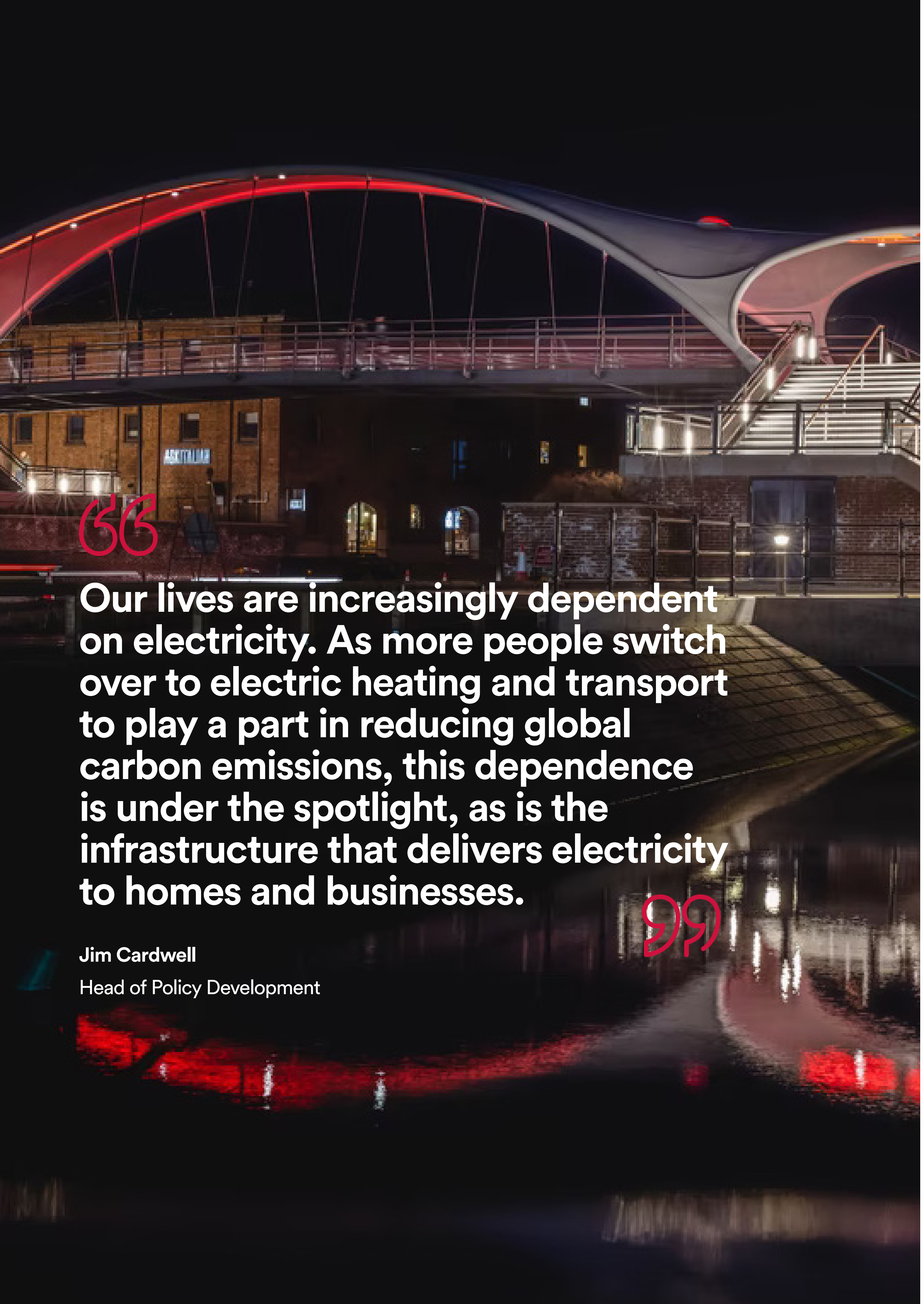
Distribution Future Energy Scenarios

Mapping net zero locally

2021 data



Our lives are increasingly dependent on electricity. As more people switch over to electric heating and transport to play a part in reducing global carbon emissions, this dependence is under the spotlight, as is the infrastructure that delivers electricity to homes and businesses.

Jim Cardwell

Head of Policy Development

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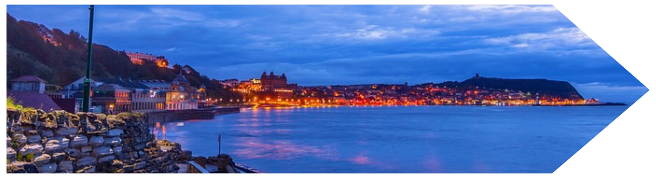

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Introduction
Foreword

Our lives are increasingly dependent on electricity. As more people switch over to electric heating and transport to play a part in reducing global carbon emissions, this dependence is under the spotlight, as is the infrastructure that delivers electricity to homes and businesses.

Northern Powergrid has a critical role to play in enabling regional and national decarbonisation. As the electricity network operator for the North East, Yorkshire and northern Lincolnshire, we are responsible for the power needs of more than eight million people, and our customers have made it clear that they want to see our region decarbonise quickly.

We are investing to enable this future and network forecasting is critical to help us focus our investment to meet the targets set by our customers and stakeholders.

Our annual Distribution Future Energy Scenarios (DFES) is an important part of the planning toolkit that enables us to forecast the pathways to decarbonisation, and the impact on the network we operate. It helps us to make more effective and data-driven investment decisions, which ultimately helps us ensure that the network is ready to meet our customers' zero carbon ambitions.

In doing so, our DFES also enables us to contribute to decarbonisation at a national level. Last year, the UK hosted COP26 in Glasgow and helped to establish the Glasgow Climate Pact, which, among other commitments, sought to phase down coal power by 2030 globally.[1] With the UK at the centre of the global stage, it became clear that 2021 was the year of formalising the plans that will enable the nation to accelerate towards net zero by 2050.

Planning to deliver a resilient and reliable low carbon network

This year, our DFES follows the publication of our business plan for 2023-28, the next Ofgem regulatory price control period.[2] The plan outlines how we intend to unlock £3.3bn of investment to prepare our region and our network for accelerated decarbonisation, as well as continuing to deliver safe and reliable power to the people we serve.

The DFES 2021 also follows in the wake of Storm Arwen, a devastating extreme weather event that caused unprecedented damage to our region including our electricity network. The impact of Storm Arwen will never be forgotten by either our customers or the people in our organisation. Scenario planning for resilience, as well as adopting the technologies that will mitigate some of the worst effects (effects that we are already starting to see), is crucial.

In the very near future, we are anticipating both an increase in reliance on electricity, as sectors such as heating and transport transition to low carbon electric technologies, and an increase in extreme weather events such as Storm Arwen.

It is therefore vital that we use our DFES to plan a network that embeds resilience throughout, to reassure our customers that the network can fully enable and support the adoption of technologies such as electric vehicles (EVs) and heat pumps.

The best way we can embed resilience is by ensuring that our network is flexible, powered by distributed electricity generation, and supported with strong network infrastructure. The five scenarios in our DFES and our related modeling of Climate Change Committee (CCC) projections reflect different and credible pathways to this future – and in the case of all scenarios, resilience is paramount.

1. https://unfccc.int/sites/default/files/resource/cop26_auv_2f_cover_decision.pdf
2. https://ed2plan.northernpowergrid.com/sites/default/files/document-library/NPg_Our_business_plan_for_2023_28.pdf

Reflecting regional and community priorities

We are more than a system of substations, overhead lines, and underground cables. We are an anchor organisation in the communities we serve and in 2021 we saw communities, businesses and individuals across our region organise and formalise their approaches to climate action.

The North East England Climate Coalition (NEECC) and the Yorkshire and Humber Climate Commission (YHCC) both assembled to amass local leadership and plan regional strategies to address the climate crisis and deliver decarbonisation.

Over 500 regional leaders and stakeholders fed into the YHCC's 50-point plan to deliver regional decarbonisation, including an 84 per cent carbon reduction by 2030.[3] The plan was announced in November 2021 and the YHCC's commitments reflect our own 2023-28 business plan, with our priorities aligning on:

- delivering a fair and inclusive transition;
- building resilience into our network and our region;
- creating new green jobs and skills to support the levelling up agenda;
- accelerating decarbonisation of our energy supply;
- introducing a smarter, more flexible network to manage demand; and
- enabling greater uptake of low carbon technologies (LCTs).

Local councils from Northumberland to North East Lincolnshire set out their action plans and road maps to net zero,[4,5] and local leadership helped to galvanise green investment in our region. The North of Tyne Combined Authority established its Green New Deal Fund to invest £18m in low carbon infrastructure to support SME business growth and innovation.[6]

Our cities also continue to lead the way. Newcastle retained its A-grade status on the CDP's list of world leading cities tackling climate change and Sunderland gained its first A-grade status.[7] They are two of just 95 cities globally to achieve this accolade, highlighting their strong climate leadership.

At a national level, laws were announced that require new homes and commercial buildings to install EV charging points from 2022,[8] and government contracts for renewable energy projects will unlock 12 GW of new renewable capacity – around twice the capacity of the previous contracts round.[9]

Our 2021 DFES and your feedback

The first four scenarios in our 2021 DFES reflect National Grid ESO's Future Energy Scenarios (FES) and showcase the insights and findings from the FES at a regional level. The fifth scenario is our own Planning Scenario, which reflects our best view scenario and evolved from insights in last year's DFES that highlighted a credible route to decarbonisation, which would see our region secure net zero carbon ahead of the UK's 2050 deadline.

With our 2021 DFES, we factor in all our local knowledge, plus the FES and regional data, to model the scenarios that will support communities, individuals and organisations in our region enable the plans and decarbonisation processes that have been laid out this year.

Your feedback is critical as it gives us a greater understanding of your plans and helps us to model and invest in a network that will help to deliver your ambitions.

By combining your plans and ambitions with our local knowledge and data-driven modelling, we can enable decarbonisation in our communities and our region. 2021 was the year we all formalised our planning – now, our DFES will help us to deliver.

Jim Cardwell
Head of Policy Development

3. https://yorksandhumberclimate.org.uk/sites/default/files/ClimateActionPlan.pdf
4. https://www.northumberland.gov.uk/Climate-Change/climate-action-plan.aspx
5. https://www.nelincs.gov.uk/north-east-lincolnshire-councils-path-to-net-zero-and-a-better-environment-set-out-in-new-reports/
6. https://www.northoftyne-ca.gov.uk/news/north-of-tyne-combined-authority-creates-18m-green-new-deal-fund/
7. https://www.bbc.co.uk/news/uk-england-tyne-59332250
8. https://www.bbc.co.uk/news/business-59369715
9. https://www.cms-lawnow.com/ealerts/2021/09/uk-government-announces-latest-round-of-the-contracts-for-difference-scheme

About Northern Powergrid

Northern Powergrid is responsible for powering the daily lives of eight million people. We are the Distribution Network Operator (DNO) for the North East, Yorkshire and northern Lincolnshire and our electricity network delivers power to 3.9 million homes and businesses.

