Politecnico di Torino

Finanziato dall'Unione europea NextGenerationEU

ENERGETICS

Offshore renewable energy generation for hydrogen

Funded By	Ministero dell'Università e della Ricerca - MUR [P.iva/CF:96446770586]
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Context of the research activity	The exploitation of offshore RESs is crucial to achieve a sustainable energy transition since they are among the largest, but still untapped, energy sources. Together with an increase in RES penetration, hydrogen is emerging strongly thanks to its ability to decarbonize industrial processes and economic sectors where the reduction in CO2 emissions is hard to achieve. The global hydrogen demand is expected to increase 10-fold by 2050, reaching a value of almost 80 EJ. In this context, offshore RESs are expected to be essential to cover the European demand of hydrogen over the next years. Research on both offshore RESs and hydrogen production is needed to favor technological progress and the large-scale penetration of these solutions.
	The main goal of the PhD activity is to investigate the feasibility of a future European energy system with large offshore renewable energy generation with hydrogen infrastructure. The activity will deal with the long-term optimal expansion planning of Europe, investigating its multi-year evolution to support the ongoing transition towards a carbon-neutral economy. 1. The potential for offshore renewable energy production (in terms of wind, wave and solar resource) will be estimated. In this context, potential offshore renewable installation areas across Europe will be identified and ranked,

Objectives	considering also socio-economic and environmental factors. 2. The hydrogen demand profile will be analyzed considering scenarios with different decarbonization targets. A study will be also performed to identify the most promising technologies for hydrogen production. 3. Mixed integer linear programming techniques will be employed to address the development of multi-year capacity expansion models. Modelling tools, such as Calliope [3] and Osemosys [4], could be also taken into account. 4. Since high-RES penetration scenarios will be developed, particular attention will be paid to obtain an accurate description of the RES variability in space and time, as well as of the storage system sizes. This is challenging since a detailed representation of the RES behaviour often requires a high temporal resolution, with consequent increase in the computational burden. Therefore, one of the objectives of the PhD activity will also consist in developing techniques to properly address the sizing of RES-based solutions, while limiting the complexity of the problem. The final aim is to derive a spatially-resolved energy system of Europe (by means of multiple interconnected nodes) to investigate the feasibility of deep decarbonization scenarios based on large-scale use of hydrogen from offshore renewable energy. References: [1] IRENA, “Geopolitics of the Energy Transformation. The Hydrogen Factor,” 2022. [2] Hydrogen Council, “Path to hydrogen competitiveness. A cost perspective,” 2020. [3] S. Pfenninger and B. Pickering, “Calliope: a multi-scale energy systems modelling framework,” J. Open Source Softw., vol. 3, no. 29, p. 825, 2018, doi: 10.21105/joss.00825. [4] M. Howells et al., “OSeMOSYS: The Open Source Energy Modeling System. An introduction to its ethos, structure and development.,” Energy Policy, vol. 39, no. 10, pp. 5850–5870, 2011, doi: 10.1016/j.enpol.2011.06.033.
Skills and competencies for the development of the activity	• Excellent knowledge of the Matlab/Python environment • Knowledge in the modeling of main renewable energy generation (e.g., PV, wind, wave) and storage (e.g., battery, hydrogen) technologies.