Keeping the Power on: our Future Energy Technology Mix

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This Evidence provides a comprehensive analysis of the UK's energy sector's state, its challenges, and the strategies needed for a transition towards sustainability and resilience. It is based on a balanced and critical consideration of various sources and perspectives. The Evidence is submitted to assist the Committee in understanding the complex and interconnected issues around the UK's energy future.

Executive Summary

- While the energy sector theoretically welcomes new technologies, adoption is often hindered by outdated regulatory frameworks, entrenched interests, public acceptance issues, and technological challenges. Innovative solutions like energy storage and smart grids are crucial but face challenges.
- Government support is critical for developing innovative energy infrastructure. The UK Government has committed to renewable energy and decarbonisation, but policy support can be inconsistent and influenced by short-term political considerations. Long-term, consistent support for all technology development stages is needed for an effective transition.
- UK's energy security plan is focused on renewable energy, particularly offshore wind. However, renewable energy sources' reliability, affordability, and intermittency challenges persist. A comprehensive, strategic approach is necessary to ensure long-term energy security.
- Several technologies, including wind and solar power, nuclear power, and emerging ones like hydrogen energy and CCUS, can enhance UK's energy security. However, their large-scale deployment needs concerted efforts to overcome technical, economic, social, and regulatory challenges.
- Deciding whether to abandon certain technologies like first-generation biofuels and CCS is complex and must be weighed carefully. Underperforming technologies might still have a role to play in niche areas or serve as steppingstones for more advanced solutions.
- Achieving net-zero emissions quickly and affordably requires a diverse energy mix, systemic changes, and a careful strategy. This includes combining renewable sources, nuclear power, hydrogen, bioenergy, and energy efficiency measures. The transition pathway must be guided by fairness and inclusivity principles.
- UK energy solutions must consider regional variations in energy resources, economic structures, and social conditions. Leveraging local strengths fosters a diverse, resilient energy system. However, regional approaches must be integrated into a nationwide strategy for a balanced and coordinated transition.

1. Is the energy sector open enough to new-generation technology?

1.1 The energy sector theoretically accommodates new technologies. Recent years have witnessed a surge in innovative advancements, including renewable energy technologies like solar and wind, electric vehicles, and energy storage systems. However, the adoption and integration pace of these technologies are dictated by diverse factors.

1.2 Regulatory frameworks are vital in shaping the industry's openness to new technologies. Unfortunately, regulatory structures often lag technological advancements. This disconnects results in a slower transition process as novel technologies struggle to fit within existing rules designed for conventional energy systems.

1.3 Entrenched interests also impact the sector's receptiveness. Established utilities might resist changes threatening their business models or requiring significant investment. Furthermore, fossil fuel industries wield considerable political influence, potentially impeding policies favouring renewable technologies. This resistance is not an insurmountable barrier but does pose a significant challenge.

1.4 Public acceptance also plays a crucial role. New energy technologies often come with changes in land use, visual aesthetics, and potential risks. For example, public concerns about wind turbine noise or visual impact have led to local opposition in certain cases.

1.5 The UK has seen robust growth in renewable energy technologies, particularly offshore wind. However, challenges around grid management and the intermittency of power supply hinder their integration into the broader energy system. Innovative solutions like energy storage and smart grids are key to addressing these issues, but they are still maturing and facing their challenges.

1.6 Additionally, emerging technologies like hydrogen energy and carbon capture, utilisation, and storage (CCUS) face significant technical, regulatory, and commercialisation challenges. They represent substantial potential for decarbonising sectors of the economy that are hard to electrify, but this potential is yet to be fully realised.

While the energy sector exhibits openness to new technology, substantial challenges must be overcome. This calls for an integrated approach that involves updating regulatory frameworks, addressing entrenched interests, fostering public acceptance, and advancing supportive technologies.

2. Does the Government sufficiently support the development of innovative energy infrastructure?

2.1 Government support is pivotal in developing and deploying innovative energy infrastructure. The transition from fossil fuels to renewable sources requires significant investment in the technologies and supporting infrastructure like electricity grids, charging stations for electric vehicles, and pipelines for hydrogen distribution. Additionally, new technologies often face a 'valley of death' between the research and development stage and commercialisation, where they struggle to become cost-competitive without support.

2.2 The UK Government has committed to transitioning towards renewable energy and decarbonisation. This is reflected in various strategies and targets, such as the Ten Point Plan for a Green Industrial Revolution, which outlines investment in offshore wind, nuclear power, hydrogen, and carbon capture. Moreover, the Government has pledged to reach net-zero greenhouse gas emissions by 2050, necessitating a substantial energy sector transformation.

