Chapter 4. Critical enablers

In Chapter 2 we have identified some of the key technology-specific actions needed to reach clean power by 2030. Many challenges are common across different technologies, requiring holistic thinking about how they can be overcome. Our analysis and engagement have highlighted six cross-cutting enablers where action is needed:

Markets and investment: Various market arrangements and investment support schemes are in the process of, or will need, reform to reach clean power and operate the system efficiently. Decisions must provide stability and confidence to underpin the large amount of investment required, while supporting innovation and efficient operation of the system. An element of competition will help to keep costs down.

Planning, consenting and communities: Significant volumes of projects need to pass through the planning system to start construction on rapid timescales, while maintaining community consent which is vital to the mission. Given that construction for many of the required projects needs to begin in the next 6-24 months to be in place by 2030, upcoming planning reforms will need to streamline and speed up processes.

Connections reform: The connections queue must be formed of ready-to-connect projects that align with government's plan for clean power by 2030 and, once developed, the Strategic Spatial Energy Plan (SSEP) and future iterations. We have begun the process of connections reform and will develop the SSEP based on government's plan for clean power by 2030.

Supply chains and workforce: Acute supply chain and workforce challenges must be overcome across nearly all generation, storage and network projects. Policy certainty, visibility of the future market and swift funding decisions are needed to ensure developers can mobilise the supply chains and workforce needed. Over the medium term, greater strategic coordination can enable delivery while supporting the growth of domestic supply chains and a skilled workforce to meet the growing pipeline of projects.

Digitisation and innovation: Prioritised and coordinated action is needed across the sector to drive digitalisation and common governance is required for orchestration of a sector-wide digital and data plan. Work has started on a common data sharing infrastructure for the sector, but this needs to be accelerated through policy and incentivisation of adoption. Accelerated AI adoption and transformative innovation need to be prioritised to align with government's plan for clean power by 2030.

NESO as a partner in delivering clean power: NESO will play a central role in delivering clean power. Putting the government's plan for clean power by 2030 into operation will require coordinated action across the energy industry and its institutions, with NESO working as a partner with Government, Ofgem and key decision makers. This includes supporting Energy Code Reform, developing our implementation and engagement plans and reviewing our operations to ensure alignment with the plan.

This chapter sets out our high-level assessment of the challenges and opportunities in this space and the action that is needed to deliver. As highlighted above, close collaboration will be needed between UK, Scottish and Welsh governments, particularly in relation to planning and consenting.

4.1 Markets and investment

Where are we now?

Since privatisation in the early 1990s, the GB electricity market has facilitated competition, investment, and innovation, with significant benefits to consumers. The Contracts for Difference (CfD) scheme, introduced in 2012, helped drive down the cost of offshore wind and propelled the UK to the forefront of the clean power transition, supporting over 19 GW of offshore wind capacity by 2024. Alongside this, the Capacity Market has supported investment into new build of capacity, providing security of supply as coal was phased out.

However, the market arrangements that underpin our electricity system were designed for the former age of large, centralised dispatchable generators. As the system evolves, we are observing ever higher constraint costs and inefficient outcomes across the market. In 2022, the government launched the Review of Electricity Market Arrangements (REMA) to ensure that the GB electricity market is fit for the future. NESO is part of the REMA Programme Board.

Where do we need to get to?

To deliver clean power by 2030, GB will need to mobilise and deploy an average of over £40 billion of investment annually in energy infrastructure over the next five years.

Having effective market arrangements and investment support mechanisms in place will be essential to unlocking this investment, while ensuring consumer value, low carbon operations and security of supply. This must be achieved in the context of a system which:

1. Encompasses assets which are increasingly geographically dispersed, connected at distribution level, automated and responsive to changes.
2. Contains significant volumes of assets supported by increasingly diverse investment support mechanisms, with different incentives that will impact on their operational decisions in different ways.
3. Is increasingly interconnected to continental markets.

A range of initiatives are already underway to deliver this, including: the new cap and floor for long duration storage that is needed to unlock investment; reforms to the balancing market to enable new types of flexibility and demand side response to compete on a level playing field; and the REMA programme, which is considering how the existing CfD, Capacity Market and wholesale market arrangements need to evolve to recognise the changing nature of the system.

What are the challenges and opportunities?

In developing this report, we engaged closely with investors, developers, industry bodies and academics. There was near unanimous agreement on the scale of the challenge and the importance of clear stable market signals and investment support needed to mobilise the capital required to deliver the significant increase required.

There were a variety of views on the benefits of fundamental reform to the wholesale market arrangements to move away from the national pricing model to a more granular level, e.g. through zonal pricing. Alongside this, many market participants considered that the introduction of significant reforms to market arrangements could create sufficient uncertainty to risk delivery of the technology pathways identified in this report, at best increasing the required cost of capital to deliver the investment and, at worst, stymieing the investment completely. Others suggested that there was already uncertainty around the future direction for the wholesale market, CfD and Capacity Market, and a swift decision on the future direction is needed.

The importance of supporting consumer and demand side flexibility enabled by digitisation was recognised as critical for delivering clean power, and some stakeholders have expressed that more granular wholesale pricing is critical for unlocking flexibility.

Actions needed to drive change

Market reform

There is currently uncertainty around the future of market arrangements and investment support which could act as a barrier to delivering clean power by 2030. Investors and market participants are likely to need clarity on these future arrangements at a suitable level to enable investment decisions in the very near future. The upcoming cap and floor decisions, design of future CfD allocation rounds, ongoing reforms to the balancing mechanism and REMA programme are all opportunities to provide such clarity.

It will be important to provide stability and confidence in the future direction of market reform to underpin the large amount of investment required, while supporting innovation and efficient decisions on the way to, and on reaching, a clean power system.

On the specific issue of wholesale market arrangements, ESO's Net Zero Market Reform[1] work has highlighted where current market design is driving inefficient outcomes and higher costs for consumers. As we move towards a clean power system, it is increasingly clear that the current arrangements will not be fit for purpose as they do not provide the right information or incentives to market participants, leading to inefficient outcomes. A locational pricing model is likely the best way of mitigating the risks and maximising the opportunities of a decarbonised power sector. Any such change would need to be accompanied by clarity on changes to other investment support elements of the market (e.g. CfDs, Capacity Market etc.) and any transition arrangements. There is a critical need for clarity on this via the REMA programme.

Unlocking flexibility

Reforms to the market supported by digitalisation and innovation are also required to unlock consumer and demand flexibility. Our clean power pathways will require demand side flexibility at peak to grow by 4 - 5 times current levels. Achieving this will need to build on the progress and innovation seen in this sector in recent years. Collaborative action across the Government, NESO, Ofgem, Elexon as the market facilitator and industry is needed to ensure demand side flexibility is considered on the same level as areas such as network build and new technology investment.

Market participants highlighted the following necessary actions and areas of focus:

- **Putting in place underpinning digital infrastructure, product policies, standards and governance, alongside access to high quality data.** Smart meters, smart appliances and EVs with vehicle-to-grid (V2G) capability will provide the foundations of this system, ensuring that consumers can participate in and benefit from demand side flexibility. To achieve this, higher levels of smart meter penetration will be needed. Consumer and industry concerns about data and privacy must be addressed. Smart appliance policies and standards must be accelerated.
- **Creating routes to markets for flexibility and facilitating continued innovation.** In parallel, market design needs to ensure flexibility is sufficiently rewarded, with markets that are open and accessible. Demand side flexibility can help operate the electricity system. As such, we need to ensure that demand side flexibility can compete in markets where it can meet system operability needs.[2] Wholesale market reform is key to ensuring that market participants with the ability to shift their demand are incentivised to act flexibly: delivering the market-wide half-hourly settlement (MHHS) programme will be critical to unlocking this. Market coordination is also required across NESO, DNOs and wider flexibility markets to ensure that flexibility providers and aggregators can stack revenue and operate seamlessly.

1 Net Zero Market Reform

2 NESO will be publishing its 'Routes to Market Review for Demand Side Flexibility' report in the coming months which will expand on its commitments.

- **Ensuring consumers can reap the benefits with consideration of the distributional effects.** For consumers to ultimately benefit from demand side flexibility, they need to have the ability to respond to a price signal. This includes industrial and commercial Demand Side Response (DSR), whereby price signals need to reflect the system value and incentivise a shift from business-as-usual activity. Our pathways assume that innovative tariffs or other retail offerings are the default from 2028, but innovation in the market to provide similar services and increased choice for consumers could deliver greater volumes of flexibility. Changes to retail regulations may also be needed to manage any complexity brought by multiple appliances and technologies and fairly pass through the value to consumers' bills. Changes must be mindful of potential negative impacts on vulnerable and low-income consumers.

Significant growth in distributed flexibility will be fundamental in delivering a decarbonised electricity system and ensuring clean and affordable energy for all. To deliver this goal at the pace required to deliver clean power, greater alignment is needed between local and national markets and services to make this a reality. We look forward to working collaboratively with Elexon as the Market Facilitator, alongside Government, Ofgem & DNO's to develop more coordinated market opportunities for all providers of flexibility in the future.

Supporting investment

Our analysis in Chapter 5 sets out the major investment programme needed for a clean power system. These are dominated by renewable investments, followed by network investments, storage and other low carbon capacity. Alongside markets, well targeted and carefully designed investment support mechanisms will play a pivotal role in mobilising the private capital needed to reach clean power by 2030:

- **Low carbon power:** Renewable generation will be the backbone of the new system and needs to be deployed at least twice as fast as ever before. An element of competition should help keep costs down, but this needs to be balanced with the needs of a clean power system in 2030 and beyond. Finding ways to maximise visibility of the future market will support the required investment at least cost, including in the supply chain. A clear strategy for contracting renewables over the coming three years could provide maximum certainty for investors and the supply chain.
- **Supply side flexibility:** With relatively long build times, rapid decisions are needed on the cap and floor mechanisms for interconnectors and the long duration storage to unlock investment in the capacities required to deliver clean power.
- **Low carbon dispatchable capacity:** Clear pathways are needed for the deployment of first-of-a-kind (FOAK) technologies such as power CCS and hydrogen to power. For these technologies to deploy successfully, investment support for the necessary infrastructure (including transport and storage) and power generation business models will need to be in place to enable construction to start swiftly.
- **Networks investment:** Quick and consistent decisions are needed to unlock investment in vital network projects for 2030. Clarity is also needed on the policy and regulatory funding mechanisms and incentives for these projects, providing certainty of revenues and target dates across transmission and distribution sectors.

Supporting the continuation of unabated gas for security of supply

Our full considerations on unabated gas are set out in Annex 1. Gas generation will play a vital role in ensuring security of supply in 2030 and beyond. As gas generators will run at significantly lower load factors than today, we would expect them to become more dependent on revenue support from the Capacity Market or an alternative, such as a strategic reserve mechanism. The future of the Capacity Market and/or the introduction of a strategic reserve should be considered alongside wider market reforms through the REMA programme. As part of this, it will be important for the Government, NESO and Ofgem to constantly monitor the effectiveness and value for money of any arrangements, ensuring there is a plan in place to manage the impact of plant exits from the market on capacity adequacy. A decision is needed in time for the publication of the Capacity Market Parameters in July 2025.

