Ocean energy: Delivering cheaper, cleaner & more secure electricity systems

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ETIP OCEAN

European Technology & Innovation Platform for Ocean Energy

Reaching zero emissions by 2050 requires a massive scale-up of renewable power production. While wind and solar will form the bulk of Europe's electricity supply, other renewable sources are needed to balance the system when there is less wind or sun.

Ocean energy is a perfect companion to variable renewables. It can fulfil the balancing role currently played by fossil fuels, making the electricity grid more secure, cheaper and 100% decarbonised.

Three reasons why ocean energy lowers system costs

1. Tidal stream is 100% predictable

Regulated by the constant cycles of the moon and the sun, tidal stream is 100% predictable. The output of tidal power is known for any moment in the future. In electricity grids that increasingly rely on variable renewables, the predictability of tidal stream generation can replace expensive flexibility solutions and lower system costs.

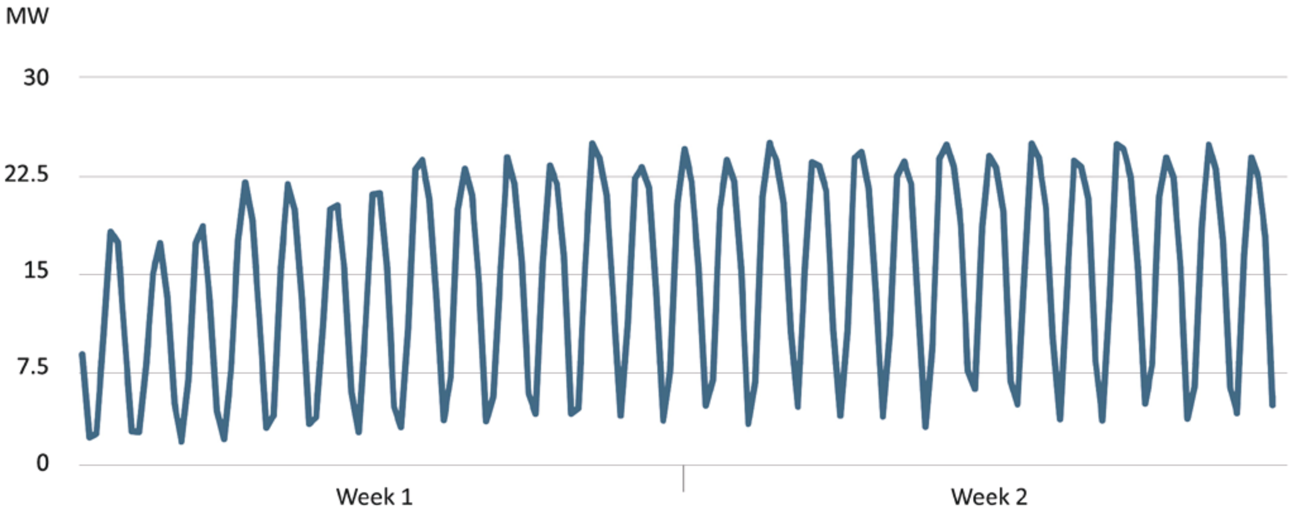


Figure 1: Exemplary power generation of 25 MW capacity over two weeks

2. Wave energy complements wind and solar

Wave energy's production pattern is different from wind and solar. Wave energy works particularly well with wind – the waves are built up by the wind, so when the wind dies down, wave energy can step in to maintain power production. Adding wave energy to wind generation makes the electricity output smoother and more stable. This stabilizes overall electricity supply and reduces the need for expensive flexibility, lowering system costs.

