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Small Modular Reactors (SMRs)

Do we need them when renewable generation is low — and are they cost-effective?

A report for Friends of the Earth by Chris Gordon-Smith

Contents

1 Introduction

Small Modular Reactors (SMRs) are a new class of nuclear reactor. The UK Government is supporting SMRs through funding,[1] planning reform,[2] and proposed regulatory changes.[3]

This briefing, written for Friends of the Earth, examines whether SMRs are needed to support the electricity system in Great Britain, with particular focus on the challenge of maintaining electricity supply during extended periods of low renewable generation. It also assesses available evidence on SMR costs.

1.1 About the Author

Chris Gordon-Smith is a retired IT professional with extensive experience in system modelling and simulation, and a long-standing interest in science including physics.

1.2 Acknowledgements

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1.3 Use of AI

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The author has checked that statements in this briefing accurately reflect the cited sources.

2 Executive Summary

Political context: The UK Government is pursuing a substantial expansion of nuclear power, including a new programme focused on Small Modular Reactors (SMRs). There is cross-party political support for this approach, with senior politicians frequently arguing that nuclear power provides reliable "baseload" electricity (see Section 4.4).

The variability challenge: As the electricity system transitions toward higher shares of wind and solar generation, the central technical challenge is not the provision of continuous baseload output, but the management of variability over timescales ranging from hours to multiple weeks. Reliability of supply depends on maintaining sufficient flexibility to manage short-term fluctuations and, crucially,

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[1] In June 2025, the government pledged over £2.5 billion for the overall small modular reactor programme. See [18].

[2] See the press release *Government rips up rules to fire up nuclear power* [19].

[3] The Nuclear Regulatory Review 2025 recommends a "radical reset" of the UK's nuclear regulatory system. See [8], page 7.

to cover the cumulative energy deficits that arise during prolonged low-renewable periods. These extended shortfalls require access to stored energy or other reliable sources capable of supplying energy when needed over the duration of the shortfall (see Sections 4.2 and 4.4.3).

High-renewables system modelling: Electricity system modelling by organisations such as the National Energy System Operator (NESO) and the Royal Society, as well as numerous academic studies, indicates that electricity systems with high shares of renewable generation can maintain reliability through combinations of storage, interconnection, demand-side flexibility and other resources (see Section 4.3). The Royal Society concludes that: “In 2050 Great Britain’s demand for electricity could be met by wind and solar energy supported by large-scale storage.”

Storage requirements: Analysis of prolonged low-renewable periods in European systems indicates that the principal system stress arises from cumulative energy deficits that build up over events lasting several days to multiple weeks. Even where substantial non-variable generation is present, shortfalls can develop over extended periods. The scale of long-duration storage required is therefore determined primarily by these extreme events rather than by typical day-to-day or seasonal variability. Quantitative estimates of storage requirements in high-renewables systems are typically measured in tens of terawatt-hours. The Royal Society estimates 60 to 100 TWh, equivalent to 4.4 to 8.1% of annual electricity demand (see Section 6.1.2).

Hydrogen storage capacity: A geological assessment of UK salt formations suggests a large hydrogen storage potential, with an estimated theoretical capacity of over 2000 TWh based on mapped salt basins. When engineering constraints including cavern spacing are taken into account, practical deployable capacity has been estimated at approximately 35 TWh or 68 TWh depending on the assumed spacing (see Sections 6.1.3.1 and 6.1.3.3). This is of a broadly similar order of magnitude to the storage requirements identified in system modelling studies, corresponding to the lower end of the estimated range and not fully meeting the upper range.

Including additional potential from facilities such as Rough strengthens this position, but does not eliminate the gap at the upper end. While higher storage scenarios may exceed these estimates, the available capacity indicates that hydrogen storage could make a substantial contribution, although it may need to be complemented by other flexibility measures to meet overall system requirements (see Section 6.1.3.5).

Overbuild: The scale of storage required depends in part on renewable overbuild—installing more wind and solar capacity than needed to meet average demand. Increasing such capacity can reduce storage requirements by lowering the depth and frequency of energy deficits. However, prolonged periods of low renewable output can still produce cumulative shortfalls, meaning that significant long-duration storage remains necessary to maintain reliability (see Section 6.3).

Interconnectors: Cross-border interconnectors allow surplus generation in one country to offset shortfalls in another and can materially reduce balancing requirements. However, modelling indicates that even with strong European interconnection, substantial long-duration storage is still required during severe multi-country low-renewable events (see Sections 6.2 and 6.1.2.2).

Hydrogen storage safety considerations: Hydrogen storage in salt caverns is an established technology with decades of operational experience in the UK and the United States. Evidence indicates that hydrogen can be stored and recovered safely over long periods. However, safety risks must be understood in the context of wider underground gas storage, particularly natural gas, where incidents such as the 2001 Hutchinson accident show that leaks can have serious consequences.

Modelling studies also indicate that, in extreme scenarios such as blowouts, explosions could have lethal effects over distances of hundreds of metres. These risks can be managed through appropriate design, monitoring and regulation, but ensuring that robust safety procedures are in place and rigorously implemented will be essential from the outset, and will become increasingly important as hydrogen storage expands (see Section 6.1.4).

Are SMRs needed during low renewable periods? This is the key question addressed by this briefing (see Section 3 for the full statement of the question).

Authoritative published modelling of Great Britain's electricity system (see Section 4.3), taken together with geological and engineering assessments (see Section 6.1.3), shows that it is possible to maintain security of electricity supply during periods of low renewable generation through a combination of long-duration storage, renewable overbuild, interconnection, demand-side flexibility and other measures. These studies do not identify SMRs as a prerequisite for reliability.

While some nuclear power plants can operate in load-following mode, adjusting output to match variations in electricity demand[4], this capability relates to short-term fluctuations in demand and supply. It does not address the challenge of prolonged periods of low renewable generation, which require sustained energy supply over extended periods.[5]

In short, on the basis of current evidence, SMRs are not necessary to maintain security of electricity supply during such periods, whatever combination of technologies is used in the electricity supply system.

SMR Costs: The available evidence suggests that the economic case for SMRs is uncertain and, in authoritative analyses, unfavourable.

Analysis by the Institute for Energy Economics and Financial Analysis (IEEFA) indicates that SMRs are likely to be costly and financially risky. A literature review by Kim and Macfarlane finds that "many studies show that the economics of SMRs will be much costlier than that of large Light Water Reactors (LWRs), thereby will not be competitive or profitable." They cite analysis by Steigerwald et

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[4] See page 6 in [23].

