Future Energy Scenarios: Pathways to Net Zero

July 2025
V.4

NESO
National Energy System Operator

Supporting Documents & Data

Alongside the *Future Energy Scenarios 2025: Pathways to Net Zero* report, we publish several associated documents and data sets.

FES Changes and Assumptions

Summary of key changes and assumptions

FES 2025 Pathway Assumptions Log

Detail on the assumptions we apply across our modelling

Modelling Methods 2025

Detail on the models we use to produce FES

FES Data Workbook 2025

A data workbook containing all charts and data from *FES 2025*

FES Data Portal

Comma-separated variable (CSV) files for all FES output data sets

Contents

Revisions

Version	Date	Description
V.2	21/07/2025	Corrected policy ref on P145, updated Figure 12, updated storage values on P21, 51 and 139
V.3	23/07/2025	Updated box on P43
V.4	18/08/2025	Commercial demand values updated to represent underlying demand and exclude rail traction on P112-113. Unit correction on P111. Revision to Figure 30

Foreword

I am proud to introduce our 2025 Future Energy Scenarios: Pathways to Net Zero. This is our fifteenth FES and our first since NESO was established in October 2024 as an independent, public corporation at the centre of the energy system.

FES provides an independent view of a range of future pathways for the whole energy system. It has become an important publication in the energy sector and is the result of a programme of close engagement with stakeholders across the industry, alongside our own extensive research and analysis.

This last year has been characterised by action, acceleration and ambition, with the government's *Clean Power 2030 Action Plan* setting out clear intent and pace. Progress is underway to deliver the infrastructure required to support this, with the extensive connections reform programme facilitating the faster connection of new supplies of clean, flexible power. We have also seen the Clean Energy Industries Sector Plan as part of the *Modern Industrial Strategy* as well as the first revenue support contracts for low carbon hydrogen and carbon capture projects in industrial clusters.

Our pathways in this year's FES, however, show the scale of work that remains. Change won't happen overnight and success relies on matching the pace and ambition of clean power, while looking beyond the power sector and beyond 2030. This means not only transforming our energy infrastructure but enabling homes and businesses to switch to low carbon energy sources for heat and transport, putting consumers at the heart of a new energy system and in control of the energy they use. Demand flexibility will play an important role here, getting more from low-cost renewable generation and helping both consumers and the energy system.

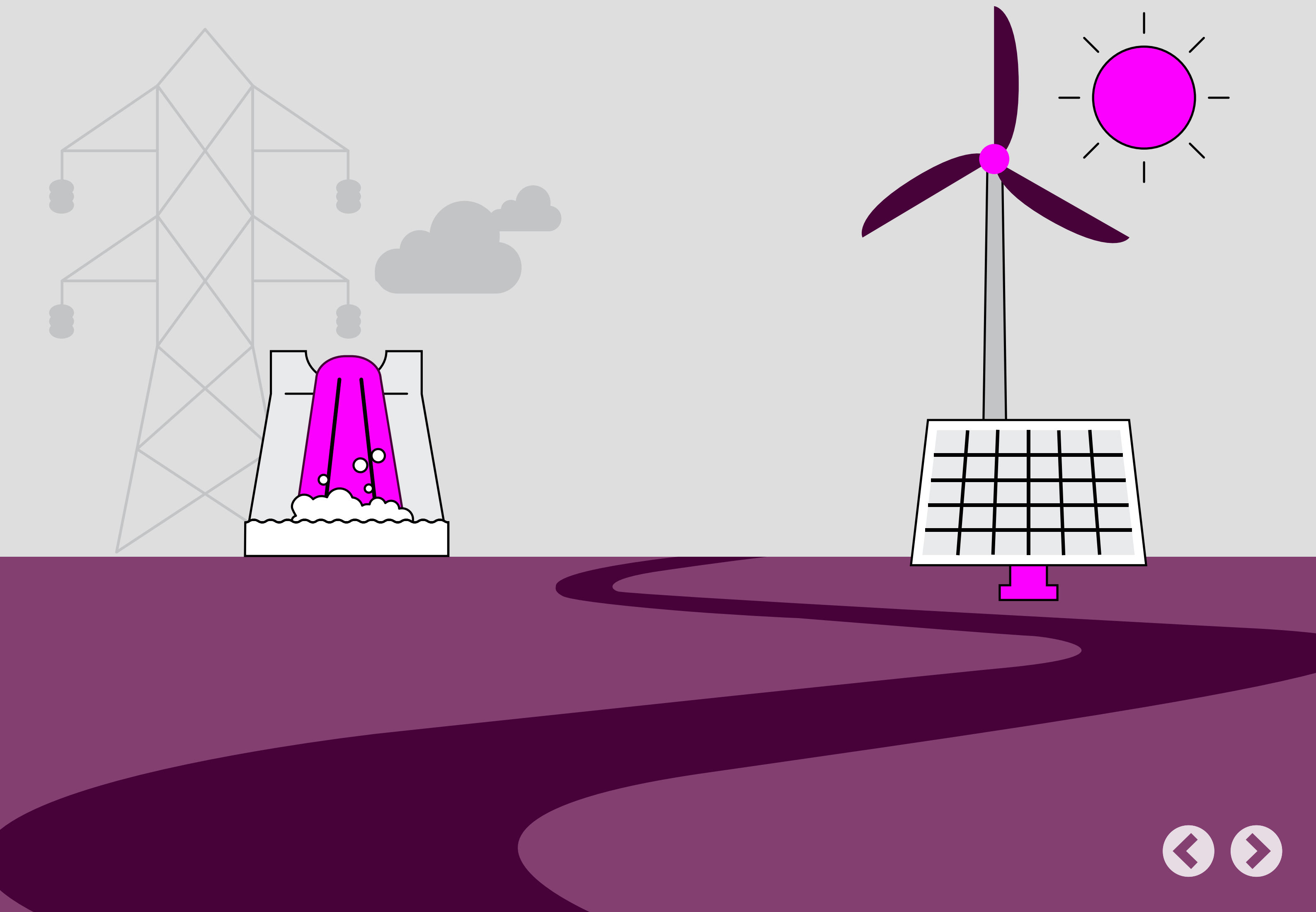
We are now in a new energy era. This era will be shaped by different waves of action. The last two decades have laid the foundations for the energy transition and the remainder of this decade will see rapid acceleration, followed by growth throughout the 2030s. All this will unlock the benefits of an affordable, secure and clean energy system on the 2050 net zero horizon.

We need to consider each of these waves now. Success along the route to 2050 will depend on the choices made today.

FES relies on robust insight and analysis. Our stakeholders are central to this, and I wish to extend many thanks for your input over the past year.

Claire Dykta
Strategy and Policy Director

Executive Summary



Unlocking the benefits of a secure, affordable and clean energy system for Great Britain requires bold ambition and progress in energy across all sectors of the economy.

Energy has always been a driver of progress in Great Britain. From the industrial revolution to the commissioning of the super grid, Great Britain has a proud history of innovation. Now, as we enter a smarter and cleaner energy era, leveraging this spirit of innovation and progress once again can unlock its full potential.

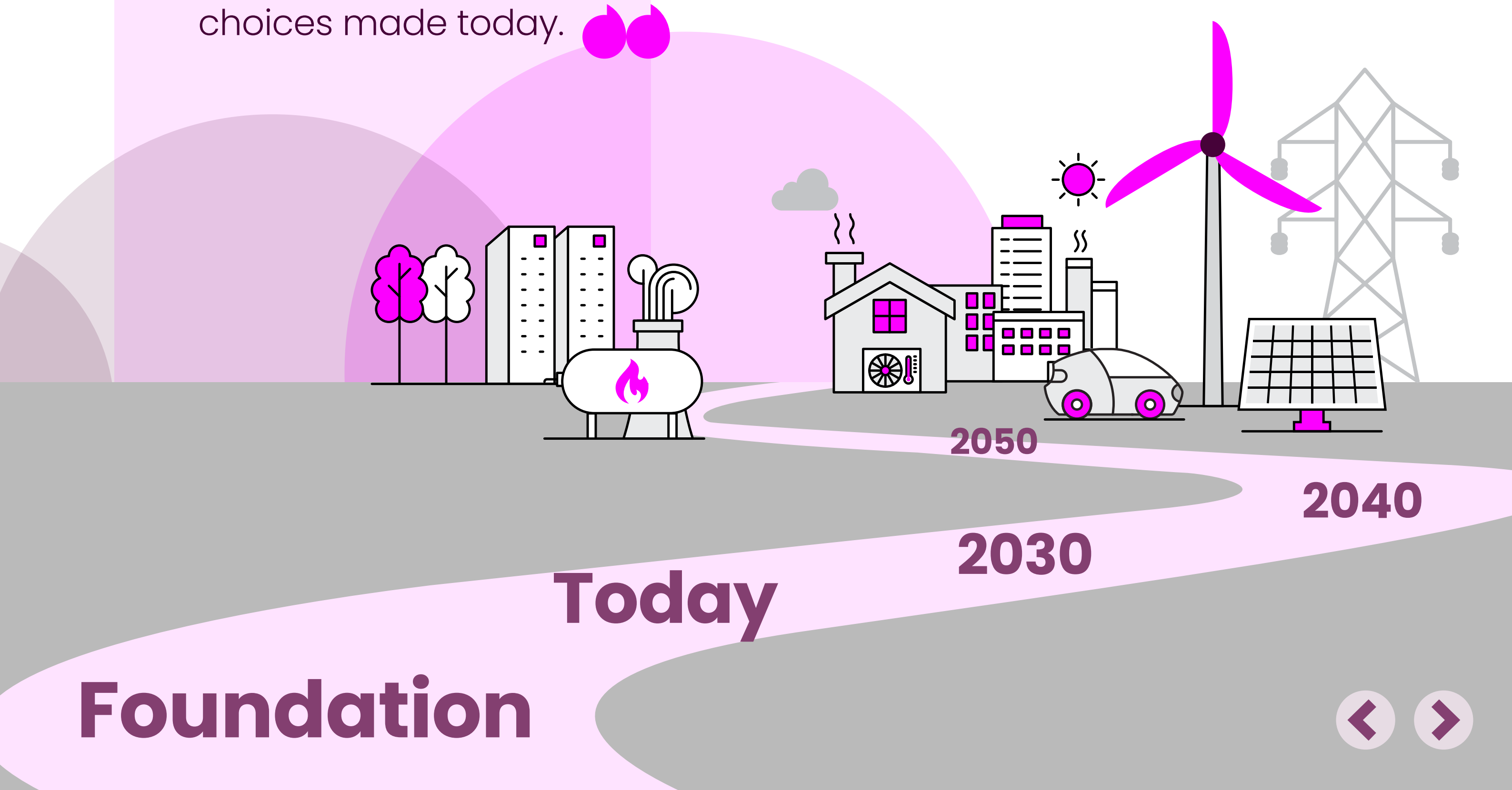
Four waves will shape the route to a resilient, net zero energy system with greater energy independence. Each will have its own defining characteristics and each will set up the progress for the following wave.

The initial foundation wave has already laid much of the necessary groundwork for the transition, such as technology development. We are now in a period of acceleration, scaling up the markets for uptake of new low carbon technologies and delivering clean power. The momentum of rapid action over the next five years will enable a third wave, one that enables energy growth with the rollout of these low carbon technologies and expansion of infrastructure. A final wave will then embed the transition to a long-term, secure and clean energy system to 2050 and beyond.

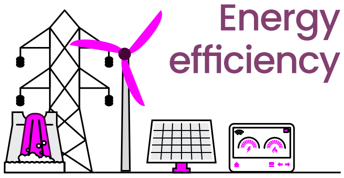
The government's *Clean Power 2030 Action Plan* sets a clear benchmark for the required ambition and represents a critical milestone. While the next few years of the acceleration wave are critical, we must also focus efforts as equally on beyond 2030, looking ahead to future waves and across the whole energy system. All sectors now need to accelerate their efforts to match the clean power pace and ambition.

> We need to consider each wave now.
>
> Success along the route to 2050 depends on the choices made today.

Our *Future Energy Scenarios: Pathways to Net Zero (FES)* explores a range of routes to net zero in 2050 for energy demand and supply by considering the choices that can be made and the uncertainties.



The critical enablers for success fall within four main areas

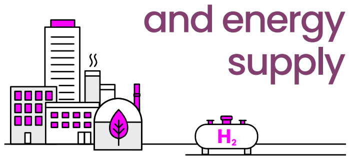


1 Energy efficiency

Energy efficiency can help manage demand growth and will reduce the cost of energy for consumers. Policy and innovation can enable efficiency improvements and adoption of measures across all sectors.

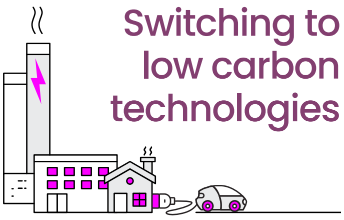
2 Demand flexibility

Greater levels of flexibility offer greater opportunities to make more efficient use of low cost renewable energy. Supply side flexibility provides most of today's flexibility and, while this must continue to grow, complementing this by increasing consumer flexibility can reduce the cost of other forms of flexibility, put consumers in control of their energy use and reduce their energy costs. Making participation effortless and fair would increase confidence in outcomes through consistent positive impact and so is critical for success.



3 Infrastructure and energy supply

Delivering energy security and resilience relies upon an expansion in infrastructure. Helping communities understand how they can directly benefit from clean energy, while recognising the impact of new infrastructure, will help support delivery of this at the necessary pace.



4 Switching to low carbon technologies

Adoption of low carbon technologies will play a vital role in the transition. Great Britain is an engineering powerhouse and harnessing this potential can enable development of electrification, carbon capture and low carbon fuels technologies.

The transition to the new energy era will deliver clean energy but the benefits go beyond securing a decarbonised future. It will mean protection against price shocks. It can offer energy security, national resilience and public trust. It can also unlock local economic growth and jobs.

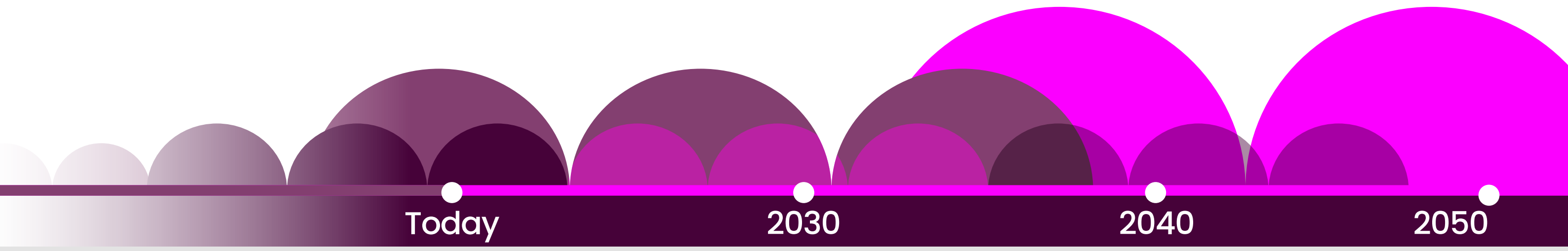
> Robust action now can futureproof this energy era and unlock the opportunities of a clean energy system.

Four distinct waves will shape the new era

The decisions for the future need to be taken now to stay on track

The waves of action

The government's *Clean Power 2030 Action Plan* sets the pace for other sectors to follow. Beyond 2030, this pace must continue to enable deeper decarbonisation and growth, laying the groundwork for the 2050 net zero horizon.



Foundation

The foundation wave.

Much of the progress over the last two decades has laid the groundwork for the transition. The development of key technologies, for example, has built a platform based on cost-competitive renewables, strong performing electric vehicles and emerging heat pump offerings. This progress has ensured a strong starting point for the waves ahead.

Acceleration

The acceleration wave from today to 2030.

Widespread action will define this period through clean power, boosting energy efficiency, driving uptake of low carbon heating and transport, and demand flexibility.

Growth

The growth wave from 2030 to 2040.

Building on the momentum of the acceleration wave, this will see the mainstreaming of clean technologies, expansion of infrastructure and transformation of industry.

Horizon

The horizon wave from 2040 to 2050 and beyond.

This wave will complete the transition. Remaining emissions will be reduced or removed to deliver a net zero energy system that is smart, resilient and built for the long term.

Delivering a clean power system in 2030 is an important milestone but there remains a great deal to do. The next few years are critical, both in making progress and in preparing for the waves to come.

> **Only bold and sustained action in all sectors will unlock the benefits of an affordable and secure, clean energy system. This means matching the ambition and pace of the clean power goal, accelerating progress across the whole energy system and looking beyond 2030.**

This means action to:

	Acceleration (Today–2030)	Growth (2030–2040)	Horizon (2040–2050)
1 Energy efficiency	Implement policy to accelerate widespread adoption of energy efficiency measures	Push forward with efforts to improve efficiency of heat pumps and electric vehicles over time	Maintain momentum on energy efficiency measures and embed optimal operating practices
2 Demand flexibility	Empower households and businesses willing and able to make informed energy choices	Rapid rollout of smart energy solutions, such as using electric vehicles to support the grid and making heating more flexible	Ensure effortless participation
3 Infrastructure and energy supply	Deliver coordinated strategic plans across electricity, gas, bioenergy, hydrogen and CO_2 transport and storage	Build the strategic whole system energy infrastructure at pace, considering electricity, gas, bioenergy, hydrogen and CO_2	Drive continuous innovation to fully realise and maximise the value of a net zero energy system
4 Switching to low carbon technologies	Implement policy to encourage homes and businesses to switch to low carbon energy sources	Deliver mass adoption of low carbon technology and infrastructure to provide certainty for industry	Further reduce reliance on unabated fossil fuels

1. Energy efficiency

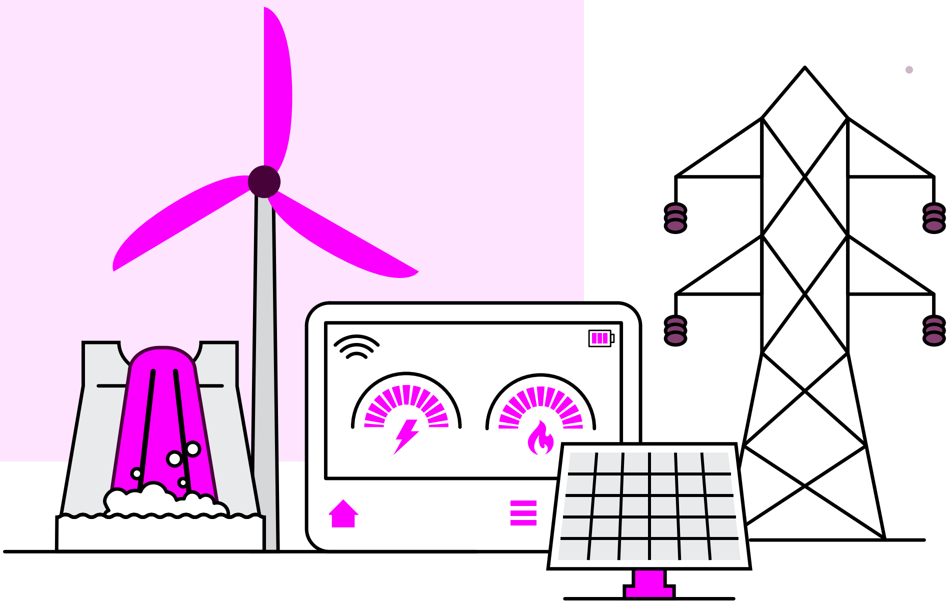
Energy efficiency measures are crucial to managing demand growth. Driving adoption of measures provides near-term benefits by reducing infrastructure needs, cutting emissions and lowering energy costs.

Energy efficiency reduces energy use at all times of the day. Many of these measures, such as thermal efficiency in buildings, reduce emissions in the short term while consumers remain heavily reliant on fossil fuels.

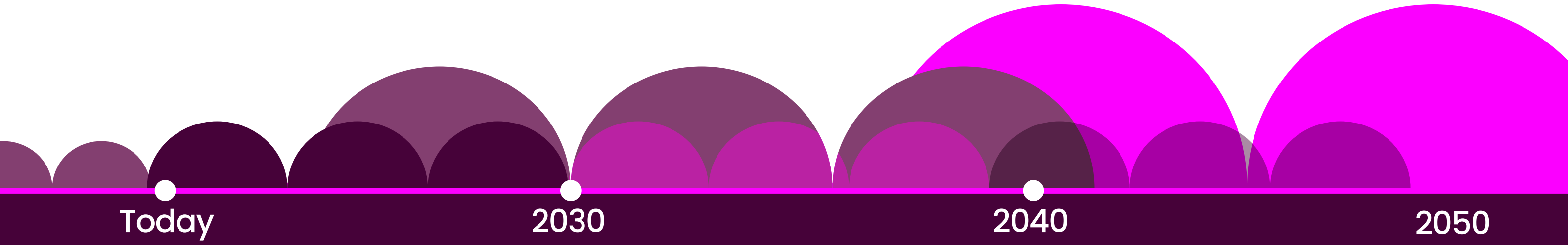
Improvements to energy efficiency of buildings and appliances could cut electricity demand by up to 127 TWh, an 18% reduction in demand from 694 TWh to 567 TWh in 2050.

Clearly communicating the benefits of energy efficiency solutions will encourage efficient operating practices. Affordability of solutions, balancing both upfront costs and long payback savings, must be addressed. Increasing consumer awareness of the range of available options will help boost uptake of higher efficiency products with lower lifetime costs. Heating installers will play an important part in fostering uptake of the most suitable efficient heating systems and insulation. Their engagement will be an important enabler to broader public awareness.

18%
reduction
(2050)



Realising the benefits for homes, businesses and industry requires a renewed focus on energy efficiency across all waves of the transition



Acceleration

Implement policy to accelerate widespread adoption of energy efficiency measures to benefit all consumers.

Driving widespread adoption of current best-in-class efficient appliances. Innovation bodies and industry R&D in efficiency will support this.

Improving insulation for new builds. This will be driven by implementation of the Future Homes Standards without further delay.

Growth

Push forward with efforts to improve efficiency of heat pumps and electric vehicles over time to further reduce the cost of energy for homes and businesses as electricity demand grows.

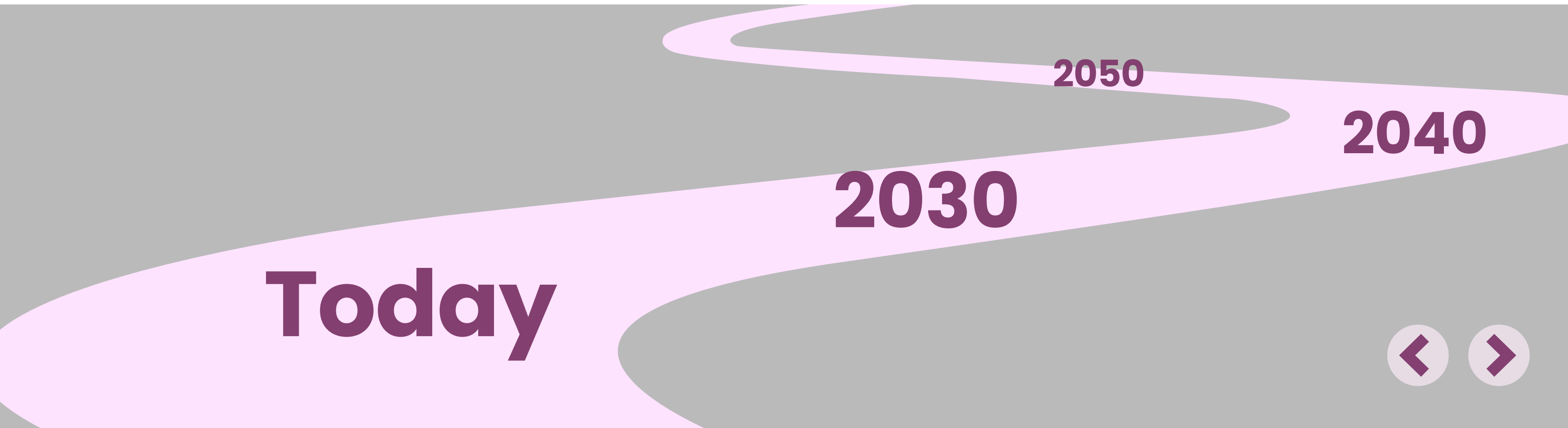
Extending energy efficiency measures. This includes rolling out minimum efficiency standards, similar to those to improve light bulb efficiencies, to other appliances and heat pumps.

Horizon

Maintain momentum on energy efficiency measures and embed optimal operating practices to save money for consumers and manage expected growth in demand.

Continuing support for improving industrial efficiency. This includes the adoption of more efficient equipment alongside ongoing automation and digitalisation to reduce wasted energy.

Unlocking opportunities around more efficient uses of transport. Reducing demand through new technologies such as autonomous vehicles as well as low carbon options, including public transport.



2. Demand flexibility

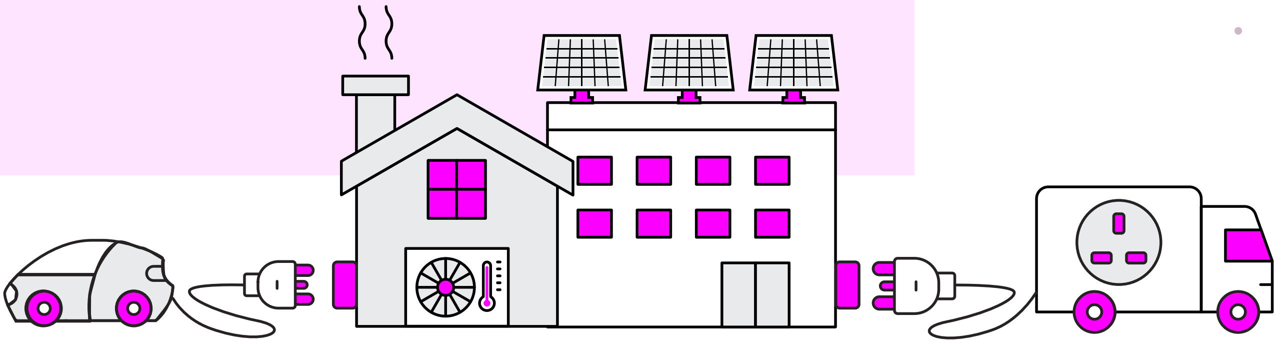
Enabling demand flexibility empowers households and businesses, which can lower consumer costs and accelerate the shift to a cleaner, smarter energy future.

A net zero energy system will rely upon flexibility in both supply and demand. Demand flexibility benefits both consumers and the energy system, getting more from low-cost renewable generation. It can offer households and businesses greater resilience against exposure to volatile prices and help reduce energy costs. Greater uptake of demand flexibility also means less need for infrastructure investment, reducing the deployment of energy storage.

Households and businesses could help reduce peak demand by up to 54% peak demand reduction (2050). Smart charging could shift EV peak demand by 83%, while heat pumps could shift their peak by 36%.

Demand flexibility as a choice. It is important to consider consumers or businesses unable to manually shift energy use (for example, due to work patterns, caring responsibilities or how they operate). Smart technologies and automation can make it easier, but consumer trust that these tools are reliable, secure and on their side is key. Access to demand flexibility relies upon access to low carbon technologies and innovation in smart energy tariffs and offerings.

54%
reduction
by 2050



To unlock the full value of demand flexibility, targeted action is needed now considering all waves of the transition

Acceleration

Empower households and businesses willing and able to make informed energy choices through innovative and flexible energy tariffs.

Developing a clear strategy for targeting different sources of flexibility. The *Low Carbon Flexibility Roadmap* is a first step towards this.

Ensuring consumers can access the value of personal flexibility. Upgrading the energy system (including rapid progress of the Market-wide Half Hourly Settlement) would enable providers to use smart meters to offer better deals based on usage.

Growth

Rapid rollout of smart energy solutions, such as using electric vehicles to support the grid and making heating more flexible, to help consumers use energy flexibly while meeting their needs and working around lifestyles.

Providing consumers with seamless tools that integrate into their daily routines. Through simple, innovative tariffs, consumers will have more control over how and when they use electricity — without needing to be tech experts.

Ensuring a flexible energy system works for all consumers. This means fair and equitable access to low carbon technologies so that no consumer is left behind.

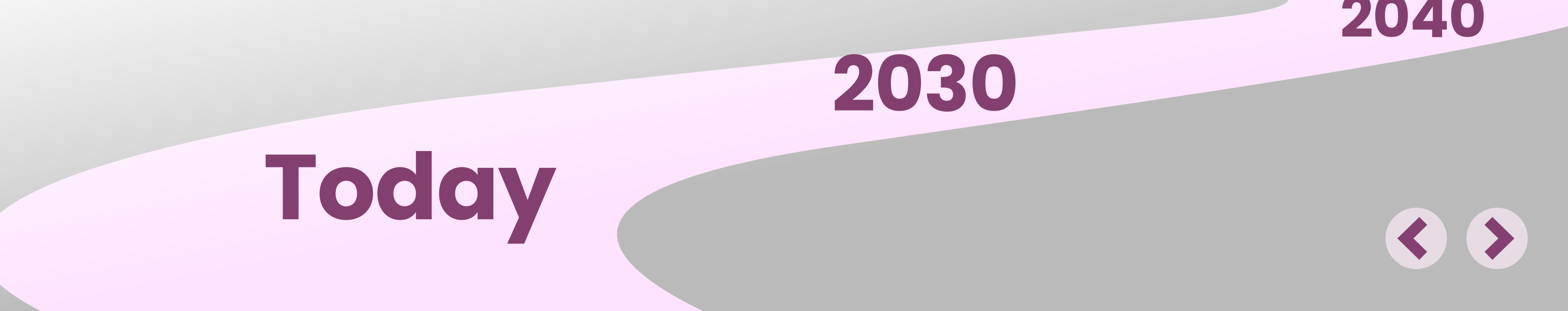
Increasing industrial and commercial participation in demand flexibility. This includes shifting demand with thermal storage for high temperature heat requirements or cooling demand in data centres.

Horizon

Ensure effortless participation with the widespread rollout of user-friendly, smart technology.

Supporting innovation in previous waves has built the foundation for energy products and services in 2050. These will keep consumers engaged, informed and empowered by choice.

Enabling consumers to connect to innovative low carbon technologies and services by unlocking the full potential of low-cost renewable energy. Vehicle-to-grid alone has the potential to supply 41 GW of flexibility at peak.



3. Infrastructure and energy supply

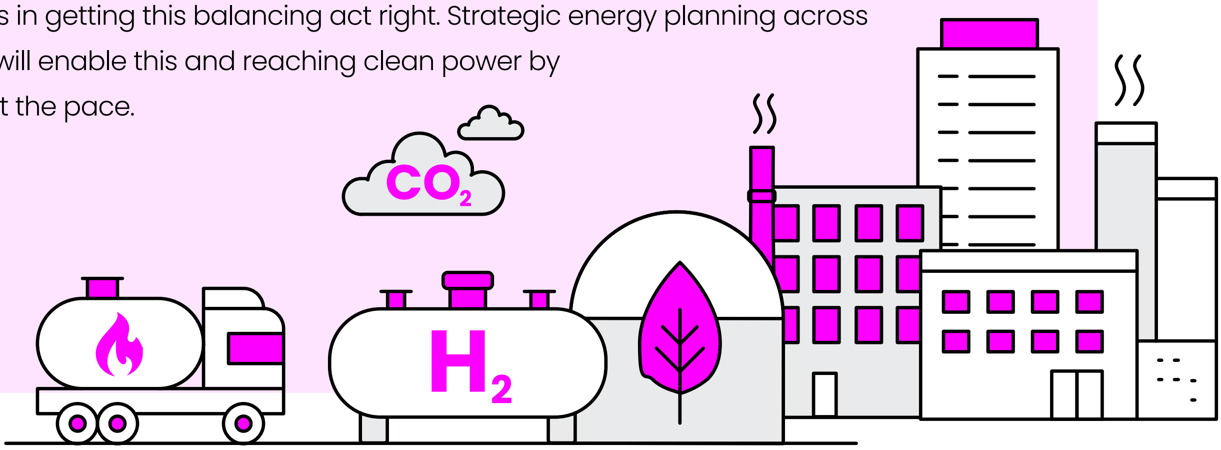
Developing low carbon electricity and hydrogen production, transport and storage infrastructure at pace, alongside carbon capture and storage (CCS) infrastructure, will offer greater certainty for industry and unlock opportunities for private investment and economic growth.

A net zero energy system will look very different to today. It will no longer rely on fossil fuels and will instead need to shift to low carbon fuels and homegrown renewables, transforming how we produce, store and use energy. Electrification of demand increases the efficiency of the whole system, reducing overall system losses. The increased linkage between electricity, gas, hydrogen, bioenergy and carbon necessitates a change in thinking. Coordinated, whole system planning will unlock investment, flexibility and support a faster, more cost-effective transition.

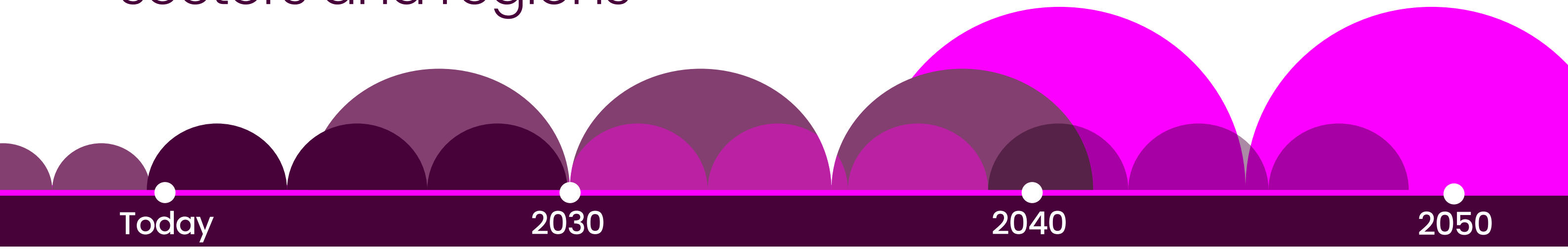
Total installed generation capacity in our pathways increases by 60-73% from today to 2030 and approximately doubles from 2030 to 2050. Low carbon hydrogen production for energy in our pathways increases from zero today to 98-325 TWh by 2050. Delivery hinges on ensuring that the enabling infrastructure, such as networks and storage, are in the right place at the right time.

Establishing the necessary infrastructure at pace not only accelerates decarbonisation but also opens up opportunities for economic growth, supporting new industries, providing certainty to support and attract private investment, creating skilled jobs and powering thriving communities.

Infrastructure must be delivered at pace while carefully navigating public consent. Success lies in getting this balancing act right. Strategic energy planning across all vectors will enable this and reaching clean power by 2030 will set the pace.



Delivering the right infrastructure at the right time requires coordinated action across all sectors and regions



Acceleration

Deliver a clean power system and coordinated strategic plans across electricity, gas, bioenergy, hydrogen and CO_2 transport and storage to provide greater certainty on options.

Optimising cross-vector interactions through strategic energy planning. Considering carbon alongside hydrogen, gas, electricity and bioenergy will provide greater clarity beyond delivery of the first industrial clusters.

Clarifying the optimal use of infrastructure and end-uses across gas, hydrogen and biomethane. This will mean greater certainty over prioritisation of applications and how low carbon gases can work together across the energy system.

Investing in low carbon technology supply chains. Taking action now will de-risk delivery whilst boosting economic growth, creating jobs and strengthening resilience for a fair and competitive transition.

Growth

Build the strategic whole system energy infrastructure at pace, considering electricity, gas, hydrogen, bioenergy and CO_2 to provide access for decarbonisation, delivery of negative emissions and enable economic growth.

Continuing the focus on reforming connections and planning. This will be vital to ensure timely low carbon energy production capacity and provide access to networks.

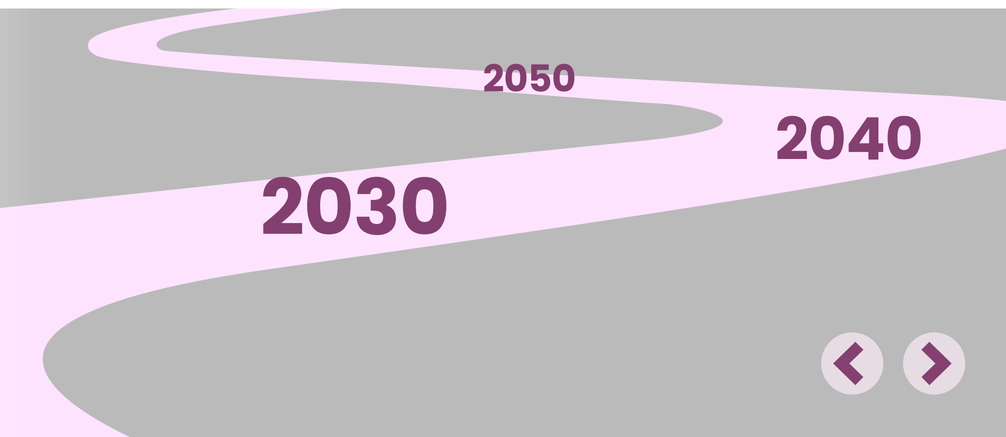
Building infrastructure at pace. Following through on strategic energy plans will deliver the necessary electricity, gas, hydrogen and carbon infrastructure.

Horizon

Drive continuous innovation to fully realise and maximise the value of a net zero energy system. This includes whole system flexibility and delivering around 25 million tonnes of engineered carbon removals by 2050 to offset residual emissions in the economy.

Continuously innovating across the whole energy system and entire value chain. The speed and scale of delivery necessitates innovation which will, in turn, further enable new products and services.

Delivering negative emissions technologies. Innovation in this area will be crucial to achieving net zero in sectors that cannot fully decarbonise by 2050.



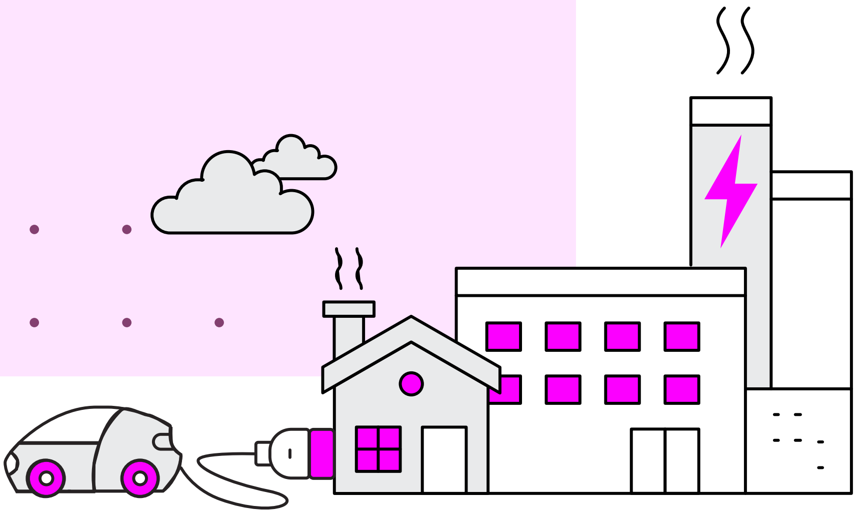
4. Switching to low carbon technologies

Adoption of low carbon technologies is a critical enabler of decarbonisation. The timely transition from high emission energy sources for heat, transport and industry is particularly vital to achieve emissions targets.

Adoption of low carbon technologies enables consumers to reduce direct unabated fossil fuel use while reducing consumer energy demand by 47%.

Infrastructure investment and reducing the price of electricity are crucial considerations for successful uptake of low carbon technologies. Initial investment costs for residential consumers may prevent some from considering the switch to low carbon alternatives, particularly without short-term payback. Businesses also face similar challenges through high capital costs along with uncertainty regarding infrastructure access and system readiness.

47%
reduction
by 2050



Insight from the *Decarbonising Heat: Consumer Choice and Affordability* survey conducted for NESO by Public First can be found on the FES website.

Switching to low carbon fuels at scale won't happen on its own and demands early action and clear direction

Acceleration

Implement policy to encourage homes and businesses to switch to low carbon energy sources and accelerate system-wide adoption by reducing the price of electricity relative to gas.

Reducing energy costs. Reforming the electricity market and addressing high levies will enable this.

EV car uptake is assumed to accelerate to reach 100% of new sales in 2030.

Increasing heat pump rollout. Heat pump installation rates require a 31% year-on-year average increase until the full phase out of new gas boiler installations in 2035.

Growth

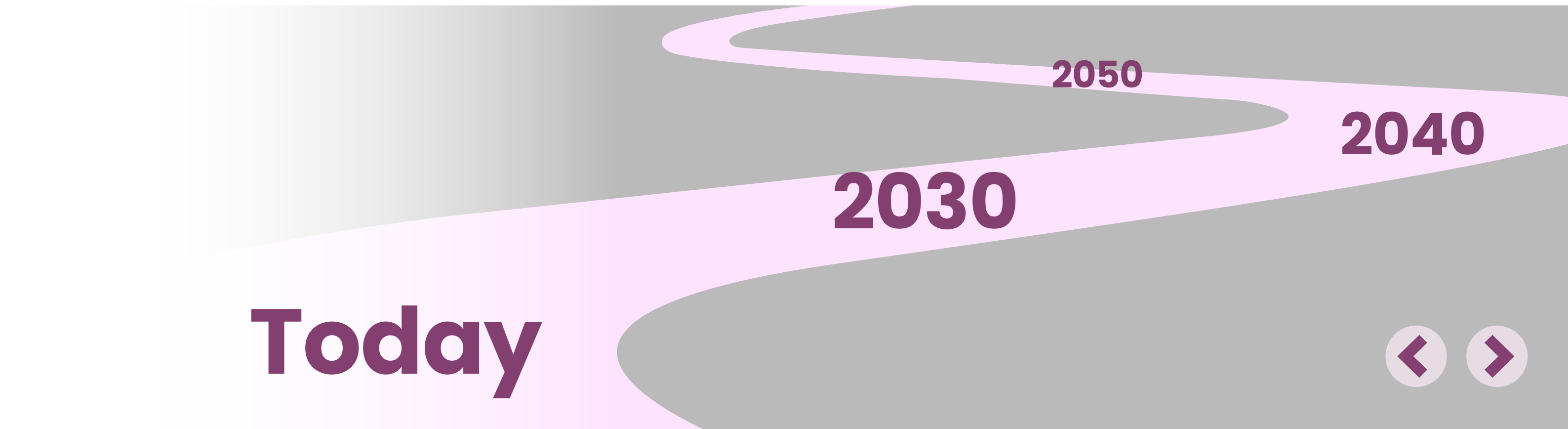
Deliver mass adoption of low carbon technology and provide certainty for industry where investment cycles are longer.

Incentivising decarbonisation of industry. Industrial emissions need to decline rapidly through the 2030s by switching to low carbon fuels and carbon capture and storage (CCS). This will be supported by clear carbon accounting policies for industrial imports of materials and products. This will need to be in place within this decade.

Horizon

Remove remaining reliance on unabated fossil fuels, providing opportunities for reduced energy costs and emissions reductions of 221 million tonnes to 2050.

Completing the switch to low carbon technologies. Careful management of the final switchover from fossil fuels, without leaving consumers behind.

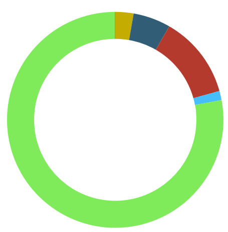
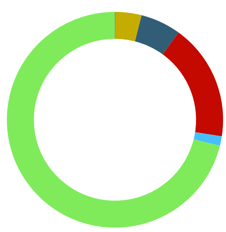
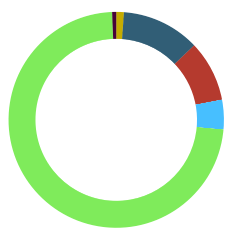
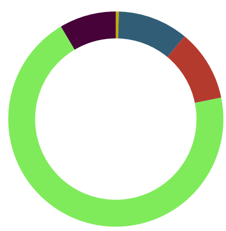
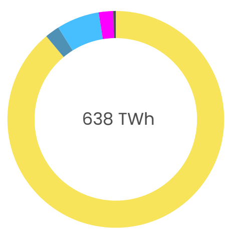
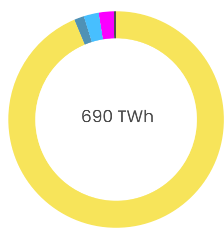
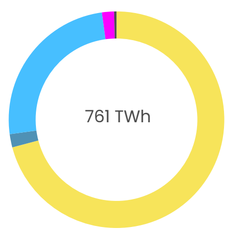
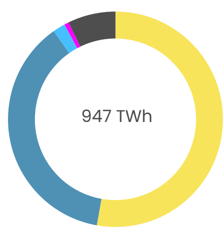


Comparing our pathways

Pathways are narrowing but optionality and uncertainty on the route to net zero remain.

Our pathways consider the different ways Great Britain can reach a net zero energy system and interim emissions reductions along the way. They explore the choices and uncertainty ahead in areas such as the speed of technology uptake, the role of both electrification and low carbon fuels and the level of consumer engagement.

Table 1: Pathways at a glance

	Holistic Transition	Electric Engagement	Hydrogen Evolution	Falling Behind
Pathway descriptor	Net zero is met through a mix of electrification and hydrogen, with hydrogen mainly used around industrial clusters. Hydrogen is not used for heat except as a secondary fuel for heat networks in small quantities. Consumer engagement is very strong through adoption of energy efficiency improvements and demand shifting, with smart homes and electric vehicles providing flexibility. A high-renewable capacity pathway, with unabated gas dropping sharply. Pathway sees moderate levels of nuclear capacity and lowest levels of hydrogen dispatchable power. Supply side flexibility is high, delivered through electricity storage and interconnectors. No unabated gas remains on the network in 2050.	Net zero is met mainly through electrified demand. Consumers are highly engaged in the transition through smart technologies that reduce energy demand, such as electric heat pumps and electric vehicles. Pathway with the highest peak electricity demand, requiring high nuclear and renewable capacities. It also has the highest level of bioenergy with carbon capture and storage across all net zero pathways. Supply side flexibility is high, delivered through electricity storage, interconnectors and low carbon dispatchable power.	Net zero is met through fast progress for hydrogen in industry and heat. Widespread access to a national hydrogen network is assumed. Some consumers will have hydrogen boilers, although most heat is electrified. There are low levels of consumer engagement within this pathway. Hydrogen is used for some heavy goods vehicles, but electric vehicle uptake is strong. Pathway sees high levels of hydrogen dispatchable power plants, leading to reduced need for renewable and nuclear capacities. Hydrogen storage provides the most flexibility in this pathway.	Considers a world where some decarbonisation progress is made against today, but at a pace not sufficient to meet net zero. Used in downstream gas and electricity security of supply processes – it is important that we use Falling Behind alongside the net zero pathways to consider the full range of potential demand levels for possible remaining reliance on unabated fossil fuels. With the current level of low carbon projects in the pipeline and increased policy ambition, we consider some level of progress in areas where there is increased certainty or progress.
Power generation (TWh in 2050)				
Demand (TWh in 2050)				
Hits net zero	Yes	Yes	Yes	No

Renewable | Nuclear | Hydrogen | Electricity | Bioenergy
BECCS | CCS Gas | Unabated Fossil | Gas | Oil

Pathway statistics

Table 2: Key statistics

Emissions	2024	2050			
	10YF	HT	EE	HE	FB
Annual average carbon intensity of electricity (g CO_2/kWh)	118	-25	-37	-7	26
Net annual emissions ($MtCO_2e$)	407	-6	-2	0	187
Electricity	**2024**	**2050**			
	10YF	HT	EE	HE	FB
Annual demand (TWh)[1]	290	705	785	797	559
Electricity demand for heat (TWh)	38	151	183	149	98
Peak demand (GW)[2]	58	120	144	122	107
Total installed capacity (GW)[3]	125	439	450	384	317
Wind and solar capacity (GW)	49	248	248	226	180
Interconnector capacity (GW)	10	22	24	18	17
Total storage capacity (GW)[4]	10	96	81	56	38
Total storage capacity (GWh)[5]	37	205	175	150	149
Maximum Vehicle-to-Grid capacity (GW)[6]	0	81	49	23	9
Natural Gas	**2024**	**2050**			
	TYF	HT	EE	HE	FB
Annual demand, with exports (TWh)[7]	743	168	166	398	640
1-in-20 peak demand (GWh/day)	5214	1382	1671	2603	4693
Residential demand (TWh)[8]	301	3	3	2	204
Imports (TWh)	448	92	155	323	580
Hydrogen	**2024**	**2050**			
	10YF	HT	EE	HE	CF
Annual demand (TWh)	0	120	98	328	18
Residential hydrogen demand for heat (TWh)	0	1	0	69	0
CCS enabled hydrogen production (TWh)[9]	0	45	32	131	5
Electrolytic hydrogen production (TWh)[10]	0	74	67	173	12
Bioresources	**2024**	**2050**			
	10YF	HT	EE	HE	FB
Bioresource demand (TWh)	160	216	191	173	114

1 Customer demand plus on-grid electrolysis meeting GB hydrogen demand only, plus losses, equivalent to GBFES System Demand Total in ED1 of data workbook.
2 Refer to data workbook for further information on winter ACS peak demand.
3 Includes all networked generation as well as total interconnector and storage capacity (including V2G available at winter peak).
4 Includes V2G capacity available at winter peak.
5 Excludes V2G.
6 Less capacity will be available during peak 5-6pm due to vehicle usage.
7 Includes shrinkage, exports, biomethane and natural gas for methane reformation.
8 Residential demand made up of biomethane and natural gas.
9 CCS enabled hydrogen is created using natural gas as an input, with CCS.
10 Electrolytic hydrogen is created via electrolysis using zero carbon electricity (this figure does not include hydrogen produced directly from nuclear or bioenergy).

Costing the pathways

Our net zero pathways see a shift away from operational spend, including significant outlay on imported fossil fuels, towards upfront investment. We will also see a shift in patterns of expenditure away from oil and gas towards the electricity sector.

Cost volatility, while not completely eliminated, will be significantly reduced in the net zero pathways compared to a system that remains reliant on oil and gas.

There are a range of uncertainties and unknowns that will affect the cost of how Great Britain's energy system develops in the future. These include consumer choices, such as the level of consumer engagement in demand flexibility, international conditions, such as the prices of oil and gas, and wider uncertainties, including uptake of AI and other technologies alongside GDP and population growth. These factors are likely to have a significant effect on the overall cost of the energy system in the next decades.

While these factors are not all within the gift of energy stakeholders or the government to control, our work within FES aims to further our understanding of the range of available trade-offs, choices and levers that can be influenced to impact overall cost. This work will then be further progressed in the Strategic Spatial Energy Plan to design energy pathways that are economically and spatially optimised.

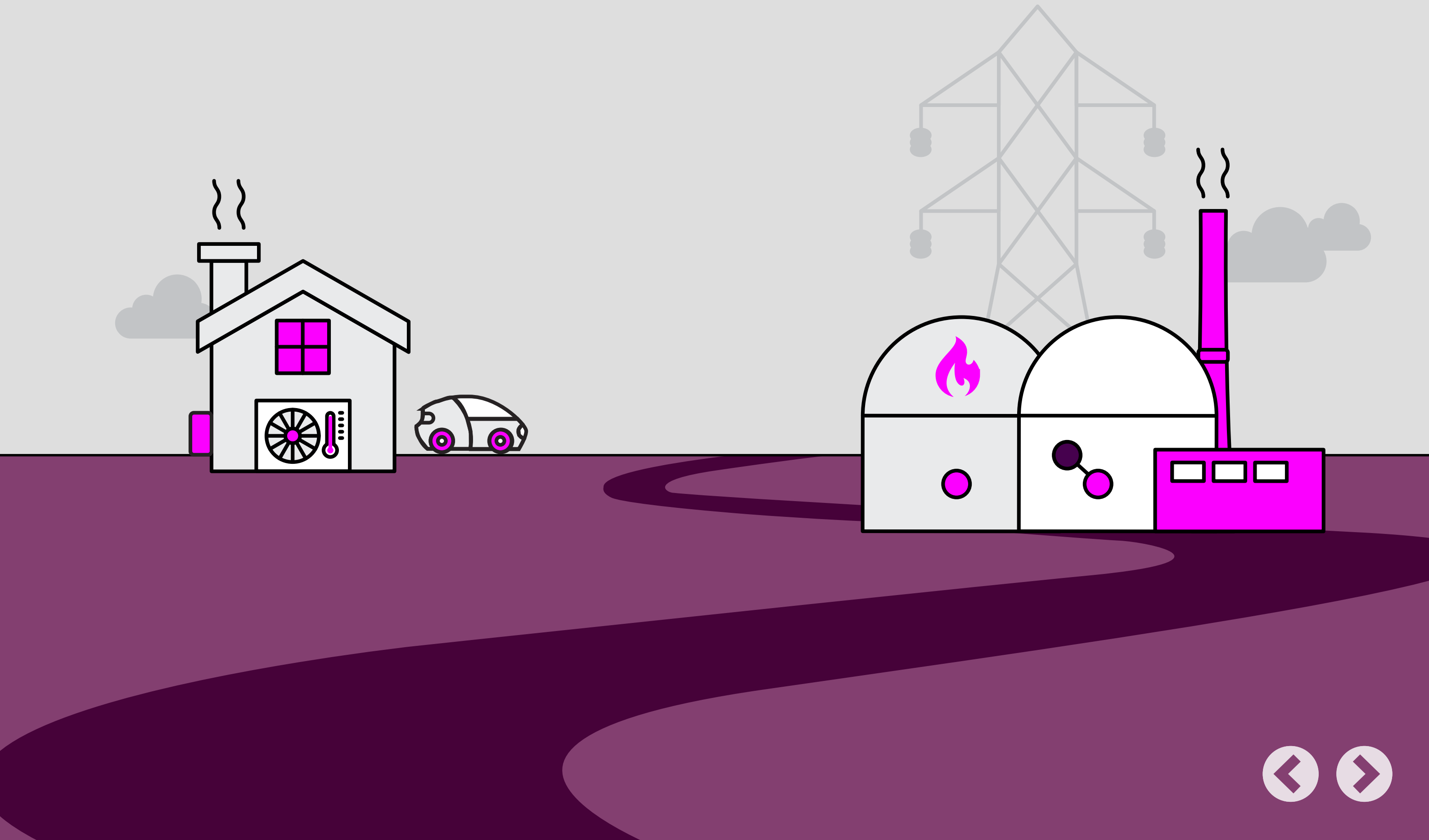
We are currently finalising our costing analysis of the *FES 2025* Pathways and will publish a Technical Annex, with methodology details and costings for each pathway, in 2025.

Each of the net zero pathways sees a sizeable shift in patterns of expenditure in the energy system – from ongoing operational costs, such as fuel purchase and maintenance, to upfront capital investment and from fossil fuels to low carbon electricity. As these patterns change, there is potential to support economic growth, high value jobs and wider environmental and health benefits across Great Britain's economy.

While there will still be some cost volatility in a net zero energy system (for example, spend on energy will be higher in cold years or in years with less wind and sun), this will be materially reduced compared to the existing fossil-based system. In particular, exposure to gas and oil price shocks will be much reduced.

How costs translate to consumers will depend on policy choices that we do not attempt to predict in this report. Policy will also have a key role to play in keeping costs as low as possible and our pathways suggest some priority areas for focus.

1. A New Era of Energy Transition



Unlocking the benefits of a secure, affordable and clean energy system for Great Britain requires bold ambition and progress in energy across all sectors of the economy.

Energy has always been a driver of progress in Great Britain. From the industrial revolution to the commissioning of the super grid, Great Britain has a proud history of innovation. Now, as we enter a smarter and cleaner energy era, leveraging this spirit of innovation and progress once again can unlock its full potential.

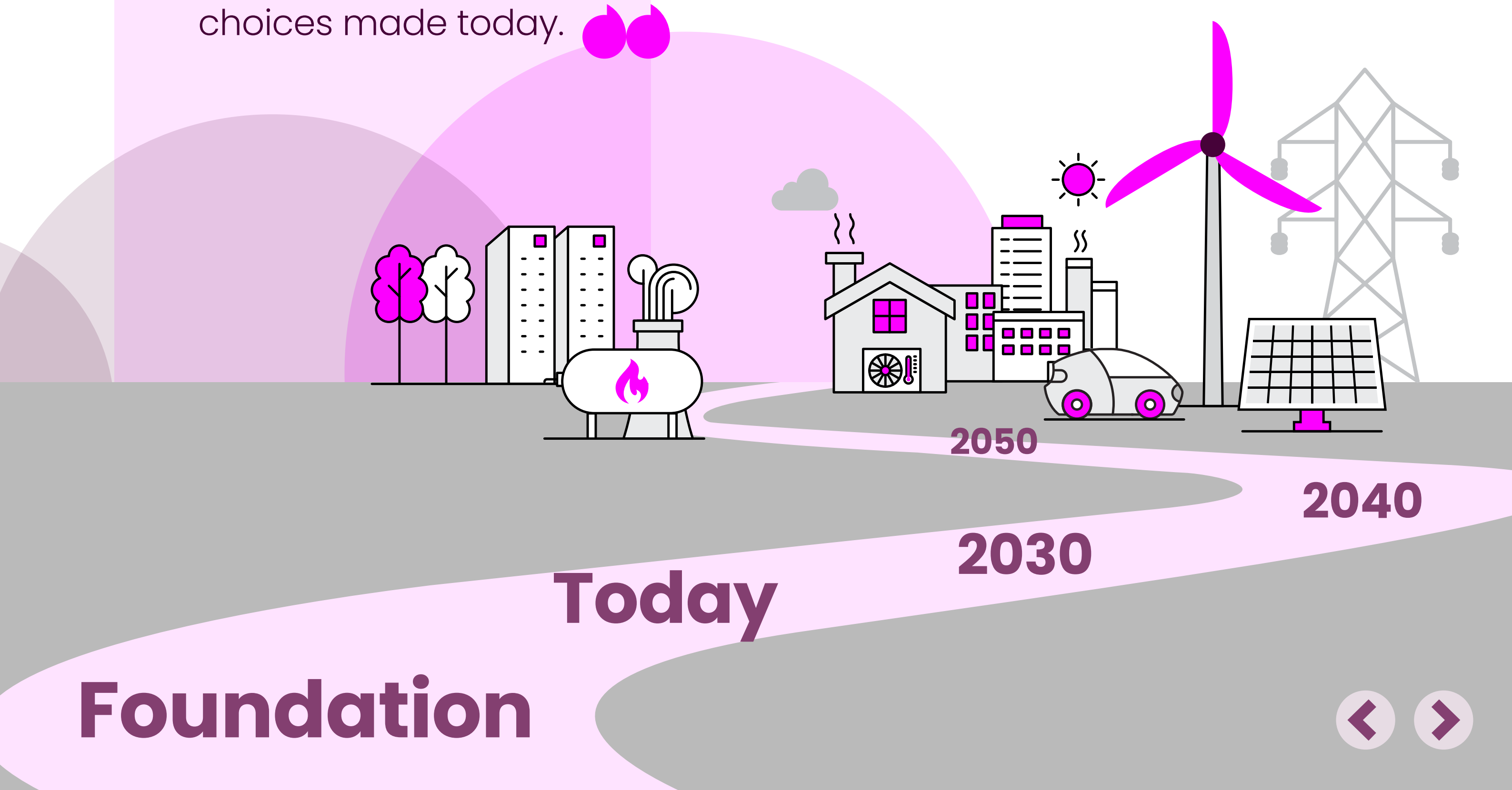
Four waves will shape the route to a resilient, net zero energy system with greater energy independence. Each will have its own defining characteristics and each will set up the progress for the following wave.

The initial foundation wave has already laid much of the necessary groundwork for the transition, such as technology development. We are now in a period of acceleration, scaling up the markets for uptake of new low carbon technologies and delivering clean power. The momentum of rapid action over the next five years will enable a third wave, one that enables energy growth with the rollout of these low carbon technologies and expansion of infrastructure. A final wave will then embed the transition to a long-term, secure and clean energy system to 2050 and beyond.

The government's *Clean Power 2030 Action Plan* sets a clear benchmark for the required ambition and represents a critical milestone. While the next few years of the acceleration wave are critical, we must also focus efforts as equally on beyond 2030, looking ahead to future waves and across the whole energy system. All sectors now need to accelerate their efforts to match the clean power pace and ambition.

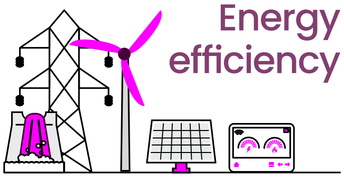
> We need to consider each wave now.
>
> Success along the route to 2050 depends on the choices made today.

Our *Future Energy Scenarios*: *Pathways to Net Zero (FES)* explores a range of routes to net zero in 2050 for energy demand and supply by considering the choices that can be made and the uncertainties.



The critical enablers for success fall within four main areas

1
Energy efficiency

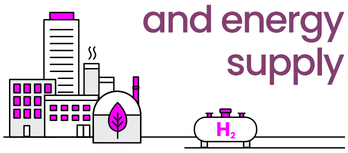


Energy efficiency can help manage demand growth and will reduce the cost of energy for consumers. Policy and innovation can enable efficiency improvements and adoption of measures across all sectors.

2
Demand flexibility

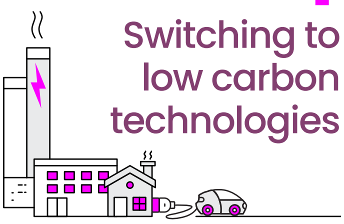
Greater levels of flexibility offer greater opportunities to make more efficient use of low cost renewable energy. Supply side flexibility provides most of today's flexibility and, while this must continue to grow, complementing this by increasing consumer flexibility can reduce the cost of other forms of flexibility, put consumers in control of their energy use and reduce their energy costs. Making participation effortless and fair would increase confidence in outcomes through consistent positive impact and so is critical for success.

3
Infrastructure and energy supply



Delivering energy security and resilience relies upon an expansion in infrastructure. Helping communities understand how they can directly benefit from clean energy, while recognising the impact of new infrastructure, will help support delivery of this at the necessary pace.