But we are more than a provider of critical infrastructure. We are an anchor organisation, committed to being a force for good for the communities we serve and live in.

We have a 2,600-strong team, working around the clock to maintain a safe, reliable and efficient electricity network and to meet the needs of our customers. Our colleagues and contractors are here to serve our communities 24 hours a day, 365 days of the year.

The network that we operate spans around 25,000 square kilometres and consists of 96,000 kilometres of overhead power lines and underground cables and more than 63,000 substations:

— 122 large substations (42 grid supply points and 80 supply points).
— 552 primary substations.
— 63,134 distribution substations.

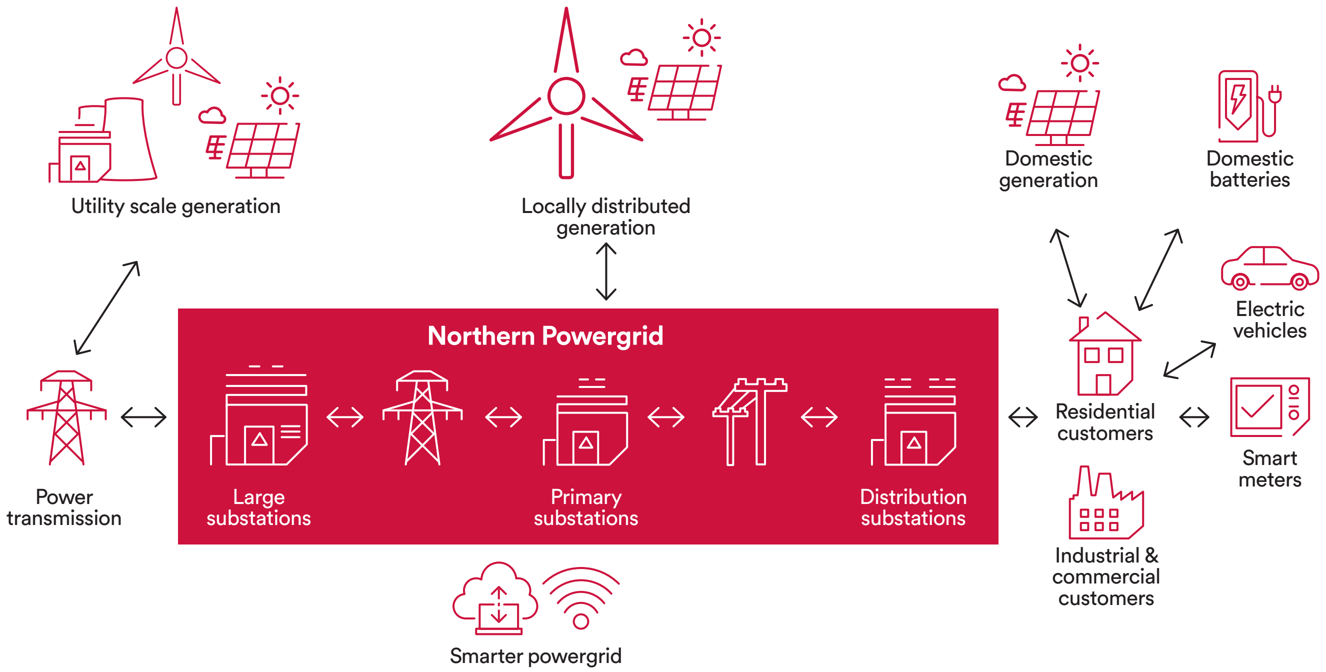
The cost of our operations is covered by a proportion of our customers' energy bills. Approximately £99 p.a. per household covers the cost of paying our dedicated workforce, maintaining the distribution network, and investing for the future.

Ofgem's price control review process defines the amount of revenue that we recover from our customers' energy bills. The next price control period will start in 2023 and finish in 2028. This is called RIIO-ED2, and we have just submitted our full business plan for it, detailing how we will invest £3.3bn to:

— deliver an environmentally sustainable network that enables net zero by 2050 or earlier;
— maintain a robust and reliable electricity network for the future;
— delight our customers with an outstanding service; and
— protect those in our society that are vulnerable.

Our 2023-28 plan sets out how we will continue our transition to deliver Distribution System Operation (DSO) functions. In fulfilling this role, we will drive decarbonisation in our region by operating a more active and flexible local electricity system.

Our 2,600+ colleagues live and work in the area we serve



For more information, refer to: ofgem.gov.uk/network-regulation-riio-model/riio-ed1-price-control

We live and work here. Our business is made up of local teams that support their communities.

3.9m
homes and businesses

8m
people served

96,000
km of overhead lines and underground cables

63,000
substations

Purpose of this publication

This is our 2021 DFES document. The scenario-based forecasting outlined in it is an essential part of our long-term planning. We need to assess how the factors that impact our network might change in the future, and what that means for our customers, so we can make the best plans to power their lives.

Background

2021 was a pivotal year for tackling climate change, with new policies and strategies announced that support the UK's goals of decarbonising by 2050. The UK government announced a new national target to reduce carbon emissions by 78 per cent by 2035,[1] and new strategies for hydrogen and heat and buildings to turn up the dial on the transition to zero carbon.[2,3] We must be ready to support this transition towards net zero, while ensuring we continue to deliver safe and reliable power, and offer ultimate value for money to all of the communities we serve.

As actions to support net zero grow at local, national and political levels, we are seeing transformational changes in the whole energy system, including:

- an expected tipping point for mass EV adoption, supported by the 2030 ban on new petrol and diesel cars, falling battery costs and expanding charging networks;
- a government-incentivised push for electric heating, with the Heat and Buildings Strategy setting out grants for heat pumps and ambitions to phase out fossil fuel heating by 2035;[2] and
- ever-increasing levels of distributed generation, with LCTs such as domestic rooftop solar photovoltaics (PV) being installed on new and existing properties, and existing solar PV being coupled with domestic storage batteries as prices of both technologies continue to fall.[4,5]

To meet the UK's legally binding net zero targets, collaboration between multiple stakeholders is essential. As a key enabler of our stakeholders' own net zero ambitions, we need to consider your plans and accompanying data in our scenarios. We want to make your plans a reality.

Many regional stakeholders are confirming their plans for decarbonisation in response to this pivotal year. It is our purpose to enable the net zero ambitions of those in our region, whether through customer flexibility, network flexibility or adding additional capacity through reinforcement.

To ensure that we cater for all our customers, we need to understand where additional flexibility and capacity is required. From local authorities to small and medium-sized businesses, we want to hear from you.

2022: keeping up the momentum

Working together and harnessing the power of shared data will reduce uncertainty and allow us to cater for realistic pathways to decarbonisation and model the network impacts of these potential futures.

We have now published our 2023-28 business plan, which will underpin one of the most transformational periods in the history of energy. It sets out the investment decisions we propose to support decarbonisation across the communities we serve.

Our last DFES, published in December 2020 and updated in May 2021, helped to inform our 2023-28 plan. The DFES process will continue to play a key role in the decisions we make to support our stakeholders and we urge you to inform us early of your plans, so we can create a safe, resilient, cost-effective and future-ready electricity network to power our region.

1. https://www.gov.uk/government/news/uk-enshrines-new-target-in-law-to-slash-emissions-by-78-by-2035
2. https://www.gov.uk/government/news/uk-government-launches-plan-for-a-world-leading-hydrogen-economy
3. https://www.gov.uk/government/publications/heat-and-buildings-strategy
4. https://www.solarpowerportal.co.uk/news/solar_pv_costs_fall_82_over_the_last_decade_says_irena
5. https://ourworldindata.org/battery-price-decline

What are DFES and why have we published them?

DFES set out several credible pathways to decarbonise the whole energy system. Power generation, transport and heat are all considered in this forecast, which we update annually. They present the underlying assumptions and potential impacts on our network. To maximise access for our stakeholders to support regional collaboration, we have worked with Open Innovations (formerly Open Data Institute (ODI) Leeds) to present our information.

The full DFES includes:

1. This orientation document

2. An online interactive visualisation tool[6]

3. Downloadable datasets[7]

Who is it for and what are the benefits?

We are publishing this document to share the data we have so far with our stakeholders for you to tell us if it supports your plans.

We urge stakeholders to reflect on whether their plans are represented in this data. It does not matter how big or small these plans are, or how early or advanced, it is imperative we know to ensure we plan our network around the needs of our stakeholders.

All our stakeholders can give feedback on the DFES, but we expect it will be of most interest to:

- local and combined authorities and Local Enterprise Partnership (LEP) planners and energy teams;
- low carbon initiative coordinators;
- economic regeneration and recovery teams;
- LCT developers and installers, across all disciplines from EVs to heat pumps; and
- housebuilders and developers.

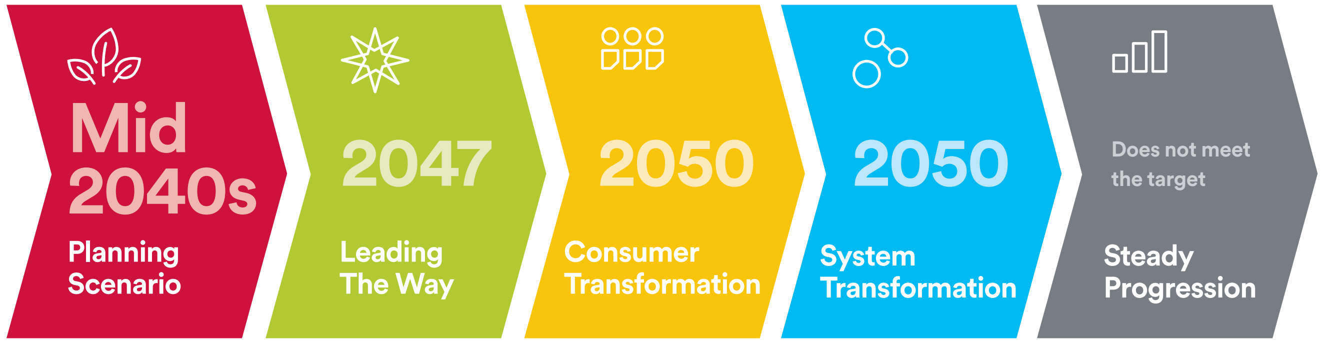
How to provide feedback?

Our Engagement section outlines in detail how you can view and interact with the scenarios and provide feedback. Both qualitative and quantitative feedback is encouraged, and we are particularly interested in:

- whether you have your own projections for any of the key parameters in our DFES;
- details of any local initiatives that you are putting in place to drive the uptake that you are forecasting for any of the parameters; and
- whether your plans align with one of the scenarios in our DFES more than others.