2.3 However, government support can be inconsistent and is often influenced by short-term political considerations. For instance, the zero-carbon homes policy, which would have required new homes to be built with high energy efficiency standards, was scrapped in 2015. The Swansea Bay Tidal Lagoon project, which could have been a trailblazer for tidal power in the UK, was cancelled due to cost concerns.

2.4 Similarly, while the Ten Point Plan highlights nuclear power and hydrogen, they have seen less policy support than offshore wind. Nuclear power plants face significant challenges with high upfront costs and long construction times, while the hydrogen economy is still in its early stages and lacks a clear roadmap.

2.5 For an effective transition towards a sustainable and resilient energy system, government support must be consistent, long-term, and encompass all stages of technology development. It also needs to account for the systemic nature of energy transitions, which involve the technologies and the supporting infrastructure, market structures, regulatory frameworks, and social aspects.

3. Is the Government's plan for energy security sufficiently long-term?

3.1 Energy security involves having a dependable, affordable, and sustainable energy supply. It is a complex issue that goes beyond simply having enough energy resources. The nature of the energy mix, the resilience of the infrastructure, and the governance structures are all crucial aspects.

3.2 The UK Government's plan for energy security is primarily based on the transition towards renewable energy, particularly offshore wind. While this is a laudable goal and crucial for sustainability, there are challenges around reliability and affordability that must be addressed.

3.3 Renewable sources like wind and solar are intermittent, meaning they do not produce power consistently throughout the day or year. This poses a challenge to maintaining a stable power supply. Solutions like energy storage, demand response, and interconnections with other countries are needed to manage this intermittency. However, these solutions are still being developed and require substantial investment.

3.4 The issue of affordability is also crucial. While the cost of renewable energy technologies has fallen, transitioning to a renewable-based energy system involves significant investment in new infrastructure. Furthermore, the shift away from fossil fuels has implications for energy-intensive industries and households, particularly those in fuel poverty.

3.5 Given these challenges, energy security requires a long-term, strategic approach. This includes diversifying the energy mix with stable, low-carbon sources like nuclear power; advancing solutions for managing the intermittency of renewable sources; ensuring a just transition that protects vulnerable industries and households; and strengthening the resilience of the energy system against shocks, including those related to climate change.

3.6 While the UK Government has made strides in addressing these issues, there is scope for a more comprehensive and long-term strategy for energy security. This would involve a holistic view of energy policy, considering the technologies and resources and the systemic and social aspects.

4. **What current technologies could usefully be deployed at scale to deliver better energy security in the UK?**

4.1 A range of technologies could enhance the UK's energy security by increasing the resilience and sustainability of the energy supply. However, deploying these technologies at scale would depend on several factors, including their maturity, cost-effectiveness, and compatibility with the existing energy system and resources.

4.2 Wind and solar power are the most mature and cost-competitive renewable technologies. With its extensive coastline, the UK has a particularly high potential for offshore wind. However, the intermittent nature of these sources necessitates complementary solutions. Energy storage technologies, such as batteries and pumped hydro storage, can store excess power for use when production is low. Demand response measures can adjust electricity demand to match supply. Yet, these solutions face challenges around cost, technical performance, and social acceptance, and their development needs to keep pace with the growth of renewable generation.

4.3 Nuclear power provides a stable, low-carbon energy source complementing intermittent renewables. The UK has a long history of nuclear power and plans to invest in new plants and potentially small modular reactors, which could be quicker and cheaper to build than conventional plants. However, nuclear power faces challenges with high upfront costs, long construction times, and managing nuclear waste.

4.4 Hydrogen energy is an emerging technology that could significantly influence the energy transition. Hydrogen, particularly when produced using renewable energy (green hydrogen), can decarbonise hard-to-electrify sectors like heavy industry and aviation. The UK Government has committed to developing a hydrogen economy and is home to several pilot projects. Nevertheless, the technology and infrastructure for large-scale hydrogen production and use are still developing.

4.5 Carbon capture, use and storage (CCUS) is another technology that could enhance energy security by allowing for the continued use of certain fossil fuels whilst mitigating their emissions. The UK has significant potential for CCUS, given its North Sea oil and gas infrastructure, which could be repurposed for CO_2 storage. The technology, however, is yet to be deployed at scale and faces challenges with cost and public acceptance.

4.6 In summary, a suite of technologies could contribute to better energy security in the UK. However, their successful deployment at scale would require a concerted effort that addresses technical, economic, social, and regulatory challenges.