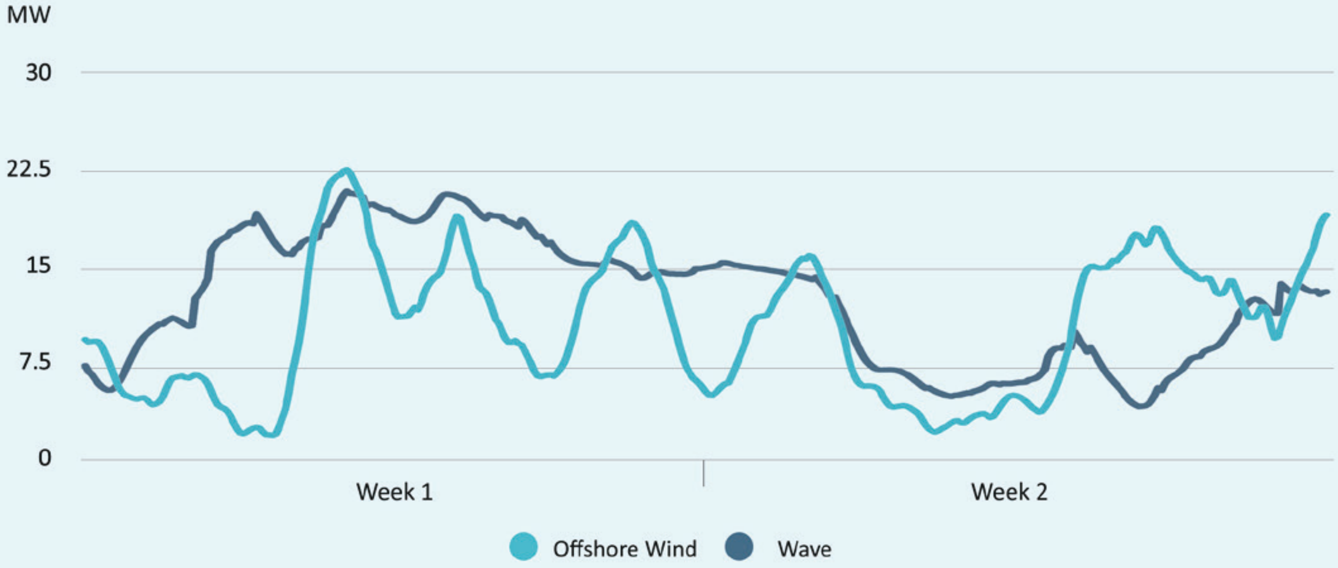


Figure 2: Exemplary power generation of 25 MW capacity over two weeks

3. Wave production is high when demand is high and solar production low

In Europe, wave energy generation is highest in winter. This is the moment when electricity demand is highest. It also means that wave production is high when solar production is low, making wave energy complementary to solar energy over the year. By matching electricity supply and demand more closely, wave energy thus reduces the need for long-term storage or thermal back-up generation in winter.

