Meeting the challenge of a Net Zero energy future

UK Power Networks
Delivering your electricity

Distribution Future Energy Scenarios 2023

Executive summary

Welcome to the summary document for our latest Distribution Future Energy Scenarios (DFES), intended to give an overview of what the DFES are, why they are important, and some of the key findings from our modelling.

This is only the fourth iteration of the DFES, and already so much has changed in the energy landscape since our first publication in 2020. We have seen the UK adopt a 2050 Net Zero target, the release of multiple policy documents including the Net Zero strategy, and the UK reach the milestone of over one million electric vehicles (EVs) on the road.

This rapidly changing energy environment means we have to continually refresh our assumptions and understanding of the energy system to ensure we make network capacity available at the right place and the right time. In this latest edition of the DFES we have revised our assumptions on supply chain availability, updated information on a number of government grants, and reflected the commitments in the British Energy Security Strategy.

The recent energy crisis, caused by soaring wholesale prices of gas and oil, has sharpened the need to move to a Net Zero economy. As a Distribution Network Operator (DNO) it is crucial that we ensure our network is up to the job of facilitating Net Zero at the lowest cost to our customers. Part of this role is benefitted by having up-to-date and accurate forecasts of where future electrical demand may materialise on our network, and the DFES contributes to this.

There are two key initiatives that we included in our recent business plan, covering the period between 2023 and 2028, that we believe will help us to facilitate Net Zero in a cost-effective manner. These are our commitment to create the UK's first independent Distribution System Operator (DSO), and our Local Area Energy Planning team.

11,000
areas with bespoke forecasts included in our DFES

The DSO will make decisions, independent from the DNO, on the most cost-effective way of expanding the capacity of the network. The benefit of this cannot be understated, our analysis shows that the DSO will deliver wider system savings of between £780 million and £2.6 billion by 2040 across our region, all while enabling unprecedented LCT growth.

Meanwhile, our Local Area Energy Planning team will be responsible for developing collaborative relationships with regional governmental bodies, such as Local Authorities, County Councils, and London Boroughs. Energy Systems Catapult estimate that a Net Zero approach that is locally planned and coordinated with electricity networks could save £252 billion between 2025 and 2050. Our Local Area Energy Planning team will work with local government to support them in creating well justified energy plans, ensuring that we can facilitate local decarbonisation while saving money for our customers.

Informed by our market intelligence and annual regional engagements, the DFES underpins all these functions, giving us an idea of when, where, and how many LCTs will be connecting to our network under a range of assumptions. We believe the DFES represents a useful resource, not just to ourselves but to external users as well. This is why we make it available on our **Open Data Portal**. We are always looking to improve, however, so if you have any suggestions, please get in touch by emailing **DFES@ukpowernetworks.co.uk.**

Suleman Alli
Director of Strategy and Customer Service

In this report

Why we're developing the DFES

As the UK heads towards a Net Zero economy, different areas will do so at different speeds and using different technologies. The best solution for densely populated urban areas is unlikely to be the same as for sparsely populated rural areas.

As different areas decarbonise at different rates, clusters of LCTs will emerge. This can present a significant challenge for our network. For example, a single ultra-rapid charge point can require as much electrical demand as 175 homes. Our DSO function will assess the most efficient route to providing capacity for these technologies to connect, whether it be building more assets, or procuring flexibility. However, both these options take time, which is why it is crucial we know as far in advance as possible where LCT clusters will emerge. Engagement through our Local Area Energy Planning team is one way we do this, and geographically bespoke forecasting through our DFES is another.

This is the fourth year we have produced the DFES, which we refresh on an annual basis to ensure our forecasts are as accurate as possible and remain fit for purpose. Some of the changes we've made this year include increasing raw material costs and supply constraints, updating our electric vehicle consumer choice model with updates to the plug-in car grant, and updating our assumptions on the boiler upgrade scheme for our heat model.

Whilst we use the DFES for a number of internal purposes, we recognise the value to external parties, such as local government and stakeholders, of having geographically specific forecasts of key low-carbon technologies. This is why we have developed a suite of resources as part of the DFES to ensure it is both useful and accessible. This includes:

A technical report, detailing the modelling process and conducting in depth analysis into the results;

Excel forecasts, the main DFES output, detailing the how many, by when, and where, for a number of low-carbon technology drivers;

An interactive mapping tool, a visualisation allowing users to see the forecasts projected onto our licence area at a range of different levels of spatial disaggregation;

This summary document, giving an overview of the DFES, the modelling, and the scenarios.

81
individual organisations engaged with ahead of this year's DFES publication

What are the DFES?

The DFES is primarily a series of granular forecasts of key drivers whose deployment are essential to achieving Net Zero. This includes EVs, decarbonised heating such as heat pumps and district heat networks, and forms of renewable energy generation and storage.