4
Switching to low carbon technologies



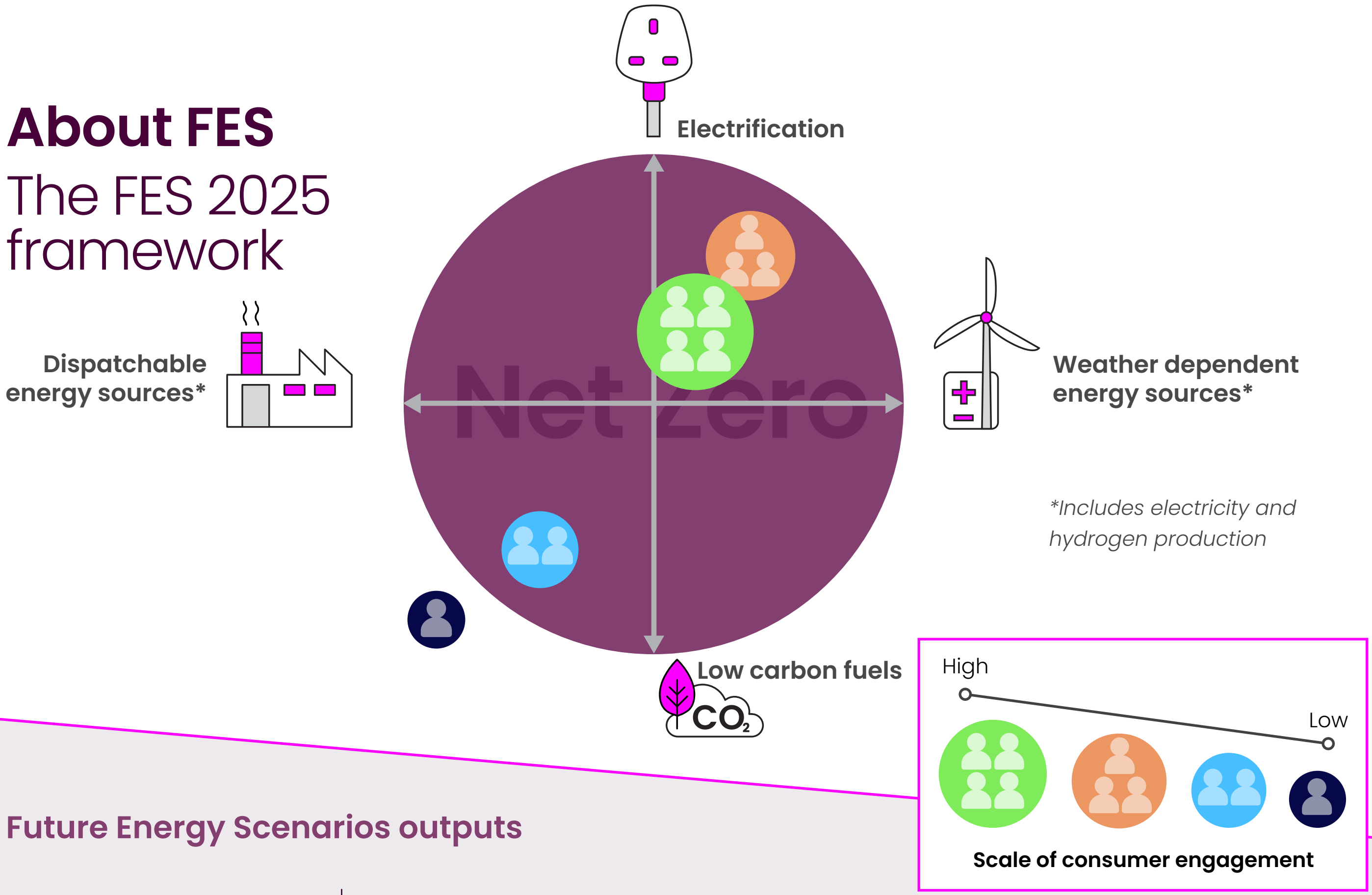
Adoption of low carbon technologies will play a vital role in the transition. Great Britain is an engineering powerhouse and harnessing this potential can enable development of electrification, carbon capture and low carbon fuels technologies.

The transition to the new energy era will deliver clean energy but the benefits go beyond securing a decarbonised future. It will mean protection against price shocks. It can offer energy security, national resilience and public trust. It can also unlock local economic growth and jobs.

> Robust action now can futureproof this energy era and unlock the opportunities of a clean energy system.

About FES

The FES 2025 framework



Future Energy Scenarios outputs

Holistic Transition

Net zero is met in Holistic Transition through a mix of electrification and hydrogen, with hydrogen mainly used around industrial clusters. Hydrogen is not used for heat except as a secondary fuel for heat networks in small quantities. Consumer engagement is very strong through the adoption of energy efficiency improvements and demand shifting, with smart homes and electric vehicles providing flexibility to the grid.

Holistic Transition is a high-renewable capacity pathway, with unabated gas dropping sharply. This pathway sees moderate levels of nuclear capacity and the lowest levels of hydrogen dispatchable power. Supply side flexibility is high, delivered through electricity storage and interconnectors. No unabated gas remains on the network in 2050.

Electric Engagement

Net zero is achieved in Electric Engagement mainly through electrified demand. Consumers are highly engaged in the transition through smart technologies that reduce energy demand, such as electric heat pumps and electric vehicles.

Electric Engagement has the highest peak electricity demand, requiring high nuclear and renewable capacities. It also has the highest level of bioenergy with carbon capture and storage across all the net zero pathways. Supply side flexibility is high, delivered through electricity storage, interconnectors and low carbon dispatchable power.

Hydrogen Evolution

Net zero is met in Hydrogen Evolution through fast progress for hydrogen in industry and heat. Widespread access to a national hydrogen network is assumed. Some consumers will have hydrogen boilers, although most heat is electrified. There are low levels of consumer engagement within this pathway.

Hydrogen is used for some heavy goods vehicles, but electric vehicle uptake is strong.

Hydrogen Evolution sees high levels of hydrogen dispatchable power plants, leading to reduced need for renewable and nuclear capacities. Hydrogen storage provides the most flexibility in this pathway.

Falling Behind

Falling Behind considers a world where some decarbonisation progress is made against today, but at a pace not sufficient to meet net zero.

Falling Behind is used in downstream gas and electricity security of supply processes – it is important that we use Falling Behind alongside the net zero pathways to consider the full range of potential demand levels for possible remaining reliance on unabated fossil fuels.

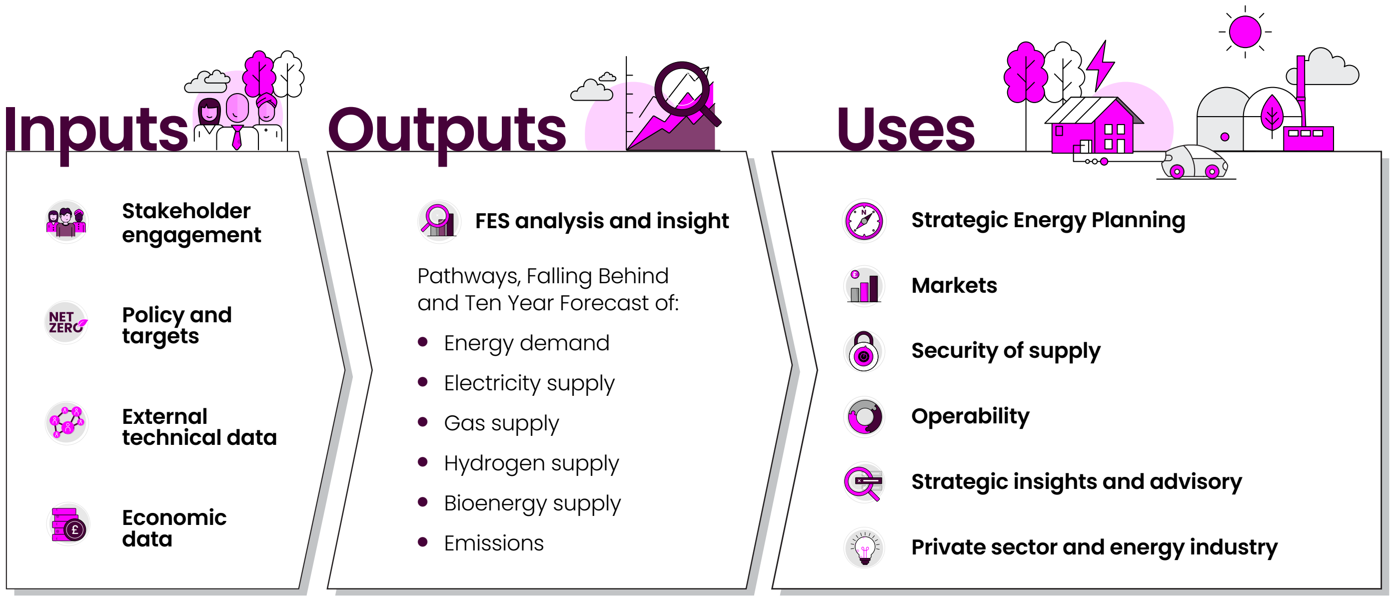
With the current level of low carbon projects in the pipeline and increased policy ambition, we consider some level of progress in Falling Behind in areas where there is increased certainty or progress. It is not a 'status quo' scenario.

FES models energy supply (electricity, gas, hydrogen) and demand (residential, transport, industrial and commercial) out to 2050. Our three net zero pathways explore credible routes to reach net zero. They are not forecasts of what will happen, the lowest cost route or what could happen at the margins of what is possible. They are developed in line with the levers set in the framework.

Alongside these we produce a Falling Behind scenario and Ten Year Forecast (10YF). Falling Behind represents the slowest credible progress towards decarbonisation but does not meet net zero by 2050. This scenario provides a benchmark, highlighting the impact of delayed or insufficient action to decarbonise. The 10YF is used for downstream security of supply planning. It represents our current view of the next ten years, taking account of where we are today, existing project pipelines and action on policy, highlighting potential gaps between stated ambition and delivery. This is the difference between where we are heading compared to where we need to get to and highlights where intervention is most needed.

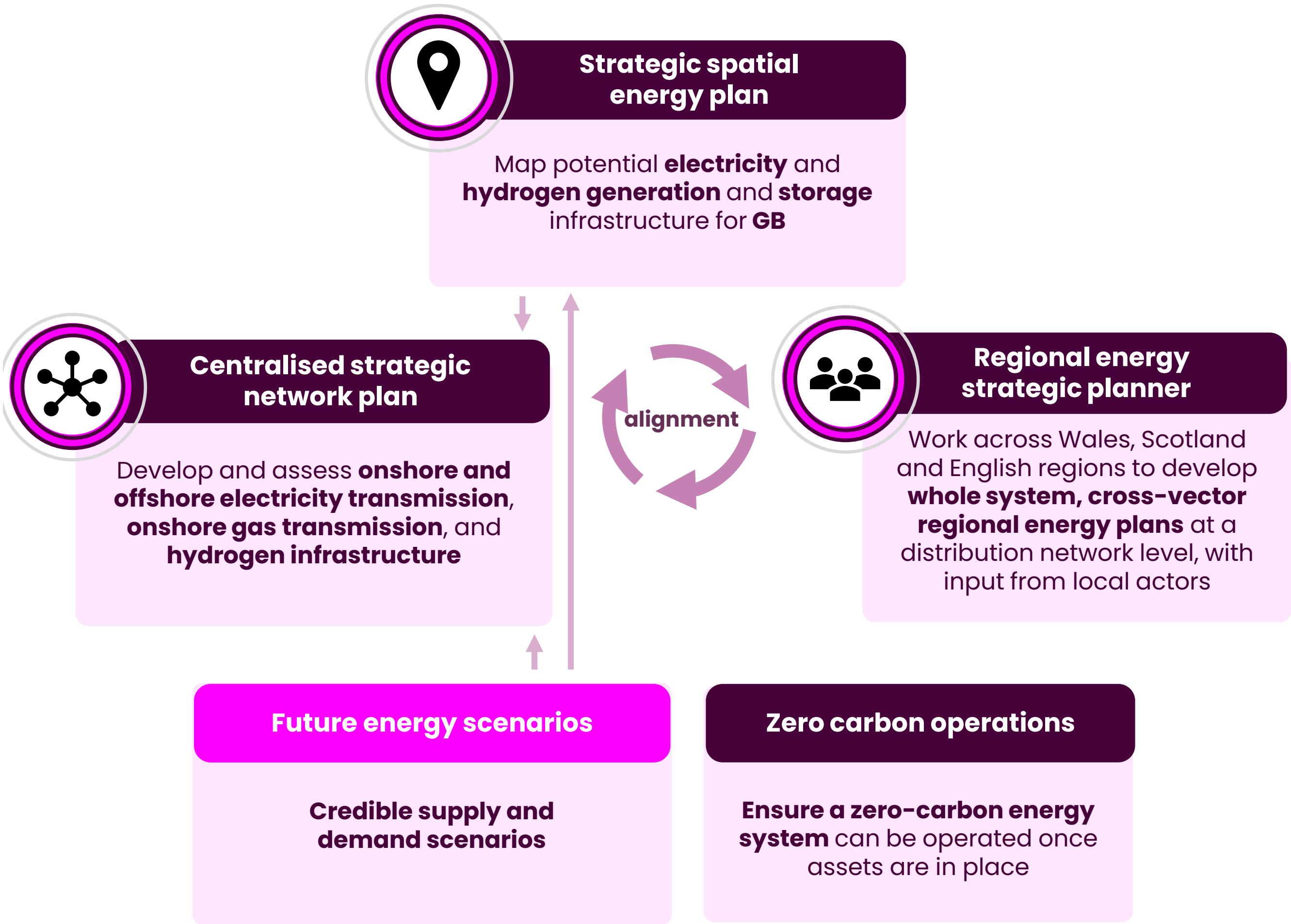
Since *FES 2024*, we have engaged with more than 84 organisations and 144 stakeholders to refine our modelling. For emissions arising from sectors that fall outside our modelling, such as agriculture, land and aviation, we use the Climate Change Committee's (CCC) Balanced Pathway from its recommended Seventh Carbon Budget, published in February 2025. These sectors fall outside the scope of our internal modelling due to their emissions arising largely from non-energy sources or the international share of their emissions.

More detail on our modelling is outlined in our *Modelling Methods* document, published on the FES webpage.



Future Energy Scenarios and Strategic Energy Planning

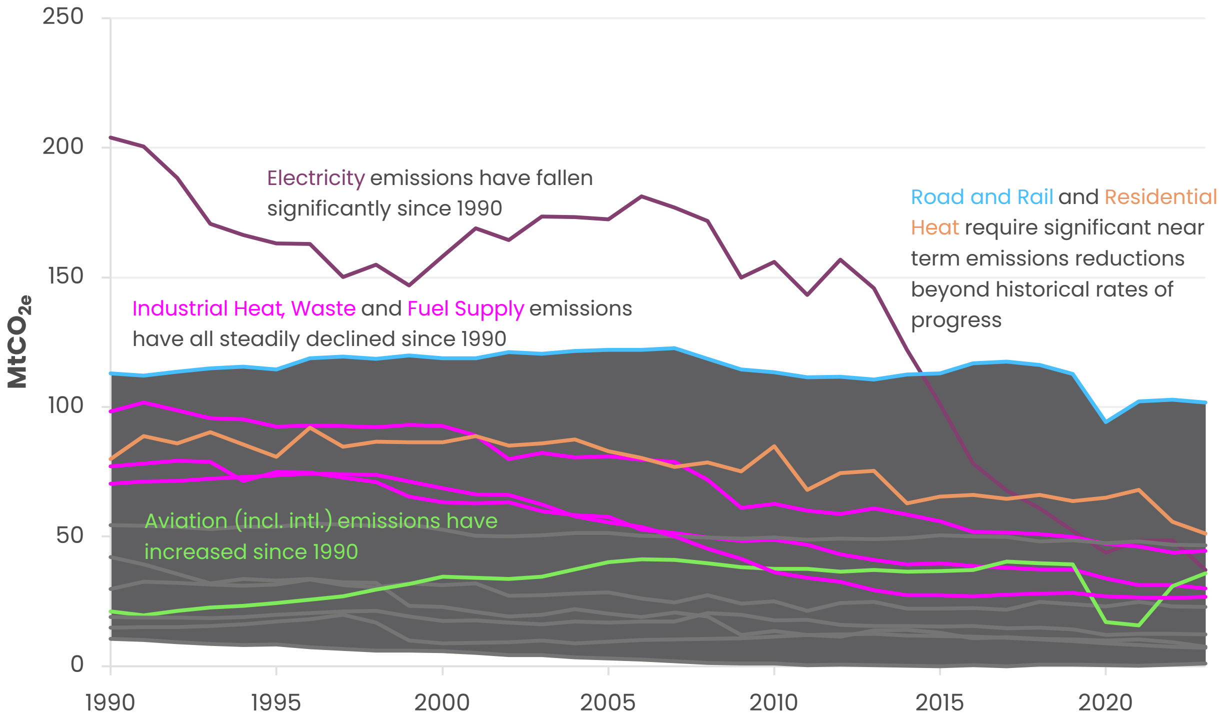
FES 2025 provides an independent view of how energy demand, supply, flexibility and emissions could evolve from today to 2050 on the route to net zero. It remains an important input for strategic planning to cover longer term uncertainty when developing and assessing onshore electricity, gas and hydrogen infrastructure. For further information, refer to page 165.



Decarbonisation to date

Our pathways show that a net zero energy system is possible with timely and coordinated action. Challenges remain but, with the right investment, planning and public engagement, the transition can secure a decarbonised energy system while unlocking wider economic and social benefits.

1. Electricity is the fifth largest sector for emissions and has been a major driver of decarbonisation to date. Other sectors must now pick up the pace.



Decarbonisation of the power sector has driven most of the progress on emissions reductions to date and, as more sectors electrify, low carbon electricity will continue to enable widespread emissions reduction across Great Britain. However, between now and 2035, around 85% of emissions reductions must come from outside the power generation sector.

Benchmarking Great Britain's pathway to net zero

Rapid and deep decarbonisation is required across all sectors starting now if we are to achieve carbon budgets and Nationally Determined Contributions (NDCs).

Nationally Determined Contributions

As part of the Paris Agreement, the UK submits an NDC emissions reduction target to the secretariat of the United Nations Framework Convention on Climate Change (UNFCCC) every five years. The UK has submitted an NDC for 2030 and 2035.

Carbon budgets

Carbon budgets are a legally binding cap on cumulative UK greenhouse gas emissions over five-year periods, set 12 years in advance. The CCC presents independent advice to government on the size of each carbon budget required to maintain sufficient progress towards net zero. The government then decides whether to adopt this advice as a legally binding target. In February 2025, the CCC delivered its advice for the recommended Seventh Carbon Budget (2038-2042). The government will decide by June 2026 at what level to set the Seventh Carbon Budget.

How does FES benchmark against NDCs and carbon budgets?

FES considers the decarbonisation of Great Britain's energy system. Carbon budgets and NDCs are scoped to cover UK-wide emissions, with NDCs also including Crown Dependencies but excluding international aviation and shipping emissions. When evaluating our pathways against NDCs and carbon budgets, we assume Northern Ireland's emissions in energy sectors follow the trajectory set out in the CCC's Northern Ireland's Fourth Carbon Budget report (March 2025). For UK-wide emissions not modelled in FES we use the CCC's recommended Seventh Carbon Budget Balanced Pathway. The only exception to this is the waste sector, where we model energy from waste as a subset of the CCC's waste sector.

All pathways achieve the Fourth and Fifth Carbon Budgets if efforts are accelerated. However, these were set under the Climate Change Act 2008's initial target of an 80% reduction in greenhouse gas emissions by 2050, relative to 1990 levels.

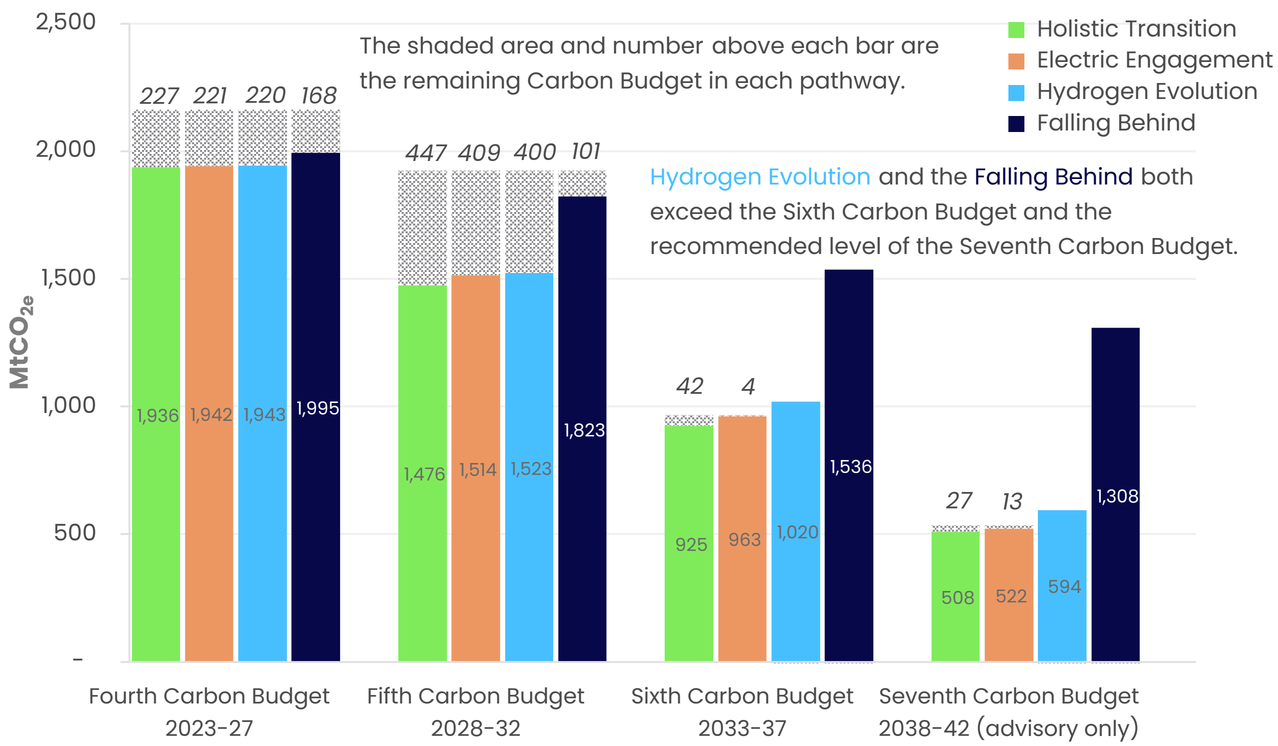
The Sixth Carbon Budget was the first carbon budget set with the net zero target in sight and the first to be set following the 2019 amendment to the Climate Change Act. This updated the 80% target to one of net zero greenhouse gas emissions in 2050. Holistic Transition and Electric Engagement both achieve the Sixth Carbon Budget. Deep decarbonisation efforts are needed now across all sectors to achieve this and to make headway towards the recommended Seventh Carbon Budget.

Emissions throughout the Sixth Carbon Budget period have an even more challenging position than modelled in *FES 2024*. We have adopted assumptions in line with recent trends for future demand for gas heating, with a third of suppressed heating demand from the energy price crisis having returned in 2024. We have also used revised future emissions profiles from non-energy sectors from the CCC's recommended Seventh Carbon Budget's Balanced Pathway. These include lower net greenhouse gas removals over the next decade from the forestry sector. These factors, and other smaller changes, make achieving the Sixth Carbon Budget even more challenging compared to *FES 2024*. However, the fact that two pathways achieve the Sixth Carbon Budget, with differing assumptions and technologies, demonstrate it is an achievable goal with some choices over the precise pathway.

Some additional actions would be required for Hydrogen Evolution to achieve the Sixth Carbon Budget. These could include some or all of the following: higher levels of engineered carbon removals, such as bioenergy with carbon capture and storage (BECCS), lower heating emissions (for instance, due to milder winters in the 2030s as a result of climate change) or taking steps to further reduce emissions in sectors that fall outside our modelling, such as agriculture or aviation. As we need to explore a range of BECCS deployment levels in our pathways, they have not been increased solely to achieve the targets in Hydrogen Evolution.

The CCC provided advice on the recommended level of the Seventh Carbon Budget (2038-42) in February 2025. Government will make a decision on the level at which to set the Seventh Carbon Budget by June 2026. Hydrogen Evolution misses the CCC's recommended level for the Seventh Carbon Budget for similar reasons to why it misses the Sixth Carbon Budget. As with the Sixth Carbon Budget, similar actions could be applied to bring Hydrogen Evolution towards the recommended level of the Seventh Carbon Budget, such as increased use of engineered carbon removals.

2. The Sixth Carbon Budget is the first carbon budget set after the net zero target and presents a significant challenge on the route to net zero. The groundwork must be laid now to meet this.



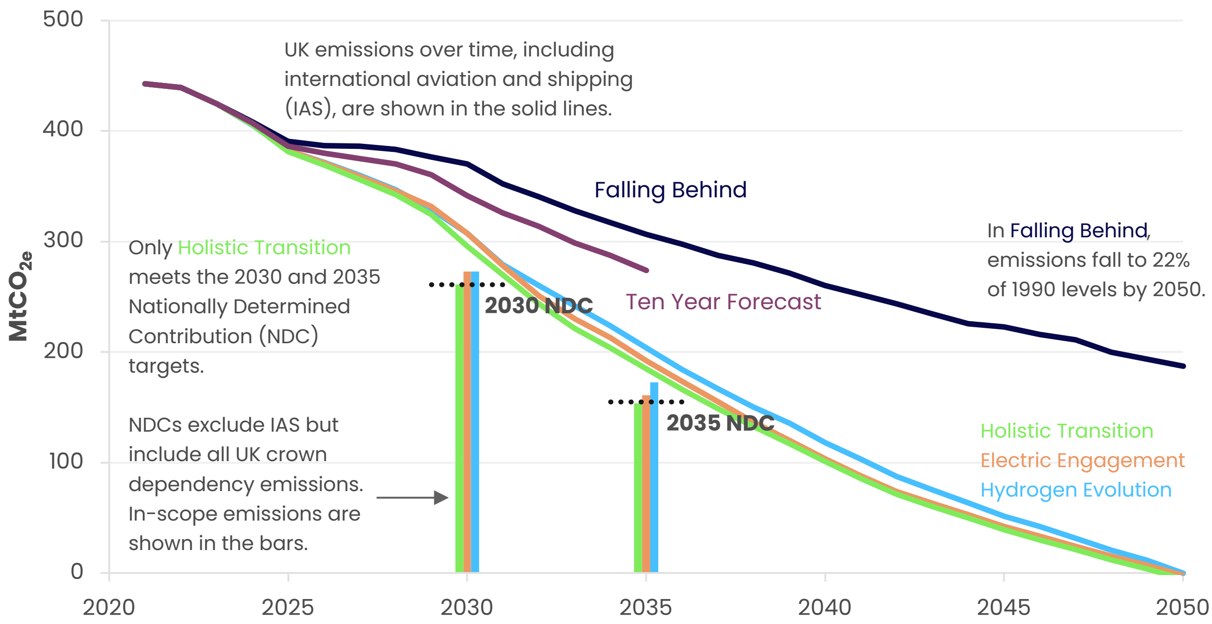
As with *FES 2024*, Holistic Transition is the only pathway achieving the 2030 NDC. Both Electric Engagement and Hydrogen Evolution miss this target by 12 $MtCO_2e$. Holistic Transition achieves this target through more rapid use of different decarbonisation approaches: biomethane injection into gas grids, carbon capture and storage (CCS) in industry and energy from waste and higher levels of biofuel blending in road transport fuels in 2030 instead of 2032 under the renewable transport fuel obligation.

In early 2025, the government set the 2035 NDC at an 81% reduction in greenhouse gas emissions compared to 1990 levels. Holistic Transition is the only pathway that meets this. Electric Engagement misses this target by 6 $MtCO_2e$ and Hydrogen Evolution misses it by 17 $MtCO_2e$. The reasons behind the larger gap in Hydrogen Evolution are similar to why it misses the Sixth Carbon Budget. Larger, quicker deployment of engineered carbon removals such as BECCS in Hydrogen Evolution would help narrow the gap to the 2035

NDC to one more like that seen in the Electric Engagement pathway. Additional drivers for Holistic Transition meeting the 2035 NDC are similar to why it achieves 2030 NDC: higher utilisation of biomethane and a more rapid use of CCS in industry and energy from waste.

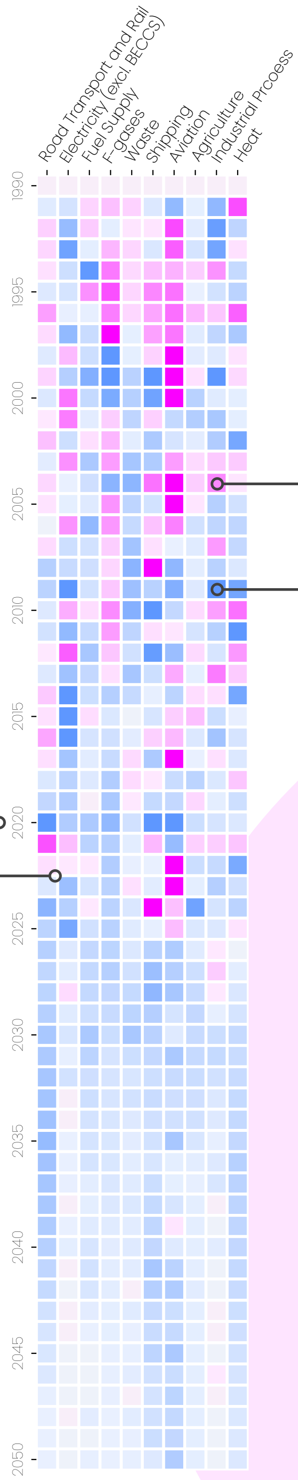
While the NDCs are not legally binding targets, they do reflect important benchmarks towards emissions reductions. Our pathways explore a range of possibilities but do not represent the only routes forward. Only one pathway meets both NDCs, reinforcing that pace is required across all sectors to rapidly reduce emissions.

3. **The 2030 NDC reflects a 68% reduction in territorial greenhouse gas emissions compared to 1990 levels. As of the end of 2023 (latest historical final figures), we have achieved a 53% reduction.**



All sectors must continually reduce their emissions almost every year from 2025.

4. This heatmap shows percentage year-on-year changes in emissions, relative to 1990 levels. Data from 2025 onwards uses Holistic Transition.



Pink corresponds to where sector emissions are higher than the previous year.

Blue corresponds to where sector emissions are lower than the previous year.

The only year since 1990 where every sector has reduced their emissions is 2020, due to COVID.

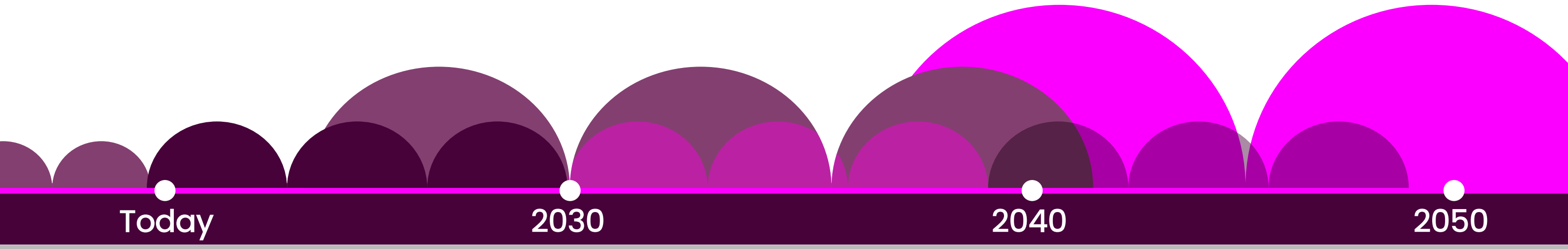
There were significant emission swings during and after COVID, for example in aviation.

A whole system, whole economy ambition

2. Shaping Energy: The Consumer

Shaping Energy: The Consumer

Our pathways see the pace of switching to low carbon technologies increase, with greater uptake of heat pumps and EVs alongside the decarbonisation of industrial and commercial sectors. Energy efficiency improvements and demand flexibility reduce consumer costs and help manage the system.



WHAT NEEDS TO HAPPEN IN OUR PATHWAYS

Acceleration

Driving widespread adoption of energy efficiency measures, including improved insulation standards for new builds

Driving early participation in demand flexibility and innovative tariffs

Removing barriers for homes, businesses and industry (including addressing high electricity prices relative to gas) to enable switching to low carbon energy sources

EV car uptake is assumed to accelerate to reach 100% of new sales in 2030.

Increasing heat pump rollout, with installation rates requiring an average 31% year-on-year increase in the 2020s, supported by workforce skills and training in low carbon technologies

Growth

Phasing out of all new installations of gas boilers from 2035

Switching to low carbon energy sources and carbon capture and storage (CCS) to enable rapid decline of industrial emissions in the 2030s

Increasing minimum energy efficiency standards for heat pumps and appliances

Providing clear information for consumers on good operating practices

Horizon

Converting harder-to-decarbonise areas to low carbon solutions, leaving no consumers behind

Reducing demand through new technologies such as autonomous vehicles as well as low carbon options, including public transport

Deploying innovative technology (such as vehicle-to-grid) at mass scale and at pace

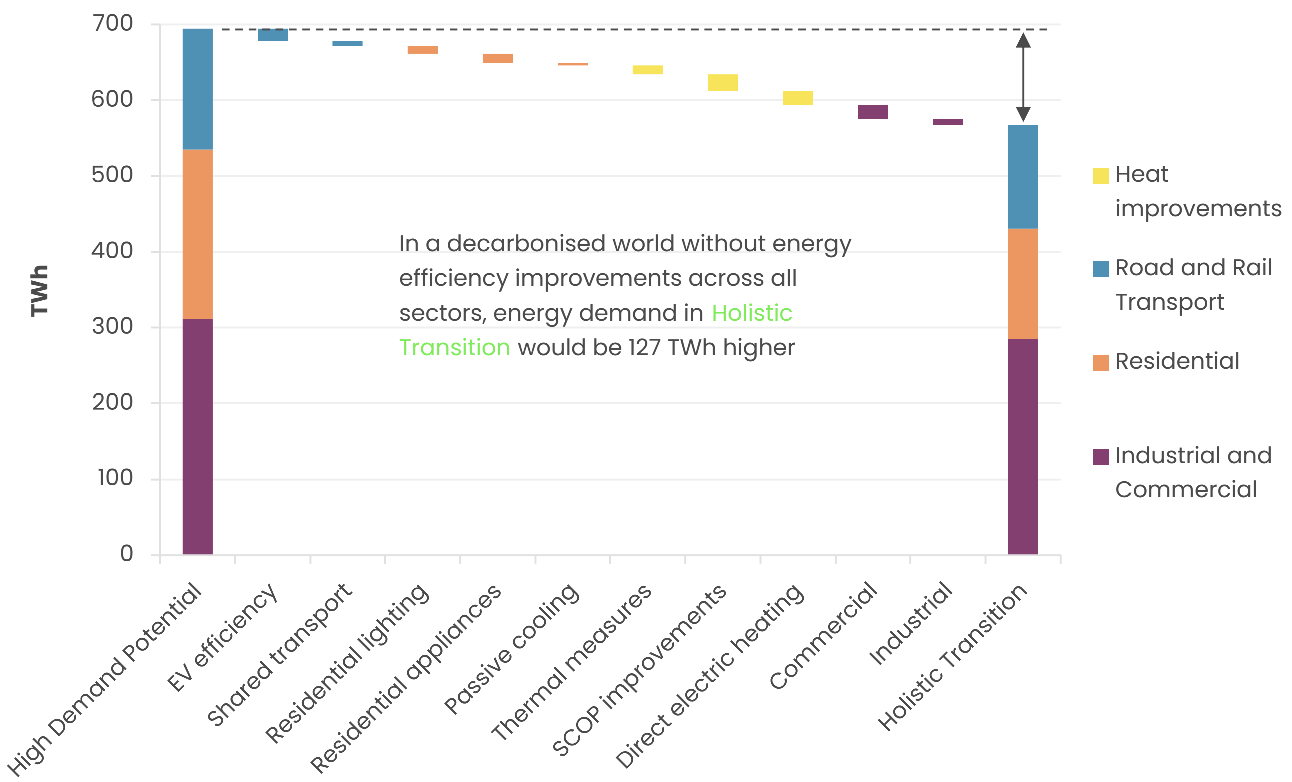
Reducing energy demand and costs through energy efficiency

Energy efficiency measures could reduce demand for every hour of the year. Insulation measures in buildings heated by gas contribute to Holistic Transition achieving the 2030 Nationally Determined Contribution (NDC) but measures are more than just insulation. Heat pump efficiency, LED light bulbs, appliances and EV efficiency each have potential to improve over time.

All measures reduce annual demand, peak demand, transmission and distribution network build out requirements, and capacity requirements.

Growing the use of shared transport, public transport, cycling and walking contribute to demand reduction. Using low carbon district heating or heat pumps wherever possible, as an alternative to direct electric heating systems, helps build a more efficient system while reducing the risk of fuel poverty. Insulation improvements in buildings also increase the duration for which homes can maintain comfortable conditions for consumers while operating heating systems flexibility.

5. Energy efficiency measures across all consumer sectors reduce 2050 electricity demand and consumer costs.



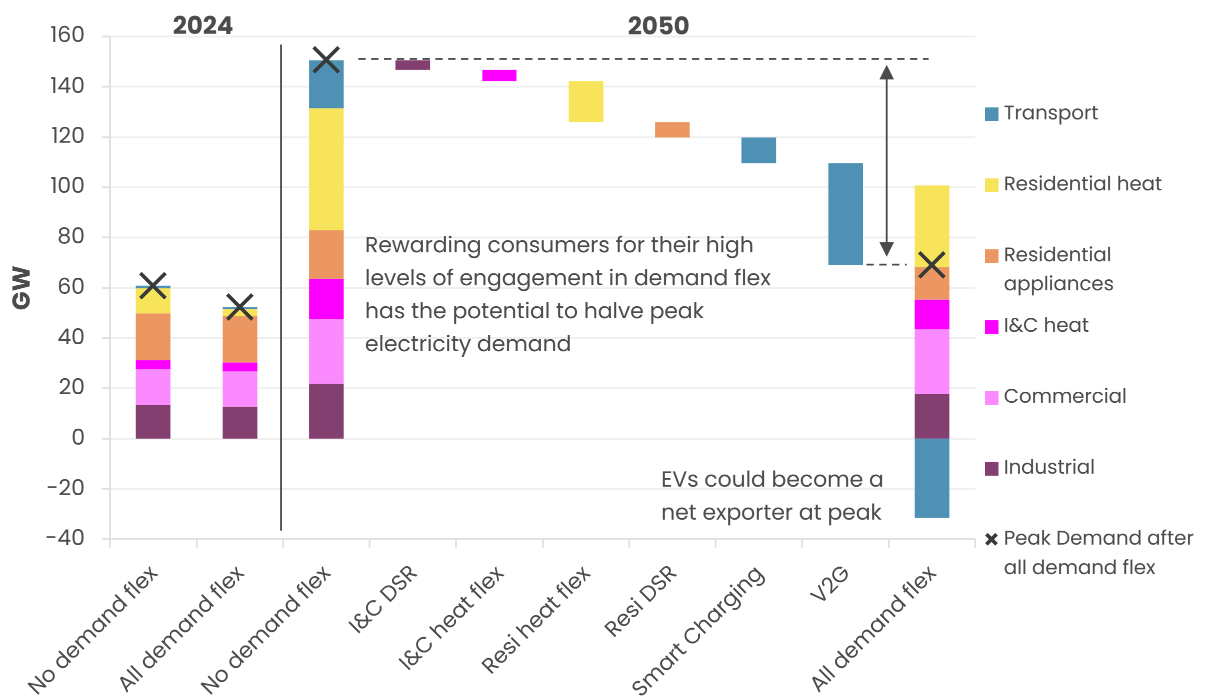
Harnessing demand side flexibility to benefit both consumers and the system

A net zero energy system will rely upon flexibility in both supply and demand. Demand flexibility puts consumers in control of their energy use and our pathways see this enabling up to a 54% reduction in peak demand in 2050, helping build a more resilient system.

Today's peak demand is largely due to residential lighting and appliances (such as cooking) overlapping with industrial and commercial demand in the early evening. Greater levels of electrified heating and transport contribute to future peak demand in our pathways, alongside growing electrified industrial and commercial demand.

Fair access to the cost savings made through demand flexibility will require equitable access to low carbon technologies. Automating demand flexibility allows for more optimal and effortless shifting of transport and some heat demand. Making smart tariffs the default option for EV owners can reward flexibility while allowing automation of charging and, over time, heating systems. EVs could be the largest source of flexibility capacity across supply and demand, providing 51 GW at peak. After partial discharging at peak, vehicles could still be fully charged by the morning without compromising their owners' driving experience. They should be the focus for flexibility, particularly given the average battery size relative to average weekly mileage. This engagement from consumers with EVs and smart tariffs encourages flexibility of heat pumps and other appliances away from peak times, such as dishwashers, washing machines and tumble driers. Industry and commercial can also offer flexibility in shifting non-time critical demand. Thermal storage could shift electrified high temperature and cooling demand, such as data centres, alongside growing flexibility from large refrigerators. At times of high demand and low renewable generation, greater levels of demand side flexibility can be dispatched; on days of surplus renewable generation, demand turn up can provide a productive use of this low-cost energy. In an environment of high energy prices, flexibility offers opportunity for real savings for consumers and businesses.

6. Demand flexibility reduces both peak electricity demand and the need for supply side infrastructure.



Switching to lower carbon fuels to drive decarbonisation and build security of supply

Switching to low carbon fuels can increase energy security by reducing fossil fuel imports and can, with flexible demand, reduce consumer bills. In our pathways, it can achieve more than 50% of whole-economy decarbonisation but the speed of adoption is crucial for meeting carbon budgets and NDCs.

All heating solutions installed in our pathways from 2035 are low carbon to meet carbon budgets and to prevent replacement of systems before end of life. Heat pumps, whether residential or district heating, are the solution for most buildings by 2050 across the pathways. In Holistic Transition, direct electric heating is only used where more practical or economical to do so and will often incorporate storage to minimise peak demand.

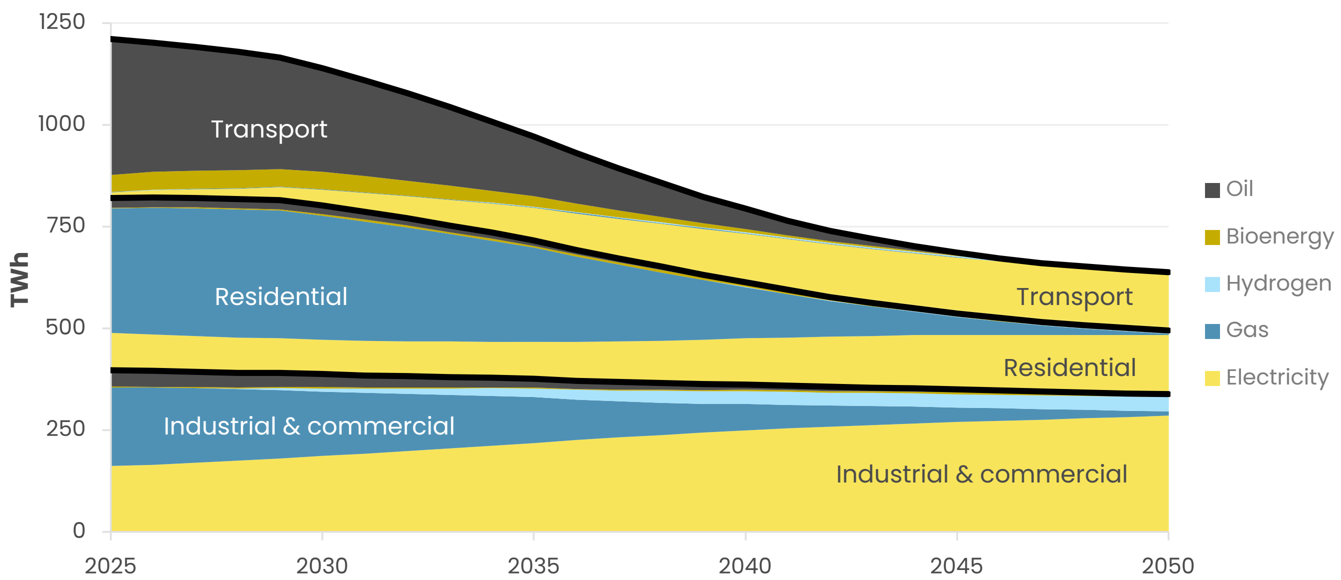
Road transport is the largest emissions sector today and has the greatest potential to drive emissions reductions to meet the 2030 Nationally Determined Contribution (NDC). All new car sales in 2030 in our pathways are EVs, requiring a current acceleration rate greater than current policy. Electrification is the main solution for road transport in our pathways, although hydrogen could play a role in larger HGVs in the 2040s.

While much of industry needs to electrify, the sector faces challenges including capital investment, high electricity prices and electricity connection times. Connection reform will help speed up connections for those ready to connect. The release of the government's *Modern Industrial Strategy* in June 2025 will help towards reducing the cost of electricity for some industry.[11]

Those unable to electrify could switch to other low carbon alternatives such as hydrogen, abated gas or biomethane but uncertainty remains over both the availability of hydrogen and CO_2 infrastructure outside the initial industrial clusters and the volume of biomethane available.

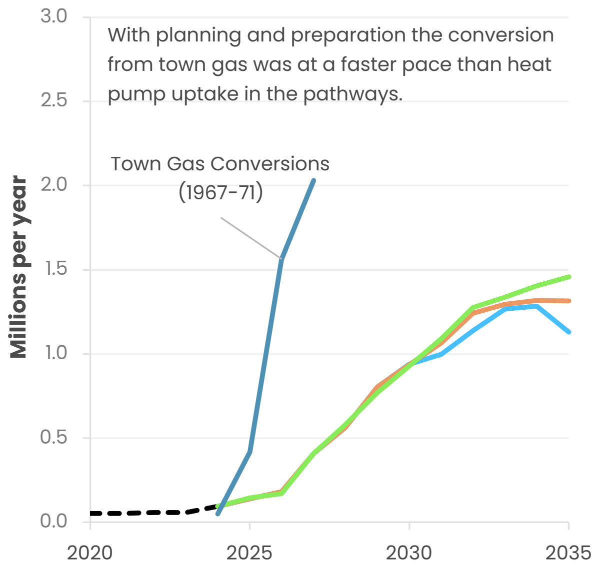
Replacing fossil fuels with more efficient electrified technologies is the main reason primary energy demand reduces by 47% from 1210 TWh to 638 TWh in Holistic Transition.

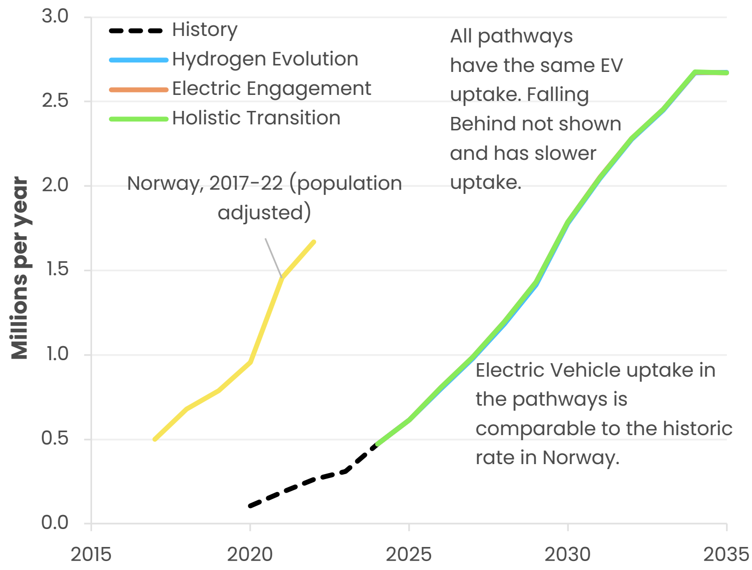
7. Electrification offers improved efficiency compared to today's fossil fuel technologies, facilitating demand reduction alongside decarbonisation.



11 *The UK's Modern Industrial Strategy 2025*, Gov.uk, 23 June 2025

8. Our pathways see rapid adoption of low carbon technologies across transport, heating and industrial and commercial sectors. While ambitious, there is precedent for success.



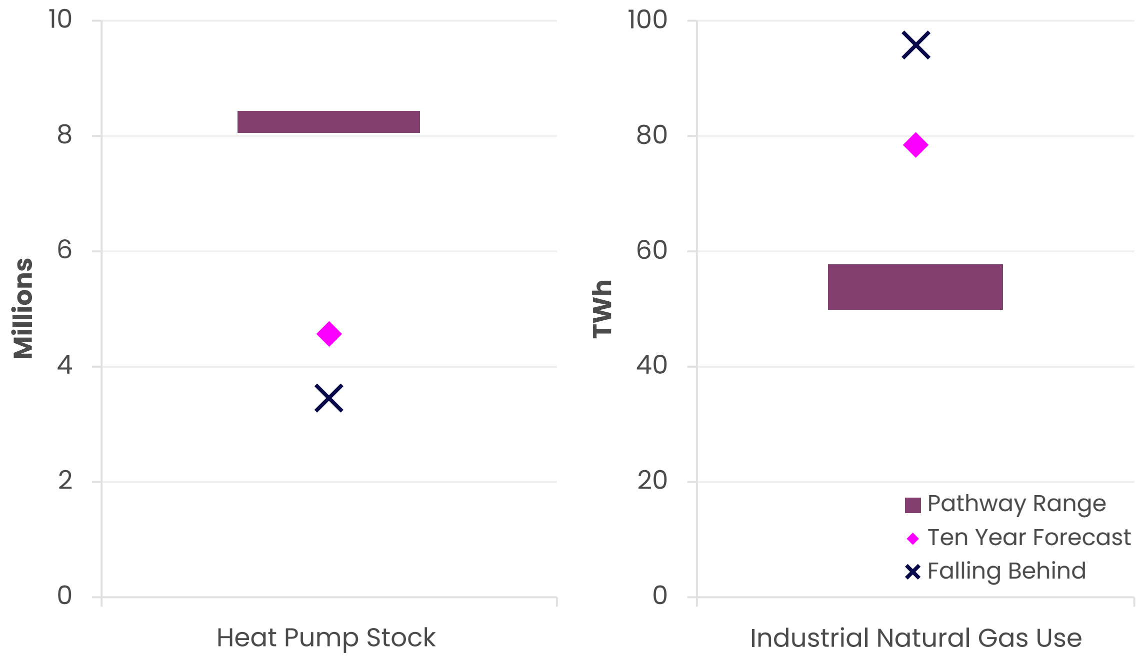


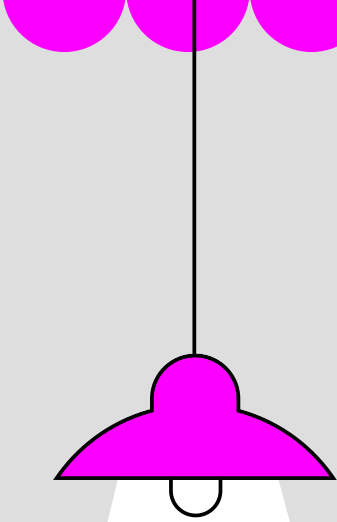
Our pathways see transport, heating, industrial and commercial sectors rapidly changing how they use energy. These transitions require a step-up from current rates, comparable to the town gas conversion in the 1960s and 1970s, adoption of EVs in Norway or heat pumps in Sweden and Finland.

Switching to low carbon fuels and technologies is crucial in all our net zero pathways. The Ten Year Forecast (10YF) has a shortfall of almost 4 million heat pump installations relative to the pathways in 2035 if progress is not accelerated. Heat is a challenging, but essential, area and a variety of measures are required to close this gap. Implementing strong policy to further incentivise heat pump uptake, such as the full phase out of new gas boiler installations in 2035, maintaining the Boiler Upgrade Scheme grant until this point, enacting the Future Homes Standard with no further delay, improving consumer and installer awareness around heat pumps, innovating with new financial and technical solutions to enable distress purchases, and reducing the gap between electricity and gas prices.

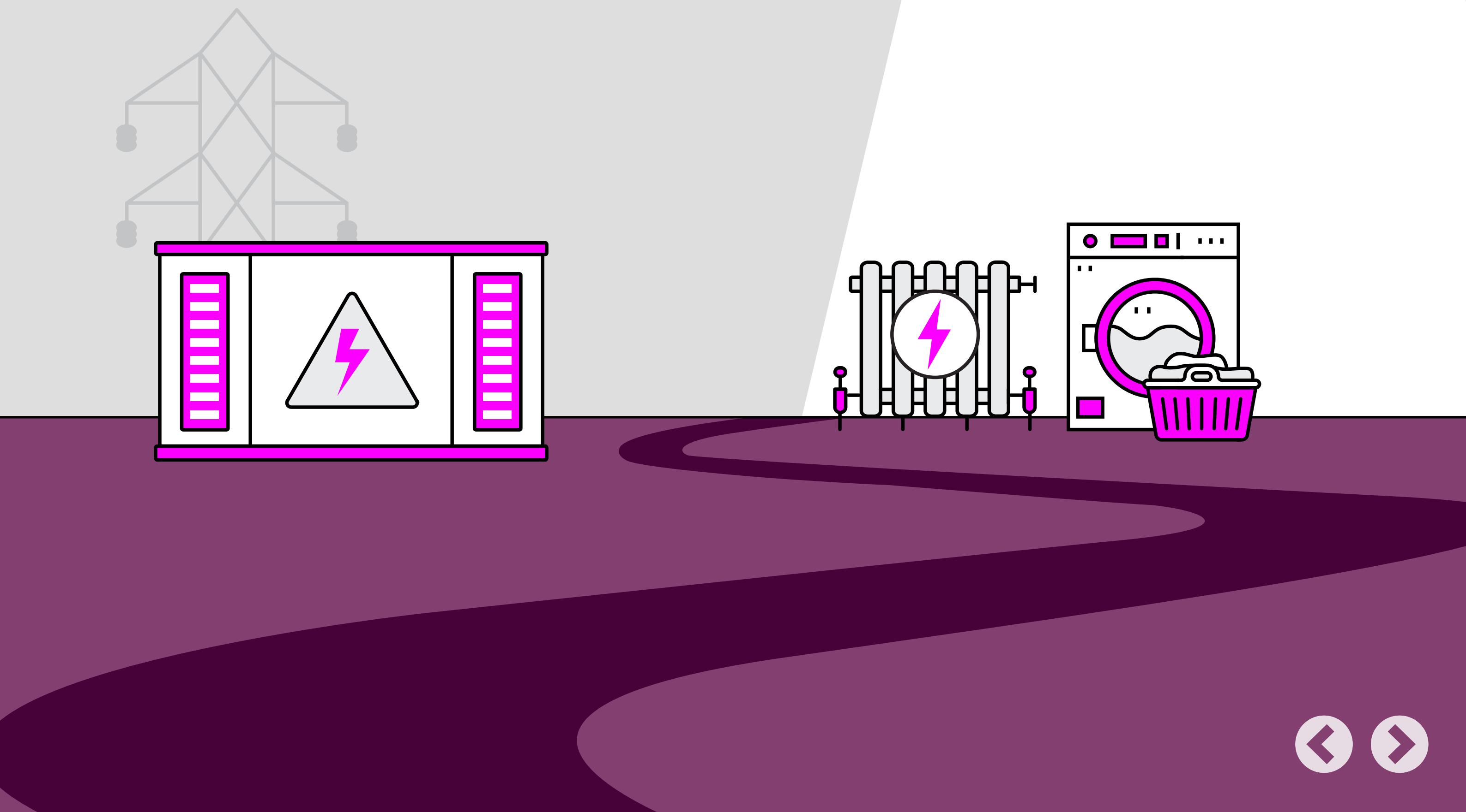
The 10YF also shows that, at the current pace, industry is unlikely to switch from natural gas to low carbon alternatives at a sufficient rate. Rebalancing electricity and gas prices and speeding up grid connections will support this, alongside strategic consideration of where to target and enable the use of hydrogen and CCS for other users. Some industry may face high upfront costs to transition to low carbon fuels and further support may be required. The industrial energy transition needs to be guided by clear long-term carbon accounting policy for industrial imports of materials and products which, in turn, makes electricity, hydrogen and abated gas more economical than unabated gas, while ensuring Great Britain remains an attractive economy for industry.

9. Ten Year Forecast Comparison in 2035



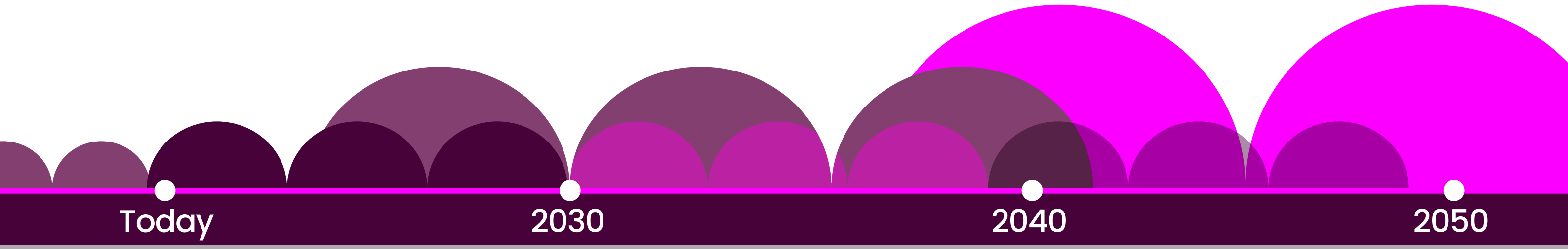


3. Powering the System: Electricity Supply



Powering the System: Electricity Supply

All pathways see significant growth of offshore and onshore wind, together with high levels of solar deployment. Flexible technologies also grow to power the country at times of low renewable generation.



WHAT NEEDS TO HAPPEN IN OUR PATHWAYS

Acceleration

Delivering strategic plans across electricity, gas, hydrogen and CO_2 transport and storage to ensure the build out of renewable and flexible technology at pace and scale

Implementing the reformed connections process and planning to enable deployment of low carbon energy capacity and access to networks

Developing the workforce and skills needed to build assets and infrastructure

Growth

Building strategic whole system energy infrastructure, considering electricity, gas, hydrogen, bioenergy and CO_2 to provide access to decarbonisation, deliver negative emissions and enable economic growth

Utilising renewable oversupply to enable deployment of flexible demand when energy cost is at its lowest

Reforming markets to drive efficient investment and operation

Horizon

Increasing long-duration energy storage (LDES) and low carbon dispatchable power to allow decarbonisation of the remaining demand

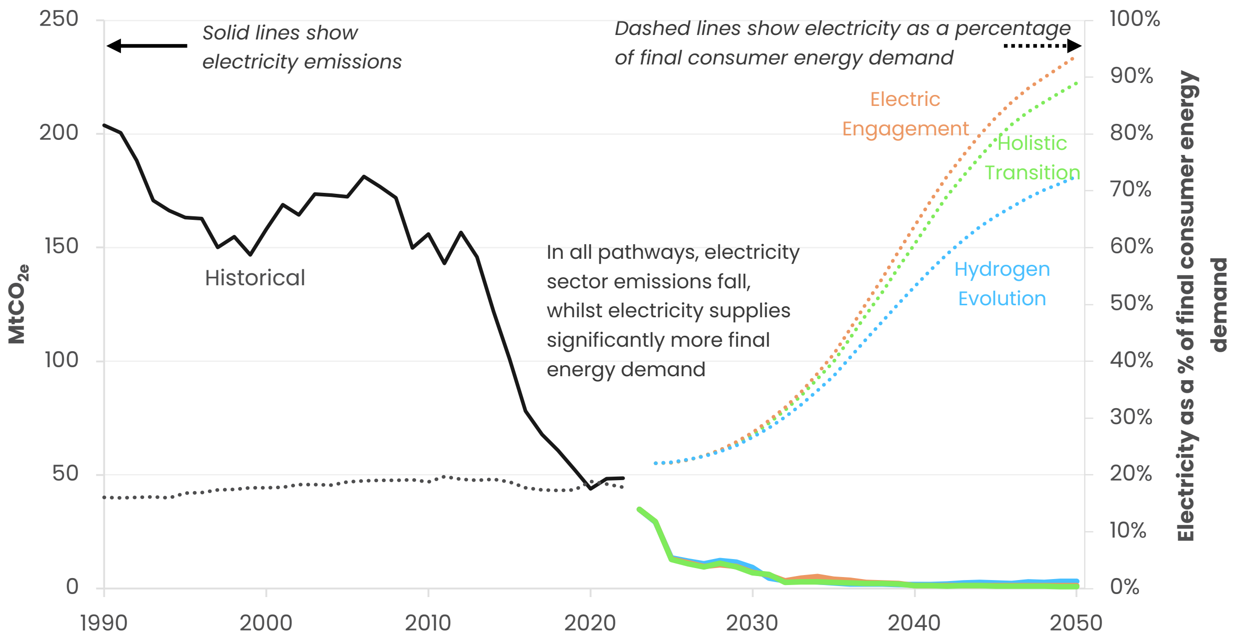
Further reducing use of unabated fossil fuels, limiting its use to security of supply only

Starting the decarbonisation journey

A decarbonised power sector is a critical milestone on the journey to net zero. The availability of low carbon power will unlock routes for many other sectors to decarbonise across our pathways.

Electricity has provided just under 20% of final consumer energy demand since 1990. As emissions in the power sector fall towards zero across our pathways, electricity demand grows as other sectors electrify. Electricity provides upwards of 70% of final consumer energy demand by 2050 in our net zero pathways.

10. Power sector emissions fall and electricity provides a significantly greater share of consumer final energy demand in all pathways.



Notes: Historical data for UK, pathway data for GB. Emissions excluding power BECCS removals.

