UCD ENERGY INSTITUTE

UCD Energy Institute response to the European Commission Consultation on the EU strategy on Smart Sector Integration

The UCD Energy Institute welcomes the opportunity to respond to the consultation on the European Commission consultation on the EU Strategy on Smart Sector Integration. The UCD Energy Institute is Ireland's leading research institute focussed on decarbonisation of Ireland's energy systems. This has expanded from a focus on electricity system research to recognise the increasing need for integration of energy systems as we move to higher levels of renewables. The Energy Systems Integration Partnership Programme (ESIPP, a Science Foundation Ireland funded research programme and flagship project of the Energy Institute) is focussed on the integration of energy systems. This programme includes researchers from a range of disciplines across 5 research institutions in Ireland in partnership with the leading players in Ireland's energy industry.

We welcome the recognition by the European Commission on the need for smart sector integration, with a focus on energy. The integration of energy systems is our primary area of research and brings together researchers from a range of disciplines too look at the technical, economic and consumer behaviour aspects of production, transportation and use of energy. It is a complex area of research that aims to explore the overlaps between energy systems with a view to providing a more efficient, flexible and resilient energy system.

With the ongoing Covid19 Pandemic, it is essential to maintain focus on addressing the ongoing climate crisis. Decarbonisation of our energy systems is an essential component in fighting climate change and will also provide opportunities for economic recovery and improved sustainability.

1. ***What would be the main features of a truly integrated energy system to enable a climate neutral future? Where do you see benefits or synergies? Where do you see the biggest energy efficiency and cost-efficiency potential through system integration?***

There is a wide range of possibilities as to what would constitute a truly integrated energy system. At a high level there is opportunity for higher levels of integration between the electricity, gas and water networks, supported by a strong communication network and underpinned by appropriate market and regulatory structures. This breaks down into many more detailed aspects of integration which can provide flexibility and resilience to our energy networks, for example utilising the gas network to minimise wind curtailment and to provide storage, enabling demand response of large energy users such as wastewater treatment plant, or using waste heat from data centres as input to other heating requirements.

We have seen significant gains in decarbonisation of our electricity system in recent years. In Ireland 33.3% of electricity came from renewable sources in 2018[1]. We have an ambitious target of 70% of electricity to come from renewables in 2030. As we increase the penetration of renewable

[1] https://www.seai.ie/data-and-insights/seai-statistics/key-publications/renewable-energy-in-ireland/

electricity, we see challenges associated with system stability and renewable energy curtailment. Integration with other energy systems such as the gas network and demand response opportunities will help deliver stability and flexibility.

With increasing levels of renewable electricity we would expect to see increasing levels of constraint and curtailment. In Ireland there is already 7.7% TSO dispatch down of wind (EirGrid Dispatch-Down Report 2019). As we continue to install wind the level of constraint and curtailment may continue to increase if we don't find alternative uses of this energy, improve system operation tools and increase infrastructure development.

Increasing reliance on the electricity system will also bring challenges in terms of resiliency and network infrastructure. Acceptance of infrastructure has posed a real challenge to the industry in recent years, so looking at ways to improve the performance of the existing infrastructure through operation and management tools will also play an important role. Distribution network management is an area of research within the ESIPP programme (MD2).

The production of hydrogen through electrolysis is an area that provides significant opportunity. The synergies of reducing renewable energy curtailment, providing alternative energy sources for transport and possibly heat, as well as decarbonising the gas network all point to hydrogen as being a real opportunity for the integration of energy systems. It also reduces the reliance on electricity network infrastructure as the hydrogen can be transported by different means. (EUI7)

In terms of the biggest cost-efficiency measures, the greatest efficiency is likely to be a combination of measures. Through integrated energy system modelling we are able to assess the optimal solutions. This is ongoing work on the ESIPP programme. (MD5) (MSP1). The Backbone Model[2] is an example of a modelling tool which can combine different aspects of energy systems and assess how changes in one aspect of the energy system will impact the other parts. The Backbone project is being led by VTT, Finland, with contribution from the UCD Energy Institute. The EMPowER modelling approach will provide the ability to model different scenarios of technology deployment (onshore wind, offshore wind, solar PV, electric vehicles, heat pumps etc.) and assess the emissions, system and cost impacts. These holistic approaches to integrated energy system modelling help to identify areas that can deliver significant benefits in support of long term planning.

While geographical integration is also a consideration through increased interconnection, we also need to be cognisant that Ireland is an island system and faces different challenges to other parts of Europe in the area of renewables integration and resilience. The different challenges faced across different parts of Europe will need to be taken into account by the Commission.