NESO's voltage, stability, reserve and response markets

Annex 3 sets out our plans for adapting our core operability markets.

The 'Voltage' and 'Stability' sections of Operability Annex 3 outline future requirements for reactive power and stability services respectively. The recently developed long-term markets for both voltage and stability are available to meet our firm long-term requirements. The mid-term markets will also be available to meet shorter-term closer to real time requirements based on their current implementation status. Both markets will enable service provision through clean generation sources.

The 2030 frequency requirements detailed in the Operability section of this report will be met through NESO's response and reserve services. We have already designed the services we need to secure and operate a clean power system and such services will continue to be procured through a transparent and competitive auction process. Details can be found in the Markets Roadmap. As we move to more intermittent and less synchronous generation, the volume required from these services will likely increase. We will continue to review our requirements and enhance our services as necessary to meet the changing needs of the system.

4.2 Planning, consenting and communities

Where are we now?

Most of the energy infrastructure required to deliver clean power by 2030 is already in the development cycle. However, an independent report[3] commissioned for ESO in spring 2024 suggested that only 6 GW of onshore wind, 15 GW of offshore wind, 10 GW of solar and 10 GW of battery storage had obtained the relevant planning consent as of April 2024. Engagement with the TOs has shown that of the network projects required, 16 projects are currently awaiting planning and consenting decisions and 28 projects are at an earlier stage of development, prior to planning and consenting.

The research also suggests it currently takes, on average, 21 months to issue a planning decision for offshore wind in England and 15 months in Scotland. For onshore wind, it takes 15 months to receive a decision after applying to local planners and 35 months at the national level.

Communities will be at the heart of the delivery of net zero in Great Britain and the planning process is a key route through which they can have their say on plans for energy infrastructure in their area and raise concerns about the impact on their local environment.

Where do we need to get to?

Unprecedented volumes of clean energy infrastructure projects are needed to meet the Government's energy ambitions. Construction for many of these projects needs to begin in the next 6-24 months. Considering the time it has taken for significant energy projects to get planning consent in recent years, those timelines look challenging. Engaging and bringing along local communities that host energy infrastructure will remain key, both in enabling delivery and maintaining widespread public support for the clean power mission.

What are the challenges and opportunities?

We established a Societal Delivery Forum to understand the views of organisations representing local communities, the natural environment, land use specialists and the planning sector to inform our advice to the Government.

Participants highlighted several consistent challenges around societal and consumer acceptance, engaging local communities, resourcing of local planning authorities and statutory consultees, ensuring the right data is available to make decisions and the experience of consenting major energy projects. Opportunities for improvement through greater coordination between developers in the building and development of infrastructure, better engagement with statutory consultees and the Government's upcoming planning reforms were put forward.

The government has begun to take steps in the planning system to enable clean power – including the removal of the moratorium on onshore wind in England, and the recently announced joint UK and Scottish Government consultation on changes to the planning regime to support energy infrastructure.

Actions needed to drive change

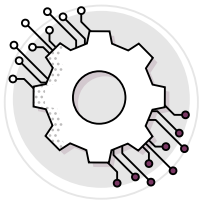
The planning and consenting processes for energy infrastructure needs to be shorter to ensure delivery by 2030. The current approach which can take in excess of two years for approval on some types of projects, and longer in some cases, poses a significant delivery risk. To have a good chance of being built in time. The next 6-24 months are critical for projects to clear planning and move into construction. Expediting the planning process, while maintaining community consent will be vital to delivering on the clean power mission, and maintaining momentum for projects needed after 2030.

3 Research commissioned by ESO and carried out by Regen in July and August 2024. This is based on connection queue and planning information from April 2024 and so figures may have changed since then. It should also be noted that, due to data availability this does not reflect all projects in the planning cycle. Research results are presented for illustrative purposes only.

Improved coordination and transparency between developers and statutory consultees and ensuring there is sufficient capacity in the system will help enable acceleration. As will cooperation between all levels of government: national, devolved and local.

Community consent and maintaining public support is vital to the delivery of net zero in Great Britain. Those asked to host energy infrastructure should continue to be effectively engaged throughout the development process, even as it accelerates, and should feel tangible benefit from the critical role their areas play in building a clean, secure and low-cost electricity system.

4.3 Connections reform



Where are we now?

The connections queue currently comprises a greater volume of projects than required for 2030 across our pathways. However: a) not all of those projects may be 'ready' or committed to progressing; and b) there may be projects with connection dates after 2030 that could usefully contribute to the 2030 system, for example with lower delivery barriers or lower costs. Some progress has been made over the last 12 months in addressing connections issues at both transmission and distribution levels. In addition, plans have been set out by NESO to move away from the concept of a 'first come, first served' approach to connections queue management, to one which will see us connect demand and the required generation in a timely and more strategic process.

Building on the plans set out by ESO earlier this year, further work is in train across NESO, DESNZ, Ofgem and industry to ensure that, in support of a clean power system, connections queue processes bring forward the right technology in the right location and when it is needed.

Further actions beyond queue reform have been set out in the joint Government and Ofgem Connections Action Plan and the previous Government's Transmission Acceleration Action Plan, with a focus on ensuring that projects with a connection offer can then be connected and energised in a timely and efficient manner.

Where do we need to get to?

To get to a clean power system by 2030, the generation and technology mix that is set out across our pathways needs to connect to the electricity system in the next six years. We need a reformed connections process that reflects the needs of the clean power mission.

What are the challenges and opportunities?

Delivering net zero will require connecting new capacity and new types of customers more quickly than at any time since the current process was established. In addition to a 'fit for purpose' process for issuing connection offers and managing the connections queue, consideration must be given to the implications of the volume of connections, as well as significant shifts in the nature of connecting customers and their needs.

The high number of connections and the associated enabling network and substation works will require a coordinated and whole system approach to considering the network planning and delivery implications at both transmission and distribution levels. More collaboration, coordination and understanding of the interactions across the whole network are required.

Given the dynamic nature of the path to clean power in 2030, action is also required to ensure that the codes and methodologies governing the approach to managing connections provide clarity and certainty for developers, while being appropriately flexible to the changing needs of the system and future strategic plans for the period beyond 2030.

Consideration should also be given to whether the open codes governance process is, in itself, sufficiently flexible and adaptable to be effective in enabling the required pace and scale of reform.

Actions to drive change

Delivering a clean power system by 2030 requires a connections process which is aligned to government's plan for clean power by 2030.

As such we have also published, for consultation, details on how we propose to align the reformed connections process with strategic energy plans (initially government's plan for clean power by 2030, and then the first Strategic Spatial Energy Plan, SSEP). The scope of our connections reform proposals includes all projects connecting at transmission level, and any generation and storage projects connecting to the distribution networks that impact upon the transmission system. Consideration will also be given to the treatment of demand connections with regards to the queue and the interaction with the generation connections.

We set out in that consultation our view that the connections process and reformed connections queue should align with the technology, capacity and regional requirements for clean power as set out within Government's clean power plan (at both a transmission and distribution level), and then with subsequent strategic plans like the SSEP. The Government's clean power plan can help ensure the efficiency of the new connections queue and that 'ready'[4] and strategically aligned projects are connected efficiently to achieve clean power. This could be achieved through including capacity requirements for different technologies connecting at transmission and distribution networks, and that the pathways within the clean power plan clearly separate the proposed mix of transmission and distribution technologies, by capacity and location.

However, the transition to net zero emissions across the economy by 2050 does not stop with achieving clean power in 2030. Projects needed beyond 2030 are in development now and require clarity on their connection agreements too. This could be achieved through the government's clean power plan providing clarity on the pathway upon which connection offers can be based for the period 2031-35.[5] Including this 2031-35 pathway in the clean power plan will provide a 10-year time planning horizon for the reformed connections queue, thereby providing longer-term investment clarity that will help ensure an efficient transition towards net zero targets beyond 2030 (including the Sixth Carbon Budget targets), while also facilitating an efficient transition to the first SSEP.

We set out more detail on the connections reform enablers in Annex 2.

Looking beyond 2030, we will publish our first SSEP by the end of 2026. It will build on the government's action plan for clean power by 2030 to support the energy transition efficiently and securely, provide greater clarity on the nation's future energy requirements, and achieve net zero ambitions in line with government targets. Once the first SSEP is in place we will then use the SSEP to prioritise future connection offers aligned to the SSEP.

4 By 'ready' we mean projects that meet the new criteria we propose to apply to the current connections queue and future applications, that would require projects to demonstrate that they have secured appropriate land rights in order to receive a confirmed connection offer and a place in the reformed connections queue.

5 We are proposing that the 2031 to 2035 pathway for connection offers should be based on the Holistic Transition scenario within our Future Energy Scenarios 2024 (FES24) to 2035.

4.4 Supply chain and workforce

Where are we now?

The global race to decarbonise is straining international supply chains and compounding skills shortages. Notably, the offshore wind sector, as well as the broader electrical component supply chain, face pronounced challenges. Shortages of construction workers and engineers across Great Britian further exacerbate project construction delays and increasing costs.

Where do we need to get to?

The Government has recognised the transition to a decarbonised energy system as an opportunity to create jobs and grow the economy, delivering wider benefits to Great Britain. However, those benefits can only be fully realised if action is taken to unblock the differing supply chain and workforce challenges for projects on the critical path to 2030.

What are the challenges and opportunities?

The supply chain and workforce challenges associated with the transition to a net zero energy system are already well described and understood.[6]

Our analysis has identified supply chain and workforce challenges across almost all technologies required to reach clean power by 2030. For example, delays in sourcing electrical components such as cabling, transformers and switchgear are hampering the delivery of network infrastructure, while the Offshore Wind Industry Council suggests more than 100,000 skilled roles are required to deliver 50 GW of offshore wind (up from 32,000).[7]

Stakeholders engaged as part of our Clean Power 2030 activity have reinforced that there are significant obstacles to accessing Original Equipment Manufacturer (OEM) supply chains, parts and materials coupled with limited domestic manufacturing and ports capacity. Securing engineers, digital specialists and construction workers is increasingly difficult due to the high demand for these skills across the economy, both domestically and globally.

Long-term policy certainty and greater collaboration were recognised as having potential to alleviate these challenges. Stakeholders also acknowledged the need to balance delivery at pace, which may depend on "buying in" parts and skills in the near term and developing local capacity which may deliver longer-term benefits to the British economy.

Actions to drive change

Our analysis and engagement with industry have identified three areas where action could help to alleviate supply chain and workforce pressures:

- **Providing consistent, long-term policy certainty and line of sight to funding to unlock investment.** In the near term, making swift investment decisions (e.g. on networks, the cap and floor or FOAK funding) can enable developers to sign supply chain contracts. Over the longer term, government's plan for clean power by 2030, SSEP and future carbon budget strategies can send the long-term signals for supply chain companies and workers to invest or train in Great Britain.
- **Exploring the opportunities for a more strategic approach to procurement and manufacturing.** This includes considering how the supply chain needs from the whole sector could be articulated centrally to investors and exploring further opportunities for central purchasing where this provides greater value for money and assurance over delivery. Finally, there may be opportunities to build strategic domestic supply chains where conditions in Great Britain mean this makes sense.

