Call for Input – Response from The Institution of Engineering and Technology

UK Parliament, Oral questions: Decarbonising the Power Sector Thursday 23 March 2023

About the Institution of Engineering and Technology (IET)

The IET is one of the world's largest engineering institutions with over 158,000 members in 150 countries. We are a diverse home across engineering and technology and share knowledge to engineer solutions to global challenges like climate change. With our roots in electrical engineering, we have been championing engineering solutions and the people who deliver them for 150 years. The IET provides independent, impartial, and expert advice, spanning multiple sectors including Energy, the Built Environment, Transport, Manufacturing and Digital.

The following represents The IET's submission to the Select Committee call for evidence and has been informed by drawing on the expertise of a wide range of industry professionals and academics within The IET's membership.

1. Background Information

The Government's Net Zero Strategy published in October 2021 aims to decarbonise the power system by 2035 and more recent geo-political events have highlighted the need for a clearer focus on the security of the nation's energy supplies. Unsurprisingly, a decarbonised electricity system will play a major part in the transition to net zero, reducing the dependence on imported fuels, but also increasing the reliance on power availability and security which is currently provided in some measure by natural gas.

1.1. Renewable resources

The UK's position in the relatively exposed north-east Atlantic, and its shallow sea shelf has enabled the hosting of some of the world's largest wind farms. Progress so far can be broadly characterised by the introduction of more intermittent, often asynchronous inverter-connected generation gradually displacing conventional synchronous generators associated with coal and gas fired power stations, along with changes from traditional locations. This has been met by a complex range of operational measures detailed in National Grid ESO's Operability Strategy Report to help meet the many system challenges.

1.2. Intermittency and the adequacy of supply

There is however a real need to focus on the type and scale of the assets that will, in conjunction with operability measures, ensure the 'adequacy' of supplies for 2035, 2050 and beyond. This is particularly important given the intermittent nature of renewables production, especially when considering the consecutive, multi-day anticyclone weather conditions experienced across northern Europe delivering extremely low renewables output.

Sustained periods of higher and lower temperatures are already impacting power generation and demand, and will ultimately also affect network assets, with the possibility that future changes to Jet Stream or Gulf Stream activity could drive more acute difficulties. Adaptation measures, protecting and strengthening essential assets have also emerged as a necessary additional feature of future planning.

1.3. Delivery timescales

Importantly many of the major production and network assets so essential to ensure the adequacy of supply have delivery timescales spanning decades and must be strategically planned and installed before the need arises. The impacts of new global supply chain difficulties are already being felt, and constraints only further extend delivery schedules. There is then growing recognition of the need to accelerate infrastructure delivery, including substantial changes to the planning, consent, and regulatory expenditure approval processes to be driven in part by the appointment of the Electricity Networks Commissioner.

1.4. Electricity supply requirements

Inevitably, ongoing innovation will offer new ideas, but it seems likely that light transport and some heavier vehicles will be electrically powered, and there is a developing case to exploit the benefits of heat pumps for domestic heating, along with appropriate building stock improvements. Some industrial processes will naturally migrate to electrical solutions, whilst others with greater heat demands could use sources such as hydrogen largely produced by electrolysis. Some key aspects of technical and commercial innovation, such as greater demand flexibility, will need to be accompanied by societal acceptance and customer engagement.

Whilst estimates vary, there is reasonable consensus around the view that electricity requirements will at least double by 2050 in response, suggesting a system with peak demand around 100GW, and an energy supply of 600TWh or more per year, depending on assumptions. Hydrogen will deliver system value, particularly in some harder to treat sectors, but any substantial move towards hydrogen production for mass home heating would further inflate these levels of power generation. Other new requirements such as demands for air conditioning, a possible increase in local food production by intensive means, and growth in onshore manufacturing could add to this assessment.

2. Meeting the Need

Whilst renewables could potentially meet much of overall annual electricity supply, today's production data, even when scaled by growth plans involving multiples of capacity, shows the inevitability of sequential periods of low output. Operational measures involving short term energy storage using batteries, pumped hydro plant, gravity systems, thermal storage etc. will be vital for intra-day support, along with an element of 'demand flexibility'- the short-term time shifting of demand by consumers or smart products.

Mass storage options for longer periods of low output are scarce when these typically last five, ten or more days, with renewables production potentially meeting a fraction of the assumed 2TWh per day 2050 requirements.

2.1. Hydrogen storage

Compressed hydrogen, largely produced from renewable electricity is sometimes seen to be the most feasible storage medium. The independent Skidmore Review – Mission Zero - cites availability of 9TWh (thermodynamically derived) salt cavern storage, providing rather less when translated to electrical output. Such stores would need commensurate delivery rates and replenishment using excess power between the depletion events.

Whilst some hydrogen storage is favourable for short-term system balancing when coupled with extensive new hydrogen turbine generation plant, the round-trip process that converts renewable electricity to compressed hydrogen and back to electricity is a very inefficient (circa. 40%) use of valuable renewable power for long term bulk storage. Nevertheless, this production of hydrogen by electrolysis using surplus wind capacity and storing it during periods when output exceeds demand could be an attractive arbitrage option. However, this depends on the practical and economic feasibility of providing new electrolyser plant, new hydrogen generation capacity and the creation of the necessary hydrogen storage capacity and transport infrastructure. This coupled with hydrogen's low volumetric energy content (one third of natural gas), and the scale of storage required to ensure that the supply is not depleted during successive periods of low renewables output demonstrates the need to balance the scale of such deployment with alternative solutions.

There is then an inevitable call for a range of substantial non-intermittent power inputs. Various estimates suggest the scale to be 80 GW or more, delivered from different sources, including distributed schemes if sufficient local zero-carbon resources are available.

