX million would be envisaged for the development of the electrolyser and its BoP (about 50% of total budget), for civil works, connection to the grid or RES site(s), hydrogen buffer storage, possible compression station and H2 storage/injection/refuelling facilities.

Combination with other EU or national financing instruments will be incentivised, namely the usage of financial instruments to de-risk the operational activity, covering the hydrogen off-take in particular in the ramping-up of the project.

Given the very risky character of this demonstration and its first of the kind pathway for large demonstration, it is expected that financial institutions will not take this risk on their own, but will expect either EU support, or national support for de-risking.

Financing plan (own resources and resources planned to be drawn from the international financial organisations need to be appended to the application).