6 Green Jobs Taskforce (2021); Mission Zero - Independent Review of Net Zero (2023)
7 Crown Estate (April 2024)

- **Exploring a broad range of options to address specific skills gaps.** In the short term, this could include targeted options to address domestic workforce shortages in key sectors, such as offshore wind. A sector skills plan could help provide the trained workers the sector needs.

4.5 Digitalisation and innovation

Where are we now?

In recent years, advancement in technology and innovative practices have enabled progress towards digitalisation of the industry. Some industry participants have introduced a digital-native approach to traditional methods and the market has been adopting digitalisation at an increasing pace, although it remains nascent compared other industries. NESO too has enhanced its interaction with the wider industry through digitalisation, such as the modernised balancing mechanism, better open data practices and greater transparency via connections platforms. However, most if not all these efforts remain siloed within organisational or sector-specific priorities rather than whole system objectives.

The Energy Digitalisation Taskforce's call for a unified digital ecosystem has resulted in further progress; for example, DESNZ's Automatic Asset Registration Programme and the NESO-led pilot of data-sharing infrastructure (DSI), both of which are expected to enable rapid digitalisation opportunities by providing foundational digital capabilities.

Broader, sector wide innovation initiatives such as SGN's Intelligent Gas Grid and NESO's Crowdflex (demand flexibility) highlight some of the great work that is being done that can support a better understanding of a future digital grid, a fundamental step towards a clean power system.

Where do we need to get to?

To deliver clean power, we need a sector-wide strategic digitalisation plan that is actionable and delivered. This needs clarity of required outcomes, prioritisation of digital solutions and an aggressive delivery programme backed by policy and regulation to drive adoption and investment where it's most urgently needed.

While robust, safe and prompt data sharing is crucial, we must also focus on platforms and technologies that accelerate progress. One essential technology area is a strategic shift towards responsible AI for better decision making in energy planning, supply chain optimisation, market and domestic flexibility and forecasting. At NESO, we are launching a portfolio of transformative AI initiatives under two programmes (Volta and Vanguard) that focus on strategic energy planning, connections, control room operations and forecasting accuracy.

Our policy and regulatory systems must be able to realise the benefits of digitalisation by defining and revising rules and regulations where appropriate. For example, initiatives like the market-wide half-hourly settlement (MHHS) must be realised promptly to support the flexibility the system needs.

Further, innovation must target transformative change that the sector can mobilise behind, such as grid enhancing technologies and demand side signals. This should be supported by a unified approach to scale innovation through conducive policies, regulations and targeted support.

What are the challenges and opportunities?

The rapid global introduction of new technologies, both in the hardware cleantech space as well as in the digital realm (i.e. AI Large Language Models (LLMs)) presents both challenges and opportunities. Timely action is critical.

Current digitalisation and innovation efforts are often siloed and lack supportive adoption policies and pathways to operational use, making it difficult to scale ideas. Additionally, the sector faces challenges with data quality, availability and sharing, which restrict opportunities to develop and test new solutions.

To meet the clean power target, our analysis raised four key outcomes innovation is required to realise. These include better utilising existing grid capacity (for example, with super conductors), new flexibility sources and reducing overall demand through energy efficiency, as well as using AI to enable the above. It is vital that industry comes together and identifies, then prioritises the key outcomes in a coordinated way that enables market-driven innovative solutions to emerge.

Maximising commercial opportunities for digital products and services could further support wider industry digitalisation, as well as foster shared capabilities and products from innovative incumbents and start-ups.

Actions to drive change

Our engagement with industry experts and leaders has led us to identify five core actions that are crucial for transformative change:

- **Unified digitalisation plan:** The sector develops and delivers on a system-wide digitalisation strategy aligned with government's plan for clean power by 2030, ensuring cohesive progress and prioritisation.
- **Enhanced data sharing:** Focus on robust and scalable data-sharing infrastructure, supported by policies and investments that encourage widespread adoption across the sector.
- **Responsible AI integration:** Develop and implement responsible AI to revolutionise decision making in energy planning, supply chain optimisation, market flexibility, grid management and forecasting. This requires the support of clear policies, technology partnerships and investments.
- **Transformative innovation initiatives:** Prioritise transformational and scalable innovation projects that can significantly accelerate progress to clean power and beyond 2030. Support these initiatives with heightened financial, policy, regulatory and industry backing to ensure broad adoption.
- **Maximise commercial opportunities for digital products and innovation:** Identify and remove barriers to create a dynamic marketplace for digital products and services, leveraging open data sharing and transparency to foster innovation from all. For example, sharing of data on open data portals by NESO and other organisations has already led to AI and technology-based products to be available in the market to solve industry challenges.

These actions are imperative steps towards creating a resilient, innovative and digitally advanced energy sector.

4.6 NESO as a partner in delivering clean power

Where are we now?

NESO was established on 1 October 2024 as a publicly owned system operator, with new responsibilities in strategically planning the whole energy system and giving advice to government and Ofgem. The Government has also committed to establishing Great British Energy as a publicly owned clean energy company and the Clean Power 2030 Unit, tasked with delivering clean power by 2030.

Where do we need to get to?

Delivering clean power will require clarity on roles and responsibilities across key organisations in the energy sector. We need to ensure that our strategy and operations are aligned with government's plan for clean power by 2030 and work effectively with new institutions within the industry to drive forward delivery to 2030.

Where are the challenges and opportunities?

The whole energy system is interested in understanding the implications of a clean power plan and what this means for consumers, communities, networks and industry codes. Stakeholders are also seeking certainty on what organisations will need to do and how they will interact in delivering clean power. Many stakeholders want to see a coordinated delivery approach and governance arrangements that clarify the different roles and responsibilities for clean power.

NESO can act as an enabler for this greater collaboration and coordination and support the Government, Ofgem and the wider industry in providing clarity and establishing the frameworks for success.

Actions to drive change

To deliver on the clean power plan effectively and in a coordinated manner, we as NESO will:

- Work with the Clean Power 2030 Unit and Ofgem to agree NESO's role in delivering the clean power mission and how progress will be monitored, ensuring this is communicated to industry.
- Following the publication of government's plan for clean power by 2030, rapidly develop our implementation plan, setting out how we will play our part in delivering the clean power mission, including reviewing our own operations, processes, systems and investment plans across all areas to reflect on the impacts to ensure alignment with government's plan.
- Put in place an ongoing plan of engagement with industry and key stakeholders to ensure an ongoing conversation about NESO's role in the delivery of the clean power mission, in line with our broader remit as the strategic planner for the energy sector and provide advice to the Government.
- Work with Ofgem to continue to push forward energy code reform and help to identify the direction of future code changes for clean power provided through the Strategic Direction Statement (SDS) and assess how code change can be more effective and responsive to changing system or market needs.

Chapter 5. Costs and benefits of a clean power system

Delivering a clean power system by 2030 will support wider and longer-term efforts to reduce greenhouse gas emissions on the path to net zero and can bring multiple benefits without increasing costs to consumers.

Carbon: Our pathways reduce emissions of carbon dioxide to below the level in the Climate Change Committee's net zero pathway. The CCC's pathway is what is needed for the UK's Nationally Determined Contribution to the global Paris Agreement. Clean power can enable full decarbonisation of other sectors, such as transport and heat, through the adoption of electric vehicles and heat pumps, sending a clear and encouraging message to consumers that the technology they are adopting is clean.

Preparing for the 2030s: Our pathways make a step change in the deployment rates for renewables. This will ensure the system is able to keep pace with accelerated electrification through the 2030s, which is expected to add approximately 19 TWh per year to demand (equivalent to the output of around 5 GW of offshore wind). Progress on new technologies, such as carbon capture and hydrogen, is also essential for decarbonising the wider economy.

Investment: Clean power can support wider economic objectives. It will involve an annual investment programme of £40 billion plus that can support economic opportunities and new jobs across the UK. New networks and an abundant supply of clean power can enable growth in other sectors, including the growing digital and data economy.

Electricity costs: A crucial determinant of overall costs will be the impact of the Government's new approach to clean power. If it can provide greater visibility and greater confidence while unblocking barriers and easing delivery, there may be opportunities for costs to fall. Conversely, if supply chains become excessively stretched, costs could escalate. Taking a neutral view over these effects, our analysis shows that overall cost to consumers would not increase as a result of the move to a clean power system. Other factors will also impact electricity bills to 2030, including a reduction in legacy policy costs (as contracts expire) and energy efficiency improvements.

Wider benefits: A clean power system reduces Britain's reliance on energy imports, as well as bringing about environmental benefits, such as cleaner air and the potential to reduce pressures on water systems. More broadly, delivering clean power by 2030 would send a strong signal internationally, given the importance of clean power in global efforts to tackle climate change.

5.1 Climate, carbon and electrification

Carbon budgets

Clean power 2030 will significantly reduce carbon emissions in the British power sector. Power sector emissions in our pathways are 5 $MtCO_2e$ in 2030,[1] less than a third of those in a counterfactual case with no increased decarbonisation efforts[2] and reduced by more than 90% against 1990 emissions. Power sector emissions in 2030 are below the level in the CCC's pathways to net zero,[3] as required for the Nationally Determined Contribution (NDC) under the Paris Agreement and the Sixth Carbon Budget.

Achieving these emissions reductions in the British power sector would help close the current policy gap to meeting carbon budgets and the NDC, as identified by the CCC.[4] The CCC's latest progress report highlights the need to increase installation rates of renewables and for 'a credible overall strategy' for decarbonising the power sector. Action is also needed to address policy gaps in other sectors beyond power.

There is a corresponding drop in the carbon intensity of power generation, from over 140 gCO_2/kWh in 2023 to around 15 gCO_2/kWh in 2030 in our pathways. With carbon dioxide removal from biomass with carbon capture and storage (BECCS) netted off, net carbon intensity in 2030 would be around 5 gCO_2/kWh in the Further Flex and Renewables pathway (with one unit converted to BECCS) and below zero in the New Dispatch pathway (with two BECCS units).

Our clean power metrics are about meeting demand and reducing unabated gas to very low levels, so do not themselves require removal from BECCS. Removal from BECCS would help with wider efforts to reach the UK's NDC and carbon budgets. Decisions over the timing and scale with which to pursue BECCS should reflect the wider carbon strategy for meeting those targets, rather than be driven by the clean power goal for 2030.

Electrification

More broadly, clean power is the foundation for wider electrification and achieving net zero. Throughout our analysis for this report, we assume progress in the electrification of heat, transport and industry, including the use of clean power to produce green hydrogen and to support carbon removal. This aligns with the carbon budgets and path to net zero, as set out by the CCC. As a result, increasing amounts of energy demand are being met by a clean power system rather than carbon-intensive fuels such as gas, petrol or diesel, driving further emissions reductions beyond the power sector. The displaced emission in residential heating and road transport by 2030 could reach 17 $MtCO_2$/yr based on our clean power pathways.