6. Visualisation tool: https://odileeds.github.io/northern-powergrid/2021-DFES/
7. Downloadable datasets: https://datamillnorth.org/dataset/northern-powergrid-dfes-2021/

Net zero



From extensive engagement,[1] we know that our customers and stakeholders want to see us enable accelerated decarbonisation and for our region to transition to net zero ahead of the national 2050 target. We have a proud regional heritage of innovation, industry, forward thinking and pragmatism, and supporting our customers' decarbonisation targets is a major objective for our business.

It is also critical that we enable net zero in a way that protects and improves quality of life for the eight million people whose daily lives we power. Decarbonisation has enormous potential to deliver widespread economic transformation, offering new industries and job opportunities to support the Government's levelling up agenda in our region. It is our responsibility as an anchor organisation within our communities to support our customers and stakeholders, ensuring they benefit from the economic and social opportunities of net zero.

We must facilitate our customers' net zero ambitions in a way that balances aggressive decarbonisation and economic prosperity, with protecting those who are vulnerable and continuing to deliver safe and reliable power to all those in our region.

The mandate to focus our business operation on decarbonisation is clear, but the pathway to secure this is yet to emerge.

Of the five scenarios in our DFES, two are compatible with pathways to meet net zero by 2050, two outline more ambitious pathways to reach net zero in the 2040s, and one achieves net zero later than 2050.

What we are doing now is making robust decisions to ensure our network meets the needs of any scenarios that come to fruition,[2] and to do this our local knowledge will come to the fore more than ever.

Every viable LCT will contribute to net zero and every section of society may undergo behavioural shifts as part of the transition. We must understand where and when these behavioural shifts will happen, and how this will impact the network in those areas. There are four key questions we must ask, outlined below, that will determine how and when we achieve net zero (see table opposite).

We can and will play a leadership role in supporting the North East, Yorkshire and northern Lincolnshire to achieve net zero, supporting a green industrial revolution and enabling economic regeneration along the way. This includes helping our regions to be UK leaders in renewable energy, carbon capture, utilisation and storage (CCUS), green marine, and low carbon industry.

To support the decision making we want to work with our regional stakeholders, National Grid ESO and our fellow DNOs to continuously improve scenarios that provide a pathway to net zero. We are seeking our stakeholders' views on our plans and expectations. If you have knowledge on any new initiatives being proposed by them or in their region to achieve net zero, please let us know. Your insight will help us deliver accurate models that help target investment, so that your ambitions can be realised.

1. https://ed2plan.northernpowergrid.com/sites/default/files/document-library/Detailed_engagement_summary.pdf
2. https://ed2plan.northernpowergrid.com/sites/default/files/document-library/NPg_Our_business_plan_for_2023_28.pdf

Net zero ?

How electrical?

- We will always rely on electricity to power our lives, but the source of that electricity is changing, and the extent to which we depend on it is yet to be determined.
- Electricity is increasingly being generated from renewable sources such as wind and solar. We expect this trend to increase as renewable technologies continue to become more cost-effective and national and regional policies encourage LCT growth to meet climate targets.
- LCTs such as EVs and heat pumps will be the main drivers of increases in demand for electricity, and the impact of the electrification of the transport and heating sectors of our economy will have a transformative effect on the electricity system.
- But technologies such as hydrogen may also emerge as a viable option for the heating and transport sectors, which would differently impact the expected increase in electricity demand.

How local?

- In a local, decentralised energy system, engaged users and producers of electricity promote efficient use of every kilowatt hour of green energy generated. Local, decentralised systems may also have capabilities to self-optimise to minimise costs. Overall, this means that electricity should be more affordable for all.
- We are connecting more locally distributed renewable generation to our network and connecting local buyers and sellers of electricity to each other. As a result of this change, we expect the amount of connected generation and storage to more than double by 2028 (see figure 19).

How flexible?

- More renewable and intermittent electricity generation will result in electricity supply peaks and troughs becoming more unpredictable. Our role is increasingly going to involve controlling and optimising the bidirectional flow of this electricity through our network to meet demand.
- The amount of flexibility in the network will drive how much additional capacity we need to add to enable an increase in both supply and demand for electricity.
- In our business plan for 2023-28 we champion a flexibility-first approach and will prioritise flexibility where we can. Greater flexibility will also ensure we can evolve and adapt to potentially changing future energy scenarios.

How fast?

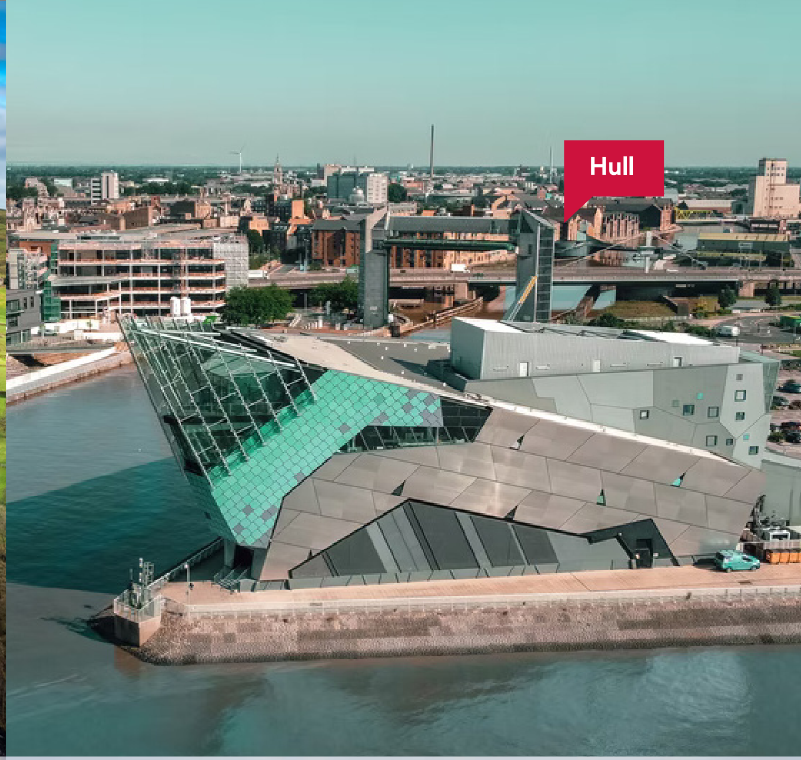
- How quickly we decarbonise will be heavily dependent on the rate at which renewables displace energy generation from fossil fuels, and how quickly customers take up LCTs for transport and heat.
- EVs are a more certain technology now, with EVs making up around 11 per cent of all new car sales in the UK in 2021, accounting for more EV sales than all the previous five years combined (2016-20).[3] This mainstream acceptance means that EV uptake is likely to happen quicker than other LCTs such as heat pumps, which are growing in acceptance, but are not yet popular enough to be considered mainstream. Hydrogen is still a fledgling technology, which means its role in the future energy system is less certain. However, government policies such as the August 2021 Hydrogen Strategy announcement have demonstrated that there is an appetite for the technology to mature quickly.[4]
- Different parts of our region will transition at different speeds based on a range of factors, including the location of carbon intensive industries and population demographics, which are likely to affect people's willingness and ability to adopt new technologies.

3. https://heycar.co.uk/blog/electric-cars-statistics-and-projections
4. https://www.gov.uk/government/news/uk-government-launches-plan-for-a-world-leading-hydrogen-economy

Our world ...

From tiny hamlets to three of the most populous cities in the UK. Our network spans four national parks, five areas of outstanding national beauty and four heritage coasts.

This is where we live, work and serve our customers.



Distribution Future Energy Scenarios
Our approach

Our Distribution Future Energy Scenarios (DFES) model the range of credible energy futures for our region. The scenarios are projections, rather than predictions, and the insight we gain from this regional real-world modelling helps us to plan and deliver services, informs investment in our network, and ultimately enables us to facilitate the region's growth and decarbonisation ambitions.

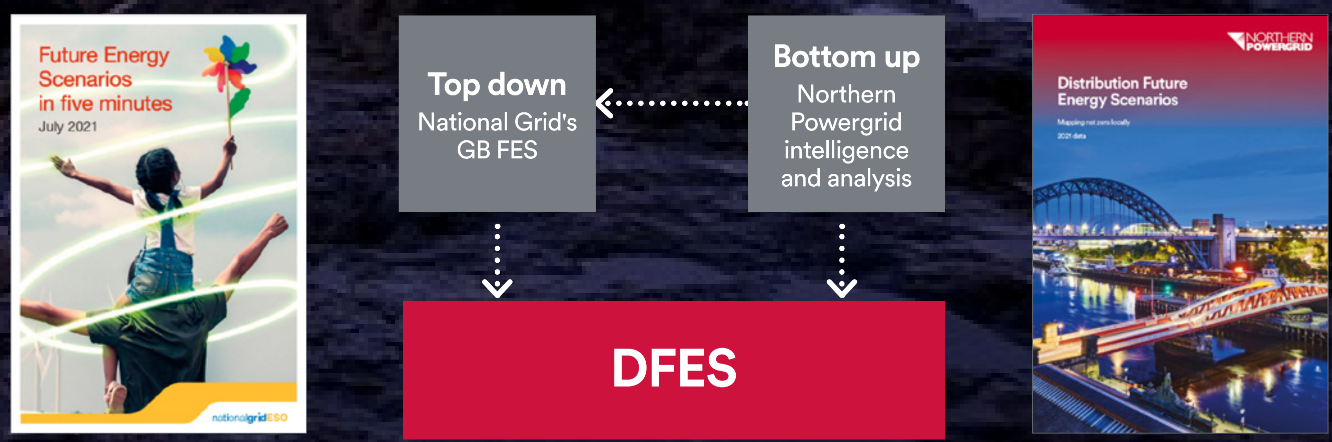
Your feedback on the scenarios is vital as it helps steer our decisions and ensures that our planning is grounded in customer and stakeholder experience, as well as data. In 2021, we submitted our RIIO-ED2 business plan for 2023-28 that will underpin a transformational change in our business and the wider energy sector.

The data in the DFES enables us to:

— facilitate our region's net zero ambitions;
— understand the projected uptake of low carbon technologies (LCTs) and the increase in distributed generation capacity;
— explore how we can proactively manage the grid to alleviate any constraints created by energy demand or generation;
— model the impact of these changes on the electricity distribution network and signal locations; and
— determine the need for intervention or investment to deliver a reliable zero carbon network.

Our regional data also helps to inform the national future energy pathways. Through our ongoing collaboration with the Electricity System Operator (National Grid ESO) and other Distribution Network Operators (DNOs), our regional DFES data contributes to national Future Energy Scenario (FES) projections and the national FES data feeds into our regional scenarios.

Figure 1: A high-level explanation of our DFES process



Our method

Our load growth model produces a regional interpretation of the FES plus our Planning Scenario. We build the DFES using local data and input key parameters of our electricity network into a scenario-based load growth model. Key input parameters include:

- the network topology;
- electricity substation half-hourly electrical data (demand and generation);
- substation locations and areas supplied (postcodes);
- annual consumption values for different profile classes; and
- connection counts by customer type – i.e., Domestic or Industrial and Commercial.

