National
Engineering
Policy Centre

Royal Academy
of Engineering

ROUNDTABLE SERIES ON DELIVERING A DECARBONISED ELECTRICITY SYSTEM

Decisions now for a future system: Making design and construction decisions for the electricity system of 2035 and 2050

Introduction

To achieve the government's target of a decarbonised electricity system by 2035, a whole systems approach is required. To feed into the government's ongoing work on a delivery plan for a net zero electricity system, the National Engineering Policy Centre is organising a series of roundtable discussions. The roundtables are convened with senior officials from industry, academia, and government to discuss crucial systems-level challenges for an effective delivery plan. The intention of the roundtables is to build a greater shared understanding and recognition of the actions and barriers that need to be addressed to implement a net zero electricity system.

This briefing summarises the discussions in the first roundtable, held on Friday 15 September, with the title *Decisions now for a future system: Making design and construction decisions for the electricity system of 2035 and 2050*. The document does not intend to give a complete view of the whole discussion, but rather to summarise key themes. The aim of these discussions is not to reach a consensus on all topics discussed but to contribute to a shared understanding through gathering key perspectives on important systems-level questions which need to be addressed in the delivery of a fully decarbonised electricity system. Given this and the broad range of stakeholders involved in the discussion, there was no definite consensus on all the topics listed below.

Roundtable 1: **Decisions now for a future system: Making design and construction decisions for the electricity system of 2035 and 2050**

The focus of the first roundtable in the series was to clarify the key urgent decisions needed to ensure a decarbonised electricity system that is fully operable, resilient and reliable. This involved exploring key dependencies that exist between electricity with other systems and how those can be planned and coordinated.

To focus the conversation, the following high-level questions formed the overall focus of the roundtable discussion:

- How do we decide now what needs to be designed and built to enable a net-zero electricity system by 2035, including dependencies?
- What assumptions do we need to make to be able to make progress in deployment at the necessary pace and scale, and what are the risks and consequences of these assumptions?
- How do we create optionality for a 2050 system when investing for the 2035 target?

Key themes of discussion

The broad range of stakeholders in the roundtable provided a diverse set of inputs, but several key themes emerged from the discussion.

Low-regret options are widely available

To decarbonise the electricity system by 2035, the immediate focus needs to be on further roll-out of the technologies and solutions which are widely available today. These can be considered no- or low-regrets options, which are necessary elements of a decarbonised electricity system. An intensified effort is therefore required when it comes to network reinforcement, on- and offshore wind power, solar PV, electric vehicle charging infrastructure, energy efficiency, heat pumps, insulation, and buildings retrofit.

While the exact demand for these technologies and solutions remains uncertain, there is a need to develop them all at pace. To achieve system functionality, some element of coordination is required.

New ways of managing risk

Investments in the electricity system, both across networks and generation, have in recent decades been very risk averse and this is one explanation for the current backlog of crucial infrastructure required for a decarbonised electricity system. There is a need for a greater risk appetite and to speed up investments in developing the networks and generation needed for the energy transition. While this will entail an increased risk that some individual projects may prove to be unnecessary, the anticipated demand for both power and networks is high enough to mean that the risk of stranded assets will remain reasonably low since new demand is likely to arise in areas where capacity is made available. Developing community energy can also be a feature of the decarbonised system and provide further resilience. A planning basis for this could then help drive enabling measures.

Planning and regulatory reforms are fundamental to unlocking opportunities

The current planning and regulatory systems and the electricity markets were developed for an energy system much different from the one needed in 2035. To unlock the opportunities available from the energy transition, electricity market reform as well as regulatory tools for decentralised power are crucial. Regulatory reform needs to encompass the interconnections of a multi-vector energy system. These points are well aligned with the ongoing electricity market reforms and the creation of the Future Systems Operator, providing a whole energy system view, and encompassing electricity, gas and ultimately other energy vectors.

