[redacted]

Reply to:

Consultation on the offshore renewable energy (ORE) Future Framework Policy Statement

Dear Minister Ryan & the Department of the Environment, Climate and Communications Team, I hope this letter finds you well. I am writing to provide feedback on the Offshore Renewable Energy (ORE) Policy Statement consultation, particularly addressing the key priorities outlined in the draft policy.

My name is [redacted], I am currently a master's student at the [redacted], majoring in [redacted]. My ongoing thesis research is on [redacted]., aiming to explore their viability and potential contributions to sustainable energy solutions. During my research, I have explored several forms of renewable energy sources, including ORE. I would like to contribute some feedback surrounding the Future Framework Policy Statement, particularly in the areas of renewable hydrogen and renewable hydrogen derivatives transport options.

Kind Regards,

[redacted],
[redacted].

Executive Summary

This submission critically assesses Ireland's potential for renewable hydrogen and its derivatives as strategic transport options, with a focus on the feasibility of hydrogen export pipeline routes by 2040. Considering Ireland's ambitious Offshore Renewable Energy (ORE) Policy Statement, this analysis explores the integration of renewable hydrogen production within the national energy strategy. It evaluates technological advancements, infrastructure requirements, environmental impacts, and market dynamics essential for establishing Ireland as a key player in the global renewable hydrogen market. This assessment aims to inform policy decisions, ensuring they align with technological viability, economic competitiveness, and environmental sustainability.

Main Findings

- Clarification sought on the selection between PEFCs and SOFCs for hydrogen fuel cell technology.
- Inquiry into how existing natural gas infrastructure can be adapted for higher hydrogen blending.
- Information required on planned infrastructure improvements to accommodate the anticipated rise in hydrogen consumption for energy storage, transportation, industry, and building heating.
- Clarification on the regulatory changes or new policy frameworks being introduced to promote the transition to a hydrogen economy,
- Concerns about managing risks associated with hydrogen combustion.
- Concerns over the potential 30% decrease in hydrogen demand and its impact on cross-border infrastructure development plans.

Recommendations:

- Conduct comprehensive comparative studies to assess the efficiency, durability, operational temperature ranges, and cost implications of Polymer Electrolyte Fuel Cells (PEFCs) versus Solid Oxide Fuel Cells (SOFCs).
- Develop a phased plan, including safety evaluations, pilot projects, and technical feasibility studies, for modifying the current natural gas infrastructure to accommodate higher hydrogen blending levels.
- Initiate a research and development initiative focused improving combustion technology to lessen the risks connected with using hydrogen; in particular, the project should concentrate on cutting NOx emissions and avoiding flashback.
- Participate in international discussions to comprehend trends in the global market and modify export plans as necessary.

Supporting Information:

The following is a reply to Action Item 20, the assessment of renewable hydrogen and renewable hydrogen derivatives transport options, including assessing the viability of potential hydrogen export pipeline routes by 2040. This assessment must consider the current state of technology, projected advancements, economic factors, and policy frameworks that will influence the development of renewable hydrogen and renewable hydrogen derivatives transport options, including the viability of potential hydrogen export pipeline routes by 2040.

This reply also touches on other questions raised in the Future Framework Policy Statement such as: What frameworks and/or supports are required for alternate routes to market such as Power-to-X projects, interconnector-hybrid projects and export projects?

The Paris Agreement, signed by 192 countries, commits the countries to keep global warming well below 2.0 ◦C, preferably at 1.5 ◦C. Reducing greenhouse gas emissions caused by human activity is essential to achieving this goal. Natural gas is a potent greenhouse gas that is utilised in every industry. Green hydrogen has received a lot of attention as a substitute. Research on greenhouse gas neutrality frequently identifies applications for hydrogen, independent of the particular political measures involved. Green hydrogen facilitates the deployment of renewable and sustainable energy systems. The demand for green hydrogen will increase and become relevant for energy supply and storage, particularly after 2030. [1]

Current State of Technology and Infrastructure:

The process of re-electrification involves directly converting chemical reaction energy into electrical energy using hydrogen fuel cells. There are two common hydrogen fuel cells used to generate electricity. Polymer Electrolyte Fuel Cells (PEFCs) and Solid Oxide Fuel Cells (SOFCs).