As a starting point for our analysis, we calculate the regionalised total quantities of energy uses such as numbers of electric vehicles (EVs) and heat pumps, and capacities of connected distributed generation across our substation population. These regionalised totals are provided to us from the preceding FES process.

The modelling process is informed by a range of data source. These data sources include:

- Experian Mosaic geographic data;
- local authority building stock projections;
- wind speed data;
- green space data;
- space heating information and the load profiles for different customer archetypes; and
- behaviour with respect to LCT usage, taken from research data such as Northern Powergrid's Customer Led Network Revolution (CLNR) project and ongoing stakeholder engagement.

More details about how we have used this model to develop the DFES can be found on the Northern Powergrid Hub on the Open Innovations website.[1]

Figure 2: Our modelling process

Northern Powergrid data inputs

- Network topology
- Substation geographic information
- Customer numbers and types
- Peak demand data (kW)
- Energy data (kWh)
- Generation capacities

External data inputs compiled and input by Element Energy

- Experian Mosaic geographic data
- local authority building stock projections
- Various LCT uptake scenarios, including GB FES
- LCT and customer flexibility solution load profiles, e.g. learning from innovation projects
- Appliance efficiency data
- Data associated with distributed generation, e.g. wind speeds, green space
- Data associated with demand from LCTs, e.g. space heating, EV indicators

Stakeholder engagement

Load forecasting model

1
Processes Northern Powergrid inputs into monthly electrical loads (demand and generation) per substation

2
Maps the external data to each substation

Outputs

Northern Powergrid data outputs

- Load forecasts – with and without customer flexibility
- Generation forecasts
- Energy consumption forecasts
- LCT uptake projections (demand technologies)
- LCT uptake projections (distributed generation technologies)
- Energy storage uses
- Generation flows
- Network development strategies
- Potential sites for DNO-enabled customer flexibility

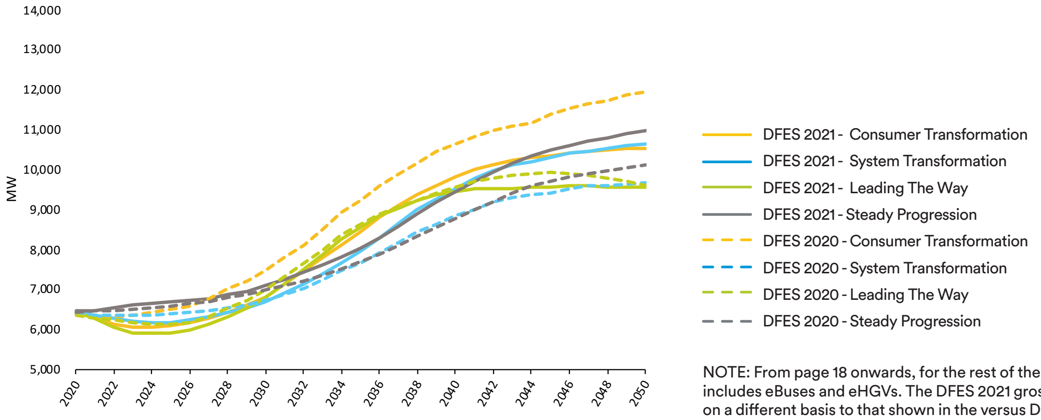
1. Leeds ODI website: https://odileeds.github.io/northern-powergrid/

DFES 2021
Comparison to 2020 DFES

Alongside the other GB DNOs, we publish our DFES annually, based upon National Grid ESO's FES. Each year we align the scenarios with new data, policies, and insights. This ensures that our projections and assumptions stay up to date with real-time knowledge and are based upon real-world decisions. It also helps to manage uncertainty year-on-year as we learn more about the technologies, behaviours and policies that impact the assumptions for each scenario.[1]

There have been some changes from last year's DFES (DFES 2020), as demonstrated in figure 3, which shows on a like-for-like basis the difference in our Gross Peak Demand projections for the distribution network between the 2020 DFES and the 2021 DFES.

Figure 3: Gross Peak Demand in MW (DFES 2021 vs 2020. 2020 figures exclude eBuses and eHGVs)



NOTE: From page 18 onwards, for the rest of the document, the gross peak demand includes eBuses and eHGVs. The DFES 2021 gross peak demand shown on page 18 is on a different basis to that shown in the versus DFES 2020 chart.

The key item to note in figure 3 is that in the 2020 DFES, the Gross Peak Demand in the Consumer Transformation scenario is higher than in this year's 2021 DFES. The reasons for this change are:

Energy efficiency

Improvements in National Grid ESO's modelling, and our interpretation of this data explain part of the variance. The FES assumes aggressive improvements in **appliance efficiency** and **energy efficiency** in some scenarios, which will help contribute to lower peak demand. This assumption translates into our regional translation of the FES scenarios.

Low carbon technologies

DFES 2021 scenario assumptions also predict that there may be a greater uptake of hybrid heat pumps than initially predicted in the 2020 DFES. Hybrid heat pumps use a range of fuel mixes and so may not require as much electricity to operate.

The 2021 National Grid ESO-aligned scenarios also predict that EVs will consume slightly less energy than anticipated in the 2020 scenario, which, when EV numbers are aggregated, accounts for the drop in Gross Peak Demand.

1. The full list of scenario assumptions can be found in Annex 1.

Our Distribution Future Energy Scenarios

Our Planning Scenario

In addition to the four FES-aligned scenarios, we are presenting our own unique fifth scenario. All the GB DNOs have agreed through the Energy Networks Association (ENA) Open Networks Project to produce a "best view", a scenario that sets out the most favourable pathway to net zero for their respective regions.

Our Planning Scenario is our interpretation of the "best view" scenario.

The Planning Scenario is based on our regional interpretation of the range of national scenarios currently available (National Grid ESO FES and the Climate Change Commission (CCC) scenarios in the Sixth Carbon Budget). It has also taken government policy and stakeholder feedback into consideration, as well as regional characteristics.

We are always mindful that the future is uncertain, and we do not yet know which LCTs will become the mainstream over the next 30 years and beyond. As a network operator, we are committed to embracing this uncertainty to ensure no matter what scenario materialises, we can deliver safe, reliable and low carbon power.

The Planning Scenario offers the most value in the short-term and while it is plotted to 2050, its one to 10-year horizon provides a higher degree of certainty which helps us as an organisation to plan for network impact assessment and investment decisions.

NATIONAL GRID'S FES SCENARIOS

LEADING THE WAY
- Fastest (national) credible decarbonisation
- Significant lifestyle change
- Mixture of hydrogen and electrification for heating

SYSTEM TRANSFORMATION
- Hydrogen for heating
- Consumers less inclined to change behaviour
- Lower energy efficiency
- Supply side flexibility

CONSUMER TRANSFORMATION
- Electrified heating
- Consumers willing to change behaviour
- High energy efficiency
- Demand side flexibility

STEADY PROGRESSION
- Slowest credible decarbonisation
- Minimal behaviour change
- Decarbonisation in power and transport but not heat

OUR "BEST VIEW" SCENARIO

PLANNING SCENARIO
- Fastest regional net zero scenario (mid 2040s)
- Highly accelerated electric heat and transport
- Highly decentralised and distributed renewable generation

Figure 4: Gross Peak Demand in MW to 2027/28

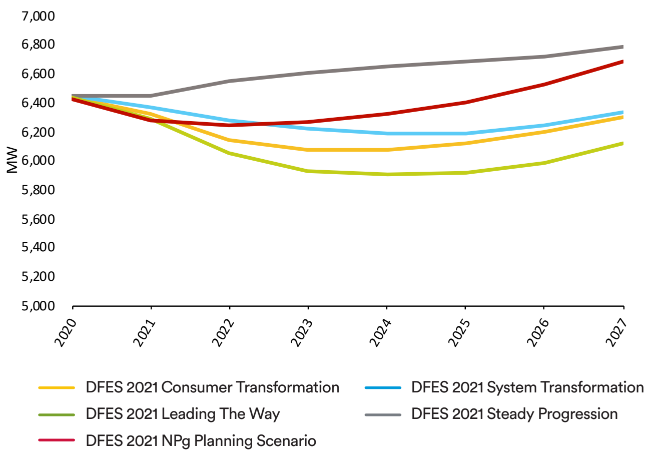


Figure 5: Gross Peak Demand in MW - All Scenarios

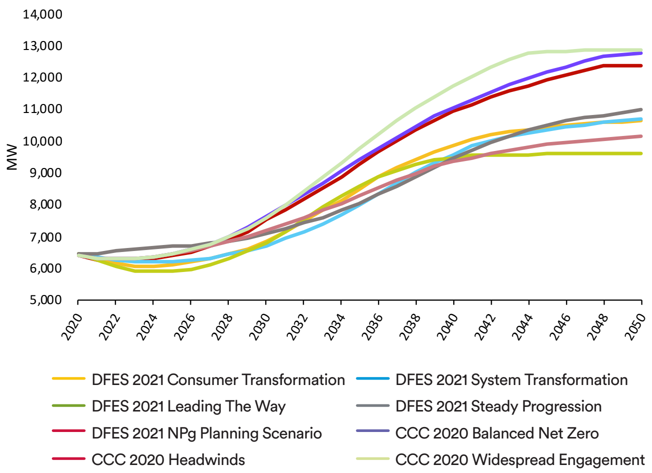


Figure 4 highlights that over the next six years, the Gross Peak Demand for our Planning Scenario sits well within the range of Gross Peak Demands predicted for the FES-aligned scenarios. Figure 4 also indicates that even in the long-term, while our Gross Peak Demand is significantly higher than the FES-aligned DFES scenarios, it still sits within the CCC scenarios.

We justify our Planning Scenario as the "best view" scenario because it meets the following criteria:

— it keeps all future credible pathways open, ensuring that we are not an obstacle to any decarbonisation pathways;
— it is within the range of Ofgem's reference scenarios, the three net zero-compliant FES scenarios by National Grid ESO, and the CCC Sixth Carbon Budget scenarios;
— it is aligned with the latest government policy; and
— it reflects what we have heard from local stakeholders about the desire to facilitate an accelerated decarbonisation pathway.

Key building block	Assumptions on latest policy
Electric vehicle uptake	— In line with the government's Ten Point Plan, it assumes a ban on the sale of new internal combustion engine (ICE) vehicles by 2030 and includes a ban on new hybrids by 2035
Heat pump uptake	— In line with the CCC's Balanced Pathway scenario, it meets the government's Ten Point Plan target of 600,000 heat pumps being installed annually in the UK by 2028 — It assumes a ban on the sale of new gas boilers for new homes from 2025
Energy efficiency	— Domestic thermal efficiency is assumed to be moderate. Appliance efficiency assumptions meet current EU targets for 2030 — Industry and commercial (I&C) energy efficiency is aligned to EU energy efficiency targets
Renewable energy sources	— Solar photovoltaics (PV) assumptions based on high large-scale solar uptake and high domestic PV uptake, reaching 1013 MW by 2030 and 2146 MW by 2050 — Wind assumption supported by recent wind turbine sizes and behaviours reaching 748 MW by 2030 and 2015 MW by 2050

Some of the key policy assumptions for the Planning Scenario are listed below. The full list of assumptions for the Planning Scenario and all other scenarios are in Annex 1. The rationale behind the "best view" scenario is in Annex 5.