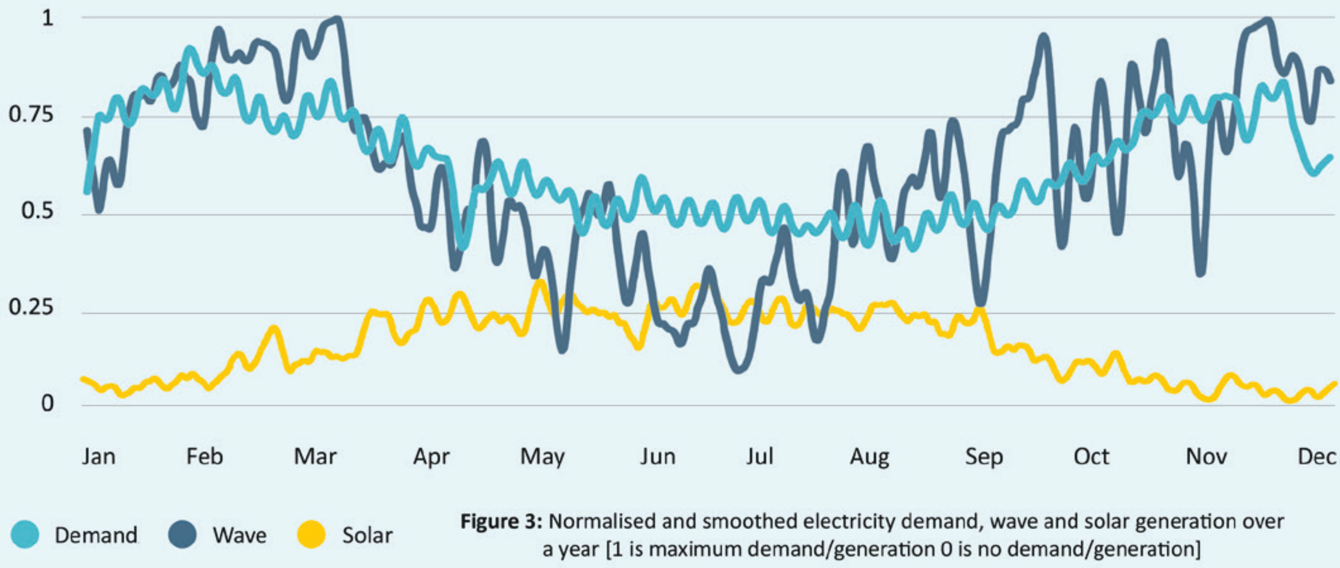


Figure 3: Normalised and smoothed electricity demand, wave and solar generation over a year [1 is maximum demand/generation 0 is no demand/generation]

Case studies – Ocean energy reduces CO_2, fossil fuel use and system costs

When ocean energy is used to balance electricity systems, it delivers several different benefits:

- Ocean energy's predictability and complementarity means that it **directly replaces backup fossil fuel consumption** when there is less wind or sun. This in turns boosts energy security.
- Less fossil fuel consumption means **large CO_2 emission savings**.
- Less fossil fuel consumption means **lower dispatch costs** – as ocean energy has almost no marginal costs.

The benefits of ocean energy to the electricity grid have been quantified for Ireland, Portugal, Great Britain and the Faroe Islands. These case studies are based on existing scenarios produced by governments or TSOs[i].

Relatively modest inclusions of ocean energy into the grid in these 4 locations deliver significantly reduced fossil fuel consumption, CO_2 and dispatch costs.