Accelerating build rates now for renewables is crucial to enabling the continued growth of demand due to electrification, which is expected to add approximately 19 TWh per year, in the 2030s, to the demand, the equivalent of the output of around 5 GW of offshore wind.

1 Excluding emissions from combined heat and power and from waste to energy and before removal of emissions from BECCS. This aligns to the CCC's emissions accounting, which attributes these emissions to the industry and waste sectors respectively and identifies removals separately.

2 Carbon emissions in the Counterfactual reported here are slightly lower than carbon emissions in the Counterfactual in FES 2024. This is due to the higher carbon price assumption in the economic analysis for Clean Power 2030. The same carbon price was assumed for all pathways, so clearer conclusions can be drawn on how such pathways differ from the Counterfactual in terms of cost.

3 As reported in Progress in reducing UK emissions - 2023 Report to Parliament.

4 As reported in 2024 Report to Parliament

Climate leadership

The UK has a strong track record of climate leadership, including being the first country to pass comprehensive climate legislation and legally binding emissions targets through the Climate Change Act (2008). The UK was also the first G20 country to set a net zero target and hosted the COP26 climate talks in Glasgow in 2021, which were a focal point for global adoption of net zero targets.

A commitment to clean power by 2030 would solidify the UK's position as a global leader. Having been the first G20 country to phase out coal-fired electricity generation, aiming for clean power by 2030 would place the UK at the forefront among economies decarbonising from historically fossil fuel-based systems. This leadership is particularly significant given the crucial role of electricity generation in global net zero pathways.

5.2 Wider environmental and local community impacts

Impacts of building clean power infrastructure

Power projects have significant impacts on the wider environment and local communities, making it crucial to consider these factors in their development. Conducting thorough environmental impact assessments, engaging with stakeholders and affected local communities and implementing mitigation measures can help minimise negative impacts and enhance projects' sustainability. The planning and consenting process for new generating sites and infrastructure development covers local environmental factors such as noise, vibration, visual impact, flood risk, heritage, ecology and waste management.

In a clean power system, more power needs to be transported over greater distances from generation sites to areas of demand. This requires various technologies, such as overhead lines, underground lines and subsea cables. Each technology has distinct technical characteristics and environmental impacts:

- Overhead lines are usually the cheapest to build but have a visual impact through pylons and wires.
- Undergrounding is more expensive and involves environmental disturbance and potential damage during installation.
- Subsea cables are also costly and require connections to the onshore network, while posing challenges in the marine environment.
- Furthermore, long-term energy infrastructure may occupy valuable sites that could be used for other purposes.

However, it is possible to minimise and mitigate these impacts. Having a clear plan for clean power allows for considering the environment holistically across the programme, making choices that collectively minimise potential negative impacts to the environment and communities and can support solutions that are positive for nature overall.

The proposed plans in this report minimise new onshore infrastructure. We are prioritising reinforcement of existing infrastructure and have identified some marine cabling by 2030. This was a core part of the network plans that form the basis for proposals in this report: those plans consider ways to maximise and upgrade the existing network first and only once this reaches a limit are new lines considered. Strengthened engagement between developers, local authorities and communities is vital for building trust, addressing community concerns and incorporating them into network plans to minimise overall impact on local people.

Air quality, water and land and seabed use

Fossil fuel-based and biomass power plants emit air pollutants, such as particulate matter (PM), SOx and NOx from their combustion processes. These have damaging effects on human health and the environment. Shifting to renewable energy sources reduces pollution and improves air quality, leading to better public health and environmental outcomes. Electrification of heat and transport further reduces air pollution from boilers and vehicles, particularly in urban areas.

Water is a valuable resource that is expected to be under increasing stress as the effects of climate change progress. A shift to clean power brings benefits for water since thermal generation technologies, such as gas-fired generation, can have higher water requirements for cooling compared to wind and solar. On the other hand, power CCS and CCS-enabled hydrogen production consume significant amounts of water.

Overall, a clean power system can reduce pressure on water supplies. The CCC anticipates that shifting to low carbon electricity generation could lead to a 10% decrease in water use in power generation by 2050 (including electrolysis). This is contingent on new nuclear capacity using sea water over fresh water, while different areas of the country will face different challenges, including availability of salt and fresh water and water quality. Accelerated construction timelines for new generation and network build may also place pressure on water systems. Consideration and planning for water availability, quality and efficient use will be important as Great Britain progresses towards a clean power system. Designing plants to maximise water efficiency, such as using seawater for cooling, can also help minimise water-related challenges.

The use of land and the seabed need to be considered for new generation and network assets. A 25 GW increase in offshore wind could occupy approximately 8,600 km^2 of sea space.[5][6] Offshore wind farms may cause seabed disturbance and noise pollution during installation, while floating wind farms reduce these impacts but may pose risks to marine habitats due to anchoring systems.[7] However, potential positive environmental impacts have been identified as well, such as the creation of artificial reefs that attract more marine life than natural reefs.[8] Onshore wind with a capacity of 27 GW would require around 3,000 km^2 of land, representing 1% of the total Great Britain land area. Approximately 99% of this land area would remain available for other uses between the turbines, allowing for shared land use, such as agriculture and pasture. Only a small portion, approximately 30 km^2, would be occupied by the turbines.[9]

In the longer term, the Strategic Spatial Energy Plan (SSEP) will provide an understanding of the spatial requirements of Great Britain's future energy system by mapping the quantities and location of energy infrastructure, while taking into account cross-sectoral demands on land and sea. This includes considering requirements for agricultural production, transport, water availability and nature recovery to help inform decision making.

5 AURES_II_case_study_seabed_auctions.pdf
6 Scotland awards seabed rights for massive amounts of offshore wind, most of it floating | WindEurope
7 670791d6196cc68984lfc02e_ODI_Offshore Wind Energy Industry Review WEB_compressed.pdf
8 Reviewing the ecological impacts of offshore wind farms | npj Ocean Sustainability
9 How can landowners harness onshore wind power opportunities -Trowers & Hamlins

5.3 Investment

Gas-fired power generation costs are primarily driven by fuel and carbon emissions, with some capital investment, while renewable costs are dominated by upfront capital investments. A clean power system therefore involves a shift from operating costs, largely from imports of gas to capital cost, requiring significantly increased investment.

Our pathways for a clean power system in 2030 envision considerable levels of investment, some of which is already underway, driven by current contracts, commitments and expansion plans for generation, storage assets and network infrastructure. In the clean power pathways, offshore wind represents the largest component of investment, with average annual investment of around £15 billion from now to 2030. Networks, onshore wind, solar and storage are other large investment items, though each less than half the scale of offshore wind.

Average annual investment of over £40 billion to 2030 represents a material increase on investment levels in recent years, with average annual investment around £30-35 billion higher over 2025-2030 than over 2020-2024. This is an increase in investment of over 1% of GDP for the entire economy. Wider electrification efforts will further drive national investment.

The main differences in investment between pathways reflect differences in capacity assumptions, as set out in Chapter 3, with similar onshore network investment assumed across scenarios. There are significant uncertainties around the precise level of investment, given wider uncertainties over project costs, as illustrated by significant variations in contracted strike prices over recent renewables auctions. We present relatively cautious (high) estimates reflective of the higher prices in the most recent auction.

Most of the investment is expected to come from the private sector, highlighting significant local economic and job opportunities. Furthermore, this investment also leads to substantial savings in operating costs, as explored in the next section.

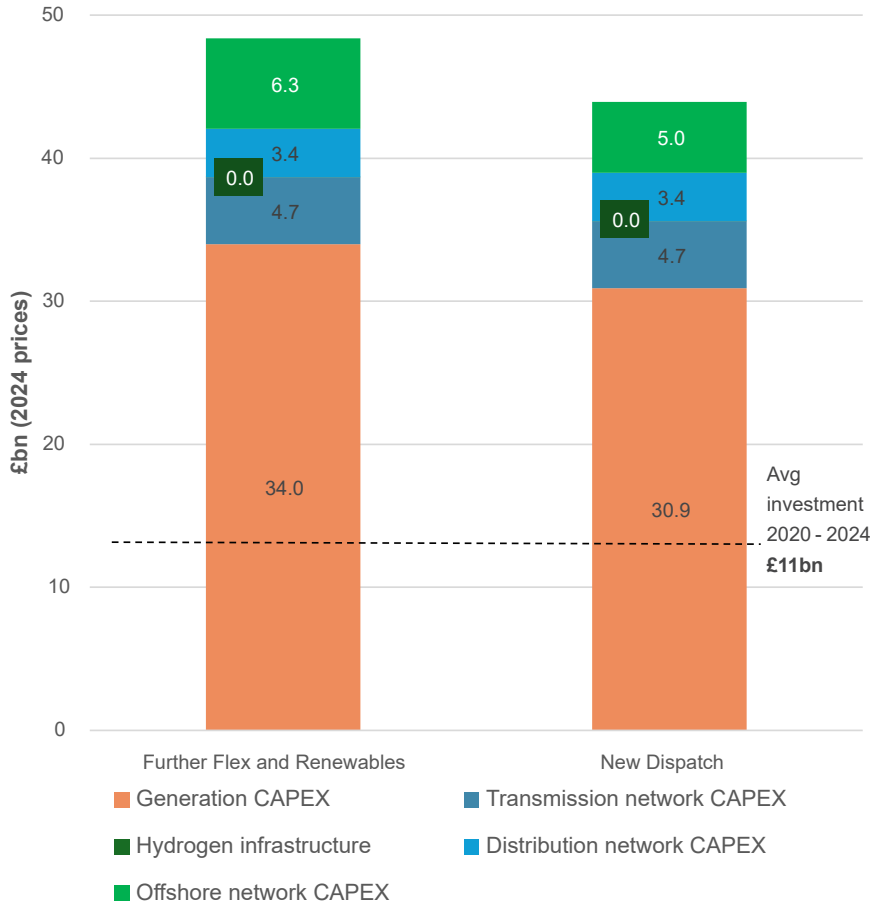


Figure 19: **Average annual investment system costs in clean power pathways 2025-2030**

5.4 Costs

While at the macroeconomic level, the shift to clean power will be seen as an increase in investment, for consumers it will be felt through its effect on electricity prices and bills. These will reflect the underlying costs of the electricity system, just one part of which is investment (or 'capital') costs, which will be recovered through sales of electricity per unit (for example, per kWh, which is roughly the amount of electricity needed to run a dishwasher cycle or a laptop all day, or per MWh, which would power a household for around four months).

Approach to our cost analysis

In our cost analysis, we focus on how electricity costs per unit can be expected to change in a clean power system. We compare how costs will change compared to the current system, how they may differ between our pathways and relative to the Counterfactual with no acceleration in delivery. We break down our cost estimates between their component parts, which include:

- **Generation costs.** The combined capital and running costs of the power plants providing generation to the system, which we break down into three components:
  - **Capacity costs.** These include the annualised investment cost of building new generating and storage capacity and the costs of operating and maintaining it, but not the fuel or emissions costs attached to use of fuels such as gas or biomass.
  - **Fuel costs.** The cost of buying and burning fuel in the plant to generate electricity.
  - **Carbon costs.** The cost of buying emissions permits under the UK's Emissions Trading Scheme.
- **Net import costs.** The cost of imports and income from exports of electricity bought from and sold to neighbouring markets over interconnectors.
- **Network costs.** The annualised capital costs and operating costs of Great Britain's transmission network,[10] distribution network, offshore network, hydrogen infrastructure for power generation and CO_2 transport and storage, which are utilised by the power generation technologies under consideration.
- **Constraint costs.** Thermal and voltage/stability costs, which make up the majority of the balancing costs and the ones most likely to change as the system develops.