For each driver, a range of forecasts are produced under different assumptions, for example; a 'high' EV scenario where charge points are abundant, battery prices continue to fall, and sales of new conventional vehicles are banned from 2030. Once the range of forecasts are completed for all drivers, they are collected into overarching scenario worlds. These help to contextualise the forecasts and give an indication of what the decarbonisation trajectory could look like under different scenarios. For example, our 'Consumer Transformation' scenario describes a world where EV uptake is high, electric heat pumps and district heat networks are used to decarbonise heating, and consumers engage with the energy system and are willing to participate in market mechanisms such as smart charging, to save themselves money and reduce the strain on the energy system.

It is important for us to model different scenarios due to the high degree of uncertainty regarding the path the UK will tread towards Net Zero, especially surrounding the decarbonisation of heat and buildings. We must ensure we are prepared for the future by understanding the potential impact of different situations regarding policy and economics.

What drivers are we modelling?

In our analysis we identified 62 individual key drivers that we believe are crucial in enabling the transition to Net Zero. These include electrical demand technologies such as battery electric vehicles, and electric heat pumps; generation technologies such as solar photovoltaic, and 'soft' factors such as consumer engagement with smart charging and domestic energy efficiency improvements. Taken together, we believe the DFES provides a holistic picture of various decarbonisation pathways, enabling us as a network operator to ensure our assets are prepared for the future.

62
individual drivers modelled year-by-year to 2050

We modelled drivers belonging to six unique groups that effect our network, these were:

Core Demand
- Building energy efficiency
- Domestic building stock growth
- Industrial and Commercial (I&C) building stock growth

Low-carbon Transport
- Electric vehicles (cars and vans)
- Electric vehicles (buses, coaches, and heavy good vehicles)

Battery Storage
- Domestic battery storage
- I&C behind-the-meter battery storage
- Grid scale battery storage

Decarbonised Heating
- Low-carbon heating technologies
- District heating

Distributed Generation
- Solar photovoltaic (PV)
- Onshore wind

Flexibility
- Electric vehicle smart charging
- Demand Side Response (DSR)

Our licence area and DFES data

We are the UK's biggest electricity distributor, ensuring that the electricity infrastructure is in place to deliver power to 8.4 million homes and business, keep the lights on across 29,250 square kilometres, and support and serve 19 million people across the London, the East of England, and the South East of England.

Our region is broken into three major regions, called licence areas:

Eastern Power Networks (EPN);

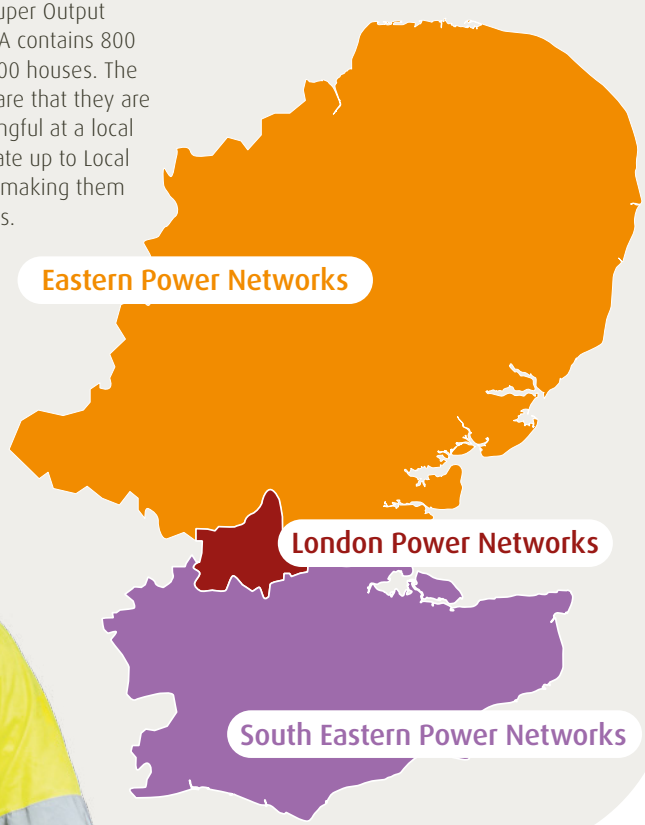
London Power Networks (LPN); and

South Eastern Power Networks (SPN).

Through engagement with our stakeholders, we decided to resolve our DFES forecasts to as granular a level as possible, allowing stakeholders to understand what the decarbonisation pathway under different sets of assumptions could mean for their local area.

To breakdown the scenarios into these smaller geographical regions we used Office for National Statistics areas called Middle Layer Super Output Areas (MSOAs); and Lower Layer Super Output Areas (LSOAs). On average, an LSOA contains 800 houses, and an MSOA contains 4,000 houses. The benefits of this level of resolution are that they are both granular enough to be meaningful at a local level, and they are easy to aggregate up to Local Authority or County Council level - making them useful to local governmental bodies.