2. ***What are the main barriers to energy system integration that would require to be addressed in your view?***

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[2] Helistö, N., Kiviluoma, J., Ikäheimo, J., Rasku, T., Rinne, E., O'Dwyer, C., Li, R., & Flynn, D. (2019). Backbone: An adaptable energy systems modelling framework. *Energies*, *12*(17), [3388]. https://doi.org/10.3390/en12173388

There are numerous barriers which need to be addressed including the need for a systems approach to tackling decarbonisation.

There need for strong political leadership which recognises the interaction of different systems and sectors, supported by experts in the various domains that will make up our future energy system, rather than focus on individual energy systems. With the ongoing Covid19 Pandemic, we need to ensure that there is continued focus on addressing the ongoing climate crisis. Decarbonisation of our energy systems is an essential component in fighting climate change and will also provide economic opportunities.

Clarity on the objectives for decarbonisation and energy system integration is required. Where there is a balance of objectives, transparency is required in the decision making processes.

There need to be appropriate market structures and incentives in place to deliver these objectives. The regulatory and planning frameworks need to facilitate the required technologies. Policy certainty is needed to provide comfort to investors and to reduce the cost of finance for investment.

It is essential that citizens are involved in the decision making process and social impacts should be considered more carefully. As such, technical, economic and social impacts of changes should be fully balanced and taken into consideration. In order to establish this balance, it is important to understand the drivers and barriers of consumers' behaviour and use these to design the tools that can help to encourage change, including education, engaging, and incentives. Research underway at the UCD Energy Institute and through ESIPP looks at such drivers and barriers of consumers' behaviour and how this may be changed. For example, research has been carried out on the uptake of energy efficient technologies, public acceptance of energy infrastructure and policies. Studies have been carried out on how people are influenced by information, labelling and the design of energy systems as well as by psychological aspects such as trust, perceived fairness, identity and psychological ownership.

- ***How could electricity drive increased decarbonisation in other sectors? In which other sectors do you see a key role for electricity use? What role should electrification play in the integrated energy system?***

Electricity can play a significant role in the decarbonisation of heating, cooling and transport where decarbonisation has proven difficult to date. There are a number of technologies, including heat pumps and electric vehicles, which can facilitate this decarbonisation, however the implications for the electricity system need to be clearly understood. We also need to understand the likely take-up rate of these technologies.

In order for decarbonisation of the electricity sector to deliver for other sectors, the level of renewables on the electricity system will also need to increase. The resiliency of our energy supply will continue to be an essential consideration, and technologies that allow for storage and flexibility will need to be developed alongside renewable energy production. Market structures that create a business case for these technologies need to be considered to bring the same cost reduction benefits through increased rollout.

Examples of areas of research focus within the UCD Energy Institute:

- Understanding how the electricity system responds to different types of generation and users on the electricity system.
- Understanding the implications of the widespread use of Distributed Energy Resources (DER), including micro-generation and solar PV combined with storage and demand side capabilities, with a specific focus on its ability to balance the provision of system services with local network objectives.
- Identifying additional technical needs of the system with higher levels of renewable generation and how to source the system support services required.
- High-level management procedures related to control power systems with high levels of renewables.
- Market arrangements for systems with high levels of renewables and procurement of system services.
- Reduction of lifetime operational costs via advanced analytics for energy prediction and early detection and characterisation of downtime.

Offshore wind is set to be very important in the context of meeting the 70% target. Although offshore wind research has many aspects, from the electrical grid perspective one of the most pressing questions is how to facilitate the significantly increased levels of non-synchronous generation. Research in the Energy Institute is investigating the control schemes which could be used in order to maintain system stability in the case of 100% generation from renewables. In particular, issues around the use of grid forming controls, provision of emulated inertia and voltage and frequency support services are being investigated. This is particularly important for offshore wind as it may represent large connections of large non-synchronous generation at relatively few connection points. Other areas of interest include the expansion of the electrical grid into offshore HVDC grids for more widespread harnessing and export of offshore energy.

While electrification will play an important role, the use of multi-energy options is an important aspect of energy systems integration. The use of energy in buildings (commercial, institutional and residential) is an area of research focus within our research group. The use of multi-energy options in commercial/institutional buildings can provide energy flexibility while reducing user impact. This research looks at real-time flexibility and optimisation strategies for improved demand-side utilisation of integrated electricity, gas and district systems in commercial/institutional buildings (EUI2). The research also investigates the use of machine learning algorithms optimise optimisation of energy systems (heating, ventilation, etc) and advanced control systems to facilitate the integration and operation of new technologies that are expected to provide increased levels of service to the power system (EUI3).

- ***What role should renewable gases play in the integrated energy system?***

Renewable gas will play an important role in providing resilience to electrical systems and in areas where electrification is more difficult, e.g. in industries where there is a high heating load such as food production or long distance transport of goods. However we need to ensure that the renewable gases provide a net benefit to the system in terms of emissions. It is also important that intermediate steps introduced in the short term do not hamper long term decarbonisation objectives. Therefore it is important that projects to promote renewable gas generation do so utilising otherwise wasted resources, and projects to promote renewable gas usage discourage the use of carbon intensive fossil fuels instead of competing with other renewable technologies. Through the use of renewable gases in gas networks the carbon footprint of all gas end-users is reduced without the requirements for device or system change.