Our pathways to clean power involve increased electrification, which leads to a higher share of British energy demand being met by power, displacing costs in other parts of the energy system. For electric vehicles, this is likely to reduce energy costs, as it could for heat pumps depending on prevailing gas prices. However, we do not attempt to estimate these effects in this work, which focuses on the costs of electricity.

How costs flow through to prices, and ultimately bills, will depend on policy design. Under current policy arrangements, there will tend to be an increase in the cost of support mechanisms such as contracts for difference (CfD), with offsetting falls in wholesale power costs. This reflects the change in underlying costs, with renewables having lower running costs and higher upfront costs. While we can identify some expected changes that will affect prices (not just costs), we do not attempt to estimate an actual electricity bill given the heavy dependence on policy choices.

10 Onshore enablers were not included in the analysis due to challenges in obtaining the relevant data.

Overall system costs in a clean power system

In estimating how costs will change compared to today's system, there are multiple effects to take account of. Power will be generated from different means with different underlying costs. More will be generated, not just to service growing demand, but because some will be curtailed, exported or lost during storage cycling. Also, there are costs to be covered in expanding the networks and storage infrastructure.

Looking across these effects in 2030, our analysis suggests a slight increase in total system costs for our New Dispatch pathway, equivalent to around £10 /MWh. This overall cost can be broken down between the different elements:

- **Cost of generation.** Contract prices for wind and solar in recent auctions (£71-83/MWh) are an indicator of the underlying per MWh costs of these new plants and of what consumers will pay for them. These are lower than the cost of generating from existing gas-fired power stations (£123/MWh at current projected 2030 gas prices and carbon prices)[11]. Combined with higher costs assumed for dispatchable power and recognising that not all the displaced generation is from gas, this shift implies a system-wide reduction in the average costs of generation of around £15 /MWh.
- **Curtailment.** The clean power pathways involve higher levels of curtailment when variable and firm generation combined is greater than needed to match demand. This means that, although each unit of generation is lower cost, more of it is needed, pushing up the average cost of meeting demand. We assign no value to this curtailed generation but note there may be opportunities for new flexible demand sources to put this unused clean electricity to positive use. Curtailment adds around £5 /MWh.
- **Net Exports.** Our pathways to clean power see Great Britain become a net exporter of electricity. Exports will be greatest at times of high renewable output, which under current arrangements imply relatively lower prices. So, while exporting will recoup some costs compared to curtailment, it will still involve some net cost to the British system overall. This effect adds around £5 /MWh.
- **Storage.** Our pathways to clean power build a large amount of new storage and use it regularly, which involves round-trip efficiency losses. These are important in reducing the overall cost of the system, for example reducing curtailment and the need for high-cost dispatchable and gas-fired generation. However, the investment and round-trip losses involve new costs, which together increase system costs by around £10 /MWh.
- **Network and constraint costs.** The major expansion in the network in our clean power pathways involves a large investment that will be paid back through increased charges per MWh. Also by 2030, some existing costs will be paid off and others will be spread over a larger demand base. Constraint costs will also change, although provided the full planned network expansion is delivered these need not increase to 2030. Together, these imply rising costs of around £5 /MWh.

Our cost estimates are anchored on the latest auction and DESNZ's published generation cost estimates, with more details set out in Annex 4. We also consider the possibility that costs could differ from these, including using high and low sensitivities for capital costs. The latest renewable auction saw higher prices than the previous one. Should costs fall back towards earlier contracted levels then system costs for a clean power system would be lower than our estimates.

11 **All the cost and price estimates in this report are in a 2024 price base, stripping out the effects of inflation.** Our 2030 gas price projection is around 100 pence/therm, as used in the Future Energy Scenarios. Our carbon price projection of £147/tCO_2 is based on independent forecasts, as used in the Future Energy Scenarios, plus a UK carbon price underpin of £25/tCO_2.

A particular risk we consider is that the need to contract and then build a large amount of generating capacity in a short period, especially for offshore wind, could lead to an escalation in CfD strike prices. Our analysis is based on an assessment of the pipeline of potential offshore wind projects and the potential for inframarginal rents from the CfD auction.[12] In an extreme case where all offshore wind projects are paid in line with the costs of the most expensive project and costs are further pushed up 25% due to supply chain pressures, average costs of the electricity system could increase by a further £15 /MWh. To keep overall costs down, it is therefore vital that an element of competitive pressure is maintained and that high inframarginal rents are avoided.

Impact of clean power on consumer energy bills

While our system cost analysis points to a slight increase from a move to a clean power sector, there will be direct benefits offsetting these, suggesting that overall costs to consumers would not increase from the shift to a clean power system (as summarised in Table 4 below). Specifically, in our clean power pathways, gas sets the price less frequently. The resulting reduction in wholesale prices would lower payments and infra-marginal rents for generation with low marginal costs, such as existing nuclear plants and those receiving Renewable Obligation Certificates (under current market arrangements). Our analysis points to this reducing average electricity prices by around £10 /MWh under a clean power system. This reduction would not happen without the shift to clean power.

Further bill reductions can be expected as levies for older renewable support schemes, such as the Renewables Obligation and Feed-in Tariffs, reach the end of their contractual periods. Some of the plants with these contracts may need new support for repowering, but this would be at much lower levels than in the legacy contracts and could come with an opportunity to increase output relatively cheaply. This effect would happen even without a shift to clean power and would reduce average prices by around £10 /MWh by 2030, with continuing falls through the 2030s.

There are also additional opportunities to reduce bills through energy efficiency. For example, our clean power pathways involve an efficiency improvement in lights and appliances for households that sees typical electricity usage drop by c. 5-10%.

More generally, bills will be affected by gas and carbon prices, though the move away from gas as the predominant price setter for electricity would greatly reduce the risk of major price spikes. Price spikes are passed on to consumers, as seen during the gas price crisis of 2022, when energy bills increased dramatically due to high gas prices. While gas prices fell into 2023, prices remained very high as forward hedging locked in higher costs. As a result, the electricity price cap for 2023 was between £150 -200 /MWh higher than implied by a system cost analysis akin to those in this chapter (consumers were protected from much of this cost through the Energy Price Guarantee, with the cost falling on the public finances instead).

While these sorts of very high price spikes are hard to predict, the shift to clean power would greatly reduce the exposure for consumers and the public purse.

The translation of clean power costs into bill impacts depends on policy choices, including how and when costs are reflected in prices and how they are distributed among different consumers. These choices will affect both current and future consumers, as well as the allocation of costs between gas and electricity consumers. The impact on bills may vary among consumers, such as those with electric vehicles or electric heating and those who have more flexibility in their electricity usage. Potential distributional impacts across residential and business users should be carefully considered when designing policies in this area.

12 Our analysis was developed with Baringa using their proprietary offshore wind CfD auction model. Infra-marginal rent refers to the extra payment (above costs) received by lower cost projects that get paid the same strike price as the more expensive projects that set the clearing price in the CfD auction.

Table 4: **Costs in 2030 in the New Dispatch pathway compared to today's system (figures rounded to the nearest £5/MWh)**

Cost component	Direction of impact	New Dispatch v today's system
Average cost of generation, per MWh produced	↓	- £15 / MWh
Higher curtailment (at times of 'excess' wind/solar)	↑	+ £5 / MWh
Exporting at low cost (at times of 'excess' wind/solar)	↑	+ £5 /MWh
Building storage and round-trip losses	↑	+ £10 / MWh
Grid expansion and constraint costs	↑	+ £5 / MWh
		Total = + £10 / MWh
Bill components resulting from clean power pathways		
Merit order effect reducing infra-marginal rents	↓	- £10 / MWh
Other bill changes to 2030		
Falling legacy policy costs	↓	- £10 / MW
Energy efficiency improvement in typical households	↓	c. 5-10% consumption

Cost comparisons between clean power pathways

As well as exploring how costs change compared to today's system for our clean power pathways, we also explore the differences between pathways and against the Counterfactual that falls short against national carbon targets. We find similar costs across all options, within the bounds of uncertainty, as set out in Figure 20 on the following page.

If gas prices remain similar to those of mid-October 2024 (around 100 pence/therm) and carbon prices rise in line with our projection, costs would be slightly lower in the Counterfactual. However, this would be mostly offset by the merit order effect described above, implying that there is no material cost advantage for the Counterfactual unless gas and/or carbon prices are at materially lower levels.

Between the clean power pathways, New Dispatch is expected to be slightly lower cost. This reflects the reduced investment in renewables and storage and lower curtailment and exports, as it has a greater ability to match dispatchable generation to demand. However, there are other factors to consider (as set out in Chapter 3), such as higher continuing exposure to gas prices (albeit still much lower than today).

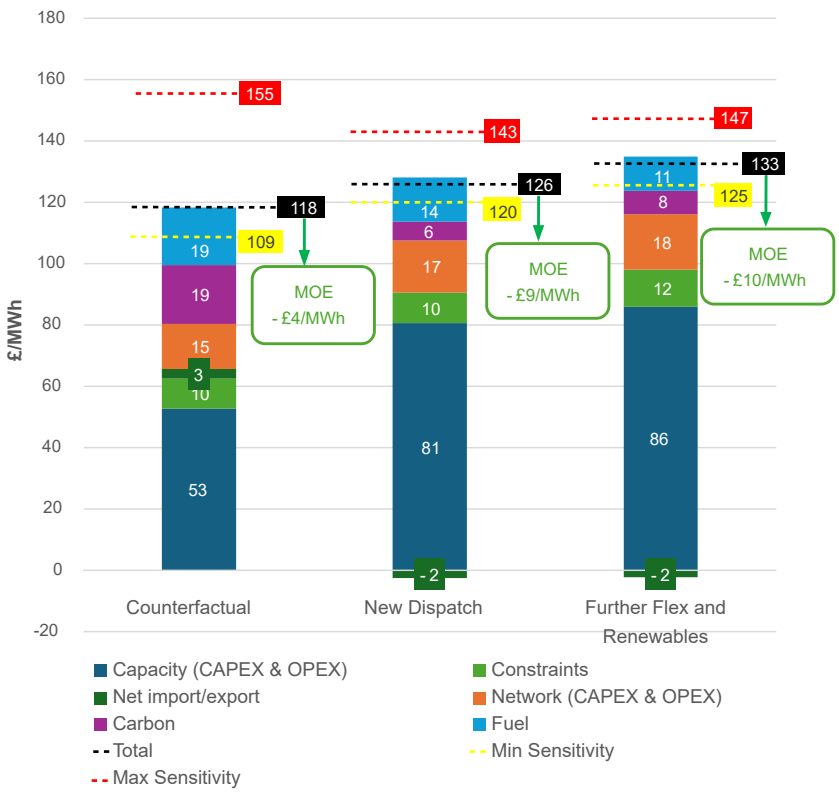


Figure 20: 2030 Annuitised system costs per useful unit of electricity with sensitivities

MOE = Merit order effect, reducing payments to some older plants

Our sensitivity analysis assesses the impact of key assumptions, including gas price projections, investment costs and CO_2 transport and storage costs. The uncertainty bars demonstrate the range of uncertainty, with the Counterfactual being particularly sensitive to gas price assumptions. For the clean power pathways, the range between the lower and upper bounds is smaller, given less sensitivity to gas prices, which outweighs greater sensitivity to capital cost assumptions.