PEFCs are specifically designed to be used as a power source for fuel-cell vehicles. It utilises a polymer membrane as an electrolyte and operates at around 80℃. The electrodes used in this process contain particles of platinum. This leads to the cell being susceptible to the aggregation of particles, or clumping, which diminishes the efficiency of the fuel cell. Additionally, there is a durability concern due to the corrosion of the carbon support material in the electrode [2].

SOFCs are commonly used in household power generation systems and utilise a solid oxygen electrolyte, as opposed to a polymer electrolyte. It operates at temperatures exceeding 600°C which allows for highly efficient chemical to electrical energy conversion. However, these high temperatures can cause difficulties like elemental diffusion between components, the production of nonconductive products, and the aggregation of metal catalysts, all of which contribute to cell degradation [2].

In light of these considerations, could you please provide clarification on the following aspects?

Which type of hydrogen fuel cell technology (PEFC, SOFC, or another) is the project planning to use?

What are the anticipated primary applications of these fuel cells within the project (e.g., transportation, household power generation, etc.)?

How does the project plan to address the specific challenges associated with the chosen type of fuel cell, including efficiency, durability, and operational temperature considerations?

Projected Advancements:

These are the projected advancements of hydrogen applications, globally, in the year 2050 according to the Hydrogen Council:

Transportation: 20–25% of each vehicle type. are anticipated to run on hydrogen. This will be around 400 million cars, 15–20 million trucks, and 5 million buses. In heavier and longer-range segments, hydrogen will be crucial, helping to meet a large amount of the CO2 reduction needed by the road transport industry [3].
Given the strategic importance of renewable hydrogen production linked with ORE deployment, could you specify the types of infrastructure developments planned to support hydrogen fueling and distribution? How will these infrastructures integrate with existing energy systems to facilitate the transition to hydrogen energy?

Energy Integration and Storage: Since hydrogen can convert and store more than 500 TWh of otherwise restricted electricity, it will make large-scale integration of renewable energy possible. This will link energy importers with areas abundant in renewable resources, facilitating energy distribution across sectors and regions [3].
While acknowledging the strategic role of hydrogen in integrating renewable energy, could you elaborate on the specific technologies and pilot projects currently being explored or implemented for this purpose? Additionally, what are the key policy initiatives supporting the technological integration of hydrogen within Ireland's renewable energy sector?

Industrial Use: Hydrogen will be used to decarbonise industrial energy use, including medium- and high-heat processes where electrification is not efficient. It will also be used as a clean feedstock in sectors like the manufacturing of methanol and steel [3].
Can you provide insights into the specific technologies or methodologies that will be employed to ensure hydrogen's role as a clean feedstock, particularly in the manufacturing of methanol and steel?

Building Heat and Power: By using the current gas infrastructure, hydrogen will help decarbonise building heat and power to meet around 10% of global heat demand [3].
What are the anticipated steps or innovations required to retrofit or adapt this infrastructure for hydrogen?

Economic and Environmental Impact: The hydrogen economy is projected to contribute to 18% of final energy demand, enable 6 Gt annual CO_2 reduction, generate $2.5 trillion in annual sales (hydrogen and equipment), and create 30 million jobs [3].

Considering the ambition for a renewable hydrogen economy, can you provide insights into any ongoing or planned international collaborations that aim to enhance Ireland's hydrogen production capabilities and export potential? How do these collaborations align with global hydrogen market developments and international climate goals?

Strategic Considerations for Hydrogen Economy Integration:

Power-to-Hydrogen is preferable for reasons of cost and efficiency as long as hydrogen can be stored and used locally, or the blending limit of the gas grid is not reached. Adapting natural gas infrastructure to higher hydrogen blending involves research and high costs. So far, 2% by volume is permitted in Germany, and 20% is considered technically possible. [4] Compressors, gas turbines and CNG tanks need modification above only a few per cent hydrogen concentrations, while pipelines can tolerate a higher hydrogen fraction, depending on maintenance conditions. This is due to its distinct physical properties when compared to traditional hydrocarbon fuels such as natural gas. Notably, hydrogen exists in a gaseous state under standard conditions with higher diffusivity and flame speed. Because of these special characteristics, designing combustion systems requires careful consideration, particularly in the case of premixed combustion applications. Premixed combustion is becoming more widely acknowledged as a way to lower emissions of pollutants in lean burn configurations. However, this method is closely associated with the risk of flashback, a sudden, potentially hazardous, movement of the flame towards the fuel source when hydrogen is used as a fuel.