[5] If SMRs were deployed primarily to provide backup during infrequent periods of low renewable generation, their utilisation would be low, increasing the cost per unit of electricity generated (see Section 7.8).

al., which finds that “none of the tested concepts is able to compete economically with existing renewable technologies.” See Section 7 for details.

3 Question: Do We Need SMRs?

The case for nuclear is often framed in terms of its ability to complement intermittent or fluctuating renewable generation (see section 4.4.1 for examples). This briefing reviews that assumption and asks the following question:[6]

> Are SMRs needed to provide power in Great Britain during reasonable worst-case periods of low renewable (wind, solar, hydro etc.) generation and high electricity demand.

Sections 4, 5 and 6 are concerned with answering this question.

4 Background

4.1 Small Modular Reactors

The Nuclear Energy Agency (NEA) has defined SMRs as:[7]

> ...nuclear reactors with a power output between 10 megawatt electric (MWe) and 300 MWe. They integrate by design higher modularisation, standardisation and factory-based construction in order to maximise economies of series (or the “series effect”). The different modules can then be transported and assembled onsite, leading to predictability and savings in construction times.

Some designs described as SMRs fall outside this nominal range. For example, the Rolls-Royce SMR has a planned capacity of around 470 MWe.[8]

The NEA report identifies the following characteristics of the series effect:[9] [10]

- reduction in unit costs with an increased number of units
- increased efficiency and cost-effectiveness through learning curves and feedback of experience

Some SMR designs incorporate *load-following* capability, enabling the generation

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[6] Northern Ireland operates within the Single Electricity Market (SEM) for the island of Ireland and is therefore assessed separately in most system adequacy studies. For this reason, this briefing concerns the electricity system of Great Britain.

[7] See page 15 in [37].

[8] See [50].

[9] See [37], page 15, footnote 1.

[10] Figure 34 in [36] illustrates a concept in which SMR economic drivers are envisaged to help compensate for diseconomies of scale.

of electricity to be changed to match the expected electrical demand.[11] Load-following is typically used to match variations that occur within a daily *load cycle*.[12]

4.2 Variable Renewable Energy Droughts

Meeting decarbonisation objectives requires a large expansion in renewable energy generation. Variable Renewable Energy Droughts (VRE Droughts) present a challenge for high-renewables electricity systems. They are extended periods with low output from variable renewable sources such as wind and solar. These events are typically driven by meteorological patterns (e.g. persistent high pressure) and can last for extended periods (see Sections 5.1 and 5.2). The impact of VRE Droughts will typically be worse in winter when electricity demand is high. They must be dealt with by:

- Using other sources of energy, or
- Reducing demand, or
- Some combination of the above.

An important 'other source' is energy that has been stored for later use. This is discussed in Section 6.1. Regarding reducing demand during a VRE Drought, the potential for this is less than on short (e.g. daily) timescales, where electricity demand can be shifted away from peak periods.

Dunkelflaute: The German term *dunkelflaute* is often used to signify a period of low availability of wind and solar energy. It means 'dark doldrums' and refers to a specific type of VRE Drought, restricted to wind and solar generation, rather than to all forms of variable renewable energy (e.g. hydro-electric power).[13]

4.3 High-Renewables Energy System Modelling

Electricity system modelling is widely used to examine how future low-carbon electricity systems can maintain reliability while reducing greenhouse gas emissions.

NESO: In the UK, such analysis is undertaken by the National Energy System Operator (NESO), which assesses security of supply under a range of possible future electricity system configurations.

In 2025, NESO published a report on energy security modelling.[14] The modelling helps NESO understand the potential risks to *resource adequacy* in the future, so

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[11] See page 6 in [23]: "Load following means to change the generation of electricity to match the expected electrical demand as closely as possible."

[12] Figure 13 in [23] shows an example from Canada. Nuclear output was reduced during some periods on some days in the first week of July 2015 to assist in balancing generation with demand. See also Figure 1 in the report, which illustrates three types of daily load-following: Planned, unplanned, and frequency regulation and control.

[13] See for example Section 1 in [43].

[14] See [34]

that actions can be taken ahead of time to ensure reliability of energy supplies.[15] The report focuses on *resource adequacy* assessments for the 2030s.

NESO's modelling identifies six *Portfolios*, each corresponding to a particular technology deployment scenario. The portfolios are designed to help identify the resources required to maintain security of supply.[16] They are not intended as recommended pathways but are designed to help understand what might be required under different 'what-if' scenarios and stress tests.[17]

Several of these portfolios include significant nuclear capacity, while others explore more limited or no new nuclear deployment.[18]

Notably, Portfolio 4 models a scenario with no deployment of SMRs.[19]

The Executive Summary states:

> Flexible resources such as storage, interconnection and demand-side flexibility will play an increasingly important role in resource adequacy. These resources can shift energy over time and across regions, helping consumers benefit by making better use of clean energy.

Royal Society: In 2023 the Royal Society produced a report[20] that considered the use of large-scale electricity storage when power is supplied predominantly by wind and solar. The report's Executive Summary states as its first conclusion:

> In 2050 Great Britain's demand for electricity could be met by wind and solar energy supported by large-scale storage.

100% Renewable Energy Systems Research: A review by Christian Breyer and others[21] published in 2022 includes a history of research into this area, which started in the mid 1970s. The review draws on a large body of academic studies[22]. It found that:[23]

> The main conclusion of most of these studies is that 100% renewables is feasible worldwide at low cost.

The review notes that 100% renewable energy scenarios "challenge the dogma

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[15] See the Executive Summary in [34].

[16] See [34], p. 30.

[17] See [34], p. 23.

[18] See [34], Table 10.

[19] NESO characterise Portfolio 4 as having "No deployment of nuclear plants beyond assumed committed levels", and have confirmed by email that as of March 2026 no SMRs were "committed".

[20] See [47].

[21] See [2].

[22] See Table 1 in the review [2]. See also Figure 2, which shows the growth of this research area since 2004.

[23] See the Abstract in [2].

that fossil fuels and/or nuclear are unavoidable for a stable energy system”[24]. It goes on to discuss objections that have been raised in several areas.[25]

While these studies differ in their assumptions and scope, they consistently frame the challenge of maintaining reliability in terms of managing variability, using combinations of storage, interconnection and demand-side flexibility to balance supply and demand over time.

However, policy discussions often frame the role of nuclear power in terms of “baseload” electricity, presenting it as a necessary complement to intermittent renewable sources. This framing reflects a different perspective from the system modelling described above. The next section examines how the concept of baseload is used and whether it provides a useful framework for understanding the challenges of a high-renewables electricity system.