Our region is made up of about 2,200 MSOAs which in turn are made up of around 11,000 LSOAs. Where possible we have published all our DFES outputs at LSOA level on our **Open Data Portal**.



Eastern Power Networks

We deliver power to the East of England region which extends from the Wash in the east, to North London and the Thames estuary, encompassing a diverse range of urban and rural areas as well as a huge coastline.

London Power Networks

We look after the electricity network for Inner London, with responsibility for delivering power to iconic buildings and businesses as well as high-profile international events throughout the year.

South Eastern Power Networks

We serve South London, Kent, East Sussex and parts of Surrey and West Sussex, covering a rich variety of customers and locations.

How stakeholders have informed our DFES

Since 2020, we have been running annual regional engagement sessions covering 127 local authorities to discuss our future energy scenarios, understand their local climate ambitions, and to gather feedback on a number of regionally-focused initiatives.

In the first year of regional engagement, one of the key outcomes was that we co-developed an interactive tool to make it easier for our regional stakeholders to access our DFES forecasts, and last year we obtained endorsements from 13 regional planning authorities (representing 93% of our total population) on our local area energy planning framework.

This year we held 13 sessions and we focused on collecting feedback for our new Local Area Energy Planning team, including market testing our ideas on supporting Local Authorities to deliver their Net Zero plans. We had representation from a broad range of organisations, including:

- Four Community Energy groups
- Three Local Enterprise Partnerships
- Greater South East Net Zero hub
- 60 Local Authorities
- 11 County Councils

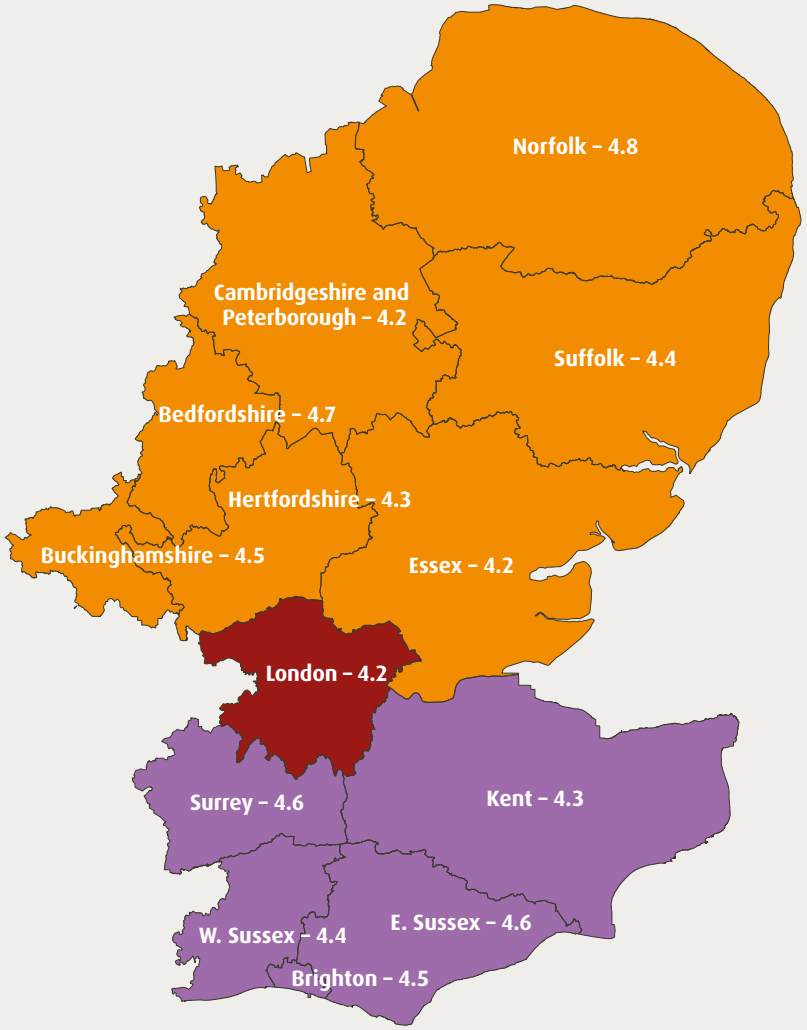
Overall, this represents coverage from all County Councils, and over 55% of Local Authorities, this is a significant improvement from our first year of engagement when we had coverage from 23% of eligible local authorities.

We believe these sessions are invaluable in allowing us to explain our plans for the future to local authorities, and for us to better understand how we can provide support to local authorities looking to decarbonise their areas. This year, we had an average satisfaction score of 4.4 out of 5, with many local authorities giving us good feedback on how to improve these sessions further.

"I think we have a really positive relationship with UKPN, I really like the way you go about your regional engagement and I've found this [regional engagement session] really informative and helpful, so thank you very much"

David Johnson
Buckinghamshire Climate Change Lead.

Our satisfaction scores by engagement region



Average satisfaction rating scored out of five.