There may be scope to further optimise the pathways to reach clean power at lower cost. For example, more demand side response could cut costs associated with curtailment, exports or storage losses, as could a further rebalancing from renewables to dispatchable generation. It may be also possible to have less, or more efficient, storage without compromising the high value it brings to the system.

We also note that there are wider opportunities and risks attached to the clean power mission to the extent that the mission can unblock barriers to delivery. There may be opportunities to reduce costs, to access cheaper capital and/or to increase competition. However, there are also risks that the accelerated pace reduces competitive pressure, increases supply chain tightness or otherwise increases costs. Managing these risks and opportunities will be a key challenge for the Clean Power 2030 Unit.

Protection from gas price volatility

The unit system costs projections above are based around our central gas price case, assuming gas prices in 2030 remain at similar levels to those in 2023.

If gas use for power generation remained at the levels of 2023 and gas prices were raised to the peak levels in 2022 (300 p/therm on average), this would add around £12 billion to annual electricity system costs in Great Britain. In the partly decarbonised Counterfactual, we estimate this gas price shock would add around £10 billion, while in the clean power pathways it would only add around £5 billion. The flow-through to electricity bills is likely to be more exaggerated given the dominant role of gas-fired generation in price setting in the Counterfactual, compared to in our clean power pathways for 2030 (Figure 21).[13]

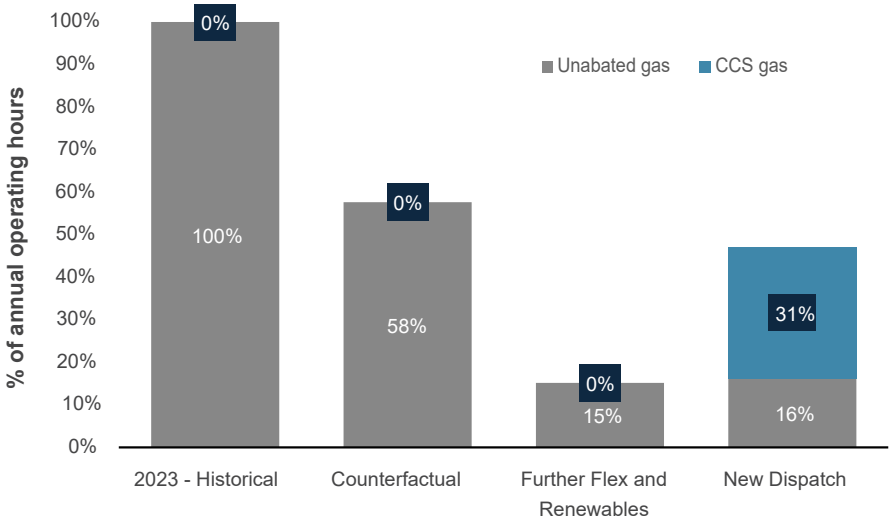


Figure 21: **Percentage of annual operating hours where gas-fired generation is used**

Gas market impact

The gas volume required to supply the gas-fired generation fleet in our clean power pathways is relatively small, compared to typical historical or current gas flows both within the British gas network and in a global market. It is not anticipated that clean power activity would lead to any significant impact on the day-to-day functioning of the gas market. Situations involving a significant national-scale increase in gas-fired generation can be anticipated in advance, based on weather conditions, allowing the gas market to price in the expected rise in gas demand.

In addition to the gas demand from gas-fired generation, there will also be a level of gas demand for hydrogen production and, more widely, for heating. Therefore, gas assets will remain a vital part of national infrastructure for some time, even in a clean power world.

13 Figure 21 shows the share of hours in which gas-fired generation operates at all. It will still be only a fraction of total generation even in these hours.

5.5 Reducing Great Britain's reliance on energy imports

Shifting to a clean power system by 2030 will significantly reduce Great Britain's reliance on energy imports for electricity generation, through several means:

- Great Britain is expected to transition from being a net importer of electricity in 2023 to becoming a net exporter by 2030.
- The amount of gas-fired and biomass generation is reduced in our clean power pathways, reducing the need for imported gas and biomass as fuel sources.
- The use of clean power for electrifying heating and transportation will further displace imports of gas and oil, reducing overall reliance on imported energy in the British energy system. However, the heating and transport sectors will still require significant amounts of gas and oil, with continued reliance on imported energy supplies.

As a result, even though Great Britain's production of oil and gas is expected to fall from now to 2030, reliance on imported fuel for power generation will reduce significantly by 2030 compared to today (see Figure 22), returning to levels last experienced in the mid-2000s.

How imports and exports are affected more broadly will depend in part on how far expansion of supply chains takes place within the country or overseas.

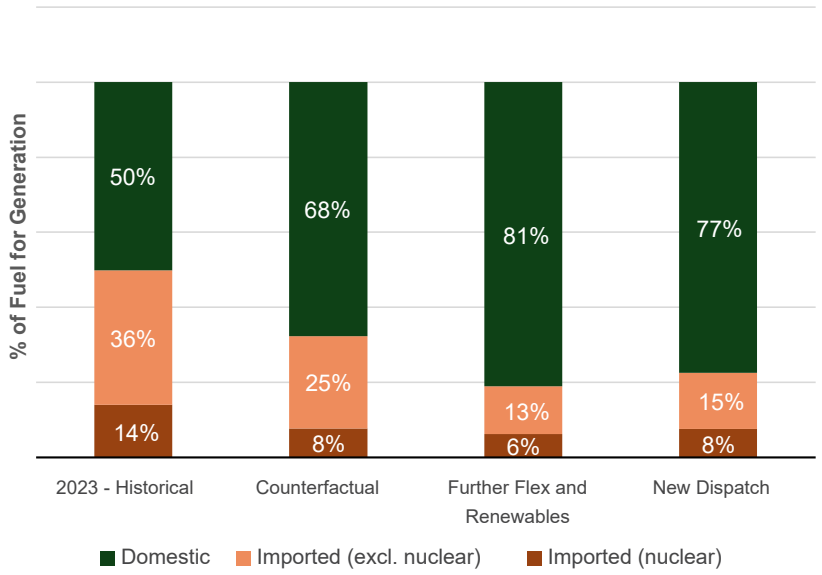


Figure 22: Split of imported and domestic fuel for generation

Wind, solar and hydro are considered British energy resources. Generation from fossil fuels and biomass are split between British and imports in line with the economy-wide shares for these fuels. Nuclear is separately identified, as its fuel is imported, but is a very small percentage of overall nuclear generation costs.

5.6 Impact on the wider British economy

The power system is a key enabler of sustainable economic growth. Households and businesses rely on access to electricity for their day-to-day needs, while increasingly demanding clean power. The transition to a clean power system by 2030 will have significant impacts on the wider national economy. While quantifying these impacts can be challenging due to the importance of wider factors, we have considered some of the key macroeconomic effects:

- The **large increase in capital investment** for clean power could potentially boost GDP and employment rates either locally or across Great Britain, but this is dependent on wider macroeconomic policy and supply side capabilities to respond to this scale-up in demand.
- The transition to a decarbonised power sector by 2030 presents a significant economic opportunity for creating and expanding **green jobs**. The low carbon energy and renewables sector in the UK has already witnessed significant growth, with employment reaching 74,000 in 2022, an over 20,000 increase from previous estimates in 2015.[14] This upward trend is expected to continue at pace. The Climate Change Committee's Net Zero Workforce (2023)[15] report presents a wide range of employment opportunities, projecting between 4,000-192,000 jobs in low carbon energy, CCS and hydrogen.
- Transitioning to a clean power system is likely to lead to a shift in the UK's **trade position**, as the country changes from a net importer to an exporter of power and reduces natural gas imports. However, this may be offset by higher imports, for example of parts and materials, influenced by the increase in capital investment.
- **UK competitiveness** will be impacted by the changing difference between British and overseas electricity prices. If consumer and industrial electricity bills reduce under the clean power pathways, it can provide economic benefits, particularly for large industrial power users, making them more competitive internationally. This of course depends on wider policies and how European power prices evolve.
- The transition to a clean power system presents **industrial opportunities**, including direct investment, a stable market for supply chains and opportunities for major power users seeking clean energy.
- **Public finances** will see some changes due to investment in clean power, but the majority will be delivered from the private sector, backed by contracts that are paid for from energy bills. Some of the potential public spending requirements, for example for CCS, have already been identified and funded by the Treasury. Reduced emissions from a clean power system decrease permit demand in the power sector's Emissions Trading Scheme, but these permits are available for sale to other sectors. Given expected price increases by 2030, the power sector is projected to raise £1.5-2 billion in 2030 (compared to £5.8 billion in 2023) even in a clean power pathway. At the same time, revenues from the Crown Estate will continue to grow due to offshore wind leasing.

5.7 Conclusion

Our analysis describes pathways to a clean power system for Great Britain by 2030 that involve a major investment programme without increasing costs to consumers, while largely breaking the link with volatile international gas prices. As well as being a major direct contributor to UK carbon targets, it would enable accelerated progress in other sectors. And it would involve development of the tools, policies and momentum to drive through 2030 to meet the ongoing challenges ahead.

This report has set out potential pathways for clean power. The Government will now reflect on those pathways and put forward its own plan. Then the hard work will begin to deliver against that plan while ensuring good value for consumers, developing opportunities across the country and building public trust and support for the clean power mission.