4.4 The Baseload

UK Government and senior opposition politicians support SMRs, citing the “baseload”. The Hansard record of a House of Lords debate on Small Modular Reactors in May 2025 illustrates the cross-party agreement on the role of nuclear in providing baseload power[26].

Lord Hunt of Kings Heath (Labour, Minister of State in the Department for Energy Security and Net Zero at the time) said:

> I believe we have a great opportunity in this country to develop small modular reactors and a UK supply chain and to get us towards net zero, because of the essential contribution that nuclear power will play in the baseload we require.

Lord Sharma (Conservative, Secretary of State For Business, Energy and Industrial Strategy in the Johnson Government, President for COP26) responded:

> My Lords, I welcome the fact that the Government hope to quadruple the amount of nuclear capacity by 2050 — the same target that the Conservative Government had — and it is very welcome in terms of baseload.

In July 2025 the concept of baseload was discussed in the House of Lords alongside concerns about the intermittency of renewable generation.[27]

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[24] See the first sentence in Section VI of the review [2].

[25] See Section VI in the review [2], which discusses objections in the following areas: energy return on investment; dealing with variability and stability; the costs of solar PV and wind power; raw material demand for 100% renewable energy systems; and community disruption and energy injustice.

[26] See the Hansard record of the debate [31].

[27] See [20]. Baroness Bloomfield of Hinton Waldrist said: “The updated national policy statements also fail to answer how we will maintain a stable, secure and affordable power system in the face of massive intermittent generation.”, continuing a few sentences later: “There is no clear path to long-term baseload capacity”.

Previously the Johnson government had supported nuclear, also citing the baseload.[28] [29]

4.4.1 Nuclear Power as a Complement to Intermittent Sources

While baseload is frequently invoked in policy discussions, the argument for nuclear power is often framed in terms of its role as a *complement* to variable renewable generation.

An interview with Sustainability magazine in November 2025 with Per Erik Holsten, President of ABB Energy Industries illustrates this:[30]

> As a complement to intermittent renewable energy sources, nuclear provides consistent, reliable baseload power that can support a stable energy grid.

The trade union Prospect also highlights a complementary role for nuclear. The article “Why new nuclear is essential to beating the climate crisis” on its website says:[31]

> To avoid dangerous fluctuations in output, we need complementary sources of low-carbon energy. These will balance out the regular occasions when output from variable renewables drops suddenly sharply, sometimes for prolonged periods.

Although the role of nuclear as a complement to variable renewable energy is not always mentioned in Government sources, it is included in “Mobilising green investment: 2023 green finance strategy'' which says:[32]

> Nuclear energy has a key role in achieving the UK’s net zero objectives, by providing clean and non-weather dependent power to complement intermittent renewable energy sources.

The International Atomic Energy Agency (IAEA) also highlights a complementary role for nuclear energy. Its 2023 report “Nuclear Energy in Climate Resilient

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[28] In 2025 the UK Government's Clean Power Action Plan [16], with forwards by Ed Miliband (Secretary of State for Energy Security and Net Zero) and Chris Stark (Head of Clean Power 2030), said “Nuclear will play an important role in our future energy system, providing low-carbon, baseload power to the grid''.

[29] In 2022 the Johnson Government's British Energy Security Strategy said “We can only secure a big enough baseload of reliable power for our island by drawing on nuclear.''See [15].

[30] See the Sustainability Magazine article by Jasmin Jessen [25].

[31] See the article “Why new nuclear is essential to beating the climate crisis” on Prospect‘s website [40].

[32] See Box 10 in Section 68 of [17].

Power Systems" says:[33]

> The climate resilience of the global nuclear fleet makes it an excellent complement to other low carbon energy sources as climate risks increase.

On the next page it brings in the variability of energy generation, mentioning:

> a growing premium on the concept of climate resilient energy, or the ability of an energy technology to consistently meet demand amid a fluctuating energy supply.

This framing differs slightly from the preceding examples, placing the argument in terms of system resilience rather than solely the variability of renewable generation.

4.4.2 No Formal Definition of Baseload

In 2023 the Green Party MP Caroline Lucas asked the Minister of State for Energy Security and Net Zero "if he will make an estimate of the amount of baseload electricity generation that is required by the UK each day; and if he will place a copy of these calculations in the House of Commons Library".

Graham Stuart, the Conservative Minister of State, responded:[34]

> Although some power plants are referred to as baseload generators, there is no formal definition of this term. The Department also does not place requirements on generation from particular technologies. As such, it is not possible to provide this information.

In short: "Baseload" does not have a formal definition. Consequently, although it is often used in policy discussion, it does not provide a clear or measurable basis for specifying quantitative requirements.

4.4.3 Beyond the Baseload

In electricity systems with high shares of wind and solar generation, the concept of baseload does not provide a sufficient framework for maintaining reliability of supply. Instead, the central technical challenge concerns the management of variability and, in particular, the cumulative energy deficits that arise during prolonged periods of low renewable output (see Section 4.2).

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[33] See the second page following the cover in the report [24].

[34] See the parliamentary answer [51]

4.5 Nuclear Technology as a Critical National Priority

The UK Government's Nuclear Regulatory Review published in November 2025 states that nuclear power is vital for meeting the UK's 2050 Net Zero commitment and for accommodating a projected doubling of electricity demand.[35]

The review also states that the full breadth of national policy must recognise the **Critical National Priority** status of nuclear technology and enable an efficient fleet-based approach.[36]

The designation of nuclear technology as a Critical National Priority reflects policy considerations across multiple areas, including energy security and net zero, economic growth, and national defence.

By addressing the question in Section 3, this briefing examines whether the deployment of SMRs is critical for maintaining reliability of supply during VRE Droughts.

5 Severity and Impact of VRE Droughts

VRE Droughts were described in Section 4.2.

Section 5.1 below highlights work by a leading economic research institute in Germany (DIW) to gauge the severity of VRE Droughts in terms of drought duration and depth of the reduction in energy generation during that period. Section 5.2 describes a scenario developed by the Committee on Climate Change (CCC) that combines a severe VRE Drought with a period of high energy demand, thereby increasing the impact of the drought. Section 5.3 concludes that the impact of VRE Droughts can be understood in terms of cumulative energy shortfall.

5.1 DIW Research: Time Series Analysis

Martin Kittel and Wolf-Peter Schill of the German Institute for Economic Research analysed historical weather data for Europe (including the UK).[37]

Their analysis shows that low renewable output can persist for extended periods. For example, in an idealised, perfectly interconnected setting (see below and Section 6.2), they identified a period in winter 1996/97 lasting **55** days during which average European renewable availability (i.e. renewable output relative to its typical level) was **47%** of its long-run mean.[38]

The analysis highlights the following effects relevant to the severity of VRE droughts:[39]

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[35] See Summary section in [8].