The transmission and distribution systems are the backbone of the electricity system and without timely network reinforcements the transition will not be possible. Achieving the network expansion needed will require changes to the planning system, while simultaneously achieving public acceptance to deliver new infrastructure in a timely way. Elements which may be considered in the planning reform are changes to environmental impact assessment requirements, sustained dialogue with affected communities and community benefits. In that sense, the participants in the roundtable were largely in agreement with the recommendations put forward in the report by the UK's Electricity Networks Commissioner Nick Winser.[1]

Making the transition just

Much of the transition required at household level requires substantial upfront costs and is therefore only immediately available to a fraction of the population. There is a need to actively ensure that vulnerable households are not excluded, nor do they suffer adversely from the transition, by being unable to invest in electric vehicles, heat pumps, solar PV, or energy efficient homes.

Managing grid constraints

In addition to reinforcing the network, another approach to connect new generation in constrained areas is to simultaneously grant access for electrolysers which could convert excess supply of electricity to hydrogen. This would allow more generation to connect to the network, while ensuring maximum delivery across different energy vectors, even in areas where the network is unable to absorb the total supply during congested periods.

Uncertainty with CCUS

While Carbon Capture Use and Storage (CCUS) is considered a key component of a decarbonised electricity system, substantial challenges remain with scalability and finance. A system planned with a heavy reliance on CCUS therefore risks falling short. Where it proves feasible, however, CCUS could provide dispatchable abated gas generation for system flexibility and help developing blue hydrogen at scale.

Clarity required for heating

The decarbonisation of the electricity system and the heating system are intrinsically linked. The roll-out of heat pumps and energy efficiency measures in homes is far slower than needed and the role of hydrogen remains unclear. The government's intention to wait until 2026 for a decision on the role of hydrogen in home heating is causing severe uncertainty for the heat and gas sectors and other sectors planning to use low carbon hydrogen, with potentially detrimental effects. While the National Infrastructure Commission's 2nd Infrastructure Assessment was not yet out at the time of the roundtable, it is notable in that it concludes that there is no public policy case for hydrogen to be used in heat individual buildings.[3]

Storage remains a challenge

Moving to an increasingly intermittent electricity supply will require vast amounts of storage and no solutions are commercially developed at scale. This makes long- and medium-term storage one of the most significant challenges to be addressed. Changes in long-term weather trends may make forecasting even more challenging, increasing the demand for storage further. While hydrogen seems to be the best technically available solution, it remains to be demonstrated at scale and is yet to demonstrate economic feasibility[i]. Due to the important role of long- and medium-term storage, policies and appropriate market and regulatory mechanisms need to be developed to encourage investment and planning to ensure energy security in the future.

For short-term storage there are ample opportunities at household level, especially when it comes to electric vehicle batteries and electric heating. For this potential to be unlocked, appropriate market signals are required. Household-level storage can also contribute to resilience, as electric vehicle batteries can provide sufficient electricity to power a home for a week, depending on their state of charge at the time and their user's requirements for mobility during the power outage. Informing consumers of these capabilities can help develop resilience and issues of unequal access to these technologies and the household-level resilience that they may provide need to be considered and addressed[ii].

Avoiding enhanced peaks in demands

While the roll-out of electric vehicles and electric heating will add substantially to electricity demand, the challenge it will provide for the networks relates mainly to the timing of the demand and whether it intensifies existing demand peaks. By ensuring the additional electricity demand mainly stays away from peaks, through smart charging and smart heating, it could in fact have significant effects on flattening peak demand, hence reducing the amount of network expansion required and increasing utilisation of existing infrastructure. For thermal storage to provide any substantial flexibility from residential electricity use, energy efficiency needs to be improved to minimise the amount of heat loss. Allowing consumers to make informed choices with the appropriate tools can therefore help facilitate support for the wider network.

Rethinking reliability

A core element of the electricity system is reliability. Current market and regulatory arrangements require all electricity providers to provide reliable electricity to all users at all times. In a decarbonised electricity system, with large amounts of storage beyond the meter, some consumers may be willing to accept different levels of reliability from the grid, if they are compensated economically by lower tariffs or prices. While this is certainly not a solution for everyone, it may be something to explore to achieve net zero at a lower cost, both for the system and for individual end users.

i The Royal Society recently released a report on large-scale storage, showing that hydrogen stored in solution-mined salt caverns was the most viable option for long-term storage for use in the electricity system. With their assumptions, the analysis showed that between 60 and 100 TWh capacity of hydrogen storage would be required to provide balancing to a fully renewable 2050 electricity system with a demand of 570 TWh per year.[2]

ii There is more to unpack on this topic, including how to achieve the active role and decision-making on the part of consumers that is necessary. This will be the subject of a future roundtable and briefing in the series. See list in the end of the document for a full view of the remaining roundtables in the series.