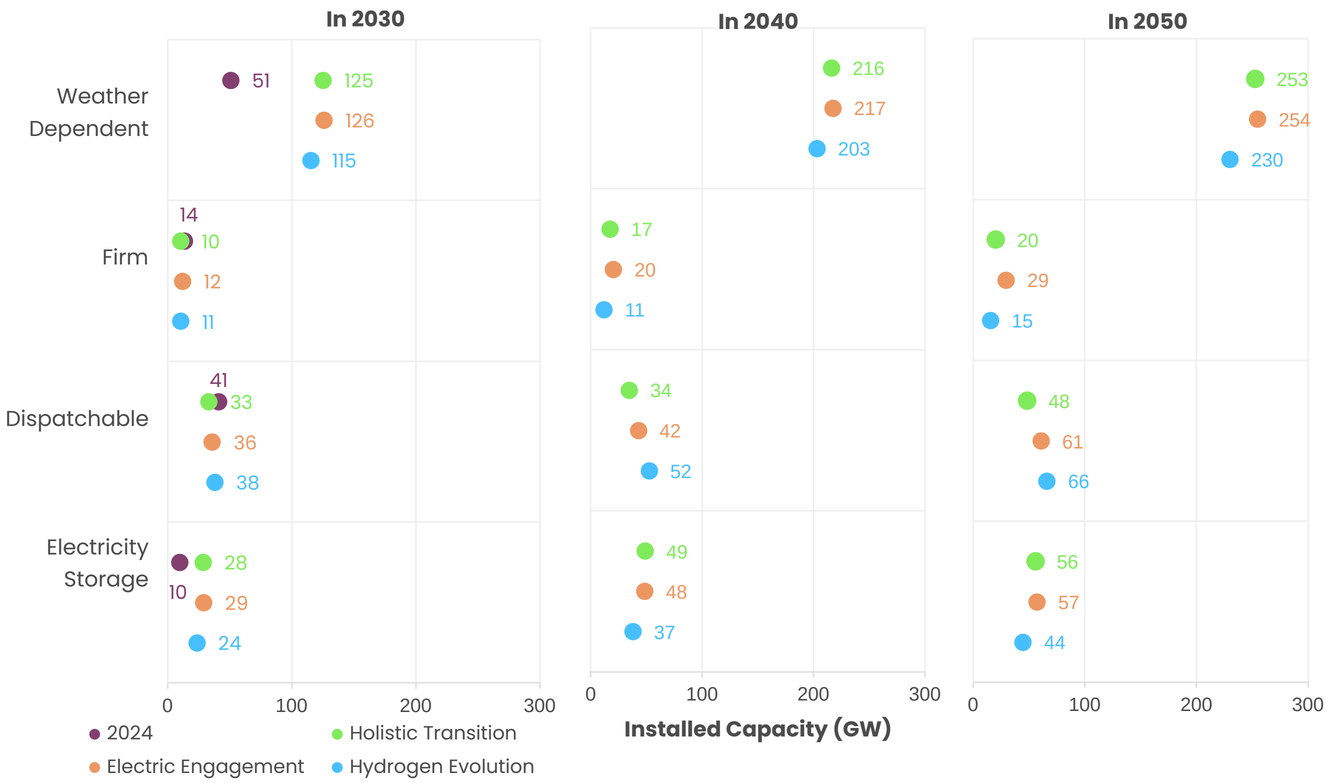
NESO's *Clean Power 2030* advice (November 2024) was based on electricity demand from the Holistic Transition pathway in *FES 2024*. Our modelling for *FES 2025* is based on updated baseline whole energy demand data.

FES electricity supply modelling provides an unconstrained view of supply and demand across the year before any unabated gas runs due to network constraints.

Delivering new power infrastructure of all types beyond 2030

Total installed generation capacity continues to grow in our pathways beyond 2030. Between 2030 and 2040, 116–125 GW is added with a further 52–74 GW added between 2040 and 2050. This reflects an ambitious, continued expansion of generation capacity as we move towards net zero.

11. All pathways see substantial and continued development of new power assets and infrastructure between now and 2050.



Capacity of different technology varies across our pathways based on the specific pathway narrative or to cover uncertainty over what will be delivered by when. There is potential to substitute within and across the categories. For example, more demand side response could substitute for electricity storage and vice versa.

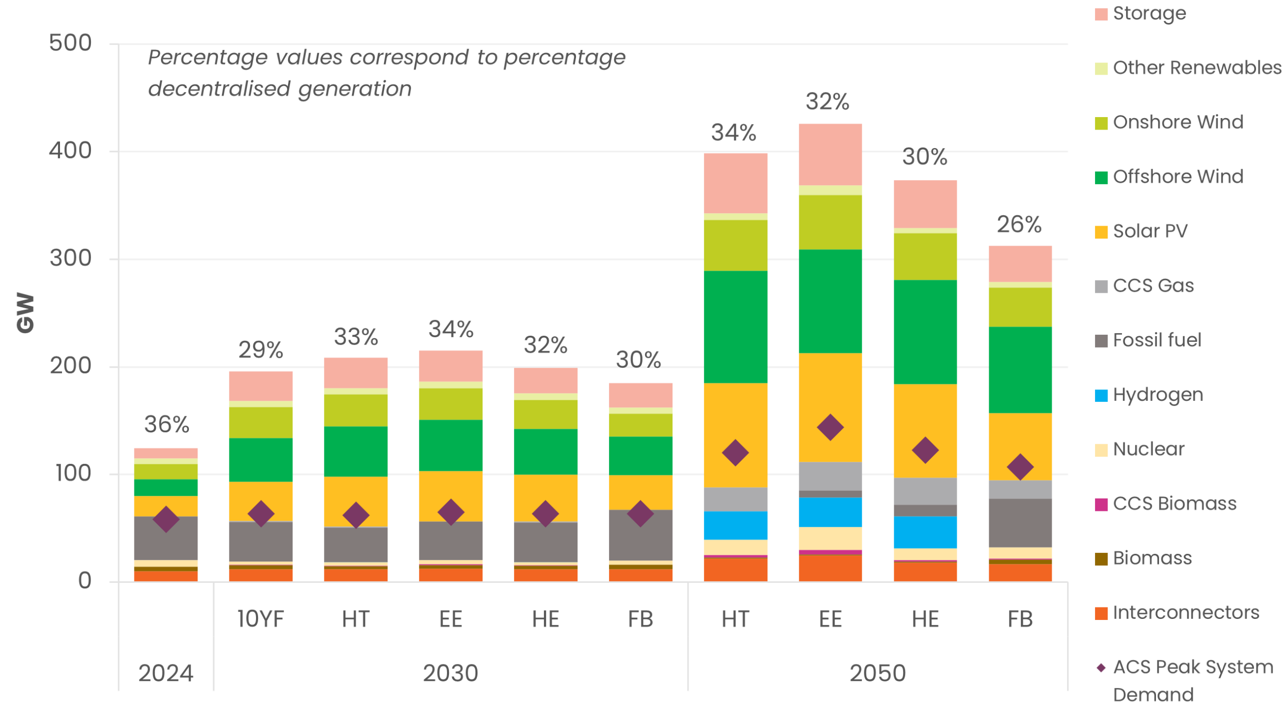
Generation capacity ranges in our pathways are narrower in the short term due to the certainty provided by existing project pipelines, the connections reform process and the government's *Clean Power 2030 Action Plan*. Beyond 2030, significant growth in generation capacity across both transmission and distribution networks continues to meet increasing electricity demand. In all pathways, a large amount of energy demand is in the form of electricity. The build-out of flexible power generation, storage and interconnectors is required alongside renewables across the pathways. Colocated assets, such as electrolysis to produce hydrogen and grid-scale battery storage for solar farms, can also leverage the combined power of renewable generation and flexible technologies.

Our technology insights in Chapter 7 show technology growth charts across all pathways.

Table 3: All pathways see substantial and continued development of new power assets and infrastructure between now and 2050.

Technology		Installed capacity ranges for net zero pathways			
		Today 2024	Acceleration 2030	Growth 2040	Horizon 2050
Renewable	Offshore wind	15.5	42.3-47.8	92.0-93.6	96.4-104.4
	Onshore wind	14.6	27.3-29.8	38.9-44.5	43.4-50.7
	Solar	18.8	43.3-46.8	68.5-77.7	87.2-101.0
Baseload	Nuclear	6.1	2.9-4.1	6.0-11.2	10.9-21.6
	Biomass/BECCS	4.3	3.7-3.9	2.4-5.3	2.3-5.2
Dispatch-able	Gas/CCS Hydrogen	0	0-1.4	25.5-35.6	48.3-55.2
	Unabated gas	39.3	31.2-36	8.6-16.3	0-10.6
Electricity Storage	Long duration electricity storage	2.8	3-5.3	9.2-14	13.2-16.6
	Batteries	6.8	20.5-25.2	28.3-35.6	31.2-40.4
Interconnectors		9.8	11.7-12.5	17.9-24.4	17.9-24.4
Demand side flexibility		8.5	10.2-15.7	23.8-65.5	40.6-81.6
Peak demand, with losses (GW)		57.5	62.1-64.7	96.5-112.0	120.1-143.6
Annual demand (TWh)		287	335-345	564-617	705-797

12. Our pathways see a diverse future energy mix to cover increased future demand between now and 2050, with 30-35% coming from distributed generation.



The proportion of distributed generation in all our pathways remains comparable to today at around 30-35% but this is as part of a far larger electricity system. Operating a clean power electricity system in 2030 and a significantly larger electricity system towards 2050 requires greater coordination between transmission and distribution assets and operators. Visibility of distribution-connected assets, including location, technology type, capacity and current or planned operational behaviour, is critical. Greater visibility will help optimise energy balancing and maintain network resilience, planning effectiveness, ancillary service procurement and network operations.

All these changes across our pathways rely on building large amounts of new assets and infrastructure. Beyond 2030, strategic energy planning should create longer-term certainty for the delivery of the right amounts of generation capacity, in the right location and at the right times alongside network infrastructure. This delivery depends on robust supply chains. By working together, government and industry can ensure a cohesive approach to supply chains, jobs, skills, innovation and enabling infrastructure.

Delivering new capacity is not only about strategic energy planning. Implementing connections reform will accelerate the development of new generation capacity. Market reform can also provide the certainty needed to drive efficient investment and ensure the timely delivery of a low-cost power mix consistent with the UK's climate targets.

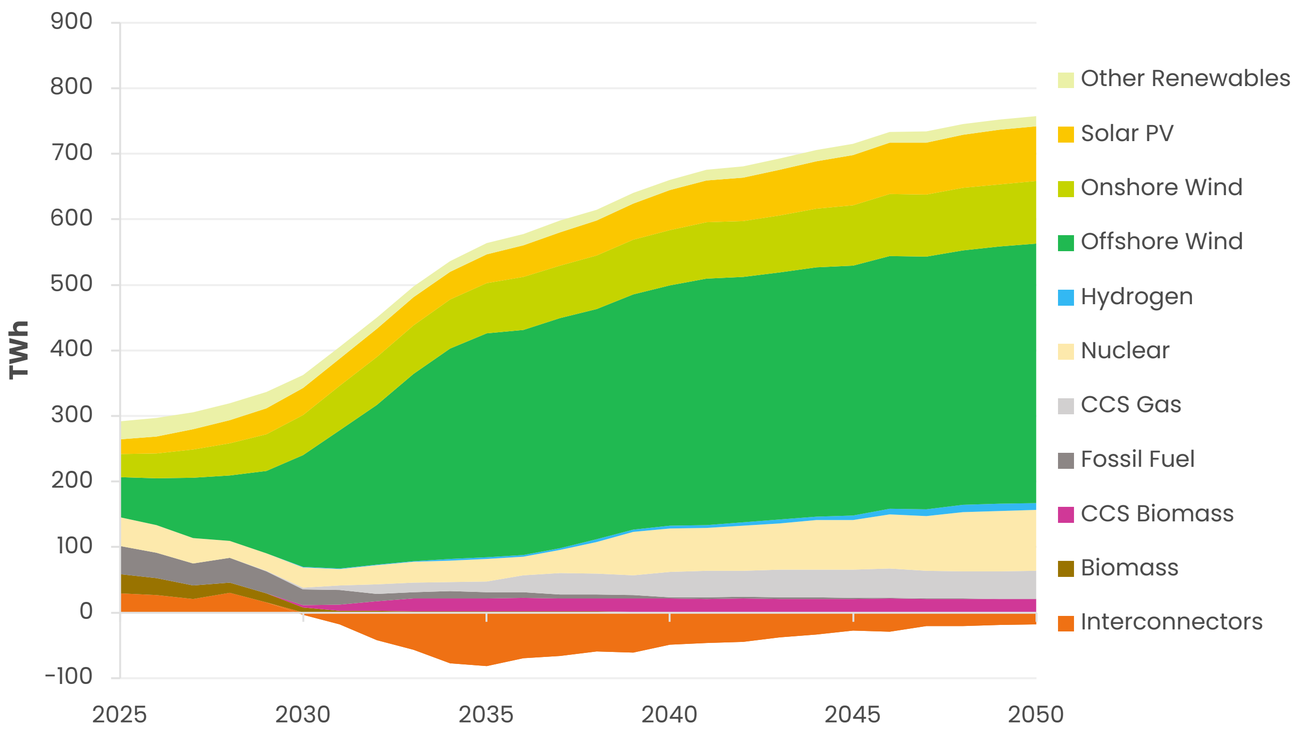
Our pathways consider deliverability in the short term through incorporating data from Transmission Entry Capacity and Embedded Capacity Registers, known project pipelines and conversations with stakeholders. Our pathways see growth across all clean technologies beyond 2030. The *Strategic Spatial Energy Plan* will further optimise the deployment of clean technologies to provide greater certainty for government and industry on the required installed capacity and location of new assets.

Generating clean power beyond 2030

As demand and renewable generation grow, our pathways use new forms of flexibility to ensure security of supply. All pathways see substantial increases in renewable wind and solar generation to supply low carbon power.

As demands for power grow in our pathways, new and expanded sources of low carbon flexibility and storage are needed to meet demands year-round.

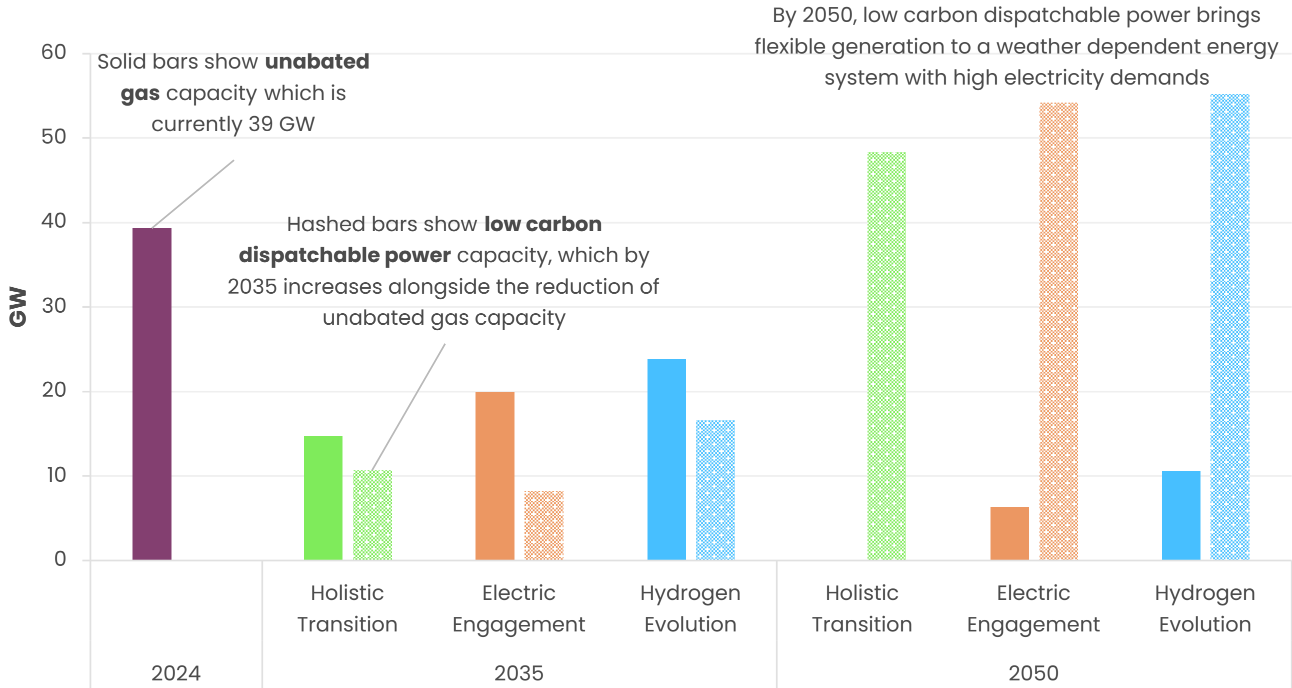
13. Wind and solar provide more than 75% of annual generation by 2050 in Holistic Transition.



At present, unabated gas power generation offers a substantial source of flexibility for the power system. Utilisation of unabated gas in 2030 can vary from 5.7% to 7.9%, depending on variation in demand and renewable generation.

In our pathways, utilisation of unabated gas plants declines in the late 2030s but remains on the system for security of supply. During periods of high demand or lower renewable generation, our pathways see low carbon dispatchable power generation play a critical and sustained role through different forms, such as gas power stations with carbon capture and storage (CCS) and hydrogen to power. Low carbon dispatchable power capacity grows substantially beyond 2030, alongside a decline of unabated gas generation.

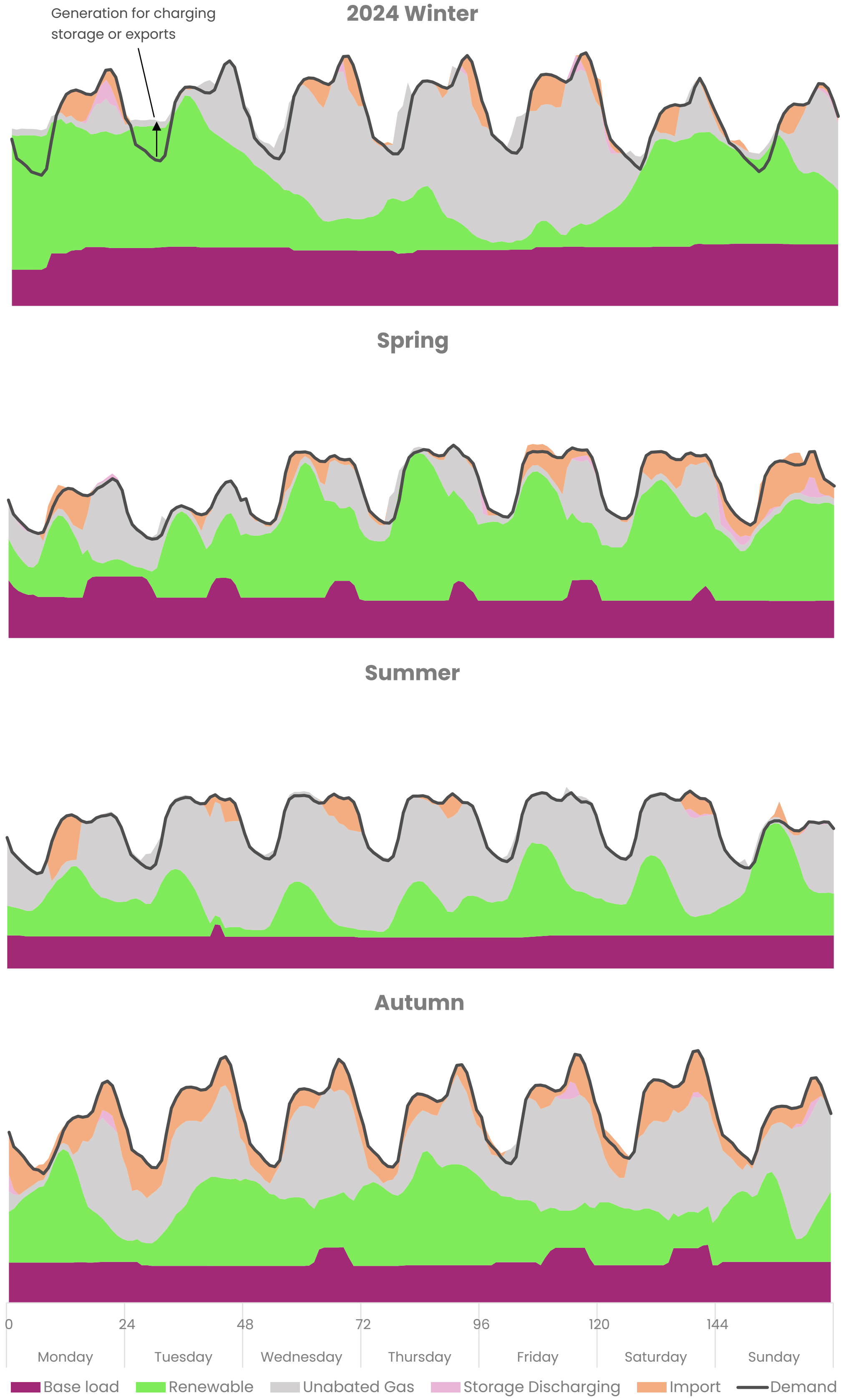
14. Our net zero pathways see a long-term reduction in unabated gas capacity, with it largely replaced with low carbon dispatchable thermal generation technologies such as gas with CCS and hydrogen generation.



Low carbon dispatchable power is not the only technological approach offering this flexibility to the system, with electricity storage and interconnectors both playing a role in meeting peak demand in periods of low renewable output. The interlinked relationship between generation types now and in the pathways is shown within the illustrative dispatch charts for 2024 and 2050, covering a week in each of the four seasons (Figures 15 and 16).

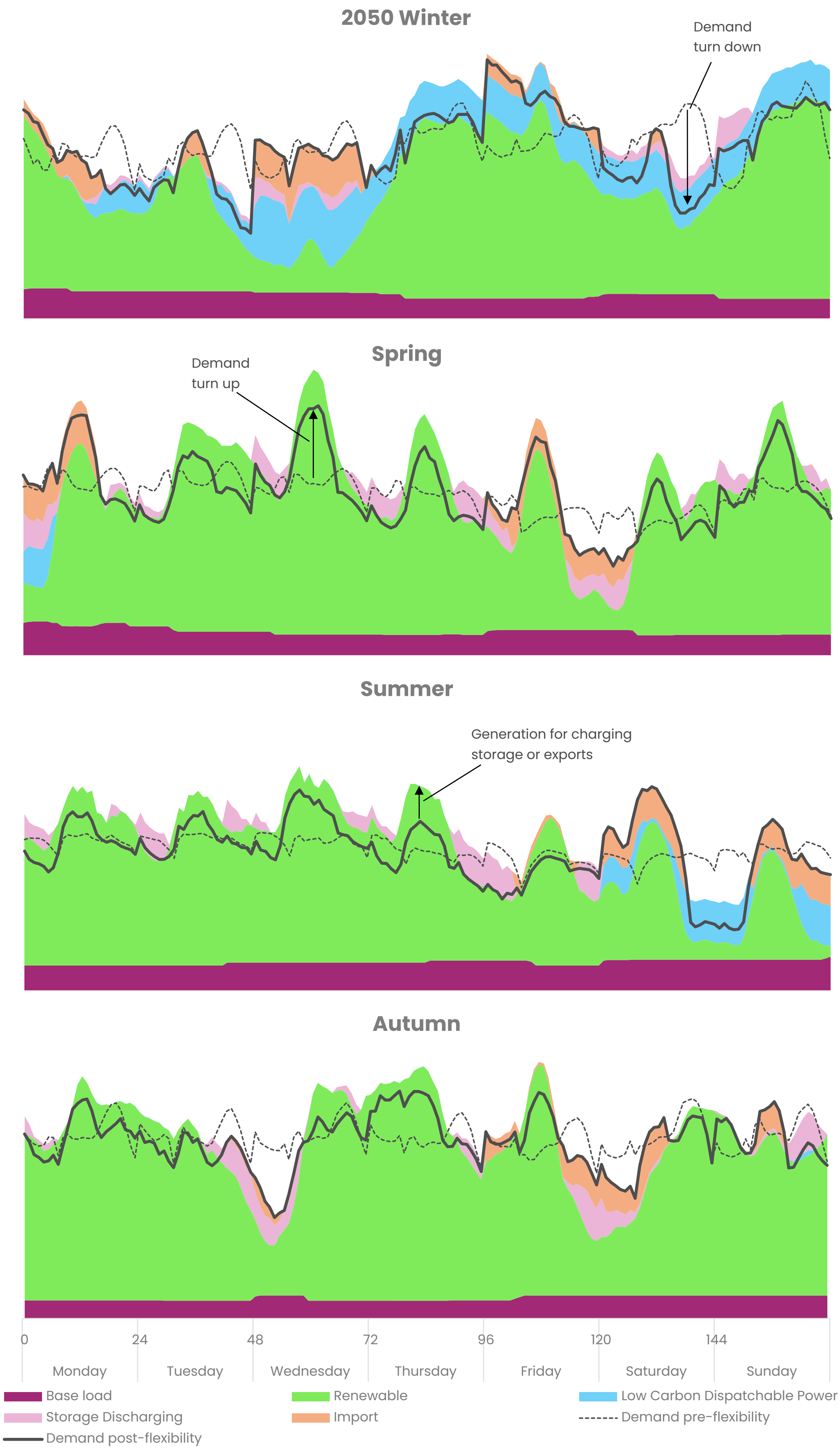
Energy storage is required in our pathways to help balance the grid and ensure security of supply. Battery storage can meet short-term variations in demand and supply, provide short-term reserve and help manage the network. LDES can help secure the system over longer periods of high or low renewable generation output. Hydrogen storage can be used together with hydrogen power generation to offer dispatchable power potentially for days at a time, depending on the amount of hydrogen stored and power requirements.

15. Modelled hourly generation profiles for 2024 for illustrative weeks in all four seasons show the changing roles and scales of dispatchable, flexible and renewable generation.[12]



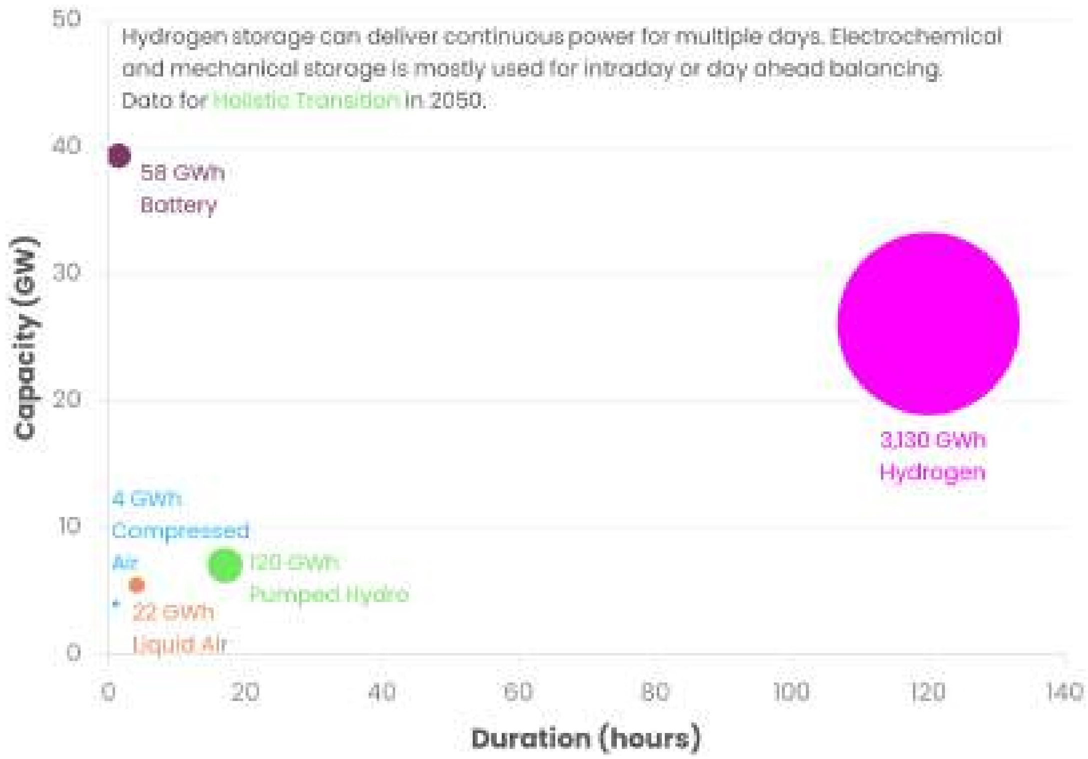
12 All demand values include electrolysis
Demand post-flexibility includes V2G exporting
2024 and 2050 graphs are at two different scales

16. Modelled hourly generation profiles for 2050 for illustrative weeks in all four seasons show the changing roles and scales of dispatchable, flexible and renewable generation.[13]



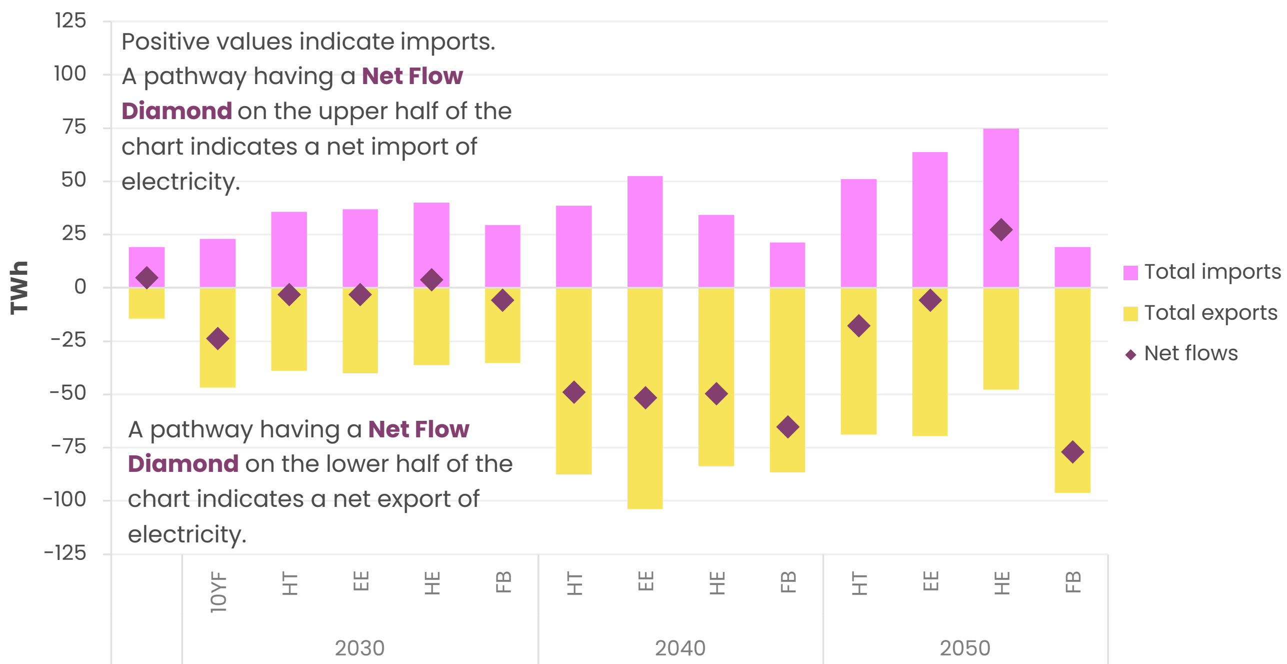
13 All demand values include electrolysis
Demand post-flexibility includes V2G exporting
2024 and 2050 graphs are at two different scales

17. Batteries and LDES play a vital role in ensuring a resilient, low-cost, decarbonised power system.



Interconnector flows balance variable, weather-dependent, renewable generation, providing the ability to import or export electricity depending on supply and demand. Their use in our pathways continues to be primarily driven by price differentials between electricity markets of the interconnected countries. Great Britain becomes a net exporter of electricity post-2030 and retains this position to 2050 in Holistic Transition and Electric Engagement.

18. Interconnection between Great Britain and other electricity markets can be used to manage variable renewable generation, export electricity to reduce curtailment and enhance security of supply.



Limiting costs from periods of high renewable generation

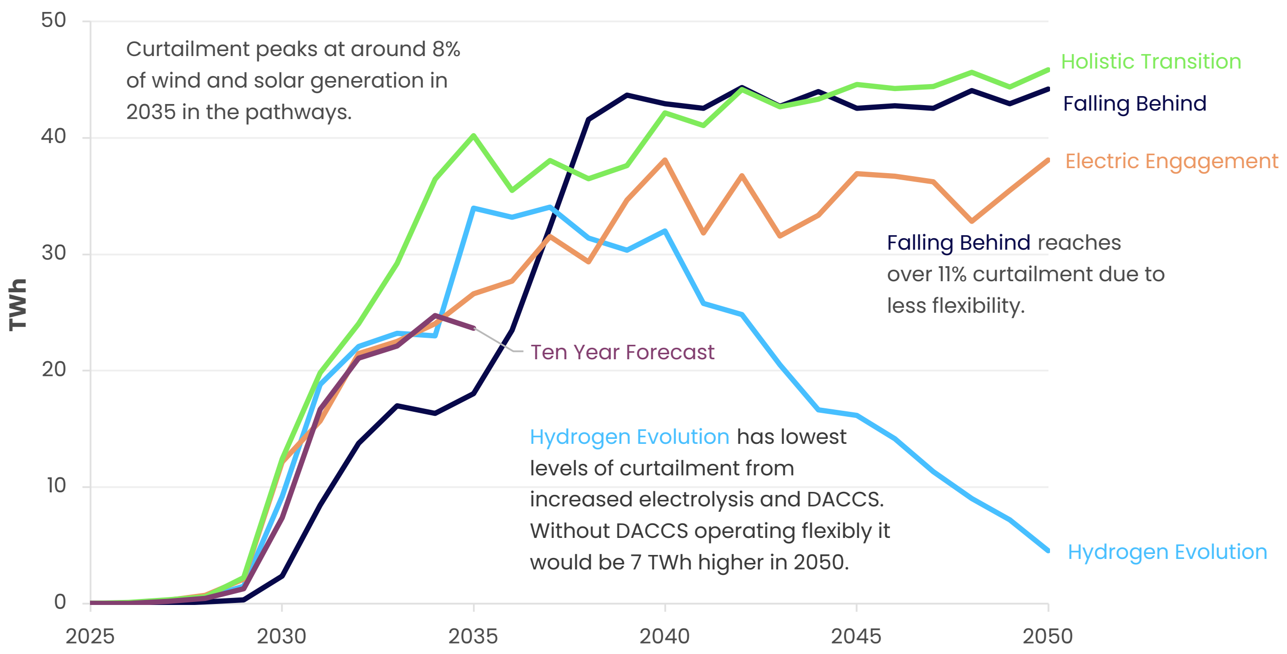
During periods of low demand and high renewable output, generation may exceed what is needed. Excess renewables add cost to the system but periods of oversupply can play a strategic role in system-wide optimisation, unlocking greater flexibility, reliability and cost effectiveness.

Curtailing supply as a last resort can limit costs and prevent overloading the system and operational issues within the network. It also avoids over-building the network, which would incur additional cost and remain underutilised for significant periods of time. Our pathways build in flexible demand, such as charging EVs or running electrolysers for hydrogen production, when energy is at its lowest cost but still see oversupply in the future. This could offer opportunity for flexible power users and associated novel business models in the future and this relies on ensuring the right operational market signals are in place. Levels of curtailment should also be considered in a whole system context. As shown in section on page 75, system-wide energy losses decrease as we decarbonise the energy system.

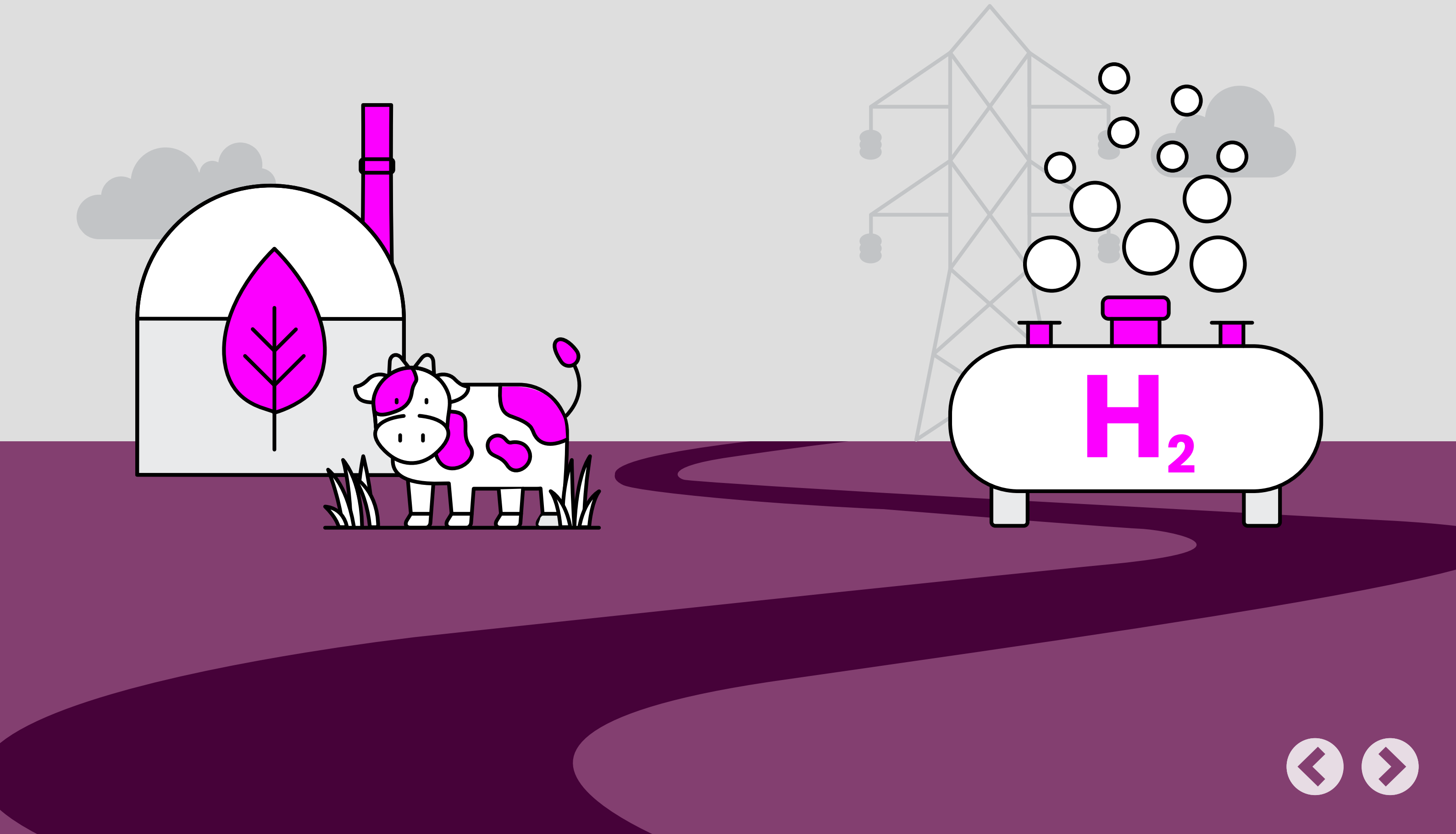
Flexible demand side technologies help balance the system in all our pathways. From the 2030s, our pathways use an increasing amount of electrolysis for hydrogen production, which can operate flexibly. From the late 2030s, our pathways use direct air carbon capture for sustainable aviation and shipping fuel production, utilising otherwise curtailed electricity.

Cost-optimal pathways may consider alternative means of reducing periods of high renewable generation, such as slower deployment in the later years or additional flexible solutions.

19. Our pathways see higher levels of renewable oversupply leading to curtailment towards 2040. This reduces in the 2040s in Hydrogen Evolution due to increasing flexibility. FES models an unconstrained network.

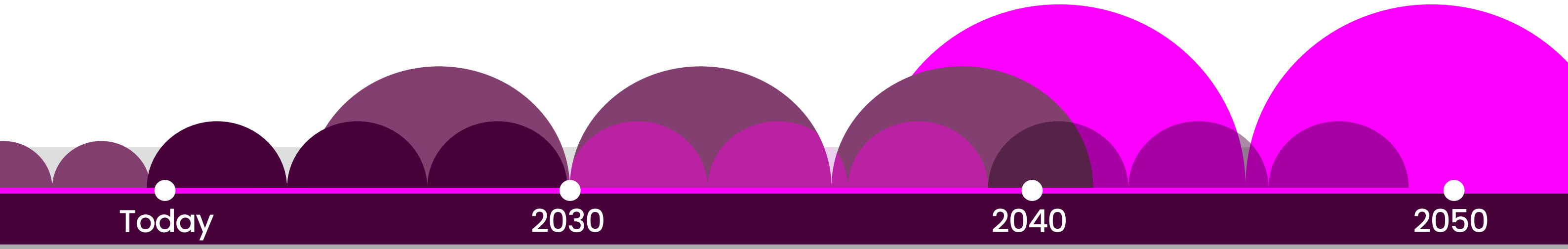


4. Fuelling the System: Gaseous Fuels



Fuelling the System: Gaseous Fuels

Gaseous fuels are crucial to our current energy system. All pathways use these fuels to fulfil a variety of energy needs across sectors such as industry and dispatchable power generation, alongside providing system-wide flexibility and security of supply.



WHAT NEEDS TO HAPPEN IN OUR PATHWAYS

Acceleration

Identifying a clear, strategic route for the future of low carbon gaseous fuel infrastructure

Expanding biomethane production within the limits of available sustainable feedstocks across Great Britain

Initial hydrogen projects begin operation

Growth

Expanding hydrogen production, transportation and storage infrastructure to meet decarbonisation needs across a variety of sectors

Continuing the increase of sustainable biomethane usage

Horizon

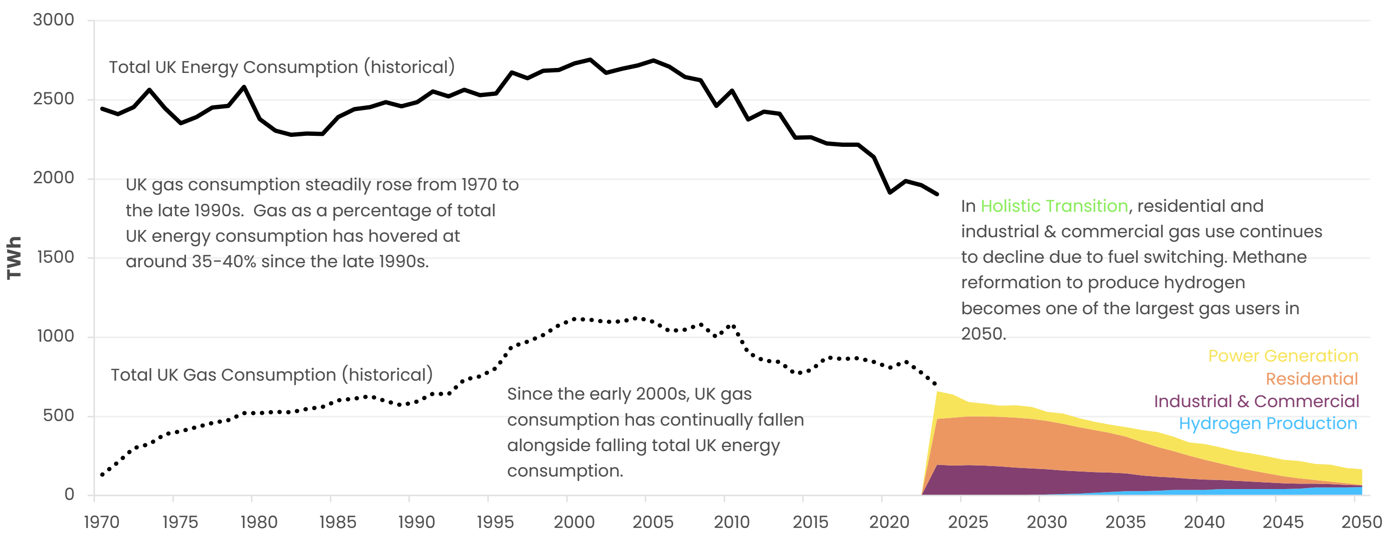
Operating gaseous fuel networks safely, securely and effectively

Utilising hydrogen in sustainable aviation fuel production

Reducing fossil gas usage

Natural gas accounts for around 40% of Great Britain's total energy supply today. As gas users switch to electrified or low carbon technologies in our pathways, gas demand falls. By 2050, up to a third of all gas demand could be used to produce hydrogen by 2050.

20. The role of gas in our energy system has changed over history and will continue to do so in our pathways. Example: Holistic Transition.



Gas is supplied from a variety of fossil sources in our pathways: the UK Continental Shelf (UKCS), Norway, Europe and liquified natural gas (LNG), with underground gas storage providing a balancing mechanism at peak periods. Today, and increasingly in the pathways, gas is also renewably sourced and produced as biomethane.

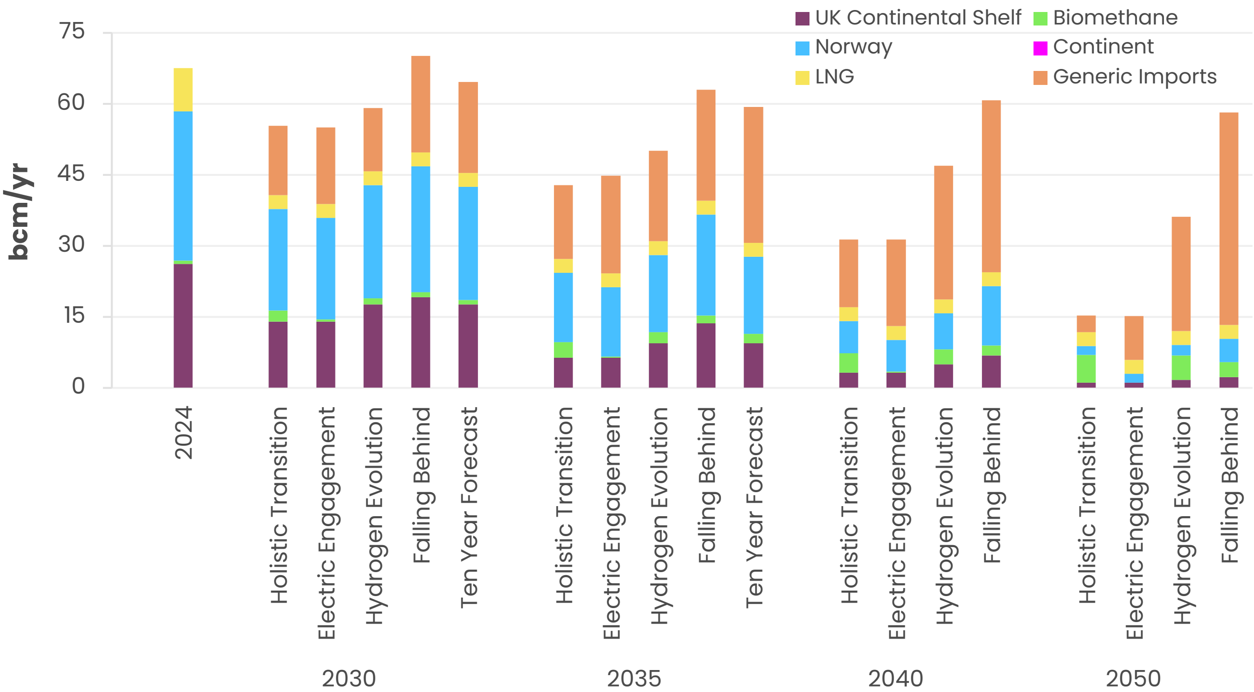
The supply sources in our pathways remain the same as today but their relative proportions differ, contributing to resilience and security of gas supply. The limited remaining proven or probable domestic gas reserves in the UKCS see our pathways and Falling Behind continue to utilise gas imports to meet future demand.

Lower gas demands to 2050 in our pathways result in lower gas supply needs, with major users of gas today, such as residential heating, industry and commercial users, largely switching to lower carbon alternatives. This reduction in demand aids gas security of supply and reduces exposure to any future volatility in gas markets.

Gas imports decrease in all pathways compared to the 40.7 bcm imported in 2024. Holistic Transition has imports (Norwegian, LNG, continental and generic) of 8.3 bcm in 2050. Electric Engagement, which has a greater need for gas for power generation, has imports of 14.1 bcm. Hydrogen Evolution, which uses more gas for both power generation and hydrogen production, has 29.3 bcm of imports in 2050. Gas imports in our Falling Behind scenario are 52.7 bcm in 2050.

NESO will be publishing a detailed *Gas Supply Security Assessment* later in 2025. This will assess gas supply security against a variety of future demand profiles with different energy mixes, including Falling Behind and our Ten Year Forecast (10YF), both of which show higher gas demands in the future compared to our pathways.

21. In our net zero pathways we have sufficient supply of gas to meet our demands. This is tested against one day demands.



Decarbonising gas with biomethane

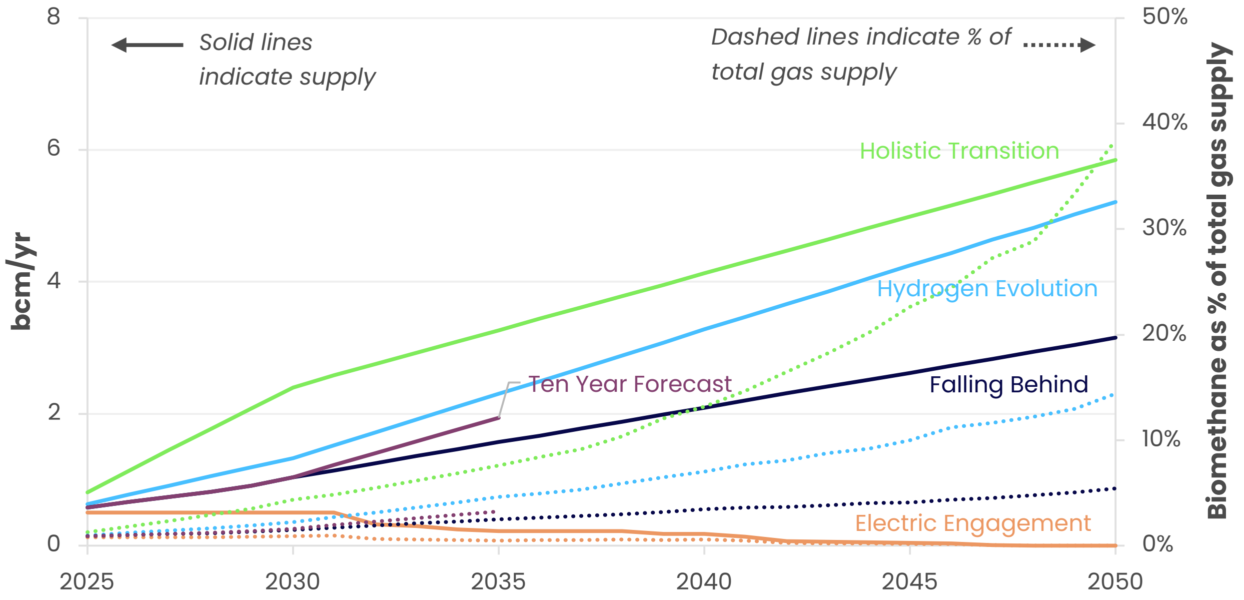
Around 5.5 TWh of biomethane is currently injected into Great Britain's gas grid. This is significantly expanded in our pathways alongside falling gas demand to provide a route to decarbonise gas supplies and contribute to security of supply, using domestic feedstocks.

Biomethane is already utilised in Great Britain but at a lower level than seen in our pathways. We commissioned an independent assessment of sustainable biomethane feedstock potential in Great Britain for *FES 2025*, which showed availability beyond even the levels required in the pathways.

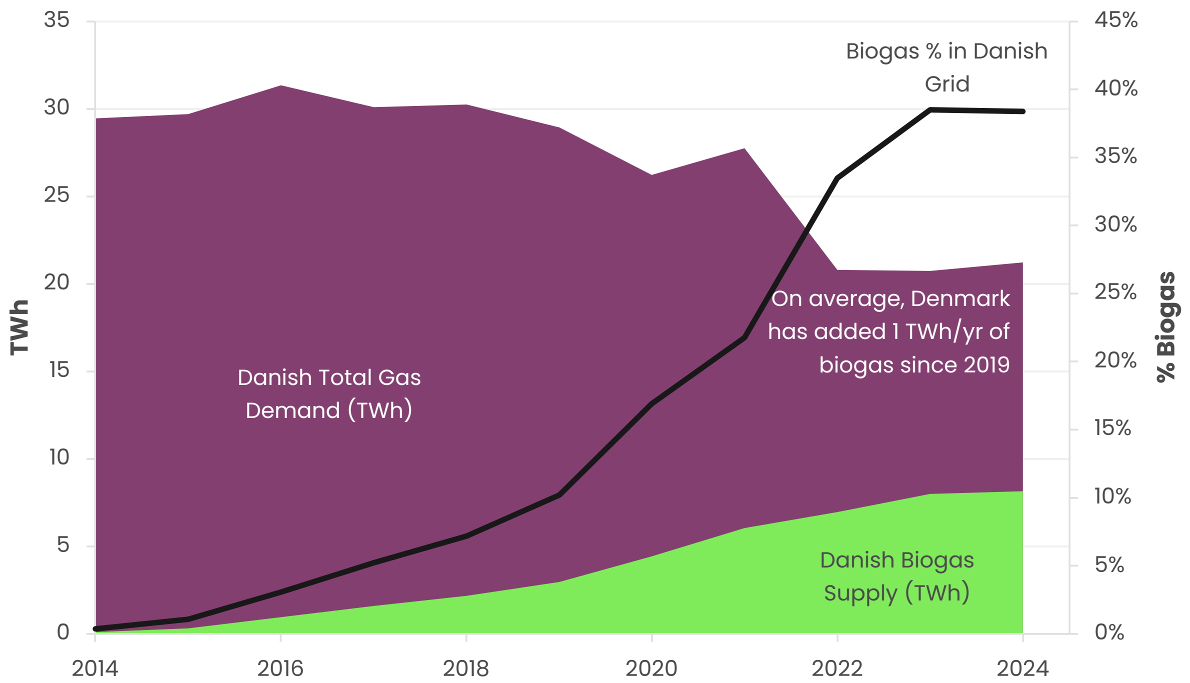
Other European nations have demonstrated that focused efforts can rapidly increase biomethane production. In the wake of the 2022 invasion of Ukraine, the European Union set an ambitious target, as part of the REpowerEU plan, to expand biomethane production to 35 bcm/yr (around 366 TWh) by 2030. Production has increased by 70% since 2022 but recent forecasts[14] show that only around 10 bcm/yr (~105 TWh) is likely to be achieved in Europe by 2030. This rate of increase since 2022 does, however, show how a rapid expansion of biomethane production is possible if backed up by strong ambition, well designed policy, available feedstocks and equipment supply chains. Denmark is a notable example. Since 2019 it has added on average 1 TWh/yr, with just under 40% of its gas grid now supplied by biomethane. It is targeting 100% biomethane by 2030.

14 Low Carbon Gas Industry Is Struggling to Lift Supply in EU (paywall), BloombergNEF

22. Biomethane can act as a low carbon alternative to natural gas. Our pathways see it supplying as much as 38% of gas demand in 2050, as total gas demand falls. It can also reduce near-term pressure on the rapid development of hydrogen supply for decarbonisation.



23. Denmark has steadily increased the use of biomethane in its gas grid over the last 10 years, representing a transition of a comparatively smaller scale gas grid than Great Britain's.



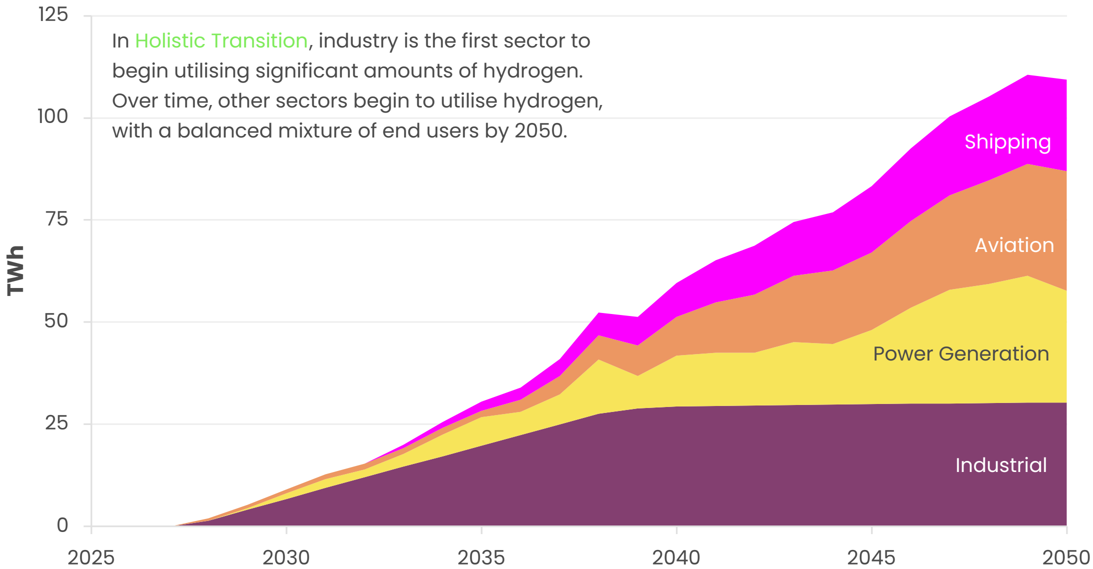
Producing low carbon hydrogen at scale and pace

Affordable low carbon hydrogen is an important enabler for the decarbonisation of several sectors. Both Holistic Transition and Hydrogen Evolution see upwards of 30 TWh of low carbon hydrogen demand by 2035.

Some gas users, particularly industrial sub-sectors requiring gaseous or liquid fuels for high-temperature processes, will likely need low carbon hydrogen to decarbonise. Other industrial users may have alternatives to hydrogen but may face practical challenges, such as space constraints or retrofit issues, with hydrogen their only viable decarbonisation option. Beyond industry, other sectors could also utilise hydrogen supply, such as dispatchable power generation or the production of sustainable aviation fuels. Scaling hydrogen supply to meet this demand in the pathways will be challenging, as it is done at speed from a starting point of zero.

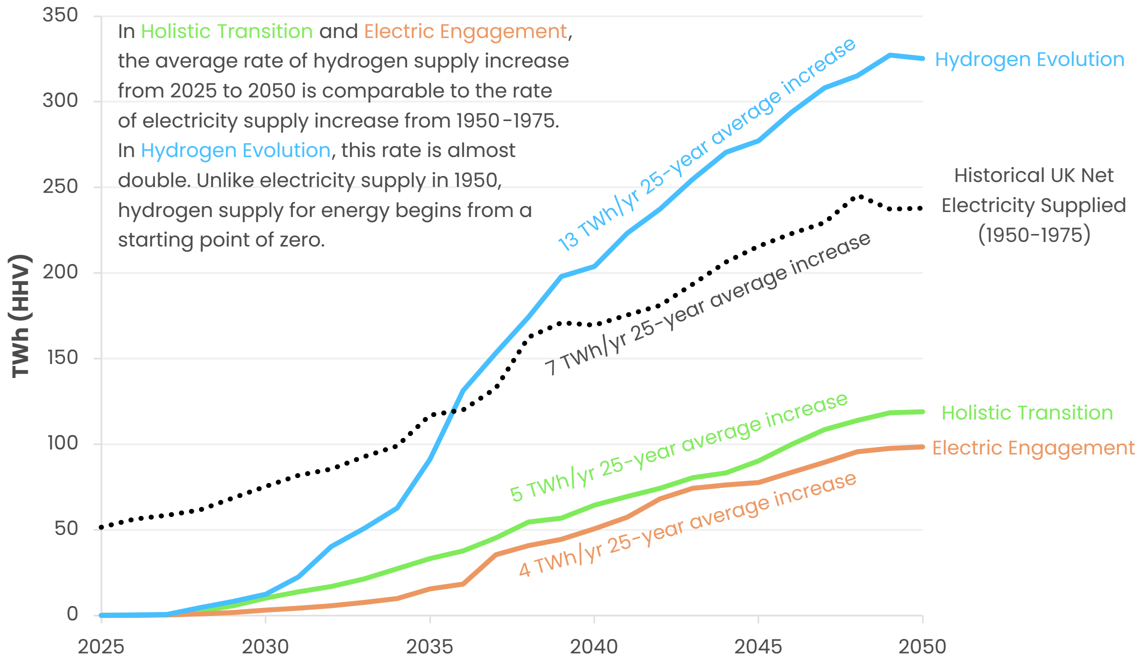
The level of hydrogen required across our pathways is lower compared to *FES 2024*. A major driver of this is reduced hydrogen demand to produce shipping fuels. We have aligned with the recommended Seventh Carbon Budget's Balanced Pathway which assumes that synthetic methanol as a shipping fuel is produced domestically and ammonia as a shipping fuel is imported. It is possible that synthetic methanol may also be imported. There may be opportunities for regions of Great Britain with significant renewable capacity to produce shipping fuels in the future. However, we do not model the shipping fuel sector in FES.

24. Our pathways see industry, power generation and aviation fuels become the main hydrogen users in 2050. The most notable difference between Holistic Transition and Electric Engagement is the latter's lower industrial usage by 2050. Compared to Holistic Transition, by 2050 Hydrogen Evolution sees higher demands for hydrogen in industry (+17 TWh), power generation (+69 TWh), residential heating (+68 TWh) and road transport (+27 TWh).



Notes: Major users of hydrogen only. Defined as demand in excess of 5 TWh in any year.

25. Scaling low carbon hydrogen production from zero will be challenging across all pathways.



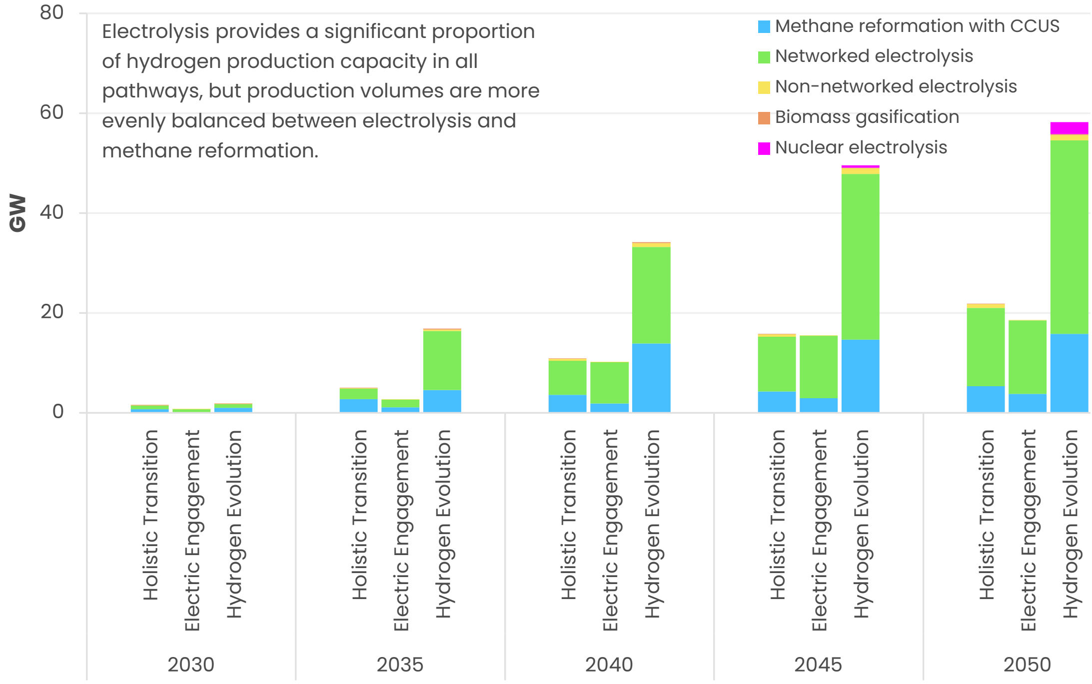
Our pathways largely use electrolysis or methane reforming with carbon capture and storage (CCS) for hydrogen production. The lower demand for hydrogen supply compared to *FES 2024* results in lower levels of hydrogen production capacity.