[36] See page 8 in [8].

[37] See [29], published on the arXiv open access repository (not peer reviewed). See also the conference presentation [28].

[38] See Abstract in [29].

[39] See page 3 in [29].

- **Geographical Balancing Effect:** A VRE Drought may affect one area more seriously than another. In such cases power can be transmitted between countries using Interconnectors.[40] This can reduce the impact of the VRE Drought.
- **Portfolio Effect:** Renewable energy is typically generated using a range of technologies. For example, solar PV, onshore wind, offshore wind. Where this is the case it may be that low output from one technology is offset by relatively higher output from another.

These two effects can substantially reduce the severity of VRE Droughts.

5.2 Climate Change Committee 30-Day Wind Drought Scenario

The UK's Climate Change Committee has investigated what a reliable, resilient, decarbonised electricity supply system could look like in 2035.[41] They tested the impact of a low wind year, using weather patterns from 2010, which is judged to have been a 1-in-50 low wind year.

Their tests also included a second scenario in which an extended 30-day period of wind drought was combined with high residual demand.[42] The report says the following about this scenario:[43]

> This is designed to test a more extreme scenario and does not have a historical precedent, but effective resilience planning requires considering potential impacts outside the historical record.

The CCC found that in an extreme extended wind drought scenario, higher levels of unabated gas generation (3% of total generation) and capacity (25 GW) are required in the model to maintain security of supply.

5.3 Impact Depends on Cumulative Energy Shortfall

The results of Kittel and Schill and of the Climate Change Committee are not directly comparable. Kittel and Schill analyse the characteristics of low-renewable periods based on historical weather data. The CCC's second scenario is a compound stress test combining an extreme extended 30 day wind drought with high residual demand.

However, taken together, these analyses highlight a common feature of VRE droughts. Periods of low renewable output can persist for extended durations and place significant cumulative stress on the electricity system.

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[40] Interconnectors are high-voltage cables that link one country's electricity grid with those of neighbouring countries, allowing electricity to flow in both directions.

[41] See [5].

[42] See page 48 in the report: “Residual demand is defined as the difference between demand at a particular point in time and the power available at that time from wind, solar, BECCS and – by virtue of its relative inflexibility – nuclear.”

[43] See page 60 in [5].

The work of Kittel and Schill shows that the *meteorological severity* of such weather events can be understood in terms of both the duration of the drought and the depth of the reduction in renewable output.

The *impact on the electricity system* depends additionally on how this reduced output interacts with electricity demand over time. The Climate Change Committee's results provide a system-level perspective, showing that maintaining security of supply under extreme conditions requires energy from other sources.

What matters is the total energy that can be supplied over the duration of the event, rather than the availability of generation capacity at any given moment. The key challenge is therefore not simply the duration of a VRE drought, but the cumulative energy shortfall that develops over the event. The implications for the scale of resources required to maintain reliability are considered in the next section.

6 Stabilising the Energy System

As noted in Section 4.2, when a VRE Drought occurs the energy shortfall must be dealt with by using other sources, reducing demand, or some combination of these.

Other potential sources include stored energy and energy imported through an Interconnector. These are discussed in Sections 6.1 and 6.2 below.

Reducing demand through demand flexibility is primarily relevant in dealing with shorter term variations and so is not covered in this briefing.

6.1 Energy Storage

Energy storage plays a key role in dealing with VRE Droughts. Section 6.1.1 discusses the different timescales for renewable energy fluctuations, and some of the technologies appropriate for each case. Section 6.1.2 discusses how much storage is needed, highlighting the work of a number of experts in this area. Section 6.1.3 considers the feasibility of providing storage on this scale, highlighting the work of geological experts. Section 6.1.4 discusses experience with gas storage (including hydrogen storage) and its safety aspects, including the potential safety impact of leaks, emphasising the need for appropriate management and safety procedures.

6.1.1 The Role of Storage as a Stabiliser

The inherently variable nature of renewable sources such as wind and solar can be addressed using stored energy. This provides the flexibility needed to maintain a reliable supply by balancing fluctuations in generation and demand.

The fluctuations occur on different timescales. In a major report the Royal Society identifies three broad timescales and technologies relevant in each case:[44]

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[44] See page 6 in [47].

- Minutes to hours: conventional ('non-flow') batteries.
- Days to weeks: flow batteries in which chemical components dissolved in liquids are pumped through the system on separate sides of a membrane, advanced compressed air energy storage, Carnot batteries that store energy as heat, pumped thermal storage, pumped hydro, and liquid air energy storage.
- Months or years: synthetic fuels, ammonia, hydrogen.

In a separate presentation, the study's leader (Sir Chris Llewellyn-Smith FRS) identifies a 'benchmark model' which uses wind and solar generation along with hydrogen for long-term storage.[45] [46]

6.1.2 How Much Storage Is Needed?

This section discusses how much storage would be sufficient for the reasonable worst-case VRE Drought. Section 6.1.2.1 highlights results from the Royal Society report mentioned earlier. Section 6.1.2.2 presents results from a research group including Martin Kittel and others, based on historical weather and demand data for Europe. Section 6.1.2.3 summarises research by Oliver Ruhnau and Staffan Qvist, focused on Germany, which combines analysis of historical time-series data with a system cost-optimisation model.

6.1.2.1 Royal Society on Hydrogen Storage Requirement The Royal Society, the UK's national academy of sciences, analysed the implications of an electricity system for Great Britain in which demand is met by wind and solar generation supported by hydrogen storage. The study used 37 years of weather data and an hour by hour model of future electricity demand to assess how much energy storage would be required to maintain supply.

Assuming an annual electricity demand of 570 TWh in 2050,[47] they found that a system in which electricity is provided entirely by wind and solar, supported by hydrogen and small-scale rapid-response storage, would require a hydrogen storage capacity ranging from around **60 to 100 TWh**.[48] Based on a simple conversion, this is equivalent to **24.8 to 46.1 TWh** of generated electricity, which

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[45] See the fourth slide in [4].

[46] The presentation points out that large scale energy storage means storage that can meet a significant fraction of demand, i.e. covers small stores cycled rapidly as well as large stores cycled slowly. It notes that the benchmark would need to include a "small amount of something - batteries? - that can respond very fast''. On the topic of alternatives to hydrogen it mentions that ammonia could "do the whole job and be located anywhere'', but would be more expensive.

[47] As with all long-term projections, this depends on assumptions about the pace and pattern of electrification.

