Draft NexSys response to the DECC Consultation on Developing a Hydrogen Strategy for Ireland

2 September 2022

NexSys welcomes the opportunity to respond to the consultation on Developing a Hydrogen Strategy for Ireland.

Next Generation Energy Systems (NexSys) is an all-island, multidisciplinary energy research programme with an aim to tackle the challenges of energy decarbonisation, developing evidence-based pathways for a net zero energy system. NexSys is hosted by the UCD Energy Institute in partnership with eight other leading research institutions: ESRI, DCU, Queen's University Belfast, NUI Galway, Maynooth University, Trinity College Dublin, UCC, and Ulster University. NexSys has received €16 million in funding through Science Foundation Ireland's (SFI) Strategic Partnership Programme (2022-26), with nine industry co-funding partners and one philanthropic donor.

The energy sector is undergoing a massive transformation driven by the need to reduce carbon emissions while meeting growing demand for energy. Renewable technologies are leading to significant decarbonisation of the electricity sector, however decarbonisation is much more challenging in other energy sectors such as heat and transport. As we move to decarbonisation of all our energy, there is an increasing need for the major energy systems to become more integrated.

Ireland has one of the best wind resources in Europewith sufficient resource for it to be exported in future years. However, with increasing levels of renewable electricity we expect to see increasing levels of constraint, curtailment and system operation challenges. As we continue to install more renewable energy production and harness Ireland's renewable resources, these challenges will continue to increase. There will be times when Ireland will be producing excess energy and, if we don't make use of this energy, Ireland will have missed an opportunity for economic development and reduced our potential for contribution to Europe's goal of being carbon neutral by 2050.

Reports by international organisations such as the International Energy Agency (IEA, 2019) and the International Renewable Energy Agency (IRENA, 2019) point to the potential for hydrogen to play a role in the just energy transition. Studies have demonstrated the potential of hydrogen for renewable energy storage (Mayyas *et al*. 2020) and for use as a fuel in energy sectors that are difficult to decarbonise with renewable electricity. These include industrial energy demands requiring high temperature or highly variable loads and in long distance transport such as freight and aviation (IEA, 2019). However, the path forward for growing the role of green hydrogen in the energy sector remains unclear. With many possible and sometimes competing paths to develop a Hydrogen Economy, research is required to assess and determine the combination of factors needed to support green hydrogen development in Ireland, accelerate its adoption, and help Ireland achieve its 2030 and 2050 CO_2 reduction goals.

Over the recent months there have been several announcements in the national media of Hydrogen hubs or Hydrogen valleys in Ireland. These are all being pushed and developed by potential Hydrogen producers. However, there currently is no market for hydrogen as an energy source in Ireland and, given it is still more expensive that alternative energy sources, potential end users (industries requiring heat) have no incentive to consume it.

The development of hydrogen as a green fuel of the future requires both a supply and a demand. Therefore initial steps need to be taken to help create a market for hydrogen as a fuel and energy vector. In the short term hydrogen can also be blended into natural gas networks at low concentrations <20% without the need to change any of the infrastructure or end use devices,

helping to partially decarbonise all natural gas end users. This concentration can be increased over time as end use devices are upgraded to be hydrogen compatible.

There are a number of approaches needed to integrate hydrogen into Ireland's future energy mix, accelerate the development of a hydrogen industry in Ireland and allow Ireland to become a world leading Green Energy Exporter:

1. Enabling the use of hydrogen within the Irish energy system irrespective of its origin[1] to allow for the accelerated development of a hydrogen market and end use technologies. This requires legalisation change to permit increased concentrations of hydrogen in the gas network above 0.5%v/v. It also requires support for the transport of compressed hydrogen to areas where the gas network infrastructure does not exist.
2. The implementation of a Hydrogen Guarantee of Origin certificate. This will allow end users benefit from the carbon free nature of Green Hydrogen, while simultaneously allowing for access to low carbon hydrogen to provide for guaranteed energy supply.
3. Encourage the utilisation of Ireland's existing and developing renewable energy facilities to produce green hydrogen which can be used to reduce the carbon emissions of all natural gas end users.
4. Commence the evaluation of the potential for an import/export hydrogen terminal, to allow for access to developing hydrogen energy market.

The approaches are not mutually exclusive and detailed analysis is required to assess at which scale and pace each approach will be best for Ireland from the perspectives of CO_2 emissions, costs, jobs, the economy, public acceptance etc. This analysis requires investigation into the technical, economic and social aspects of transitioning to hydrogen as a low or zero carbon fuel source.

Ongoing Research Activities

Hydrogen research in Ireland spans all aspects of the hydrogen economy, from hydrogen generation, through storage transport and end use. This section outlines some of the recent and ongoing research activities in which members of the NexSys team are involved.