14 ONS Low Carbon and Renewable Energy Economy (LCREE)
15 CCC (2023) – A Net Zero Workforce

Glossary

AGR	Advanced Gas-cooled
AI	Artificial Intelligence
ASTI	Accelerating Strategic Transmission Investment
BECCS	Bioenergy with Carbon Capture and Storage
BM	Balancing Mechanism
CAPEX	Capital Expenditure
CCC	Climate Change Committee
CCS	Carbon Capture and Storage
CfD	Contract for Difference
CHP	Combined Heat and Power
CO_2	Carbon Dioxide
CSNP	Centralised Strategic Network Plan
DACCS	Direct Air Carbon Capture and Storage
DESNZ	Department for Energy Security and Net Zero
DNO	Distribution Network Operator
DSI	Data Sharing Infrastructure
DSR	Demand Side Response
ENCC	Electricity National Control Centre
EPR	European Pressurised Reactors
ESO	Electricity System Operator
ESRS	Electricity System Restoration Standard
EV	Electric Vehicle
FES	Future Energy Scenarios
FOAK	First of a Kind
GETS	Grid-enhancing Technologies
GW	Gigawatt
GWh	Gigawatt Hour
HT	Holistic Transition (Future Energy Scenarios pathway)
HVDC	High Voltage Direct Current
IBR	Inverter-based Resources
IDNO	Independent Distribution Network Operator
LAES	Liquid Air Energy Storage
LDES	Long Duration Energy Storage
LLM	Large Language Models
MHHS	Market-wide Half-hourly Settlement
MWh	Mega Watt Hour
NDC	Nationally Determined Contribution
NESO	National Energy System Operator
NTS	National Transmission System
OEM	Original Equipment Manufactuer
OPEX	Operating Expenditure
PHES	Pumped Hydro Energy Storage
PP	Percentage Points
REMA	Review of Electricity Market Arrangements
SMR	Small Modular Reactors
SPS	Strategy and Policy Statement
SSEP	Strategic Spatial Energy Plan
TO	Transmission Owner
TWh	Terawatt Hours
V2G	Vehicle-to-Grid
VirtualESZ	Virtual Energy System

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Appendix S3:

Clean Power 2020 Action Plan, December 2024

UK Government

Clean Power 2030 Action Plan: A new era of clean electricity

December 2024

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List of Abbreviations

AGR	Advanced Gas-cooled Reactor
BECCS	Bioenergy with Carbon Capture and Storage
CB	Carbon Budget
CCUS	Carbon Capture Usage and Storage
CfD	Contracts for Difference
CHP	Combined Heat and Power
CM	Capacity Market
DESNZ	Department for Energy Security and Net Zero
DPA	Dispatchable Power Agreement
DSR	Demand Side Response
DNOs	Distribution Network Operators
EEP	Energy and Emissions projections
H2P	Hydrogen to Power
H2PBM	Hydrogen to Power Business Model
gCO2e/kWh	Grams of carbon dioxide equivalent per kilowatt-hour of electricity
GBE	Great British Energy
GDP	Gross Domestic Product
GW	Gigawatt
LAES	Liquid Air Energy Storage
LDES	Long-duration Electricity Storage
MHHS	Market-wide Half Hourly Settlement
MoD	Ministry of Defence
MW	Megawatt
NESO	National Energy System Operator
NSIP	Nationally Significant Infrastructure Projects
NSTA	North Sea Transition Authority
OBR	Office for Budget Responsibility
Ofgem	Office of Gas and Electricity Markets
REMA	Review of Electricity Market Arrangements
SSEP	Strategic Spatial Energy Plan
TNUoS	Transmission Network Use of System

Foreword from the Secretary of State

We will usher in a new era of clean electricity for our country, with our plan to deliver the most ambitious reforms to our energy system in generations.

Since Russia's invasion of Ukraine, Britain has experienced a devastating cost of living crisis caused by our exposure to volatile fossil fuel markets. Every family and business in the country has paid the price and we remain exposed to future energy shocks. In an increasingly unstable world, our dependence on fossil fuels leaves us deeply vulnerable as a country – and that is true no matter where they come from.

But there is a solution: by sprinting to clean, homegrown energy, we can take back control from the dictators and the petrostates. That is why the Prime Minister has put delivering clean power by 2030 at the heart of one of his five missions and Plan for Change.

The age of clean electricity is about harnessing the power of Britain's natural resources so we can protect working people from the ravages of global energy markets. This plan will provide the foundation for the UK to build an energy system that can bring down bills for households and businesses for good. And it is also about creating the sort of country that we know people want to see - reindustrialising our heartlands with good jobs and tackling the climate crisis.

This plan sets out how the government will work with the clean power sector, including industry, trade unions, investors, policy makers and others to achieve our clean power goal. 2030 is just six years away, and we are under no illusions

about the scale of the task ahead, but mission-driven government is about acting with urgency and determination to rise to the challenges we face.

That is why, in my first week in office, I appointed Chris Stark as Head of Clean Power 2030 in my department, leading a new mission control to drive progress towards our target. As a first step we commissioned the National Energy System Operator (NESO) to provide independent, expert advice on delivering clean power by 2030. Their advice, published earlier this year, showed that we can achieve our goal, protecting consumers and delivering a more secure energy system.

This plan builds on that advice, setting out the government's view of the pathway to 2030 and the steps needed to get there.

Ultimately, we need to move fast and build things to deliver the once-in-a-generation upgrade of our energy infrastructure Britain needs. In our first five months, we've already lifted the onshore wind ban, established Great British Energy, consented almost 2 GW of solar, delivered a record-breaking renewables auction, and kickstarted our carbon capture and hydrogen industries. This is the speed at which we will continue to work.

As the Prime Minister has made clear, clean power is an urgent priority for our country. The clean power sprint is the national security, economic security, and climate justice fight of our time - and this plan gives us the tools we need to win this fight for the British people.

Foreword by the Rt Hon Ed Miliband MP

Secretary of State for Energy Security and Net Zero

Foreword from the Head of Clean Power 2030

Cleaning up our power system has long been understood as central to decarbonising the whole economy. With a clean electricity supply, the electrification of heat, transport and industry open up as routes to net zero. But the wider benefits of clean power have also become clearer. In Britain, we have pioneered policies to grow renewable industries, attract investment and deploy clean energy technologies at a scale that was once thought impossible. There is now a route to more stable energy bills for households and businesses, as they increasingly go electric. We have also experienced the harsh repercussions of Britain's over-reliance on fossil fuels, which left us badly exposed to the cost of globally traded oil and gas in the wake of recent global insecurity.

Achieving clean power is now a broader goal, key to a growing economy, our national security and improving our standards of living. We should be in a hurry to achieve it.

This year, Britain closed its final coal-fired power station, completing a successful transition from the most polluting energy source. Clean power by 2030 is our next milestone, but it requires us to act with much greater urgency. Britain has some of the world's greatest clean energy resources, but we have planning and consenting processes that are far too slow to build the infrastructure needed to exploit them. That must change.

NESO's recent analysis shows the pipeline of projects needed for clean power by 2030. Their pragmatic advice is that security of power supply can be provided if we maintain

Britain's fleet of gas power stations but reduce their use to no more than 5% of total generation. That clarifies the task: build the grid that Britain needs, overturning decades of delay; install clean sources of power at a pace never previously achieved; identify the energy mix needed for the 2030 power system and reorder the connection queue to achieve it; develop a flexible system that can accommodate and store Britain's renewable resources; deliver these benefits to consumers, people, households, and businesses as swiftly as possible.

This requires a mission-focus – industry and government working in partnership at pace. The steps in this Action Plan will reform planning and consenting processes, contract new renewable power generation at the scale required, encourage long-duration energy storage and first-of-a-kind flexible clean capacity and open the path to clean power and new opportunities for consumers to save.

For the first time, we will have eyes on a programme of clean power investment estimated to be around £40 billion per year for the next 6 years. That visibility allows a more active focus on removing the barriers to its achievement, supporting greater coordination of supply chains, with more UK-based production, and ensuring there are trained workers to meet the requirements across the country. This is the real prize, ensuring we are ready to meet the growth in electricity demand that we expect over the 2030s and 40s.

Britain's clean power mission is now underway.

Foreword by Chris Stark

Head of Clean Power 2030

Summary

Clean Power by 2030 will herald a new era of clean energy independence and tackle three major challenges: the need for a secure and affordable energy supply, the creation of essential new energy industries, supported by skilled workers in their thousands, the need to reduce greenhouse gas emissions and limit our contribution to the damaging effects of climate change. Clean power by 2030 is a sprint towards these essential goals.

We have accepted independent advice from the National Energy System Operator (NESO), on the energy infrastructure required to deliver Clean Power 2030. In a typical weather year, the 2030 power system will see clean sources produce at least as much power as Great Britain *consumes* in total over the whole year, and at least 95% of Great Britain's *generation*; reducing the carbon intensity of our generation from 171gCO_2e/kWh in 2023[1] to well below 50gCO_2e/kWh in 2030.

The path to 2030

Successful delivery will require rapid deployment of new clean energy capacity across the whole of the UK, reflecting the shared renewable ambitions of the UK, Scottish and Welsh Governments. In this plan, we are accepting government's central role in steering the creation of this new energy system, setting our expectations for the 2030 capacities of key technologies at national and regional level.

We have high ambition. That means 43-50 GW of offshore wind, 27-29 GW of onshore wind, and 45-47 GW of solar power, significantly reducing our fossil-fuel dependency. These will be complemented by flexible capacity, including 23-27 GW of

[1] Department for Energy Security and Net Zero (DESNZ) (2024), *'Digest of UK Energy Statistics (DUKES) 2024'* (viewed in December 2024).

battery capacity, 4-6 GW of long-duration energy storage, and development of flexibility technologies including gas carbon capture utilisation & storage, hydrogen, and substantial opportunity for consumer-led flexibility[2].

In line with the NESO advice, this new capacity must be underpinned by the rapid delivery of 80 network and enabling infrastructure projects, most of which are already at an advanced stage of planning and development.

Over the period to 2030, security of supply will be protected with the maintenance of an expected 35 GW of unabated gas reserve capacity.

Growing our clean energy system in this way will see once-in-a-generation levels of energy investment – an estimated £40 billion[3] on average per year between 2025-2030, spreading the economic benefits of clean energy investment throughout the UK with the collaboration of the Scottish and Welsh Governments. These investments will protect electricity consumers from volatile gas prices and be the foundation of a UK energy system that can bring down consumer bills for good. Every choice we make will be scrutinised to maximise the impact it can have in reducing consumer bills.

The new industries and employment opportunities created by the huge investment ahead will also ensure there are lasting economic benefits from clean power throughout the country.

Delivering Clean Power 2030 also paves the way to decarbonising the wider economy by 2050 as we pursue the electrification of heat in buildings, transport, and industry. By 2050, annual electricity demand is likely to at least double. Clean power by 2030 prepares us for the rapid growth in power demand expected over the 2030s and 40s.[4]

Actions we are taking to accelerate delivery

To hold to our path to 2030, we know that the government must take radical action, quickly. This document sets out our first major steps towards clean power, in partnership with the Scottish and Welsh Governments, industry and the public:

Electricity Networks and connections

We need to reform the grid connections process and reduce the queue to connect, working with NESO and Ofgem to provide a framework through which NESO can work with Transmission Owners (TOs) and Distribution Network Operators (DNOs) to prioritise projects needed for 2030, while maintain a robust pipeline beyond 2030. Around twice as much new transmission network infrastructure will be needed in the nation's grid by 2030 as has been built in the past decade[5].

[2] These voluntary offers of flexibility by energy consumers (whether households or industries) can also be referred to as demand side response (DSR) or demand flexibility.
[3] Undiscounted, 2024 prices. This includes £30bn investment in generation assets, and £10bn investment in transmission network assets. See the Technical Annex for more detail on how this was calculated.
[4] Department for Business, Energy & Industrial Strategy (BEIS) (2022), *'Electricity networks strategic framework, Appendix 1 – Electricity Networks Modelling'* (viewed in December 2024).
[5] National Energy System Operator (NESO) (2024), *'Clean Power 2030'* (viewed in December 2024).