[48] See pages 5 and 6 of the Executive Summary in (main report) [47].

is **4.4 to 8.1%** of the assumed annual demand.[49] [50]

This long-duration storage would be used to balance supply and demand during prolonged renewable droughts, ensuring security of supply. The report states that "In GB, the leading candidate is storage of hydrogen in solution-mined salt caverns, for which GB has a more than adequate potential, albeit not well distributed."[51]

6.1.2.2 Kittel, Roth and Schill: Coping With the Dunkelflaute Kittel, Roth, and Schill extended the analysis described in Section 5.1 to examine the implications of *Dunkelflaute* events for a fully renewable European[52] electricity system. Using historical weather and demand data for Europe, they modelled how different levels of cross-border interconnection affect the need for long-duration electricity storage. They write:[53]

> Assuming policy-relevant interconnection in our model, we find 351 TWh long-duration storage capacity or **7%** of yearly electricity demand in the least-cost system that can cope with the most extreme event in Europe.

They also find that even with perfect interconnection, allowing unlimited cross-country exchange of electricity and hydrogen, around 159 TWh of long-duration storage (**3.2%** of annual European electricity demand) is the minimum long-duration storage capacity needed for a reliable, fully renewable European energy system.[54]

In system modelling, one potential role for nuclear generation is to reduce long-duration storage requirements. The authors find that low levels of nuclear power reduce the least-cost long-duration storage energy capacity across all investigated interconnection scenarios only to a minor extent. Their analysis also suggests that even in cases with high nuclear capacities, substantial long-duration storage investments remain optimal in the least-cost solution.[55]

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[49] The Royal Society report notes that the figure of 60 to 100 TWh is expressed in terms of the 'Lower Heating Value'. According to [46], the Lower and Higher Heating Values (LHV and HHV) for hydrogen are 33.3 kWh/kg and 39.4 kWh/kg respectively, so that the 100 TWh of hydrogen at LHV is equivalent to 118.3 TWh at HHV. The efficiency of production of electricity from hydrogen (using HHV and assuming gas turbine generation) is 35 to 39% (see Table 3 in [14]). Using the lower efficiency estimate for the lower end of the Royal Society range and the higher efficiency for the upper end of the Royal Society range, the 60 to 100 TWh (LHV) can be converted to a range of 24.8 to 46.1 TWh of generated electricity.

[50] The calculation of these percentages does not include transmission and distribution losses. The percentages would be slightly lower if these losses were included.

[51] See [47], page 5.

[52] EU27, the UK, Norway, Switzerland, and the Western Balkans.

[53] See the Abstract in [27], version 5, published on the arXiv open access repository (not peer reviewed). Bold text added.

[54] See page 10 in [27]. See also [28].

[55] See pages 14 and 15 in [27].

6.1.2.3 Ruhnau and Qvist: Storage Requirements in a 100 Percent Renewable Electricity System

Oliver Ruhnau and Staffan Qvist analysed thirty-five years of hourly weather and demand data to determine how extreme and recurrent low-renewable periods influence storage requirements in a 100% renewable electricity system.[56] Their cost-optimisation model for Germany[57] incorporates wind and solar generation, short-term battery storage and long-term hydrogen storage, allowing for electrolysis and associated reconversion losses. They found that the maximum energy deficit occurred over a period of nine weeks, and that the period defining storage sizing, once charging and efficiency losses were included, was around **twelve weeks**. The cost optimal configuration required about **36 TWh** of electricity storage, equivalent to roughly **7%** of annual demand,[58] primarily provided by hydrogen stored in salt caverns.

6.1.2.4 DESNZ on Hydrogen Storage

The following is from parliamentary evidence submitted by DESNZ to the Energy Security and Net Zero Committee in September 2023:[59]

> In the 2023 Future Energy Scenarios (FES) report, National Grid ESO estimates 2030 hydrogen storage requirements ranging from 2-4TWh. This is the first step in a steep curve in the UK's hydrogen storage needs. FES estimates suggest we may need between 12 and 56TWh of hydrogen storage by 2050 to reach net zero. This remains subject to uncertainty and is likely to change substantially depending on future policy decisions on hydrogen production and demand. Literature is consistent in indicating an increased need for hydrogen storage as the hydrogen economy grows.

The FES hydrogen storage range (**12 to 56 TWh** by 2050) is of the same order of magnitude, although lower than, the Royal Society's estimate of 60 to 100 TWh (see Section 6.1.2.1).[60] One reason for the difference may be that the Royal Society's estimate assumes power is generated entirely from wind and solar, whereas the Future Energy Scenarios do not.

6.1.2.5 Ballpark Hydrogen Storage Requirement for GB

The above sections show estimates from three separate research groups of the level of storage needed for a 100% renewable energy system. The Kittel group estimates around 7% of annual demand. Ruhnau and Qvist also find a value of around 7%. The Royal Society estimates 60 to 100 TWh, which is 4.4 to 8.1% of annual demand.[61] Some divergence is always to be expected between different estimates. In addition, there are differences in what is being estimated. For example:

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[56] See the Abstract in [43].

[57] See page 3 and Appendix B in [43].

[58] See the Abstract in [43].

[59] See page 4 in [11].

[60] The FES document does not specify whether these figures are expressed on the same Lower Heating Value (LHV) basis as the Royal Society's estimates, which may affect direct comparability.

[61] See footnotes in Section 6.1.2.1 for calculation of these percentages from the Royal Society's storage requirement figures.

- The geographical areas covered are different
- The Kittel group includes a level of interconnection, whereas the Royal Society report does not take account of interconnectors[62]

For the purposes of this briefing, the Royal Society range of **60 to 100 TWh** (equivalent to **4.4 to 8.1%** of annual demand) is adopted as an indicative estimate of the level of hydrogen storage that will be required in 2050. As noted by the Royal Society, this is expressed as the thermal energy content of the stored hydrogen in terms of the Lower Heating Value.

6.1.3 Can Enough Hydrogen Be Stored?

This section discusses the question of whether the level of hydrogen storage described in Section 6.1.2.5 is feasible.

6.1.3.1 Williams et al. on Potential Hydrogen Storage Capacity In a 2022 study[63] Williams et al. assessed the geological potential for large-scale hydrogen storage in onshore UK salt caverns, focusing on bedded halite[64] formations. They estimate that the upper bound potential capacity for hydrogen storage onshore in the UK is **2150 TWh**.[65]

The report's authors make clear throughout the report that the estimate is *theoretical*. They also identify a number of limitations of the study. For example, a significant proportion of the estimated storage capacity is located in regions where there is little information on the suitability of the halite for purposes of salt cavern development. However, they conclude that:[66]

> Despite these limitations, the estimated storage capacities suggest that the available resource is sufficient to enable significant hydrogen storage in addition to further [Compressed Air Energy Storage] or natural gas storage caverns.