The SFI funded Energy Systems Integration Partnership Programme (ESIPP) investigated a number of aspects of the energy transition, including

- Operation of electrical Transmission networks with 100% RES-E
- The integration and interaction of all aspects of the energy systems.
- Economic drivers for investment in green energy systems
- Decarbonisation of domestic and industrial heating, and transport
- The continued use of the Natural Gas Network to provide flexibility and resilience to a decarbonised energy system.

Research from ESIPP and in the UCD Energy Institute examined some of the technical and economic aspects of hydrogen within the Irish energy system, clearly identifying a strong opportunity for this technology to address some of our decarbonisation challenges. Modelling of green hydrogen in the gas network highlights how the gas network can provide support to the electricity network and how the gas network itself may need to change in the transition to a net-zero energy system

[1] The recent Government announcement of a target of 2GW of Green Hydrogen by 2030 creates a clear signal that investment in hydrogen production should focus on Green Hydrogen produced from renewable energy.

Some publications arising from ESIPP are listed below. A more complete listing can be found at https://esipp.ie/research/gas

Operational challenges for low and high temperature electrolyzers exploiting curtailed wind energy for hydrogen production Chandrasekar A, Flynn D, Syron E 18 Aug 2021 International Journal of Hydrogen Energy 46(57):28900-28911 https://doi.org/10.1016/j.ijhydene.2020.12.217

Investigation of the multi-point injection of green hydrogen from curtailed renewable power into a gas network Ekhtiari A, Flynn D, Syron E 2 Nov 2020 Energies 13(22) https://doi.org/10.3390/en13226047

Gas networks, energy storage and renewable power generation Ekhtiari A, Flynn D, Syron E 16 Oct 2019 22nd Conference on Process Integration for Energy Saving and Pollution Reduction (PRES 2019) Link

Synthetic natural gas production: Production cost, key cost factors and optimal configuration Devaraj D, Syron E, Donnellan P 30 Jun 2020 International Journal of Energy Production and Management 5(2):91-101 https://doi.org/10.2495/EQ-V5-N2-91-101

Green hydrogen for heating and its impact on the power system Genaro Longoria, Muireann Á Lynch, John Curtis August 3, 2021 International Journal of Hydrogen Energy, Vol. 46, Issue 53, August, 2021, pp. 26725-26740. https://doi.org/10.1016/j.ijhydene.2021.05.171

NexSys has built on the capability and experience of the ESIPP team through increased collaboration with other universities in Ireland. In the area of Hydrogen, additional expertise from Dublin City University has been brought to the research team. Some sample publications include:

Enabling the scale up of green hydrogen in Ireland by decarbonising the haulage sector; J. Laguipo, C. Forde, J. G. Carton 2022; https://www.sciencedirect.com/science/article/pii/S0360319922026404

Technology Brief Hydrogen, 2021; UNECE, https://unece.org/sites/default/files/2021-12/Hydrogen%20brief_EN_final.pdf

At What Cost Can Renewable Hydrogen Offset Fossil Fuel Use in Ireland's Gas Network, T.Gunawan, A.Singlitico, P.Blount, J. Burchill, J. G. Carton R. F. D. Monaghan, 2020 https://www.mdpi.com/1996-1073/13/7/1798/htm

Identifying the relative and combined impact and importance of a range of curtailment mitigation options on high RES-E systems in 2030 & 2040, J. G. Carton, SEAI, 2020 https://www.seai.ie/documents/research-projects/RDD-000326.pdf

New Research Areas

The NexSys research programme aims to tackle the challenges of energy decarbonisation, developing evidence-based pathways for a net zero energy system. Work Packages within the NexSys research programme that are related to Hydrogen, along with the relevant objectives, are listed below.

ES1: Roadmap - Modelling & Data Coordination

- Understanding and utilising the potential flexibilities between different energy sectors
- Finding the optimal investment plans for system reinforcement considering the exchangeable flexibilities and services (Potential impacts: cost reduction, improved utilisation of assets)

ES2: Power System Operation, Adequacy, Balancing & Markets

- Long-term (seasonal) storage, green hydrogen, and grid- forming converters represent emerging innovations and will be studied as part of new operational practices.

ES6: Gas Networks & Hydrogen (Utilisation, Storage and Transport)

The objective of this work package is to investigate how the specific unique characteristics of using hydrogen as an energy vector will affect the operation and economics of energy systems en route to 2050. This will be achieved through:

- Investigating and quantifying the potential future end uses and demands for hydrogen in the carbon free energy system.
- Studying the major influencing factors which will determine the speed and direction of energy systems transformation and how they will influence the development of Hydrogen.
- Investigating the best use of gas networks for energy systems integration
- Expanding upon current integrated Electricity and Gas network models to test the suitability of renewable gasses including hydrogen to provide inter-seasonal renewable energy storage.