Another difference compared to *FES 2024* is initial hydrogen production projects. *FES 2024* saw a greater use of methane reforming with CCS in the 2030s to meet large demand. Our *FES 2025* pathways see lower hydrogen demand through the 2030s, with electrolysis providing a greater share of this production. This is due to lower hydrogen demand as well as the volume support funding mechanisms available from the government for electrolytic hydrogen projects.

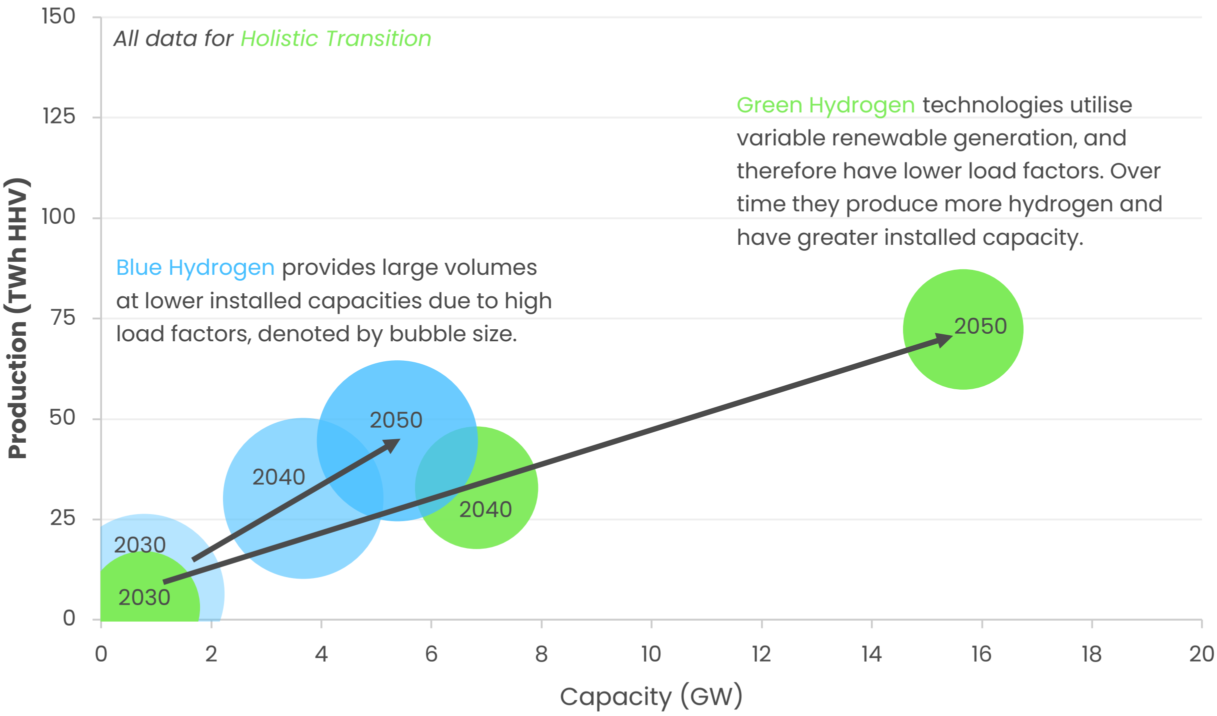
Some of our pathways also see limited use of high temperature nuclear electrolysis in later decades alongside some use of biomass gasification for hydrogen production paired with CCS. Biomass gasification is a technological precursor for future sustainable aviation fuel production routes. Therefore, if current technological challenges for biomass gasification are overcome, it could also offer net carbon negative hydrogen production.

The relative proportions of hydrogen production capacity do not reflect the proportion of hydrogen produced by each as seen in Figure 27. Methane reformation with CCS provides large volumes, operating at a high load factor. Electrolytic hydrogen production has greater installed capacity but operates at lower load factors using renewable electricity at periods of high generation. These electrolytic load factors are derived from expectations from hydrogen allocation round 1 (HAR1) projects and an earlier availability of clean power.

26. Electrolysis and gas reformation provide the majority of hydrogen production capacity in all pathways, although this split does not map directly to volumes of hydrogen produced by each technology.



27. Gas reformation with CCS produces hydrogen at higher load factors with lower installed capacity. Electrolytic hydrogen production capacity operates at a lower load factor, harnessing variable renewable generation. Data from Holistic Transition.

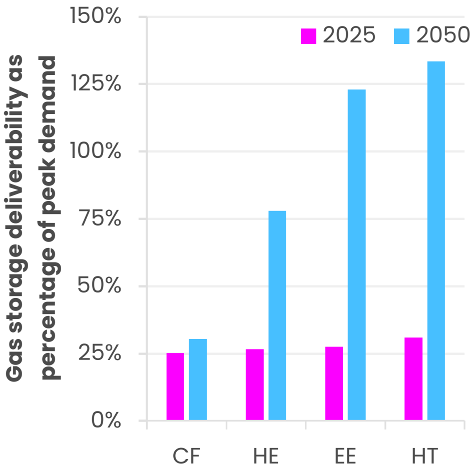


Solving the low carbon gas infrastructure puzzle

Gas transmission and distribution networks run thousands of miles across the country and gas storage facilities deliver large volumes of gas to provide flexibility and security of supply. Our pathways see a changing role for gas and a growing need for hydrogen storage, alongside a longer-term decline in overall gas demand.

Great Britain has approximately 35 TWh of gas storage capacity, in addition to the volumes within gas pipelines (linepack). However, decreasing seasonal and daily price spreads have caused challenges for existing business models. Our pathways show a changing role for gas alongside a longer-term decline in overall demand. The impact of this on the operation of gas storage facilities needs to be carefully managed and considered into the future.

28. What drives gas storage?

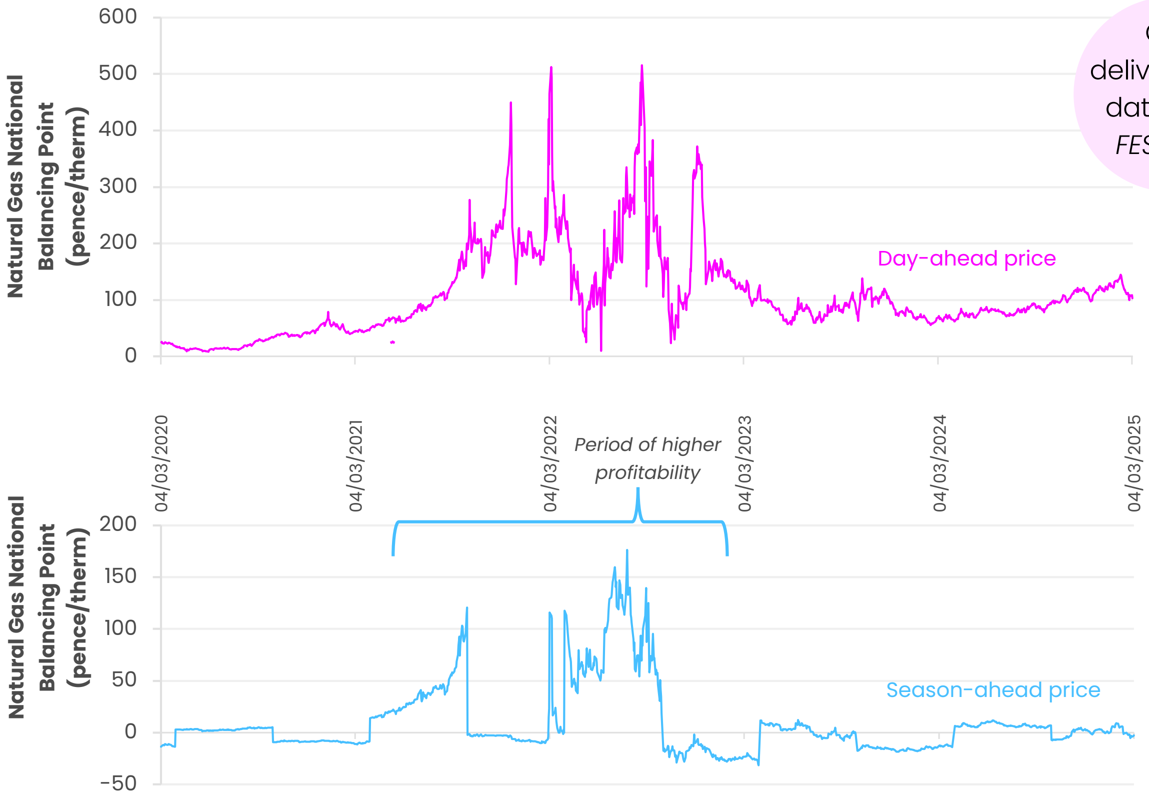


The value of Great Britain's gas storage facilities is in delivering large values of gas to balance demand volatility.

As gas demand falls over time, and supplies from the UK Continental Shelf and Norway reduce, storage facilities will have a greater ability to balance demand.

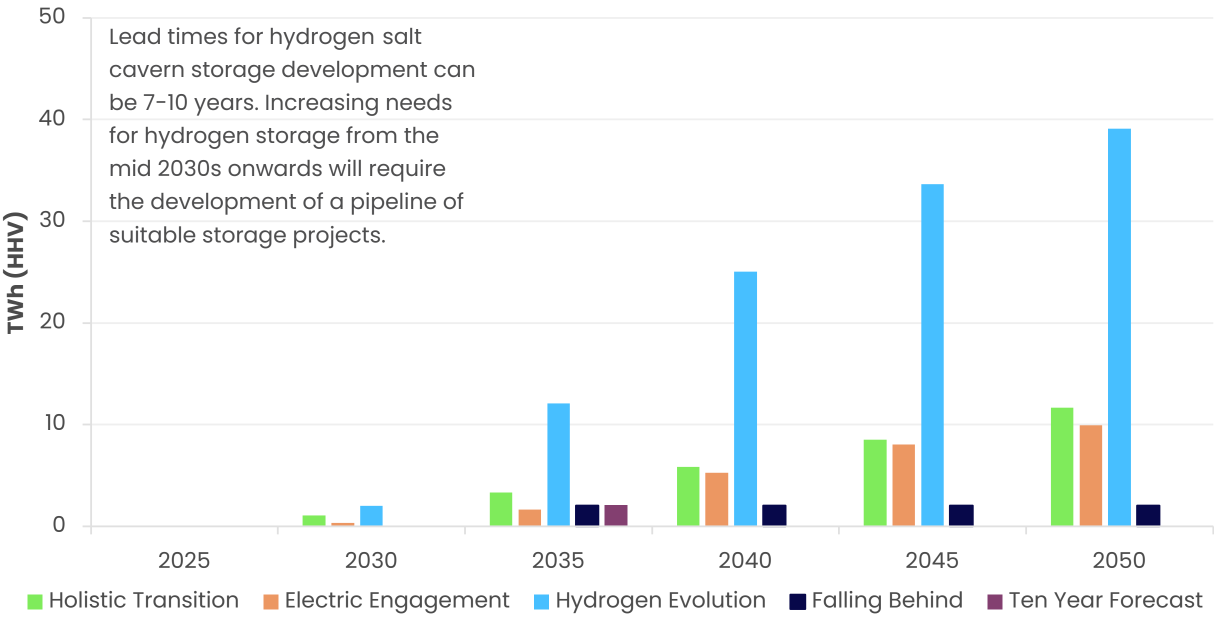
However, there have been challenging market conditions for gas storage operators in recent years. Storage facilities benefit from greater swings in season-ahead and day-ahead prices, and these have decreased in recent years.

Gas deliverability data from *FES 2024*



Our pathways also use hydrogen storage. This is largely to align with the electrolytic production of hydrogen during periods of high renewable generation, which is then drawn down by consumers as needed. These consumers may be dispatchable hydrogen power generation units in periods of low renewable generation or industrial users of hydrogen operating at high utilisation factors. The need for hydrogen storage emerges in the pathways in the mid-2030s. Efforts are required to match hydrogen storage to future supply and demand needs, particularly given that lead times for large-scale salt cavern storage can be up to ten years. Alongside this, the pathways see the need for a hydrogen transmission network in the 2030s to move hydrogen produced electrolytically in the north of Great Britain towards major consumers such as industrial clusters. Hydrogen Evolution, which explores the use of hydrogen for residential heating, also requires the growth of hydrogen distribution networks to homes. The government's forthcoming hydrogen transport and storage allocation round, due to open in 2026, may begin to build this pipeline of infrastructure projects.[15]

29. Efforts are required to develop a sufficient pipeline of hydrogen storage capacity.



Enabling the co-existence of hydrogen and gas

Natural gas, biomethane and hydrogen co-exist in our pathways to 2050. Assets for each fuel will continue to be developed, refurbished or repurposed for both the supply and demand side.

Some assets may be repurposed from gas to hydrogen where technically and economically viable, while maintaining gas security of supply. However, many will remain for natural gas and biomethane users to 2050. All pathways see the use of gas in the power generation mix to 2050, within gas power stations equipped with CCS. Maintaining sufficient availability of gas transportation and storage will be essential.

Policy decisions, such as on hydrogen for heating and the planned role for NESO as the hydrogen system planner from 2026[16], may influence where and how different gaseous fuels will be used in the future energy system. Additionally, industry has previously presented hydrogen network plans, such as National Gas'

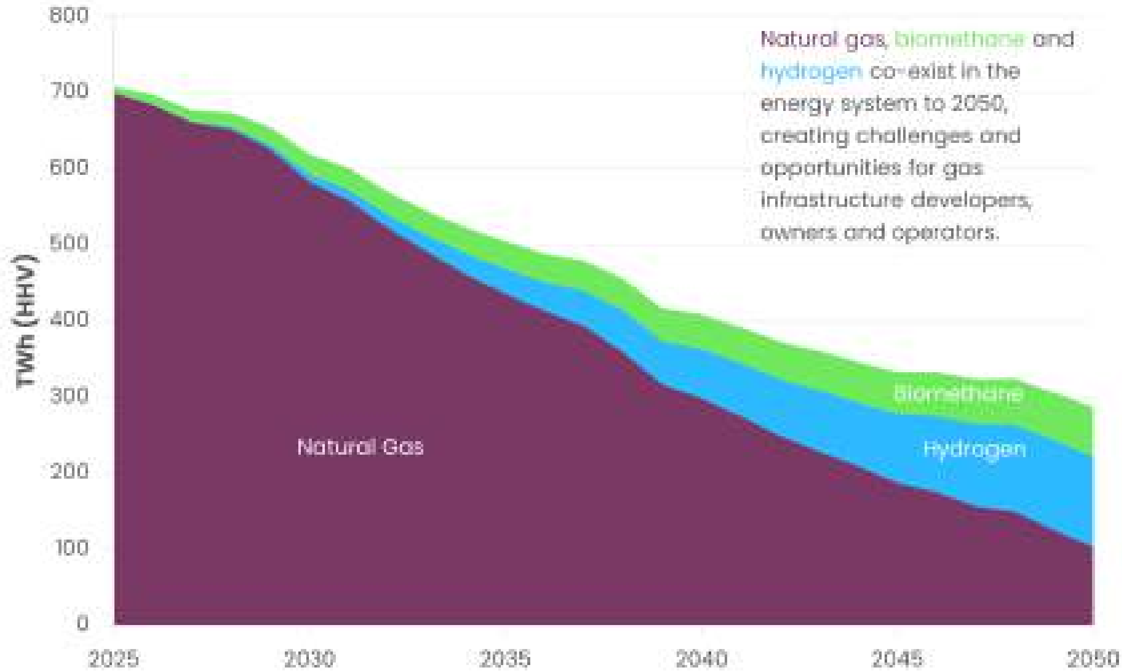
15 *Clean Energy Industries Sector Plan*, Gov.uk, 23 June 2025
16 *Hydrogen Strategy Update to the Market: December 2024*, DESNZ

Project Union or industrial cluster hydrogen networks such as HyNet and East Coast Hydrogen. In June 2025 the government confirmed £500m of funding for hydrogen infrastructure[17].

Plans to connect large assets to gas today will have long-term impacts on the future needs of gas networks and, in many cases, the needs of CCS networks to decarbonise these assets in the future. Such developments will influence any ability to repurpose parts of the gas network for hydrogen. The interactions of gas, CCS and hydrogen should, therefore, be considered in strategic energy planning.

At present, there is no clarity for gas or hydrogen suppliers, network operators or end users on how these fuels will develop and operate together. This urgently needs focus, given that our pathways see a substantial change in gaseous fuel supply and demand in the 2030s. Strategic energy planning can begin to clarify the roles and interactions between these networks and the government's call for evidence on transitioning the gas system, due to open in 2026, may also begin to bring clarity to this area.[18]

30. Gas, biomethane and hydrogen will co-exist in the future energy system in Holistic Transition and Hydrogen Evolution, creating challenges and opportunities for new asset development, asset re-purposing and asset refurbishment. Electric Engagement has low levels of biomethane but continued use of natural gas with developing use of hydrogen.



Pipelines in perspective: Gas and hydrogen transmission networks

5,000 miles of the existing gas National Transmission Network (NTS)

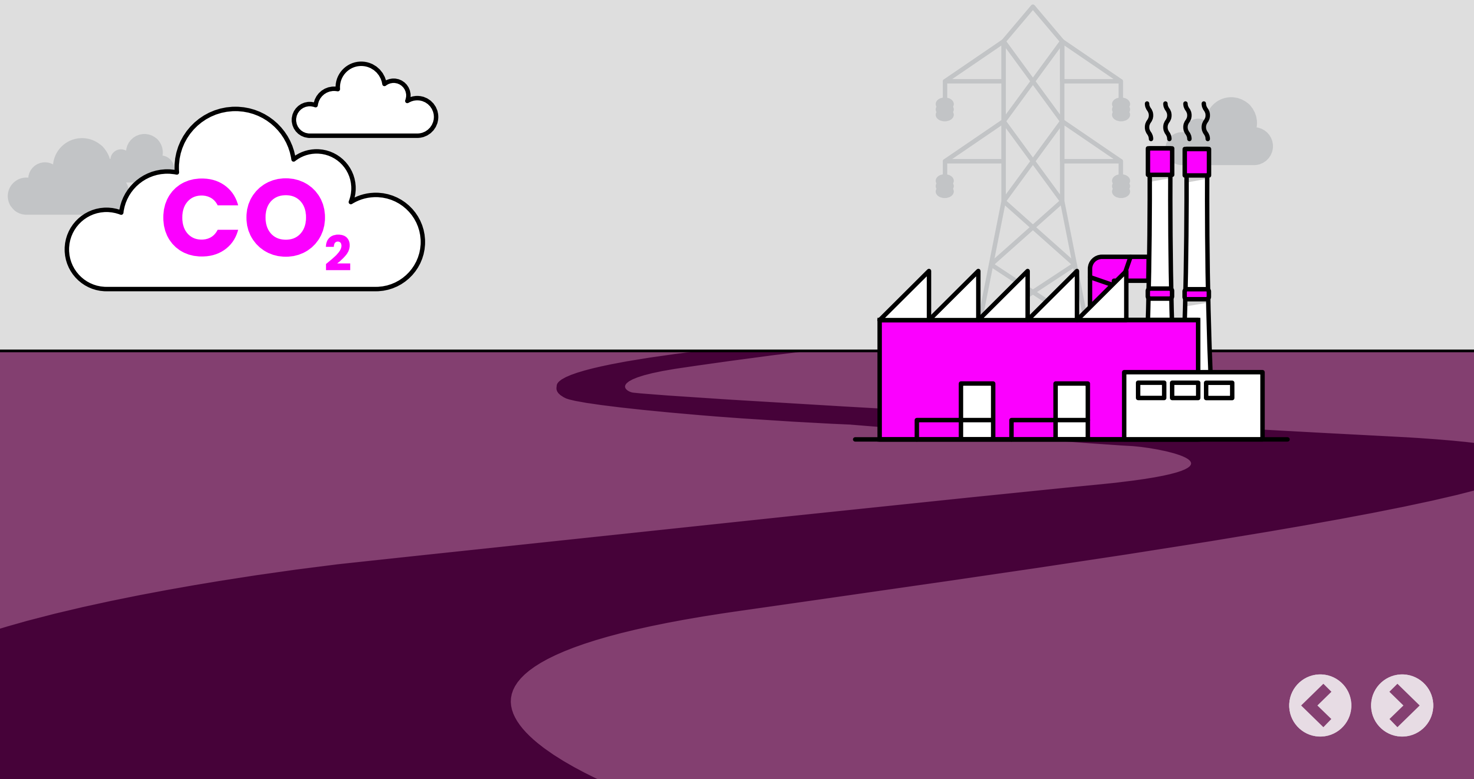
1,500 miles of the planned Project Union national hydrogen transmission network, some of which is proposed to be re-purposed from the NTS

1,578 miles of the NTS came online between 1966 and 1971

17 £500m boost for hydrogen to create thousands of British jobs, Gov.uk, 13 June 2025

18 Midstream gas system: update to the market, Next Steps, Gov.uk, 30 June 2025

5. Crossing the Horizon: Carbon Capture and Storage and Negative Emissions



Crossing the Horizon: Carbon Capture and Storage and Negative Emissions

Carbon capture and storage (CCS) is initially used across our pathways in hard-to-decarbonise industrial sectors and low carbon dispatchable power. Engineered carbon removals are essential from the 2030s, together with carbon removals from the land sector, to offset residual emissions from sectors such as agriculture and aviation.

Today | 2030 | 2040 | 2050

WHAT NEEDS TO HAPPEN IN OUR PATHWAYS

Acceleration

Initial deployment of large-scale CCS projects in Great Britain, including transportation and storage networks

Advancing progress and creating certainty for potential CCS users in Track 2 and beyond

Growth

Developing CCS projects across industry, dispatchable power and blue hydrogen production, targeting areas with limited alternatives

Development and operation of additional CO_2 networks beyond the Track 1 funded pipelines

Operating CCS networks flexibly to meet the diverse needs of users across different sectors

Commissioning initial BECCS projects with expansion of BECCS use throughout the decade

Horizon

Continued safe and secure operation of CCS networks and storage for all users

Using CO_2 in some sustainable aviation fuel and shipping production

Deploying direct air carbon capture and storage (DACCS) to offset any remaining residual emissions

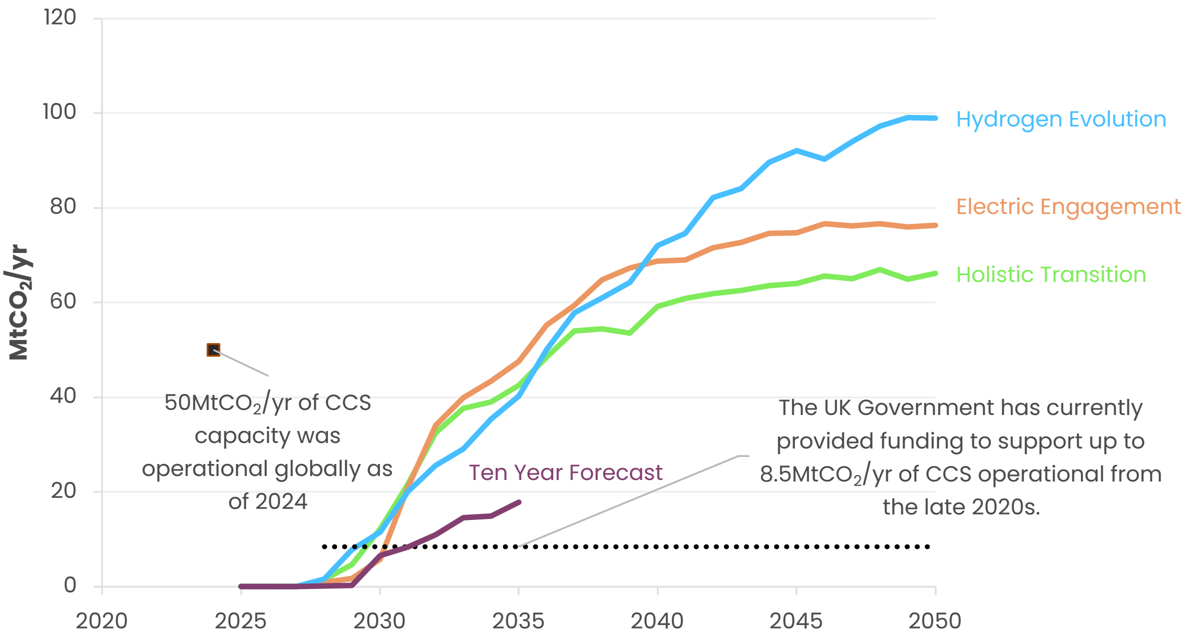
Understanding the need for carbon capture and storage

While renewables and electrification account for the bulk of decarbonisation in our pathways, there remains a targeted and strategic need for CCS. Initial deployment is underway but our pathways utilise over 65 $MtCO_2$/yr of CCS by 2050, highlighting the need for further focus.

The near-to-medium term availability of low carbon dispatchable power in our pathways is likely to come from gas power stations with alongside biomass power, with alternatives such as large-scale dispatchable hydrogen power generation facing scaling challenges due to infrastructure needs, as noted in the government's recent hydrogen-to-power call for evidence[19]. Additionally, several energy-from-waste facilities plan to retrofit with CCS. These facilities will fall within scope of the UK Emissions Trading Scheme (ETS) which will create smaller CCS users with high load factors across the waste and power sectors.

Our pathways see hydrogen production via methane reforming with CCS available from around 2030 to supply industrial clusters. This will create additional CCS network users, as well as users of initial hydrogen networks. Some industrial sectors and sites may opt for CCS to decarbonise unavoidable process emissions (for example, in cement or lime production) or if CCS offers a more viable option for a specific site or process. Our pathways show these users starting to deploy CCS from the end of the 2020s, using the CO_2 networks funded by the government to date.

31. Recent government funding will support the initial development of CCS but there remains a significant gap between this and what is required in our pathways in both the medium and long term.



Sources: NESO analysis, UK Government, Global CCS Institute.

19 Innovative hydrogen-to-power projects: call for evidence, Gov.uk, 31 March 2025

Carbon removal technologies are also deployed in the 2030s across our pathways, beginning with BECCS. Hydrogen Evolution additionally sees the use of direct air carbon capture and storage (DACCS) in the 2040s. Upgrading biogas to biomethane also offers potential to remove CO_2 emissions, creating engineered carbon removals but this has not been modelled or assumed in the pathways.

This creates a complex picture of CCS developments and operation. These networks will need to be ready to connect users from different sites, across substantially different CO_2 capture amounts and operating modes. For example, some connected sites may be smaller continuously operated industrial facilities, while others might be larger dispatchable gas power stations. The demands placed on these CCS networks will be driven by the broader needs of the decarbonising energy system. Additionally, some may have users drawing off and utilising CO_2, such as sustainable aviation fuel or shipping fuel production facilities.

Despite this complexity there is no formal planning role for the development of these networks to ensure they can meet the decarbonisation needs of the energy sector.

CCS infrastructure should be strategically planned alongside electricity, gas and hydrogen to ensure alignment across the whole energy system.

Progress on CCS in Great Britain

In October 2024, the UK government pledged £22bn of funding over 25 years for CCS projects in Teesside and Merseyside. In December 2024, two Teesside projects achieved final investment decision (FID): the Northern Endurance Partnership (which will develop CO_2 transport and storage infrastructure) and the Net Zero Teesside project (a 742 MW_e gas power station equipped with CCS). Both are expected to complete in 2028. In late April 2025, Liverpool Bay CCS pipeline and storage project achieved its FID. That same month, Perenco successfully completed the safe injection of 5,000 tonnes of CO_2 into depleted gas fields in the North Sea, performing 15 injection cycles. This was a UK first for both the North Sea and for depleted gas field injection. In June 2025, the government announced that the Acorn CCS network in Scotland and the Viking network in Humberside would move forward under the Track 2 cluster process.

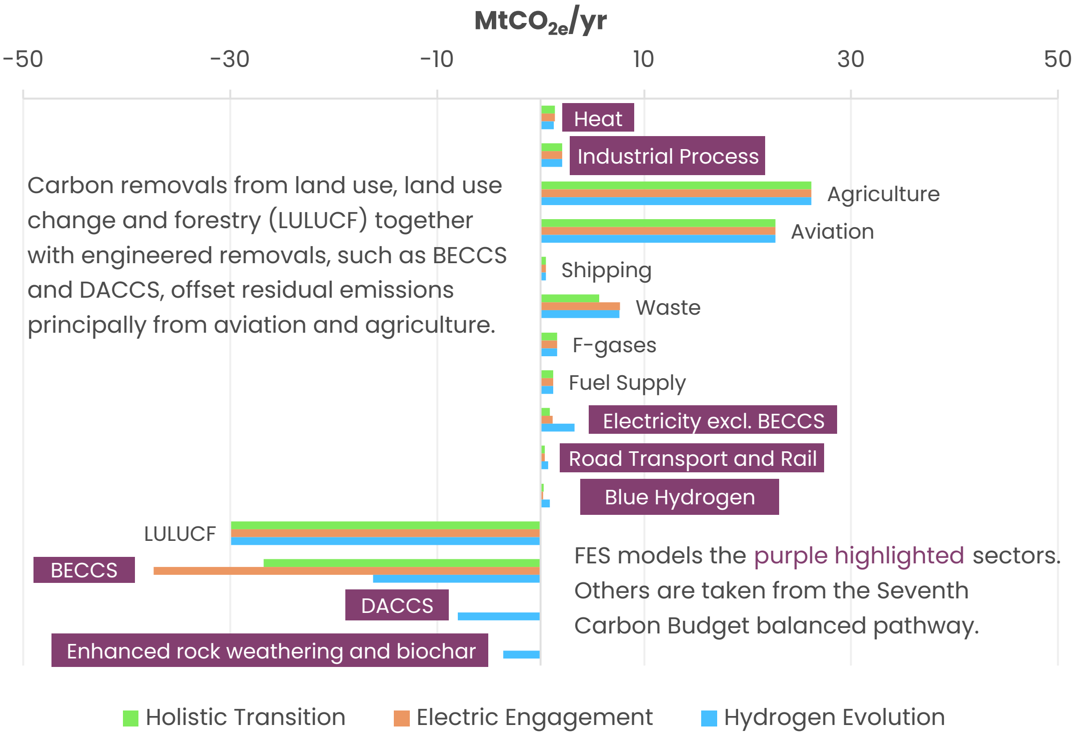
Using engineered carbon removals as the final step towards net zero

Residual emissions in hard-to-decarbonise sectors, such as aviation and agriculture, necessitate the use of engineered carbon removals. Analysis from the Climate Change Committee's (CCC) recommended Seventh Carbon Budget report shows that, as in the Sixth Carbon Budget report, residual emissions will remain in 2050 which will need to be offset and removed.

Sectors such as agriculture and aviation are commonly considered hard-to-decarbonise. Analysis from the Climate Change Committee's (CCC) recommended Seventh Carbon Budget shows that, as in the Sixth Carbon Budget, there is no clear pathway to fully decarbonise either sector over the next 25 years, with both remaining significant sources of emissions in 2050 under a net zero pathway.

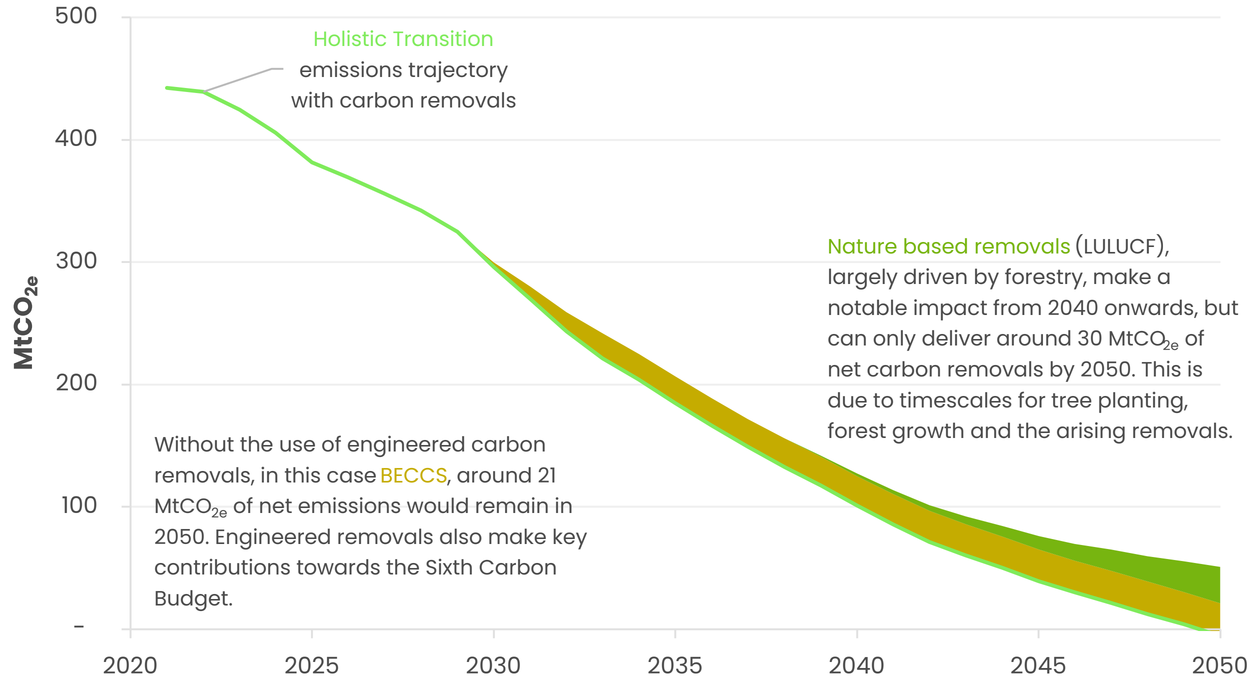
For non-energy sectors, including agriculture and aviation, we take emissions reduction pathways from the CCC's recommended Seventh Carbon Budget. Emissions in agriculture are due to the way we farm and use land and the largely unavoidable emissions associated with animals. Aviation, meanwhile, faces immense technological challenge to directly decarbonise the sector in the next 25 years and instead is likely to need to use engineered removals to offset remaining emissions.

32. Aviation and agriculture are the major sources of residual emissions in 2050.



Sectors outside aviation and agriculture will still have small-to-moderate residual emissions in our pathways in 2050. For example, the manufacturing processes of some ceramics and brick products result in the unavoidable release of carbon. While it is possible for some sites to remove these with CCS, some residual emissions will remain due to both the broad geographic spread of these industries and the prevalence of small-to-medium scale sites.

33. Engineered carbon removals are necessary in our pathways to achieve net zero emissions and interim carbon budgets.



Nature-based solutions, such as tree planting and peat bog restoration, can deliver around half the carbon removals required in 2050. However, even with the ambitious levels of tree planting in the CCC's recommended Seventh Carbon Budget's Balanced Pathway, such solutions cannot deliver all the scale and speed of required removals and do not always result in permanent removals. For example, land used for forestry could be changed again in the future or planted forests may be susceptible to the effects of climate change, such as extreme weather or disease.

Using bioenergy with carbon capture and storage for carbon removals

Biomass feedstocks are currently used in Great Britain's fleet of biomass power stations, with most commissioned under schemes such as the Renewables Obligation and further deployment under subsequent schemes more limited. BECCS is essential across our pathways, where usage of biomass in power BECCS facilities is at a comparable level to today's usage in biomass power generation.

Sustainable biomass is a limited resource and should be prioritised where it can have the greatest net impact on emissions reductions, such as where there are no other low carbon alternatives to biomass or where it can provide the greatest net impact on decarbonisation, inclusive of carbon removals. As part of its 2023 Biomass Strategy, the government has committed to developing and consulting on a common framework for biomass sustainability[20].

20 *Biomass Strategy 2023*, Gov.uk, 10 August 2023

Our pathways see a changing role for biomass use in power generation. Towards 2050, the total amount of biomass feedstock used falls in Holistic Transition and Hydrogen Evolution and remains at comparable levels to amounts used in recent years in Electric Engagement. This feedstock is instead used in power BECCS facilities to provide carbon removals, instead of current use in unabated biomass power generation.

Biomass feedstocks represent an important starting point in our pathways for engineered removals in the early 2030s and, when used in BECCS facilities, hold significant value in reaching net zero targets. Achieving carbon budgets and NDC targets from 2030 is challenging, even with rapid decarbonisation across sectors. BECCS can contribute to these targets and remains a cornerstone of the required engineered carbon removals in all our pathways by 2050. Hydrogen Evolution, which uses BECCS to a lesser extent, does not achieve either the Sixth or recommended Seventh Carbon Budget. The shortfall by which it misses each carbon budget is broadly equivalent to the amount of removals provided by power BECCS in the other pathways.

There are alternative carbon removal technologies. DACCS uses significant amounts of energy to remove CO_2 from the atmosphere but does not rely on biomass feedstocks and can be manufactured and deployed in a modular fashion. Biochar and enhanced rock weathering is used in small amounts in Hydrogen Evolution, in line with the low levels in the CCC's recommended Seventh Carbon Budget's Balanced Pathway. Both biochar and enhanced rock weathering face additional challenges around monitoring and verifying the removal of CO_2 from the atmosphere. Both DACCS and BECCS, however, have a pipeline with a measurable flow of CO_2 into a geological store.

34. Electric Engagement uses the most power BECCS facilities for carbon removals. Biomass usage remains comparable to today's levels.

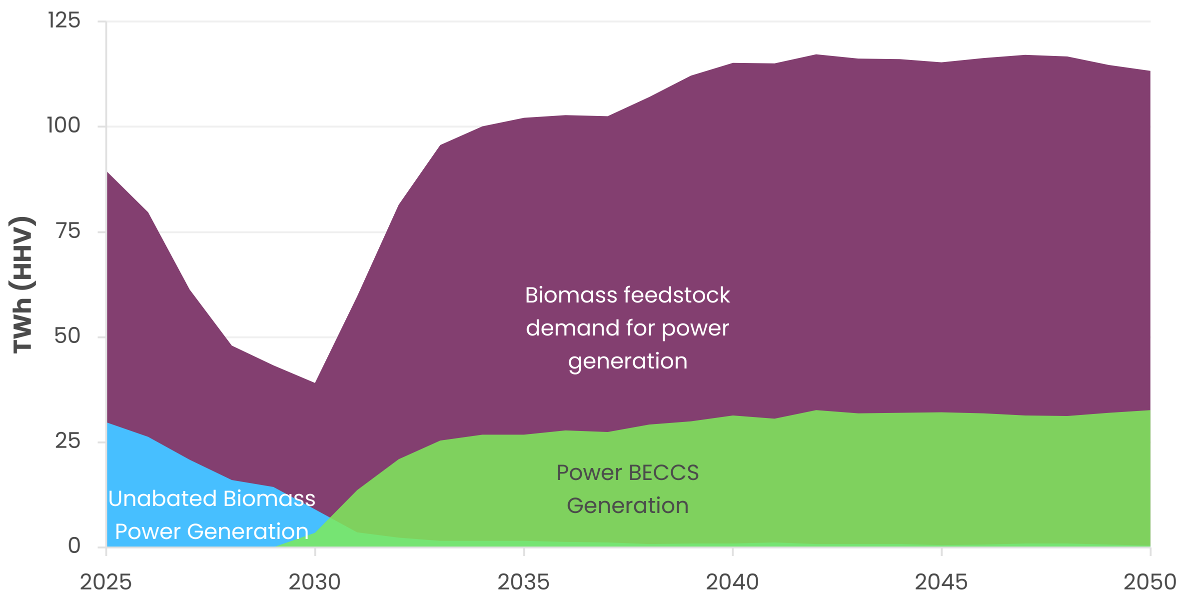


Table 4: Snapshot of BECCS facilities currently in development across Europe.

Company	Project	Location	Removals (tCO_2/yr)	Status
Stockholm Exergi	Beccs Stockholm	Stockholm, Sweden	800,000	FID reached March 2025, targeting operation in 2028
Ørsted	Asnæs Power Station	Kalundborg, Denmark	280,000	Under construction, planned operation in 2026
Ørsted	Avedøre Power Station	Copenhagen, Denmark	150,000	Under construction, planned operation in 2026

Using direct air carbon capture and storage to provide a scalable alternative for carbon removals in later years

DACCS offers another engineered carbon removal approach, with different trade-offs to BECCS. It is an energy intensive process but novel electrochemical approaches could substantially reduce the energy requirement.

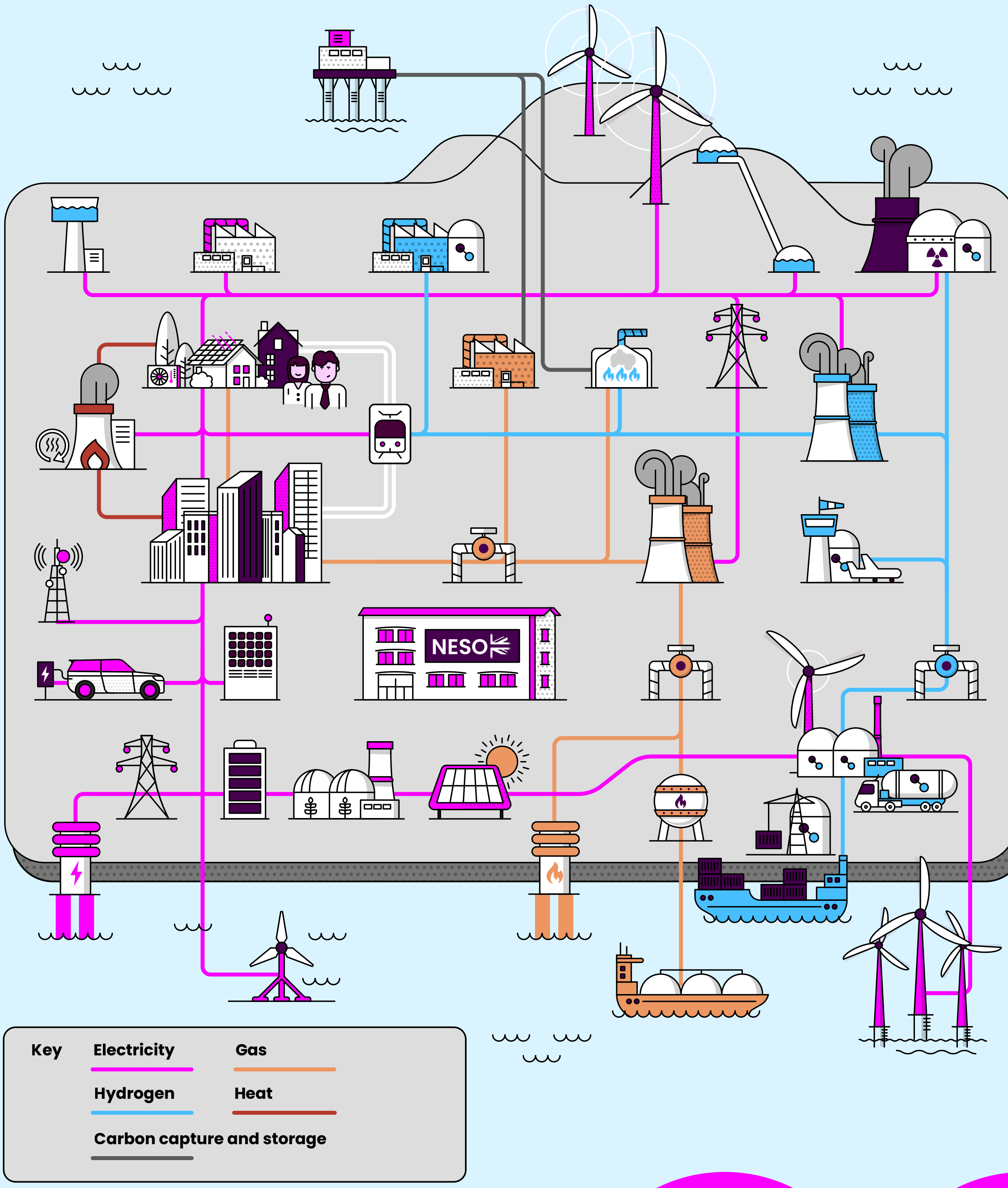
While DACCS does not have the land requirements for feedstock growth associated with BECCS, it does require greater energy, has a higher cost per tonne of CO_2 captured and does not produce a useful energy by product. Current approaches require around 2 MWh of energy input per tonne of CO_2 captured and approximately 80% of this required energy is in the form of heat. Whereas delivery of all required engineered carbon removals with BECCS would require more land use and imports, delivery of all removals with DACCS would require a significantly larger energy system.

Using data from the CCC's recommended Seventh Carbon Budget's Balanced Pathway, all our pathways use some direct air capture (without storage), where CO_2 is combined with hydrogen as a feedstock to produce sustainable aviation fuels. A similar approach is used for synthetic shipping fuel production. This begins at scale in the late 2030s.

Holistic Transition and Electric Engagement both meet the Sixth and recommended Seventh Carbon Budgets, but need large scale engineered carbon removals in the 2030s to do so. In such a short timescale, and with such demand, BECCS is viewed as the more feasible option to deliver, as there are several potential large-scale projects in Great Britain and BECCS does not create the additional energy demands that DACCS would create alongside other decarbonisation activity across the economy. Hydrogen Evolution sees the additional deployment of DACCS for engineered carbon removals in the 2040s.

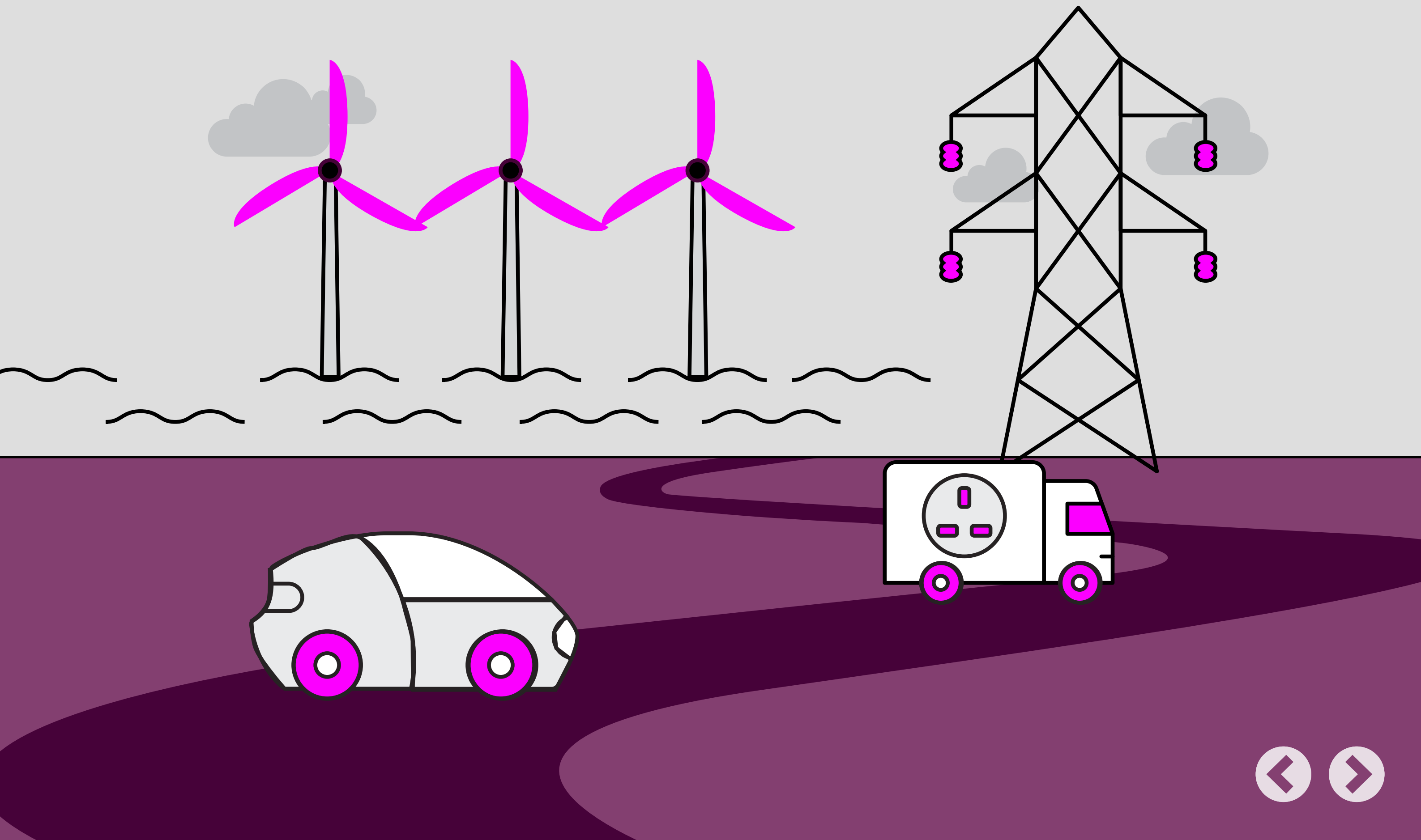
At present, the largest DACCS project in development globally is the Stratos facility in Texas. This facility is targeting commercial operation in 2025 and will capture 500,000 tonnes of CO_2 per year when complete.

In our pathways, direct air capture utilises either renewable electricity, which would otherwise be curtailed, for all energy needs, including heat, or uses waste heat from sources, such as industry or nuclear to meet its heat requirements, alongside electricity to meet its electrical demands.



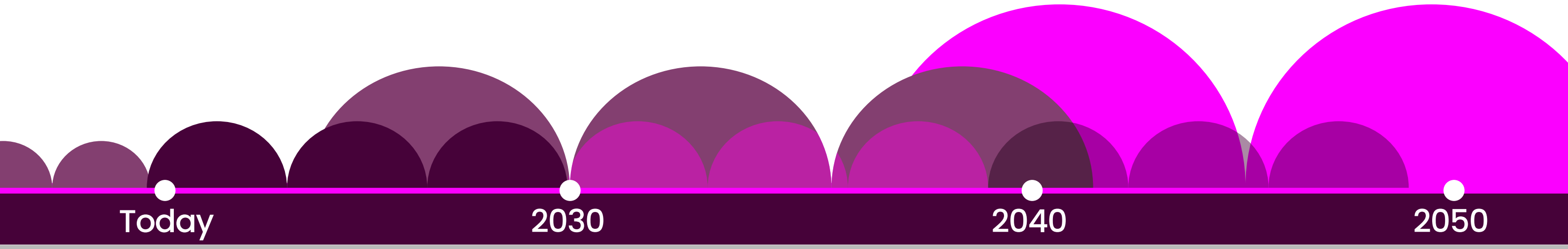
In our net zero pathways, the energy system looks substantially different to today

6. Whole System Opportunities on the Route to Net Zero



Whole System Opportunities on the Route to Net Zero

Electricity is at the heart of the future energy system, supported and enabled by a variety of additional fuels and energy vectors such as gas, hydrogen and bioenergy, and a broad range of low carbon generation and storage technologies.



WHAT NEEDS TO HAPPEN IN OUR PATHWAYS

Acceleration

Reducing reliance on gas for electricity production and operating the system with a high share of renewables for the majority of the time

Growth

Expanding energy storage across vectors to enhance resilience

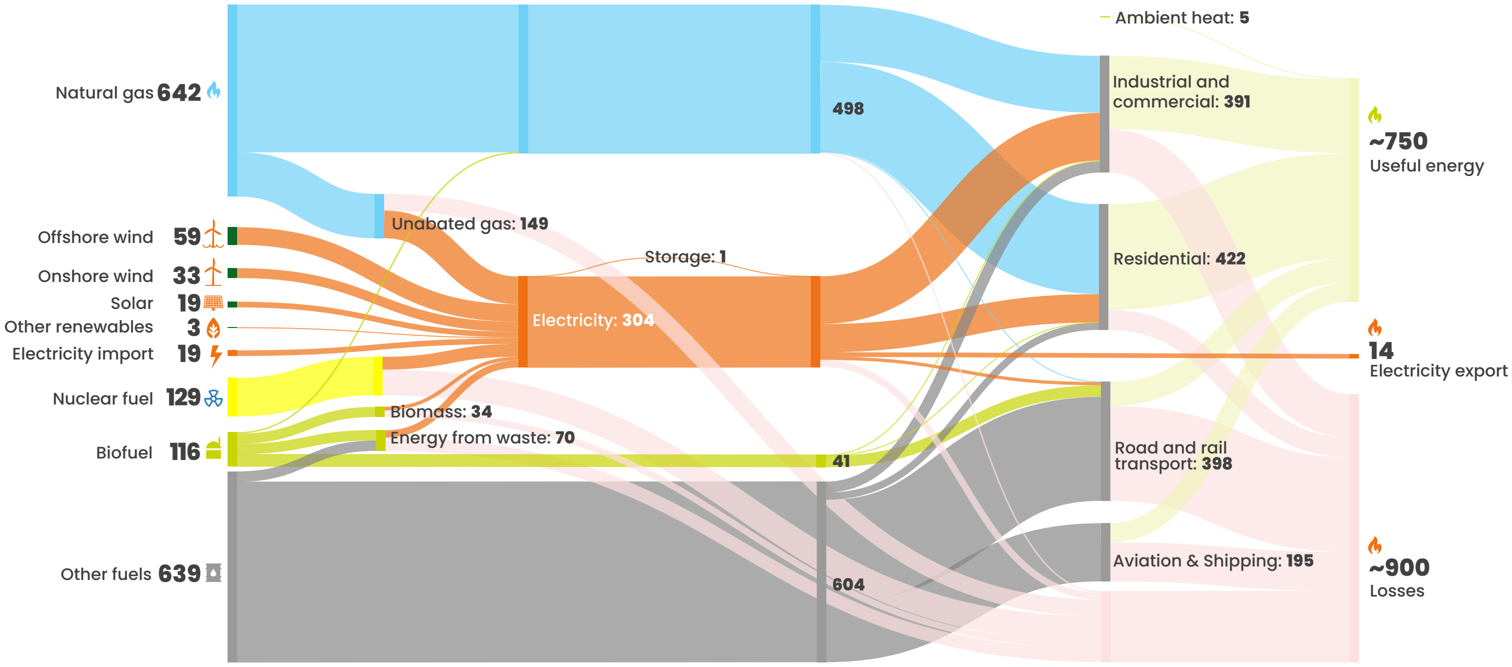
Horizon

Substantially reducing imports of gas, enhancing energy independence

Lower losses of energy across the whole system

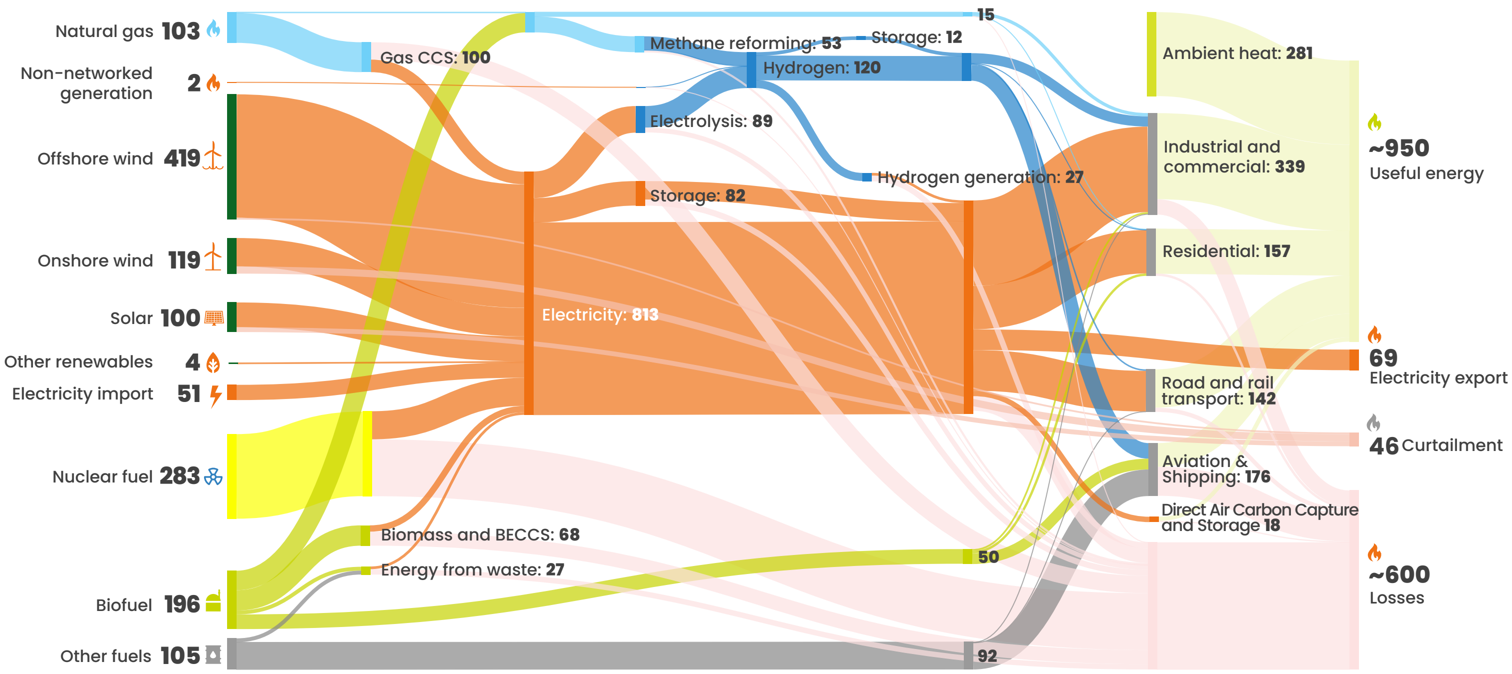
Picturing the energy future

35. Our current energy system has a high reliance on fossil fuels, with large losses of energy. Sankey diagram showing energy flows, interactions, usage and losses across the whole system today.

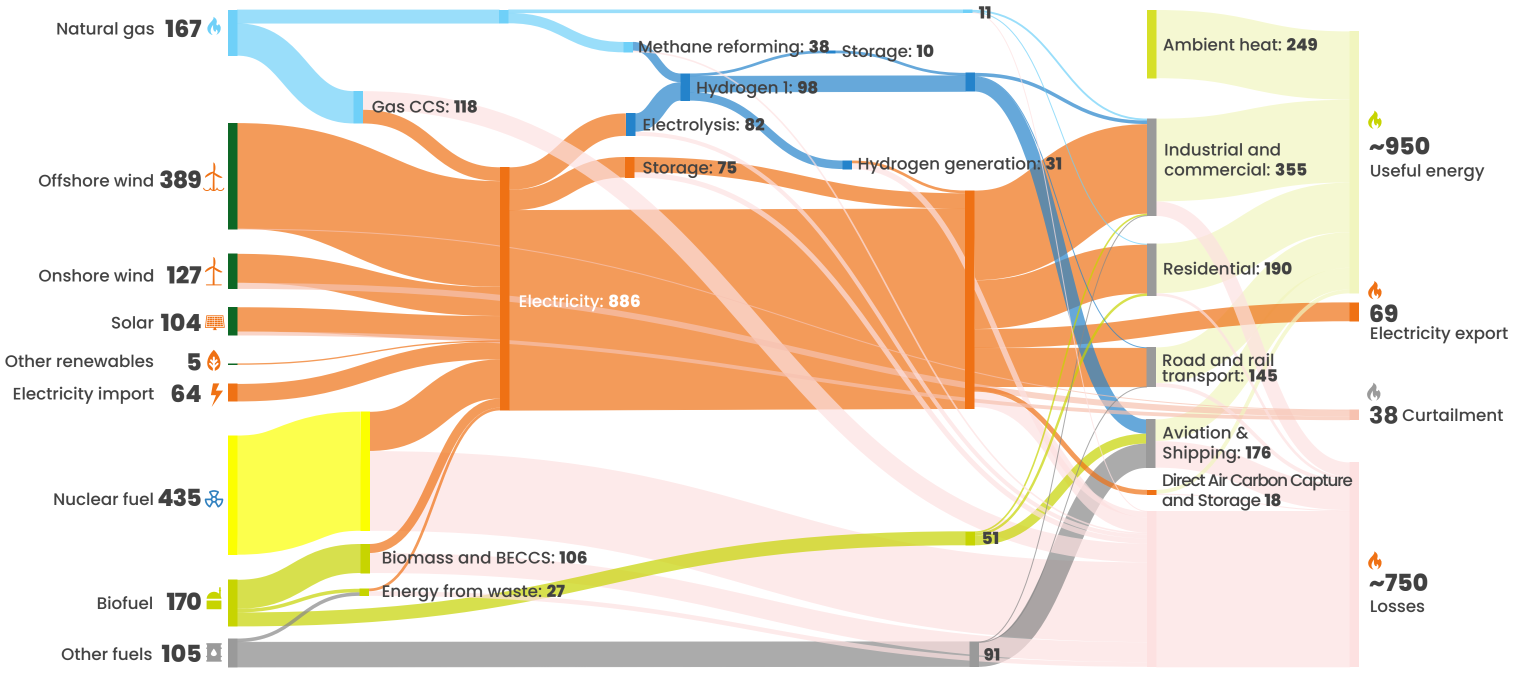


Much of the primary fossil energy we extract today is wasted, predominantly as heat, in power stations or internal combustion engines. A heavily electrified decarbonised energy system leads to higher overall and round-trip efficiencies. Electric vehicles convert 80-90% of electrical energy into mechanical energy by their motors, compared to internal combustion engines converting 20-30% of their fossil energy into useful energy. Similarly, gas condenser boilers have an efficiency of 80-90% compared to heat pumps with efficiencies of more than 300% by using electrical energy to extract useful energy from the air, ground or water by a compression cycle.