6.1.3.2 Royal Society on Potential Hydrogen Storage Capacity The Royal Society storage report mentioned in Section 6.1.2.1 references the Williams et al. study.[67] Citing this work, it notes that:

> The potential capacity in East Yorkshire alone is far more than required to provide the ~ 100 TWh_{LHV} of hydrogen storage that would be needed to support GB's electricity system in the case of hydrogen storage only.

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[62] See page 7 in [47].

[63] See [54].

[64] Rock salt.

[65] See the Abstract in the report [54]. The report makes clear on page 9 that storage capacity figures are based on Lower Heating Value.

[66] See page 17 of the report [54].

[67] See page 39 in [47].

6.1.3.3 Arup on Hydrogen Storage in the East Coast Cluster

Arup, a global engineering firm, in partnership with University of Edinburgh and supported by the British Geological Survey, has produced a report on hydrogen storage at locations along the North-East coast of England:[68]

- The report distinguished between *reserve potential*, *resource potential*, and *realisable potential*. Resource potential is a comprehensive theoretical storage amount, accounting for geological factors, and some social and environmental limitations. Realisable potential is the refinement (narrowing) of resource potential based on technical, social and economic viability. Reserve potential is the broadest category, with resource potential and realisable potential representing progressively more constrained subsets.[69]
- The report found that existing assumptions on resource capacity of salt caverns for hydrogen storage were many levels removed from the feasible workable storage volume i.e., the realisable potential. The report indicated that existing published work, including Williams et al., had appraised only the 'reserve potential' of salt cavern storage in the East Coast region.[70] Williams et al. had themselves made clear that their estimates were for *theoretical* hydrogen storage capacity.
- The Arup report concluded that as a result of rationalising the workable volume towards a "realisable potential" it had "reduced the previous best estimates of storage capacity by c.95%".[71]
- The report also says that the findings can be extrapolated to derive an approximation of the UK's total revised resource potential for salt cavern storage of approximately **35 TWh**. A higher figure of **68 TWh** is shown for a case in which caverns are more closely spaced.[72] [73]

6.1.3.4 Transforming Rough Storage

Hydrogen storage in caverns is recognised in UK Government policy as part of the transition to a low-carbon energy system. The UK Hydrogen Strategy sets out the role of hydrogen in providing system flexibility and supporting energy security, including through storage.[74]

This policy direction has since been developed further, with the government introducing a Hydrogen Storage Business Model to support investment in storage infrastructure.[75]

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[68] See [1].

[69] See Figure 13 in the report [1]. The figure shows a Venn-like diagram with realisable potential within resource potential, and resource potential within reserve potential.

[70] See the section *Research Outputs - Capacity Modelling in the East Coast Cluster - Executive Summary* in the report [1].

[71] See the first conclusion in the *Research Outputs - Capacity Modelling section in the East Coast Cluster* section in [1], which states that "assumptions around capacity of caverns are overstated".

[72] See Table 10 in the *Research Outputs - Capacity Modelling in the East Coast Cluster - Key Findings: Capacity* section in the report, along with *Appendix B - Geometrical Assessment: Cavern Fitting*.

[73] Arup make clear (in *Appendix B - Storage Capacity and Deliverability Calculations*) that their capacity figures are based on Lower Heating Value (LHV). This unit is also used by The Royal Society.

[74] See [6], page 10.

[75] See [7].

In parallel, industry is engaged in developing potential projects. For example, analysis presented by Centrica, drawing on work with the Energy Research Accelerator, suggests that the Rough gas storage facility could be transformed to provide around **16 TWh** of hydrogen storage capacity.[76]

Taken together, these strands of evidence in Sections 6.1.3.1, 6.1.2.1 and 6.1.3.3 indicate that hydrogen storage in caverns forms part of ongoing policy development and industrial activity.

6.1.3.5 Hydrogen Storage Capacity: Summary Although the theoretical potential hydrogen storage capacity of salt caverns is very large, practical considerations (e.g. technical, social and economic) are likely to substantially reduce this. Salt cavern storage should not be regarded as an unlimited resource.

However, although Arup's estimates of realisable salt cavern capacity (approximately 35 TWh / 68 TWh depending on cavern spacing) are far lower than the theoretical potential, their upper figure is broadly of the same order of magnitude as the Royal Society's 60 to 100 TWh of required system storage.

Centrica's analysis suggests that transforming the Rough facility could provide up to 16 TWh of additional hydrogen storage capacity, adding to the overall scale of storage.

Overall, these estimates suggest that while hydrogen storage alone may not fully meet the highest projected system requirements, the scale of feasible storage is of a similar order of magnitude and could meet a substantial proportion of long-duration storage needs, particularly at the lower end of the requirement range.

Delivering such a system would require substantial deployment of infrastructure, and this presents significant practical challenges.

Electricity system modelling does not rely on hydrogen storage in isolation; rather, combinations of storage, interconnection, renewable overbuild and demand-side flexibility determine overall system adequacy.

6.1.4 Hydrogen Storage: Experience and Safety

Hydrogen storage in salt caverns is an established technology with a long operational history. Its safety is best understood in the context of the broader experience of underground gas storage. Hydrogen has been stored in salt caverns in Teesside in the UK since 1972, and has also been stored over extended periods in salt caverns in the United States at three sites in Texas:[77]

- Clemens: since 1983
- Moss Bluff: since 2007
- Spindletop: since 2017

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[76] See [3], slide 10.

[77] See Table 3 in [33], and page 6 in [13].

In a review paper, Miocic et al. state that: “The experience from these operations in both bedded and domal salt highlights that hydrogen can be securely stored and recovered from salt caverns over many decades”.[78]

While the operational experience of hydrogen storage is positive, much of the evidence on safety risks comes from the wider experience of underground gas storage, particularly natural gas. Gas leaks and blowouts can have serious consequences. An extreme example occurred in 2001, when damage to a borehole casing at the Yaggy storage facility in Kansas led to natural gas escaping. The gas leak “caused several incidents over 14 km, including explosions at two different sites (town of Hutchinson and a mobile home park) about 3 km apart”.[79] The accident killed two residents and damaged several businesses.[80]

The incident at Hutchinson was the result of gas leakage over a period. There are also safety risks associated with blowouts. In research[81] partly funded by the European Union and published in 2022 in the peer reviewed journal ‘Energies', researchers modelled the consequences of a blowout in a salt cavern used to store hydrogen. They calculated distances at which lethal effects could occur in various scenarios. In the case of overpressure effects generated by an Unconfined Vapour Cloud Explosion (UVCE), lethal effects could occur at up to 246 metres.[82]

The Environment Agency report outlines monitoring and mitigation strategies to reduce the risks of storing hydrogen in salt caverns.[83] As deployment expands, it will be essential to ensure that robust safety procedures, monitoring systems and regulatory frameworks are in place and rigorously implemented from the outset.

