

IET response to the Environment and Climate Change Committee inquiry 'Dunkelflaute and the risks of electricity intermittency'

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Questions

- 1. How are Dunkelflaute events defined and how far in advance can they be predicted? How likely is it that the UK will be impacted by Dunkelflaute events lasting days to weeks and is that likelihood expected to change in the future?**

A Dunkelflaute, or a period of low wind and limited solar generation, is not a rare event and should not be viewed as an exceptional occurrence. Extended periods of high-pressure weather systems leading to low wind output over several days, and in some cases weeks, are normal features of the UK climate and should therefore be treated as expected system conditions rather than low-probability anomalies. Two features of Dunkelflaute events are particularly relevant: the magnitude of their impact on renewable generation, with wind and solar output capable of falling considerably within a short period of time, and their duration, which can extend from a few hours to several weeks. At present, such events are managed predominantly through the operation of gas-fired generation. Whilst the UK system has storage options such as pumped storage hydro and batteries, these cannot currently compensate for either the scale of the generation deficit that may arise or, in particular, its duration. Interconnector support can and does contribute to system resilience, but Dunkelflaute events are often experienced across neighbouring countries at the same time, meaning that interconnectors cannot be relied upon as the sole source of support.

The prediction of Dunkelflaute events is affected by many non-controllable factors. The Met Office examines how the UK will be affected by climate change, outlining that winters are expected to become wetter and warmer, with more frequent and intense weather extremes. Whilst forecasting capabilities continue to improve, the electricity system should not be designed on the assumption that Dunkelflaute events can be predicted with sufficient accuracy weeks in advance. Recent events have demonstrated the challenges associated with accurately forecasting renewable output even over much shorter timescales. Whilst forecasting can help mitigate the impacts of Dunkelflaute, government must also focus on increasing the availability of reserves and developing a broader portfolio of balancing technologies and infrastructure.

Current government terminology and expectations should be reviewed and brought into line with the realities of large-scale long-duration energy storage. Current "ultra-long-duration" storage solutions remain at an early stage of deployment, and there is limited evidence of

technologies operating at the scale that would be required to address a severe multi-week Dunkelflaute event. Government should therefore provide greater clarity regarding the terminology used for electricity storage. Terms such as "long-duration" and "ultra-long-duration" storage are often used inconsistently, despite technologies offering fundamentally different storage capabilities ranging from hours and days to potentially much longer durations. Clear and consistent definitions are needed to improve policy certainty, avoid market distortion and strengthen investor confidence.

Estimates vary, but the UK may require around 30-50 TWh of large-scale long-duration energy storage by 2030 if electricity supplies are to remain resilient and secure ([Large-scale electricity storage policy briefing](#), The Royal Society, 2023). However, this raises wider questions regarding the future design of the energy system. In addition to Dunkelflaute events, consideration should also be given to other weather-related system stresses, such as periods of prolonged heat and low renewable output, as well as periods of renewable overproduction where generation exceeds demand and flexibility requirements increase.

Increased investment in long-duration energy storage, long-distance interconnectors, dispatchable generation and other balancing technologies that provide low-carbon or near-zero-carbon electricity will help reduce the impact of Dunkelflaute events. However, no single technology should be considered a complete solution. A resilient electricity system will require a portfolio of measures that combines storage, dispatchable power, interconnection and firm low-carbon generation to manage both the magnitude and duration of prolonged periods of low renewable output.

2. How significant could the future demand-supply gap be during a Dunkelflaute in 2030 and 2050, under current plans and targets? Is the UK on track to deliver the infrastructure required to address these gaps?

Under current plans and targets, significant demand-supply gaps during Dunkelflaute conditions are not expected in 2030, provided that the existing 35GW gas fleet capacity is retained alongside planned deployment of renewable generation, storage and interconnection. The UK will continue to rely on a combination of gas-fired generation, nuclear capacity, renewable generation, storage and interconnectors to maintain security of supply. However, the UK's ability to address future demand-supply gaps is dependent on the timely delivery of the infrastructure required to support this transition. Looking towards 2050, the challenge may become more significant as electricity demand increases through the electrification of heat, transport and industry, whilst many of the technologies expected to provide long-term low-carbon flexibility remain at an earlier stage of commercial maturity.

Whilst certain technologies needed in the future will help address such gaps, their development and deployment extend far beyond 2030. The primary challenge is not necessarily identifying potential technical solutions but deploying them at sufficient scale within realistic timescales. Many of the technologies frequently cited as solutions to prolonged Dunkelflaute events remain commercially immature or face substantial supply-chain, planning and delivery constraints that make widespread deployment before 2030 unlikely. This is not to say that these technologies should not be invested in and supported,

but achievable deployment timescales beyond 2030 must be recognised if they are to be delivered in practice. In the meantime, government must ensure that the Combined Cycle Gas Turbine (CCGT) fleet is sufficiently remunerated to provide the backup and security needed, whilst ensuring adequate gas supplies remain available to support its operation.