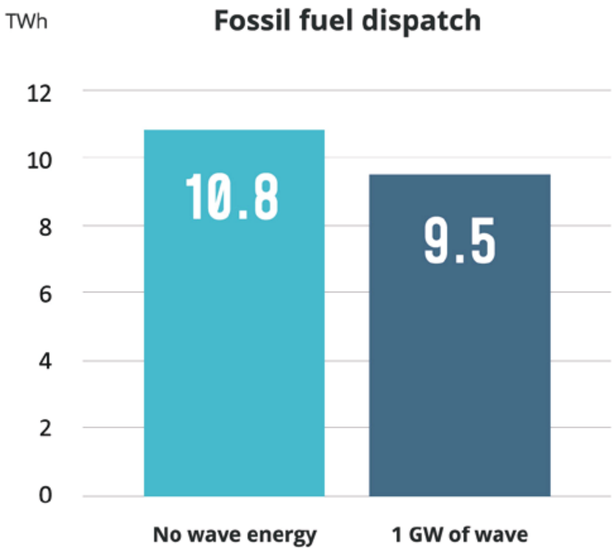
Ireland

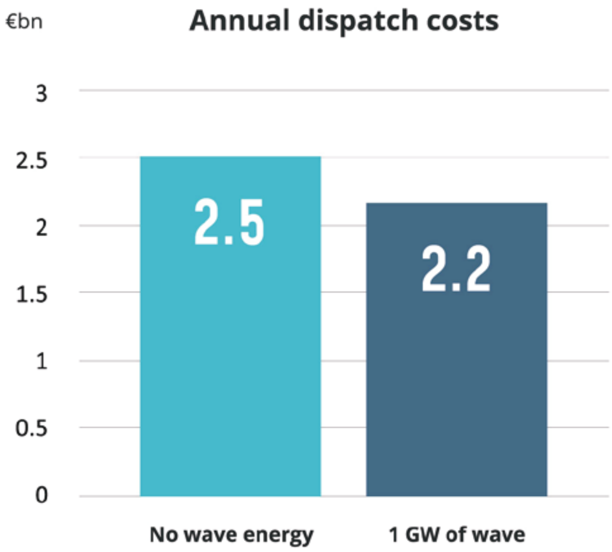
Ireland's main ocean energy resource is wave. Ireland's practical wave energy potential[ii] is 89.7 TWh – equivalent to 18.8 GW of installed capacity – which is circa three times Ireland's annual electricity demand of 30.4 TWh (IEA,2023).

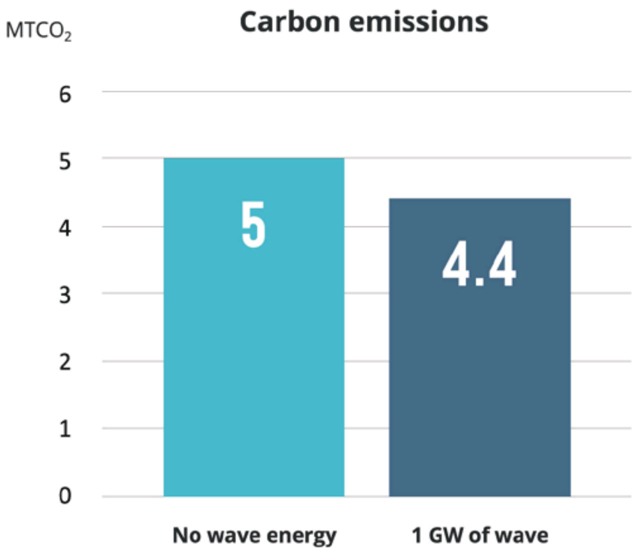
The 2030 energy mix will consist mainly of onshore and offshore wind, fossil fuels, solar PV and storage. The total generating capacity is expected to reach circa 23 GW[iii].

1 GW of wave energy in the 2030 Irish grid will reduce fossil fuel dispatch and annual carbon emissions by 12%. It leads to savings in annual dispatch costs of €300m (10.9%)[1].

Benefits of 1 GW of wave energy in the Irish grid







1. Potential discrepancies between calculations in the text and the bar graphs are due to rounding errors

Portugal

Portugal's main ocean energy resource is wave. The total practical wave energy potential is 57.3 TWh – equivalent to 15.5 GW of installed capacity – surpassing Portugal's annual electricity demand of 50.3 TWh (IEA, 2023).

In 2030, the energy mix will consist mainly of hydropower, onshore wind, solar PV and fossil fuels, with some offshore wind and biomass included. The total generating capacity is expected to reach 25 GW[iv].

Including 1 GW of wave energy in the grid will reduce fossil fuel dispatch by 16.7%. This reduces annual carbon emissions by 16.4% and total annual dispatch costs by €230m (3.7%).

Benefits of 1 GW of wave energy in the Portuguese grid

Great Britain

Great Britain has a great resource for both wave and tidal energy. The total practical potential of ocean energy is 134.9 TWh – 106.7 TWh of wave and 28.2 TWh of tidal, equivalent to 24.8 GW and 10.4 GW of installed capacity, respectively. Ocean energy could thus cover circa half of the annual electricity production of Great Britain, which for the whole UK is 285 TWh (IEA, 2023).