The transition to hydrogen or hydrogen-blended fuels in non-premixed combustors is not without its complications. A significant hurdle is the increased production of Nitrogen Oxide (NOx), particularly under dry conditions. The production of NOx increases significantly with temperature, especially in the hot spots formed when hydrogen burns. In addition, NOx formation is influenced by residence time, equivalency ratio, and pressure levels. However, the negative effects can be somewhat minimised by introducing nitrogen dilution or steam, which will keep emissions within the limits established by international regulations [5].

In light of these considerations, could you please provide clarification on the following aspects?

With the injection limit quickly reaching lower fossil gas flow rates, what innovative solutions or technologies are being developed to enhance hydrogen buffer storage capabilities and manage grid blending limitations?

Adapting the natural gas infrastructure for higher hydrogen blending poses significant challenges and costs. How are these being addressed, and what progress has been made towards achieving higher blending thresholds safely and economically?

The specific characteristics of hydrogen combustion require careful system design to mitigate risks like flashback and NOx emissions. What advancements are being made in combustion technology to manage these risks, particularly in premixed combustion applications?

In light of Ireland's commitment to achieve net-zero emissions and the growth of a renewable hydrogen sector, could you elaborate the specific changes in rules or new policies being introduced to support this change? Also, what measures are being taken to ensure that these regulations for the hydrogen sector remain relevant and effective as market conditions and technology evolve?

Hydrogen Infrastructure and Export Strategies:

Ireland is positioning itself in a position to take advantage of its significant offshore renewable energy potential in order to become a key exporter of green hydrogen within the EU. Sensitivity analyses that were carried out offer crucial insights into the structural and strategic considerations necessary for Ireland's integration into a broader European hydrogen economy, particularly from an export perspective. These analyses evaluate the resilience of infrastructure requirements in different scenarios, such as shifts in the demand for hydrogen, the strategic distribution of capacities for variable renewable energy sources, and the increased electrification of the energy sector.

The analysis indicates that a combination of factors, including advancements in energy efficiency, deeper electrification across various sectors, and the strategic reallocation of renewable energy sources closer to demand centers, could result in a potential 30% decrease in hydrogen demand. Consequently, this reduced demand for hydrogen could significantly lessen the need for extensive hydrogen infrastructure development, aligning with a more efficient and optimized future energy system that prioritizes direct electrification and uses hydrogen where it is most effective [6].

Given Ireland's export ambitions, how does the government plan to mitigate the risk of overcapacity and ensure the economic viability of its hydrogen infrastructure investments?

Bibliography:

[1] v. Mikulicz-Radecki, F. et al. (2023) “Evaluation of hydrogen transportation networks - A case study on the German energy system,” Energy (Oxford), 278, pp. 127891-. Available at: https://doi.org/10.1016/j.energy.2023.127891.

[2] Matsuda, J. (2023) “In situ TEM studies on hydrogen-related issues: Hydrogen storage, hydrogen embrittlement, fuel cells, and electrolysis,” Microscopy [Preprint]. Available at: https://doi.org/10.1093/jmicro/dfad060.

[3] Hydrogen Council, 2017. Scaling up Hydrogen: Pathways to Hydrogen as a Key Enabler of the Global Energy Transition. [pdf] Hydrogen Council. Available at: https://hydrogencouncil.com/wp-content/uploads/2017/11/Hydrogen-Scaling-up_Hydrogen-Council_2017.compressed.pdf

[4] Sterner, M. and Specht, M. (2021) “Power-to-Gas and Power-to-X—The History and Results of Developing a New Storage Concept,” Energies (Basel), 14(20), pp. 6594-. Available at: https://doi.org/10.3390/en14206594.

[5] Mehta, N. et al. (2022) “Evaluating the opportunity for utilising anaerobic digestion and pyrolysis of livestock manure and grass silage to decarbonise gas infrastructure: A Northern Ireland case study,” Renewable energy, 196, pp. 343–357. Available at: https://doi.org/10.1016/j.renene.2022.06.115.

[6] Arduin, I., Andrey, C. and Bossmann, T. (2022) "What energy infrastructure will be needed by 2050 in the EU to support 1.5°C scenarios? [version 1; peer review: 2 approved]," *F1000 research*, 11, pp. 387–387. Available at: https://doi.org/10.12688/f1000research.109399.1.