The more immediate challenge is therefore not the availability of potential technical solutions, but the timely delivery of the infrastructure required to support them. A major blocker is project consenting processes. As raised by the Electricity Networks Commissioner ([Accelerating electricity transmission network deployment: Electricity Networks Commissioner's recommendations - GOV.UK](#), GOV.UK, 2023) The consenting process needs to be made easier for major infrastructure reinforcements. New transmission infrastructure is urgently needed to connect and transmit large scale new generation such as new offshore wind farms. However, technologies including new onshore overhead lines are often delayed due to consenting issues. For example, Norwich to Tilbury OHL proposal to build a new 400 kilovolt (kV) electricity transmission connection in support of offshore wind projects in the North Sea was in Consultation for three years and will not be potentially operational until 2031, despite launching in 2022 ([Norwich to Tilbury | National Grid](#)). Further delayed projects also include Green Gen Cymru's 132kV OHL project in mid Wales that would connect planned onshore wind projects to the grid at Swansea that released its first consultation in 2023 and will not be potentially operational until 2029 ([Consultation - Green GEN Cymru consultation](#), Green Gen Cymru, 2026). <https://xlinks.co/morocco-uk-power-project/> Supply-chain constraints should also be considered. Key equipment required for major transmission projects, including HVDC infrastructure, is already experiencing extended procurement lead times due to increasing global demand. This further reinforces the need for early decision-making and long-term planning.

3. Which low-carbon technologies are most effective at addressing long-term dunkelflaute events, lasting days to weeks? At what point could these technologies be deployed at a system-wide level and what are the main barriers to their deployment?

The maturity of long-duration storage technologies is essential for understanding their effectiveness at addressing long-term Dunkelflaute events that last days to weeks. Whilst storage technologies capable of providing storage over hours and days are becoming more readily available, no low-carbon storage technology is currently deployed at the scale required to fully address a severe multi-week Dunkelflaute event. Long-duration energy storage technologies, including hydrogen storage, flow batteries, liquid air energy storage and compressed air energy storage, have the potential to contribute to managing prolonged periods of low renewable output. At present, dispatchable generation, principally Combined Cycle Gas Turbine (CCGT) plant operating on natural gas, remains the only proven technology capable of addressing severe Dunkelflaute events lasting days to weeks at system scale. Whilst hydrogen-fuelled generation may offer a lower-carbon alternative in future, the additional costs associated with hydrogen production, storage and use must be factored in.

When mature no single technology is likely to provide a complete solution to prolonged Dunkelflaute events. A resilient system will require a portfolio approach that combines storage, demand-side flexibility, interconnection, dispatchable generation and low-carbon firm power technologies. One of the largest barriers to the development of long-duration storage technologies is cost. Commercial viability remains a significant concern, alongside uncertainty over future revenue streams and the absence of proven business models for assets that may only be called upon infrequently but are nonetheless critical for system resilience. Whilst these technologies should continue to be invested in and supported, their deployment at system scale is unlikely before the 2030s for many of the technologies currently under development.

The current limitations of these technologies reinforce the need for a mixture of approaches to storage and generation, including the continued availability of flexible dispatchable generation. From 26 February to 8 March 2021, wind generation fell as low as 0.6GW and the UK experienced its longest cold and calm spell in over a decade. The impact of this event was limited because the shortfall in wind generation was largely met by fossil-fuelled generation, particularly gas-fired power stations. This demonstrates the continuing importance of dispatchable generation in maintaining security of supply during prolonged periods of low renewable output. Firm low-carbon technologies may reduce exposure to weather-dependent generation over time, but dispatchable generation capacity will continue to play an important role in maintaining resilience.

Other technologies such as SMRs may also play a role in addressing Dunkelflaute scenarios by providing increased volumes of low-carbon firm generation. Whilst SMRs will not directly address short-term intermittency, they have the potential to strengthen system resilience through the provision of low-carbon firm power and should therefore be considered as part of the wider portfolio of technologies supporting electricity security. However, these developments are unlikely to contribute at scale before 2035 and will require continued investment and planning before system-wide benefits can be realised.

4. What role will gas with carbon capture or other dispatchable generation need to play during a severe Dunkelflaute? What are the challenges associated with installing carbon capture for retained gas plants?

It is likely that, by 2030, the UK will continue to rely on its existing unabated gas-fired power plant fleet to provide secure and reliable electricity supplies during periods of severe Dunkelflaute. Given the current pace of deployment of technology, retained gas generation is likely to remain essential for system security through the remainder of this decade.