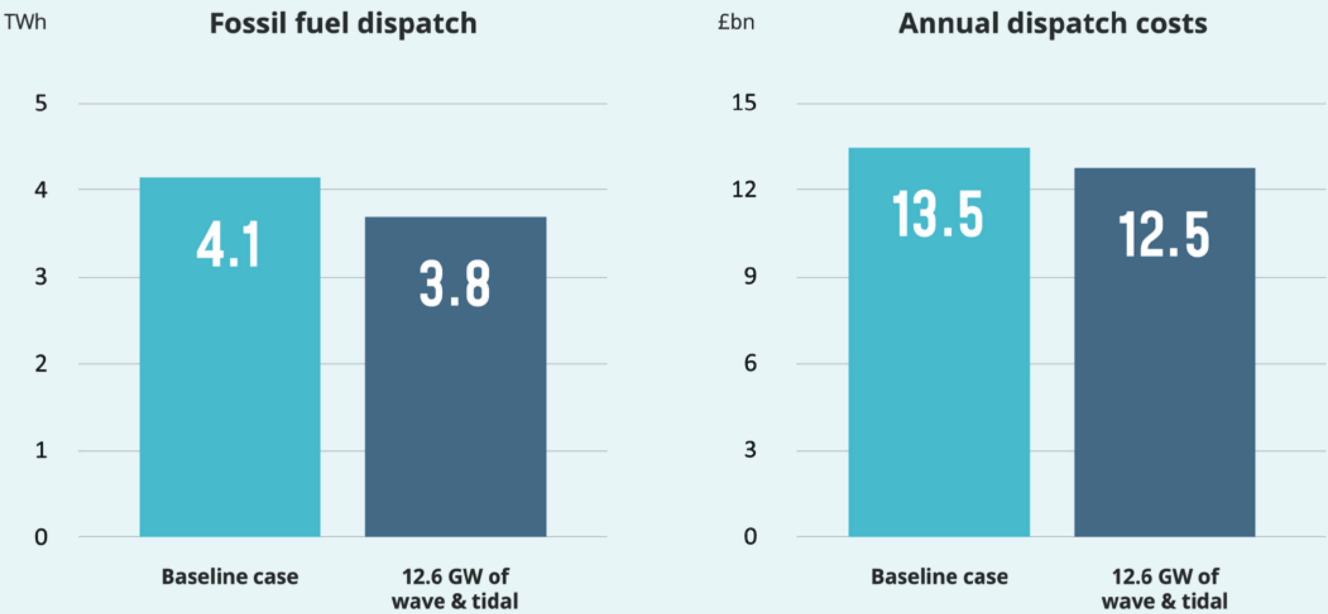
In 2030, the energy mix will consist mainly of onshore and offshore wind, solar PV, fossil fuels, storage, biomass and nuclear. The total generating capacity is expected to reach circa 170 GW[v].

Adding only 1 GW of tidal or wave energy[vi] into the grid will reduce fossil fuel dispatch by circa 2.5%, which will reduce annual carbon emissions by circa 2.6%. This will result in a circa £100m reduction in total annual dispatch costs.

The 1 GW represents only 0.5% of the total generation in Great Britain, but the benefits are already very clear. Fossil fuel dispatch, carbon emissions, and dispatch costs will continue to go down as more ocean energy capacity is installed.

In a different scenario, assuming a much more decarbonised grid, including circa 12 GW of wave and tidal energy reduces fossil fuel dispatch by 7.3% and the annual dispatch cost by £1.03bn[vii].