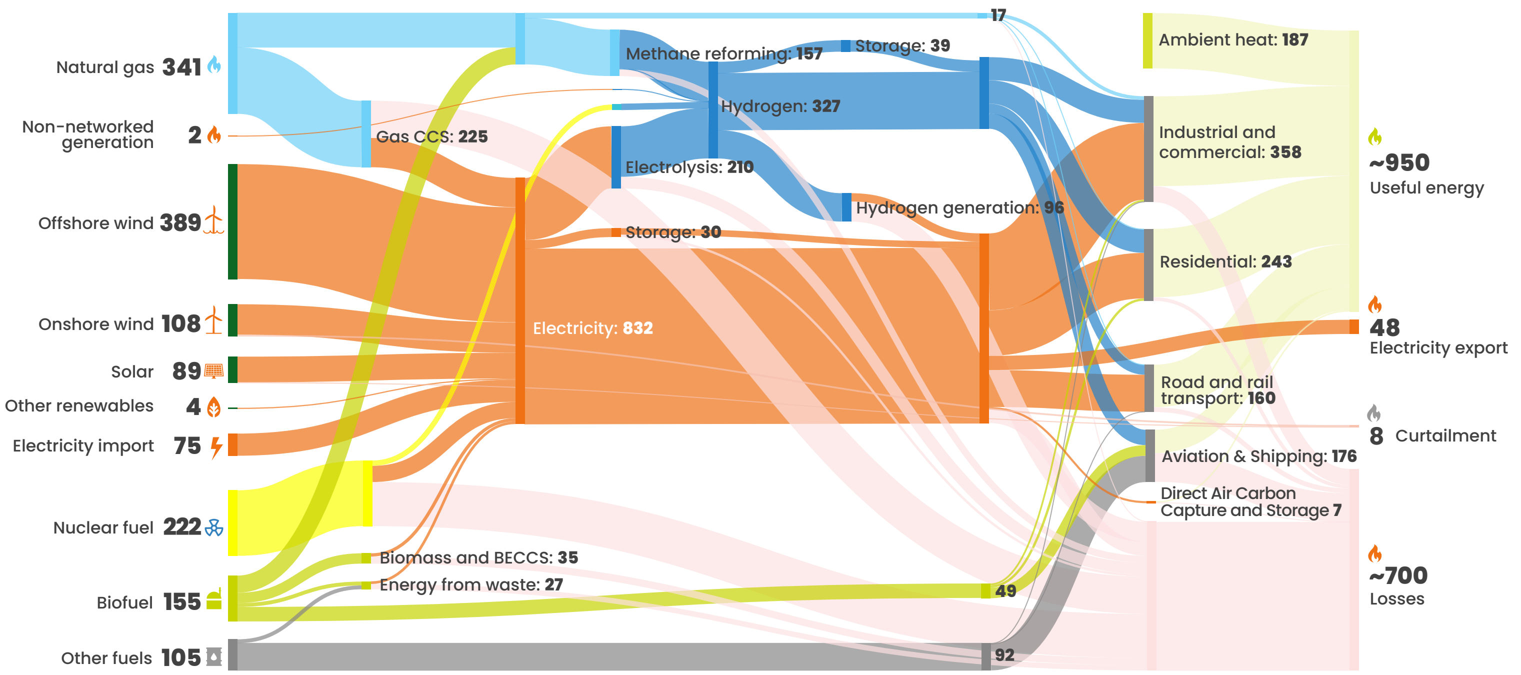
36. Holistic Transition shows an example of a net zero energy system where there are significant changes across supply and demand versus today, and a reduction in overall losses of energy. Sankey diagram showing Holistic Transition in 2050.



37. Electric Engagement has a higher usage of nuclear power, greater electrification of demand, and lower usage of hydrogen. Sankey diagram showing Electric Engagement in 2050.



38. Hydrogen Evolution explores a future where hydrogen takes a more prominent role in the energy system. Sankey diagram showing Hydrogen Evolution in 2050.



Exploring the choices in our pathways

While our pathways offer distinct strategic routes to net zero, some technologies or approaches must be utilised regardless of pathway. It is important to consider where key areas of commonality or difference exist, as these can inform future decisions.

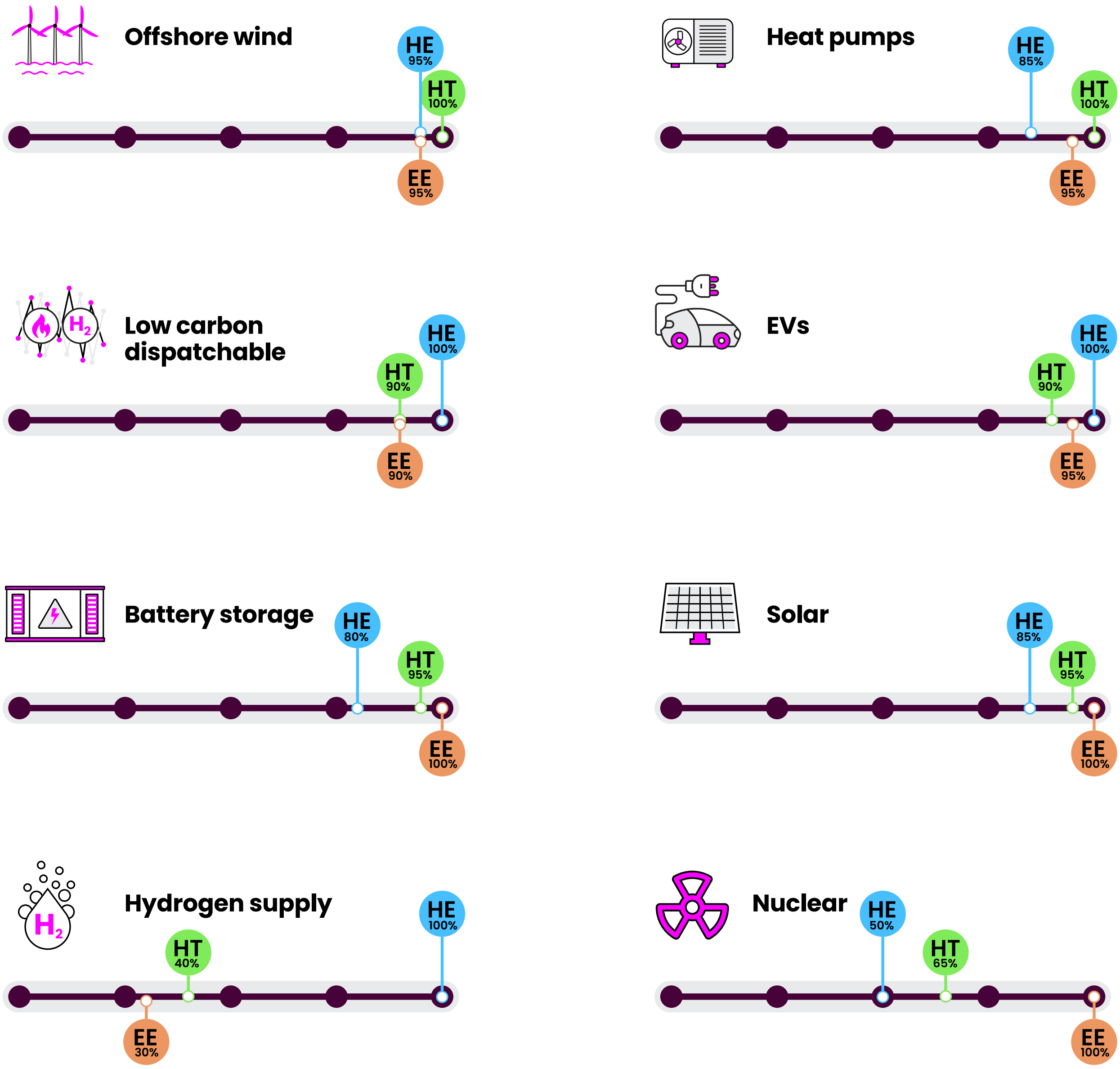
Table 5: Significant commonalities and differences across our pathways.

Commonalities across all pathways All pathways require these actions	**Differences** The most significant differences
EVs make up 100% of new car sales by 2030.	Demand flexibility varies across the pathways due to optionality and uncertainty. Holistic Transition has 82 GW by 2050, while Electric Engagement has 67 GW and Hydrogen Evolution has 41 GW.
Heat pumps and low carbon district heating are the only option for new homes from 2027. No new fossil fuel boilers are installed from 2035.	High uncertainty on future growth of data centres leads to their 2050 demand ranging from 30-71 TWh, including Falling Behind.
By 2035 industry reduces gas demand by 47% in Holistic Transition, 46% in Electric Engagement and 53% in Hydrogen Evolution, compared to 2024 levels.	The choice of low carbon fuel for industry in 2050 ranges from 131 TWh of electricity and 11 TWh of hydrogen in Electric Engagement to 91 TWh of electricity and 47 TWh of hydrogen in Hydrogen Evolution.
By 2035, all pathways have at least 65 GW offshore wind capacity, 35 GW onshore wind capacity and 55 GW solar capacity.	Interconnectors offer different levels of supply side flexibility across the pathways. Holistic Transition has 21.8 GW by 2050, while Electric Engagement has 24.4 GW and Hydrogen Evolution has 17.9 GW.
All pathways have at least 40 $MtCO_2$/yr captured via CCS in 2035.	Hydrogen storage capacities are significantly higher in Hydrogen Evolution by 2050, at 39 TWh. Holistic Transition and Electric Engagement have 12 TWh and 10 TWh respectively.
All pathways have at least 25 $MtCO_2e$ of engineered carbon removals by 2050. Deployment begins from the early 2030s, as these are an important contribution towards the Sixth Carbon Budget.	In 2050, Holistic Transition and Electric Engagement have around 100-120 TWh hydrogen demand, while Hydrogen Evolution has 280 TWh due to residential heating and wider use across sectors.

Is there any slack in the system?

Our pathways deploy different technologies to different levels. One pathway having a lower deployment level than another suggests there may be potential to deploy more if the need arises. For example, another technology falls behind. However, technologies with significant deployment level variations across pathways could be viewed as challenging with regards to policy and incentives, as poor design of these could lead to a far greater uptake than required. Technologies which are deployed to high levels in all pathways could be viewed as important areas to drive progress and uptake regardless of the route to net zero, as well as being technologies that cannot be pushed much harder if others fall behind. It is important, therefore, to understand where additional deployment potential may exist in the future energy system, while recognising that this view is based on what we know at present.

Variation in installed capacity in 2050 for select technologies, relative to the highest level installed in any one pathway.



Highest installed capacity is denoted by the right-most marker

Costing the pathways

Costs in the energy sector are a mix of capital investment, such as vehicles, heating systems, power generating capacity and transmission networks and operational spend, such as fuel costs and maintenance. These costs have fluctuated in the past and will continue to in future.

Our FES pathways have implications for costs; how costs change over time, the distribution of expenditure across different sectors and the balance between capital investment and operating costs. While any projection inevitably involves uncertainty, there are clear trends that can be expected. The net zero pathways see a shift away from operational spend towards investment, and away from imported oil and gas towards increasingly homegrown electricity. The pathways also see options that are expected to add to costs and options that are expected to yield savings compared to today.

We will publish cost analysis in a technical annex in summer 2025, including the estimated costs of the pathways and our costing methodology.

FES does not aim to optimise future pathways around costs. It presents a broad view of possible pathways and looks at a range of outcomes across supply and demand. It deliberately includes different options (some of which will be more expensive) to demonstrate the potential range of uncertainty and options in line with each pathway's core narrative. Therefore, the costings we will present in our technical annex are not estimates of the cost of net zero – rather they explore the potential cost implications of the options and choices available to decarbonise Great Britain's energy system.

In addition, although various factors can influence the comparative cost of the pathways, a significant proportion of costs and savings are effectively already committed when looking forward to 2050 and so are the same across all pathways. These would include costs such as support costs for existing renewables, the maintenance of existing networks and committed network spend, along with savings from switching to electric vehicles.

Various previous analyses have specifically explored more optimised scenarios and this optimisation approach will be an integral part of the *Strategic Spatial Energy Plan* (SSEP). For example, the Climate Change Committee (CCC) identifies that the additional cost of its Balanced Pathway to net zero emissions in 2050 would be below 1% of GDP (0.2% in its latest estimates), on average over 2025-2050 relative to CCC's no-action baseline[21].

Cost estimates are not the same as consumer impact, which is a function of policy and will not be estimated in our analysis.

21 *The Seventh Carbon Budget*, Climate Change Committee, February 2025, p85

Alongside possible costs and savings, the decarbonised pathways see other changes that previous analyses have identified as bringing benefits for job creation, reduced volatility and wider benefits, such as on health.

Economic growth and job creation

There is a potential boost to GDP as the UK economy shifts away expenditure from imported fossil fuels to domestic investment in the UK. For example, a recent report by the CBI and ECIU[22] notes that the net zero sector has grown rapidly in recent years and is now directly or indirectly supporting just less than 1 million jobs, with employment typically in highly productive roles that pay higher than average wages. Many of these roles are located outside London, with net zero employment providing a significant boost to regional economies.

Reduced volatility and exposure to global fossil fuel price shocks

Fossil fuel price shocks have played a major role in economic downturns in the UK, with crude oil supply shortages being a key contributor to the sharp drop in economic output in the early 1980s, with a 3.4% reduction in 1980, and the consequent rise in unemployment[23].

More recently, the Russian invasion of Ukraine in 2022 took place alongside tight supply side conditions in the UK. This led to increased fossil fuel prices, subsequent increases in energy prices and rises in the cost of living for the UK population[24], contributing to a recession and over £75 billion of government spending on energy support schemes[25].

Recent modelling from the Office for Budget Responsibility[26] also considers the potential macroeconomic impacts of future gas price spikes taking place every decade, assuming the UK's reliance on natural gas does not change from today. This finds that there would be a material impact on inflation following each spike and a cutback in domestic spending which reduces real GDP by around 1% (compared to baseline assumptions) each time a gas price shock occurs.

Against this backdrop of exposure to international fossil fuel prices, the transition to net zero offers an opportunity to protect the UK economy from global volatility. As the economy decarbonises, an increasing proportion of the energy used in Great Britain will be produced domestically, reducing reliance on imported fuels and improving energy security.

Non-monetised benefits

There are a number of co-benefits attributable to decarbonisation activity, such as positive health outcomes due to warmer, less damp homes and improved air quality.

We have not attempted to quantify these in the pathways, but their potential impact is likely to be significant. For example, the CCC estimates co-benefits in its Balanced Pathway as providing £2.4 to £8.2 billion per year in net benefit by 2050[27]. Health benefits from improved air quality are the largest contributor to those.

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22 *The Future is Green: The economic opportunities brought bythe UK's net zero economy, February 2025*, CBI Economics,
23 *Fiscal risks and sustainability, July 2023 – CP 870*, Office for Budget Responsibility, p70
24 *The Seventh Carbon Budget*, Climate Change Committee, 26 February 2025, p330
25 *Economic and fiscal outlook - March 2023*, Office for Budget Responsibility, p57
26 *Fiscal risks and sustainability, July 2023 – CP 870*, Office for Budget Responsibility, Chapter 3
27 *The Seventh Carbon Budget*, Climate Change Committee, 26 February 2025, Section 8.4

Policy has a key role in minimising cost

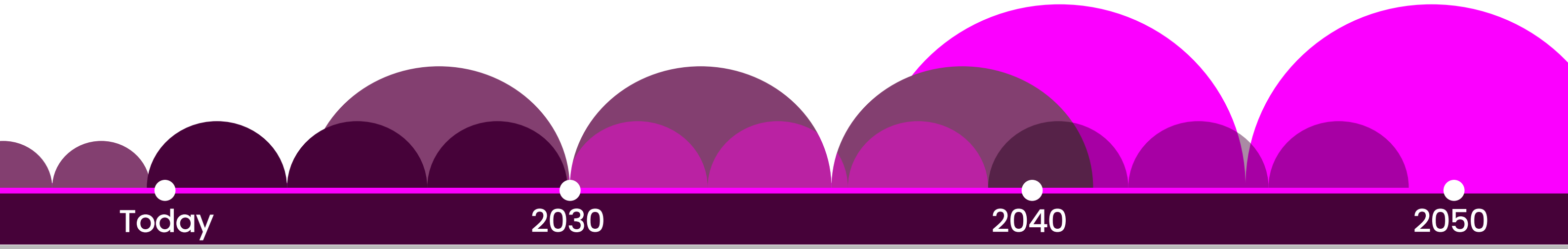
Policy has an important role in keeping costs as low as possible and our pathways suggest some priority areas:

- Keeping costs of capital low. Our pathways (and others, such as the CCC's Balanced Pathway) see a shift away from operating costs towards capital investment. Well-designed policies and a positive investment climate can support lower costs of capital and, therefore, lower costs overall. The Contracts for Difference scheme for renewables is a good example of success on this point.
- Deploying lower cost technologies. In some cases, there are multiple low carbon options to choose from. The lowest cost pathways will deploy the cheapest options most frequently.
- Ensuring efficient system dispatch. Beyond initial investment, there will be choices in how deployed technologies are used. The lowest cost pathways will use the technologies with the lowest operating costs the most and avoid dispatching those with higher costs ahead of their 'merit order'.
- Coordination across the energy system. As decarbonisation progresses it will become ever more important that there is coordination: across sectors, between demand, supply and flexibility, and across energy production and networks for its transmission and distribution. If some areas do not keep pace with others there is a risk of available low-cost energy being wasted and, if supply moves ahead of demand, is a risk of overbuild and excessive investment spending.

The *SSEP*, due to be published in 2026, is a key tool in better coordination for Great Britain's energy system. It will design pathways to support the most economically efficient and spatially optimal pathway to net zero. The first SSEP will include infrastructure for the generation and storage of electricity and hydrogen. Future iterations could cover other energy vectors, like natural gas to encompass a cost-optimised plan for the whole energy system.

Innovating across our pathways

Innovation is a vital force across our pathways. Many of the key technologies in our pathways are technically feasible or commercially available today. However, they may not be affordable for all industrial or domestic consumers, offer the same convenience as fossil fuel technologies or be supported by the right business models. Widespread adoption of low carbon technologies relies on these offering a comparable or better option compared to fossil fuel-based technologies.



WHAT NEEDS TO HAPPEN IN OUR PATHWAYS

Acceleration

Continuing funding for research and innovation across the whole energy system and entire value chain

Innovating in whole energy market and policy to enable acceleration of decarbonisation and reduction of costs for consumers

Growth

Increasing attractiveness and reduced costs of low carbon technologies for consumers

Continuing innovation across the entire value chain for core supply side technologies such as renewables and storage, to enable continued rapid deployment

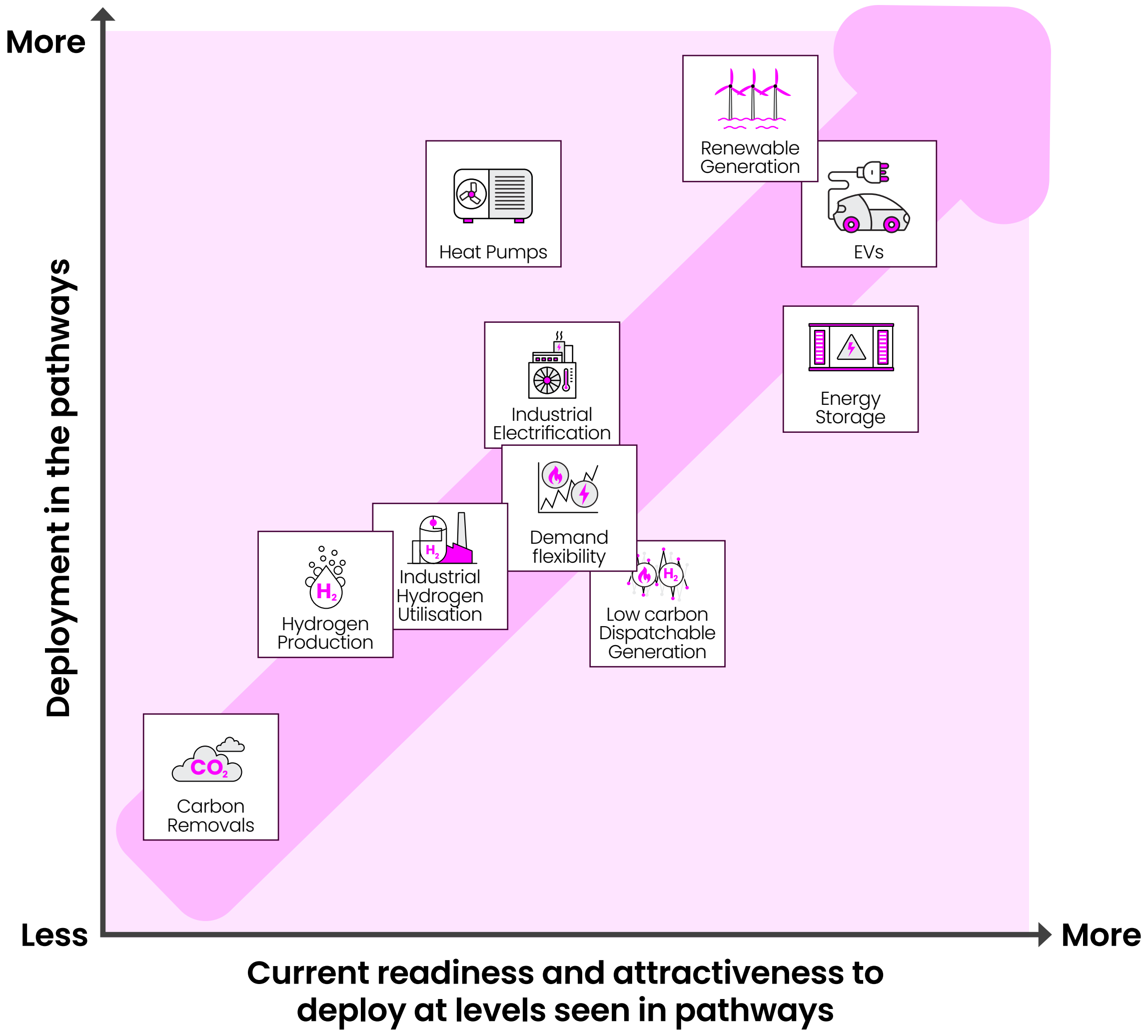
Supporting initial deployment and scaling of nascent technologies such as carbon removals

Horizon

Realising a broad range of affordable, low carbon technologies across the energy system, alongside a supportive policy, regulatory and business ecosystem

Innovation is essential across the entire energy sector value chain: design, manufacturing, construction and installation, operation and maintenance, workforce training, digitalisation and data, policy, and markets. This also extends to leveraging emerging opportunities as the nature of our energy system changes, such as in flexibility. It can create new businesses and industries, increasing productivity and export opportunities.

Low carbon technologies need to be both technically suitable and attractive to a range of consumers, from residential to industrial, to drive widespread adoption.



The government has, in recent years, been a significant enabler of energy innovation. As an example, the headline £1bn Net Zero Innovation Portfolio (NZIP) has driven innovation and new jobs across dozens of projects and ten portfolio theme areas[28]. Analysis by the Startup Coalition[29] using publicly available information has estimated that 199 UK start-ups have received between £208-250m of NZIP funding, going on to raise a further £500-900m of venture investments. This is equivalent to £2.40-£3.60 of private sector investment for every £1 of NZIP funding received. The final government impact and economic assessment of NZIP is not expected until 2028[30].

Government should maintain a continued role in enabling energy innovation across the whole system, entire value chain and at different technological readiness levels. This is essential if we are to accelerate progress on decarbonisation by 2030, realise widespread adoption and deployment of low carbon technologies through the 2030s and reach net zero by 2050.

28 *Net Zero Innovation Portfolio*, Gov.uk, 25 May 2023
29 Warm Words on Climate Innovation Must be Matched With Investment, Startup coalition, 04.04.25
30 *Net Zero Innovation Portfolio and the Advanced Nuclear Fund: progress report 2021 to 2022*, Gov.uk, 25 May 2023

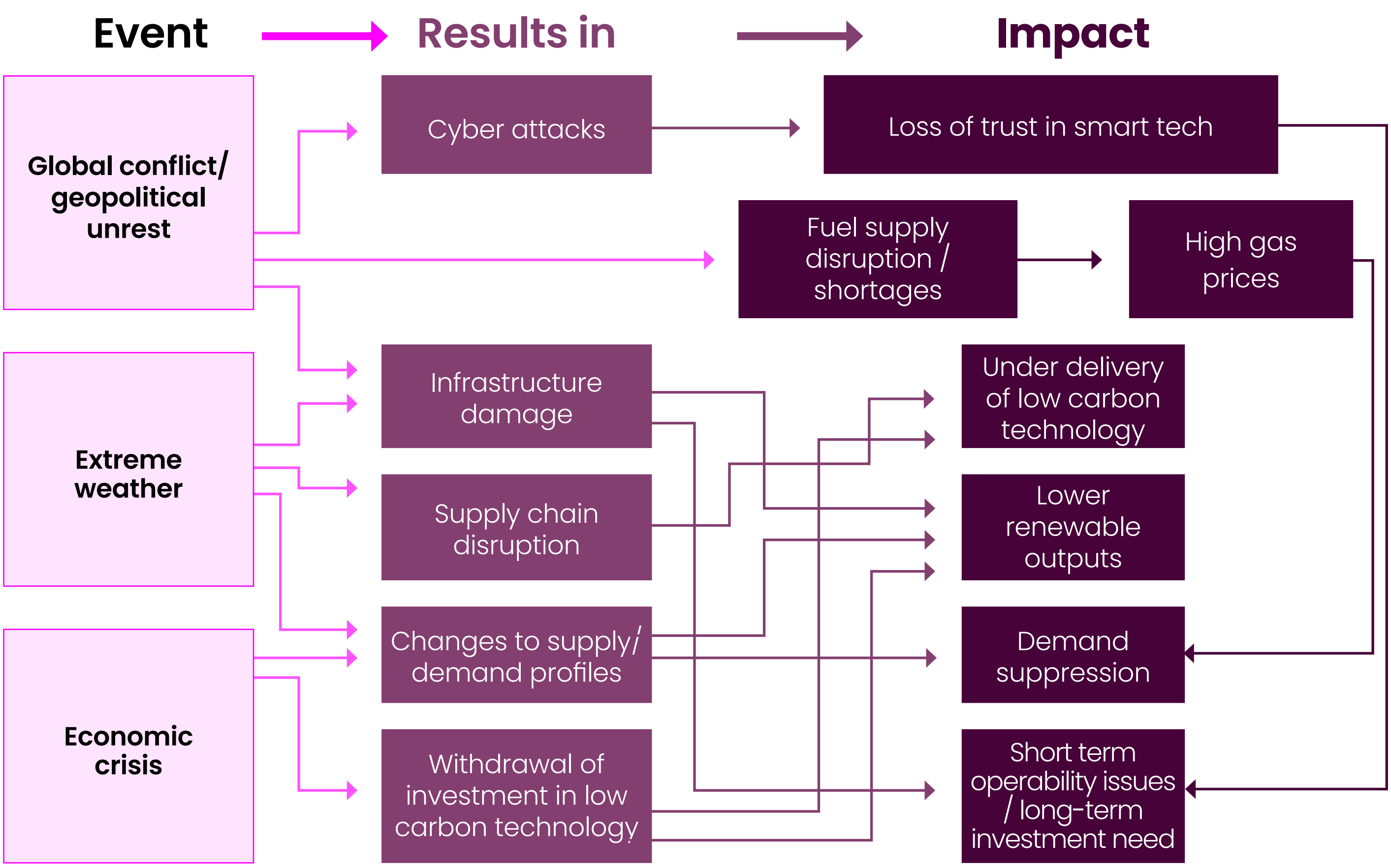
Exploring the extremes

Extreme weather, geopolitical conflict and financial shocks are examples of the types of events which could have an impact on the energy system.

Extreme events can be wide reaching, affecting homes and businesses across the country. As the energy system operator, NESO's approach is to build resilience in to help manage the unexpected without compromising the transition to a cleaner, smarter energy system.

NESO's Resilience and Emergency Management function explores extreme impacts and the recently published *Resource Adequacy in the 2030s* models the impact of extreme weather and technical outages of equipment on security of supply. Analysis from *FES 2024* was used as a basis for this and has been incorporated into our *FES 2025* analysis, particularly for unabated gas generation.

Extreme events could have wide-reaching and interlinking impacts.



We must understand how impacts, regardless of cause, could challenge the core assumptions behind our pathways and lead to deviations. We consider the uncertainty around demand and supply in our modelling, such as future data centre demand, consumer engagement in demand flexibility and the levels of hydrogen demand in industry. We have assessed where the impact of extreme events could differ from these.

How these events affect Great Britain's ability to remain on track for net zero depends on various factors, such as the duration of the event and the decarbonisation progress made up to that point. Many of these impacts are also interlinked. Disrupted gas supplies could, for example, lead to high prices which, in turn, leads to demand suppression.

Loss of trust in smart technology

Without trust in smart technology, the country would not see the level of demand side flexibility outlined in our pathways. Any loss of trust towards the end of the growth and horizon waves could hold back the use and effectiveness of any technology already installed. This would have the greatest impact in our Holistic Transition and Electric Engagement pathways, which have higher levels of consumer engagement.

High international gas prices

Gas prices significantly influence emissions today while Great Britain relies heavily on gas for industry, heat and power. Recent price spikes have increased electricity costs, with gas setting the marginal price. High prices reduce emissions by discouraging gas use and incentivising investment in non-fossil technologies for those able to do so. However, they also have a significant impact on consumer costs and affordability of low carbon technologies. This reduces in the horizon wave as gas use substantially declines.

Under delivery of low carbon technology

If low carbon technology rollout falls below the levels in our pathways, homes, businesses and the power sector will be reliant on natural gas. This would likely depend on existing systems and plant on both the demand and supply sides of the energy system (for example, gas boilers and unabated gas power stations) and would slow progress towards climate goals and leave the country vulnerable to price spikes. Depending on the extent of delays, it could also move us closer to, or beyond the extents of, the Falling Behind scenario. This would have a similar impact across all pathways, which rely on timely delivery of roll-out of low carbon technology.

Low renewable output

Periods of low renewable output increase the need for unabated gas generation for security of supply, increasing energy prices and emissions. While our pathways all see significant growth in renewable energy, the impact of this on emissions reduces with increased reliance on long-duration energy storage (LDES) and low carbon dispatchable power. Unabated gas remains in all pathways through the horizon wave. Prolonged periods of low renewable output have been assessed quantitively in our *Resource Adequacy In The 2030s* report.

Demand suppression

Reducing consumption today directly cuts emissions by reducing the need for fossil-fuelled heat, transportation and power. An event like the energy crisis could again suppress gas heating demands and associated emissions by 18%. As the country electrifies and emissions from heat, transport and power reduce, the positive emissions impact of demand suppression reduces. Demand suppression has a positive impact on security of supply today due to reduced stress on generation. In a net zero energy system this will need to be managed through increased flexibility, exports or curtailment.

Increased demand

An increase in demand today would raises emissions due to the need for greater fossil-fuelled energy production. This would have less impact in 2050 but would depend on the levels of low carbon flexibility in the system. Without energy efficiency improvements, demand could be 23% (127 TWh) higher in 2050. Any increase in population above that forecast would lead to increasing demand. Using 2022 high demographic data from the Office for National Statistics (ONS), there will be a population increase of one million in 2050. This would increase peak electricity demand by 0.8 GW and annual electricity demand by 3.1 TWh.

Short-term operability issues and the need for long term investment

Emergency response plans are in place to deal with short-term operability issues caused by extreme events. This often includes rerouting energy flows, deploying repair teams to quickly address damaged infrastructure and coordinating reserve supplies and back-up systems to maintain service continuity.

7. Pathway Insights

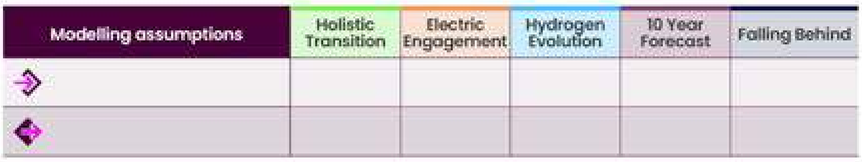
Navigating These Insights

Future Energy Scenario outputs

Our three net zero pathways, Falling Behind and 10 Year Forecast are denoted by a set colour palette, which features across many of our graphs in the *Future Energy Scenarios 2025 Data Workbook.*

You will see these colours referenced within the 'modelling assumptions' tables across our factsheets.

The key differences between these are explained on page 20 in the Executive Summary of the document.



Inputs

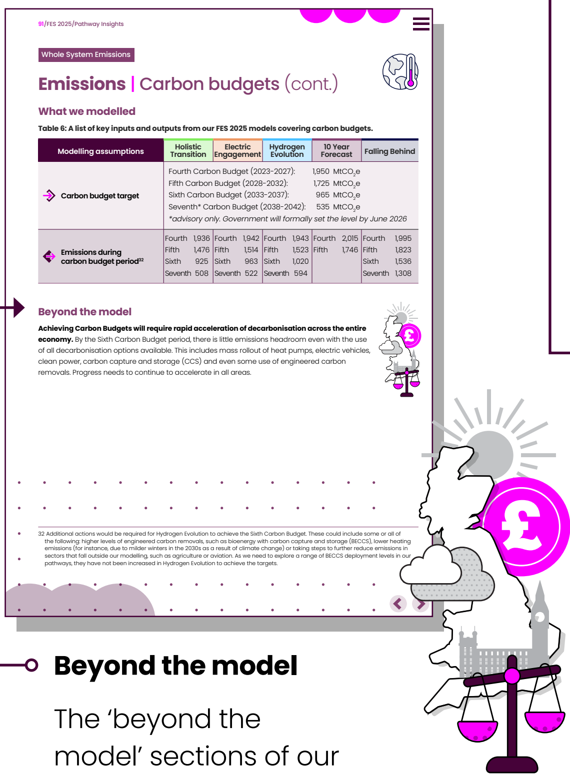
You can find a list of the key inputs that underpin the modelling of specific energy vectors and technologies in the 'modelling assumptions' tables across the factsheets. These inputs are determined through a mix of stakeholder collaboration, research and external data sources from organisations such as the Climate Change Committee.

For a comprehensive list of our inputs and key assumptions, please refer to the *Future Energy Scenarios Pathway Assumptions 2025* document, which can be found via our FES homepage on the NESO website.

Outputs

We also list the key outputs of our modelling in the 'modelling assumptions' tables across the factsheets – these outputs are a result or consequence that emerge from the input, assumptions and modelling logic applied under certain constraints or scenarios.

For a comprehensive list of our outputs, please refer to the *Future Energy Scenarios 2025 Data Workbook*, which can also be found via our FES homepage on the NESO website.



Beyond the model

The 'beyond the model' sections of our factsheets detail general assumptions that would need to happen for the pathways to be possible. These are assumptions on factors that are not directly captured within our models.

Acronyms

We use common industry acronyms throughout this report, including the factsheets. Please refer to the glossary at the end of this document for a full list of acronyms featured within this publication. build rate limits for solar and onshore wind.

Minimum and maximum build out rates

Minimum and maximum build out rates are set for generation capacities, and optimised in our capacity expansion module. These are included to capture variables that are not within the modelling, such as land constraints, grid constraints and policy ambition. This includes minimum build rates for nuclear and offshore wind and maximum build rate limits for solar and onshore wind.

Whole System Emissions

Whole System Emissions

Emissions | Carbon budgets

Overview

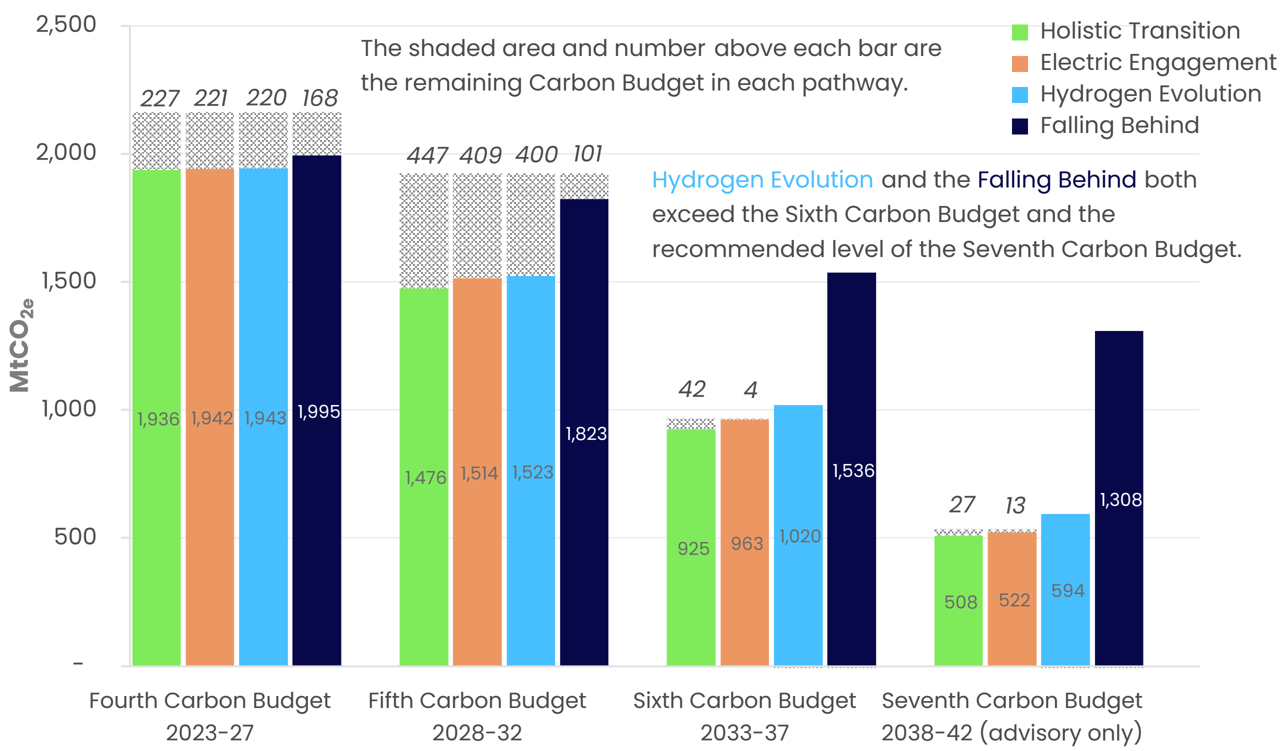
Carbon budgets are legally binding emissions limits that encompass a five-year window of emissions in the UK.

There are a variety of routes by which we could decarbonise to achieve the Fourth (2023–2027) and Fifth (2028–2032) Carbon Budget, though these were set under the Climate Change Act's former target of an 80% greenhouse gas reduction by 2050.

The Sixth Carbon Budget (2033–2037) presents an immense challenge, as it is the first net zero compliant carbon budget. To maximise our opportunity to meet these targets, we need to use a variety of rapid and deep decarbonisation options, and must scale many of these now to ensure we are decarbonising at a sufficient pace.

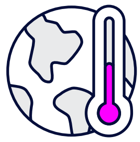
The government must formally set the level of the Seventh Carbon Budget period (2038–2042) by June 2026.

39. Accumulated emissions for carbon budget period



Whole System Emissions

Emissions | Carbon budgets (cont.)



What we modelled

Table 6: A list of key inputs and outputs from our FES 2025 models covering carbon budgets.

Modelling assumptions	Holistic Transition	Electric Engagement	Hydrogen Evolution	10 Year Forecast	Falling Behind
Carbon budget target	Fourth Carbon Budget (2023-2027): 1,950 $MtCO_2e$ Fifth Carbon Budget (2028-2032): 1,725 $MtCO_2e$ Sixth Carbon Budget (2033-2037): 965 $MtCO_2e$ Seventh* Carbon Budget (2038-2042): 535 $MtCO_2e$ **advisory only. Government will formally set the level by June 2026*				
Emissions during carbon budget period[31]	Fourth 1,936 Fifth 1,476 Sixth 925 Seventh 508	Fourth 1,942 Fifth 1,514 Sixth 963 Seventh 522	Fourth 1,943 Fifth 1,523 Sixth 1,020 Seventh 594	Fourth 2,015 Fifth 1,746	Fourth 1,995 Fifth 1,823 Sixth 1,536 Seventh 1,308

Beyond the model

Achieving Carbon Budgets will require rapid acceleration of decarbonisation across the entire economy. By the Sixth Carbon Budget period, there is little emissions headroom even with the use of all decarbonisation options available. This includes mass rollout of heat pumps, electric vehicles, clean power, carbon capture and storage (CCS) and even some use of engineered carbon removals. Progress needs to continue to accelerate in all areas.

31 Additional actions would be required for Hydrogen Evolution to achieve the Sixth Carbon Budget. These could include some or all of the following: higher levels of engineered carbon removals, such as bioenergy with carbon capture and storage (BECCS), lower heating emissions (for instance, due to milder winters in the 2030s as a result of climate change) or taking steps to further reduce emissions in sectors that fall outside our modelling, such as agriculture or aviation. As we need to explore a range of BECCS deployment levels in our pathways, they have not been increased in Hydrogen Evolution to achieve the targets.

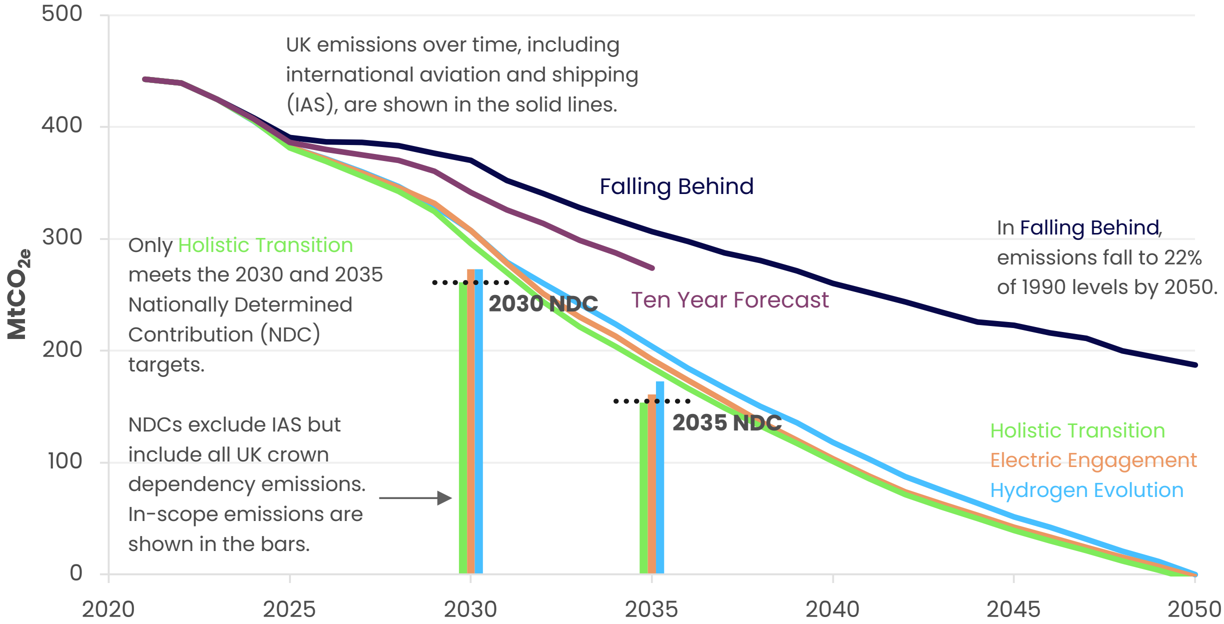
Whole System Emissions

Emissions | Whole economy emissions

Overview

Achieving net zero is possible, but the road from here requires greater decarbonisation efforts in sectors beyond power, such as transport and heating. Many of the required technologies, such as wind, solar and electric vehicles, have a track record of delivery at scale in the UK and internationally. Some others, like low-carbon hydrogen production and carbon capture, are technically feasible but have a smaller record of deployment at scale. The challenge is to make sure they are attractive, affordable and adoptable for all consumers who will require them.

40. Greenhouse gas emissions over time and nationally determined contributions



Road and rail currently has the highest emissions of any single sector at 102 $MtCO_2e$ in 2023.

What we modelled

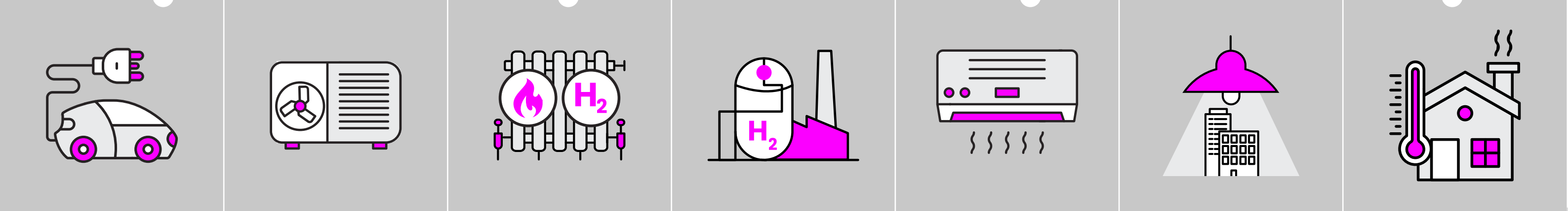
Table 7: A list of key inputs and outputs from our FES 2025 models covering emissions.

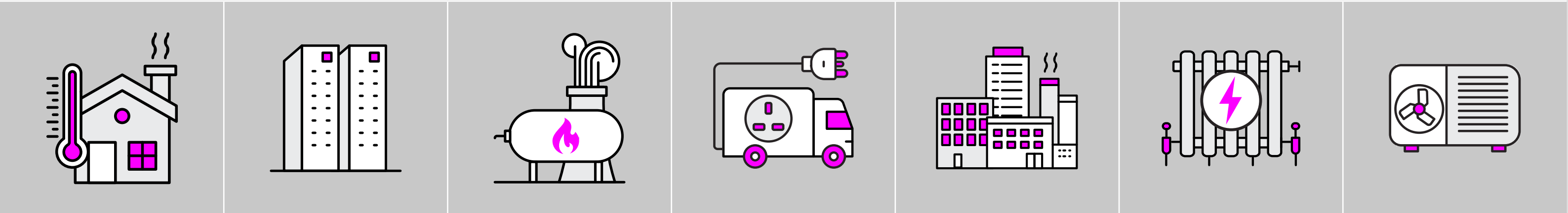
Modelling assumptions	Holistic Transition	Electric Engagement	Hydrogen Evolution	10 Year Forecast	Falling Behind
Meeting 2030 Nationally Determined Contribution target of 261 $MtCO_2e$	261	273	273	304	330
Meeting 2035 Nationally Determined Contribution target of 155 $MtCO_2e$	154	161	172	241	272
Emissions in 2050	-6	-2	0	N/A	187
Non-modelled sectors	Emissions were taken from CCC's CB7 Balanced Pathway for agriculture, aviation, shipping, waste, fluorinated gases, BECCS for biofuels, fuel supply and LULUCF.			Approach from DESNZ Carbon Calculator, as used in FES 2024	

Beyond the model

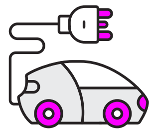
Our pathways show that a range of technologies and approaches are required across all sectors to reach net zero. Delaying decarbonisation progress will, at the very least, mean failing to meet interim carbon budgets, necessitating even deeper and faster emissions reductions in later decades.

Shaping Energy: The Consumer





Shaping Energy: The Consumer



Transport | Electric cars

Overview

Road transport is the largest emitting sector – double any other sector modelled within FES – with cars making up approximately half of road transport demand and emissions.

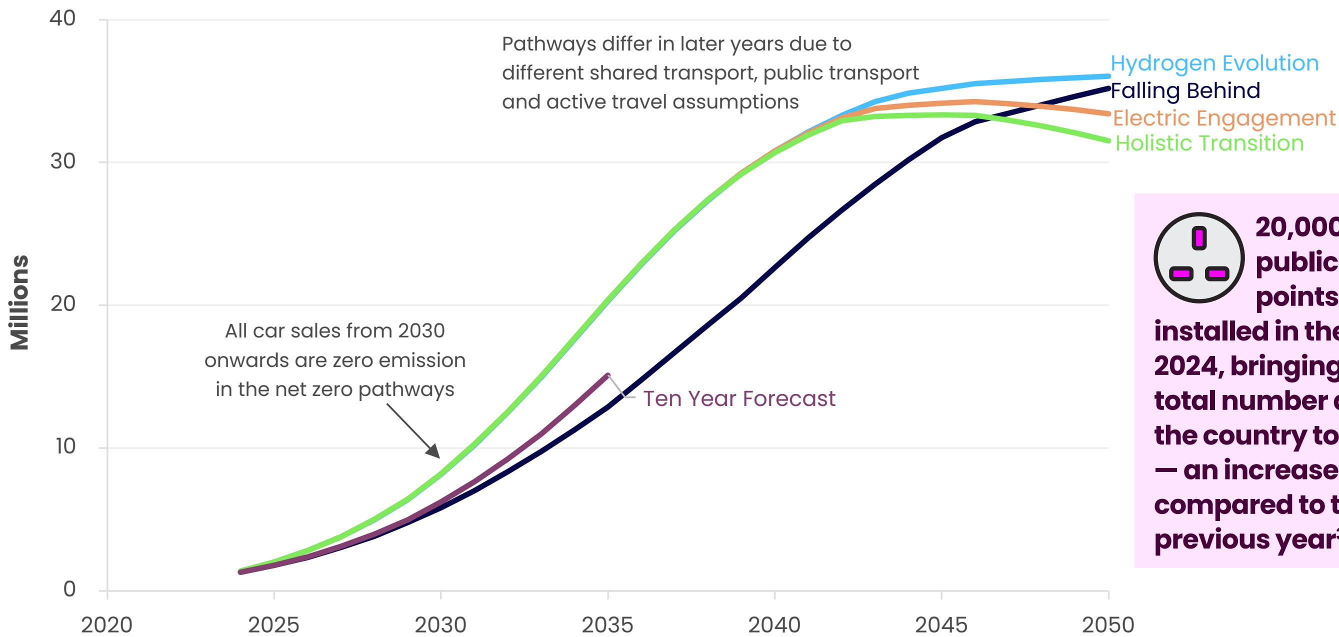
For a breakdown of emissions per sector, please refer to page 29 of the report.

With the UK Government's Zero Emission Vehicles (ZEV) mandate firmly established for the sale of new EV cars and vans out until 2035, the transport sector has the power to be a positive driver of decarbonisation.

In 2024, 19.6% of new car sales were EVs, showing that mandate figures were only achieved by using flexibilities permitted through methods such as credit offsetting. The 2024 EV sales figure is marginally lower than required in our FES 2024 net zero pathways, making it imperative that sales of new low carbon vehicles strive to hit mandated targets to help achieve Great Britain's wider net zero targets. Factors including price differentiation between EVs and internal combustion engine (ICE) vehicles continue to contribute to a lack of uptake, although this is quickly reducing, with many new EV models now costing less than their ICE equivalents and widespread purchase cost parity expected in the coming years. November and December 2024 saw high EV sales through competitive pricing and increased promotion – December 2024 even saw EVs achieve the highest sales of all fuel types.

Consumer confidence in communal charging, on average, is growing as Great Britain's public and destination charging infrastructure continues to expand and, with contactless payment availability on >8kW chargers improving, aiding convenience and user experience. Despite this, public charging costs are often higher than refuelling ICE vehicles, creating inequality and little incentive to adopt EVs for those without lower-cost home charging, continually cited as a significant blocker for EV adoption for those that have not yet made the switch.

41. Electric cars on the road



20,000+ new public charge points installed in the UK in 2024, bringing the total number across the country to 74,000 — an increase of 38% compared to the previous year[32].

32 EV charging statistics 2025, Zapmap

Shaping Energy: The Consumer

Transport | Electric cars (cont.)

Stakeholder views

Most stakeholders felt the ZEV mandate is challenging, but some stakeholders felt it is possible to go faster due to increasing economic competitiveness of battery electric cars.

Purchase cost difference between new EV and ICE vehicles reducing, with EVs 51% more expensive in 2018 down to 18% more expensive in 2024[33].

How we addressed feedback

The speed of EV adoption has increased in *FES 2025* and the net zero pathways are faster than the ZEV mandate to meet emissions targets. The Ten Year Forecast and Falling Behind are slower than the ZEV mandate targets, in line with most stakeholder feedback.

EVs are now able to last as long and drive as many miles as an ICE equivalent[34].

What we modelled

Table 8: A list of key outputs from our FES 2025 models covering energy demand from cars (both ICE and ZEVs).

Modelling assumptions	Holistic Transition	Electric Engagement	Hydrogen Evolution	10 Year Forecast	Falling Behind
No more new ICE sales	2030	2030	2030	2030	2035
No more new PHEV sales, all new sales are only pure EV	2030	2030	2030	2035	2040
Total EVs on the road in 2050. Differences due to levels of shared transport, public transport and active travel	31.5m	33.4m	36.1m	N/A	35.2m

Beyond the model

EV charger deployment focuses on improving access for those without home charging. Building on the total number of chargers in relation to EVs on the road to date, future deployment of chargers meets the needs of consumers without access to home charging, alongside growth in rapid en-route chargers across all regions of Great Britain. This helps to remove the regional divide.

Public charging rates are reduced to ensure EVs offer a lower fuel cost than ICE equivalents. Measures such as reducing VAT on public charging to align with home electricity rates, and reducing standing and capacity costs for charge point operators improve equity for EV ownership for those without home chargers.

Growth in en-route charging infrastructure facilitates the uptake of smaller, more affordable EVs by reducing the perceived need for higher range vehicles. This promotes the mass market uptake of EVs. The manufacture of smaller vehicles lower embodied emissions from manufacturing and higher efficiencies are encouraged.

Clear, up-to-date information on EVs and charging is promoted while removing old or inaccurate information. Consumers are informed of the approaching cost parity, the benefits of off-peak charging, charger availability, actual range requirements, driver experience and that high power charger costs are not the normal way for most consumers to charge.

33 Closing the gap: the progress towards affordable EVs and the rising competition from China, Jato

34 Electric cars: Facts and figures, Autotrader

Shaping Energy: The Consumer

Transport | Other vehicles

Overview

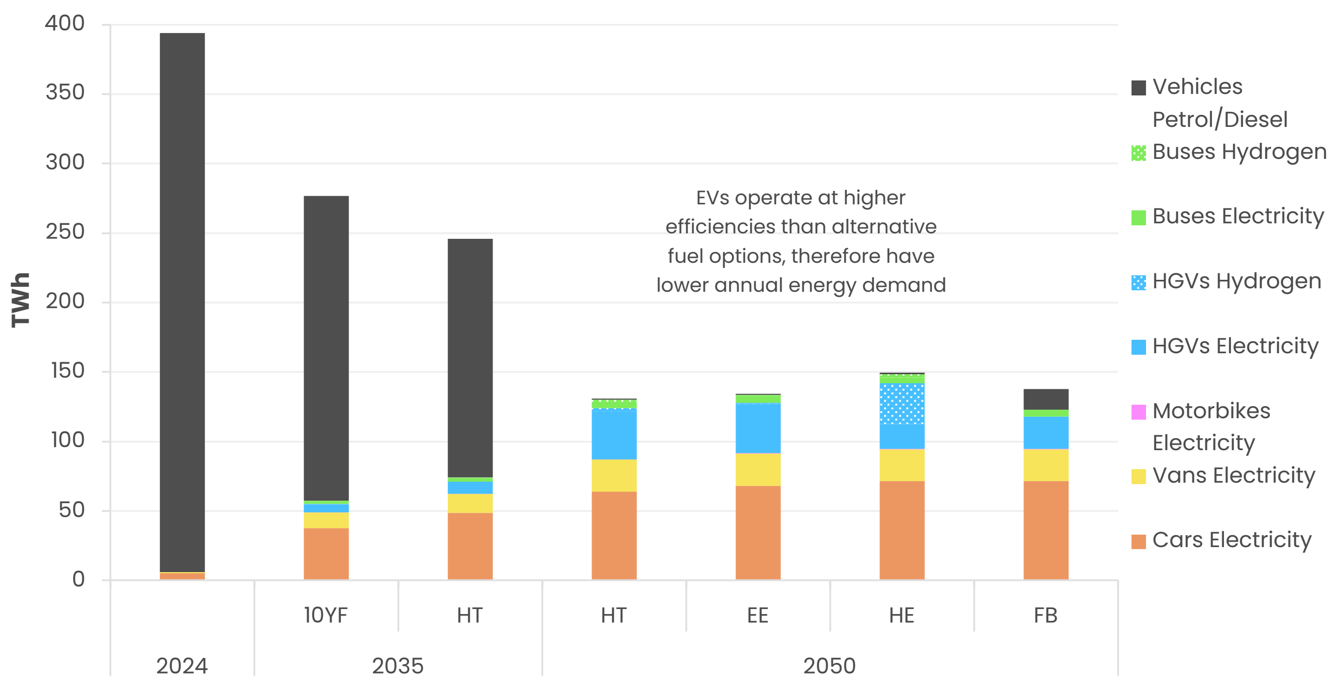
Vans and heavy goods vehicles (HGV) are starting to decarbonise, gradually following the car market. The ZEV mandate for vans has created policy certainty for industry and is demonstrated by the fact that 52%[35] of all new van models were battery EVs at the start of 2025.

Currently, there are limited low carbon HGVs on the road, but developments in the vehicles and chargers alongside growing orders show the potential.

Buses are decarbonising faster than other transport sectors. Although the number of registered hydrogen buses and coaches on the road is decreasing, as access and cost of hydrogen remain a challenge for transport, electrification of this sector is progressing well as the technology develops.

Energy demand for road transport reduces to a third of 2024 demand in 2050.

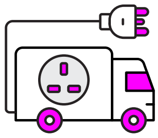
42. Road transport energy demand



35 Electric van demand static in 2024 despite biggest overall market in three years, SMMT

Shaping Energy: The Consumer

Transport | Other vehicles (cont.)



Stakeholder views

Most stakeholders expressed a preference for battery HGVs over hydrogen. They also suggested a slower shift away from diesel HGVs in Falling Behind compared to *FES 2024*.

How we addressed feedback

Reduced amount of hydrogen in HGVs across pathways and increased amount of diesel HGVs in Falling Behind.

What we modelled

Table 9: A list of key outputs from our FES 2025 models covering energy demand from other electric vehicles.

Modelling assumptions	Holistic Transition	Electric Engagement	Hydrogen Evolution	10 Year Forecast	Falling Behind
Vans on the road in 2035 that are EVs	56%	56%	56%	46%	33%
Buses on the road in 2035 that are EVs	52%	52%	53%	40%	27%
Share of HGVs on the road that are electric and hydrogen in 2050	93%, 7%	98%, 2%	65%, 35%	N/A	71%, 0%

Beyond the model

Policies like the ZEV mandate are applied to other vehicle sectors to increase certainty for the industry and encourage investment. Petrol and diesel phase-out dates are confirmed for all vehicle sectors to drive this confidence.

A nationwide high-power charging infrastructure for HGVs, buses and coaches is deployed. This is enabled by faster grid connections for en-route charging hubs for large and commercial vehicles.

Shaping Energy: The Consumer

Residential | Appliances

Overview

Our residential appliance modelling covers all demand in residential properties other than demand associated with transport or space and hot water heating.

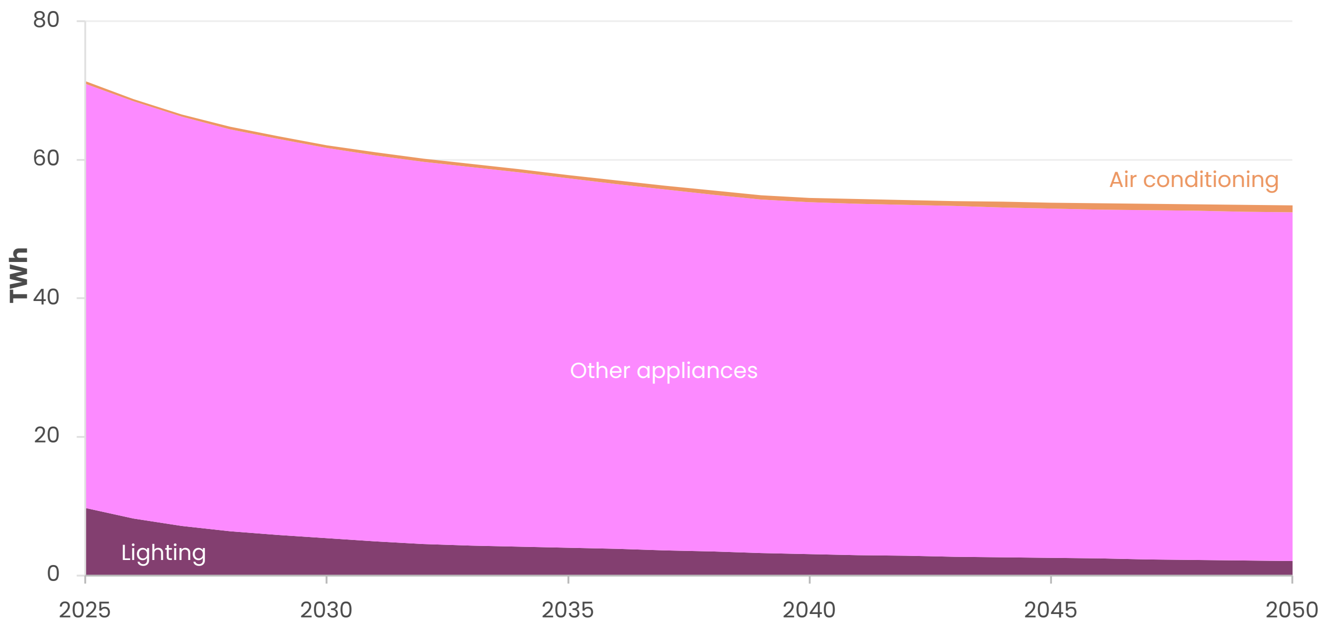
Historic trends have reduced residential appliance demand due to efficiency improvements. This has mainly come from legislation on phasing out less efficient lighting. Looking forward, the efficiency improvements for residential appliances include fridges, freezers, TVs, home computing and cooking appliances (appliances that are projected to continue to be widely used).

Air conditioning is currently estimated to be used in 3% of homes today, equating to a 0.3 TWh demand. The energy demand of air condition units still face uncertainty, with their adoption and usage dependent on climate change and associated extreme heat events, as well as upfront costs for consumers. The impact of climate change is expected to be greater post-2050.

Growing population and changes in appliance ownership and usage patterns also play an important role in changing appliance demand.

Appliance efficiency improvements reduce peak demand by 4 GW in Holistic Transition, equivalent of four power stations, by 2035.

43. Residential electricity demand for appliances in Holistic Transition



Shaping Energy: The Consumer

Residential | Appliances (cont.)