Whole system costs

While the energy transition will require record amounts of finance and investment – to reinforce networks, expand renewable generation, improve energy efficiency, realise the potential for flexible demand and build storage – it can be expected to provide substantial savings elsewhere. In addition to reaping the benefits of being one of the lowest CO_2 countries in the world, the transition could reduce the amount of energy imports and increase energy security, reduce subsidies to fossil fuel companies and reduce the costs for climate change adaptation. In addition to this, the emergence of a new low-carbon economy can generate new sources of revenue, jobs, and taxation.

Operating at very low inertia

One of the main technical challenges of decarbonising the electricity system is operating the electricity network with very low levels of inertia. As the electricity system is decarbonised, plants with large rotating masses, such as gas power plants, are removed from the system, which change its characteristics substantially. These rotating masses provide stability to the system. If there are sudden changes in the frequency of the network, due to sudden shifts in demand or supply, or faults, the rotating masses act as shock absorbers and slow the rate of change. This is referred to as the inertia of the system.

In an increasingly renewable electricity system, there will be less inertia, giving rise to problems such as a weaker and more unstable grid, lower power quality, and higher risks of load shedding. To counter this problem, there is a need to study how inertia and other stability services can be provided from non-conventional sources, such as synthetic inertia from batteries, wind power or high-voltage direct current (HVDC) connections.

Securing supply chains

There is presently a shortage of capacity in supply chains in the energy sector and procurement presents a major challenge for decarbonising the electricity system. To deliver a fully decarbonised GB electricity system, particular emphasis is required on developing the supply chains needed and models of procurement which will enable the GB to compete within a highly competitive global context. This relates to all technical aspects of system decarbonisation, for example electrolysers for hydrogen, EV batteries, cables, switchgear, HVDC convertors, transformers, renewable and nuclear power, and CCUS.

"Don't let uncertainty lead to paralysis"

The exact characteristics of the decarbonised electricity system of 2035 remain uncertain, but with plenty of low-carbon technological solutions readily available, there is a need to move quickly on the low-regrets options. The transmission network for 2035 has already been planned and, in addition to expanding the network as planned, the focus now needs to be on procuring key items at scale whilst also developing the tools and markets required to achieve wide-spread roll-out of the solutions necessary for a decarbonised electricity system, across generation, storage, and flexible demand.

Key messages from the NEPC Working Group on decarbonising the electricity system

The roundtable highlighted some of the key challenges that need to be addressed in decarbonising the GB electricity system by 2035 in a secure and affordable way. Based on this discussion, the NEPC Working Group on decarbonising the electricity system has identified a number of urgent actions. While these were informed by the discussion in the roundtable, the conclusions were developed and are made independently by the Working Group and do not reflect the opinions of the participants in the roundtable.

- **The Future System Operator**
  There is an immediate need to establish the Future System Operator (FSO) and to further clarify its role. We encourage the FSO to encompass the role of a systems architect, allowing it to engage in planning for and delivery of a decarbonised energy system. This will require coordination at all levels and careful clarification of roles and duties of all relevant bodies, government departments and local and regional authorities.

- **A delivery plan**
  A delivery plan is required for the whole energy transition to achieve a decarbonised electricity system by 2035. This needs to include how National Grid ESO's transmission plan can be delivered by 2035 as well as a whole systems view of generation, distribution, flexibility, energy efficiency, the role of hydrogen, CCUS and electrification. This will require a supply chain strategy as well as immediate commitments, which could include for example, seeking manufacturing investment at scale into GB in extra-high voltage (EHV) cables, EHV switchgear, HVDC converters, HVDC cables, EHV transformers and access to installation vessels by about 2025. The delivery plan would benefit from using the Strategic Spatial Energy Plan suggested by the Electricity Networks Commissioner as a starting point.