Benefits of 12.6 GW of wave & tidal energy in the Great Britain grid



The Faroe Islands

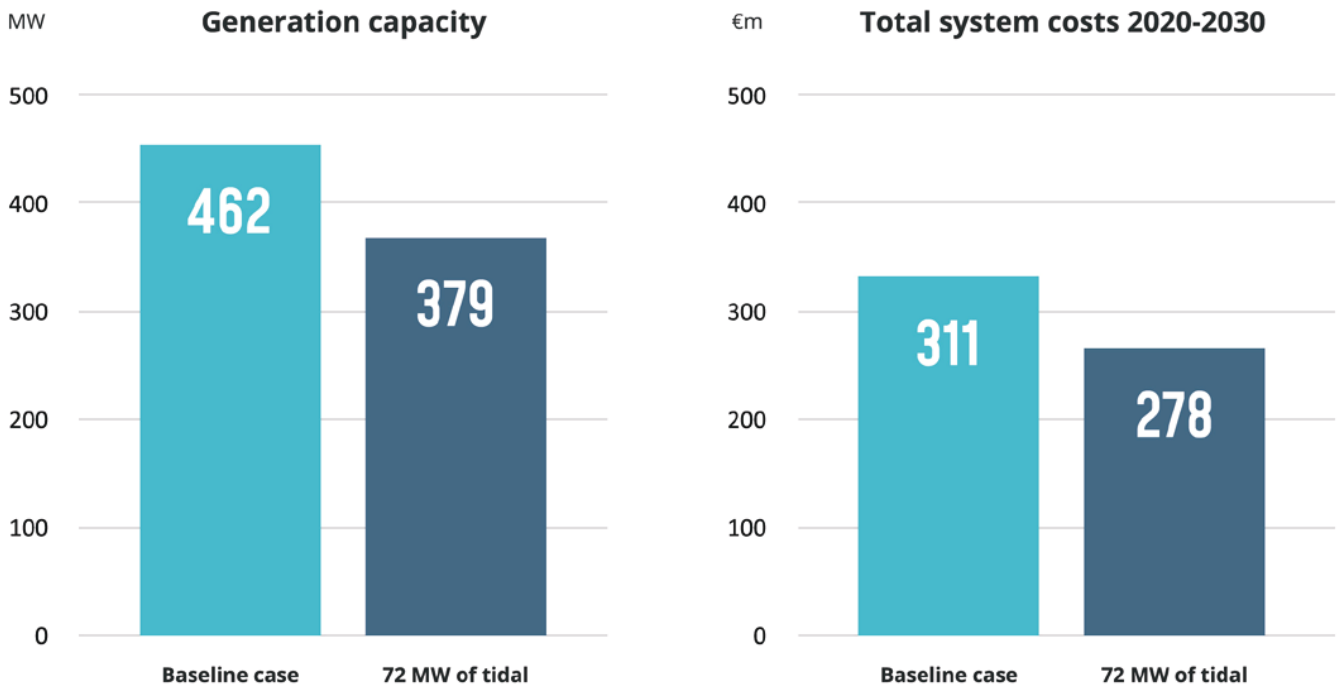
The Faroe Islands consist of 18 islands that are mainly powered by fossil fuels and hydropower. The Faroese utility SEV is aiming for a 100% renewable electricity sector by 2030.

Tidal energy is particularly attractive. The Faroe's geography means that there is always tidal power being generated in some areas, so tidal baseload generation is possible. This significantly lowers the required volume of generation capacity.

According to modelling by SEV, including 72 MW of tidal energy into the grid will reduce the net generation capacity need by 83 MW (18%)[viii].

Including tidal energy in the energy mix will reduce the total system costs from 2020-2030 by €33m (11%).

Benefits of 72 MW of tidal in the Faroese grid



Scaling up ocean energy will generate greater system benefits

The figures differ between countries due to their specific characteristics. However, the overall trend is clear: even limited amounts of ocean energy can significantly reduce fossil fuel dispatch, CO_2 emissions, and system costs.

To reap those benefits, ocean energy must be scaled up. Acting on the key recommendations identified in the ETIP Ocean Industrial Roadmap for Ocean Energy will trigger ocean energy's industrial roll-out.

Grant funding enables technology development
As projects at R&D and prototype stage do not generate revenue, public funding is the main source of funds for technology development. Direct grants that are able to cover up to 100% of the costs enable early-stage research as well as the development of prototypes, which are a prerequisite for pre-commercial and commercial projects. Public funding programmes can be set up at the regional, national or international levels.

Investment aid and revenue support get pilot farms to financial close
Ocean energy pilot and pre-commercial farms are project-financed and require private capital. Public financial instruments offering zero- or low-cost finance help get them to financial close by reducing the cost of capital and attracting private investors. The financial instruments should be complemented by revenue support that will make projects bankable and ensure a return for investors. The electricity price alone cannot deliver this before those technologies go down the cost curve. Innovative projects need a "top-up" on the electricity price to have a business case.