Our scenario worlds

We adopted the scenario framework published by National Grid Electricity System Operator (ESO) in their latest Future Energy Scenarios as well as that used by the other UK DNOs in their DFES. This framework includes four potential energy pathways to 2050, three of which reach Net Zero emissions by 2050 at the latest.

These pathways represent different positions with regards to their speed of decarbonisation and level of societal change. A notable update from the latest Future Energy Scenarios is the renaming of the least ambitious scenario, formerly 'Steady Progression', to 'Falling Short' reemphasising how the scenario does not achieve the UK target for Net Zero by 2050. The general scenario narrative for Falling Short has remained unchanged.

We developed bespoke scenarios for each driver of demand and generation and constructed four overarching scenario worlds that align with the narratives of the pathways from National Grid. By developing our own uptake scenarios with local knowledge, we are able to more accurately reflect UK Power Networks' region, the customers within this region and the current deployment of low-carbon technologies.

The four scenario worlds are structured as follows:

Falling Short

General progress is made towards decarbonisation; however, this is the only scenario world that does not meet Net Zero by 2050.

Consumer Transformation

The 2050 Net Zero target is met by a high degree of societal change as well as deep electrification of transport and heat.

System Transformation

The 2050 Net Zero target is met by relying on hydrogen to decarbonise the more difficult sectors of heat and heavy transport.

Leading the Way

This is the fastest of the scenario worlds to achieve Net Zero, with the highest level of societal change, utilising both hydrogen and electric low-carbon technologies.

Falling Short

The Falling Short world sees the least amount of societal change and has the slowest speed of decarbonisation. In all sectors, from transport to energy efficiency, decarbonisation is not the priority and while some areas see meaningful improvements there is no holistic strategy. This results in progress made towards Net Zero, but ultimately the target is not reached by 2050.

There is considerable uptake of EVs and by 2050 it is the most popular choice of passenger vehicle; however, a lack of widespread access to public charging infrastructure means that some consumers continue to rely on internal combustion engine (ICE) vehicles instead. This is made possible as no policies are put in place to remove ICE or plug-in hybrid electric (PHEV) vehicles from the vehicle stock. A lack of viable options for Heavy Duty Vehicles (HDV) means that decarbonisation of large road vehicles is much slower.

Does not meet Net Zero

Business-as-usual

Natural gas for heating

2027/28

2,500,000

Number of electric cars and vans

830% increase on 2021/22

Key assumptions

Energy efficiency
Low Medium High

Electric vehicles (cars and vans)
Low Medium High

Number of heat pumps
Low Medium High

District heat uptake
Low Medium High

Small scale solar PV
Low Medium High

Large scale solar PV
Low Medium High

Onshore wind
Low Medium High

Domestic battery storage
Low Medium High

Grid-level battery uptake
Low Medium High

EV smart charging
Low Medium High

Falling Short continued

Net Zero by 2050

Hydrogen gas grid

Electric cars and vans in 2027/28
2.5 million

Homes with solar panels in 2027/28
185,000

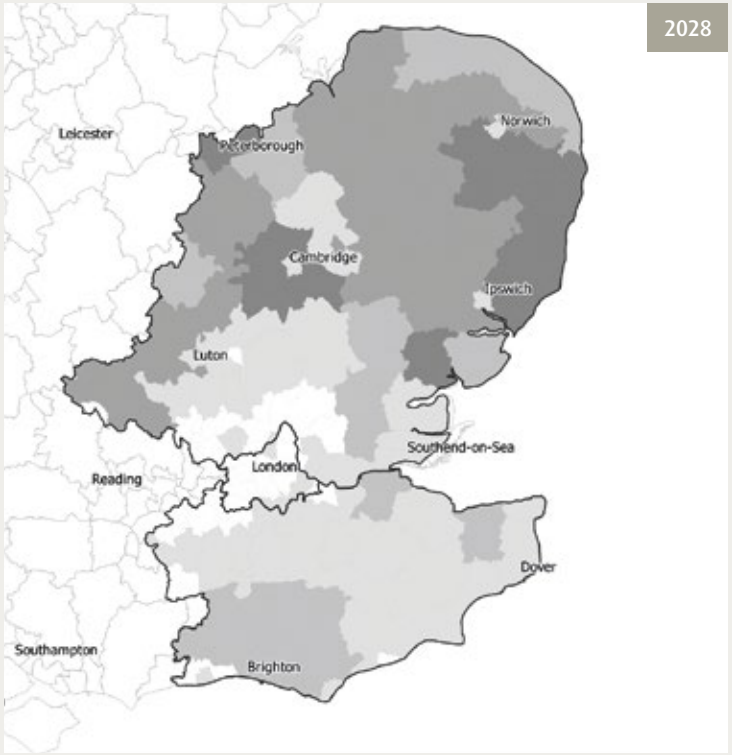
Grid scale battery capacity in 2027/28
1.4GW

Heat pumps in 2027/28
183,000

Natural gas continues to be the primary heating fuel and the uptake of heat pumps is limited despite the phase out of oil and other fossil fuel boilers in off-gas properties. This is the only policy put in place to remove fossil fuel heating sources, and there is no extension to existing subsidies designed to encourage the purchase of low-carbon heating units. As a result, this scenario sees low uptake of heat pumps and decarbonised district heat networks. Some biogas is introduced into the gas grid, but not in any significant capacity.

