**Written evidence submitted by The UK Energy Research Centre (UKERC) (POW0077)**

## Introduction to UKERC

The UK Energy Research Centre (UKERC) carries out world-class, interdisciplinary research into sustainable future energy systems.

It is a focal point of UK energy research and a gateway between the UK and the international energy research communities.

Our whole systems research informs UK policy development and research strategy.

UKERC is funded by the UK Research and Innovation Energy Programme.

## 1. Is the energy sector open enough to new generation technologies?

The UK energy sector has benefitted from the introduction of a wide range of new technologies in the last three decades. This includes introduction of gas-fired combined cycle turbines in the early 1990s; the first onshore wind farms at around the same time; the development of offshore wind farms in the early 2000s; the emergence of a solar photovoltaic installation industry from around 2008; and the connection of grid-connected batteries from around 2016. In addition to this, the UK has installed demonstrations of wave and tidal stream energy, and is currently one of the few OECD countries proceeding with the construction of a new nuclear power station. Plans are also proceeding with power stations equipped with carbon capture and storage (although two earlier demonstration efforts failed, in part due to political factors). We therefore suggest that the UK energy sector is indeed open to new generation technologies.

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

We refer the Committee to the UKERC submission to the parallel inquiry, ‘a flexible grid for the future’, which discusses support for energy infrastructure.

## 3. Is the Government’s plan for energy security sufficiently long term?

The most extensive Government statement is the March 2023 document *Power Up Britain: Energy Security Plan*[1]. There is much in the plan that makes sense, but the vast majority is not new and amounts to a promissory note to build a low-carbon energy system by the late 2030s rather than an energy security strategy. There is new detail on enhancing security of gas supply. The strategy refers to how the UK needs to ensure a diversity of sources of supply and a reliance upon ‘friendly nations.’ This is approach has merit but does not directly address the interrelated nature of physical security and price. Experience has shown that we can be confident in physical security of supply, but such an approach cannot mitigate against high prices, determined by global market conditions. We may yet have two more difficult winters, but it is likely that the global gas market will rebalance in coming years and, given many countries’ efforts to reduce dependency on gas, may even be over-supplied by the end of the decade.

[1] https://www.gov.uk/government/publications/powering-up-britain/powering-up-britain-energy-security-plan

The most significant medium- and longer-term challenges to the UK's energy security relate to 'transition risk': the uncertainties created by the energy transition itself. UKERC has argued that transition risks are difficult for individual investors to manage, and this reinforces the case for policy mechanisms that can help to re-risk investment in renewables, such as the Contracts for Difference (CfD)[2]. Similar considerations apply to new nuclear, CCUS and hydrogen, and we cautiously welcome the extension of a CfD-style approach to the latter two options. However, the transition will also threaten the integrity of the incumbent fossil-fuel based infrastructures up to the point when they are no longer needed. Previous UKERC work has emphasised the importance of maintaining the viability of the gas infrastructure for as long as it is needed – an approach we describe as 'gas by design'[3].

We can think of the energy transition in terms of three phases, roughly aligned with three time or investment horizons: prevailing or contemporary; transition or intermediate; and reformed or new steady state[4]:

The prevailing paradigm was in play at around the turn of the Century when UK gas production peaked and import dependence started to increase. In this phase, the dominant source of insecurity was the growing exposure to global gas markets; oil was seen as far less of a problem. Various Governments were happy to reply on market forces to deliver the gas the country needed. The height of this 'market complacency' came in 2017 when the Government of the day decided not to support keeping the Rough Storage Facility operational. However, by then the UK's energy system had entered into the second phase of the transition, what colleagues at UKERC call the 'build phase', as significant amounts of renewable power generation are invested in. We remain in this build phase and now have a hybrid system where gas continues to play a significant role, but there is a clear trajectory to reduce the role of unabated gas in power generation and an intent (as yet very limited progress) to replace gas boilers with electric heat pumps. This raises concerns about the medium- to long-term prospects for the current gas infrastructure: how long will it be needed, and can it be reconfigured to support hydrogen and CCS? That infrastructure is in private, and largely foreign hands; what happens if the current owners decide to divest, or assets get stranded?