National deployment targets show the path to market
National deployment targets, coupled with earmarked revenue support, give private investors clear signals on future markets. Such targets directly publicise the size of the market, reduce the capital costs of projects by decreasing perceived market risks, and increase access to finance.

Streamlined permitting processes accelerate deployments and reduce costs
Tailor-made and streamlined permitting for ocean energy will accelerate development and reduce the costs of the process. Appointing a single point of contact and setting a time limit of one year for the whole permitting process for single devices or small pilot farms are considered the best practices in the industry. This would ensure that the costs and timelines related to permit are proportionate to the size of the project.

Data sources

EVOLVE project – Quantifiable system benefits (in terms of economics, carbon reduction and power system operation) of wave and tidal stream deployments in Great Britain, Ireland and Portugal

Methodology:

- Historical data from 2019 and future projections were collected for Great Britain, Ireland and Portugal, based on official roadmaps and energy scenarios.
- Hourly availability profiles for wind, solar, wave and tidal energy were derived using 2019 data to maintain consistency with demand.
- Economic dispatch models for Great Britain, Ireland and Portugal were developed using Python for Power Systems Analysis software.
- A sensitivity analysis was performed, including ocean energy in the generation mix and comparing it to additional offshore wind capacity.

100% Sustainable Electricity in the Faroe Islands: Expansion Planning through Economic Optimization

Methodology:

- "The optimisation tool Balmorel was used to optimise investments and dispatch, considering system specifications, investment options and policy constraints."
- A method to translate optimal results to a realistic RoadMap was developed and applied.
- The impact of different technologies and costs was investigated through multiple scenarios.

i Modelling work for Ireland, Portugal and Great Britain funded by Scottish Enterprise, Swedish Energy Agency and Fundação para a Ciência e a Tecnologia through the EVOLVE project. Additional modelling work for the UK funded by the UK RI Engineering and Physical Sciences Research Council through the SUPERGEN project. Modelling work for the Faroe Islands funded by SEV, the Faroese Power Company.

ii The practical potential considers climatic, natural, engineering and technological constraints, as well as economic and legal constraints, making it the most conservative figure. This potential can increase as costs go down and legislation improves.

iii EirGrid, "Tomorrow's Energy Scenarios 2019 Ireland: Planning our Energy Future," EirGrid, Dublin, Ireland, 2019.