Strategies for maintaining worked gas quality within acceptable range

- Determine the hydrogen storage and import requirements to maintain networked gas quality

Centralised or distributed green hydrogen production and injection into Irish Gas Network

- Evaluate the advantages and disadvantages for the integrated energy system of distributed vs centralized green hydrogen production and injection into the Irish Gas Network

Resiliency of energy supply in a decarbonised Irish Hydrogen Valley

- Determine the most efficient and economic approach to ensure robust and resilient hydrogen supply for a decarbonised Irish Hydrogen Valley (IHV).

Hydrogen's potential in Ireland and its role in our decarbonisation strategy

Assess the role hydrogen of in Ireland and the role Ireland can play in the Global Hydrogen Economy examining:

- the role of hydrogen in Ireland's decarbonisation strategy;
- the scale of technology and timeline of investments in developing hydrogen in Ireland;
- how hydrogen can shift some variability caused by renewables on the electricity grid towards other uses;
- the various models and means by which hydrogen is incorporated into the energy supply chain in Ireland;
- the Techno, Economic and Societal aspects of hydrogen economy,

Developing a hydrogen blueprint for offshore wind development in Ireland

- Map potential renewable energy development locations in Ireland and determine their integration into the electricity grid and wider energy system;

- Identify suitable onshore and offshore locations with existing or the potential to develop infrastructure;
- Evaluate the potential roadmaps for hydrogen development in Ireland and how this aligns or differs with the UK and the EU;
- Develop a model to map costs of energy supply.
- Evaluate potential routes to market for green hydrogen;
- Identify the range of capabilities and resources needed to support renewable energy developers and contractors

Future Research

In order for Ireland to address the challenges associated with decarbonising our entire energy system, it is essential that we examine the role that Green Hydrogen can play. We welcome the consultation on a Hydrogen Strategy for Ireland. A strategy will provide direction to the industry and investors, and provide a focus for new funding opportunities.

Which areas of hydrogen research require further examination?

- An assessment of the pathways to Green Hydrogen for Ireland through assessment of multiple scenarios. This analysis requires investigation into the technical, economic and social aspects of transitioning to hydrogen as a fuel source.
- Identification opportunities for hydrogen export (e.g. Germany) supported by our extensive renewable energy resources, including vast potential for offshore wind as technology matures and becomes more cost effective.
- The development of energy scenarios outlining the potential role of hydrogen in our future energy mix.

What can an Irish hydrogen strategy could do to drive innovation?

- Innovation is driven by research and investment and a hydrogen strategy can provide signals to these communities that there are opportunities for innovation and collaboration in areas of both supply and demand.
- The development of testing facilities and demonstration sites would provide the required infrastructure to bring the research to higher Technology Readiness Levels (TRLs).
- The UCD integrated energy lab has the facilities to investigate the operation of hydrogen end used devices as well as how green hydrogen production can be integrated with a renewable electrical network.

What are the research priorities for the development of each hydrogen end-use (demand) in Ireland?

There are a number of research priorities that have been highlighted at a European level including:

- Increase hydrogen demand
- Industry & Energy & efuels
- Innovative Hydrogen Electrolyser Manufacturing
- Innovative logistics solutions – Transport road freight & Rail
- Regulation frameworks & standardisation hydrogen quality, technology, pipes valves, etc

- Digital ecosystem where hydrogen data and services can be made available, collected and shared in a trusted manner.

Some specific questions for Ireland include the following:

- *To what extend is Ireland's gas network hydrogen ready and what can be done to accelerate this?*
- *If the gas network on the Island of Great Britain incorporates Hydrogen, does the Irish network have to follow?*
- *What are the economic, social and environmental benefits to incentivising the development of a Hydrogen industry in Ireland?*
- *To what extent can Hydrogen support a 100%Res-E system?*

In conclusion, the NexSys team, along with our wider network of collaborators, is well placed to support these activities with rigorous research support. Our experience in the area of Energy Systems Integration through the ESIPP project ensures that this is examined within the context of the wider energy system. A coordinated strategy will ensure that this continues to be an important area of research focus, enabling increased capacity to be developed and maintained to support the decarbonisation of our energy future.

References

International Energy Agency (2019). *The Future of Hydrogen - Seizing today's opportunities.* Available at: https://www.iea.org/reports/the-future-of-hydrogen (Accessed 10/05/2021).

International Renewable Energy Agency (2019). *Hydrogen: A renewable energy perspective.* Available at: https://www.irena.org/publications/2019/Sep/Hydrogen-A-renewable-energyperspective (Accessed 10/02/2021).

Mayyas, A., Wei, M. and Levis, G. (2020) 'Hydrogen as a long-term, large-scale energy storage solution when coupled with renewable energy sources or grids with dynamic electricity pricing schemes', *International Journal of Hydrogen Energy*, 45(33),pp. 16311-16325