During the current build phase, the traditional concerns remain in relation to gas security of supply, but a new, and much more significant, set of energy security concerns are impacting the ability of the UK to build the low-carbon energy infrastructures needed to deliver a green power system by 2035 and a Net-Zero economy by 2050. Critical materials are one factor. Other issues include the necessary supply chains (what new dependencies are emerging?), the domestic industrial and manufacturing base, the right skills, the right policy framework, the planning and permitting system and the sources of finance needed to build a low-carbon energy system at pace. In short, the potential failure to deliver on the low-carbon energy system is the most significant energy security risk facing the country. The slower the pace of progress, the longer we remain exposed to the more traditional fossil fuel security of supply risks.

Eventually, the energy system will move into a third 'steady state' phase with the low-carbon system operational. Doubtless that will present its own set of challenges. However, except for any remaining dependency on fossil fuels as feedstocks for manufacture of other fuels

[2] https://ukerc.ac.uk/publications/transition-risk-investment-signals/
[3] https://ukerc.ac.uk/news/still-waiting-on-gas-by-design/#:~:text=That%20is%20the%20purpose%20of,transforms%20to%20become%20net%20zero.
[4] see: Curry, Andrew & Hodgson, Anthony. (2008). Seeing in Multiple Horizons: Connecting Futures to Strategy. Journal of Futures Studies. 13. https://jfsdigital.org/wp-content/uploads/2014/01/131-A01.pdf

(with capture of the CO2 generated) or in ensuring reliable electricity production (again with CCS), those fossil fuels risks will have disappeared[5].

For the moment, the UK is firmly in the build phase, and we need an energy security plan that recognises this. Current Government plans focus too much on the short-term challenge of gas security of supply. At the same time, the current plan is a long list of the things that need to be done, rather than an appraisal of the energy security challenges that must be managed while we build a future low-carbon energy system. In short, we are in the messy middle ground between a past fossil fuel system and a future low-carbon energy system, and we need a conception of energy security and a plan that reflects this.

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

Any energy production technologies that reduce vulnerability to volatile markets and imports can be usefully deployed at scale to improve energy security. If the cost of production of energy from these technologies is lower than alternatives, price insecurity is also reduced. This is true of wind energy, both onshore and offshore, and solar PV[6]. Industry has developed in the UK with the capability to develop and operate these technologies at scale and at low cost. However, they now face risks including: the difficulty of gaining planning consents onshore, for both generation plants and network capacity; supply chain capacity constraints; and inflationary pressures, affected not only by limited capacity across the supply chain but also global commodity prices[7]. We discuss planning and grid connection issues in UKERC's response to the parallel inquiry into flexible grids.

In very general terms, all the technologies to generate electricity from non-fossil sources and to electrify end-uses such as transport and heating have the potential to increase energy security. This therefore includes new nuclear power stations, and the ongoing expansion of electric vehicles. Roll-out of electric heat pumps is much more limited. Experience from around the world demonstrates that new nuclear power stations take a long time to commission and build, so their value to energy security is many years hence (this does not mean unimportant). However, it is also important to be clear that energy security is multi-faceted, and whilst one (currently dominant) aspect is to reduce dependence on fossil fuels, there are others. For example, availability of cooling water for nuclear reactors, or a fault that affects many such reactors at once, can lead to supply shortages. Renewable sources may be subject to climatic factors such as extended periods of low wind or low rainfall (affecting hydro-generation). New nuclear reactor designs that do not yet have regulatory approval cannot be considered as 'current' technologies.