6.2 Interconnectors

Interconnectors are high-voltage cables that connect the electricity systems of neighbouring countries.[84] They allow power to be transferred from areas with surplus generation to areas where it is needed, helping to balance overall supply and demand and minimise curtailment.[85]

Great Britain is connected to France, Belgium, Norway, Denmark, and the Netherlands. National Grid expects that by 2030, 90% of the energy imported through interconnectors will be from zero-carbon energy sources.[86]

Interconnection can reduce the long-duration storage needed to maintain security of supply during prolonged periods of low renewable output (see Section 6.1.2.2 for details of the modelling by Kittel, Roth and Schill).

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[78] See page 77 in [33].

[79] See page 17 in [44].

[80] See [22].

[81] See [9].

[82] See page 15 in [9].

[83] See page 30 in [44].

[84] See [35].

[85] Curtailment is the reduction of power output needed to maintain grid stability, for example when more power is available than the grid can accommodate.

[86] See [35].

6.3 Overbuild

In electricity systems with high shares of wind and solar generation, system balancing can be supported through renewable overbuild, whereby installed variable renewable capacity exceeds average electricity demand. During periods of favourable weather conditions, the resulting surplus electricity can be used to charge storage systems, produce hydrogen or increase exports through interconnectors. Where this is not possible, it is curtailed.[87]

Increasing renewable generation capacity relative to average demand reduces the depth and frequency of energy deficits during typical periods of low wind and solar output, and thereby reduces the amount of long-duration storage required. Modelling of high-renewables systems shows that additional wind and solar capacity reduces residual demand that would otherwise require long-duration storage discharge, illustrating a trade-off between renewable overbuild and storage. However, prolonged periods of low renewable output can still produce cumulative shortfalls. As a result, while overbuild can substantially reduce storage requirements, significant long-duration storage is still likely to be necessary, including in cases with high nuclear capacities.[88]

7 SMR Costs

The economic case for Small Modular Reactors (SMRs) is central to the question of whether they should play a significant role in the UK's future electricity system. Proponents argue that modular construction, standardisation and series production could reduce costs compared to conventional nuclear power (see Section 4.1). However, as SMRs are not yet deployed at scale, their costs remain uncertain and must be assessed using a combination of industry estimates, historical evidence, and independent analysis.

This section reviews available evidence on SMR costs, focusing on Levelised Cost of Electricity (LCOE) estimates, real-world project experience, and findings from academic and policy studies.[89]

7.1 Rolls-Royce SMR Estimate

In November 2021 Rolls-Royce established an SMR business.[90] The following year in a presentation to the Foundation for Science & Technology, Rolls-Royce indicated an LCOE range of £35 to £50 per MWh.[91] [92]

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[87] See footnote in Section 6.2.

[88] See for example page 17 in [27].

[89] The Levelised Cost of Electricity (LCOE) is a standard metric used to compare the cost of electricity generation across different technologies, expressed in £/MWh.

[90] See [41].

[91] See page 4 in [42].

[92] Rolls Royce added the following note: "2021 economics, 2 unit plant, range dependent on financing mechanism".

More recent media reporting indicates that Rolls-Royce is aiming for an LCOE below £70/MWh,[93] although this has not been confirmed in a primary source from the UK Government or Rolls-Royce in the materials reviewed for this briefing. This is higher than in the 2022 presentation, although differences in assumptions may mean the figures are not directly comparable.

Section 7.7 includes written evidence on SMR costs given to Parliament's Energy Security and Net Zero Committee.

7.2 No Published UK Government LCOE Estimates for SMRs

The UK Government periodically publishes estimates of LCOE for various technologies. The latest version (Electricity Generation Costs 2025) was published in early 2026.[94] However it does not include LCOE estimates for SMRs. The report explains that the SMR Programme is in the early stages of development and cost estimates are expected to mature.[95]

7.3 NuScale Cost Escalation

The **NuScale** project in the United States was cancelled in 2023 after the projected electricity price rose from an estimated $58/MWh to $89/MWh (with an even earlier estimate of $55/MWh), which contributed to the project’s cancellation after participating utilities withdrew support.[96]

The **Institute for Energy Economics and Financial Analysis** (IEEFA)[97] noted that “Remarkably, the new $89/MWh price of power would be much higher if it were not for more than $4 billion in subsidies NuScale and UAMPS expect to get from U.S. taxpayers through a $1.4 billion contribution from the Department of Energy and the estimated $30/MWh subsidy in the Inflation Reduction Act (IRA).” [98]

7.4 IEEFA: SMRs Still Too Expensive, Too Slow and Too Risky

In 2024 the IEEFA published a report on SMRs which concluded that “Small modular reactors still look to be too expensive, too slow to build, and too risky to play a significant role in transitioning from fossil fuels in the coming 10–15 years.”[99]

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[93] See [38].

[94] See [12].

[95] See page 28 in [12].

[96] See [32] and [21].

[97] The IEEFA is a United States-based nonprofit organization that promotes the transition to cleaner energy. Its reports are used by many news organisations. See [53].

[98] See [21].

[99] See page 3 in [10].

7.5 Kim and Macfarlane on SMR Costs

A 2026 paper[100] by **Philseo Kim and Allison Macfarlane**[101] in the peer reviewed journal 'Progress in Nuclear Energy' presents a comprehensive analysis and review of the levelised cost of electricity (LCOE) and nuclear waste generation of four distinct SMR types.

The paper's conclusions include the following:[102]

- SMRs are expected to have higher electricity costs than standard large light water reactors (LWRs).[103]
- Historical evidence suggests that expected cost reductions from learning effects, modular construction, and shorter build times may not materialise significantly.
- The authors note that their analysis focuses on the United States and that caution must be applied in extending their findings to other contexts. However, they indicate that deploying SMRs may "exacerbate financial risks" for both established nuclear countries, and countries new to nuclear power.

The authors state that:

> ...due to the uncertain development and commercialization timelines, as well as the diseconomies of scale associated with these SMR designs, this technology is unlikely to significantly impact the reduction of carbon emissions in the foreseeable decades. Moreover, new approaches to nuclear waste management and disposal will be imperative to commercialize non-LWR types. This makes SMRs less directly relevant to current climate change challenges.