- **Implement known no-regrets solution**
  There is a multitude of solutions which are readily available, and which need to be rolled-out at a much-intensified pace. These no-regret solutions include energy efficiency measures and homes retrofit, on- and offshore wind power, grid expansion and reinforcement, electric vehicle charging stations and the roll out of heat pumps. A higher risk appetite is required for rolling

these out at sufficient pace, and the low risk of stranded assets need to be balanced against other, potentially much higher, risks such as climate change, reduced reliability, and certain groups of people being left behind.

- **Grid reinforcement**
  To achieve the grid reinforcements required, the eighteen recommendations in the recent report by the Electricity Networks Commissioner Nick Winser need to be implemented with urgency. As part of this, and highlighted in the Winser Review, it is critical that local voices are heard and that local communities are appropriately compensated for the impact of new infrastructure.

- **People and skills – a barrier to be addressed**
  A major barrier is the availability of skills. The current skills challenge, especially when it comes to engineering and technician skills, will grow dramatically as energy investments soar during the coming decade. This challenge needs to be appropriately addressed both to meet the target, and to ensure we can adapt and maintain our infrastructure systems in the decades to follow. The gap is both a capacity and capability gap and needs to be addressed accordingly.

- **Realistic expectations on near-time applicability**
  Engineering and commercial challenges remain on specific technologies which need to be addressed to understand applicability and achieve scale by 2035 and beyond. These include large-scale hydrogen storage, the broader development of a hydrogen economy, new nuclear power, and carbon capture and storage. While continued work is required, and should continue, on the technical and commercial feasibility and scale up of these technologies, an excessive reliance on them may create unnecessary risks for achieving a decarbonised, secure, and affordable electricity system by 2035.

- **Accelerated RD&D efforts**
  There is an immediate need to accelerate efforts on late-stage research, development, and demonstration of certain technological aspects of the energy transition. These include grid stability in low-inertia systems, commercial scale demonstration of technologies such as hydrogen and CCUS, and validation of models and means for achieving demand flexibility.

- **Rethinking resilience**
  As the electricity system is decarbonised, there is a need to rethink and redefine both resilience and reliability. Current definitions and measures for both of these are insufficient to meet the challenges of the future energy system, and more work is required. This relates both to the opportunities of the future energy system, including those provided by household-level storage in batteries and electric vehicles for example, and challenges, such as increased climate risks and a vastly increased reliance on electricity as the main energy vector.

> Don't let uncertainty lead to paralysis. Decarbonising the electricity system is the largest system change in decades, but solutions are readily available and the benefits vastly outweigh the costs. What is required is clarity and commitment at the highest level.

Roundtables and briefings in the series

This is roundtable 1 of a series. The full series of roundtables and reports is listed below:

Roundtable 1	**Decisions now for a future system: Making design and construction decisions for the electricity system of 2035 and 2050**
Roundtable 2	**Local and national: What interests, opportunities and challenges exist at these levels? How does each contribute to a net zero outcome?**
Roundtable 3	**Consumers, flexibility and efficiency: How can consumption contribute to the decarbonisation of the electricity system?**
Roundtable 4	**Governing transformation, transforming governance: Managing ambiguity, interconnection and digitalisation**
Roundtable 5	**Delivering electricity decarbonisation by 2035: What do we need across industry capacity, procurement and skills?**

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2 *Large-scale electricity storage*. (2023). The Royal Society. https://royalsociety.org/-/media/policy/projects/large-scale-electricity-storage/Large-scale-electricity-storage-report.pdf

3 *Second national infrastructure assessment*. (2023). National Infrastructure Commission. https://nic.org.uk/studies-reports/national-infrastructure-assessment/second-nia/

This roundtable series is being convened by the National Engineering Policy Centre (NEPC).

The working group includes representatives from the Institution of Engineering and Technology (IET), the Energy Institute (EI), the Institution of Mechanical Engineers (IMechE), the Institution of Civil Engineers (ICE), the Permanent Way Institution (PWI), the Royal Academy of Engineering and the Energy Systems Catapult.

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