It is important to note that energy efficiency improves energy security, since it reduces overall demand, hence reducing reliance on a 'marginal unit' of power or gas that may be most expensive and/or difficult to secure. Building insulation also helps provide resilience if supplies were to experience short-term interruptions, for the obvious reason that a well-insulated building will stay warm for longer than a poorly insulated one. Large-scale energy efficiency retrofit is the most obvious and important of the current technologies that could

---

[5] Blondeel, M., Bradshaw, M. J., Bridge, G. and Kuzemko, C. 2021 The geopolitics of energy system transformation : a review, Geography Compass, 15, 7, e12580, **https://doi.org/10.1111/gec3.12580**

[66] Climate Change Committee, Delivering a reliable decarbonised power system, March 2023, https://www.theccc.org.uk/publication/delivering-a-reliable-decarbonised-power-system/

[7] Justin Jacobs "Rising prices and supply chain risks threaten Europe's renewable aims", Financial Times. November 30 2022; Renewable UK, "The Government needs to be realistic and act fast to avoid losing the renewables race", February 2023, https://www.blog.renewableuk.com/post/the-government-needs-to-be-realistic-and-act-fast-to-avoid-losing-the-renewables-race

help to enhance energy security. We discuss the barriers to energy efficiency in more detail in our response to the ‘heating our homes’ inquiry.

There has been some discussion around the development of new gas storage facilities, noting the partial reopening of Rough. However, large-scale investment in new gas storage facilities is not a short-term solution, and would appear to run into problems of asset stranding as the UK also seeks to reduce reliance on gas altogether. The UK has now started to roll out plans that will initiate development of hydrogen storage, and is developing policies to promote longer duration electricity storage[8]. These options will both help improve energy security in the medium term.

It is also important to note that security is not just delivered through domestic developments. Throughout the difficult period since Russia invaded Ukraine, the UK-EU interconnectors for both gas and electricity have helped to keep us all more secure. LNG terminals in Britain helped fill gas storage on the continent and flows in both directions (responding to market prices as they should), help to keep the lights on and homes warm on both sides of the Channel and across the Irish Sea. Energy security should not be conflated with energy independence. Whilst developing domestic renewables enhances both, UKERC has also stressed the central role of collaborative and cooperative relations with neighbours that take a Europe-wide approach to energy security.

**5. What energy generation mix will get us to net zero the quickest in the most affordable way?**

There is a happy coincidence that the cheapest forms of energy also have the lowest associated carbon emissions: wind and solar power. However, the levelised cost of producing electricity from these technologies is not the whole story. Demand for energy needs to be met reliably, across a year, as demand varies, e.g. for heating in winter and more cooling in summer, and wind speeds and solar irradiance change, and energy needs to be moved from where it is produced to where it is used. Extra costs are added by the need for flexible energy production resources capable of increasing or decreasing their production as the difference between demand and energy from renewables, i.e. the ‘residual demand’, changes minute by minute, and for network capacity[9]. Flexibility of demand – the ability of users of energy to change the time of use to match the availability of energy from renewables – will reduce this cost somewhat, but will not remove the need for substantial investment in flexible generation, storage and network capacity[10]. These need to be properly planned and financed.

Based on the best knowledge we have now it appears that net zero will be most cost-effectively delivered through a significant expansion of wind and solar, an ongoing but smaller role for nuclear (not likely to be significantly increased on current levels before 2035), with a mix of technologies to provide flexibility. There is some uncertainty around the mix of options that can provide flexibility at the scale required, but it is likely to be gas power stations with CCS, hydrogen storage, some new pumped hydro, and increased interconnection. Batteries and demand response will also be important, but do not provide bulk energy storage. Whilst net zero in 2050 has quite a bit of uncertainty, the path to decarbonisation of power in 2035 is largely already baked into the plans to develop renewable energy, Hinkley C nuclear power station, upgrade grids and interconnectors,

---

[8] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1096002/large-scale-long-duration-electricity-storage-govt-response.pdf
[9] Climate Change Committee, Delivering a reliable decarbonised power system, March 2023, https://www.theccc.org.uk/publication/delivering-a-reliable-decarbonised-power-system/
[10] National Grid ESO, Future Energy Scenarios, July 2023, https://www.nationalgrideso.com/future-energy/future-energy-scenarios

encourage demand response and bring on stream some hydrogen/CCS. Because 2035 is a such short time away in energy system terms it is too late consider changes that might be 'quicker'. In any case it is hard to imagine options that could deliver more quickly.