There is a slight increase in the renewable generation capacity of the UK, with increases primarily seen in both small and large-scale solar photovoltaic installations. However, this scenario continues to rely on electricity generated from natural gas out to 2050. There is limited appetite from the public to participate in the energy market via smart mechanisms such as demand side response and time-of-use tariffs.

Domestic solar PV capacity per local authority



Consumer Transformation

The Consumer Transformation world sees the UK reach Net Zero by 2050, thanks to widespread electrification, the decarbonisation of the electricity supply, and consumers willing to modify their behaviour and engage with new, smart technologies. This scenario sees a great deal of societal change, and many of the decarbonisation efforts are aided by increased flexibility in the energy system, such as high uptake of EV smart charging.

This scenario world sees a widespread uptake of EVs, especially cars and vans. Consumers are passionate about Net Zero in general, and for decarbonised transport this enthusiasm is supported by a ban on new ICE vehicles by 2030 and a widely available charging network. The decarbonisation of larger vehicles is slower, but by the mid 2030's there is a wide range of zero emission HDVs available, and a nationwide refuelling network completed by 2045. Electrification will be the main decarbonisation option for HDVs, with green hydrogen being deployed for a limited number of use cases.

Electrically powered

Engaged consumers

Net Zero by 2050

2027/28

840MW

Domestic solar PV capacity

75% increase on 2021/22

Key assumptions

Energy efficiency

Low — Medium — High

Electric vehicles (cars and vans)

Low — Medium — High

Number of heat pumps

Low — Medium — High

District heat uptake

Low — Medium — High

Small scale solar PV

Low — Medium — High

Large scale solar PV

Low — Medium — High

Onshore wind

Low — Medium — High

Domestic battery storage

Low — Medium — High

Grid-level battery uptake

Low — Medium — High

EV smart charging

Low — Medium — High

Consumer Transformation continued

Net Zero by 2050 ✓

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Hydrogen gas grid ✗

↓

Electric cars and vans in 2027/28
3.0 million

↓

Homes with solar panels in 2027/28
281,000

↓

Grid scale battery capacity in 2027/28
3.4GW

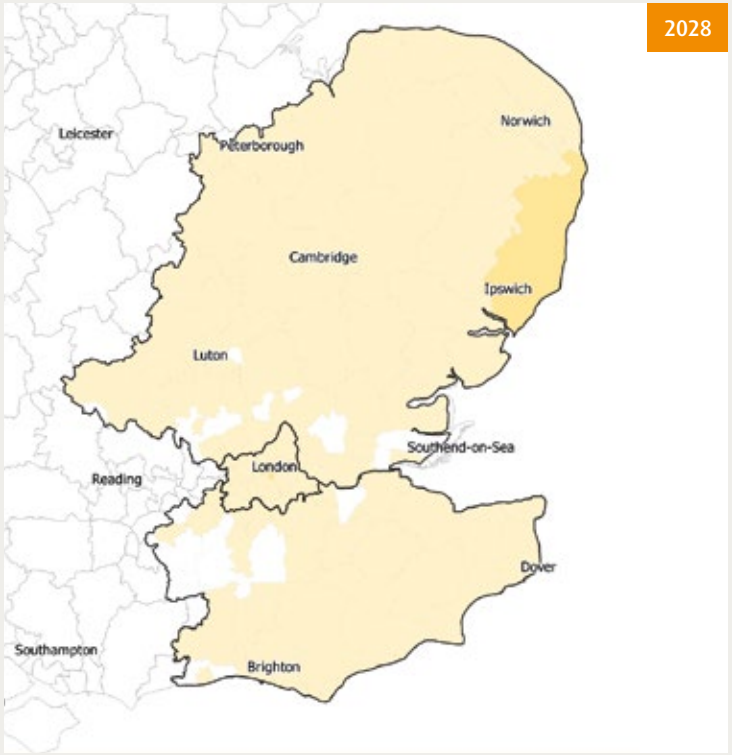
↓

Heat pumps in 2027/28
436,000

The Government decides that the electrification of heat is the best way to decarbonise the sector. New build homes cannot install gas boilers from 2025 onwards, and sales of new gas boilers are banned outright by 2035. There is a nationwide programme of energy efficiency improvements to all buildings, reducing the amount of electricity needed to heat people's homes. Various subsidies designed to make heat pumps more affordable are put in place and existing subsidies see their scope extended and are kept in operation until the late 2020s. This scenario also sees high uptake of properties connecting to district heat networks. In most cases the heat for these heat networks is generated from either electric heat pumps or waste heat.