Stakeholder views

Stakeholder consensus was that air conditioning growth is inevitable. The majority of stakeholders said that cooking demand would be electrified instead of fuel switching to hydrogen, due to the popularity of induction hobs.

How we addressed feedback

We have increased the minimum growth of air conditioning and modelled the electrification of all residential cooking by 2050 across all pathways.

What we modelled

Table 10: A list of key inputs and outputs from our FES 2025 models covering energy demand from residential appliances.

	2035	2050				
Modelling assumptions	Ten Year Forecast	Holistic Transition	Holistic Transition	Electric Engagement	Hydrogen Evolution	Falling Behind
Homes with air conditioning	8%	5%	10%	20%	20%	40%
Air conditioning demand	0.8 TWh	0.5 TWh	1.1 TWh	2.1 TWh	2.1 TWh	4.3 TWh
Lighting demand	4.2 TWh	4.0 TWh	2.1 TWh	2.4 TWh	2.4 TWh	3.2 TWh
Other appliance demand	57.6 TWh	53.3 TWh	50.3 TWh	55 TWh	55 TWh	61.4 TWh

Beyond the model

Minimum efficiency of appliances and lighting increase over time, continuing the trend of reducing demand for consumers.

Passive cooling measures become widely used to limit the need for air conditioning and to reduce overheating, especially for lower income consumers and those in vulnerable situations. New buildings to include best passive cooling practices.

Shaping Energy: The Consumer

Residential | Thermal efficiency

Overview

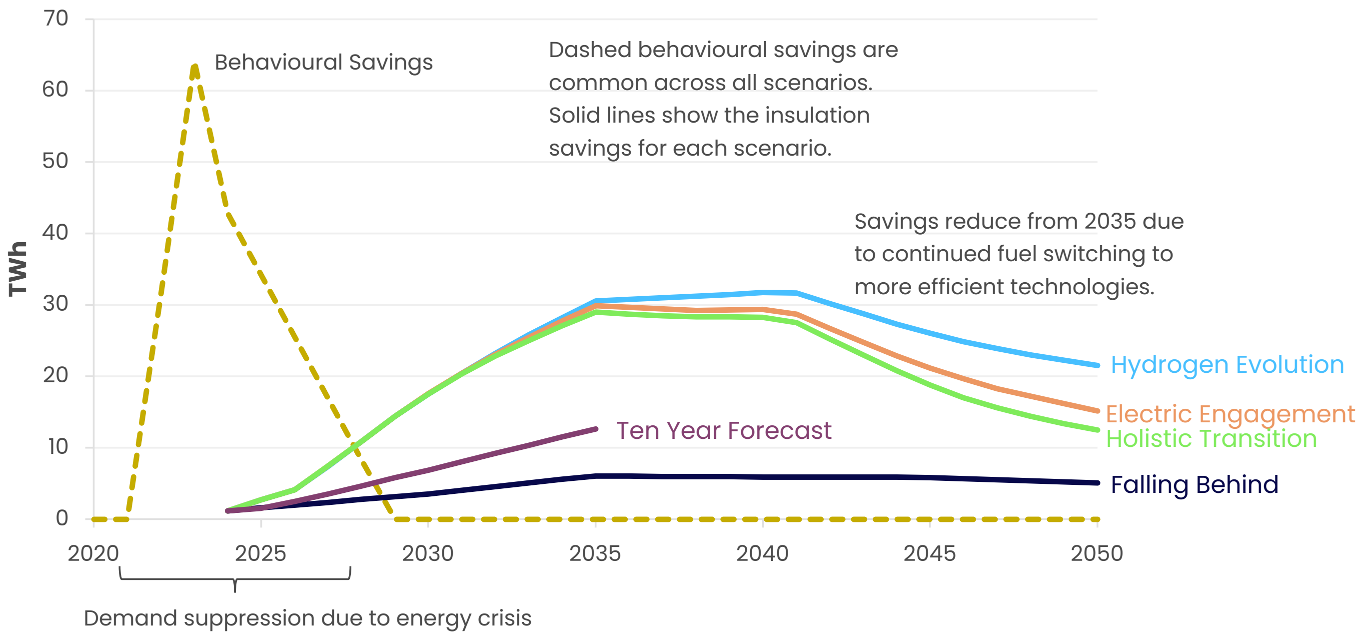
Thermal efficiency measures include any actions that reduce underlying thermal demand from heating buildings – this includes draught proofing and insulation improvements to roofs, walls, windows and hot water tanks.

Thermal efficiency measures reduce consumer bills, but despite this, all thermal efficiency has seen limited deployment over the last decade relative to housing stock needs. Although there is now insufficient time for a 'fabric-first' approach, and it is more widely accepted that high insulation levels are not required for heat pumps, there are still benefits to quick deployment of thermal efficiency measures as they decrease emissions from gas boilers and, in the long-term, they reduce the need for network investment and generation capacity.

The term 'thermal efficiency' also includes how consumers change their heating patterns, as seen in the energy crisis, when high costs suppressed energy demand. In 2023, at the high point of high energy costs, consumers reduced their demand by 18% (equivalent to a 1.5°C reduction to thermostats) but by 2024 this demand suppression started to reduce.

The graph below shows thermal efficiency measures for retrofit and improved new build standards. It also shows the behavioural measure changes relative to the baseline of 2020, pre-energy crisis.

44. Residential fuel demand savings from insulation improvements and behavioural change



Shaping Energy: The Consumer

Residential | Thermal efficiency (cont.)

Stakeholder views

Most stakeholders expressed a lack of enthusiasm for thermal efficiency measures due to rising costs. They advised it was important for consumers to understand that high levels of insulation are not essential for having a heat pump.

How we addressed feedback

To meet the 2030 emissions targets, deployment of thermal efficiency measures was retained in the pathways as this reduces gas demands. Lower levels are used in Falling Behind and the Ten Year Forecast.

What we modelled

Table 11: A list of key inputs and outputs from our FES 2025 models covering residential thermal efficiency.

Modelling assumptions	Holistic Transition	Electric Engagement	Hydrogen Evolution	10 Year Forecast	Falling Behind
Thermostat turn down/ Demand suppression	Tapers out by 2029				
All new homes built to future homes standard	2027	2027	2027	2027	2031
Fuel savings from thermal measures by 2035	29 TWh	30 TWh	31 TWh	13 TWh	6 TWh

Beyond the model

Deployment of thermal efficiency measures doubles to reduce emissions in the short term.

There is consistent, long-term support for thermal efficiency measures to reinforce the future system network benefits, whilst enabling the industry to build back up. Insulation quality standards are high to prevent downstream issues and encourage higher uptake.

Shaping Energy: The Consumer

Residential | Gas and hydrogen for heat

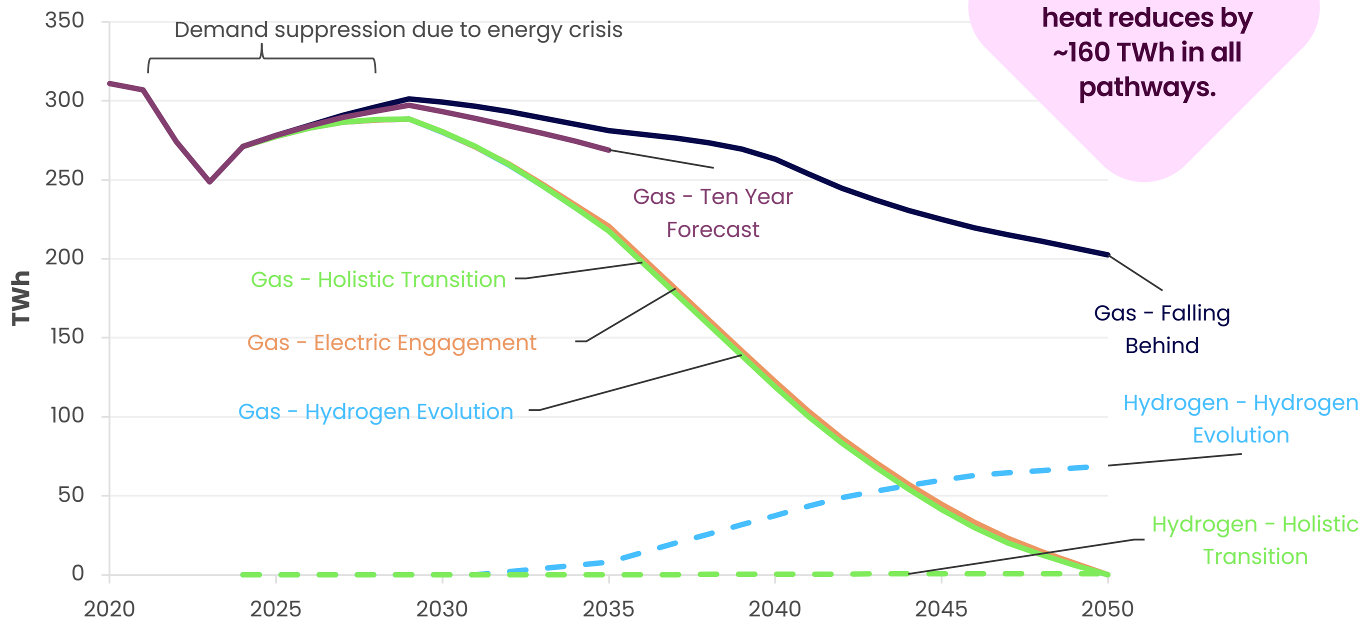
Overview

Gas demand is starting to return to pre-energy crisis levels, with less demand suppression in 2024 compared to 2023.

This suppression tapers out over the next 5 years in our analysis. Gas demand for heating needs to reduce to meet the 2030s emissions targets, mainly through electrified heating, however there is still a low public recognition of the need to reduce emissions from heating[36] which needs to be overcome. Ahead of a government decision on the use of hydrogen for heating, our FES pathways continue to consider all potential options for the use of hydrogen in heating – from hydrogen boilers in homes to a secondary fuel in district heating.

In the 2030s gas demand for heat reduces by ~160 TWh in all pathways.

45. Annual natural gas and low carbon hydrogen demand for residential heat



Stakeholder views

Most stakeholders felt that hydrogen would be expensive for heating homes and may only be available near industrial clusters if used at all.

How we addressed feedback

We have reduced the use of hydrogen for heating across all pathways, but kept options until the UK Government decision is made.

36 NESO Whole Energy Insight - Decarbonising Heat: Consumer Choice and Affordability

Shaping Energy: The Consumer

Residential | Gas and hydrogen for heat (cont)

What we modelled

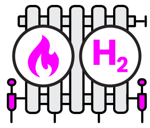


Table 12: A list of key inputs and outputs from our FES 2025 models covering residential gas and hydrogen for heating.

Modelling assumptions	Holistic Transition	Electric Engagement	Hydrogen Evolution	10 Year Forecast	Falling Behind
No new gas connections	2027	2027	2027	2027	2031
No gas boiler installs	2035	2035	2035	N/A	(Gas boilers never phased out)
No oil boiler installs	2029	2029	2029	N/A	(Oil boilers never phased out)
Access to hydrogen for heat	District heating	None	National network	None	None
Gas demand for residential heating in 2035	218 TWh	221 TWh	218 TWh	269 TWh	281 TWh
Hydrogen demand for residential heating in 2050	1 TWh	0 TWh	69 TWh	N/A	0 TWh

Beyond the model

Electricity prices reduce comparatively to gas, making heat pumps cheaper to operate on a flat tariff. Alongside this, hybrid natural gas heat pump systems are no longer installed, as they are not net zero compliant.

Direction from UK Government on the use of hydrogen for heating homes is announced. In our Hydrogen Evolution pathway, Government reduces the cost of hydrogen for heating for consumers through operational subsidies. In Holistic Transition, hydrogen acts as a secondary fuel in industrial clusters at district heating energy centres, used to reduce peak electricity demand. Hydrogen is not used for heat in our Electric Engagement pathway, this is also the same for our Falling Behind and the 10 Year Forecast.

Shaping Energy: The Consumer

Residential | Heat pumps

Overview

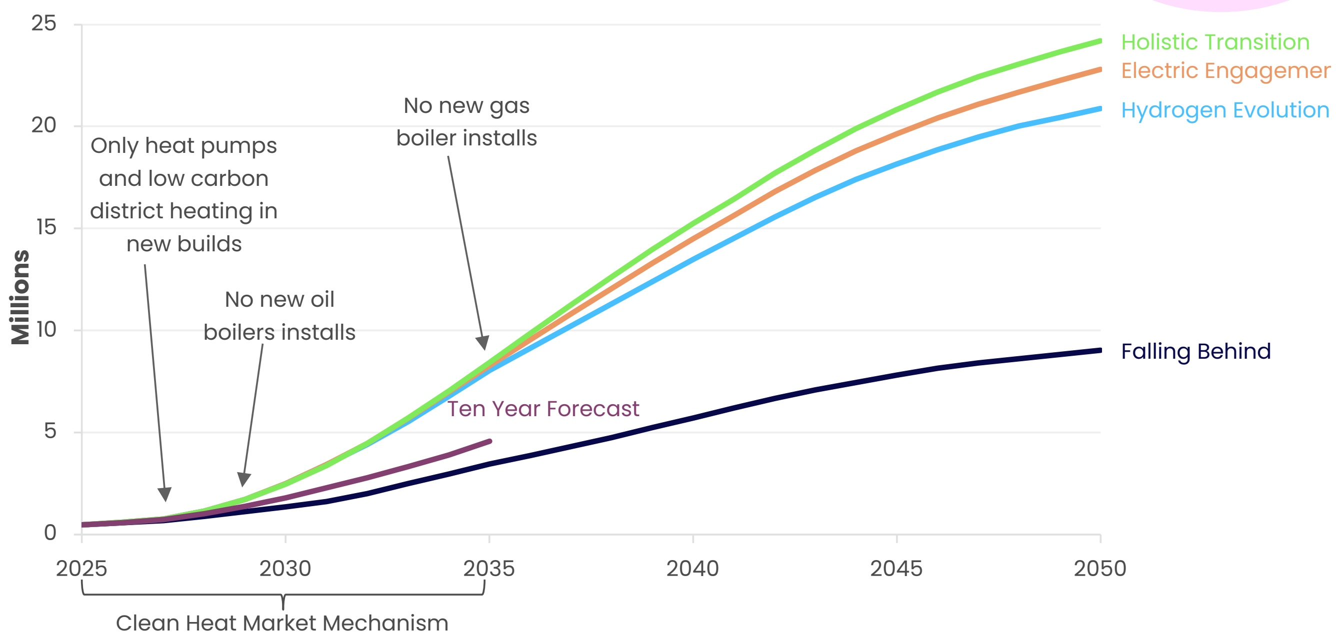
Decarbonisation of heat is one of the biggest challenges to achieving net zero, with three key barriers: lack of consumer awareness, high one-off upfront transition costs and too long a payback time relative to a gas boiler.[37]

Despite this, 2024 saw a 56% increase[38] in heat pump sales compared to 2023, driven largely by continuing the £7,500 Boiler Upgrade Scheme (BUS) grant that was increased in October 2023 to support the one-off transition cost to a heat pump system.

Our neighbours across Europe are showing what is possible with higher heat pump deployment, with multiple Scandinavian countries driving heat pumps as the main replacement solution for heating systems already, due to lower electricity prices in comparison to gas. These high-efficiency units are suitable for many homes and will be the default low carbon solution for most residential houses, with other low carbon technologies available for applications where heat pumps may not be the most economical or practical solution. The average unit today operates with a Seasonal Coefficient of Performance (SCOP) efficiency of 2.9 (how many units of heat are generated per unit of electricity used), although heat pumps have much higher potential if correctly installed and configured.

Heat pumps operate at less than a fifth of associated emissions compared to gas boilers in 2024.[39] This will continue to reduce as power decarbonises.

46. Heat pump stock



37 NESO Whole Energy Insight – Decarbonising Heat: Consumer Choice and Affordability
38 Statistics, Heat Pump Asscociation
39 NESO Whole Energy Insight – Britain's Electricity Explained: 2024 Review

Shaping Energy: The Consumer

Residential | Heat pumps (cont.)

Stakeholder views

All stakeholders felt that 600,000 heat pump annual installations by 2028 is unlikely to be achieved if current barriers – predominantly high electricity costs – remain. Most stakeholders suggested that *FES 2024* projections for SCOP were too optimistic, with Holistic Transition reaching 3.8 and both Electric Engagement and Hydrogen Evolution reaching 3.4 by 2035.

How we addressed feedback

Heat pump uptake has been reduced within the pathway constraints on emissions reductions and SCOP values have been reduced across pathways, Falling Behind and the Ten Year Forecast.

What we modelled

Table 13: A list of key inputs and outputs from our FES 2025 models covering energy demand from residential heat pumps.

Modelling assumptions	Holistic Transition	Electric Engagement	Hydrogen Evolution	10 Year Forecast	Falling Behind
SCOP value by 2035 (compared to 2.9 today)	3.5	3.1	3.1	Maintain 2.9	Maintain 2.9
Only heat pumps or low carbon district heating in new builds	2027	2027	2027	2027	2031
Heat pump uptake by 2028	580,000	562,000	563,000	382,000	254,000

Beyond the model

Increased consumer and installer awareness on the importance of decarbonising heat and of the range of low carbon heating technologies is achieved.

Ongoing equitable support or incentives with the high one-off transition cost. Electricity prices are reduced compared to gas, making heat pumps cheaper to operate on a flat tariff than gas boilers. Financing mechanisms to reduce the payback period of heat pumps relative to gas boilers.

Clean Heat Market Mechanism continues out to a full new gas boiler install phase out in 2035, allowing the supply chain and skills to build up.

Shaping Energy: The Consumer

Residential | Other heating technologies

Overview

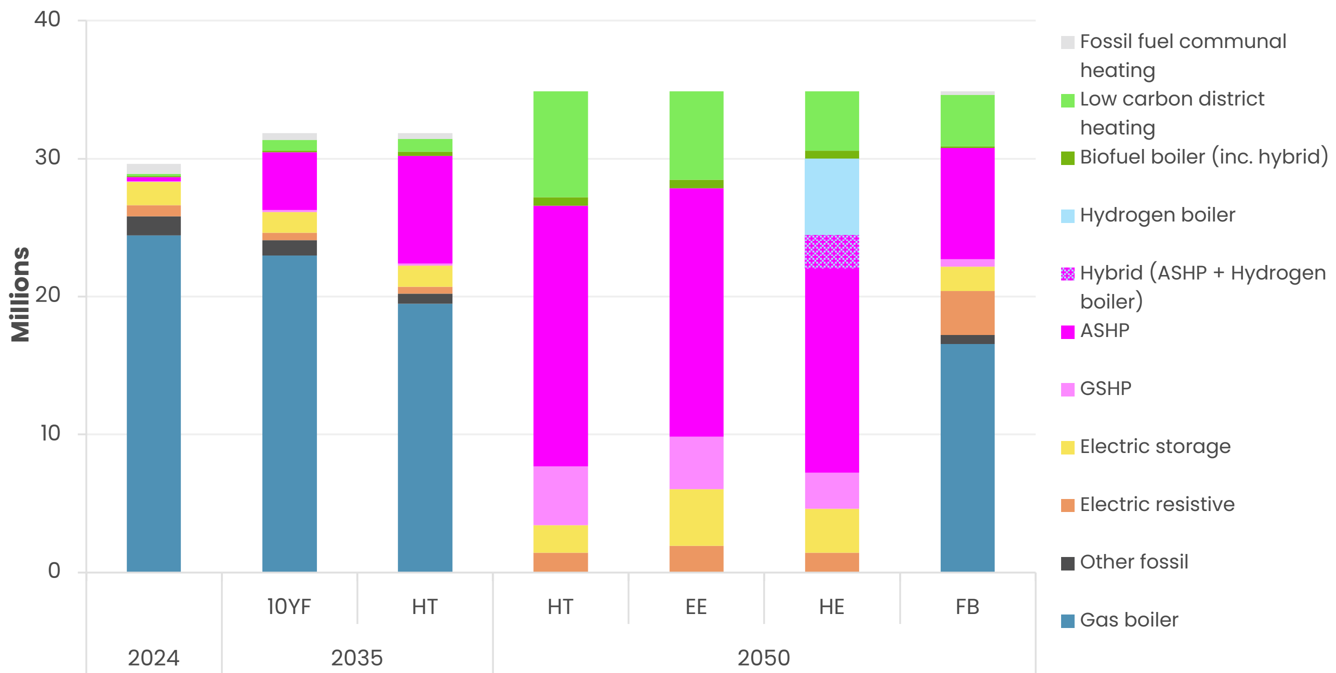
Here we present other heating technologies not covered in dedicated pages, focusing on low carbon district heating, electric storage and electric resistive heating systems.

Today, 0.6% of homes are heated from low carbon district heating and 2.4% are heated from fossil fuel communal heating (which will need to transition to using clean sources).

Electric storage is any direct electric heating system that includes a way to store thermal energy, from traditional methods to new emerging technologies, these are used in 5.7% of homes today. Electric resistive is any direct electric heating system that does not include any thermal storage from room storage heaters or central storage heaters, these are used in 2.7% of homes today. Both types of direct electric systems are popular in smaller homes that have lower heating demand, where there is less justification for higher purchase cost technologies that have lower running costs.

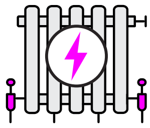
The 17% of homes using direct electric heating account for 37% of electricity demand for heat in 2050 in Electric Engagement.

47. Residential heating technology mix today, in 2035 and 2050



Shaping Energy: The Consumer

Residential | Other heating technologies (cont.)



What we modelled

Table 14: A list of key outputs from our FES 2025 models covering energy demand from other residential heating technologies.

	2035		2050			
Modelling assumptions	**Ten Year Forecast**	**Holistic Transition**	**Holistic Transition**	**Electric Engagement**	**Hydrogen Evolution**	**Falling Behind**
Homes using low carbon district heating	2.5%	2.9%	22.0%	18.4%	12.4%	10.7%
Homes using electric storage	4.7%	4.8%	5.8%	11.8%	9.1%	5.1%
Homes using electric resistive	1.7%	1.5%	4.1%	5.6%	4.1%	9.1%

Beyond the model

Clear prioritisation of heating systems is given to provide certainty for industry and drive consumer adoption towards efficient technologies. Direct electric heating systems may become more popular when fossil fuel is phased out due to lower upfront installation costs than heat pump systems, as found in a Public First and *NESO Decarbonising Heat: Consumer Choice and Affordability survey*[40]. The popularity of direct electric heating could also increase as homes become better insulated and their demand lowers.

District heating is the first option considered for areas identified in a heat network zone and for new build estates. Heat pumps are then the default next option, and the only other option for new builds. Flexibility is then prioritised with electric storage, with the final option being electric resistive that doesn't provide flexibility, but only where other solutions aren't feasible.

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Shaping Energy: The Consumer

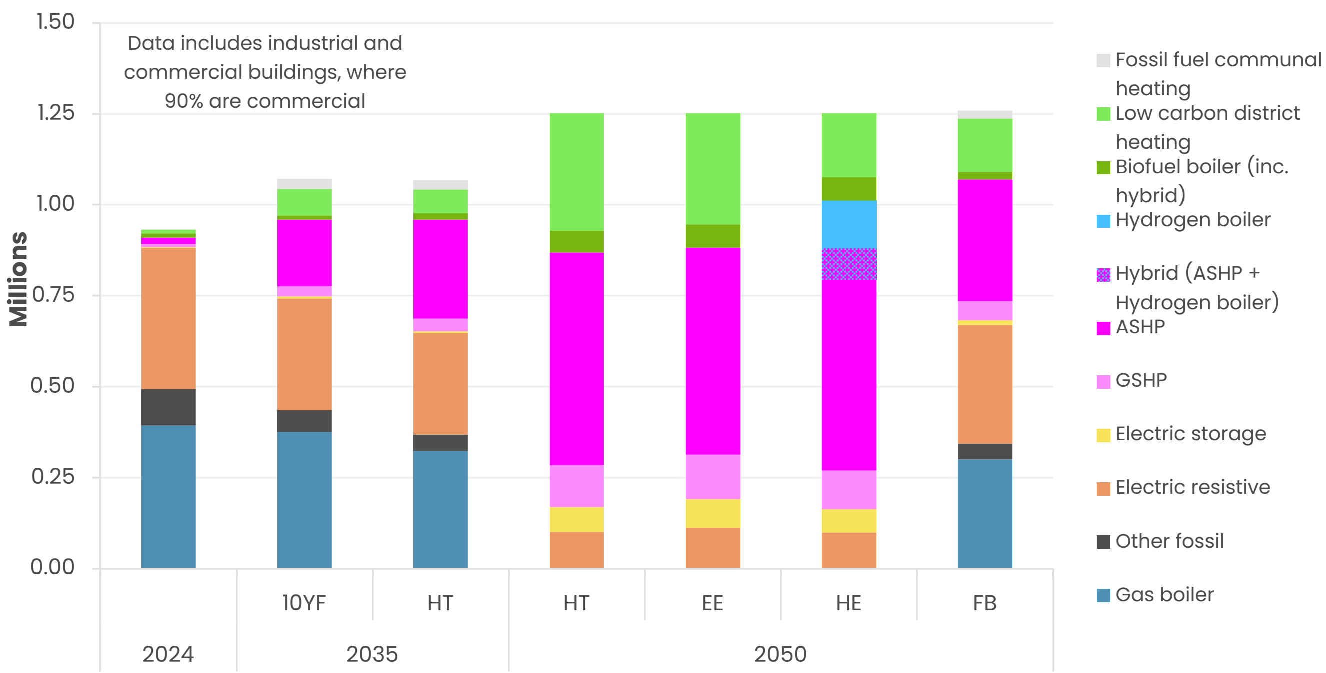
Commercial | Heat

Overview

Unlike residential homes, industrial and commercial buildings currently use a larger variety of space and hot water heating technologies.

Electric resistive heating is used in 42% of non-residential buildings, however as these tend to be smaller buildings with lower demand, they only contribute 12% of fuel demand for non-residential spaces and hot water heating. Fossil fuels provided 84% of the heat demand to non-residential buildings in 2024.

48. Non-residential heating technology mix today, in 2035 and 2050



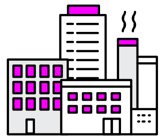
Stakeholder views

The majority of stakeholders advised that district heat networks would be most suitable for dense urban areas, particularly in commercial buildings. They did however acknowledge the challenges of retrofitting existing heating technologies.

How we addressed feedback

The commercial share of district heating connections has increased relative to residential buildings across all pathways, Falling Behind and the Ten Year Forecast.

Shaping Energy: The Consumer



Commercial | Heat (cont.)

What we modelled

Table 15: A list of key outputs from our FES 2025 models covering energy demand from commercial heating.

	2035		2050			
Industrial and commercial buildings in our analysis	Ten Year Forecast	Holistic Transition	Holistic Transition	Electric Engagement	Hydrogen Evolution	Falling Behind
Heat pumps	21%	30%	58%	57%	59%	32%
District heating	7%	6%	26%	24%	14%	12%
Electric storage	0%	1%	5%	6%	5%	1%
Electric resistive	29%	26%	8%	9%	8%	26%

Beyond the model

There are no new fossil fuel boiler installations in new buildings after 2026, or in any buildings after 2035.

Commercial buildings act as anchor loads to heat networks, securing viability of their development.

More efficient heating systems, such as low carbon district heating and heat pumps, are prioritised over less efficient technologies.

Shaping Energy: The Consumer

Commercial | Data centres

Overview

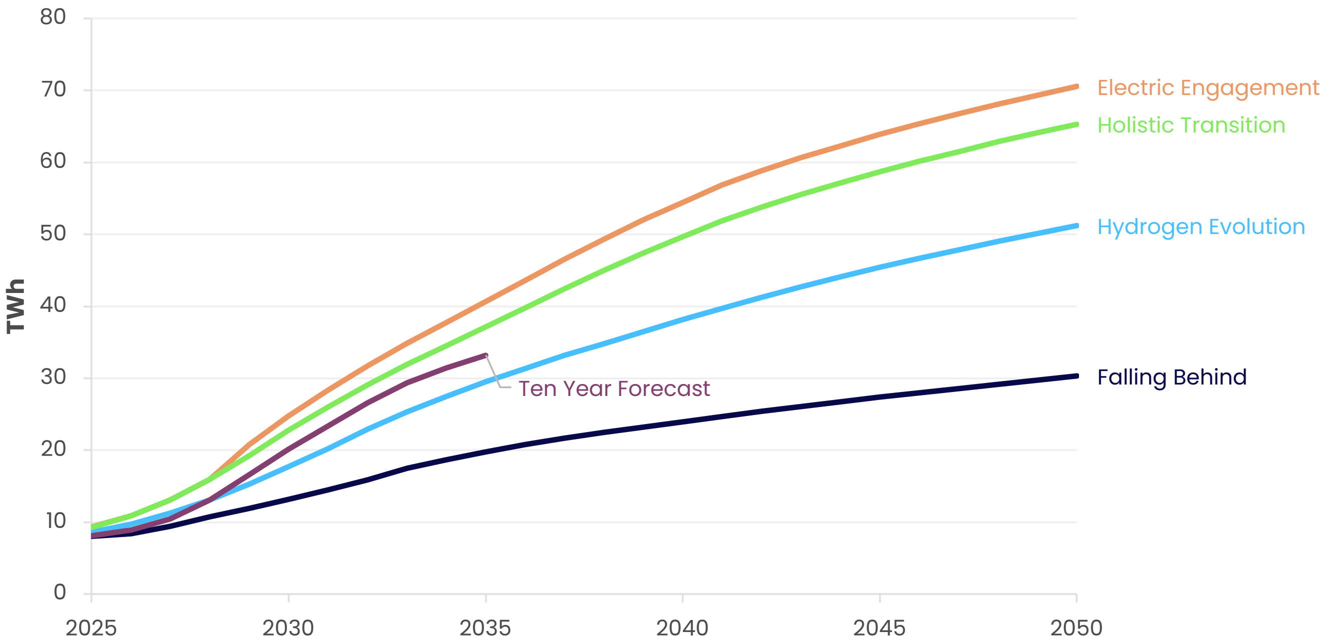
We define 'data centre demand' as demand from dedicated buildings for computing, excluding servers within other commercial buildings.

Data centre demand in Great Britain is estimated at 7.6 TWh from the 2.4 GW connected facilities, mainly for traditional services such as banking, which often requires close proximity to London. We expect future data centres to be increasingly utilised for AI, which may result in less importance on location and latency issues, compared to the existing data centre fleet.

Government's creation of the AI Opportunities Action Plan shows ambition in the field. The main uncertainty for future data centre demand is how much will be located within Great Britain compared to other competitive global markets. The demand shown below covers electricity demand, however many data centres may install on-site generation, often as a backup for security of supply – this generation is captured within our supply modelling. With sufficiently strong locational signals, we anticipate a maximum of 20% of future data centre demand could be located in Scotland, helping reduce network constraints. Cold thermal storage can allow shifting of cooling demand away from peak times and further operational flexibility may also be possible for non time critical operations.

46% of global data centre demand comes from the USA, followed by Germany and the UK, both requiring around 4%

49. Electricity demand for data centres



Shaping Energy: The Consumer

Commercial | Data centres (cont.)

Stakeholder views

Some stakeholders have said the improvement rate for data centre site energy efficiency was too high in *FES 2024*. Growth rates were generally correct, but ramp-up rates were too conservative. Stakeholders suggested a faster ramp-up rate and having a pathway with high data centre demand.

How we addressed feedback

Data centre building efficiency improvements have been limited and ramp-up rates of sites to full commercial load is faster across all pathways. Maximum data centre demand has also been increased.

What we modelled

Table 16: A list of key outputs from our FES 2025 models covering energy demand from data centres.

Modelling assumptions	Holistic Transition	Electric Engagement	Hydrogen Evolution	10 Year Forecast	Falling Behind
2035 electricity demand	37 TWh	41 TWh	30 TWh	33 TWh	20 TWh
2050 electricity demand	65 TWh	71 TWh	51 TWh	N/A	30 TWh
2050 connections	14.1 GW	14.6 GW	9.9 GW	N/A	6.1 GW

Beyond the model

Data centre locations are optimised and operated flexibly (where possible) alongside other data centre requirements.

Holistic Transition and Electric Engagement's high levels of demand are met from strong support at both national and local level, alongside a competitive data centre market in Great Britain.

Shaping Energy: The Consumer

Commercial | Electricity demand

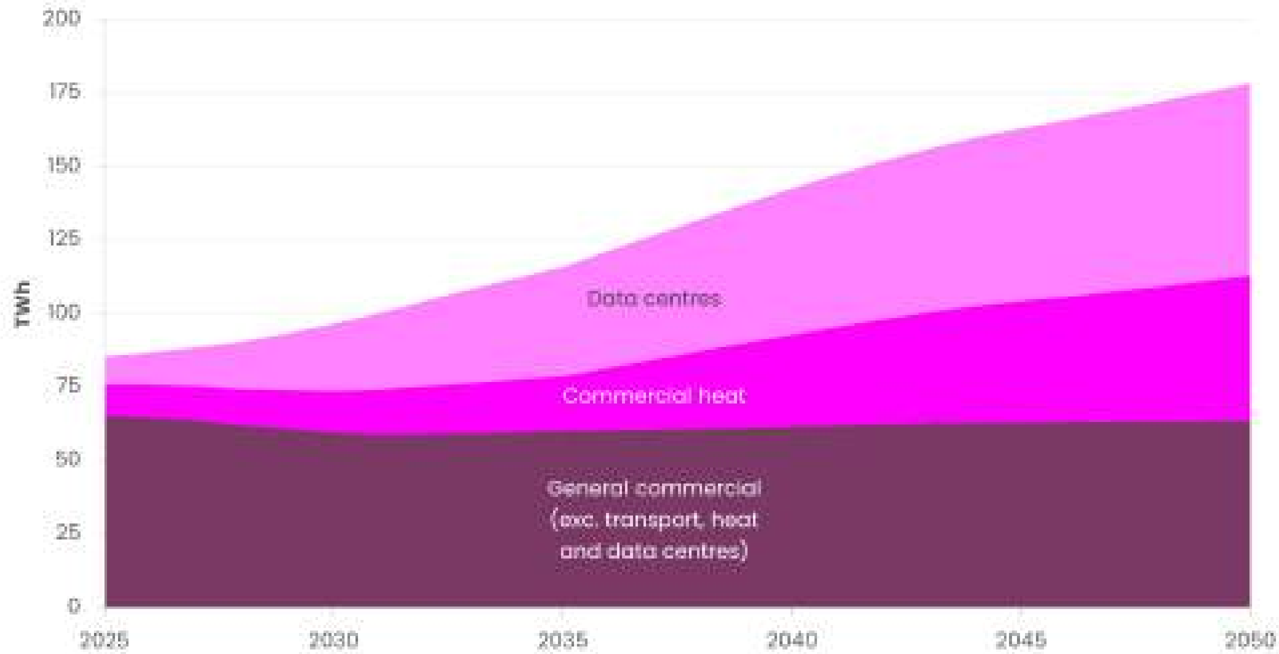
Overview

Data centre growth and electrification of heating (covered in page 108 and page 111) are the key influencers of change for commercial sector demand.

Alongside data centres and heating, commercial demand also comes from lighting and other general requirements in these types of buildings. Below, we show how all elements come together to create the total commercial electricity demand figure. This broad range – from supermarket fridges to NHS electrical medical equipment – makes up the majority of commercial electricity demand today at 66 TWh.

Fossil fuel use in the commercial sector (outside of space and hot water heating) comes from 9 TWh of gas use, mainly from catering, and 13 TWh of diesel use for off-road agriculture and construction vehicles. Off-road sectors offer valuable opportunities for hydrogen use, due to charging infrastructure challenges for electric off-road vehicles.

50. Electricity demand in the commercial sector in Holistic Transition

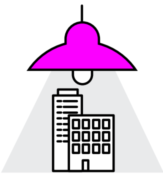


Stakeholder views

Most stakeholders felt that energy efficiency progress is slower than expected but noted where measures have been implemented (particularly in lighting and building structures) they have exceeded forecasts – supermarkets are actively pursuing these gains. Some stakeholders suggested that grid capacity issues are hindering deep electrification of gas loads. Several stakeholders noted that hydrogen uptake for catering is currently unattractive due to cost and that some chain restaurants require uniform kitchen designs. It was noted that some chains are already electrifying, but feel that catering will convert at a slower rate due to the cost benefits of using gas.

Shaping Energy: The Consumer

Commercial | Electricity demand (cont.)



How we addressed feedback

Delay to deployment of energy efficiency measures across all pathways, although the impact of the measures has been increased in Holistic Transition. Reduced use of hydrogen for catering across all pathways.

What we modelled

Table 17: A list of key outputs from our FES 2025 models covering commercial electricity demand.

Modelling assumptions	Holistic Transition	Electric Engagement	Hydrogen Evolution	10 Year Forecast	Falling Behind
2035 electricity demand from general commercial (excluding heat and data centres)	60 TWh	61 TWh	65 TWh	59 TWh	72 TWh
2050 electricity demand from general commercial (excluding heat and data centres)	64 TWh	69 TWh	69 TWh	N/A	80 TWh
2050 hydrogen demand, excluding heat	4 TWh	2 TWh	14 TWh	N/A	0 TWh

Beyond the model

Low carbon options of electrification and hydrogen, where applicable, are economically competitive for consumers, encouraging fast decarbonisation of heat, catering and off-road vehicles to reduce emissions in the short term.

Connections reform facilitates faster demand connections for the commercial sector.

Shaping Energy: The Consumer

Industry | Gas demand

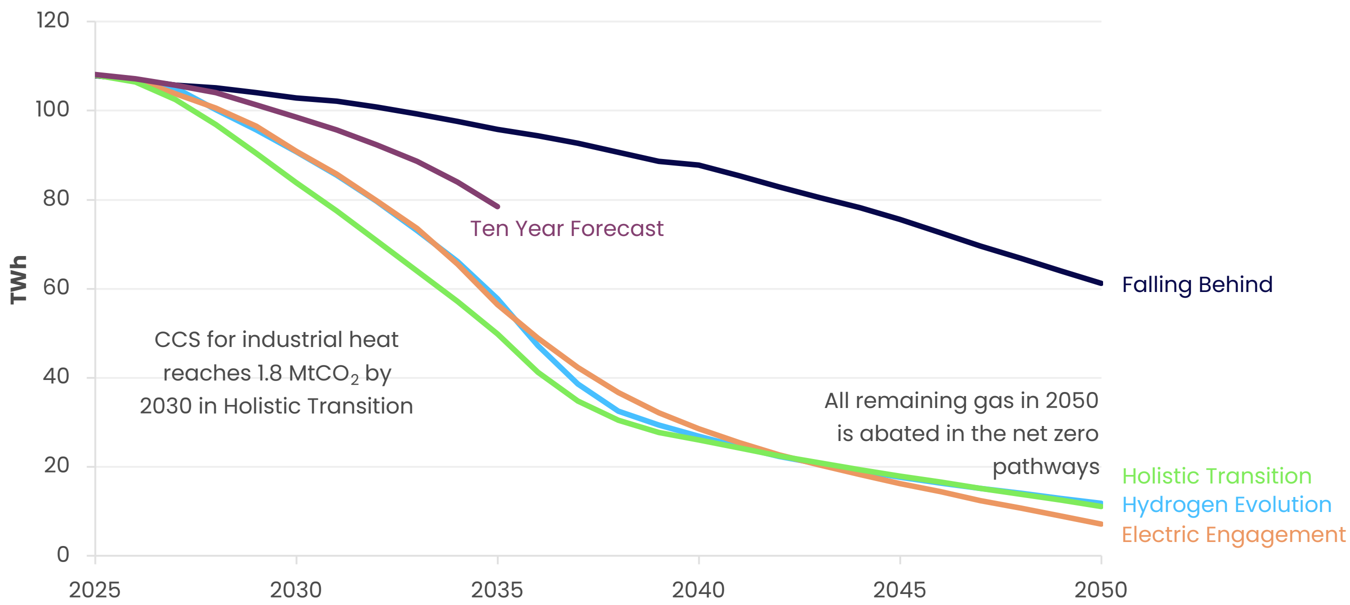
Overview

Emissions from industry in Great Britain have fallen since 1990, mainly due to the reduction of energy intensive industry. In 2024, gas was the largest source of energy for industry, making up 57% of industrial fuel supply, or 106 TWh of gas demand. We model the decarbonisation of industry together with growth in industrial activity.

Decarbonisation options exist for industry depending on the sector, process and access to infrastructure. These include fuel switching from gas to electrification or hydrogen and abating gas emissions with CCS. Some industries require gas as a feedstock for their industrial process as they inherently release CO_2 due to their chemistry, such as calcination during cement production. Other sectors have multiple options that they could use. Two industrial clusters have reached final investment decision on CO_2 pipelines at present. Outside of these clusters there is less clarity on future infrastructure availability, alongside uncertainty in future regulations and market formation. Industrial decarbonisation faces a variety of challenges such as siting (cluster instead of dispersed sites and space availability on each site), access to infrastructure (grid connection, hydrogen and CCS), high upfront costs and potential operating costs.

At least 80% of 2024's gas demand is decarbonised by 2040 across all pathways

51. Abated and unabated industrial gas demand



Shaping Energy: The Consumer

Industry | Gas demand (cont.)

Stakeholder views

Some stakeholders expressed views that a Carbon Border Adjustment Mechanism (CBAM) will be limited to specific industrial products. Stakeholders representing some industries discussed the difficulties they faced in decarbonising when they needed to remain located near raw materials, such as crops or clay. These locations may be challenging for grid connections, hydrogen or CCS access.

How we addressed feedback

The decarbonisation of industry has been slowed down in Falling Behind and the Ten Year Forecast to reflect this, however the pathways need to maintain pace to achieve interim emissions targets.

What we modelled

Table 18: A list of key outputs from our FES 2025 models covering demand from industrial gas use.

Modelling assumptions	Holistic Transition	Electric Engagement	Hydrogen Evolution	10 Year Forecast	Falling Behind
Unabated gas demand in 2035	39 TWh	50 TWh	48 TWh	76 TWh	93 TWh
Abated gas demand in 2035	11 TWh	6 TWh	10 TWh	3 TWh	3 TWh
Abated gas demand in 2050	11 TWh	7 TWh	12 TWh	N/A	3 TWh

Beyond the model

Clear, long-term carbon accounting for industrial imports of materials and products creates a strong signal, which in turn makes electricity, hydrogen and abated gas more economical (relative to unabated gas), while ensuring Great Britain remains an attractive economy for industry.

Deliver infrastructure to enable the decarbonisation of industry alongside a clear plan of the future availability of gas and low carbon options for those both within industrial clusters and at dispersed sites.

Shaping Energy: The Consumer

Industry | Electricity demand

Overview

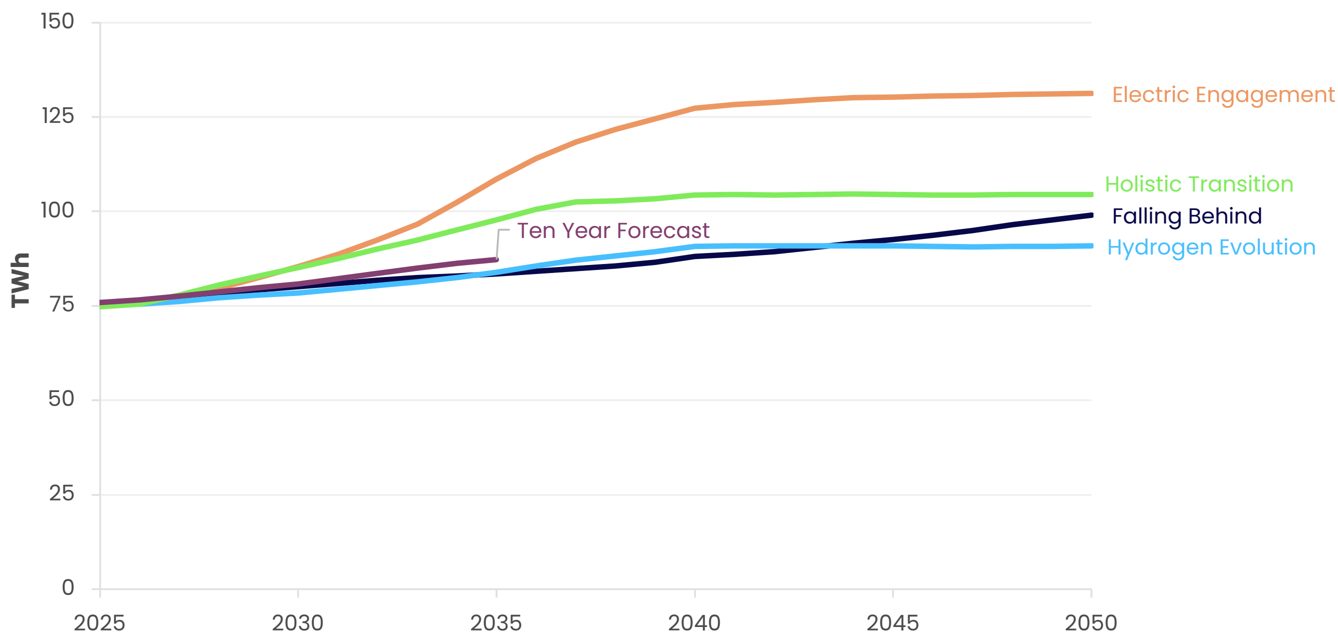
In 2024 electricity made up 40% of industrial fuel supply, at 74 TWh of electricity demand. Electrification will be the solution for large amounts of industry to decarbonise, although not for all as some are either harder to electrify or have viable alternatives which may be preferable.

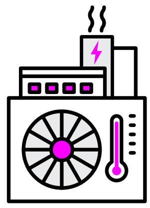
Innovation within the industrial electrification space continues, creating more solutions such as electric boilers and industrial heat pumps achieving higher temperatures and becoming a credible option for many industries.

Often, electrified solutions are a more efficient use of energy than combustion technologies, requiring less electricity per unit of production than the use of gas that has been displaced. Coupled with the potential for ongoing efficiency improvements, this can limit an increase in electricity demand. Connections reform should speed up demand connections that are ready to go live.

On average across the pathways, 98% of the increase in electrification occurs by 2040.

52. Industrial electricity demand (excluding hydrogen production)





Shaping Energy: The Consumer

Industry | Electricity demand (cont.)

Stakeholder views

Views from stakeholders on decarbonisation plans for UK industry varied. Electrification was frequently mentioned by some as a crucial decarbonisation option for industry, but others felt that barriers to connection could lead to the loss of industry, particularly for multi-national corporations.

How we addressed feedback

Electrification needs to happen at a faster pace than implied by stakeholder feedback to meet emissions targets in Electric Engagement and Holistic Transition. The slower electrification feedback is reflected to greater levels in the Ten Year Forecast, Hydrogen Evolution (where there is greater hydrogen use) and Falling Behind.

What we modelled

Table 19: A list of key inputs and outputs from our FES 2025 models covering industrial electricity demand.

Modelling assumptions	Holistic Transition	Electric Engagement	Hydrogen Evolution	10 Year Forecast	Falling Behind
Industrial economic growth	High energy intensive industry maintain the same level of productivity, growth in less energy intensive industry.				
Electricity demand in 2035	98 TWh	108 TWh	84 TWh	87 TWh	83 TWh
Electricity demand in 2050	104 TWh	131 TWh	91 TWh	N/A	99 TWh

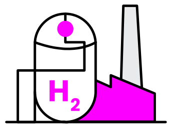
Beyond the model

Electricity costs are reduced relative to gas, for example by removing levies from electricity. This incentivises the main option that industry will use for decarbonisation. Additionally, it promotes growth of industry in Great Britain, compared to overseas.

Faster electricity connections, enabled by connections reform, supported by pre-emptive distribution reinforcements, prevents industrial downturn from current gas users when carbon accounting policies are reinforced.

Shaping Energy: The Consumer

Industry | Hydrogen demand

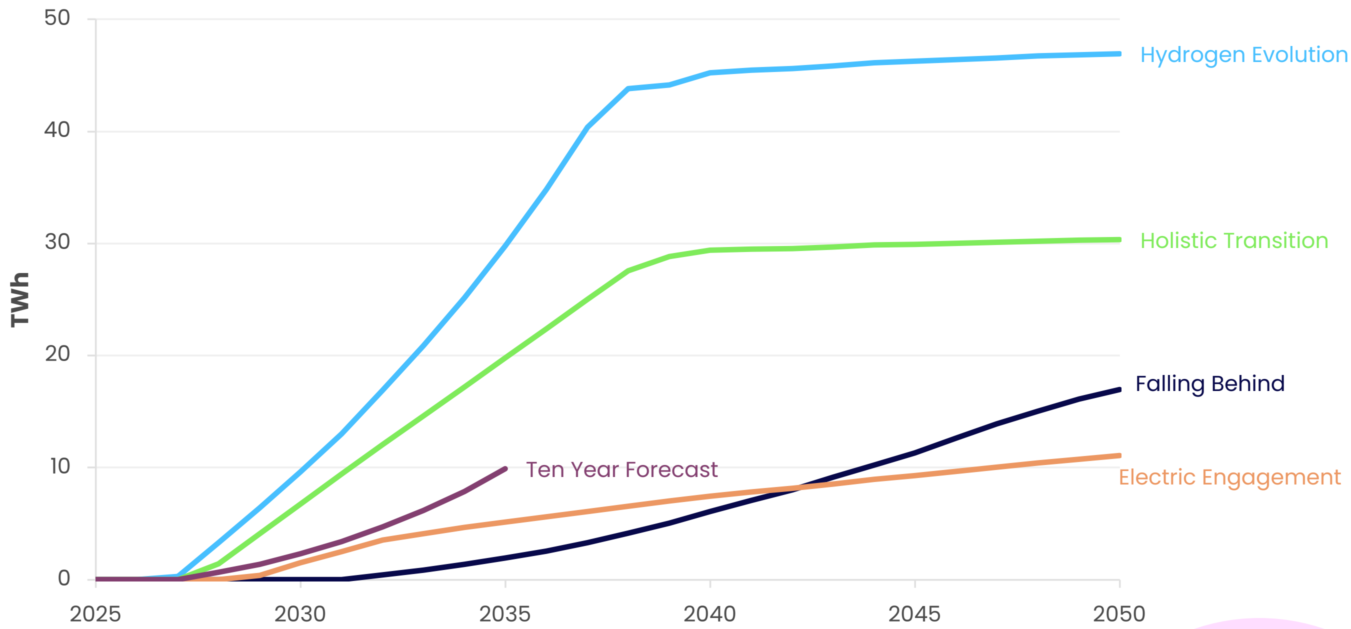


Overview

Hydrogen can provide a decarbonisation option for industrial sectors where the required temperatures or chemical processes make electrification less suitable, and where siting, process or cost reasons equally make CCS less suitable.

In some cases, a switch to hydrogen may not be economically viable without support mechanisms for end users. There are initial plans for pipeline hydrogen access in larger clusters, but pipeline access beyond these remains uncertain.

53. Industrial low carbon hydrogen demand



Hydrogen replaces 7–43% of 2024 industrial gas demand by 2040 in the pathways

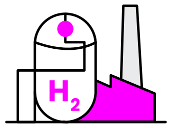
Stakeholder views

Some stakeholders felt that hydrogen development is slowed down by the investment challenge of needing simultaneous development of supply, storage, transmission and demand of hydrogen and CO_2 (where applicable).

They suggested that hydrogen production requires better investment certainty and resilience to justify infrastructure costs and advance the hydrogen market.

Shaping Energy: The Consumer

Industry | Hydrogen demand (cont.)



How we addressed feedback

Use of hydrogen has reduced relative to *FES 2024*. However, there is a limited degree to which the rollout can be slowed in the short term, as fast delivery of hydrogen is required to reduce emissions.

What we modelled

Table 20: A list of key inputs and outputs from our FES 2025 models covering industrial hydrogen demand.

Modelling assumptions	Holistic Transition	Electric Engagement	Hydrogen Evolution	10 Year Forecast	Falling Behind
Hydrogen access	Only in industrial clusters	Only in industrial clusters	Grows from industrial clusters to national network	Only in industrial clusters	Only in industrial clusters
Hydrogen demand in 2035	20 TWh	5 TWh	30 TWh	10 TWh	2 TWh
Hydrogen demand in 2050	30 TWh	11 TWh	47 TWh	N/A	17 TWh

Beyond the model

There are clear long term hydrogen supply, network, storage and demand plans beyond the initial clusters for all of Great Britain. This allows industry to know what options will be available for them to decarbonise and make the necessary investment.

Hydrogen network infrastructure grows at pace to match the increasing industrial demand.

Shaping Energy: The Consumer

Aggregate | Demand flexibility

Overview

Demand flexibility covers all aspects of consumer flexibility but excludes flexibility from electrolysers and behind-the-meter generation. There is uncertainty over the current and future levels of demand flexibility when considering unknown consumer engagement.

Consumers can be rewarded for their demand flexibility through mechanisms such as smart tariffs – this can reduce bills and the payback time of low carbon technologies which is a significant barrier to their uptake. Demand flexibility can help balance the grid when demand is high and make use of surplus energy during periods of excess supply, while providing financial benefits to consumers. Higher levels of demand flexibility allow for lower levels of supply side flexibility, such as batteries and low carbon dispatchable power, which may be more expensive.

Electrification of transport has the largest potential for flexibility as it requires relatively low effort from consumers compared to the rewards and then becomes an enabler for other demand flexibility through greater awareness. Since February 2024, NESO has enabled greater participation of aggregated flexibility assets into the Balancing Mechanism by lowering (operational) metering requirements. Despite the network balancing and consumer financial benefits, we estimate that only 25% of EV owners today engage in smart charging (although there is limited data available), revealing that most EV owners are not yet benefiting from low-cost off-peak charging rates, along with studies showing consumers are unaware of the potential savings available.

Vehicle-to-grid (V2G) is a technology that enables an EV to discharge some of its surplus energy to help meet grid demands. Our modelling focusses on V2G, but V2H technology – where energy is not exported to the grid but instead utilised by a household – can also contribute to reducing peak demand. Vehicle and charge point manufacturers increasing their V2G offerings will continue to facilitate growth in the technology. The cost of V2G chargers has rapidly decreased as residential AC V2G chargers are expected to be available in 2025, further opening up the accessibility of this technology to more consumers.

An average residential fossil fuel boiler typically experiences two daily demand peaks – morning and evening – when the heating is generally turned on. Heat pumps, however, tend to be operated with a flatter profile to provide a gradual household temperature build up before the morning peak, to then maintain that temperature out to the evening – delivering a much higher efficiency heating system, which in turn lowers peak demand. Further flexibility can come from increasing the heat pump's set point temperature before the peak, and reducing it slightly during, using the thermal mass of the building to maintain comfortable living temperatures for a few hours without turning the heating on. A NESO Decarbonising Heat: Consumer Choice and Affordability survey has shown 50% of consumers are willing to accept these changes in indoor temperature for a short time if it helps reduce energy bills[41].

Modern high heat retention storage heaters and novel thermal storage technologies (that couple with direct electric heating) can

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Shaping Energy: The Consumer

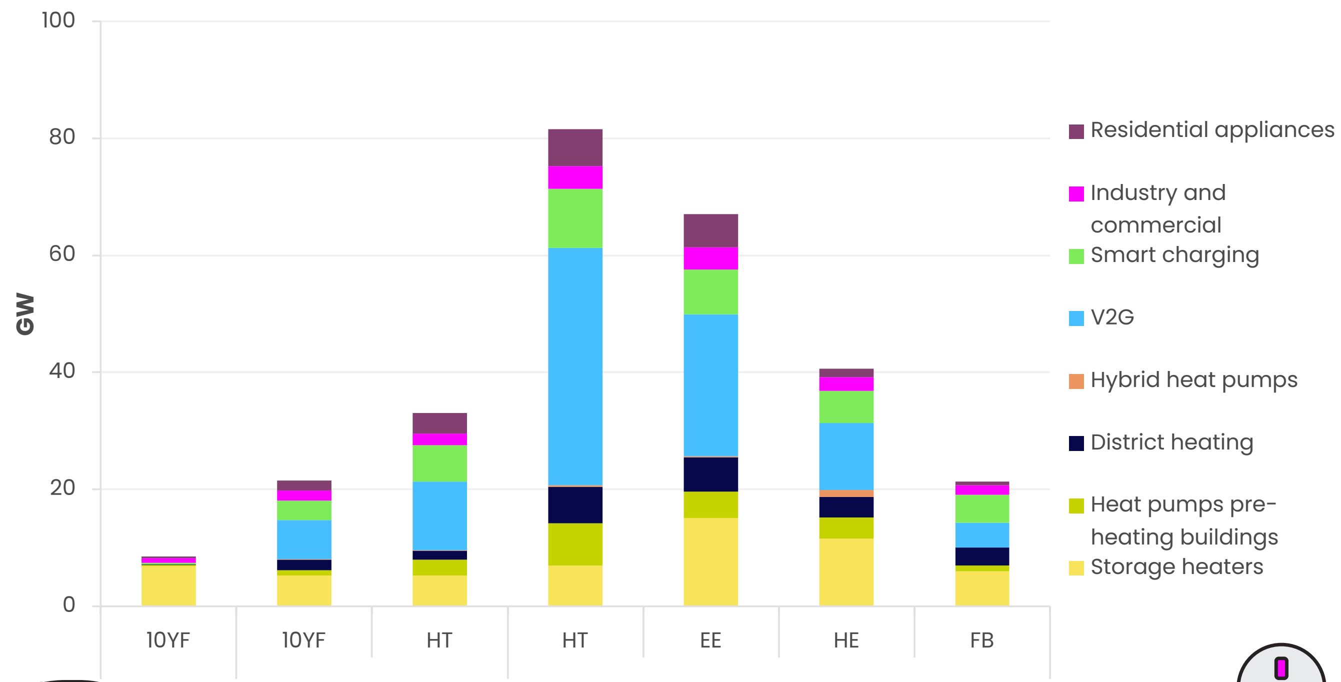
Aggregate | Demand flexibility (cont.)

See full intro text edit on previous page.

shift high percentages of household heating demand in lower demand homes that they are typically suited to. Additionally, thermal storage may also couple with district heating and heat pumps, although with economic and spatial constraints this may be limited to shifting hot water demand for individual heat pumps.

NESO's Demand Flexibility Service has helped grow the familiarity of demand flexibility alongside growing the number of smart tariffs available and supplier schemes, yet outturn data has shown reduced levels of industrial and commercial (I&C) demand flexibility, potentially a consequence of triad cost avoidance opportunities no longer being available. High temperature thermal storage and flexibility from data centres are crucial areas of growing demand flexibility from I&C sectors. Demand flexibility is mainly on the distribution network providing flexibility throughout the networks. Automation of demand flexibility through smart appliances reduces the effort for consumers and should increase engagement levels, although the number of working smart meters, implementation of market-wide, half-hourly (MHHS) settlement and use of smart tariffs are also enablers for demand flexibility.

54. Demand side flexibility capacities at peak



V2G and EVs combined provide 51 GW of demand flexibility and are the largest source of any flexibility capacity (including supply side) in Holistic Transition.

Shaping Energy: The Consumer

Aggregate | Demand flexibility (cont.)

Stakeholder views

Stakeholders suggested that smart charging would be easy to implement for commercial vehicles. Several stakeholders expressed uncertainty around V2G, feeling that there would be a greater chance of implementing V2H. Some stakeholders suggested V2G may be easier to implement in commercial vehicles.

There were positive indicators from stakeholders for participation in heat flexibility, with most saying that pre-heating homes before peak times is likely to be the main method for heat flexibility.

Some stakeholders have expressed views that I&C consumers can be unwilling to sign up to DSR as this does not provide a stable revenue stream for them. Smart management of demand and active shifting of elements like refrigeration and process heating is growing rapidly, but not entirely marketable to ancillary services, so is occurring largely between suppliers and consumers.

How we addressed feedback

We have kept the wide range of V2G to reflect uncertainty across the pathways and incorporated V2G for commercial vehicles in all pathways, Falling Behind and the Ten Year Forecast. We have included pre-heating of homes in the heat flexibility figures in Holistic Transition.

What we modelled

Table 21: A list of key inputs and outputs from our FES 2025 models covering demand side flexibility.

Modelling assumptions	Holistic Transition	Electric Engagement	Hydrogen Evolution	10 Year Forecast	Falling Behind
Smart meters in 2035	29.4 m	29.4 m	27.2 m	28.4 m	25.7 m
Residential smart charging engagement in 2035	83%	68%	48%	58%	30%
Residential V2G engagement in 2050	45%	26%	12%	N/A	5%
Heat profile and flex approach	36% flex from pre-heating	20% from flat heat pump profile	20% from flat heat pump profile	20% from flat heat pump profile	Consumers prefer traditional on/off profile
Residential appliance demand engaged in flex in 2035	25%	19%	7%	11%	3%
Industrial and commercial demand engaged in flex in 2035	5.8%	5.4%	5.8%	5.5%	4.0%

Shaping Energy: The Consumer

Aggregate | Demand flexibility (cont.)

Beyond the model

Smart tariffs are the default option for EVs charging at home by 2030 in Holistic Transition, enabled by implementation of a MHHS without further delay. Consumers have equitable access to low carbon technologies and demand flexibility markets.

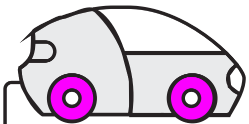
Information is widely communicated, especially to new EV and heat pump users, on best operating efficiency and flexibility practices. Consumers and installers are aware of the benefits of flatter heat pump operation and pre-heating to reduce bills.

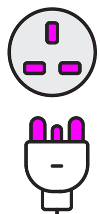
Market signals are well coordinated, so they do not contradict each other and respect local network constraints: this is especially important for demand turn up. Smart appliances reduce the effort for consumers to participate in flexibility and increase capacity at peak times. Consumer confidence rapidly grows in demand flexibility and automation as they are rewarded for their engagement. Automation of charging within required consumer usage schedules allows EVs to provide flexibility across multiple days. Car manufacturers include V2G in warranty terms.

Where there is sufficient charger access, public charging encourages charging outside of the evening peak, rather than to a short off-peak window that may lead to low charger utilisation.

Heating system installations are designed around peak demand. Where direct electric heating systems are the most suitable option, they are coupled with thermal storage. District heating uses heat pumps as a primary heat source and non-electrified low-carbon fuels as the secondary heat source. Where this is not possible, heat pumps are used for secondary heating instead of direct electric boilers.

Long-term certainty on demand flexibility incentives allows industry to invest in participating and stay engaged.





V2G reaches the same capacity as a power station by 2030 at 1.2 GW, growing to 41 GW in 2050 in Holistic Transition.