Beyond 2030, the UK should seek to transition this functionality towards lower-carbon forms of dispatchable generation. While gas-fired generation equipped with Carbon Capture, Usage and Storage (CCUS) could help this transition, there are significant practical and economic barriers to widespread deployment. Only a limited number of CCUS projects are under development and their viability remains dependent on government support for the Cluster Sequencing programme and the rollout of regional transport and storage infrastructure. Without access to a nearby transport and storage network, the costs associated with transporting captured carbon dioxide can become expensive, limiting the number of retained gas plants that could viably adopt CCUS.

This challenge is particularly significant because much of the UK's gas turbine fleet is not near the designated CCUS clusters. Although the East Coast Cluster and HyNet North West Cluster are progressing through development, extending CO₂ transport infrastructure across large distances would represent a large cost considering it may only operate infrequently during rare system stress events. However, CCUS is unlikely to provide a comprehensive solution for the wider retained gas fleet.

Given the expected rarity of severe Dunkelflaute events, a pragmatic approach would be to maintain sufficient dispatchable capacity to protect system resilience while avoiding disproportionate investment in technologies that may be used only occasionally. In the near term, this is likely to require continued reliance on existing gas-fired generation.

5. What is the role of demand management in shifting or reducing the demand-supply gap during extended Dunkelflaute events (days to weeks)?

Demand-side flexibility is likely to be most effective in addressing intra-day fluctuations in generation rather than prolonged periods of renewable scarcity lasting multiple days or weeks. Whilst electric vehicles, flexible domestic demand and certain commercial processes can provide valuable short-term flexibility, their contribution during a severe and sustained Dunkelflaute event is likely to be limited.

Time scales are vital in understanding the role of demand management in shifting or reducing the demand supply gap during extended Dunkelflaute events. Due to the nature of their operations, industry/services will not be able to manage or shift demand to such an extent to reduce the demand-supply gap for any meaningful period of time. For example, Hospitals will not prioritise demand management over their other responsibilities of care. Reliance on pricing mechanisms alone could also disproportionately impact vulnerable consumers and energy intensive industries. Therefore, demand management or shifting will need to be focused at a domestic level to have any impact.

6. How important is international cooperation on electricity supply for resilience to Dunkelflaute events? What are the barriers to further cooperation?

International collaboration is important for the resilience of electricity supply during Dunkelflaute events. International co-operation with Europe provides access to interconnection capacity and can help support security of supply during periods of system stress. Collaboration on gas supply is also important, with UK gas supplies sourced from domestic production, Norway, European interconnectors and LNG imports. LNG can be transported over greater distances through well-established supply chains, allowing the UK to maintain relationships with a broader range of international partners.

However, interconnection should not be considered a guaranteed source of resilience during widespread regional weather events. Extended periods of low renewable output can affect multiple neighbouring countries simultaneously, reducing the availability of surplus electricity for export and limiting the practical value of interconnectors during periods of system stress. Recent experience has also demonstrated that countries are likely to prioritise domestic security of supply during periods of uncertainty, which may further reduce the availability of imports when they are needed most.

International cooperation should therefore be viewed as part of a portfolio of solutions rather than the primary means of addressing Dunkelflaute risks. Alongside cooperation agreements, the UK should continue to prioritise domestic resilience and a greater degree of energy self-sufficiency. Stable, long-lasting relationships with trusted partners will remain important, but these should complement rather than replace domestic generation, storage and system flexibility.

Barriers to further cooperation include the potential for simultaneous scarcity across interconnected markets, differing national priorities during periods of system stress, geopolitical uncertainty affecting global energy supply chains, and the complexity of coordinating infrastructure and market arrangements across jurisdictions. Government should therefore ensure that international cooperation arrangements recognise the potential for simultaneous scarcity and provide sufficient clarity on how constrained resources would be allocated during such events.

Looking further ahead, consideration should also be given to the role of low-carbon fuels in supporting energy security. Alongside securing existing gas supply arrangements, the development of indigenous hydrogen production, storage and import capabilities may offer an additional route to strengthening long-term system resilience while supporting decarbonisation objectives.

7. What analysis has been done to identify the most cost-effective approach to maintaining security of supply and meeting electricity demand under long-term Dunkelflaute conditions?

Analysis undertaken by National Grid in its 2026 research on the future of security of electricity supply highlights that growing electrification of heat, transport and industry is expected to increase both demand for, and societal dependence upon, reliable electricity supplies. As a result, future planning standards may need to place greater emphasis on resilience and the ability to withstand extreme system conditions.

NESO has also carried out work on resource adequacy that concludes that the future UK electricity system is likely to become more exposed to lower-probability but higher-impact events. Whilst attention is on Dunkelflaute, other external factors such as prolonged heatwaves should also be considered.