Although the Rolls-Royce SMR is not one of the four designs analysed, the authors' wording does not indicate that other designs would avoid the financial risks they identify.

The paper goes on to suggest a strategic shift to "reduce the cost overruns of large LWRs while improving safety features".

7.6 Model-Based Analysis of SMR Costs

Kim and Macfarlane note that "many studies show the economics of SMRs will be much costlier than that of large LWRs"[104] and so will not be competitive or

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[100] See [26].

[101] Allison Macfarlane is Professor and Director of the School of Public Policy and Global Affairs within the Faculty of Arts at the University of British Columbia.

She previously served as Chair of the United States Nuclear Regulatory Commission. Most recently, she directed the Institute for International Science and Technology Policy at the George Washington University. She has also held a fellowship at the Wilson International Center for Scholars in Washington, DC, and was Fulbright Distinguished Chair in Applied Public Policy at Flinders University and Carnegie Mellon Adelaide in Australia. See [52] and [49].

[102] See page 12 in [26].

[103] Light water reactors are by far the most common type of nuclear reactor. See Table 1 in [30].

[104] See page 2 in [26].

profitable. They cite, among others, a model-based analysis by Björn Steigerwald et al. which evaluated various SMR concepts[105]. They concluded that:

- "None of the tested concepts is able to compete economically with existing renewable technologies, not even when taking their variability and necessary system integration costs into account."[106], and that
- "Based on a large-scale Monte Carlo analysis of potential net present values (NPVs) and levelized costs of electricity (LCOE), we find that SMR concepts do not seem to be an economic alternative to existing low-carbon technologies during our design lifetime simulation using the most favorable parameter values based on the literature. Even when using the overly optimistic manufacturer-advertised construction costs in the simulation, the majority of examined SMR concepts cannot deliver a positive NPV."[107]

7.7 Professor Stephen Thomas: Evidence to Parliamentary Committee

The following is from written evidence given to the Parliament's Energy Security and Net Zero Committee by Stephen Thomas, Emeritus Professor of Energy Policy, University of Greenwich:[108]

> The estimate of £2.2bn per [SMR] reactor or £4700 per kW of capacity seems implausibly low. The cost estimate for Sizewell C is equivalent to £12,000 per kW, two and a half times the Rolls Royce cost estimate. It is not surprising that Rolls Royce has not updated the 2021 estimate and this early estimate must be seen as a marketing device with no come-back to Rolls Royce when the estimate proves unrealistic. Nevertheless, to allocate public money equivalent to the total approximate estimated cost of one reactor just to get to a [Final Investment Decision] does seem extraordinary. The figure of £2.5bn seems high enough to suggest that no additional private money is expected to be involved or will be needed.

7.8 Overall Assessment of SMR Costs

Taken together, the available evidence suggests that the economic case for SMRs remains highly uncertain and, in many analyses, unfavourable.

Industry cost projections from Rolls-Royce indicate potentially competitive costs, but these are based on projected future deployments and have not yet been demonstrated in practice. By contrast, real-world experience—most notably the NuScale project—shows that costs can increase substantially during development, undermining economic viability.

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[105] See [45].

[106] See the Abstract in [45].

[107] See the Conclusion in [45].

[108] See Section 3 in [48] available at [39].

Analysis by IEEFA indicates that SMRs are likely to be costly and financially risky.

Kim and Macfarlane highlight the financial risks of SMRs and cite a model-based analysis which finds that “none of the tested concepts is able to compete economically with existing renewable technologies.”

This assessment of SMR costs is consistent with evidence submitted to the UK Parliament by Professor Stephen Thomas, who questions whether the cost estimates presented by Rolls-Royce for its SMR design are realistic.

More broadly, the absence of published, standardised figures reflects the early stage of SMR development and the limited availability of transparent cost data.

Cost-effectiveness must also be considered in the context of system requirements. As discussed in Sections 5 and 6, the principal challenge for a high-renewables electricity system is the provision of energy during extended periods of low renewable output. Technologies such as long-duration storage, interconnection and demand-side flexibility are specifically designed to address this challenge of variability. By contrast, SMRs are typically designed to provide continuous generation. This does not directly address the challenge of cumulative energy shortfalls over extended periods.

If SMRs were deployed primarily to provide backup during infrequent periods of low renewable generation, their utilisation would be low, potentially increasing the cost per unit of electricity generated.

Overall, current evidence does not demonstrate that SMRs provide a cost-competitive or low financial risk option for electricity generation in the near to medium term.

8 Conclusion

This briefing has examined whether Small Modular Reactors (SMRs) are needed to support the electricity system in Great Britain, with particular focus on maintaining security of supply during extended periods of low renewable generation. It has also examined the levelised costs of electricity from SMRs.

The key conclusions of this briefing, on both system need and cost, are as follows:

1. On the basis of current evidence, SMRs are **not required** to maintain security of electricity supply in Great Britain during extended periods of low renewable generation.
2. This **conclusion does not depend on certainty regarding the deployment of long-duration storage or other flexibility options**. While there is uncertainty regarding the scale and pace at which these can be deployed, available evidence does not demonstrate that SMRs are necessary to maintain security of supply in Great Britain during reasonable worst-case periods of low renewable output and high demand.
3. The central system challenge is **cumulative energy shortfall** over extended periods, with system requirements typically estimated at tens of

terawatt-hours (around **60–100 TWh** in Great Britain, equivalent to roughly **4.4–8.1%** of annual electricity demand).

4. Continuous **“baseload” generation**, including from SMRs, does not directly address this challenge, as the total energy required depends on the **cumulative shortfall** over the duration of the event.
5. If SMRs were deployed primarily to provide backup during extended periods of low renewable generation, they would operate at low utilisation for much of the time, increasing the cost per unit of electricity generated. By contrast, long-duration storage is designed both to **reduce curtailment by storing surplus energy** and to **supply energy during shortfalls**.
6. Evidence from electricity system modelling indicates that the challenge of cumulative energy shortfalls over extended periods can be addressed through a combination of **long-duration storage, renewable overbuild, interconnection and demand-side flexibility**.
7. Geological and engineering assessments indicate that **hydrogen storage at a scale of tens of terawatt-hours is feasible** in Great Britain and **could make a substantial contribution** to system requirements, although subject to technical, economic and deployment constraints.
8. The economic case for SMRs is **uncertain and, in many analyses, unfavourable**, with no demonstrated cost competitiveness relative to existing low-carbon technologies.

There are broader considerations that may affect policy decisions on SMRs, including safety, waste, energy system resilience, diversification, and economic factors such as jobs and growth. However, policy decisions should not be based on the argument that SMRs are needed to maintain security of supply during extended periods of low renewable generation.

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