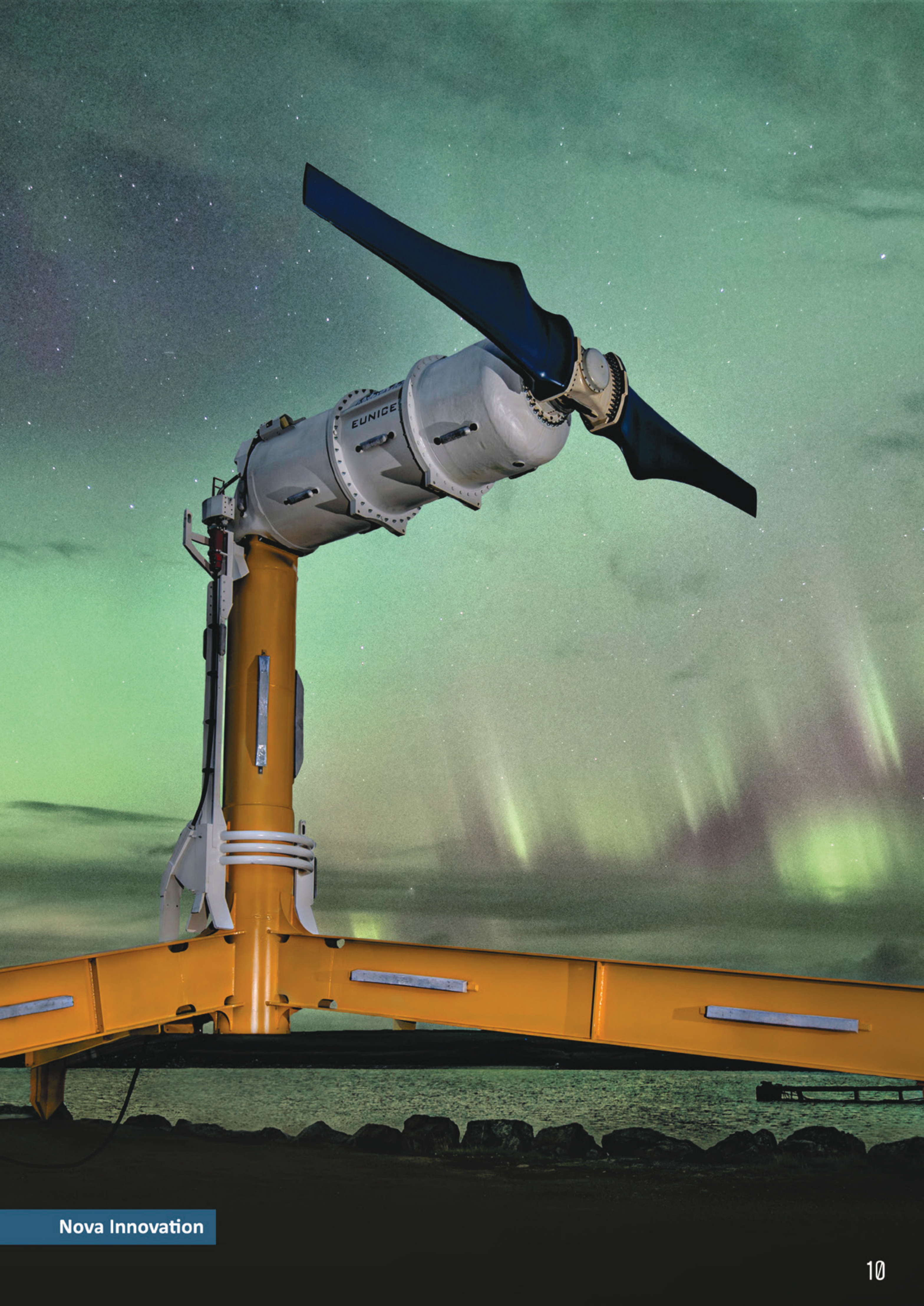
iv DGEG, "Energy Scenarios in support of the Portuguese Strategy for Hydrogen. DEIR Studies on the Portuguese Energy System 002," Directorate-General for Energy and Geology, Lisbon, Portugal. ISBN 978-972-8268-53-4, 2020.

v National Grid ESO, "Future Energy Scenarios 2021," 2021.

vi The EVOLVE study does 2 scenarios for Great Britain – one with 1GW of wave, and the other with 1GW of tidal. The figures presented above are an average of these 2 scenarios. Full figures are available in table 1 of the EVOLVE final report.

vii S. Pennock and H. Jeffrey, 'What are the UK power system benefits from deployments of wave and tidal stream generation?', Supergen ORE, Jan. 2023.

viii Tróndheim, Helma Maria, et al. "100% sustainable electricity in the Faroe Islands: Expansion planning through economic optimization." IEEE Open Access Journal of Power and Energy 8 (2021): 23-34.



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ETIP Ocean brings ocean energy experts together to share knowledge and define priorities to boost the sector's development.

ETIP Ocean maximises knowledge-exchange across the ocean energy sector through webinars and workshops. It puts forward recommendations for policymakers and industry in high-quality publications. Together with the SET Plan Implementation Working Group for Ocean Energy, ETIP Ocean launched the Forum for Sectoral Dialogue for Ocean Energy bringing public and private leaders in ocean energy together.

ETIP Ocean is a recognised advisory body to the European Commission, as part of the SET Plan – the EU's main research and innovation policy instrument.

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