Evidence from Drax's analysis¹ of the extended Dunkelflaute event experienced in 2021 provides a practical example of how the UK currently maintains security of supply during prolonged periods of low renewable generation. The report demonstrates that the electricity system was able to remain secure largely because dispatchable thermal generation, particularly the existing gas turbine fleet, was available to compensate for reduced wind output. This experience suggests that retained gas-fired generation is likely to remain an important component of security-of-supply arrangements throughout the remainder of this decade, consistent with wider system planning assumptions in the Clean Power 2030 pathway.

Using the available evidence, the most cost-effective approach is unlikely to involve a single technology solution, but a combination of retained dispatchable generation, continued

¹ [Electric Insights](#)

investment in renewable generation, energy storage, network reinforcement, demand-side flexibility and the progressive development of low-carbon fuels.

8. Do current market arrangements provide sufficient incentives for investment in the range of solutions needed to maintain security of supply during Dunkelflaute conditions? Do market arrangements support the establishment of a 'strategic reserve'?

The current market arrangements do not provide sufficient incentives that encourage investment in the range of technologies and infrastructure required to maintain security of supply during prolonged Dunkelflaute events. The UK's electricity market primarily rewards energy production, and short-term system balancing, rather than resilience against rare but potentially high-impact periods of extended low renewable output.

Government needs to address the difficulties facing potential solutions for Dunkelflaute resilience, such as ultra long-duration energy storage (ULDES), strategic reserves and low-carbon dispatchable generation. These face uncertain revenue streams and long investment timelines, often leading to unclear economic cases for investors to justify investment into potential infrequent events.

The IET is concerned that the UK seems to respond only after supply concerns emerge, as opposed to placing in parameters to prevent them from occurring. Policy intervention will help ensure that sufficient resilience assets are available ahead of circumstance. Government should consider additional support mechanisms, or resilience-focused market reforms, to heighten investability to strengthen the security of supply during prolonged periods of renewable fluctuation.

9. What, if any, are the key decisions that Government needs to take before 2030 in relation to long-duration energy storage and low-carbon dispatchable power solutions to support a resilient decarbonised electricity system?

Government should establish a clear and suitable framework for maintaining electricity security during periods of renewable inconsistency and undertake a comprehensive assessment of the future role of existing flexible gas generation within a decarbonised electricity system. Existing gas turbine assets continue to provide essential balancing and security functions, and premature assumptions regarding their replacement risk undermining system resilience. This should include robust analysis that considers severe Dunkelflaute events and assesses the contribution required from ULDES, dispatchable low-carbon generation and existing thermal generation assets.

A key priority should be to take a strategic view of both the Clean Power 2030 and Net Zero 2050 pathways, identifying the infrastructure, technologies and policy interventions that may be required to maintain security of supply whilst supporting decarbonisation objectives. This should include consideration of the future role of long-duration energy storage, low-carbon dispatchable generation and the infrastructure needed to support them.

It is also important to recognise the role of flexible generation in system stability. Gas turbines play a critical role in balancing the electricity system on a second-by-second basis

and may continue to be important during prolonged periods of low renewable output. Decisions regarding future low-carbon dispatchable power and LDES should therefore be informed by realistic assessments of system security requirements rather than assumptions based on average renewable generation conditions.

Government should ensure that policy decisions are guided by a whole-system resilience approach and long-term security of supply objectives. Clear signals on the future role of ULDES technologies and dispatchable generation will help support investment and reduce uncertainty for developers and network operators. Strategic planning should be informed by whole-system scenario analysis that explicitly assesses severe but credible system stress events rather than relying exclusively on average renewable generation assumptions.

Before 2030, government should also determine whether additional infrastructure, including large-scale energy storage and supporting networks, will be required to deliver a resilient net zero energy system by 2050. Early decisions are important because many of the technologies and infrastructure options being considered have long development and delivery timescales. Delayed decisions risk increasing costs, reducing optionality and making future delivery more challenging.

10. What best practice can be learned from other countries about the innovative use of technologies for managing the risk of intermittency from renewables?

When drawing on international comparisons, the value of greater system integration and resource diversity in renewable management can be seen. Countries in Europe benefit from interconnection that allows a wider range of resources across multiple markets and regions. These approaches reduce exposure to localised weather conditions and improve overall system resilience. International experience demonstrates the value of resource diversity alongside interconnection. Countries with significant hydroelectric resources are often able to use these assets to balance variable renewable generation. Whilst the UK has more limited hydroelectric potential, the principle of maintaining a diverse generation portfolio remains relevant.

However, international comparisons should recognise important geographical and resource differences. Many European countries benefit from greater access to hydropower and more diverse generation portfolios than the UK. Therefore, reinforcing the need for a balanced approach that combines interconnection, storage, dispatchable generation and a mix of energy resources.