Shaping Energy: The Consumer

Aggregate | Consumer demand

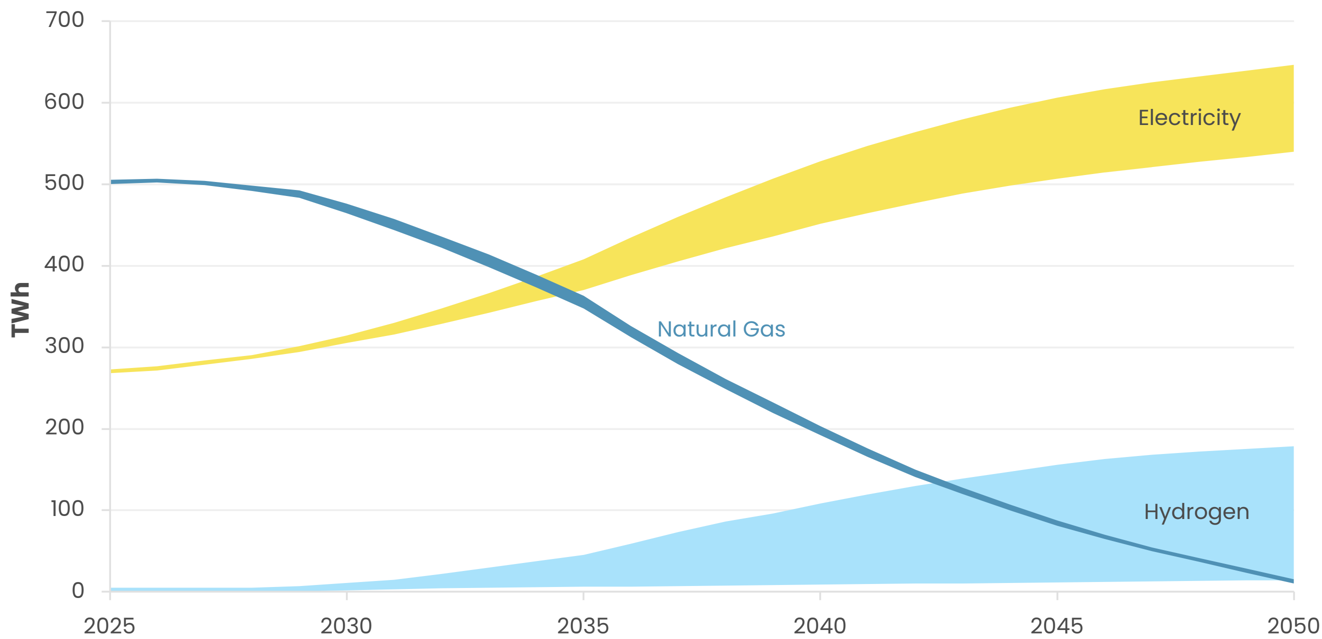
Overview

This factsheet covers consumer electricity, hydrogen and gas demand. 'Gas demand' includes residential (including residential heating and cooking), transport, industry and commercial demand, but excludes demand for power and hydrogen production.

In 2024, electricity demand was 267 TWh and was approximately split between residential, commercial and industry sectors, with a small amount of demand required for road transport. In comparison, gas demand was 493 TWh and approximately two thirds today comes from residential heating, with the remaining demand shared between industry and commercial applications.

Unabated gas use must decrease at pace to reduce emissions in the short term – this can be achieved through electrification and switching to clean fuels such as hydrogen and biomethane.

55. Total annual consumer demand ranges, excluding the Ten Year Forecast and Falling Behind



Total consumer energy demand (including oil) reduces by 47%, driven by more efficient electrified sources in Holistic Transition.

Shaping Energy: The Consumer

Aggregate | Consumer demand (cont.)

Stakeholder views

Stakeholders consistently said that fuel switching at the scale needed will not happen unless electricity prices are reduced relative to gas. Most stakeholders felt that electrification is the most suitable low carbon option for most consumer applications, yet electricity grid connection timescales are a significant barrier.

How we addressed feedback

We have increased the amount of electrification across all pathways relative to use of other low carbon fuels. The limitations from emissions targets prevent slower electricity grid connection in the pathways, but we have reflected this in Falling Behind and the Ten Year Forecast.

What we modelled

Table 22: A list of key outputs from our FES 2025 models covering aggregate consumer demands.

	2035		2050			
Modelling assumptions	Ten Year Forecast	Holistic Transition	Holistic Transition	Electric Engagement	Hydrogen Evolution	Falling Behind
Total gas demand (unabated and abated)	443 TWh	348 TWh	14 TWh	10 TWh	15 TWh	355 TWh
Electricity demand	353 TWh	388 TWh	567 TWh	646 TWh	540 TWh	500 TWh
Hydrogen demand	11 TWh	22 TWh	39 TWh	14 TWh	179 TWh	18 TWh

Beyond the model

Reduced electricity prices relative to natural gas promote decarbonisation at pace to drive lower emissions in the short term.

Strategic plans and policy decisions provide clear signals to industry and residential consumers on which low-carbon technology options will be available to them.

Powering the System: Electricity Supply

Powering the System: Electricity Supply

Electricity and gas peak demands

Overview

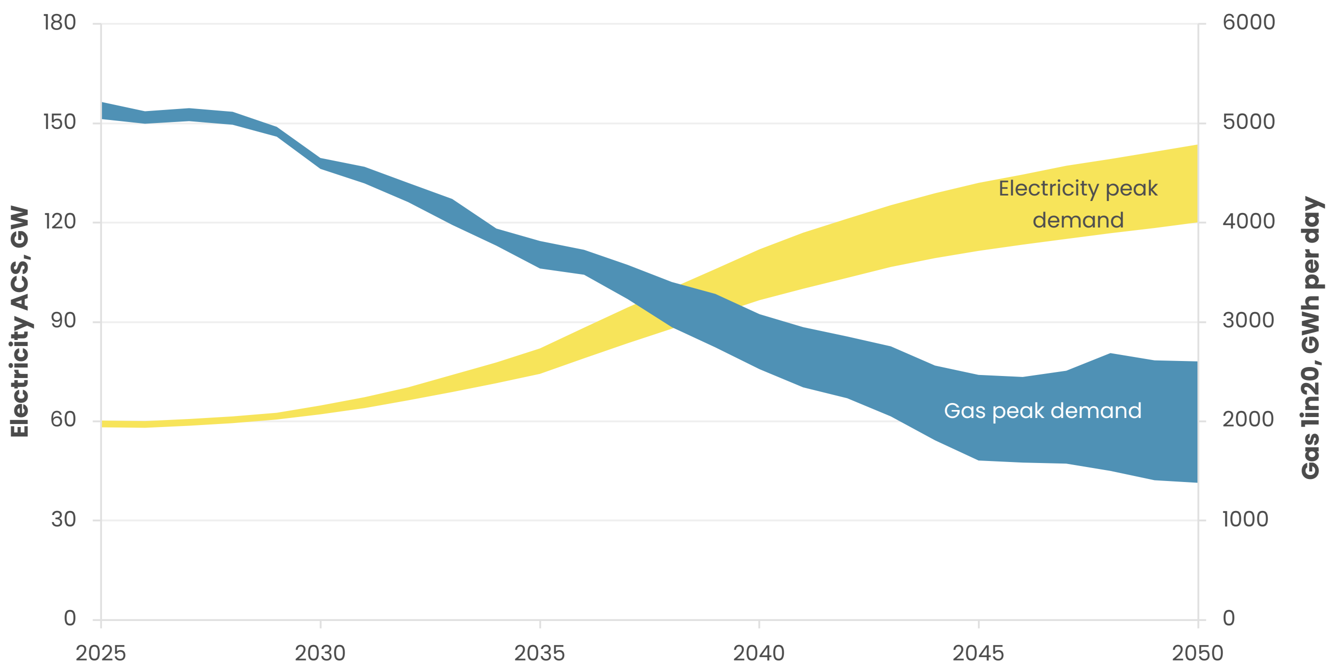
Peak demands are crucial metrics that define the stress points on both the electricity and gas networks – this helps determine the capacity that transmission and distribution networks are designed for, along with the firm capacity required to meet the demand.

Electricity Average Cold Spell (ACS) peak demand is the highest electricity demand seen across an average weather year. Electricity peak demand is defined as consumer demand (including network losses but excluding embedded generation) and is measured after all demand flexibility (other than V2G) eases the demand at peak.

Peak electricity demand in 2024 was 58.3 GW – this is expected to rise, partly due to a growing population, but mainly from increasing electrification of consumer demand. This increasing electrification is partly countered by energy efficiency improvements, alongside growing demand flexibility. Higher amounts of energy efficiency and demand flexibility result in lower firm capacity requirements and less infrastructure reinforcement.

Gas peak demand uses a 1 in 20 weather year, as per the standard metric used for the gas network, which is a worse case than the ACS method used for electricity peak demand. The peak gas demand for power (which is part of the overall gas peak demand), includes estimates for gas-fired generation from constrained electricity network, unlike all other parts of our analysis that assume an unconstrained network. In 2024, peak gas demand was 5214 GWh per day. As consumers shift to electricity (or hydrogen in harder-to-electrify applications) gas peak demand will reduce. Some gas will remain for industry and the power sector, to ensure peak electricity demand is being met with sufficient supply, but by 2050 this will all be abated.

56. Electricity and gas peak demands, excluding the Ten Year Forecast and Falling Behind



Powering the System: Electricity Supply

Electricity and gas peak demands (cont.)

What we modelled

Table 23: A list of key inputs and outputs from our FES 2025 models covering electricity and gas peak demands.

	2030		2050			
Modelling assumptions	**Holistic Transition**	**Ten Year Forecast**	**Holistic Transition**	**Electric Engagement**	**Hydrogen Evolution**	**Falling Behind**
Gas peak demand	4543 GWh per day	5076 GWh per day	1382 GWh per day	1671 GWh per day	2603 GWh per day	4707 GWh per day
Method to reduce peak electricity demand	High level of demand flexibility	Low level of demand flexibility	High level of demand flexibility	Medium level of demand flexibility	High usage of hydrogen at peak	Low level of demand flexibility
Electricity peak demand	62 GW	64 GW	120 GW	144 GW	122 GW	107 GW

Beyond the model

Progress on connections reform drives down the cost of electricity prices and enables the adoption of electrified technologies as a consequence.

Demand flexibility grows with the increased use of smart tariffs and the implementation of the Market-wide Half Hourly Settlement.

Powering the System: Electricity Supply

Electricity | Offshore wind

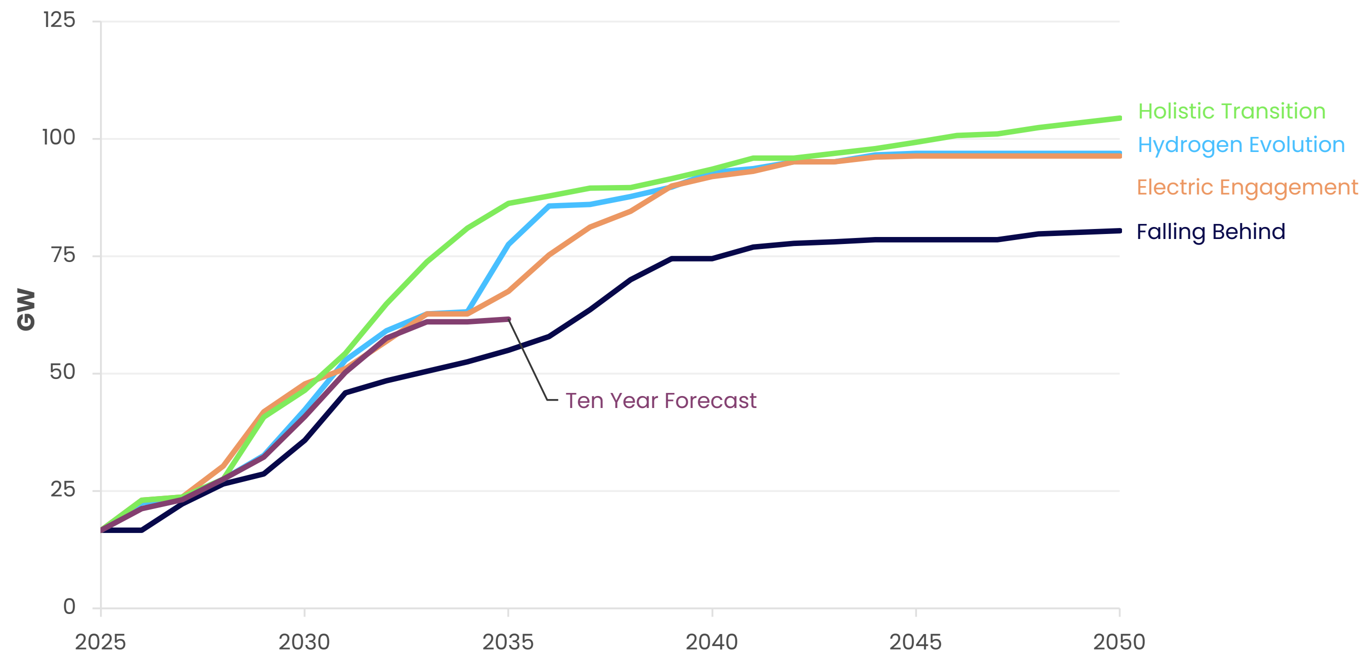
Overview

Over the past decade, the UK has established itself as a world leader in offshore wind deployment. Offshore wind plays a critical part in meeting our net zero targets and makes up most of our generation output.

Continued growth in the sector, however, requires significant infrastructure investment to move generated power from coastal landing points to where the energy is needed most across the country. Investment in the technology's supply chain and connections reform development is critical to reduce connection delays and expand deployment. Contracts for Difference (CfD) auction rounds also ensure necessary financial support for offshore wind developers.

45-52% of GB's 2050 supply generation dispatch comes from offshore wind.

57. Offshore wind capacity



Powering the System: Electricity Supply

Electricity | Offshore wind (cont.)

Stakeholder views

Some stakeholders highlighted that the delivery of 55 GW in 2030 pushes the bounds of deliverability due to network capacity and timeline constraints.

How we addressed feedback

We have reflected this in our analysis by reducing the upper range within our pathways to 47.8 GW.

What we modelled

Table 24: A list of key inputs and outputs from our FES 2025 models covering electricity supply from offshore wind.

Modelling assumptions	Holistic Transition	Electric Engagement	Hydrogen Evolution	10 Year Forecast	Falling Behind
Queue to 2030 (including built capacity)*	51 GW				
Max load factor in 2050	46%				
Offshore wind capacity till 2030	46.5 GW	47.8 GW	42.3 GW	40.8 GW	35.7 GW
Offshore wind capacity till 2050	104.4 GW	96.4 GW	96.8 GW	N/A	80.4 GW

*Data as of December 2024

Beyond the model

Government support is delivered to build out the supply chain and speed up the deployment of future offshore wind projects. This expediency ensures we have sufficient materials to build infrastructure at the required pace, accounting for the competition with other technologies such as international interconnector manufacturing.

Sufficient offshore wind projects are delivered to achieve adequate transmission infrastructure (linked to specific connection dates) and seabed leasing opportunities. This mitigates the risk of non-delivery and accommodates the increase in required capacity.

Locational, environmental barriers are acknowledged, evaluated and addressed to ensure safe delivery of offshore wind projects.

Powering the System: Electricity Supply

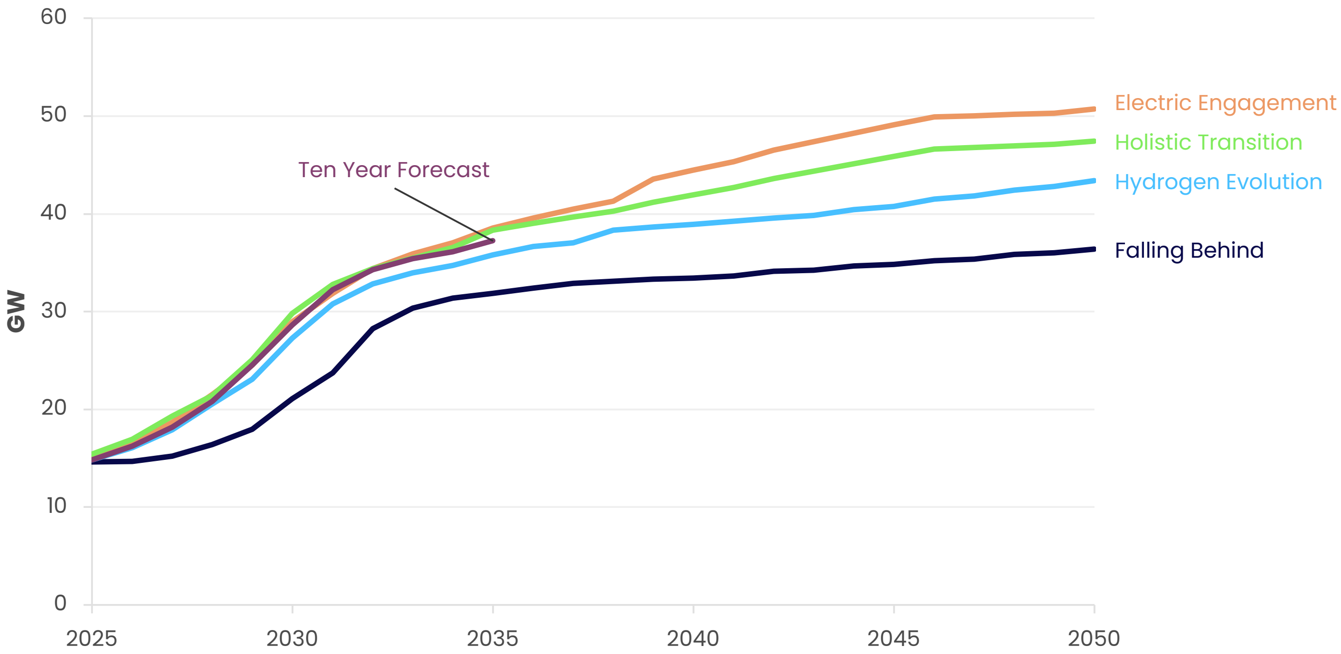
Electricity | Onshore wind

Overview

Onshore wind is one of the lower cost, clean power options available and will play an important role in the journey to net zero because of its scalability - from community-owned wind turbines to large, industrial wind farms. This means onshore wind can deploy at a faster rate than offshore wind projects.

Despite the potential, deployment of onshore wind has been slower over recent years due to planning restrictions across England and Wales, network connections, supply chain considerations and inflation of materials costs. However, the de facto ban on onshore wind in England and Wales (in place since 2015) was lifted on 8 July 2024, providing positive signals for future developers.

58. Onshore wind capacity



Powering the System: Electricity Supply

Electricity | Onshore wind (cont.)

Stakeholder views

The majority of stakeholders highlighted that planning restrictions, alongside connection challenges, have led to limited onshore wind deployment in England and Wales in recent years.

How we addressed feedback

Within our pathways we have reviewed the range of different locations and capacities of onshore wind to reflect the impact of changes from government policy, connections reform, and planning considerations.

What we modelled

Table 25: A list of key inputs and outputs from our FES 2025 models covering electricity supply from onshore wind.

Modelling assumptions	Holistic Transition	Electric Engagement	Hydrogen Evolution	10 Year Forecast	Falling Behind
Queue to 2030 (including built capacity)*	30.3 GW				
Max load factor in 2050	29%	29%	28%	N/A	28%
Onshore wind capacity till 2030	29.8 GW	29.0 GW	27.3 GW	28.7 GW	21.1 GW
Onshore wind capacity till 2050	47.5 GW	50.7 GW	43.4 GW	N/A	36.4 GW

*Data as of December 2024

Beyond the model

Investment across Great Britain in policy, markets, planning and connections reform, alongside strategic network planning through the Strategic Spatial Energy Plan (SSEP) and Centralised Strategic Network Plan (CSNP) delivers the certainty needed to speed up onshore wind deployment in England and Wales.

Powering the System: Electricity Supply

Electricity | Solar

Overview

Solar generation is a clean source of energy and will play an important role in meeting demand. Solar deployment has been widespread across the globe over the past few years. In Great Britain, most of our solar generation is currently connected to the distribution networks, with the first larger-scale solar plant only recently connected onto the transmission network in 2023.

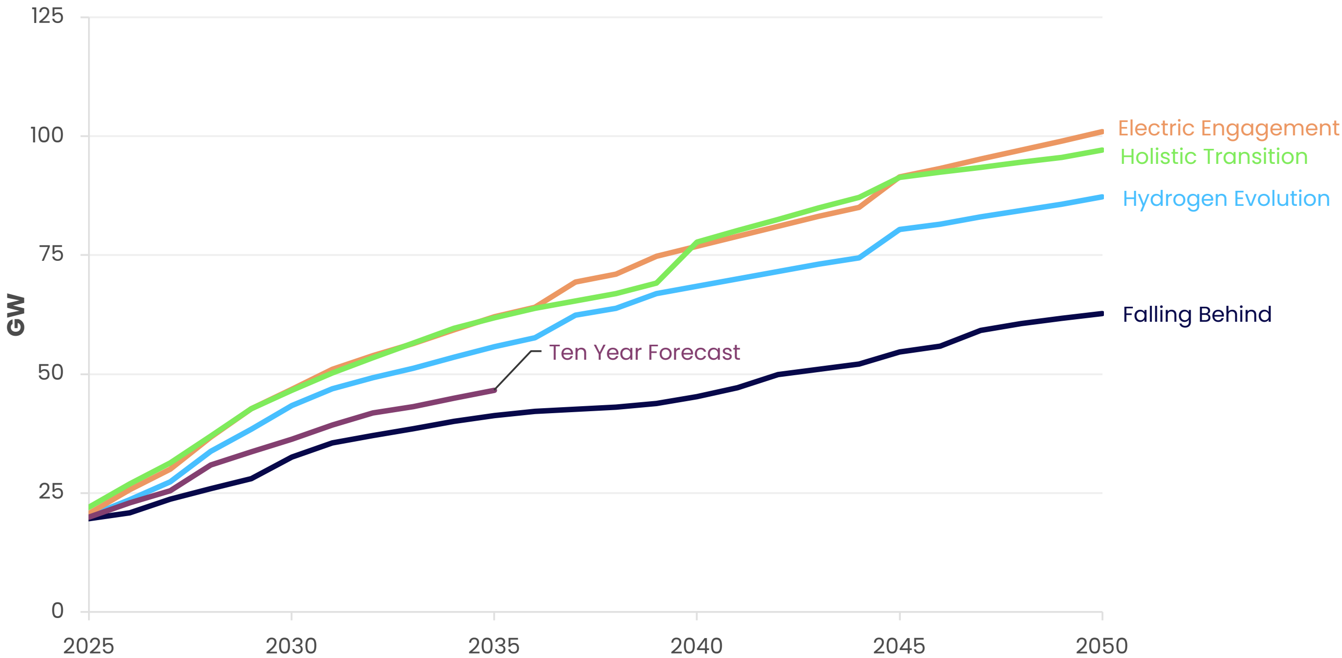
Solar transmission is expected to grow in the next few years, driven by planning approval of (standalone) large-scale solar farms and the *Clean Power 2030* commitment.

Like onshore wind, solar is a cheaper source of clean power, with largely complementary generation patterns. Alongside the potential to deploy in transmission and distribution networks, it also has residential applications via household rooftop solar photovoltaic (PV) panels.

Primary solar generation (excluding storage) builds across all three of our net zero pathways in the 2020s to meet increasing demand and to offset the use of high-carbon generation, while helping to achieve emissions targets.

Great Britain achieved a new maximum solar generation record on 6 April 2025 at 13.2GW.

59. Solar capacity



Powering the System: Electricity Supply

Electricity | Solar (cont.)

Stakeholder views

The majority of stakeholders highlighted solar energy's potential (especially in rooftop applications), but acknowledged the challenges this technology faces such as planning constraints and the need for policy support to overcome this. A small number of stakeholders felt that solar energy is significantly underestimated in our pathways, with a potential of over 50GW by 2030.

How we addressed feedback

Our pathways reflect a range of different deployment rates for solar generation, recognising the challenge in achieving very high uptake rates. We also examine a range of different sized projects and their connection points within the electricity network.

What we modelled

Table 26: A list of key inputs and outputs from our FES 2025 models covering electricity supply from solar generation.

Modelling assumptions	Holistic Transition	Electric Engagement	Hydrogen Evolution	10 Year Forecast	Falling Behind
Queue to 2030 (including built capacity)*	71.5 GW				
Max load factor in 2050	12%				
Total solar capacity in 2030	46.7 GW	46.8 GW	43.3 GW	36.3 GW	32.6 GW
Total solar capacity in 2050	97.0 GW	101.0 GW	87.2 GW	N/A	62.8 GW

*Data as of December 2024

Beyond the model

UK Government's regional capacity transmission limits (~11GW) are delivered as set out in their Clean Power Action Plan.

Colocated assets, such as grid-scale battery storage for solar farms, will leverage the combined power of solar generation and other flexible technologies over shared connections.

Powering the System: Electricity Supply

Electricity | Tidal

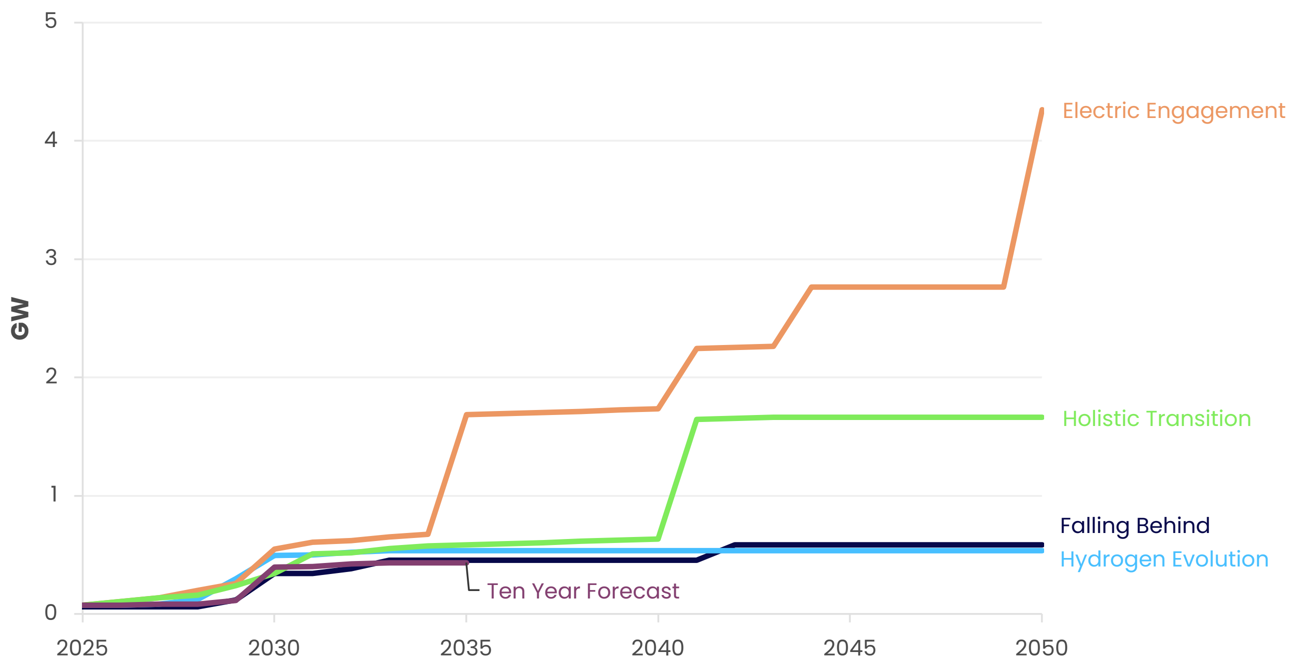
Overview

Marine energy generation uses the natural movement of water to produce electricity and is a highly predictable form of generation across all seasons.

There are two types of tidal generation – tidal stream, which captures the kinetic energy of tidal currents, and tidal range, which captures energy created by the difference in water levels. It is estimated that the UK has around 50% of Europe's tidal energy resource.

While tidal generation is a reliable source of power and has a long lifespan, these assets do have high upfront costs and limited subsidy support at present. In addition, environmental challenges must be acknowledged and evaluated to ensure safe operation within marine ecosystems.

60. Tidal capacity



Powering the System: Electricity Supply

Electricity | Tidal (cont.)

Stakeholder views

Stakeholders acknowledged that although tidal output is variable, it still follows a more predictable pattern to wind and solar. They also noted the higher investment costs required.

How we addressed feedback

We have included tidal generation in larger quantities in Holistic Transition and Electric Engagement in the late 2030s and early 2040s to reflect technology readiness and policy support that will ensure deployment.

What we modelled

Table 27: A list of key outputs from our FES 2025 models covering electricity supply from tidal generation.

Modelling assumptions	Holistic Transition	Electric Engagement	Hydrogen Evolution	10 Year Forecast	Falling Behind
Max load factor in 2050	19%				
Tidal capacity in 2040	0.6 GW	1.7 GW	0.5 GW	N/A	0.5 GW
Tidal capacity in 2050	1.7 GW	4.3 GW	0.5 GW	N/A	0.6 GW

Beyond the model

Tidal technologies receive investment through government support with financial backing for larger-scale projects and investment in research and development for novel applications.

Environmental barriers and supply chain constraints are addressed to ensure delivery of tidal technologies in later years.

Powering the System: Electricity Supply

Electricity | Battery energy storage

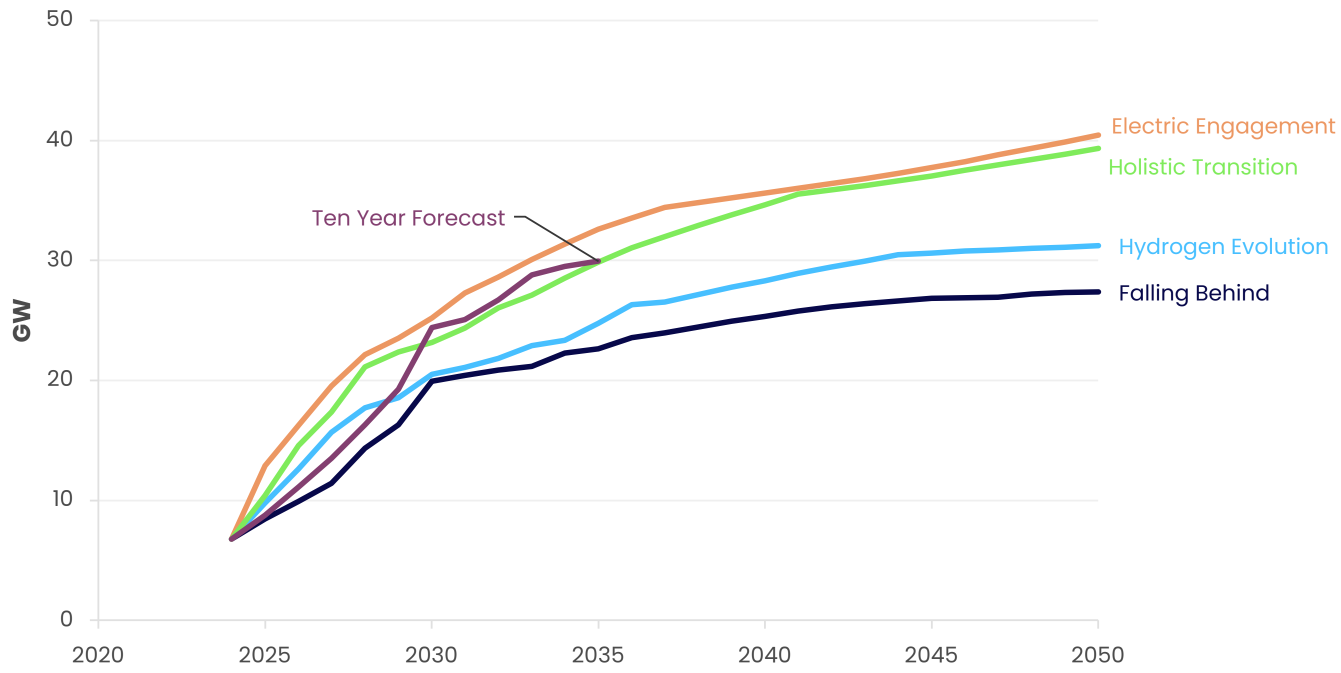
Overview

The principal role of batteries today is to provide within-day flexibility to help match supply and demand. Batteries also provide vital system services, such as frequency response, for which their role is likely to grow to 2030 as the use of gas generation falls. Two- to four-hour storage can also provide short-term reserves and help manage the network.

Industry and NESO have been working closely to access battery storage effectively and incorporate into NESO's economic dispatch process. These process developments have been designed to ensure that batteries will be included on a level economic playing field with all other technologies.

Further delivery relies on continuing the reforms to the connections queue, planning issues being resolved and market structures providing certainty and the right revenue opportunities.

61. Battery storage installed capacity (excluding electric vehicles)



Powering the System: Electricity Supply

Electricity | Battery energy storage (cont.)

Stakeholder views

Many stakeholders acknowledged that strategic planning, as well as connection and market reforms, will be crucial in unlocking the full potential of battery storage in the energy sector.

How we addressed feedback

We have evaluated both supply chain uncertainties and various battery storage policies to inform our storage growth and build-out rate.

What we modelled

Table 28: A list of key inputs and outputs from our FES 2025 models covering electricity supply from battery energy storage.

Modelling assumptions	Holistic Transition	Electric Engagement	Hydrogen Evolution	10 Year Forecast	Falling Behind
Queue to 2030 (including built capacity)*	49.8 GW				
Installed capacity in 2030	23.2 GW	25.2 GW	20.5 GW	24.4 GW	19.9 GW
Installed capacity in 2050	39.3 GW	40.4 GW	31.2 GW	N/A	27.4 GW

*Data as of December 2024

Beyond the model

Challenges remain around the supply chain and highlights the need to align battery growth with the lithium reserves available. Few challenges may also be present with regards to the grid and compliance tests causing commissioning and deployment delays for large commercial operations. These challenges limit our deployment, where appropriate, at both grid-scale and micro-battery storage.

Colocated assets, such as grid-scale battery storage for solar farms, will leverage the combined power of solar generation and battery storage over shared connections.

Powering the System: Electricity Supply

Electricity | Long-duration energy storage

Overview

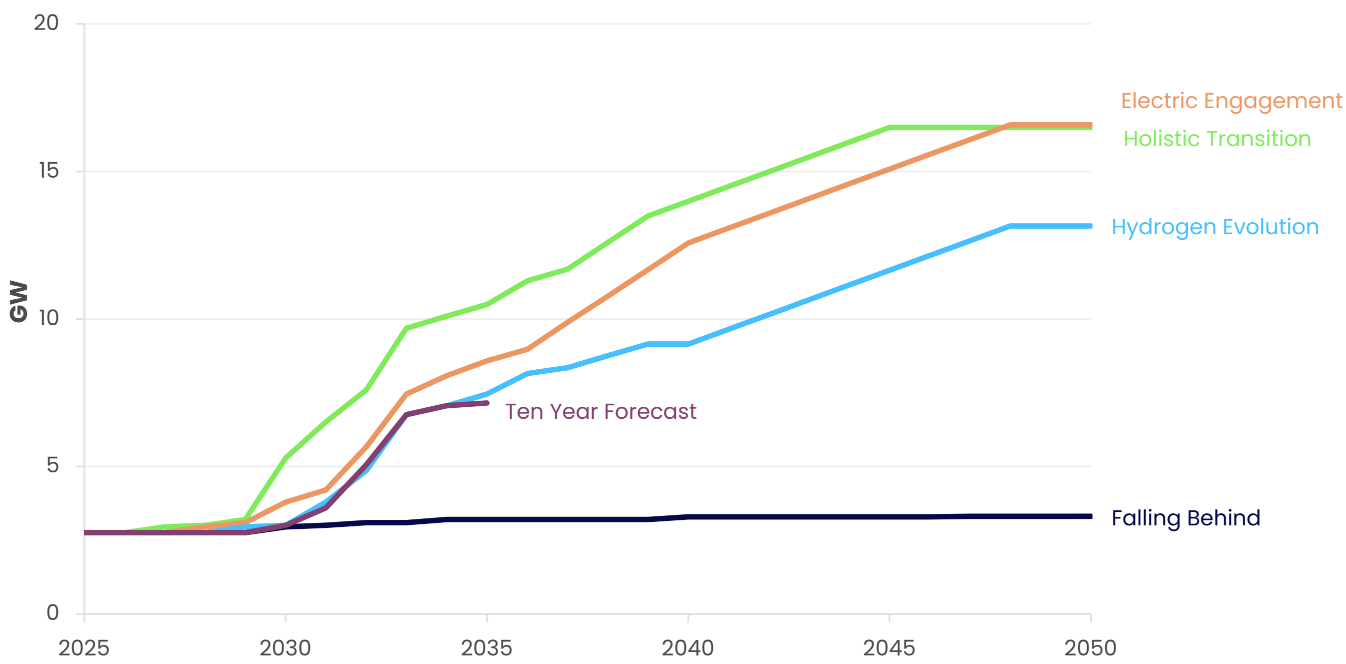
Long-duration energy storage (LDES), such as pumped hydro storage and liquid air, is particularly important for longer-term flexibility and additional operability needs, for example during extended periods of wind drought or to spread demand between weekends and weekdays. LDES is used to bolster high renewable periods and delivers flexibility through sustained response capability.

Due to longer lead and planning times and high capital expenditure, our pathways don't see many LDES projects coming online before 2030, and the pipeline of options to deploy before 2030 is limited. Increased deployment would require the completion of Great Britain's first pumped hydro stations in more than 40 years.

UK Government and Ofgem's 'cap and floor' funding scheme was introduced in April 2025 to further boost deployment and accelerate delivery, but the call for projects is under evaluation and the benefits have not been realised yet.

Installed pumped hydro storage is currently 28 GWh with 2.74 GW of capacity

62. Long-duration energy storage installed capacity (excluding electric vehicles and hydrogen)



Powering the System: Electricity Supply

Electricity | Long-duration energy storage (cont.)

Stakeholder views

New and innovative LDES, such as liquid air and compressed air projects, have successfully operated at a small scale. Work has started on new projects and feedback from stakeholders confirm that our lower range is within what they can build for 2030.

How we addressed feedback

We conducted a storage technology radar through stakeholder discussions and research. This helped us closely assess which storage technologies are commercially ready for delivery now, and explore expected timelines if they are not yet ready.

What we modelled

Table 29: A list of key outputs from our FES 2025 models covering electricity supply from long-duration energy storage.

Modelling assumptions	Holistic Transition	Electric Engagement	Hydrogen Evolution	10 Year Forecast	Falling Behind
Queue to 2030 (including built capacity)*	7.9 GW				
Installed capacity in 2030	5.3 GW	3.8 GW	3.0 GW	3.0 GW	3.0 GW
Installed capacity in 2050	16.5 GW	16.6 GW	13.2 GW	N/A	3.3 GW

*Data as of December 2024

Beyond the model

Adequate levels of energy storage and low carbon dispatchable power are delivered to buffer the retirement or conversion of unabated gas plants post-2030, to ensure security of supply.

Policy support via the cap and floor scheme is delivered to help bring forward the investment needed for LDES.

Supply chain uncertainties related to LDES inform our storage growth and build-out rate.

Powering the System: Electricity Supply

Electricity | Interconnectors

Overview

Interconnectors facilitate the integration of weather-dependent and distribution-connected energy generation and are vital as we transition to net zero.

Levels in our net zero pathways vary depending on the levels of hydrogen storage and other flexibility options. Great Britain becomes a net exporter of electricity post-2030 and retains that position in 2050 in Holistic Transition and Electric Engagement.

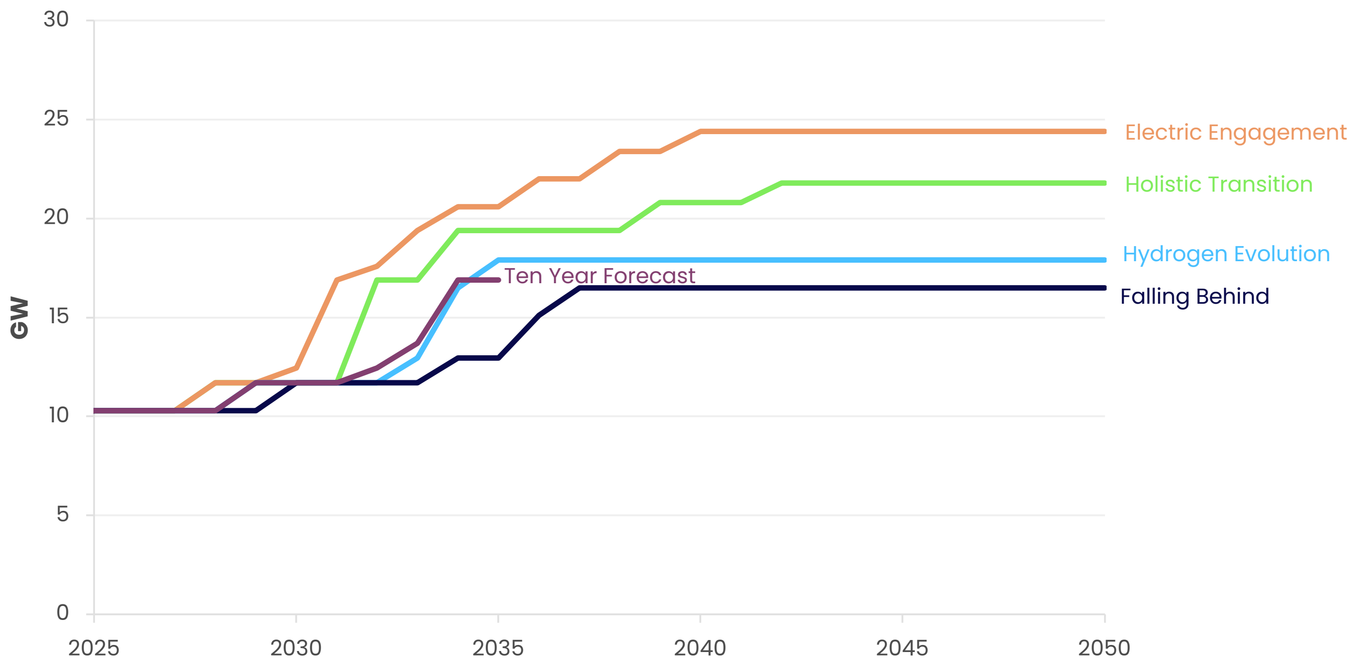
UK Government and Ofgem's cap and floor regime continues to deliver a steady pipeline of projects out to early 2040, however interconnector total capacity is slower in the short term to reflect complex interconnector project negotiations across Great Britain and Europe, as well as other regulation considerations between countries.

The longer-term outlook for increased levels of interconnection remains uncertain. Countries on both sides must be confident that projects will be beneficial for consumers. Once delivered, the movement of power over interconnectors will continue to be driven by the price differentials between electricity markets.

Project deployment can also be made challenging through supply chain bottlenecks of competing technologies (such as offshore wind turbines) which require similar equipment, highlighting the need to address these supply chain challenges swiftly.

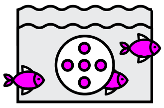
British interconnector installed capacity to other European countries is currently 10 GW

63. Interconnector capacity



Powering the System: Electricity Supply

Electricity | Interconnectors (cont.)



Stakeholder views

The majority of stakeholders acknowledged that the sector faces regulatory and policy challenges associated with developing and maintaining interconnector infrastructure. Stakeholders also pointed out challenges and barriers to interconnector project delivery around obtaining connection agreements, supply chain, securing manufacturing slots and the scheduling of cable-laying vessels.

How we addressed feedback

We assessed interconnector project delivery through further stakeholder and government engagement alongside research. We also expanded the explanation of the interconnector forecast methodology in our *Future Energy Scenarios 2025 Modelling Methods* document.

What we modelled

Table 30: A list of key inputs from our FES 2025 models covering electricity supply from interconnectors.

Modelling assumptions	Holistic Transition	Electric Engagement	Hydrogen Evolution	10 Year Forecast	Falling Behind
Queue to 2030 (including built capacity)*	28.1 GW				
Interconnector capacity in 2030	11.7 GW	12.5 GW	11.7 GW	11.7 GW	11.7 GW
Interconnector capacity in 2050	21.8 GW	24.4 GW	17.9 GW	N/A	16.5 GW
European Union Carbon Border Adjustment Mechanism	We do not consider the European Union CBAM in our modelling, as there is considerable uncertainty since an agreement to being talks about linking the British and European Union carbon markets.				

*Data as of December 2024

Beyond the model

Reforms to market design and policies supporting energy assets in Great Britain and neighbouring countries influence the future development of interconnectors and their flows. Potential saturation of markets and constraints around Great Britain's connection locations is a consideration in the future growth of interconnectors. We continue to monitor market conditions alongside the appetite and political landscape of the rest of Europe.

Powering the System: Electricity Supply

Electricity | Nuclear

Overview

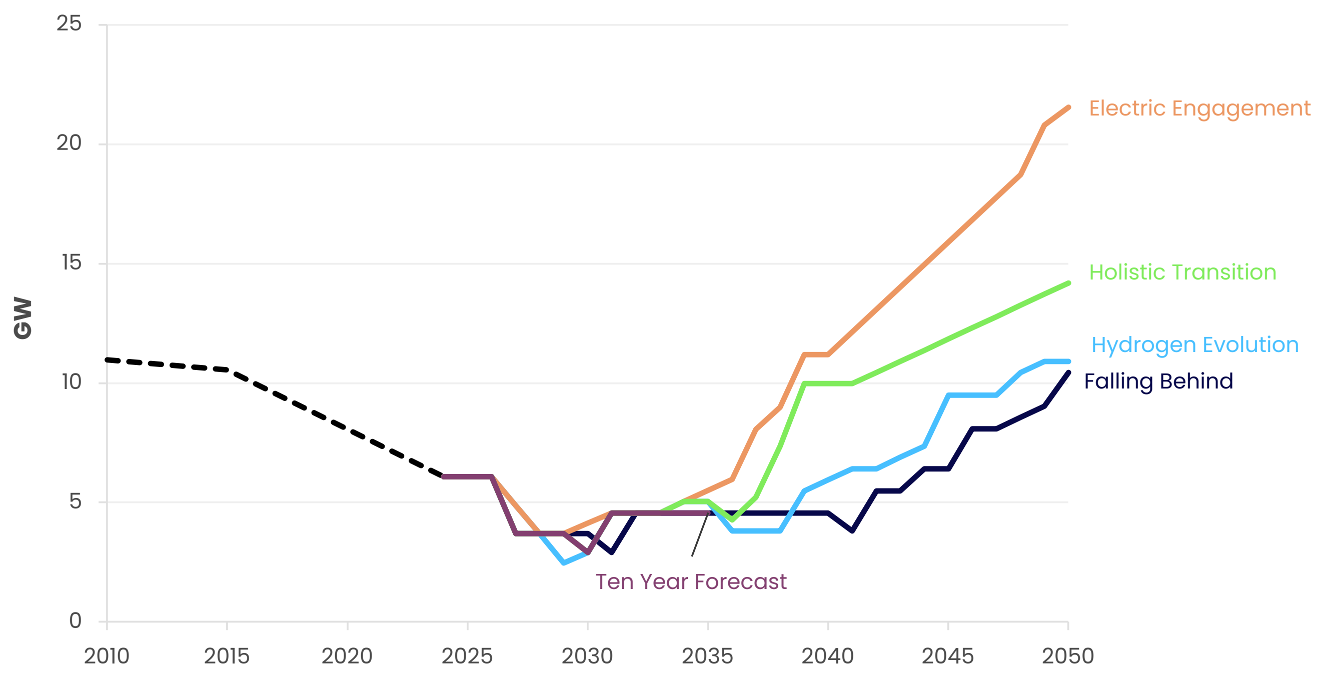
Nuclear power will play an important role in achieving a clean power system by 2030 and beyond, through a new generation of nuclear plants that will replace retiring capacity and meet growing demand as the economy electrifies.

Most of Great Britain's existing nuclear plants are due to retire before 2030 – some before new plants come online – creating a transition challenge. Because of this, select plants are currently being considered for life extension, subject to approval from the Office for Nuclear Regulation.

The UK Government aims to clarify its current (long-term) nuclear ambitions and the path to achieving them. A final investment decision on the Sizewell C large-scale nuclear project is anticipated later in 2025, while the outcome of the previous government's Small Modular Reactor (SMR) competition is also expected to be announced soon.

39-59% of the installed nuclear capacity is represented by SMRs in the pathways.

64. Nuclear capacity



Powering the System: Electricity Supply

Electricity | Nuclear (cont.)

Stakeholder views

Most stakeholders acknowledged the role of nuclear to ensure energy security and meet decarbonisation targets. Despite this, many stakeholders pointed out the challenges in the sector, such as long lead times for building large nuclear power plants, public perception and planning issues.

How we addressed feedback

We have used details of upcoming projects from nuclear developers and government bodies for input into our transmission generation background modelling. We have also ensured that where nuclear is utilised in conjunction with hydrogen or industrial heating production, the dates and locations of deployment are consistent with hydrogen development and production or industrial heating requirements.

What we modelled

Table 31: A list of key inputs and outputs from our FES 2025 models covering electricity supply from nuclear power.

Modelling assumptions	Holistic Transition	Electric Engagement	Hydrogen Evolution	10 Year Forecast	Falling Behind
Queue to 2030 (including built capacity)*	5.7 GW				
Max load factor in 2050	80%	81%	79%	N/A	79%
Nuclear capacity in 2030	2.9 GW	4.1 GW	2.9 GW	2.9 GW	3.7 GW
Nuclear capacity in 2050	14.2 GW	21.6 GW	10.9 GW	N/A	10.4

*Data as of December 2024

Beyond the model

Along with the extension of existing plants, long-term government support is delivered to build the supply chain out for new infrastructure, including large-scale nuclear projects and more novel projects such as SMRs.

Powering the System: Electricity Supply

Electricity | Low carbon dispatchable power (cont.)

Overview

The ability to ramp up supply to meet demand is a key requirement of the energy system. Traditionally, this would have been provided by unabated gas generation and coal power plants, but as we shift away from these sources of power, new solutions are required and the role of gas is evolving to ensure a secure power supply and enable the transition to low carbon dispatchable power.

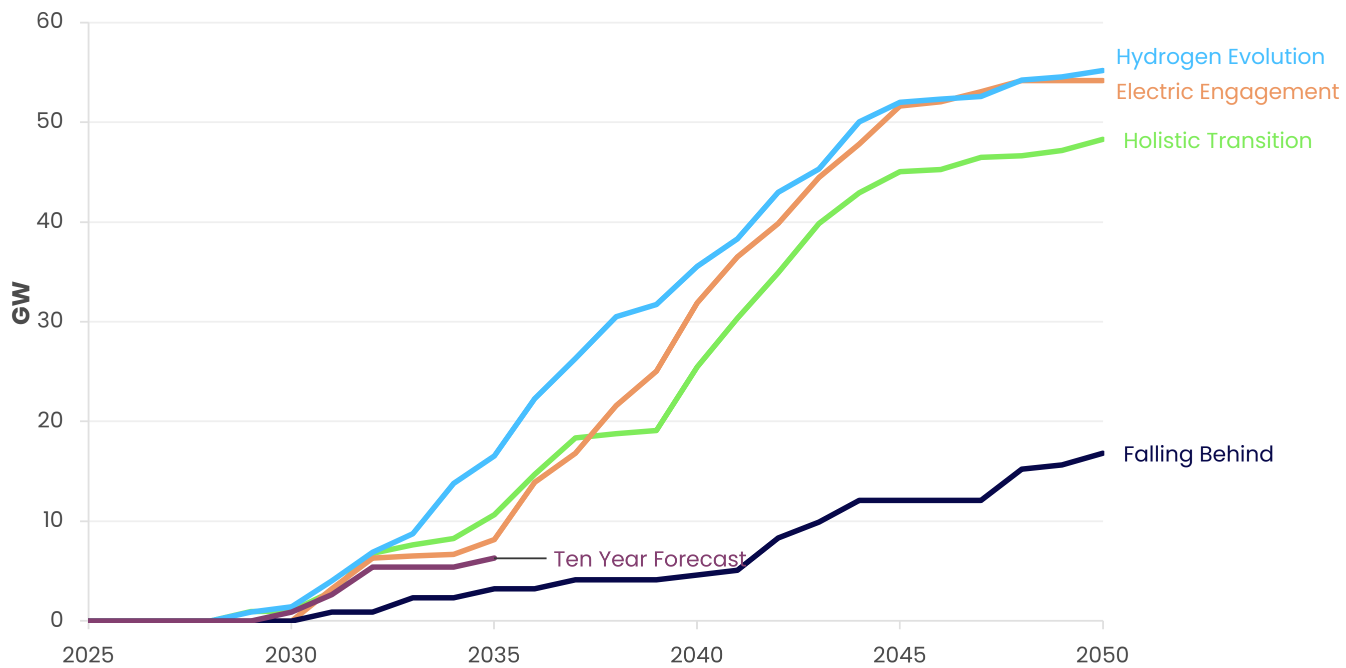
We define 'low carbon dispatchable power' as gas power plants coupled with CCS and hydrogen to power (H2P) plants. These plants can dial up and down to match peak demand and fill gaps during periods of low renewable output – this is an important requirement of a clean power system in 2030. After 2030, low carbon dispatchable power could be built up to replace the need for the remaining unabated gas generation.

Revenue support from government for gas CCS generation will be available through Dispatchable Power Agreements (DPAs).

Government is developing a H2P business model based on the DPA style mechanism.

UK Government's Track-1 Cluster Sequencing Process recently announced that the Teesside and HyNet clusters are the first to secure funding

65. Low carbon dispatchable capacity



Powering the System: Electricity Supply

Electricity | Low carbon dispatchable power

Stakeholder views

The majority of stakeholders highlighted the need for dispatchable generation for security of supply purposes and the need to convert these plants from unabated gas.

How we addressed feedback

We have utilised NESO's *Clean Power 2030* analysis in our generation background modelling, supported by stakeholder bilateral meetings discussing gas-to-power and conversion to low carbon dispatchable power. Beyond 2030, we utilise our Capacity Expansion Model for transmission to ensure that our net zero pathways meet security of supply, including contribution from low carbon dispatchable gas generation. Our dispatch model then assesses how we can meet carbon budgets with this low carbon generation capacity in the generation mix.

What we modelled

Table 32: A list of key inputs and outputs from our FES 2025 models covering electricity supply from low carbon dispatchable power.

Modelling assumptions	Holistic Transition	Electric Engagement	Hydrogen Evolution	10 Year Forecast	Falling Behind
Queue to 2030 (including built capacity)*	4.3 GW				
Max load factor in 2050	92%				
Low carbon dispatchable capacity in 2030	1.0 GW	0.0 GW	1.4 GW	0.9 GW	0.0 GW
Low carbon dispatchable capacity in 2050	48.3 GW	54.2 GW	55.2 GW	N/A	16.8 GW

*Data as of December 2024

Beyond the model

Natural gas plays a role in industry and (peaking) power generation to provide low carbon flexibility when used with CCS, as well as in the production of low carbon hydrogen.

Policy support for low carbon dispatchable power is provided, to account for lower operating load factors out to 2050. This enables delivery of CCS at scale along with hydrogen and CO_2 storage, to ensure a reliable whole energy system.

Powering the System: Electricity Supply

Electricity | Unabated gas

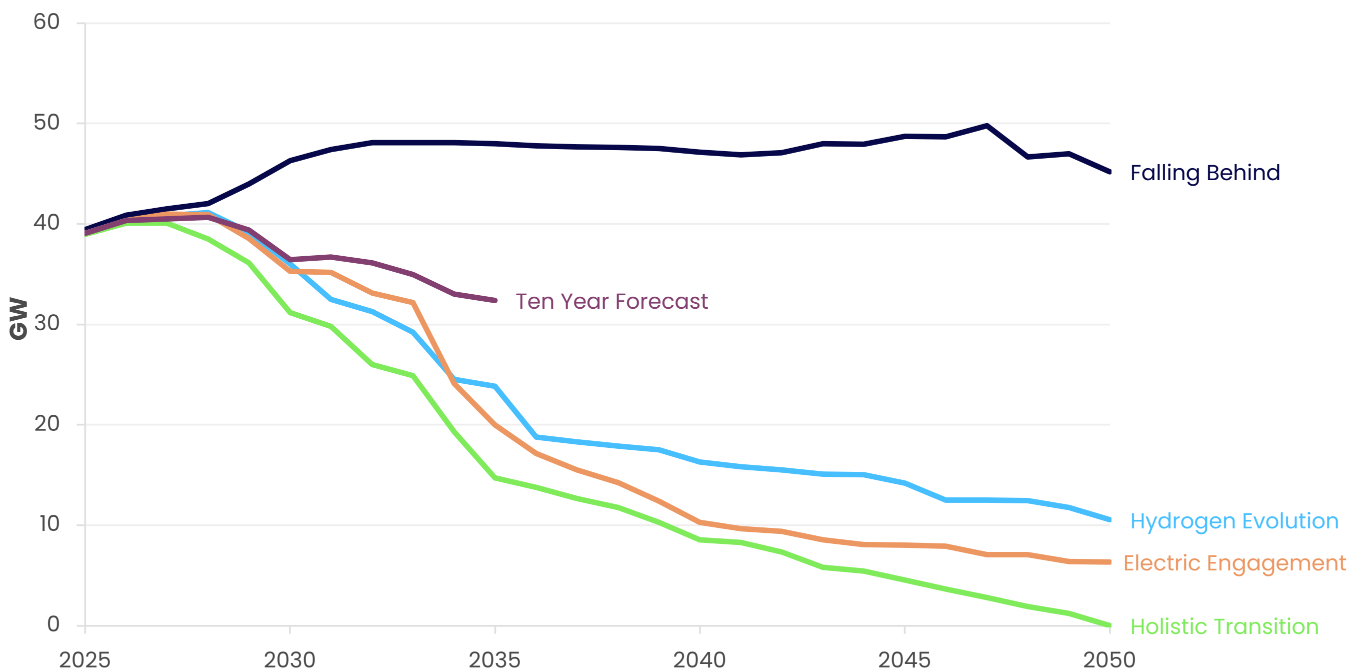
Overview

Gas power remains an important part of today's generation mix and helps ensure security of supply (SoS) and will help support the transition to low carbon dispatchable power in the future.

Recent Capacity Market (CM) auctions reveal a lower participation from unabated gas plants. Despite this, these levels are higher than that in NESO's *Clean Power 2030* advice to government in Electric Engagement and Hydrogen Evolution, as we have not retired any large stations before 2030 that have not already submitted notice of closure, have legal requirements to close or are converting to gas with CCS.

Unabated gas capacity remains on the system operating at low load factors between 12-13% in the pathways in 2030.

66. Unabated gas capacity



Powering the System: Electricity Supply

Electricity | Unabated gas (cont.)

Stakeholder views

The majority of stakeholders acknowledged that while levels of electricity from gas will reduce as the main source of dispatchable power generation at the scale needed today, it will still be required for SoS, filling shortfalls during periods of low renewable output.

How we addressed feedback

We used NESO's *Clean Power 2030* analysis in our generation backgrounds, supported by additional stakeholder engagement and market intelligence. Beyond 2030, we used our Capacity Expansion Model (CEM) for transmission to ensure SoS from dispatchable gas generation. Our dispatch model then assessed the utilisation rates with different generation mixes.

What we modelled

Table 33: A list of key inputs and outputs from our FES 2025 models covering electricity supply from unabated gas.

Modelling assumptions	Holistic Transition	Electric Engagement	Hydrogen Evolution	10 Year Forecast	Falling Behind
Transmission Entry Capacity and Embedded Capacity Register to 2030	47.2 GW				
Max load factor in 2050	N/A	93%	92%	92%	92%
Unabated gas capacity in 2030	31.2 GW	35.3 GW	36.0 GW	36.4 GW	46.3 GW
Unabated gas capacity in 2050	0.0 GW	6.3 GW	10.6 GW	N/A	45.2 GW

Beyond the model

After 2030, unabated gas generation is used sparingly, primarily when renewable output is low and demand is high, further reinforcing the need for government support.

Negative emissions technologies are used to offset emissions for remaining unabated gas capacity on the system, which operates at low load factors.

Powering the System: Electricity Supply

Bioenergy | Biomass power with carbon capture and storage

Overview

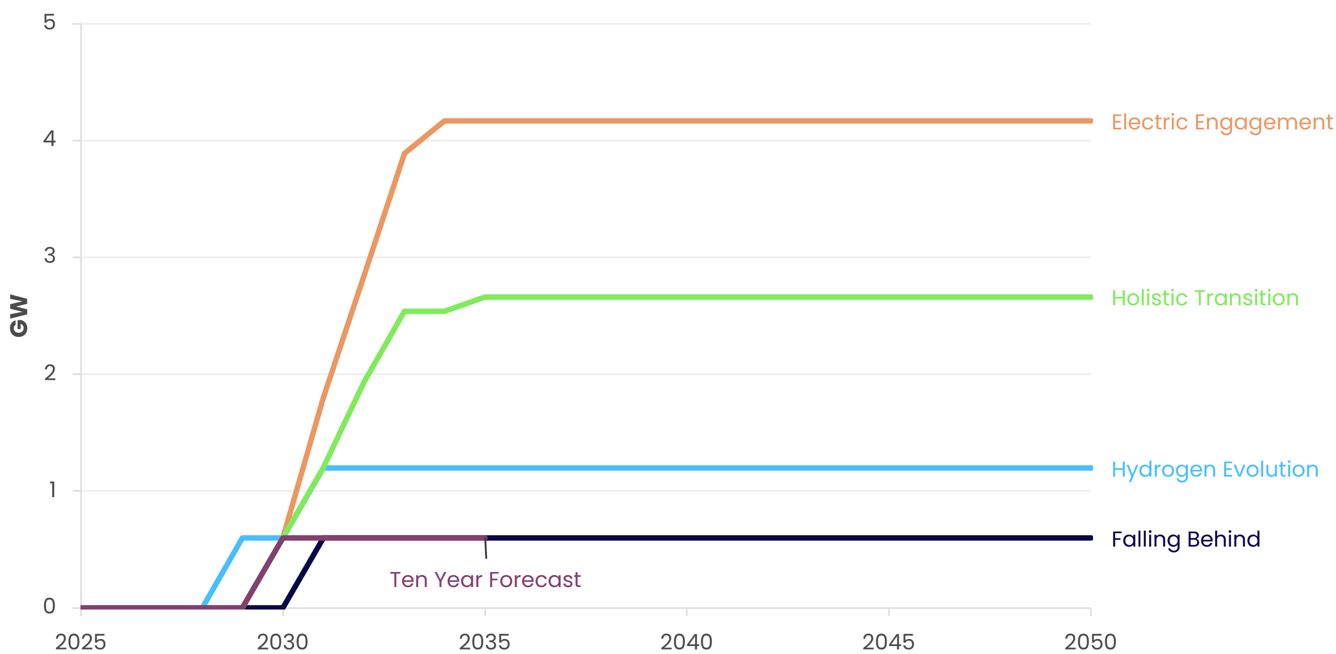
Bioenergy with carbon capture and storage for electricity generation (power BECCS), plays an important role in our net zero pathways by providing negative carbon emissions to offset residual emissions in hard-to-decarbonise sectors.