- ***What measures should be taken to promote decarbonised gases?***

While small scale R&D continues to require funding, the funding or support of viable demonstrator and large scale projects is crucial to advancing and promoting the uptake of new initiatives and technologies. This will help to eliminate uncertainty and reduce risk associated with developing all the decarbonised gases. Energy customers want minimum disruption which decarbonised gases can provide but require large initial investment. Projects such Northern Lights or Hystra, while not commercially viable or ready, pave the way for others to follow suit. Through these large scale R&D projects real problems are encountered and real solutions are found for a more sustainable future.

- ***What role should hydrogen play and how its development and deployment could be supported by the EU?***

We believe that hydrogen will play a significant role in our energy future. Its role will eventually span across transport, heating and will also provide flexibility to the variable renewables in the electricity system. In times of high renewable energy, the excess electricity can be used to power electrolysers and produce hydrogen which can then be stored, shipped and traded as a source of energy across the globe. The current debate of blue vs green hydrogen is ongoing and the most likely solution is a combination, at least in the nearer term. Both of these approaches need to be supported in order to develop technologies of scale for the storage and transport of hydrogen while the development of electrolysers gathers pace and the costs reduce. The synergies of reducing renewable energy curtailment, providing alternative energy sources for transport and possibly heat, as well as decarbonising the gas network all point to hydrogen as being a real opportunity for the integration of energy systems. (EUI7)

- ***How could circular economy and the use of waste heat and other waste resources play a greater role in the integrated energy system? What concrete actions would you suggest to achieve this?***

One of the areas being explored in the ESIPP programme is ensuring that the waste heat from data centres can be better captured so that it can be used to provide heating to other energy users (EUI6). As we look to our future research programme we are looking at expanding this to other industries such as the food and drink sector. In Ireland, there is limited experience in district heating solutions and sharing of energy resources, with concerns arising over security of supply. Often the sites which can supply excess energy are not located adjacent to a heat load, and therefore options are not available. Further work is required to investigate the barriers and potential solutions in this area to ensure that best use is made of unused energy.

- ***How can energy markets contribute to a more integrated energy system?***

As we move to decarbonised energy systems and zero marginal cost energy, markets will need to change to reflect what provides value to the energy system. In Ireland, EirGrid (the TSO) have identified the need for system services as we move to high levels of renewables (through the DS3 programme) and have introduced payments for providers of these services. With less conventional generation on the system, concerns have arisen over the stability of the system as we move to high penetration of renewables. These system service payments provide an incentive to make these services available when they are required and provide payments aside from energy payments. As we continue to increase the amount of renewables on the system the technical needs of the system will need to be reviewed and monitored, and appropriate services may need to be remunerated. A holistic approach to market design that delivers investment in renewable generation and supporting technologies needs to be taken.

- ***How can cost-efficient use and development of energy infrastructure and digitalisation enable an integration of the energy system?***

The efficient use of energy infrastructure will help keep costs down. Long term planning and policy certainty will provide clarity in relation to what areas require investment in new infrastructure, and how some types of infrastructure may need to be adapted over time, e.g. some gas networks could be converted to hydrogen networks, as is currently being demonstrated in the UK. By understanding how the infrastructure may be used in the future, flexibility can be built in at the development stage.

3. ***Are there any best practices or concrete projects for an integrated energy system you would like to highlight?***

The ESIPP Programme looks at the interaction between different energy systems. By looking at these systems in an integrated manner we can improve our understanding of how changes in one system may impact another system, for example by changing the timing of wastewater treatment processes, the peak demand of the electricity system can be reduced, or by using the gas network for storage, curtailment of renewable electricity can be decreased. As this research is still ongoing we do not yet have practical implementation of this work. Through the development of the Integrated Energy Lab in UCD and working with the energy industry in Ireland we will be able to further develop some of this research into higher TRL activities which will bring the ideas closer to deployment.

4. ***What policy actions and legislative measures could the Commission take to foster an integration of the energy system?***

Integration of energy systems will involve long term planning and investment, with clear policy objectives. Due to the timeframe of energy investments it is important to provide clear signals early to the investment community to ensure we aren't locked into higher carbon technology and to deliver signals for investment in low carbon technology and innovation.

Continued research in this area will help gain deeper knowledge and understanding of the technical and non-technical challenges associated with energy systems integration. Funding for research and innovation will remain an essential component of delivering the energy transition.

A market that delivers decarbonisation will be required. This may require a move away from traditional energy market structures.