We are particularly interested in feedback on where it may be possible to go faster still to meet net zero and get nearer to the aspirations from some of our local authorities to deliver the environmental and economic benefits of net zero emissions earlier than 2050.

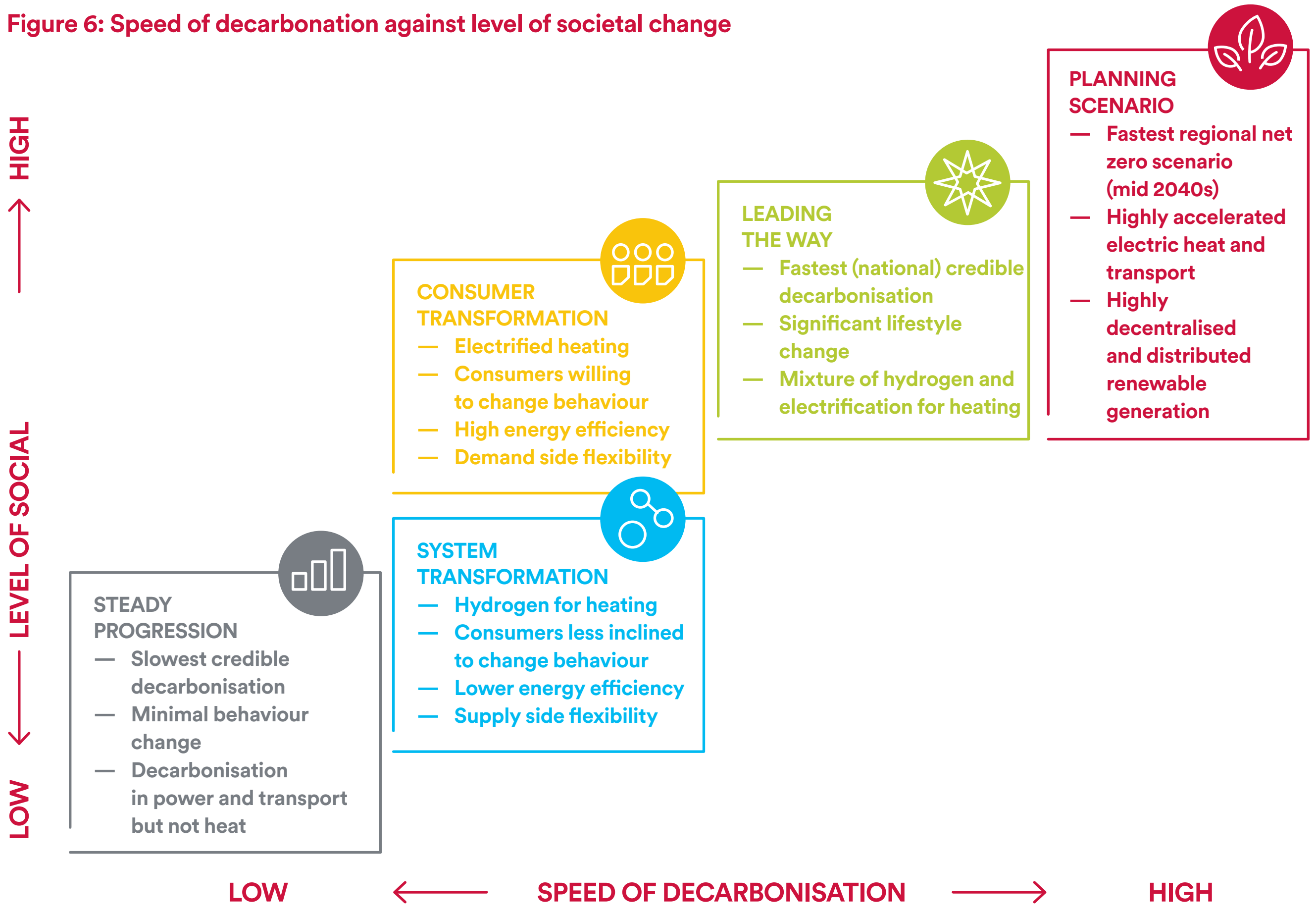
DFES building blocks

A summary of the building blocks underpinning all scenarios can be found in Annex 1. More information about the FES scenarios and their underlying assumptions can be found in National Grid ESO's Future Energy Scenarios document.[1]

Our DFES present at a local-level view for each of the five scenarios, including:

- impact of LCT uptake assumptions on future energy demand projections
- impact of generation assumptions on future generating capacity projections
- proactive grid management looking at energy storage in all scenarios and a focused look at flexibility assumptions in the Planning Scenario
- conclusions: a snapshot through the decades to 2050; and
- impact on our electricity distribution network.

Figure 6: Speed of decarbonation against level of societal change

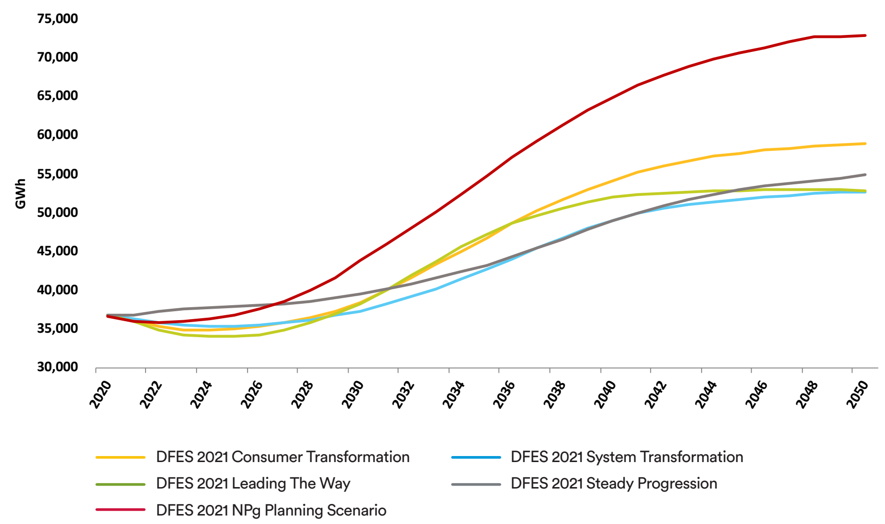


1. National Grid FES Documents 2020: https://www.nationalgrideso.com/future-energy/future-energy-scenarios/fes-2020-documents

Forecast outputs: demand

Electrical energy consumption

Figure 7: Electrical Energy Consumption



In the four National Grid ESO FES-aligned scenarios, electrical energy consumption remains at a net constant over the next ten years. The System Transformation, Leading the Way, and Consumer Transformation scenarios all indicate slight falls in energy consumption up to 2027, before increasing back to 2020 levels. This drop is largely due to expected improvements in energy efficiency that will outweigh increasing electric load growth from new LCTs such as EVs and heat pumps.

However, from 2027 onwards, these three scenarios all start to see an increase in electrical energy consumption, with expected increases in LCT adoption overtaking the energy efficiency measures.

In our own Planning Scenario, the consumption curve begins to rise earlier, with 2025 set to be the inflection year for growth. This is because we anticipate fewer energy efficiency measures being implemented than the FES-aligned scenarios (see 2020 comparison). Therefore, in this scenario, the accelerated early adoption of LCTs will cause electrical energy consumption to rise but will not be tapered so early by energy efficiency measures that could curb the impact on electrical energy consumption.

From 2029 onwards, the Consumer Transformation, Leading The Way, and Planning Scenarios all see a sharp increase in electrical energy consumption, as the 2030s are expected to herald a mass adoption of LCTs across our region. System Transformation and Steady Progression see moderate increases because Steady Progression assumes that few technological and societal changes are adopted, and System Transformation follows a hydrogen-based route to net zero which would require less electricity.

The electrical energy consumption curve in our Planning Scenario rises more steeply than the four FES-aligned scenarios, and results in a peak that is 13,000 GWh higher in the Consumer Transformation scenario, which encompasses the next highest peak. This is partly due to our Planning Scenario anticipating lower implementation of energy efficiency measures compared to the FES-aligned scenarios (explained in DFES 2020-21 comparison). It is also because our Planning Scenario predicts the highest uptake of LCTs such as EVs, heat pumps and commercial EVs, including buses and heavy goods vehicles (HGVs) – this aligns more closely with the predictions made in the CCC scenarios, as outlined in the Sixth Carbon Budget.

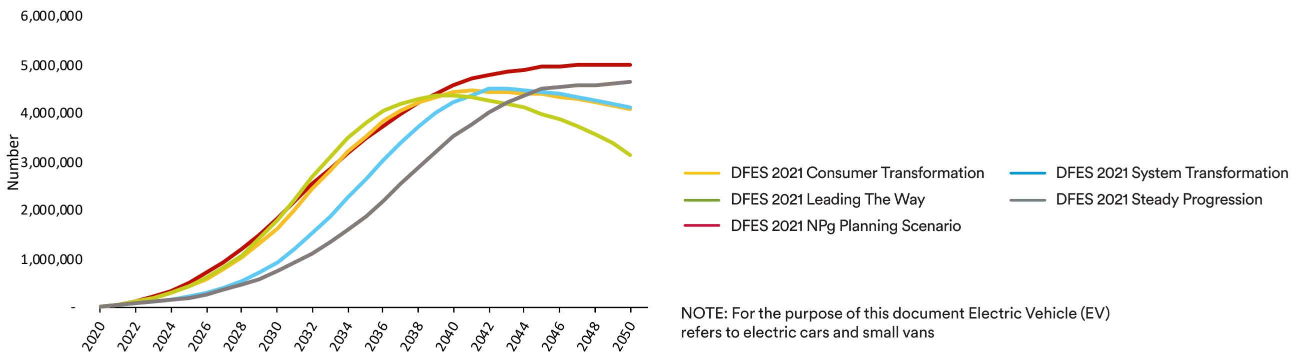
There are instances where the assumptions in the FES 2021 building blocks differ from those identified by our own modelling. FES 2021 assumes aggressive energy efficiency savings which our modelling does not recognise whilst also underestimating the potential growth of Electric Heavy Goods Vehicles (EHGVs) in response to recent technological advances. We anticipate, based on bilateral engagement with National Grid ESO, that both assumptions will be subject to review ahead of the FES 2022.

Low carbon technologies

The two most significant drivers of the increase in electrical energy consumption are heat pumps and EVs. As displacers of traditional fossil fuel-operated technologies (ICE vehicles and gas boilers), these LCTs will disrupt markets and change the way we and our customers interact with electricity. Overall, as shown in figure 7, the increased adoption of these technologies will cause a substantial increase in the amount of electricity that our customers consume. Electric buses and HGVs also have a notable impact on electrical energy consumption, particularly in the case of our Planning Scenario, where electric buses and HGVs significantly impact the expected electrical energy consumption. The below charts (figures 9, 10, 11, 12) show the expected trends for each individual LCT in each scenario over the next 30 years.