Bioenergy plants provide a source of ancillary services essential to the operation of a future energy system dominated by renewables. For those that suit CCS, high load factors will remain desirable, but the role of biomass (without CCS) should shift to dispatchable to help meet demand during times of low wind and solar output.

The future role of BECCS was highlighted in DESNZ's Biomass Strategy 2023, which emphasised the importance of sustainability with regards to any use of biomass. The strategy also outlined the governments intention to consult and develop a cross-sector biomass sustainability framework.

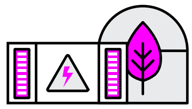
We assume conversion of biomass to BECCS beginning by 2030 in our pathways.

67. Bioenergy with carbon capture and storage capacity



Powering the System: Electricity Supply

Bioenergy | Biomass power with carbon capture and storage (cont.)



Stakeholder views

BECCS was cited as critical by a few stakeholders for achieving net zero by offsetting emissions. However, they also felt that the sector faces challenges such as the need for policy and economic support for CCS.

How we addressed feedback

Power BECCS is a key technology to achieve the Sixth and recommended Seventh Carbon Budgets, as well as net zero.

What we modelled

Table 34: A list of key inputs and outputs from our FES 2025 models covering electricity supply from biomass and bioenergy with carbon capture and storage.

Modelling assumptions	Holistic Transition	Electric Engagement	Hydrogen Evolution	10 Year Forecast	Falling Behind
Max load factor in 2050	89%	90%	88%	N/A	87%
Installed capacity in 2030	0.6 GW	0.6 GW	0.6 GW	0.6 GW	0.0 GW
Installed capacity in 2050	2.7 GW	4.2 GW	1.2 GW	N/A	0.6 GW

Beyond the model

Government consultations have confirmed that a dual CfD approach for both electricity generation and carbon removal is preferred and economic incentives for BECCS are provided to encourage widescale deployment. Some biomass power stations convert to power BECCS and negative emissions technologies take high priority for connection to CO_2 networks.

Fuelling the System

Fuelling the System

Gas | Gas supply, storage and networks

Overview

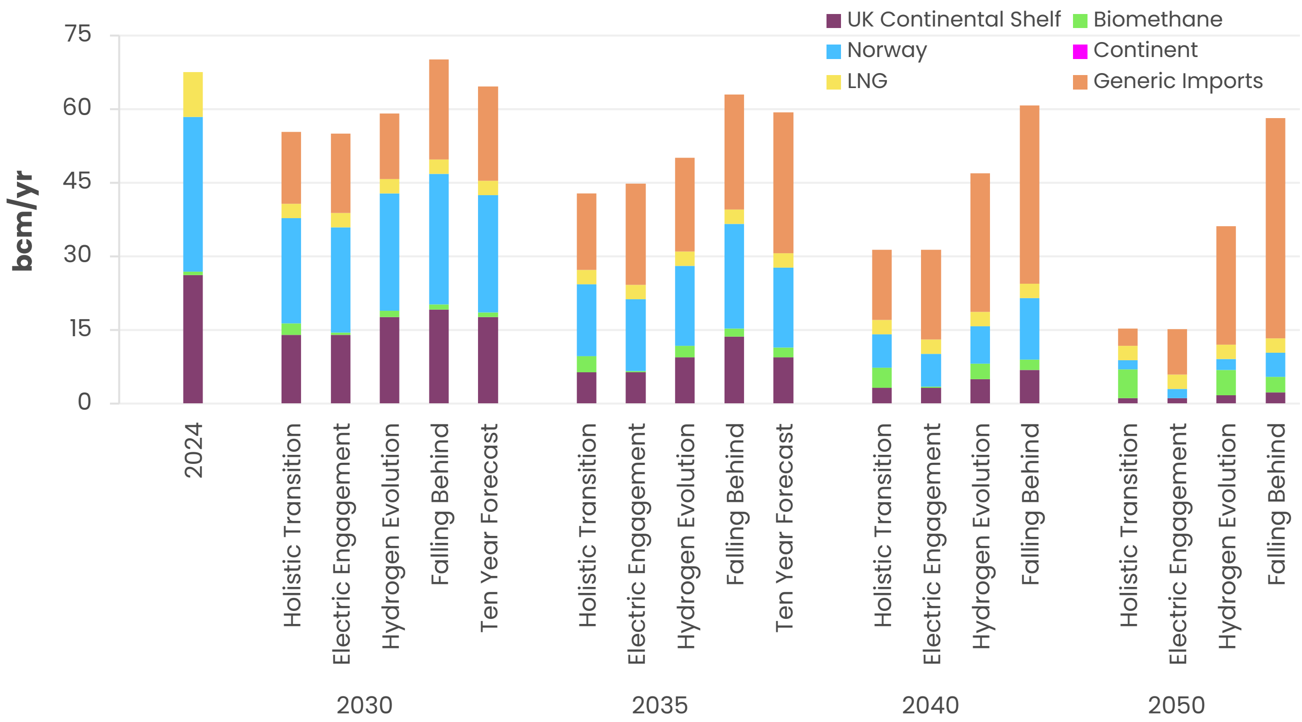
Natural gas plays an essential role in Great Britain's energy system for power, heat and industry. Our net zero pathways show a changing role for gas, with it principally providing low carbon power flexibility and low carbon hydrogen production.

Gas does remain part of the energy system in all net zero the pathways out to 2050, therefore future infrastructure and security of supply requirements must be considered.

Great Britain has historically benefited from a diverse range of gas supply sources, supporting its energy security. Our domestic gas reserves, however, are 20 years beyond their peak production. The North Sea Transition Authority's latest assessment shows that there are limited proven and probable remaining UK gas reserves. This leaves our current gas-heavy energy system reliant on highly flexible supply sources being delivered when we need it, without being able to rely on our historic baseload from the North Sea[42].

In 2024, the largest single source of gas supply was Norway, accounting for 46% of gas supply

68. Gas supply mix by pathway



42 *Reserves and Resources Report as at end 2023*, North Sea Transition Authority, 22 Oct 2024

Fuelling the System

Gas | Gas supply, storage and networks (cont.)

Stakeholder views

Stakeholders stated that gas will still be a major energy vector over the near-to-medium horizon, and that infrastructure will be required into the future. Stakeholders noted that greater global supply availability of LNG will be beneficial to Great Britain as a gas importer.

How we addressed feedback

All the pathways continue to use a range of gas sources to 2050. In addition, we have commissioned and utilised data from a new study on biomethane potential in Great Britain.

What we modelled

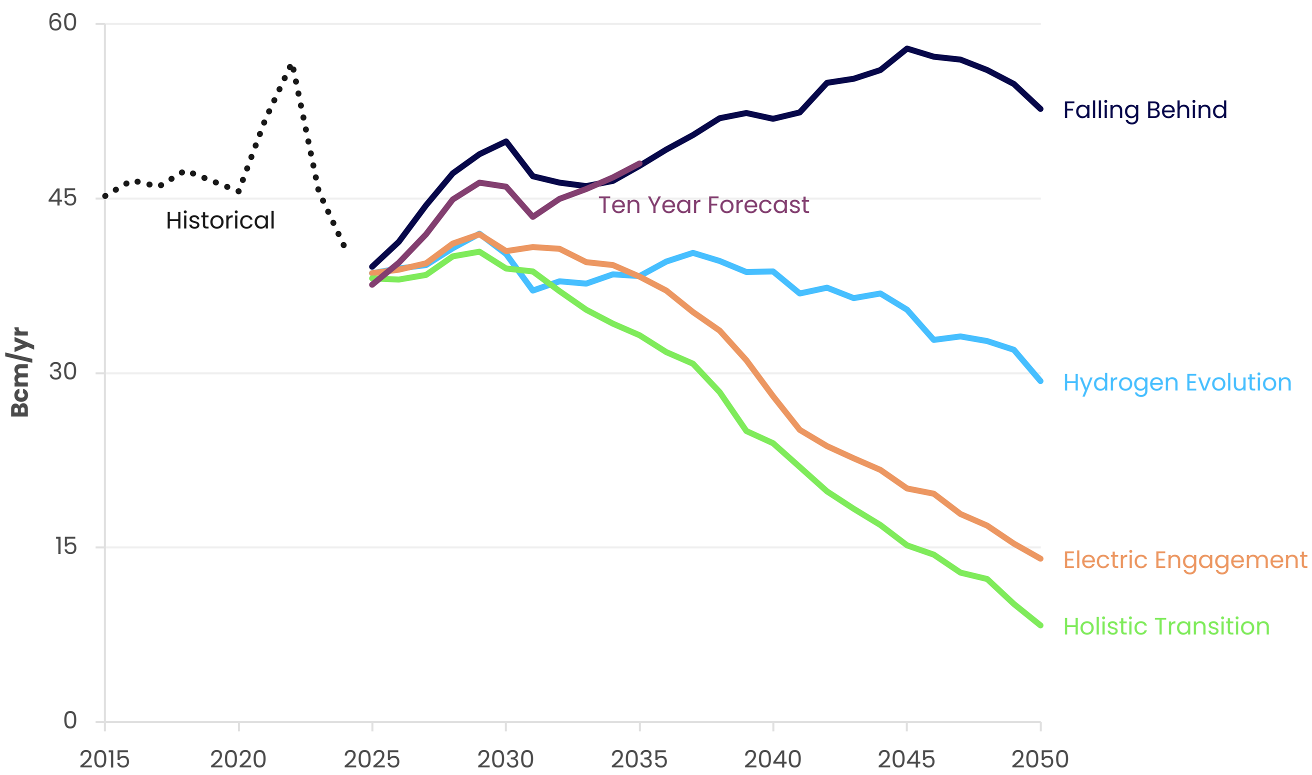
Table 35: A list of key inputs and outputs from our FES 2025 models covering gas supply, storage and networks.

Modelling assumptions	Holistic Transition	Electric Engagement	Hydrogen Evolution	10 Year Forecast	Falling Behind
Gas demand in 2035, as a percentage of 2024 gas demand	63%	66%	74%	88%	93%
Gas demand in 2050, as a percentage of 2024 gas demand	23%	22%	54%	N/A	86%
Gas import volume in 2050 in bcm (2024 = 41 bcm)	8.3	29.3	14.1	N/A	52.7
Gas storage	All pathways, Falling Behind and Ten Year Forecast assume a continued availability of gas storage to 2050, though we do not directly model future gas storage needs and requirements.				
Gas networks	All pathways, Falling Behind and Ten Year Forecast assume a continued presence of a gas transmission network to 2050.				

Fuelling the System

Gas | Gas supply, storage and networks (cont.)

69. Imported gas volumes by pathway



Beyond the model

Natural gas has a role in the future energy system across all our net zero pathways. Strategic energy planning clarifies how this role will be maintained alongside supplying low carbon hydrogen. All the net zero pathways utilise both hydrogen and natural gas concurrently to 2050. Strategic planning will help us understand where, when, and how this relationship between gas and hydrogen will develop across Great Britain to 2050.

Gas production from the UK Continental Shelf continues to decline but remains part of the wider gas supply mix energy security is tested against. But meeting demand will always need additional imports as remaining proven and probable domestic gas reserves cannot meet current or future needs.

As gas remains part of the energy system to 2050, SoS needs to be maintained. We need to efficiently manage our sources of gas and critical supporting infrastructure such as pipelines, LNG terminals and storage locations to 2050. NESO will be publishing our *Gas Supply Security Assessment* later in 2025.

Fuelling the System

Gas | Biomethane

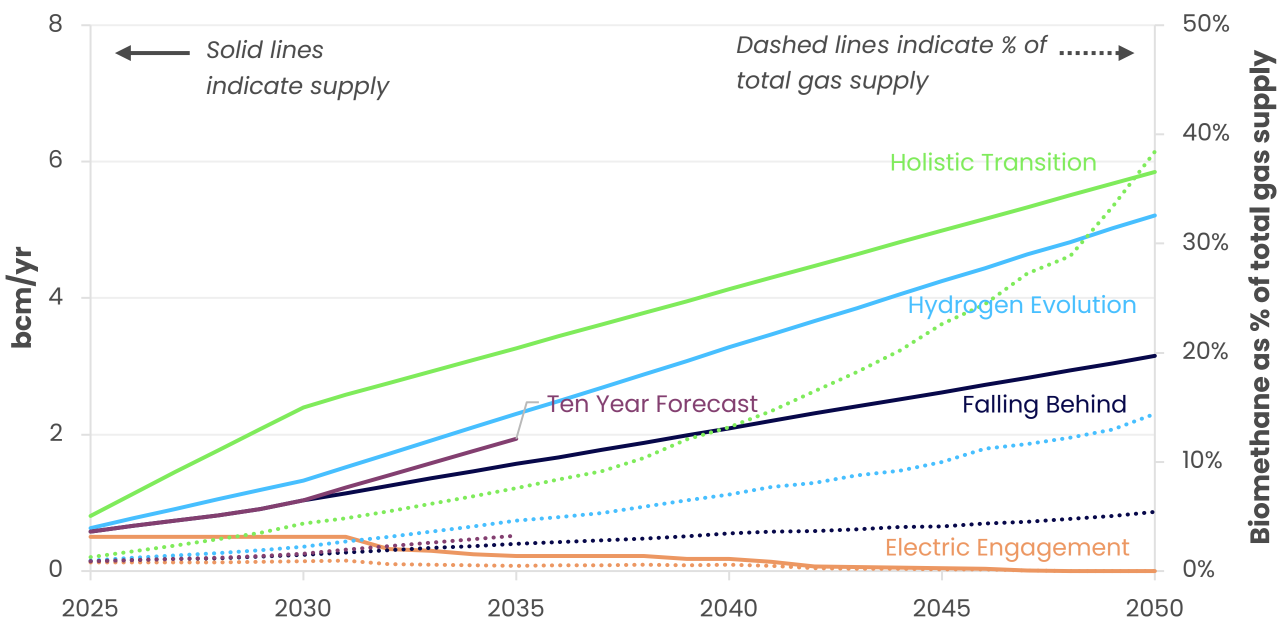
Overview

Biomethane is produced from the anaerobic digestion of biomass (such as agricultural wastes, crops, or sewage) into biogas which is a mixture of methane and CO_2.

The CO_2 is separated and removed, and the methane is conditioned to meet standards for injection into gas distribution or transmission networks. This provides a low carbon alternative to natural gas, as the CO_2 emissions arising from biomethane use are derived from biogenic waste that would otherwise have decomposed into methane. The UK currently has over 100 facilities that upgrade biogas to biomethane and inject it into the gas grid.

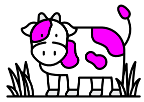
In 2024, 5.5 TWh of biomethane was injected into the British gas grid.

70. Biomethane supply



Fuelling the System

Gas | Biomethane (cont.)



Stakeholder views

Many stakeholders suggested that there was potential for greater biomethane supply than utilised in *FES 2024*, particularly as hydrogen production prices are higher than anticipated earlier this decade, which may otherwise limit the rate at which gas users decarbonise by switching to hydrogen. Long-term support mechanisms for biomethane would reduce uncertainty and improve investment in the sector.

How we addressed feedback

We commissioned an independent analysis of biomethane potential in Great Britain out to 2050, which has informed our pathway utilisation of the fuel.

What we modelled

Table 36: A list of key outputs from our FES 2025 models covering supply from biomethane.

Modelling assumptions	Holistic Transition	Electric Engagement	Hydrogen Evolution	10 Year Forecast	Falling Behind
Biomethane supply by 2035	36 TWh	2 TWh	25 TWh	21 TWh	17 TWh
Biomethane supply by 2050	64 TWh	0 TWh	57 TWh	N/A	35 TWh

Beyond the model

Certainty around a long-term support mechanism incentivises greater biomethane production. Long term support mechanisms, beyond the Green Gas Support Scheme ending in 2028, will ensure a consistent pipeline of new production projects.

Clarity around the role of future low carbon gaseous fuel networks. Use of biomethane implies continued availability of gas networks – these will be utilised by a smaller number of users over time. A clearer vision is needed about the scale and role of biomethane in the future and what this means for optimal use of gas infrastructure.

Fuelling the System

Hydrogen | Hydrogen supply

Overview

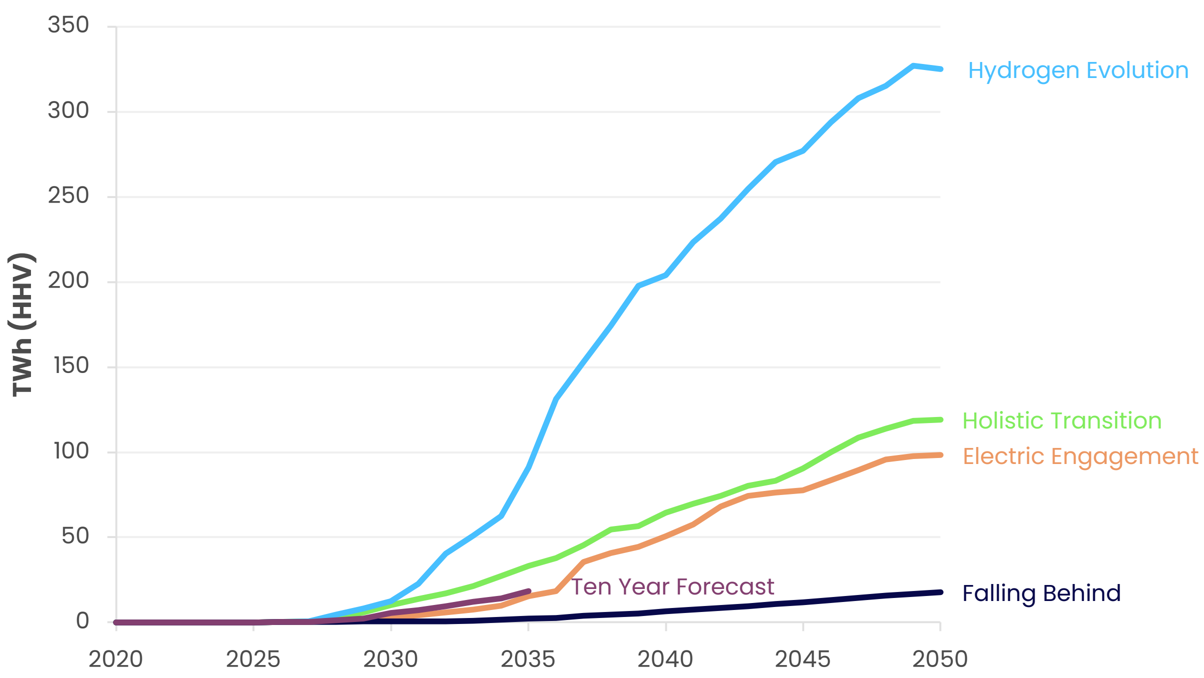
Low carbon hydrogen supply is utilised in all the net zero pathways and is prioritised towards users and sectors with few alternatives for decarbonisation.

Great Britain has a deep pipeline of low carbon hydrogen supply projects, though no large-scale hydrogen projects have reached final investment decision in Great Britain as of June 2025. Higher than anticipated costs, lack of off-takers and lack of enabling infrastructure have all limited development of initial hydrogen supply projects.

In addition to decarbonising energy demand, hydrogen supply plays an important role in the broader whole energy system picture. Electrolytic hydrogen production is often fuelled by otherwise curtailed renewable generation, offering a route to long term energy storage. This can be used to balance demand, be it baseload demand from industry or flexible demand, such as dispatchable hydrogen power generation.

The pathways use multiple approaches to produce hydrogen. Predominantly, these are methane reformation to turn methane (CH_4) into hydrogen, then capturing and storing most of the CO_2 emissions from the process and electrolysis to split water molecules into hydrogen and oxygen using electricity. The pathways also use limited amounts of other approaches such as biomass gasification and high-temperature nuclear electrolysis.

71. Hydrogen supply by pathway



Fuelling the System

Hydrogen | Hydrogen supply (cont.)

Stakeholder views

Stakeholders highlighted the higher-than-anticipated costs of initial hydrogen projects, and the general lack of clarity for long-term support mechanisms. They suggested that hydrogen will play a role in the future of Great Britain's energy system, but that natural gas and biomethane will be essential in the near-to-medium term. Some stakeholders felt that Great Britain should promote the trade of hydrogen, harnessing future renewables capacity.

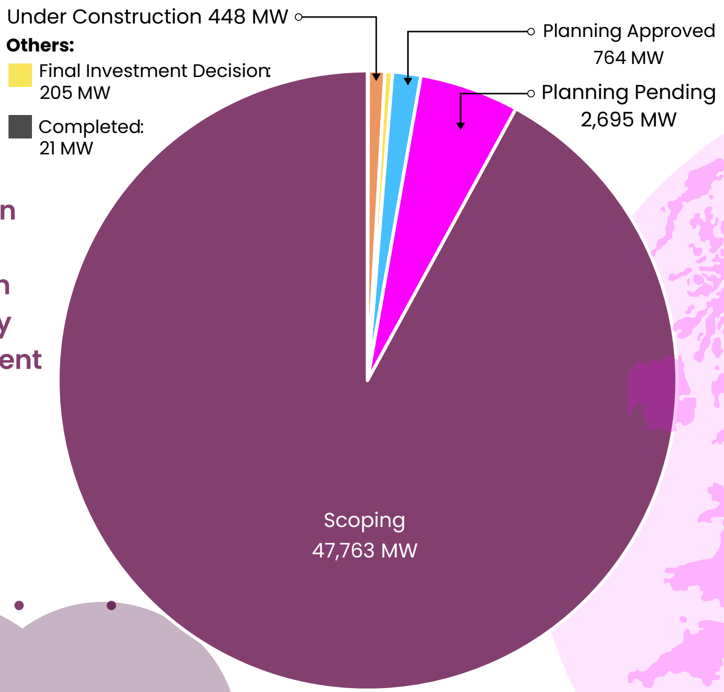
How we addressed feedback

Future supply needs of hydrogen out to 2050 have reduced across all pathways. A large part of this is because of reduced needs in shipping and aviation. We have utilised demand for these sectors from the Climate Change Committee's (CCC) recently published recommended Seventh Carbon Budget, where the assumption is that these fuels are largely produced abroad and imported.

What we modelled

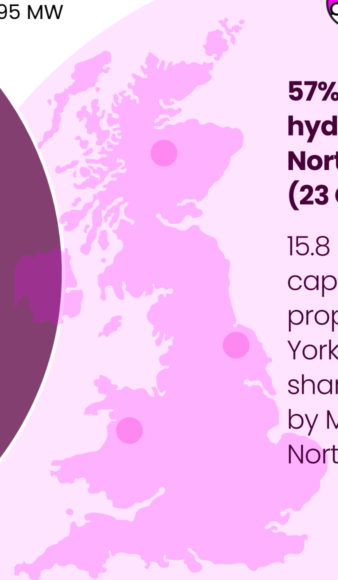
Table 37: A list of key inputs and outputs from our FES 2025 models covering supply from hydrogen.

Modelling assumptions	Holistic Transition	Electric Engagement	Hydrogen Evolution	10 Year Forecast	Falling Behind
Hydrogen supply in 2035	33 TWh HHV	15 TWh HHV	91 TWh HHV	19 TWh HHV	2 TWh HHV
Total hydrogen production capacity in 2050	22 GW	19 GW	58 GW	7.1 GW (in 2035)	4.8 GW
Imports and exports of hydrogen	Not modelled, due to significant amounts of uncertainty around available volumes, locations, and enabling infrastructure				



72. Low carbon hydrogen production projects by development stage

Source: NESO data as of June 2025



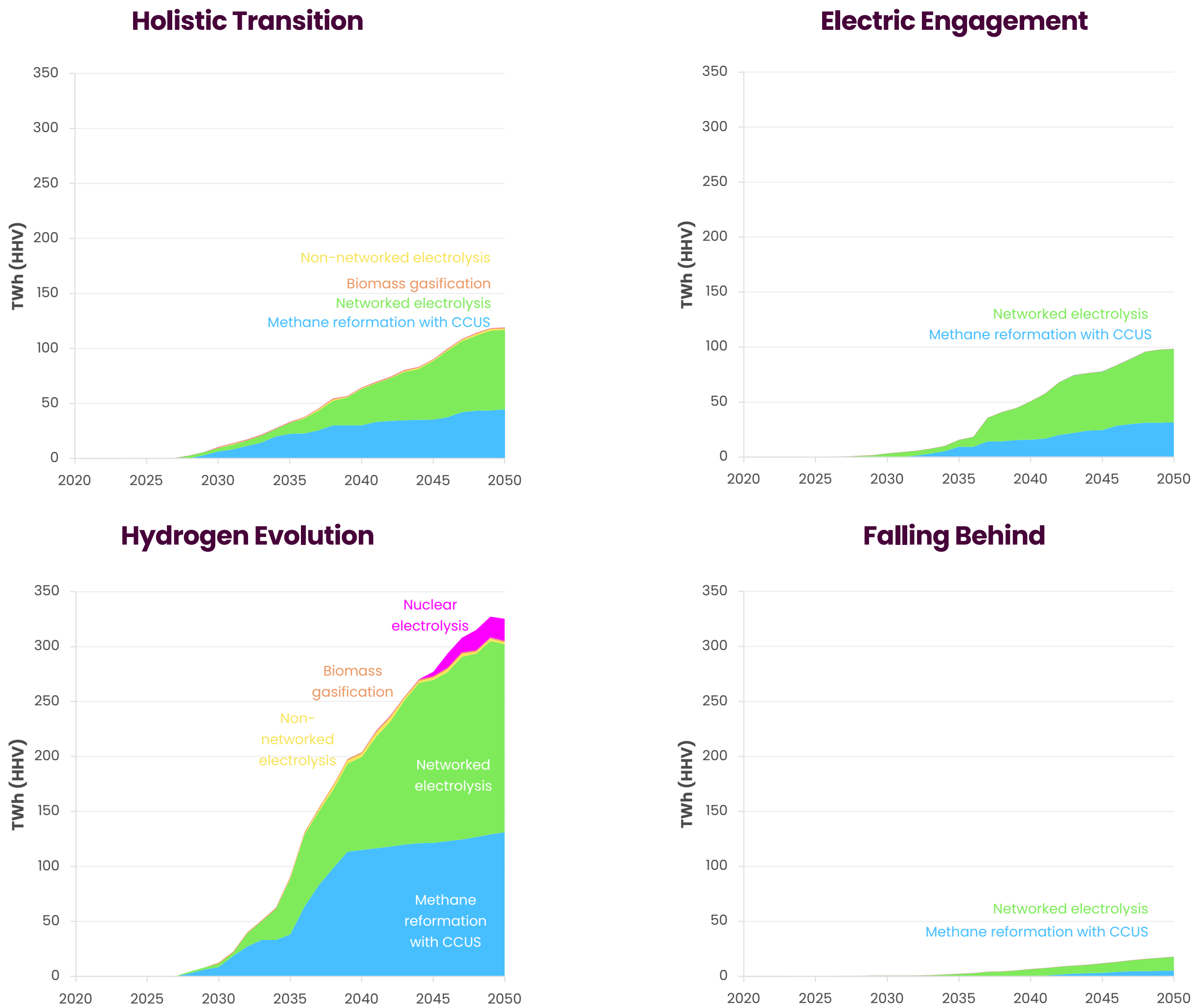
57% of proposed green hydrogen capacity is in Northern Scotland (23 GW out of 40.5 GW).

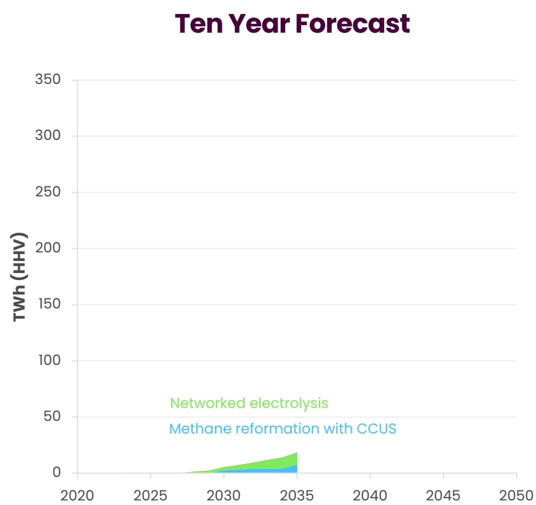
15.8 GW of blue hydrogen capacity has been proposed. Of this, Yorkshire has the highest share at 5.5 GW, followed by Merseyside and North Wales (2.6 GW).

Fuelling the System

Hydrogen | Hydrogen supply (cont.)

73. Hydrogen supply breakdown in each pathway, Ten Year Forecast and Falling Behind





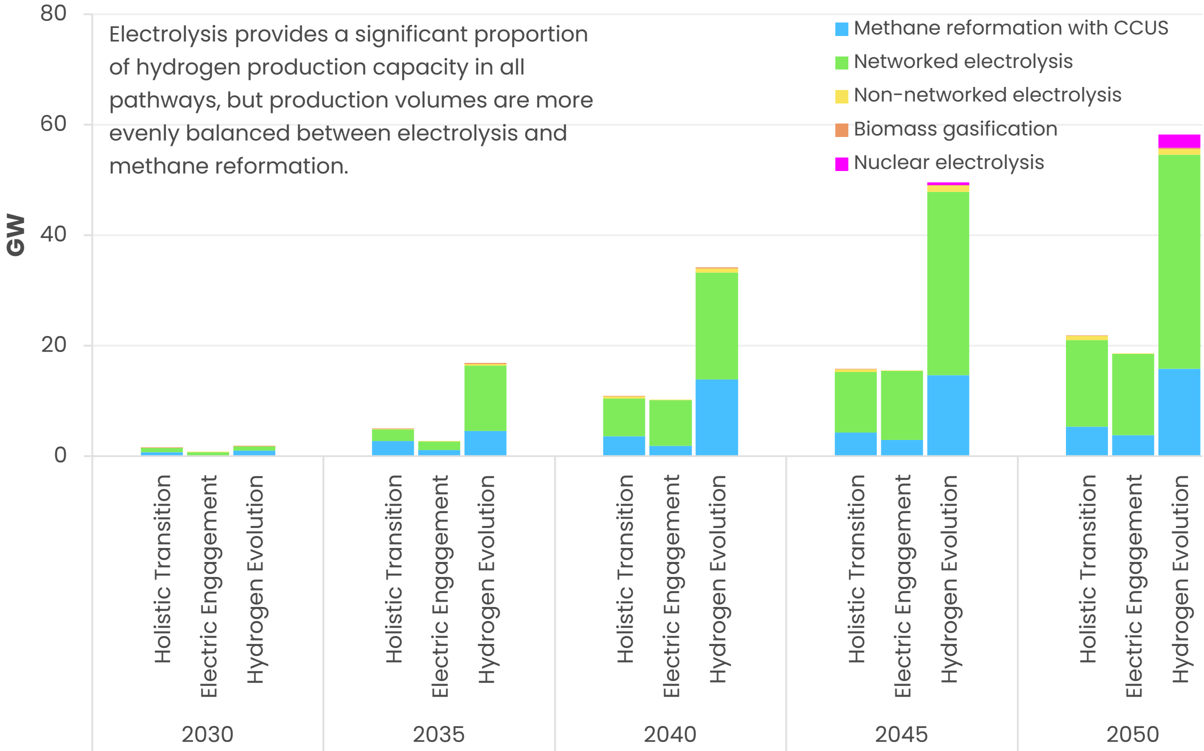
The largest low carbon hydrogen project current in construction is the NEOM project in Saudi Arabia, which will produce 600 tonnes per day of green hydrogen for ammonia production, when operational in 2026.

The project will have 2.2 GW of electrolysers power by 4 GW of renewable electricity from wind and solar.

Fuelling the System

Hydrogen | Hydrogen supply (cont.)

74. Hydrogen production capacity by pathway



Beyond the model

Whole system strategic planning can bring clarity to where, when, and how gaseous fuels will interact. Gas, biomethane and hydrogen will all be present until 2050. Users shouldn't be left unsure if there will be hydrogen available, or if they need to pursue alternatives. Strategic energy planning should clarify how these gaseous fuels will interact with each other and the wider energy system.

Support initial hydrogen production projects, focusing on cases where off-takers have few to no alternative options. Projects that succeeded under Hydrogen Allocation Round 1 (HAR 1) at the end of 2023 have not reached final investment decision, though such decisions may be forthcoming. The outcomes of HAR 2 are yet to be announced, but 27 projects have been shortlisted as of April 2025. Given the high cost of low carbon hydrogen production, support should be prioritised for users with little to no alternative to decarbonise. This may be due to factors such as hydrogen being essential to their process, or site configuration considerations that would limit other retrofit opportunities. The government have announced plans for HAR3 to run in 2026 and HAR4 to run in 2028[43].

Continued investment in research and development for the effective production, usage, transport and storage of hydrogen for use-cases where there are no alternative. The UK government has provided significant support into research and development for hydrogen production and utilisation, largely via the Net Zero Innovation Portfolio. Examples include the Industrial Fuel Switching programme, the Industrial Hydrogen Accelerator programme, and the Hydrogen BECCS Innovation programme. Low carbon hydrogen remains a relatively nascent sector with key future end users who have little alternative to hydrogen for decarbonisation.

43 *Clean Energy Industries Sector Plan*, Gov.uk, 23 June 2025

Fuelling the System

Hydrogen | Hydrogen storage and networks

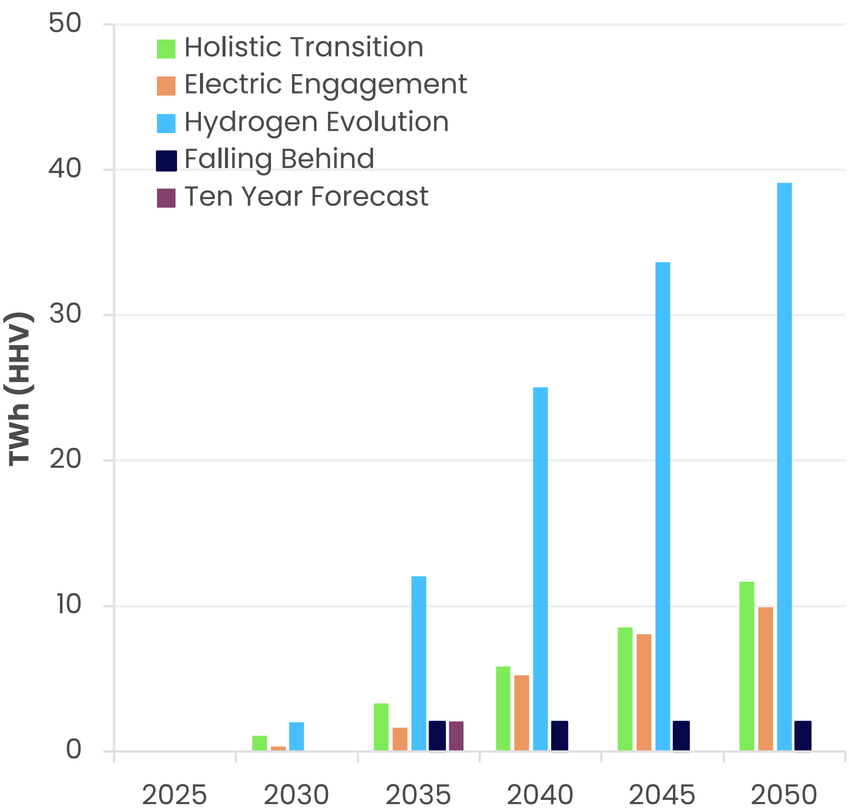
Overview

Hydrogen storage and networks will be essential for any widespread use of hydrogen, particularly for seasonal 'users' such as dispatchable power generation.

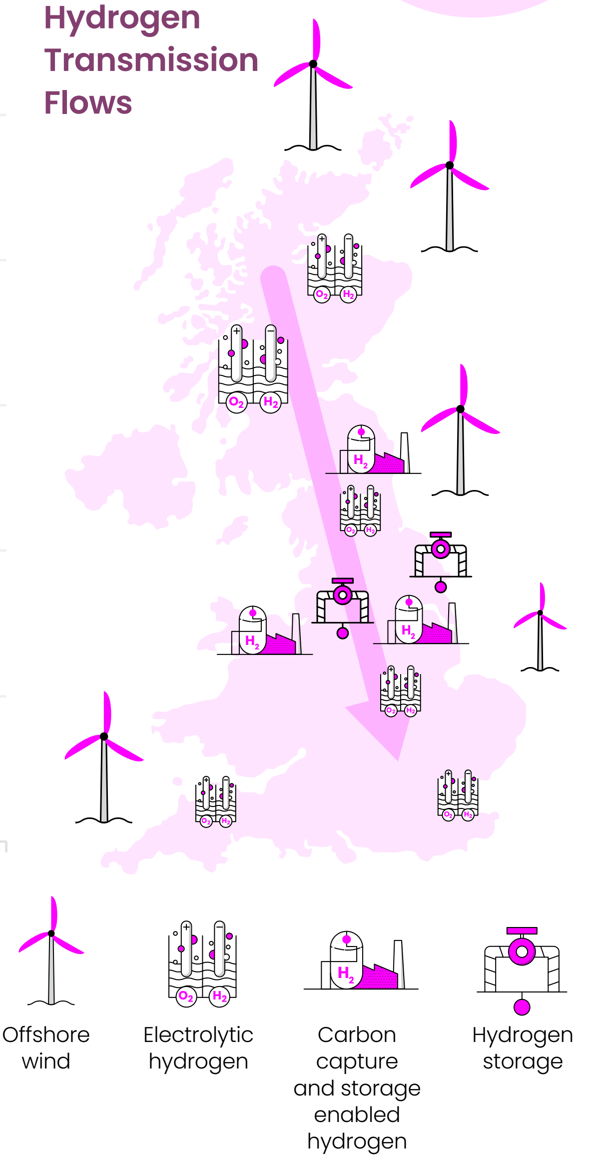
Initial hydrogen projects in the pathways largely colocate supply and demand. In the long term, the pathways show significant amounts of hydrogen produced using otherwise curtailed wind resource, largely in Scotland. This will necessitate a transmission network to move hydrogen to end users elsewhere. Large-scale hydrogen storage will be required to ensure security of supply through periods of low renewable generation. As an example of the scale of proposed hydrogen storage projects, the Keuper Gas Storage project in Chesire would offer the equivalent of 1.3 TWh of hydrogen storage and is currently in its front-end engineering design phase.

25 GWh of hydrogen salt cavern storage has been operational in Teesside since the 1970s.

75. Hydrogen storage capacity requirements



Hydrogen Transmission Flows



Fuelling the System

Hydrogen | Hydrogen storage and networks (cont.)

Stakeholder views

Stakeholders highlighted the high degree of uncertainty around hydrogen network infrastructure, both "where and when", as well as how it may function alongside the continued use of gas.

How we addressed feedback

We assume the development of a hydrogen transmission network at different points in time, alongside sufficient storage capacity to balance seasonal variations in hydrogen demand.

What we modelled

Table 38: A list of key inputs and outputs from our FES 2025 models covering hydrogen storage and networks.

Modelling assumptions	Holistic Transition	Electric Engagement	Hydrogen Evolution	10 Year Forecast	Falling Behind
Hydrogen networks	Transmission network necessary from 2035, plus industrial cluster networks. Additional availability of hydrogen for district heating schemes around industrial clusters.	Transmission network necessary from 2035, plus industrial cluster networks.	Transmission network necessary from 2032, plus expanding national availability of hydrogen for domestic heating.	Colocated hydrogen supply/demand projects and localised cluster networks only.	Colocated hydrogen supply/demand projects and localised cluster networks only.
Hydrogen storage capacity in 2035	3 TWh	2 TWh	12 TWh	2 TWh	2 TWh
Hydrogen storage capacity in 2050	12 TWh	10 TWh	39 TWh	N/A	2 TWh

Beyond the model

Clarify where and when a hydrogen transmission network will be available, while gas continues to be a key energy vector. Hydrogen suppliers and end users need to understand this to develop their decarbonisation plans. Equally, government direction on the usage of hydrogen for heating will clarify hydrogen demand and future needs for hydrogen network development. The governments planned consultation in 2026 on transitioning the gas system may also aid with this[44].

Developing a suitable pipeline of large-scale hydrogen storage facilities. Large-scale salt cavern storage projects can have lead times of 7–10 years from initiation to operation. A suitable pipeline of projects needs to be developed to ensure hydrogen security of supply in the future. The governments planned hydrogen transportation and storage allocation round 1 in 2026 can begin to develop this pipeline[45].

44 Midstream gas system: update to the market, Gov. uk, 30 June 2025
45 *Clean Energy Industries Sector Plan*, Gov.uk, 23 June 2025

Fuelling the System

Biomass | Biomass supply

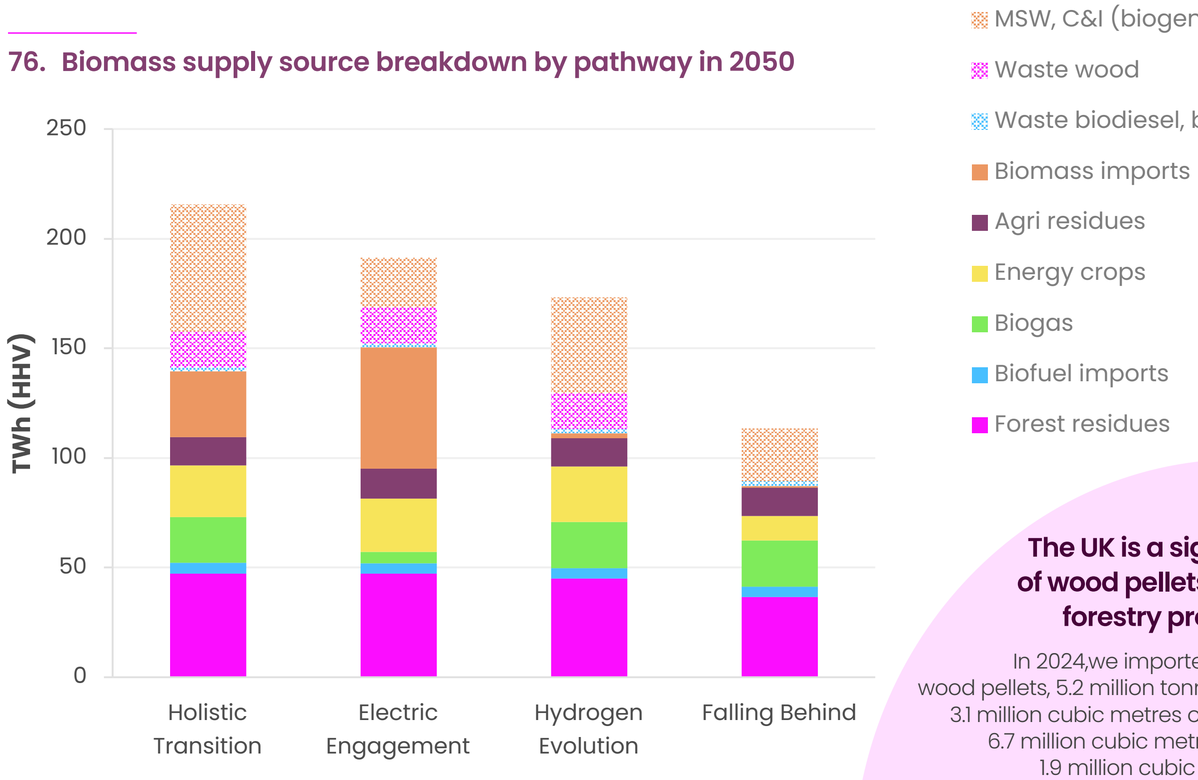
Overview

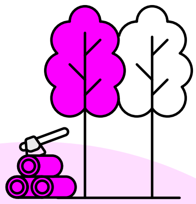
Biomass is currently a key part of Great Britain's renewable energy supply.

The overall supply and use of biomass in the pathways in 2050 remains broadly similar to levels of usage today; however, the types of biomass utilised and the technologies in which they are used will change significantly.

Currently, large amounts of biomass are used for power generation, heating and for liquid biofuels blended into road transport fuels. As we move towards net zero in the pathways, biomass is increasingly used to produce biomethane, for engineered carbon removals with BECCS and the production of sustainable aviation fuels (SAF).

76. Biomass supply source breakdown by pathway in 2050





The UK is a significant importer of wood pellets for power and of forestry products in general.

In 2024,we imported 9.3 million tonnes of wood pellets, 5.2 million tonnes of pulp and paper, 3.1 million cubic metres of wood-based panels, 6.7 million cubic metres of sawn wood, and 1.9 million cubic metres of other wood.

Forest Research 2024 Provisional Figures

Stakeholder views

Stakeholders emphasised the need to consider biomass sustainability. Other stakeholders highlighted the broad range of opportunities for biomass utilisation, such as biomethane production and sustainable aviation fuels.

How we addressed feedback

We don't currently model biomass supply, instead utilising published data from various external organisations (primarily by the CCC), but recognise the importance of biomass sustainability for ongoing use. The use of engineered carbon removals from biomass is seen as essential across all pathways to achieve net zero.

Fuelling the System

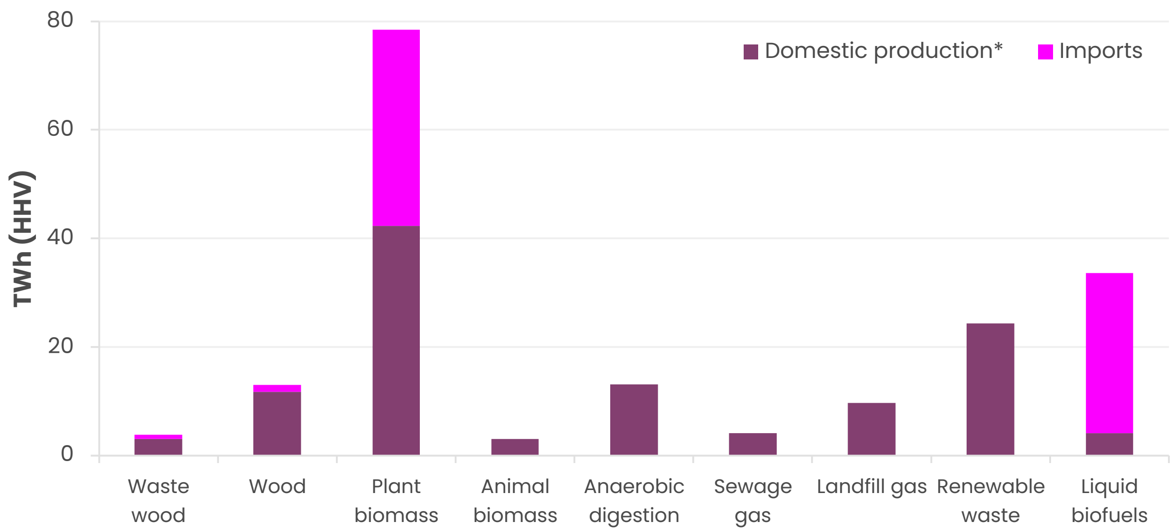
Biomass | Biomass supply (cont.)

What we modelled

Table 39: A list of key inputs and outputs from our FES 2025 models covering supply from biomass.

Modelling assumptions	Holistic Transition	Electric Engagement	Hydrogen Evolution	10 Year Forecast	Falling Behind
Biomass total supply in 2050	216 TWh HHV	191 TWh HHV	173 TWh HHV	N/A	114 TWh HHV
Biomass supply for power sector in 2050	73 TWh HHV	113 TWh HHV	37 TWh HHV	N/A	13 TWh HHV
Biomass import percentage in 2050	16%	31%	4%	N/A	5%

77. Breakdown of 2023 biomass supply by source and location



Beyond the model

Bring clarity to biomass supply sustainability. UK Government's *Biomass Strategy 2023* outlined their intention to consult and develop a cross-sector biomass sustainability framework. Such a framework is necessary to ensure the responsible use of biomass across all sectors.

Create a clear pathway to having the right kind of domestic feedstock, in the right location, at the right time. Our pathways use high levels of domestically grown feedstock, in particular energy crops (700,000 hectares by 2050), as per data from the CCC. At present, there are around 10,000 hectares of energy crops in Great Britain, an amount that hasn't changed in over a decade. Moreover, much of the underlying modelling for biomass feedstock potential in Great Britain, particularly energy crops, was performed by others and dates back to over 10 years ago. It is important to have a clear spatial pathway of where and when different domestic feedstocks will need to be planted to meet end user needs, without compromising the needs of other sectors (such as farming and timber) or other goals, such as those around biodiversity. Not all biomass users can utilise all types of biomass, a factor made more difficult when users must also consider where, when and how much feedstock is needed.

Appendix

Future Energy Scenarios and Strategic Energy Planning

The SSEP will plan across Great Britain and zonally map capacities of generation and storage of hydrogen and electricity infrastructure. It will establish a single generation and demand pathway to 2050, selected by the Secretary of State and co-optimised with high-level network needs. More information on the SSEP is available on our website.

The CSNP will plan the network in anticipation of the future customer connections that will be informed by the energy needs identified in the SSEP. Driven by the SSEP, it will plan the wider network strategically and in anticipation of future customers. The network design will also be tested against FES. This will stress-test the network design against a range of credible futures to provide confidence on the needs case of required reinforcements. FES will enable modelling of multiple long-term strategic energy pathways that will highlight what must happen across the energy vectors to enable net zero.

The RESPs will develop bottom-up regional plans at distribution level that span across all energy vectors. NESO will be producing RESPs across the 11 nations and regions defined by Ofgem. These are set out in Ofgem's RESP Framework Policy decision (April 2025). The RESP boundaries have been developed through consideration of cross-vector planning potential, sufficiency of scale, fullness of Great Britain's coverage and, critically, being deliverable at pace.

FES and SSEP

While FES complements the SSEP, providing additional data that is utilised by the programmes and ensuring a range of outcomes are considered in downstream network planning, the scope and inputs/assumptions of the pathways differ in some key areas in this first cycle:

	FES	SSEP
Electricity supply	✔	✔
Hydrogen supply	✔	✔
Gas supply	✔	✖
Bioenergy supply	✔	✖
Whole system emissions modelling	✔	✖
Single planning pathway	✖	✔
Fully cost optimised pathway(s)	✖	✔
FES sector demand projections	✔	✖
FES locational demand data	✔	✔
DESNZ demand projections	✖	✔
Environmental assessment	✖	✔
Geospatial assessment	✖	✔
Extensive cross-sector stakeholder engagement	✔	✔

FES is produced under the electricity system operator and the gas system planner licences held by NESO as issued by Ofgem in accordance with Ofgem's Future Energy Pathways Guidance document. The SSEP is commissioned by UK, Scottish and Welsh Governments and overseen by Ofgem.

A key difference between FES and SSEP is the demand data against which the electricity supply modelling is optimised. FES is based on NESO demand analysis built up by sector, while SSEP is commissioned to use DESNZ demand data. SSEP does, however, incorporate the locational demand splits produced by FES. NESO and DESNZ have worked closely to understand differences in demand projections.

While FES and SSEP use the same model for electricity capacity expansion, the SSEP will optimise the build-out of interconnectors and co-optimise the development of hydrogen and electricity.

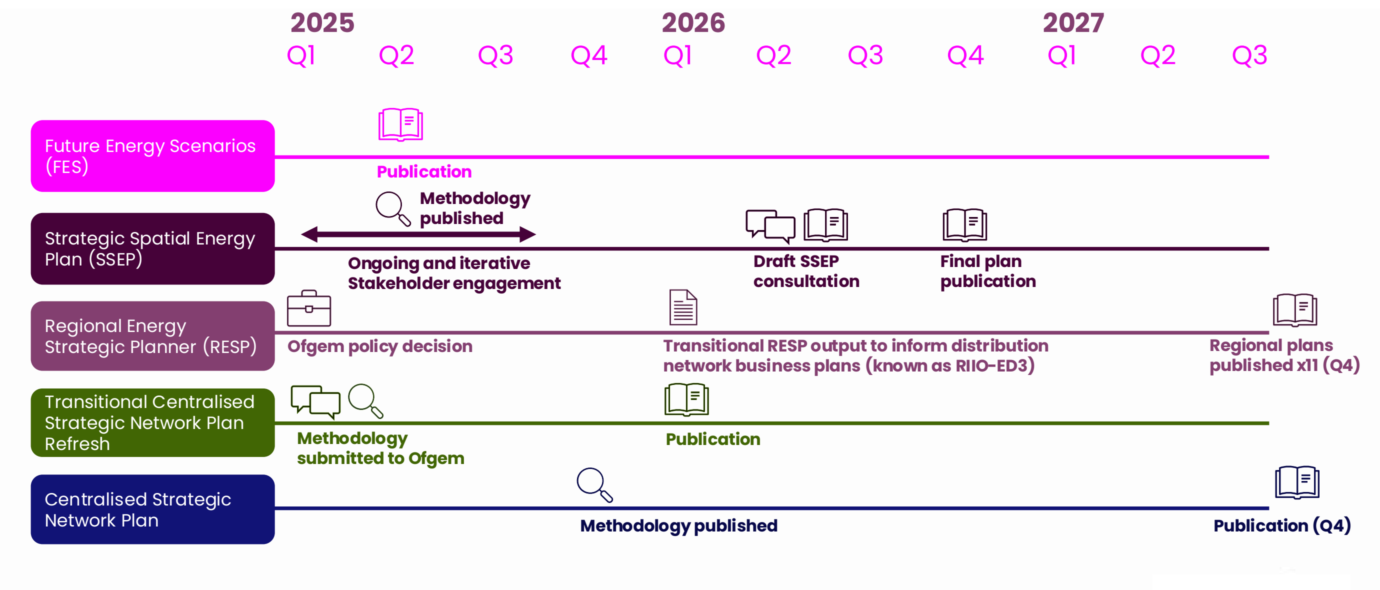
Weekly sessions between FES and SSEP teams have been held to run through modelling improvements or challenges, understanding differences and sharing of outputs as part of established challenge and review processes as set out in the FES methodology document. Both processes also have their own internal Steering Committees, which each include senior manager representation from the other team.

FES and RESP

FES provides regional breakdowns of national data through top-down analysis. These were intended to provide additional clarity for stakeholders on alignment of FES and Regional Distribution Future Energy Scenarios (DFES) produced by Distribution Network Operators. They are not intended to be used for the creation of regional pathways.

The first RESPs are expected to be published in late 2027. However, to support the upcoming electricity distribution price control (ED3), a transitional RESP output will be consulted on in September 2025 and published in January 2026. The tRESP output will include regional conditions and priorities, identified areas of strategic need, modelled short-term and long-term pathways and consistent planning assumptions. The baseline for the tRESP pathways outputs is a new bottom-up disaggregation of FES 2025 at a very local level which is then reaggregated to Grid Supply Point (GSP) feeding area.

Milestones

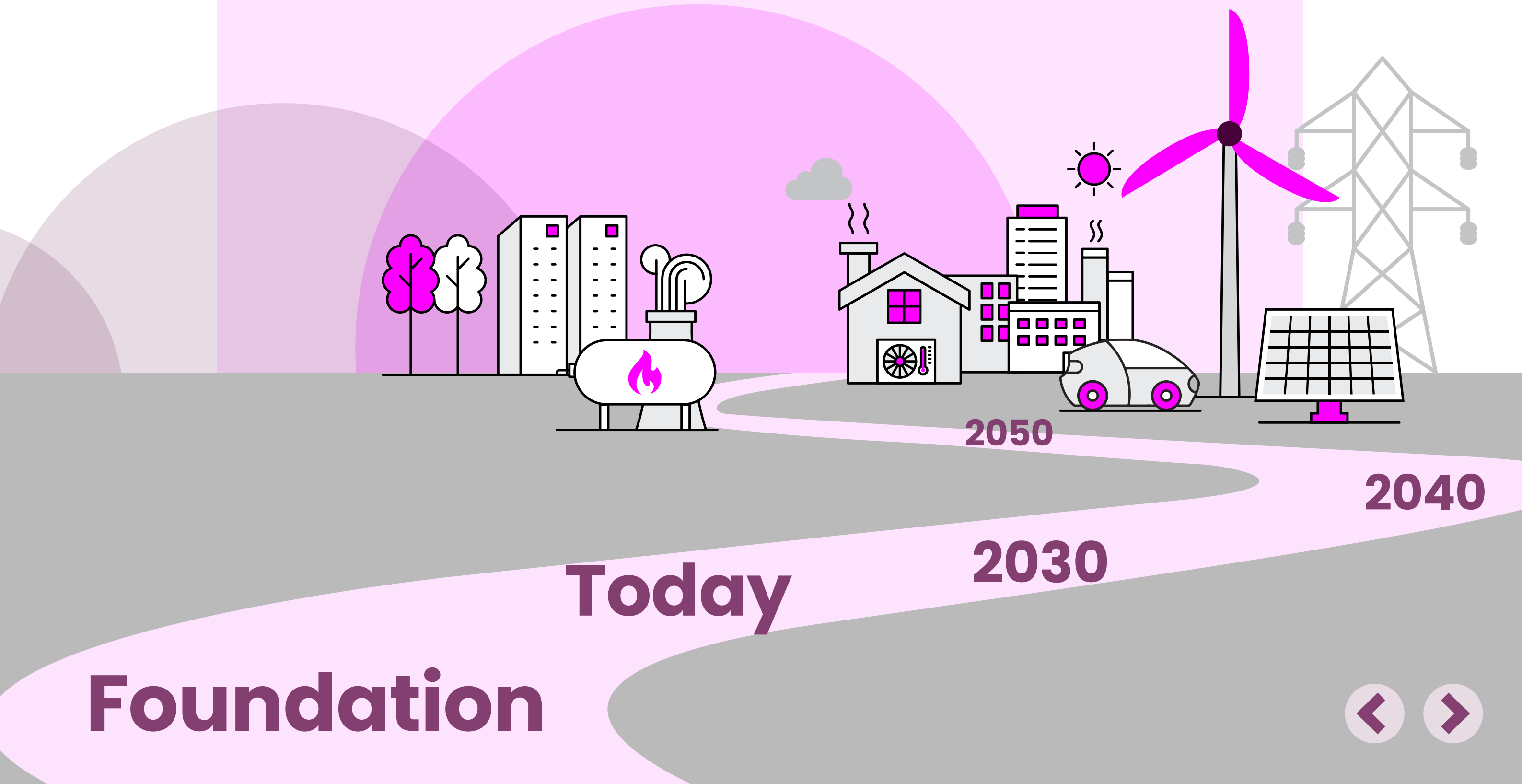


*dates subject to change; not all methodologies may be public

The future of FES

Once the SSEP and the RESPs are in place, the role of the FES will continue to ensure that NESO maintains an independent view on the range of options, trade-offs, risks and opportunities that exist for the future of energy, and their implications across the whole energy system. There are numerous downstream processes, including those relating to gas security of supply and the Electricity Capacity Report, which will continue to rely on our pathways and forecasts.

It is our intention that the inputs to FES 2028 will broaden to include learnings from, and elements of, SSEP and RESP, such that we can continue to iterate across the programmes over the three-year cycle and continuously improve the assumptions that underlie FES and the value this can add to the sector and, ultimately, consumers.



Glossary

Acronym	Description
10YF	Ten Year Forecast
ACS	Average cold spell
ASHP	Air source heat pump
BCM	Billions cubic metres
BECCS	Bioenergy with carbon capture and storage
BUS	Boiler Upgrade Scheme
CBAM	Carbon Border Adjustment Mechanism
CCC	Climate Change Committee
CCS	Carbon capture and storage
CEM	Capacity Expansion Model
CfD	Contracts for Difference
CH_4	Methane
CM	Capacity Market
CO_2	Carbon Dioxide
CSNP	Centralised Strategic Network Plan
DACCS	Direct air carbon capture and storage
DESNZ	Department for Energy Security and Net Zero
DPA	Dispatchable Power Agreements
DSR	Demand side response
ETS	Emissions Trading Scheme
EV	Electric Vehicle
FES	Future Energy Scenarios
FID	Final investment decision
GB	Great Britain
GW	Gigawatt
GISP	Gas Insulated Switchgear Project
GSHP	Ground source heat pump
GSP	Grid supply point
GWh	Gigawatt-hour
GVA	Gross added value
H2P	Hydrogen to power
HAR	Hydrogen Allocation Round
HGV	Heavy goods vehicle
I&C	Industrial and commercial
ICE	Internal combustion engine

Acronym	Description
LNG	Liquefied natural gas
LDES	Long-duration energy storage
LULUCF	Land use, land-use change and forestry
MHHS	Market-wide Half-Hourly Settlement
$MtCO_2e$	Metric tonnes of carbon dioxide equivalent
MW	Megawatt
NESO	National Energy System Operator
NZIP	Net Zero Innovation Portfolio
NDC	Nationally Determined Contribution
NTS	National Transmission Network
Ofgem	Office of Gas and Electricity Markets
ONS	Office for National Statistics
PHEVs	Plug-in hybrid electric vehicle
PV	Photovoltaic
RESP	Regional Energy Strategic Planner
SAF	Sustainable aviation fuel
SCOP	Seasonal coefficient of performance
SMR	Small Modular Reactor
SoS	Security of Supply
SSEP	Strategic Spatial Energy Plan
tCO_2/yr	Tonnes of carbon dioxide per year
TWh	Terawatt hour
TWh HHV	Terawatt-hour Higher Heating Value
UNFCCC	United Nations Framework Convention on Climate Change
UK	United Kingdom of Great Britain and Northern Ireland
UKCS	UK Continental Shelf
V2G	Vehicle-to-grid
V2H	Vehicle-to-home
ZEV	Zero Emission Vehicle

Legal Statement

Under its electricity system operator licence, National Energy System Operator Limited (NESO) is the system operator of the national electricity transmission system. NESO also holds a gas system planner licence.

For the purpose of this document, the terms "NESO", "we", "our", "us" etc. are used to refer to National Energy System Operator Limited (company number 11014226).

NESO has prepared this document pursuant to its statutory duties and its electricity system operator licence in good faith, and has endeavoured to prepare this document in a manner which is, as far as reasonably possible, objective, using information collected and compiled from users of the gas and electricity transmission systems in Great Britain together with its own analysis of the future development of those systems.

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