5. **Are there technologies that have been unable to develop their potential and should be abandoned?**

5.1 Developing energy technologies is a complex process involving technical, economic, social, and regulatory aspects. It is often the case that technologies face significant challenges in their journey from lab to market. Therefore, whether a technology should be abandoned is not straightforward.

5.2 First-generation biofuels, made from food crops, are often cited as an example of a technology that has not lived up to its potential. They were initially hailed as a solution for reducing greenhouse gas emissions in the transport sector. However, concerns arose about their impact on food prices, deforestation, and net carbon emissions when considering the full lifecycle.

5.3 Given these concerns, some could argue that first-generation biofuels should have been abandoned. However, their development has paved the way for second and third-generation biofuels, which use non-food crops or waste materials and have a better sustainability profile.

5.4 Carbon Capture and Storage (CCS) has been criticised for its slow progress. Despite being recognised as a key technology for achieving climate targets, it has not yet been deployed at scale due to high costs, regulatory challenges, and lack of commercial viability. But rather than being abandoned, CCS could be pursued with a more strategic approach, considering its potential for decarbonising industrial processes and enabling negative emissions when combined with bioenergy (BECCS).

5.5 In conclusion, decisions about abandoning technologies should be carefully weighed and considered in the full context. Technologies that seem to underperform might still have a role to play in certain niches, in combination with other solutions, or as steppingstones towards more advanced solutions. They could also provide learnings for the development of other technologies and strategies. Therefore, a nuanced and flexible approach is needed.

6. What energy generation mix will get us to net zero most quickly and affordably?

6.1 Achieving net zero emissions most quickly and affordably is a complex task that requires a diverse energy mix, systemic changes, and careful strategy. There is no one-size-fits-all solution due to the varying characteristics of different energy sources and technologies and the unique circumstances of each country or region.

6.2 The energy mix should be diversified to enhance resilience and flexibility. Renewable sources, particularly wind and solar, should play a significant role given their decreasing costs and low carbon footprint. However, their intermittency requires complementary solutions. Energy storage and demand response can manage short-term fluctuations, while interconnections with other countries can balance supply and demand over larger areas and timescales.

6.3 Nuclear power can provide a stable, low-carbon energy source, complementing renewables. However, it needs to overcome challenges with cost and public acceptance. Small modular reactors could offer a more flexible and cost-effective solution if proven successful.

6.4 Hydrogen and bioenergy, combined with carbon capture and storage, could decarbonise sectors that are hard to electrify, such as heavy industry and aviation. These technologies, however, are still in development and require a strategic approach to overcome their technical, economic, and regulatory challenges.

6.5 Energy efficiency measures are a crucial part of the mix. They can reduce energy demand and, therefore, the scale of supply-side solutions needed. Energy-efficient buildings, industrial processes, transport modes, and behaviour change can contribute to this.

6.6 Regarding affordability, transitioning to a net-zero energy system involves substantial investment. However, in terms of impacts on health, ecosystems, and the economy, the costs of inaction on climate change would be far greater. Moreover, the transition offers economic opportunities, such as job creation in renewable industries and benefits from improved energy efficiency.

6.7 Principles of fairness and inclusivity should guide the pathway to net zero. The transition should be just, ensuring that vulnerable groups and regions are not left behind and that benefits are shared broadly.

7. Are the energy solutions universal across the UK, or are there regional and local approaches to fuel and energy?

7.1 Energy solutions cannot be universally applied due to regional resource variations, economic structures, and social conditions. Instead, local and regional strengths should be leveraged, fostering a diverse and resilient energy system.

7.2 The UK exhibits significant regional variation in energy resources. Scotland, for instance, is rich in wind and wave resources, while Southern England receives more sunlight, making it suitable for solar power. Northern England and Scotland have the potential for carbon capture and storage due to their North Sea oil and gas infrastructure. Regions with heavy industry, such as the North of England and Wales, could benefit from hydrogen and CCUS technologies.

7.3 Besides physical resources, the social and economic context also matters. Public acceptance of energy projects can vary across regions due to differing local values, experiences, and interests. Regional strategies can consider these factors, fostering public engagement and ownership.

7.4 Moreover, localised energy solutions can provide benefits such as increased energy security, reduced transmission losses, and opportunities for local economic development. They can also be more flexible and adaptable to changes.

7.5 That said, regional and local approaches should be integrated nationwide. This ensures coordination, shares best practices, and provides the necessary support. The transition to a sustainable and resilient energy system requires a combination of local and national strategies and a balance between diversification and coordination.