Electric vehicles

Figure 8: Electric Vehicles



NOTE: For the purpose of this document Electric Vehicle (EV) refers to electric cars and small vans

In all scenarios, the 2030s is the decade of unprecedented EV uptake. Government policies including banning the sale of new ICE vehicles from 2030 will play a large part in this increase. Consumer Transformation, Leading The Way, and the Planning scenarios all see EV adoption start to rise significantly from around 2023. This could be because many customers and consumers will switch to an EV early as they become aware of and support the direction in which the technology is going in terms of mainstream acceptance.

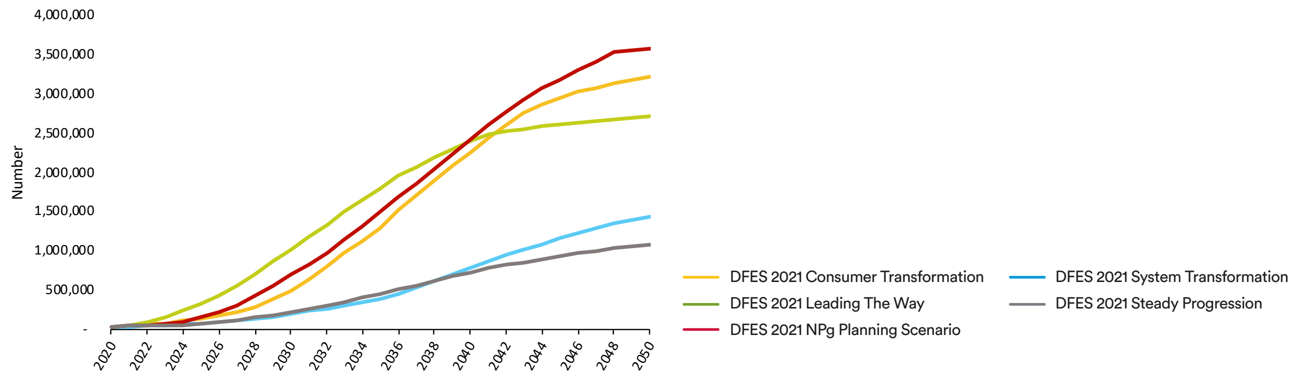
The Leading The Way, Consumer Transformation and System Transformation scenarios all show a drop off in EV numbers after their peaks (between 2039 and 2043). This is assumed to coincide with the introduction and uptake of shared autonomous vehicles.

Steady Progression – despite not meeting net zero by 2050 – shows significant uptake of EVs. This is because EVs are fast becoming an accepted mainstream consumer technology, meaning the behaviour change required to take up EVs is already well underway. Last year, 28 per cent of new cars sold in the UK were either fully electric or hybrid. In the same year, new diesel car sales fell by 63 per cent and new petrol car sales fell by 10 per cent.[1]

1. https://www.theguardian.com/business/2021/dec/06/electric-vehicle-boom-fuels-rise-in-uk-new-car-sales

Heat pumps

Figure 9: Total Heat Pumps



Heat pumps are the other major driver of the increase in electrical energy consumption. In Figure 9, total heat pump numbers increase steeply in the Consumer Transformation, Leading The Way and Planning Scenario, with uptake in Consumer Transformation and our Planning Scenario accelerating well into the 2040s – in the case of our Planning Scenario, this is as a result of higher uptake of I&C heat pumps throughout the 2040s, and for Consumer Transformation this is as a result of higher residential heat pump uptake throughout the 2040s. Leading The Way heat pump uptake starts to plateau in the 2040s. In these scenarios, the acceleration in heat pump uptake also starts towards the end of the 2020s. Again, this is supported by predictions that the cost of heat pumps could fall by 40 per cent by 2030.[2] Heat pump numbers will also be bolstered by the government's announced goal to install 600,000 heat pumps per year between now and 2028.[3]

The System Transformation scenario does not show the same uptake in heat pumps as the other scenarios that reach net zero by 2050. This is because System Transformation predicts a route to net zero that sees the early maturation of hydrogen technology to meet both industry and domestic power needs and as a result, fewer heat pumps would be required.

Figure 10: Residential Heat Pumps

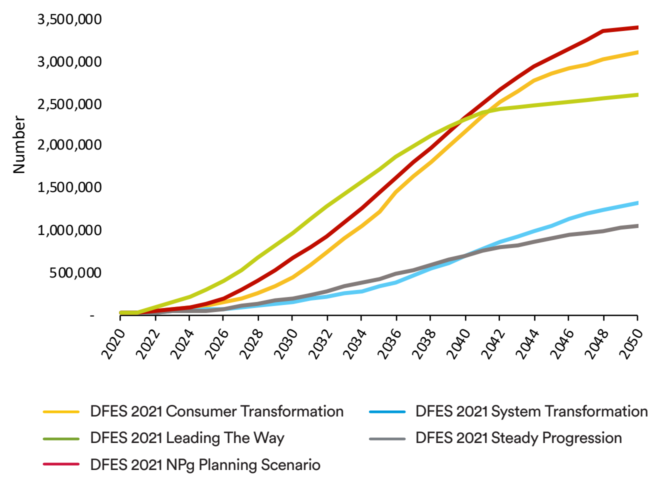
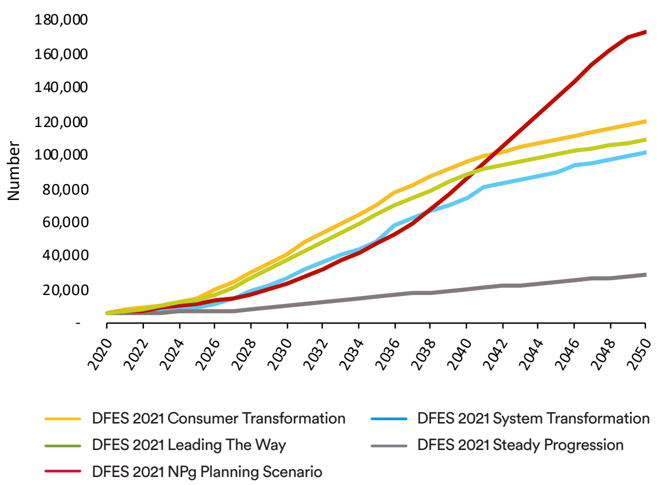


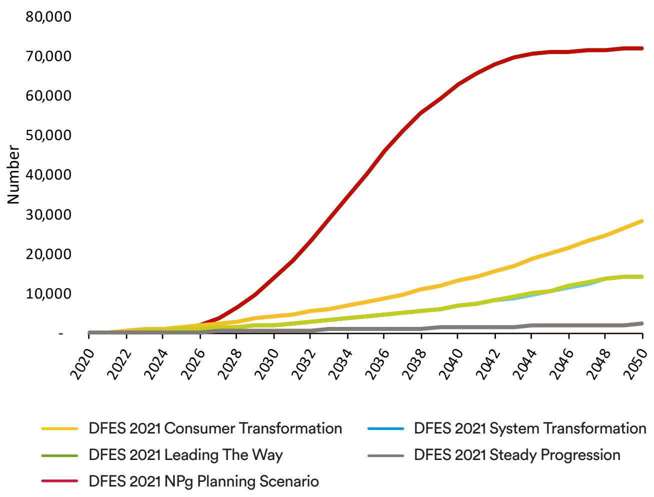
Figure 11: I&C Heat Pumps



2. https://www.energylivenews.com/2021/10/27/heat-pumps-could-cost-40-less-by-2030/
3. https://theconversation.com/heat-pumps-uk-to-install-600-000-a-year-by-2028-but-electrical-grid-will-need-massive-investment-to-cope-168221

Electric HGVs

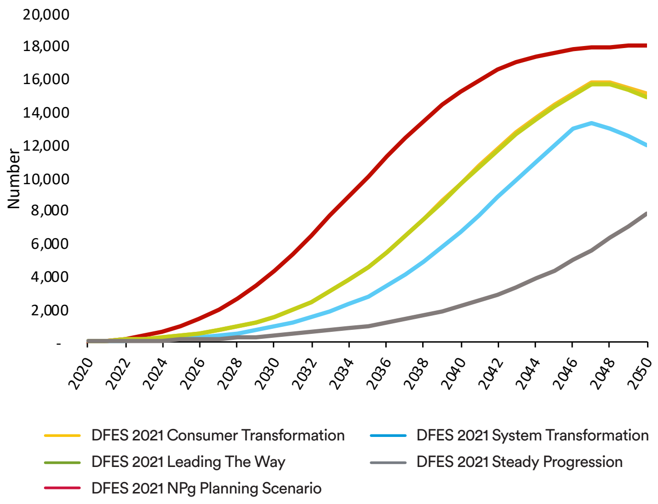
Figure 12: Electric HGVs



Electric HGV numbers are also expected to rise significantly over the next 30 years with our Planning Scenario predicting substantial increases in electric HGV numbers, particularly throughout the 2030s. The FES-aligned scenarios show significantly lower expected uptake of electric HGVs,[4] but we are expecting that the 2022 FES (published in July 2022) will show an increase in the expected numbers of electric HGVs, closer in line to the large increase in HGV numbers that we have predicted in our Planning Scenario.

Electric buses

Figure 13: Electric buses



All scenarios predict an increase in the number of electric buses on our roads over the next 30 years. In all scenarios that meet net zero by 2050, the number of electric buses is expected to peak between 2045 and 2047, and in the Steady Progression scenario (which does not meet net zero by 2050), electric bus numbers will be increasing in 2050, but will not yet have peaked. This is in line with the assumptions of Steady Progression that suggest changes in technologies, behaviours and policy will happen but over a slower period. Our Planning Scenario anticipates the largest number of electric buses across the period, which aligns with our view that heavier vehicles such as buses and HGVs will be predominantly powered by electricity rather than hydrogen (see **Annex 1** for full list of assumptions and building blocks).