Regulatory reform will ensure Clean Power 2030 is better integrated into planning and decision making, so investment can be made ahead of need and the time taken to build and deliver network projects can be reduced in line with 2030 requirements. This includes working with Ofgem to explore the appropriateness of tightening the incentives and penalties on electricity transmission owners and distribution network operators to drive the acceleration of network delivery. The Scottish and Welsh Governments are considering how their planning and consenting regimes will also integrate with Clean Power 2030.

An improved planning and consenting environment will accelerate the expansion and upgrade of transmission and distribution networks. We will consult on expanding planning consent exemptions to include low-voltage connections and upgrades in England, and engage with MHCLG on opportunities to provide further flexibilities for the consenting of electrical substations. It is essential that we engage effectively and thoroughly with communities that will host new transmission network infrastructure, so they can be a part of the change to our system and benefit from it.

The Scottish Government will shortly consult on the refresh of its Good Practice Principles for community benefits for onshore and offshore net zero energy infrastructure. The government's view is that communities that host clean energy infrastructure should benefit from it. As a first step, we will publish guidance to increase the quantum and consistency of Community Funds and support the launch of industry public communications campaigns to encourage public awareness on the importance of networks infrastructure in supporting net zero.

Planning and consenting

With a prioritised grid queue, we can signal key projects for clean power and speed up planning and consenting processes across Britain. We will ensure communities directly benefit from hosting new clean energy infrastructure. We know that the majority of 2030 clean power projects are already in the pipeline, and so there is therefore a major opportunity in rewiring the planning system and unblocking bottlenecks to ensure projects can receive timely decisions so they can get building.

We will do this first by upgrading the planning system itself, equipping organisations with the flexibility they need to manage the increased caseload it faces. This includes workforce reform and development as well as a commitment to reviewing resourcing within the system.

Next, we will ensure the system can prioritise 2030-critical projects. We will make 2030 a core priority in updated planning policy vehicles and guidance. We have brought onshore wind back in to the Nationally Significant Infrastructure Project (NSIP) regime. We will bring forward a Planning and Infrastructure Bill with measures to streamline the delivery of critical infrastructure in the planning process, and convene community, nature, and industry groups on complex projects to stress-test them prior to application. In line with Lord Banner's recommendations, we will also progress work exploring changes to the legal challenge process for major infrastructure projects.

We will ensure that a reformed planning system enhances the restoration of nature. We will do this by delivering the Marine Recovery Fund for Offshore Wind and are considering strategic mitigation approaches for onshore infrastructure in England. The UK government and the Scottish Government

are also working together to establish a similar Marine Recovery Fund for projects in Scotland.

Devolved administrations are taking positive steps towards speeding up energy infrastructure planning and consenting too. In Wales, the Infrastructure (Wales) Act 2024 sets out the new consenting process for significant infrastructure projects, replacing multiple consenting processes in Wales with a single process. In Scotland, work is underway to secure the pipeline of future planners and increase skills and capacity within planning authorities. We are working closely with the Scottish Government on reform to deliver a streamlined and efficient legislative framework for electricity infrastructure consenting.

Renewable and nuclear project delivery

Addressing blockages to networks, connections and planning progress will significantly help us deliver the renewable capacity we need for 2030. But there are specific issues to address.

The Contracts for Difference allocation process needs to meet our 2030 ambitions and put an end to the stop-start failures of recent years. We need high levels of renewables to protect consumers and they need to be secured at the best price. Offshore wind has a particularly important role as the backbone of the clean power system.

Following discussions with industry and subject to further assessment, we are minded to implement a package of targeted reforms. We will consider changes to the information the Secretary of State can use to inform the final budget for fixed-bottom offshore wind, an auction schedule to improve transparency and predictability, and review auction parameters, including our approach to the reference prices used to estimate the budgetary impact of bids. To maximise the competitive process, we are also minded to relax eligibility criteria for fixed-bottom offshore wind projects so projects that have yet to obtain full planning consents can participate. We will consult on these changes ahead of Allocation Round 7.

We will leverage Great British Energy, and wider policy measures to support local and community-led renewable capacity, including for homes, businesses, public buildings and land, and shared spaces. Great British Energy will provide support to deliver the Local Power Plan, putting local authorities and communities at the heart of restructuring our energy economy. It will also align with NESO's publications and the government's response to identify locations for new generation projects on private land and undertake development on public land, unlocking scope for generation on government estates.

Solar panels are already an eligible measure in existing programmes like the Warm Homes Local Grant and Warm Homes Social Housing Fund, and we will provide further details on how else solar could be supported in the Warm Homes Plan after the second phase of the Spending Review. We will also assess the potential to drive the construction of solar canopies on outdoor carparks through a call for evidence next year.

We are also committed to nuclear, including the lifetimes of existing nuclear projects where possible, and the development of emerging low carbon and renewable technologies that will play an important role beyond 2030, continuing to recognise that the policy of the Scottish Government is not to support new nuclear developments in Scotland.

Electricity market reform

Reforming the electricity markets will support clean power generation and networks. Reform is vital in ensuring our market arrangements are fit for the 2030s and beyond. We must ensure that the market

works in tandem with support schemes to deliver the right investment and operational signals and that any sector-specific barriers to deployment are addressed, to enable the huge volume of deployment that will underpin Clean Power 2030.

A significant increase in short-duration flexibility of 29-35 GW[6] across battery storage, consumer led flexibility and interconnection capacity from 2023 levels will reduce the amount of more costly generation and associated network infrastructure that needs to be built, whilst maintaining security of supply. Reforming the transmission network charging (Transmission Network Use of System (TNUoS) charges) is critical in order to enable the increased deployment of future generation.

The REMA Autumn Update outlines our ambition to conclude the policy development phase of the REMA programme by around mid-2025 and confirms that the timetable for REMA decisions will align with the timetable for the next allocation round (AR7) for the Contracts for Difference (CfD) scheme in order to reduce uncertainty.

Short-duration energy storage and flexibility

As we build an energy system reliant increasingly on variable renewables, improving the flexibility of the wider electricity system is key. A Low Carbon Flexibility Roadmap will be published next year, with new actions to drive clean power flexibility by 2030. We will introduce new market reforms to provide batteries and consumer-led flexibility with appropriate and fair access to, and utilisation within, relevant markets, and we will consult on how grid-scale batteries could be referenced in future planning reforms, and on including grid-scale batteries within the Environmental Permitting Regulations.

We will consider financing options for retrofit works, including batteries, in the Warm Homes Plan in England. We will consult to remove external display requirements for device meters from the Measuring Instrument regulations, and, in Summer 2025, we will publish a consultation on consumer engagement, including on how to help coordinate and amplify accurate messaging on consumer-led flexibility. We will also consider reform on the Maximum Resale Price and will introduce new Guaranteed Standards of Performance relating to smart metering in 2025.

We will respond to recent consultations on Energy Smart Appliance interoperability, a new licensing regime for service providers for consumer-led flexibility and load controllers, and tariff data accessibility. These will be followed up with detailed consultations on draft ‘first phase’ Energy Smart Appliance legislation, establishing minimum cyber security requirements for appliances in scope and a smart mandate for heat pumps; draft consumer-led flexibility service providers and load controller regulations and licence conditions, and measures to improve time of use tariff data accessibility. We will implement Capacity Market policy proposals, including permitted augmentation of storage, adjustments to Extended Performance Testing Requirements and making 3-year Capacity Markets agreements to low carbon technologies requiring no capital expenditure.

Long-duration flexibility

We are projected to need 40-50 GW[7] of dispatchable and long-duration flexible capacity in 2030 to support our power

[6] See Table 1. This is the difference between the current capacity of batteries, interconnectors, and consumer-led flexibility, and capacities in 2030 under the DESNZ *‘Clean Power Capacity Range’*. Differences in total figures are due to rounding.
[7] The sum of with low carbon dispatchable power, unabated gas, and LDES capacities in Table 1, rounded to the nearest 5GW. Dispatchable technologies are ones which combust fuel to produce electricity and, by varying the rate at which fuel is burned, can respond to meet the needs of the grid with varying levels of flexibility.

system in extended periods of low renewable output. We are determined to drive the development of low carbon long-duration flexibility, which presents a substantial opportunity. We have announced Final Investment Decision for Net Zero Teesside, the world's first at scale gas power plant with carbon capture, and we are also developing a Hydrogen to Power business model which will de-risk investment and bring forward capacity. We also need to scale up deployment of pump storage hydropower and foster further innovation in more nascent long-duration storage technologies such as liquid air energy storage. The cap and floor scheme, which could open in Q2 2025, will support investment in the sector. Unabated gas will continue to play a back-up role throughout the transition to clean power, ensuring security of supply. This means that we will retain sufficient capacity until it can be safely replaced by low carbon technologies.

Supply chains and workforce

Clean power by 2030 is a signal to investors to locate in the UK and build strong domestic supply chains for key aspects of our clean power system. Actions to support and accelerate delivery will give developers greater route-to-market certainty, but we will go further, including with the forthcoming Industrial Strategy, which will include a sector plan for clean energy industries. We will convene a new supply chains and workforce industry forum for key Clean Power 2030 sectors, including trade unions, to develop a deep understanding of system-level supply chain and workforce planning needs for Clean Power 2030 delivery and devise targeted collective actions to ensure they are met. The Clean Industry Bonus will support manufacturing in coastal and energy communities and cleaner, more sustainable supply chains, while increased transparency and predictability in future Contracts for Difference allocation rounds will support investment. The National Wealth Fund will focus at least £5.8 billion of its capital on green hydrogen, carbon capture, ports, gigafactories, and green steel, while Great British Energy will support the growth of clean power supply chains around the UK.

The clean power transition also needs a skilled workforce, with thousands of new jobs throughout low carbon sectors. Details of the Clean Energy Skills Challenge have been published alongside this Plan. The Office for Clean Energy Jobs will work with the sector, trade unions and the devolved governments to support regions transitioning from carbon-intensive industries to clean energy sectors, to ensure jobs are high quality, with fair pay, favourable terms, and good working conditions. This work includes targeted interventions to reskill and upskill workers across the economy, supporting access to training schemes, and promoting the opportunities of clean energy jobs so that a lack of skilled workers does not become a bottleneck in the achievement of our Clean Power ambition.

How we will work, as government and with everyone involved, to deliver

The Clean Power 2030 Unit will look across delivery of the key 2030 projects, working to identify blockages and ensuring that the clean power programme stays on track.

To do this we will draw together a mix of skills and experience from government and the clean power sector, underpinned by an Advisory Commission of leading figures from across industry and academia. The Unit will work closely with those involved in practical delivery, including the devolved governments, to cut through issues quickly and to build a comprehensive view of the power infrastructure currently in development.

This insight, coupled with a strong underlying data capability that will bring together data and insight from across government and the clean energy sector, will help understand what is likely to be delivered, by when, and quickly identify emerging challenges. This will help the Unit take rapid action wherever it is needed to ensure delivery.

This Action Plan is our first major step towards Clean Power by 2030. The coming months and years will see a new programme of activity emerge, relying on the work of a wide range of businesses, many parts of government at central, regional and local level across England and the Devolved governments, the third sector, communities, and individuals.