With both heat and transport becoming electrified, there is a requirement for much more electricity in the grid. This increase in demand is met predominantly through solar and wind installations, which become ever more affordable as their industries grow. As the amount of renewable generation grows, so does the amount of both grid scale and domestic battery storage.

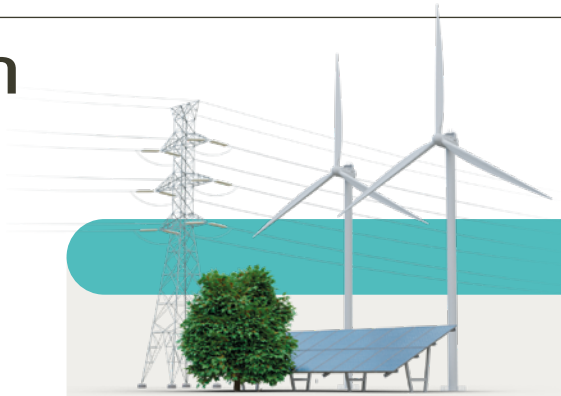
Number of domestic heat pumps per local authority



System Transformation

In a System Transformation world, the UK reaches its Net Zero target in 2050 by relying on hydrogen to decarbonise the more difficult sectors of heat and heavy transport. While engagement from consumers is not as high as other scenarios, centralised and effective decarbonisation solutions mean that consumers do not have to do as much individually for their lifestyle to be decarbonised.

As battery prices continue to fall, EVs reach price parity with ICE vehicles sooner than previously expected and high demand for EVs is seen from the early 2020s. As with Consumer Transformation, a ban on new ICE vehicles by 2030 is introduced and there is sufficient charging infrastructure to meet this demand. Global production of hydrogen fuel cells ramps up, which enables large scale supply of zero emission HDVs, including buses, coaches and heavy goods vehicles, to be available from mid-2030s.