2.2. Interconnectors

Whilst interconnection with neighbouring countries is valuable for balancing, the extent is influenced by their similar climatic and political constraints and their application is beyond direct operational control. Norway for example has become concerned about hydro power exports given the low rainfall impacts on stored water levels and their own energy security priorities. Looking further afield, interconnection with countries in southern Europe or northern Africa could be feasible for solar power, though possibilities are likely to be challenged by the requirement for multiple circuits with a wide variety of geographical and political sources needed to help mitigate linked asset risks, economic dependence, and ensure coordinated operational control.

2.3. Gas Turbines

Gas-fired turbine generation combined with CCS will be a vital component during transition, and emerging technologies can now significantly increase CO_2 capture rates. The continuing reliance on a fossil fuel and its associated geopolitical, economic and security issues will influence its ultimate relevance for 2050 and beyond.

2.4. Biofuels

Biofuels have many attractive characteristics including the possibility of ‘negative emissions’ if combined with carbon capture. The scale of production and imports, lifecycle assessments of emissions from production to end use, along with competitive pressure from ‘hard to treat’ sectors and environmental concerns seem likely to limit the extent of their application for power generation.

2.5. Pumped hydro, tidal flow and tidal stream.

Whilst pumped hydro will continue to serve short term peaks, topographical storage and downstream limitations constrain the development of larger output volumes. Energy price increases and the growing need for non-intermittent power could now enhance the value and prospects for the predictable outputs of tidal flow and tidal stream sources relative to their competition.

2.6. Nuclear

It is difficult to envisage a successful transition without new nuclear power solutions, despite the gap in nuclear development in the UK and continuing commissioning challenges. This would not only deliver the system capacity so vital to ensure adequacy of supply, but potentially also provide hydrogen production capability for industry, transport, and system balancing, and help many of the system operational challenges that become increasingly acute in a renewables dominated system.

3. Actions

3.1. Whole system

The IET is a strong supporter of Net Zero and believes that a decarbonised electricity system is feasible provided the transition is managed through a whole energy system approach across energy vectors electricity, gas (methane and hydrogen) and heat, and holistically in terms both of technological and market developments. The extensive engagement of customers and stakeholders is important, as is recognition the strategic interdependencies between sectors: energy, data/telecommunications, transport, water, food production etc.

3.2. System adequacy

It is essential that electricity system adequacy considerations are promptly and fully addressed to ensure timely delivery of the non-intermittent generation capacity which will be required in parallel with renewable generation development, and the transmission and distribution networks so vital for future energy security. Planning and construction timescales for electricity infrastructure can span decades and are further exacerbated by supply chain difficulties and the often-protracted process for obtaining consents and planning approvals for new transmission lines. It follows that those commitments to infrastructure investment must be made well in advance of the need for network capacity arising.

3.3. Telecommunications

Telecommunications requirements to meet the needs of an increasingly digitised energy system are an essential consideration in terms of traffic volume, points of connection and security against physical and cyber threats. National strategic development responsibilities need identification to drive actions coordinated with energy transition.

3.4. System impacts of climatic changes.

Paradoxically the changing climate is a key driver of transition, so new approaches to outage risk will be needed to account for a future reliance on climate dependent generation sources, increased societal reliance on electricity, and the impacts on demand, production, storage, and distribution.

Irrespective of progress against Net-Zero objectives, global warming will increasingly give rise to more extreme weather in the form of storms and flooding, and potentially periods of both very high and very low ambient temperatures. The impact on asset resilience, electricity demand and asset thermal ratings will therefore need to be considered in determining the ability of the assets to cope with more challenging operating conditions.

3.5. Strategic planning

A transition of this scale is unprecedented and therefore needs clear strategic planning of architecture, coordination of investment and delivery, and a more agile governance process. Existing detailed techno-economic optimisation models can provide powerful insights and guide strategic decisions.

Operability measures have supported the incremental incorporation of renewables thus far, but the processes of design and operation are fundamentally different in character and execution. Now a shift is essential to identify responsibility for planning and undertaking the coherent development of a system architecture that is actually designed for its energy efficiency and operability. In addition to power system integration challenges, this vital shift requires prompt and substantial re-positioning of the Future System Operator (FSO) role to emphasise the immediate need to focus on the whole system architecture.

Such a strategy forms the foundation of essential policy development, infrastructure planning (including onshore and offshore transmission as well as local networks), regulation development, incentive planning, markets design, resource partnership and skills development, as well as being a vital basis for local strategic planning. In that regard we believe the proposed Future System Operator working in close cooperation with Regional System Planners will have a critical role to play provided the necessary responsibility and authority for national and subnational strategic energy planning is institutionally incorporated and adequately resourced.

3.6. Avoiding higher costs and missed targets.

The world is changing rapidly as evidenced by climate change, geopolitical shift, and supply chain difficulties. Given the scale and speed of investment in energy infrastructure required, establishment of effective regulation and business planning processes must be implemented well in advance of the need if any level of long-term success is to be achieved.

Failure to address these requirements will bring higher costs, piecemeal development of poorly targeted or stranded investment, reduced system security, degraded system performance, and potentially failure to meet the targets or provide secure energy for future generations.

3.7. Longer term innovation

Finally, but importantly the technologies needed for 2050 are deliverable today, albeit with some continuing development. Longer term solutions will emerge and become practical for future generations. The field of nuclear fusion is more active than ever, and ‘energy from space’ could one day become a feasible reality, as could UK based geothermal power as deep drilling and extraction technologies improve. Support for such ongoing energy innovations is more vital than ever, but their promise should not be a distraction from current imperatives.

We welcome the opportunity to meet with you to answer any questions, or to explain our considerations detailed in this report, in further detail.