Figure 14: Planning Scenario - Energy Consumption breakdown by decade

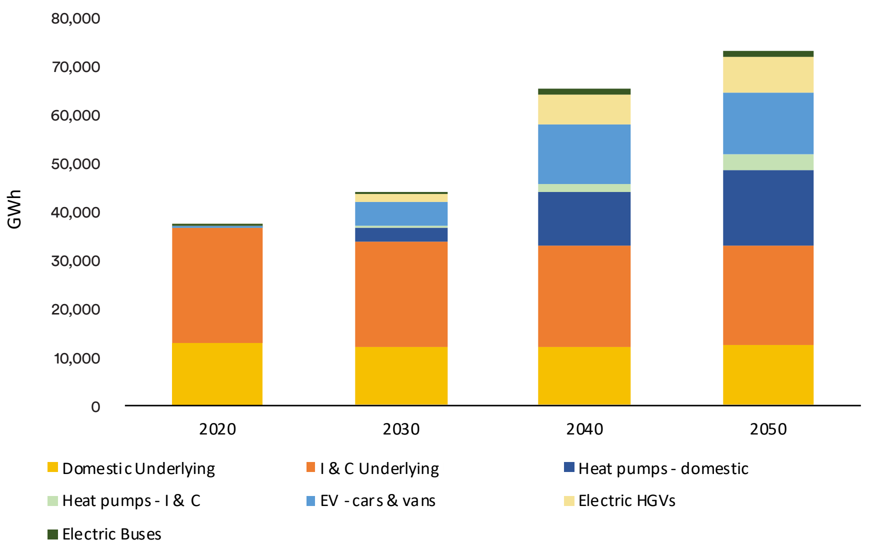


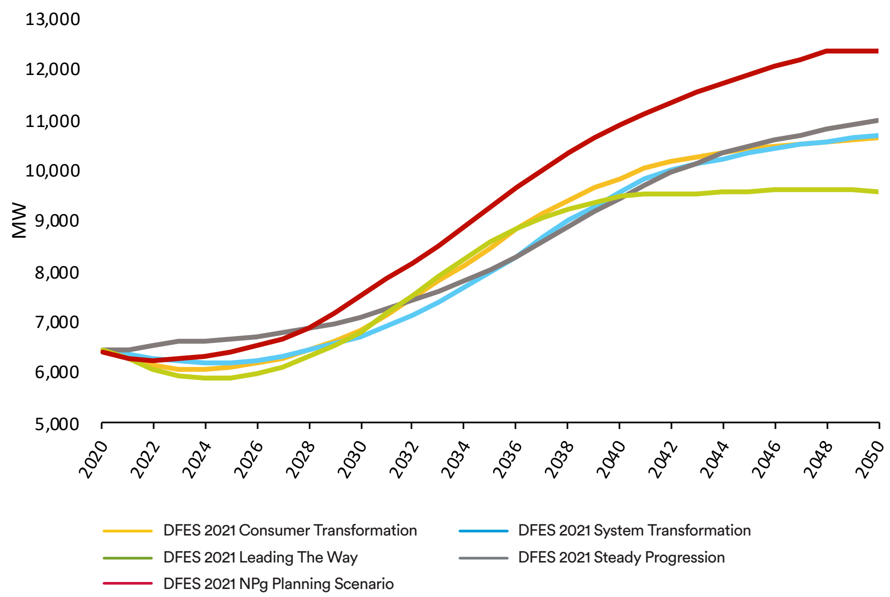
Figure 14 echoes the trends in electrical energy consumption and breakdown of LCT technologies, highlighting that the anticipated uptake in LCTs is responsible for the steep increase in electric energy consumption. The considerable jump in EV, heat pump, electric HGV and electric bus numbers in the 2030s highlights that this will be the decade of significant change, with heat pump numbers continuing to rise well into the 2040s.

Throughout this same period, domestic underlying energy consumption remains largely static, which considers population increase, increased reliance on technology and power, but also the energy efficiencies that will mitigate any rises. Over time, I&C underlying power decreases slightly, which again is due to improved energy efficiency measures.

4. National Grid ESO has already stated that its estimates for electric HGVs in the 2021 FES were very conservative. This impacts our regional translation of the FES scenarios.

Gross Peak Demand

Figure 15: Gross Peak Demand in MW



Gross Peak Demand is a combination of both the recorded peak demand and the generation running at the time (i.e., the suppressed demand). **Our role as a network operator is to ensure that this demand is always met with safe and reliable electricity.**

As a result of widespread LCT uptake causing increased electrical energy consumption, Gross Peak Demand on our electricity network is also expected to increase significantly between now and 2050.

In all scenarios, the trends generally follow that of electrical energy consumption, with our Planning Scenario seeing Gross Peak Demand peaking late into the 2040s.

Leading The Way has the lowest Gross Peak Demand by 2050, which is assumed to be delivered through widespread advancement in energy efficiency solutions.

Steady Progression has the second highest Gross Peak Demand because, while this scenario is expected to deliver a lower uptake of LCTs (and therefore have a lesser impact on electricity demand), there is still sufficient uptake to cause an increase in electrical energy consumption. This will not be met, as it is in other scenarios, with the network balancing effects of improved energy efficiency and increased flexibility and therefore Gross Peak Demand will be higher.

Figure 16: Contributions to peak demand MW - NPg

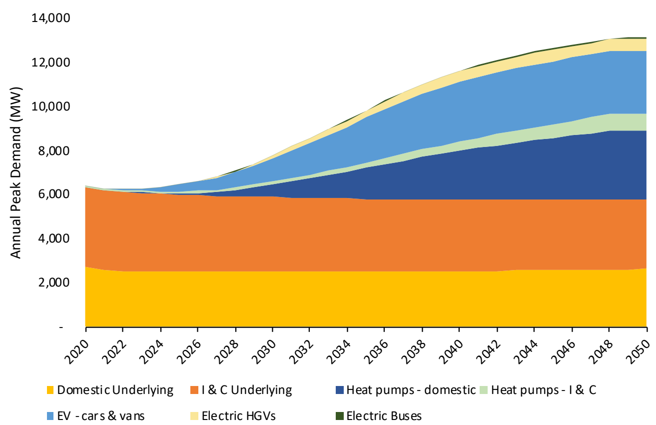


Figure 16 shows the primary contributors to Peak Demand in the case of our Planning Scenario and confirms that the primary contributions to the increase in Gross Peak Demand (with the exceptions of domestic underlying and I&C underlying respectively) are EVs and heat pumps. This trend is replicated across all scenarios, and as the two primary drivers of the increase in electrical energy consumption, this is to be expected. However, beyond EVs and heat pumps, there are additional contributing factors to Gross Peak Demand that show a significant impact from the mid 2030s onwards.

As highlighted in figures 15 and 16, we anticipate considerable growth in both electric buses and HGVs, which in turn causes Gross Peak Demand to increase. These two LCTs would in fact have a larger impact if it weren't for the assumption that most of these heavier vehicles would be charged at night when demand on the network is lower.

Figure 17: Additional industries load study

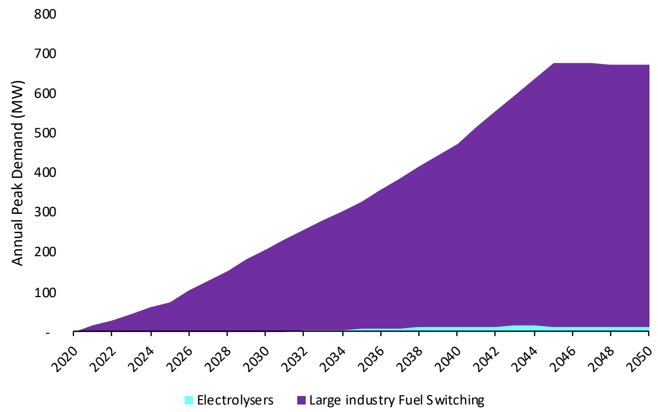


Figure 17 highlights some of the smaller, but still significant, contributors to Gross Peak Demand. Moving into the late 2030s and 2040s, new technologies such as electrolysers are expected to become more commonplace, as hydrogen production, management and usage matures and become more widely adopted. The Humber region is already positioning to become a leading hydrogen cluster, which we expect will contribute to this increase in electrolysers. Industrial fuel switching will also have an impact on Gross Peak Demand, as electricity becomes the primary fuel source for more heavy industries.

Forecast outputs: generation

Over the next 30 years, it is expected that generation capacity will increase on the distribution network that we operate. Falling costs of generation from LCTs such as solar PV will have an impact, as more of our customers consider investing in this technology at a domestic or commercial level.

Total generation

Figure 18: Total Non-renewable DG

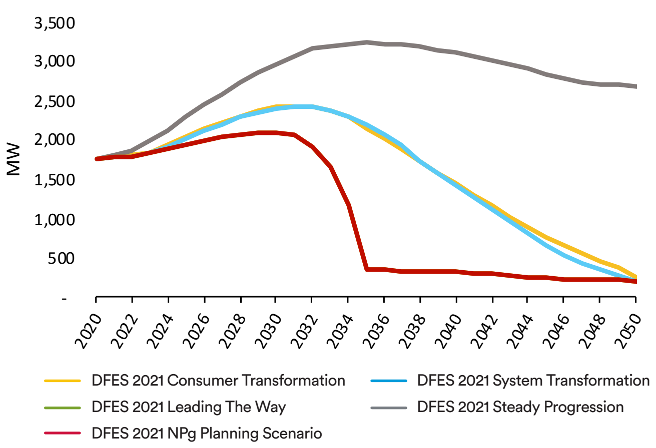


Figure 19: Total Renewable DG Capacity

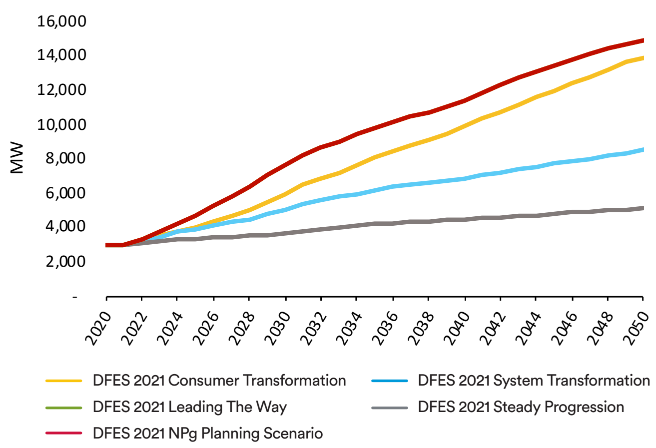


Figure 18 highlights that in all scenarios that reach net zero by 2050, fossil fuel and non-renewable generation will be phased out across our region by 2050. Our Planning Scenario and Leading The Way scenario share identical assumptions from 2021 until 2050, with both scenarios forecasting that non-renewable generation will see a small increase between now and 2030, followed by a swift phase-out between 2030 and 2035. The System Transformation and Consumer Transformation scenarios both anticipate a steeper increase in non-renewable generation between now and 2030, followed by a gradual phase-out of the technologies by 2050. Our assumptions include the expectation that some existing non-renewable generation will be adapted to run on renewable sources over time.

In contrast to the phase-out of non-renewable distributed generation (DG) capacity shown in figure 18, figure 19 highlights that renewable generation capacity is expected to increase significantly. In the Planning Scenario, Leading The Way and Consumer Transformation, renewable generation is set to increase consistently to around five times its current capacity in 2050. The Planning Scenario and Leading The Way scenario share identical forecasts for the period, with renewable generation reaching over 15 GW by 2050. In comparison, Consumer Transformation forecasts renewable generation to be around 1 GW lower, at over 14 GW. The System Transformation scenario anticipates a smaller increase in renewable DG capacity, peaking in 2050 at around 8500 MW. This is due to the assumption that System Transformation includes more hydrogen fuel switching to achieve net zero by 2050, which would result in fewer customers and businesses investing in electricity generation. Under the Steady Progression scenario, renewable generation would increase only slightly. Steady Progression would not meet net zero by 2050.