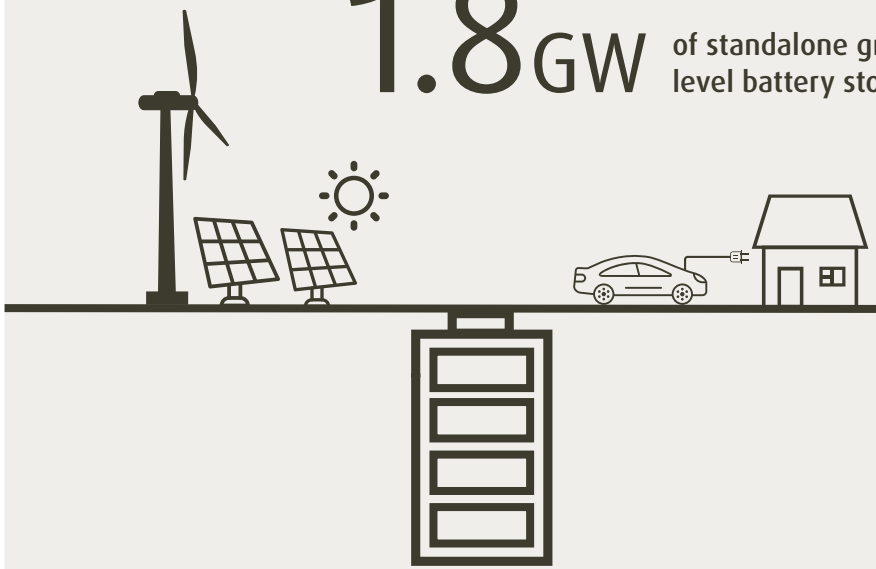
Hydrogen heating

Centralised solutions

Net Zero by 2050

2027/28

1.8GW of standalone grid-level battery storage



350% increase on 2021/22

Key assumptions

Energy efficiency
Low — Medium — High

Electric vehicles (cars and vans)
Low — Medium — High

Number of heat pumps
Low — Medium — High

District heat uptake
Low — Medium — High

Small scale solar PV
Low — Medium — High

Large scale solar PV
Low — Medium — High

Onshore wind
Low — Medium — High

Domestic battery storage
Low — Medium — High

Grid-level battery uptake
Low — Medium — High

EV smart charging
Low — Medium — High

System Transformation continued

Net Zero by 2050 ✓

↓

Hydrogen gas grid ✓

↓

Electric cars and vans in 2027/28
3.0 million

↓

Homes with solar panels in 2027/28
216,000

↓

Grid scale battery capacity in 2027/28
1.8GW

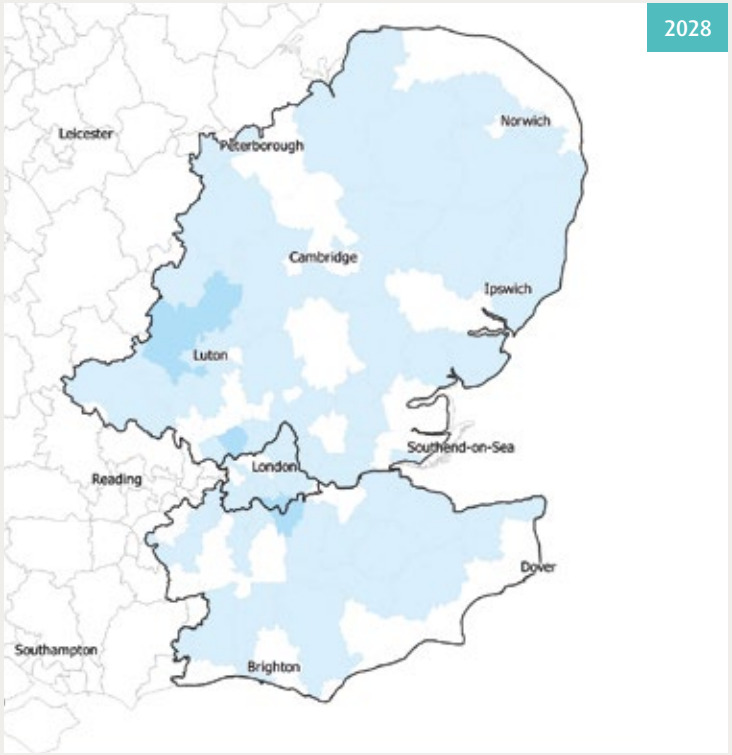
↓

Heat pumps in 2027/28
283,000

The Government has chosen to decarbonise heat in existing buildings by repurposing the natural gas grid to distribute low-carbon hydrogen and installing electric heat pumps in new builds. By 2040 the gas grid is fully transitioned to accept hydrogen and other low carbon gases, and by 2050 hydrogen ready boilers are found in the majority of domestic buildings. There is also a fair uptake of properties connecting to district heat networks, which are predominantly supplied by hydrogen and waste heat. Of all the Net Zero scenarios, System Transformation sees the lowest uptake of thermal efficiency measures.

As heat and heavy transport is transitioned to hydrogen, there is less demand on the electricity network and as a result the installed capacity of distributed generation, including solar PV and other renewable generation, increases steadily in this scenario. However, there is a significant increase in transmission connected offshore wind generation, used for large scale green hydrogen electrolysers. There is also a moderate level of grid flexibility provided by a variety of technologies, including by demand side response, electric vehicle smart charging, as well as domestic, co-located, and grid scale battery storage installations.

Number of battery electric vehicles per local authority



Leading the Way

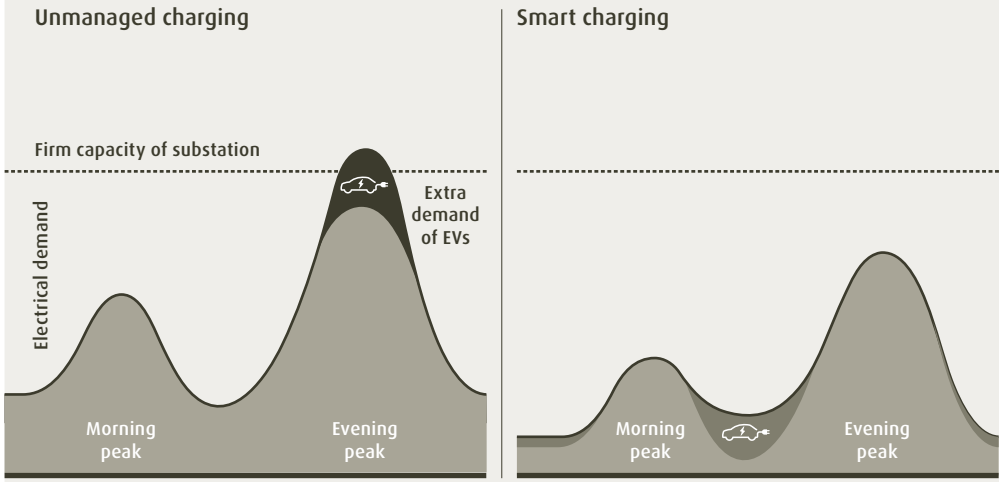
In Leading the Way, the Net Zero target is reached before 2050 with the highest level of societal change involved. By utilising state of the art low-carbon technologies, both hydrogen and electric options, this is the fastest of the scenario worlds to achieve Net Zero. Consumers engage with market mechanisms such as smart charging and time of use tariffs, as well as efficiency measures to reduce their heating demand. Aiding this high level of engagement are centralised solutions such as the decarbonisation of the gas grid.