### 6. Are the energy solutions universal across the UK or are there regional and local approaches on fuel and energy?

We argue in our submission to the inquiry into flexible grids that the UK needs to re-engineer its electricity network to access resources of renewable energy that have the potential to be abundant and cheap but may be remote. Energy solutions are far from universal: there are strong regional variations in both available resources and opportunities for implementation.

Development of wind generation capacity needs space and high wind speeds; large-scale solar PV production also depends on space and is most efficient in the places with most sunlight. Nuclear power generation requires land plus access to cooling water. These factors naturally lead developers to favour investment in particular locations. However, wind and solar generation are scalable – the number of turbines and panels installed can be adapted to fit the space available. This provides a degree of flexibility in deployment that may be able help somewhat to resolve a tension, for example, between where the best wind resources are and a desire to minimise the need for network investment – see the UKERC submission to the enquiry on flexibility of supply. However, small-scale generation developments lose economies of scale, and wind generation nearer to the largest demand centres – onshore in the south-east – will deliver less output and have a higher cost per unit of energy due to lower wind speeds. Wind and solar developments are more likely to face opposition and/or be less likely to secure planning permission in areas where competing pressures on land are greater, due to larger populations. For all of these reasons we do not believe that energy solutions are universal. It is therefore important to take an approach to energy system planning that recognises the geographical realities of the UK. The power system of the 20th century was built to deliver 'coal by wire'. The power system of the 21st century needs to deliver 'wind by wire'.

Demand-side technologies may offer more widespread applications, though here too there are geographical specificities. The exact means by which heat can be provided from heat pumps depends on local conditions, e.g. heat demand in blocks of flats or large offices might be best met via a heat network served by one or a few relatively large heat pumps. Depending on the location, these might make use of heat in rivers, flooded mine workings or sewage plants.

As a general rule, the lowest cost means of meeting demand for energy in a low-carbon way is via electrification of end use and production of low-carbon electricity. That also permits significantly improved energy efficiency, e.g. through use of heat pumps to keep buildings warm and heat up water, or through electric motors in vehicles[11]. However, electrification might sometimes be problematic. This includes where getting enough electricity network capacity would be too expensive or attract irresolvable local objections, or where battery storage would be too heavy for the required energy. Also, the variability of wind speeds and solar irradiance give rise to a need for energy storage to, in effect, move energy in time. These scenarios point towards some role for low-carbon fuels, e.g. hydrogen manufactured by low-carbon means.

Although many respected commentators, such as the Climate Change Committee, are now confident that hydrogen will play an important role in our future energy system, there is

[11] Climate Change Committee, The Sixth Carbon Budget:
The UK's path to Net Zero, December 2020, https://www.theccc.org.uk/publication/sixth-carbon-budget/

disagreement about the extent of its role[12]. There is an existing industrial demand for hydrogen that should be decarbonised, and hydrogen made from surplus electricity, stored, and then used to generate electricity when wind speeds and solar irradiance are low looks likely to be the best option for inter-seasonal or, taking account of year-to-year variations in energy demand and wind speeds, inter-annual energy storage. Hydrogen used in some form, e.g. ammonia, may also prove essential for the manufacture of low-carbon fuels, such as for shipping. However, it should be used in other industrial processes, or heat in buildings, only where local conditions make electrification difficult and low-carbon hydrogen can be readily accessed[13]. Energy users' desire for choice in how their energy needs are met should also be noted. However, the need to access sufficient supplies of either low-carbon electricity, low-carbon hydrogen or other low-carbon fuels and the different costs of doing so in different locations are likely to limit the choices available in any one place.

*August 2023*

[12] Climate Change Committee, Delivering a reliable decarbonised power system, March 2023, https://www.theccc.org.uk/publication/delivering-a-reliable-decarbonised-power-system/
[13] Climate Change Committee, Hydrogen in a low-carbon economy, November 2018, https://www.theccc.org.uk/publication/hydrogen-in-a-low-carbon-economy/