A rapid uptake of electric vehicles is seen in this scenario as all ICE and PHEV sales are banned from 2030 and 2035 respectively and there is widespread access to public EV charging. At the same time consumers are more willing to take public transport and opt for active transport such as cycling and walking, resulting in a lower growth of car and van stock relative to other scenarios. This results in the fastest uptake of electric taxis, buses, and coaches. As a consequence, there is a smaller overall vehicle stock than in other scenarios by 2050. For HDVs, both batteries and hydrogen fuel cells are developed at scale, and diesel ICE vehicles are completely phased out by the 2040s.

As fast as credible

Net Zero ahead of 2050

Electric and hydrogen technologies



Smart charging allows EVs to be charged outside of peak times, flattening the demand curve. This means substations do not get overloaded and reduces the amount of reinforcement expenditure required, keeping customers' bills as low as possible.

Key assumptions

Energy efficiency
Low — Medium — High

Electric vehicles (cars and vans)
Low — Medium — High

Number of heat pumps
Low — Medium — High

District heat uptake
Low — Medium — High

Small scale solar PV
Low — Medium — High

Large scale solar PV
Low — Medium — High

Onshore wind
Low — Medium — High

Domestic battery storage
Low — Medium — High

Grid-level battery uptake
Low — Medium — High

EV smart charging
Low — Medium — High

Leading the Way continued

Net Zero by 2050
Faster than 2050

Hydrogen gas grid
Low-carbon gases

Electric cars and vans in 2027/28
2.8 million

Homes with solar panels in 2027/28
281,000

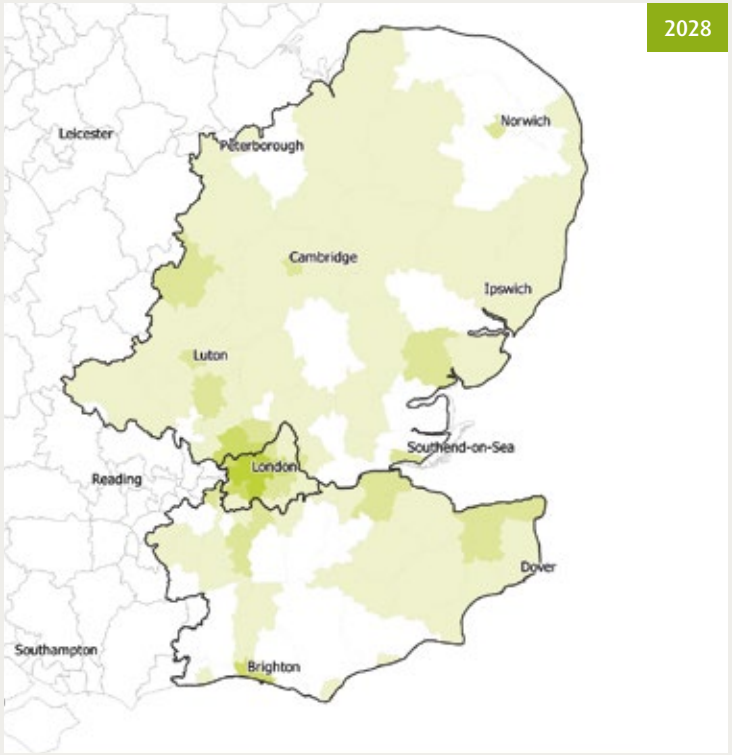
Grid scale battery capacity in 2027/28
2.4GW

Heat pumps in 2027/28
767,000

The decarbonisation of heat is achieved through a hybrid approach, deploying both high numbers of heat pumps as well as a gas grid converted to distributing low-carbon hydrogen. This provides a platform for hybrid heat pumps, combining electric heat pumps with hydrogen boilers. In addition to heat pumps and decarbonised gas connections, there is a high uptake of district heat networks powered by both electric heat pumps and waste heat. A significant policy development in this scenario is that environmental taxes are removed from the cost of electricity and shifted onto natural gas prices in a phased transition from 2025-2028.

The electricity generation capacity required to support the many EVs and heat pumps deployed in this scenario is high and will be met with a more centralised approach than in Consumer Transformation. With large solar PV being more popular, there is a high uptake of co-located battery storage. Consumers are willing to participate in flexibility programmes, with over 80% of those with EV charging at home taking part in some form of smart charging by 2050.

Number of domestic properties connected to district heat networks per local authority



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UK Power Networks Holdings Limited
Registered in England and Wales No. 7290590
Registered office: Newington House,
237 Southwark Bridge Road, London SE1 6NP

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Useful links

Open Data to kick start Net Zero plans

- Check out our **Local Area Energy Plan**
- Let us know what other data themes, uses cases or datasets you wish to see evolved or included **here**

Need a new connection?

- Click **here** to find out more

A free self-service digital planning tool under development to support best choices for communities in developing their Local Area Energy Plans

- Click **here** to find out more

Read our Annual Review

- Click **here**

Get in touch

- Any questions or clarifications please get in touch with us at **DFES@ukpowernetworks.co.uk**