Types of renewable generation

The cost of renewable generation technologies is falling. Solar panels are now 82 per cent cheaper than they were a decade ago, and new policies to lower the carbon footprint of new build domestic properties could see a steep increase in domestic rooftop solar PV.[1,2] Our Planning Scenario is our "best view" scenario (see annex 5) and highlights that renewable DG capacity will grow fivefold between now and 2050. Below, figures 20, 21, 22 & 23 highlight what we anticipate the energy mix will look like over the next three decades in the Planning Scenario, and the expected growth in wind and solar generation technologies in all scenarios.

Figure 20: Residential PV Capacity

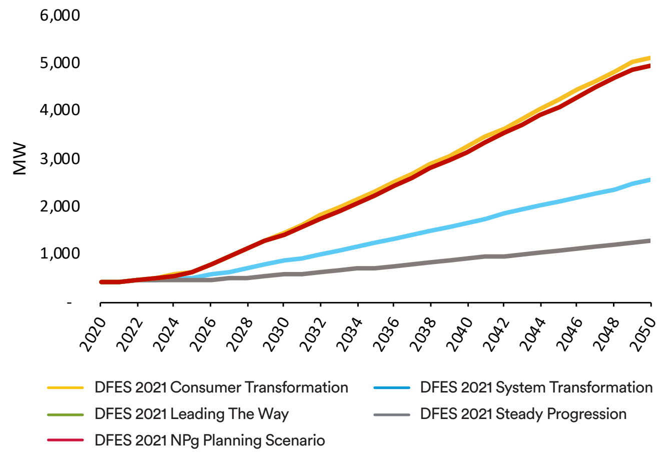
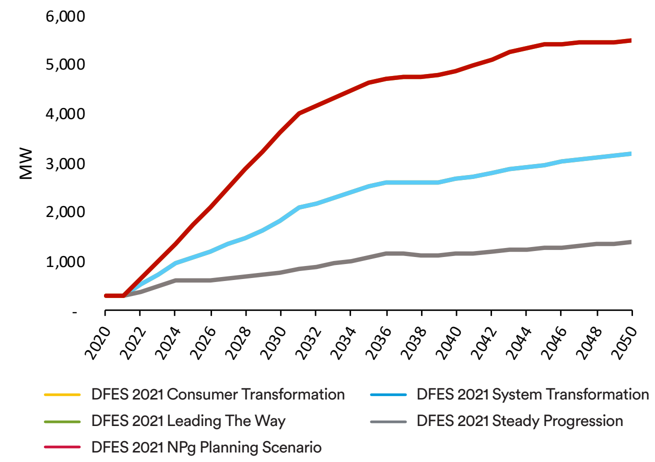


Figure 21: Large Scale PV capacity



As solar PV becomes cheaper and more accessible, we expect more homeowners and residences to install rooftop or free-standing solar PV systems to generate their own power. The Consumer Transformation scenario predicts the greatest amount of solar PV uptake of the five scenarios, with more than 5 GW of installed capacity expected by 2050. Our Planning Scenario and Leading The Way once again have identical assumptions and expect only marginally lower uptake compared to Consumer Transformation, with just below 5 GW of capacity expected by 2050. The trend reflected by all three scenarios anticipates an increase of approximately 1 GW of additional residential solar capacity every five years.

These three scenarios will deliver a substantial change to the way we operate and manage our network. It will change the relationship we have with our customers as more begin to generate their own electricity, resulting in more bi-directional power exchanges with our network.

Under more conservative scenarios such as Steady Progression or the hydrogen-forward System Transformation, we still expect residential solar PV capacity to steadily increase over time until 2050, due to the inherent benefits of owning residential solar capacity. The System Transformation scenario expects solar PV to steadily rise to over 2 GW by 2050. The Steady Progression scenario, which does not reach net zero, still expects residential solar PV capacity to reach over 1 GW by 2050.

Our Planning Scenario and Leading The Way also expect significant growth for large-scale solar PV capacity, with accelerated uptake to be front-loaded and reach 4 GW before 2030 in both scenarios. This is due to the falling cost of solar PV and the increasing trend of building large-scale solar PV to offset business electricity bills and operational costs. Many new large-scale solar PV sites are also accompanied with battery energy storage, as developers seek increased profitability and optimisation for supply-side flexibility.

Consumer Transformation and System Transformation share identical forecasts for large-scale solar generation, which predict a lower rate of increase in capacity. This is caused by a greater focus on domestic generation in the Consumer Transformation scenario, while hydrogen fuel switching in the System Transformation scenario is the reason for reduced capacity.

As with residential solar PV, all scenarios show an increase in large-scale solar PV sites reaching 1-5 GW of installed capacity by 2050.

1. https://www.solarpowerportal.co.uk/news/solar_pv_costs_fall_82_over_the_last_decade_says_irena
2. https://www.gov.uk/government/news/new-homes-to-produce-nearly-a-third-less-carbon

Figure 22: Wind Energy Capacity

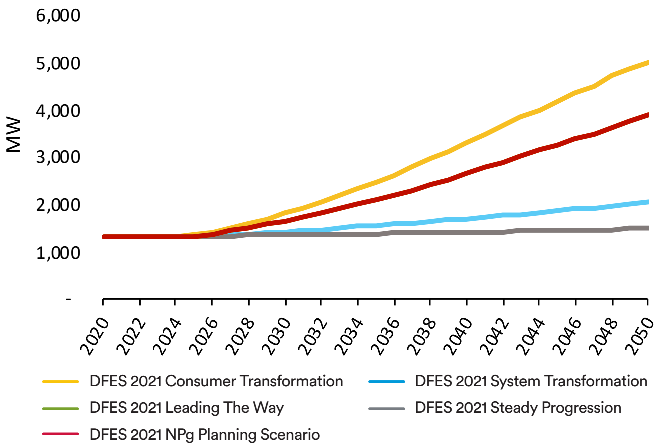
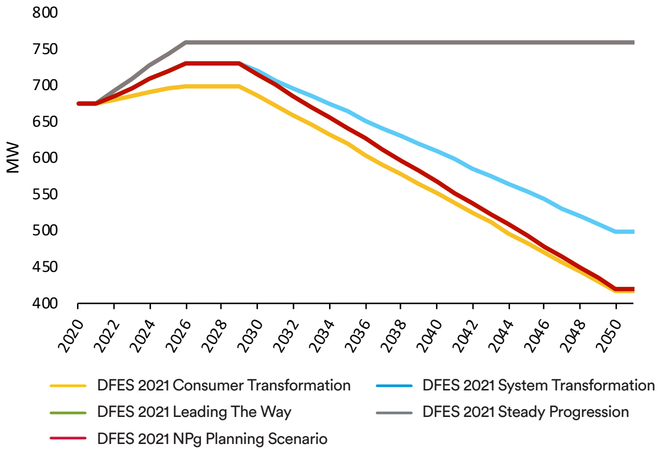


Figure 23: Total Biomass and Energy Crops DG Capacity



Onshore wind energy capacity displays varying pathways between the scenarios. Under the Consumer Transformation scenario, we expect onshore wind capacity to increase to approximately 5 GW by 2050. This indicates a shift in behaviour, as consumers and businesses support and invest in onshore wind energy capacity.

Our Planning Scenario and Leading The Way once again share the same forecast and both project a more conservative estimate of approximately 3.5 GW of capacity and the Steady Progression and System Transformation scenarios anticipate small to negligible increases in onshore wind capacity by 2050.

In all scenarios, our modelling highlights that biomass and energy crops could increase as a proportion of distributed generation capacity until 2025. This is then expected to plateau as capacity for this type of generation is reached.

The Steady Progression scenario, which demonstrates less solar PV and wind capacity, presents the greatest amount of biomass and energy crop capacity. The Consumer Transformation, Leading The Way and System Transformation scenarios share the same forecast, which anticipates capacity to be significantly lower than Steady Progression by 2050. This is due to zero carbon generation technologies such as solar PV and wind taking precedence in these scenarios; there will be less need for biomass which, while renewable, does still generate CO_2. Our Planning Scenario sits between these projections and predicts biomass and energy crop generation to reach approximately 750 MW capacity by 2050.

Distributed energy mix

Figure 24: Distributed Generation Mix in 2050

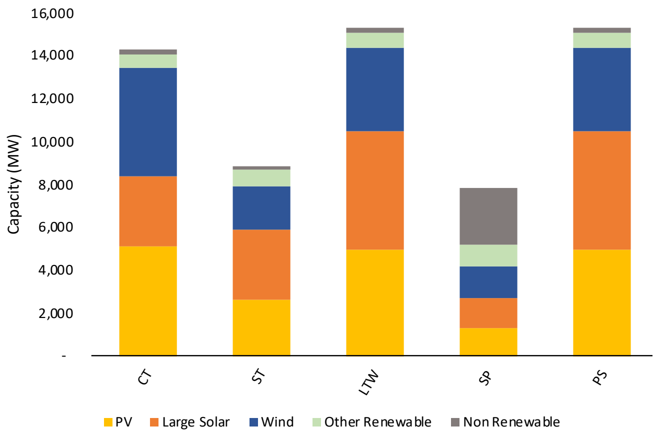
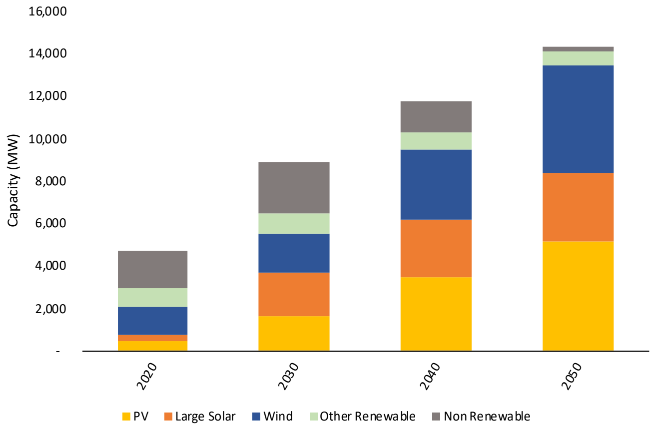


Figure 25: NPg Distributed Generation Mix Through Time (Planning Scenario)



Across all five scenarios there is significant variation in the volume and mix of electricity generation technologies by 2050. DG capacity in the Steady Progression and System Transformation scenarios is predicted to be significantly lower than the other three scenarios, with both reaching around 9 GW. This is a result of lower levels of electrical fuel switching in favour of hydrogen, in the case of System Transformation, or the continued use of fossil fuels in 2050 for the Steady Progression scenario, where by 2050 non-renewable generation would still account for around 2 GW generation capacity.

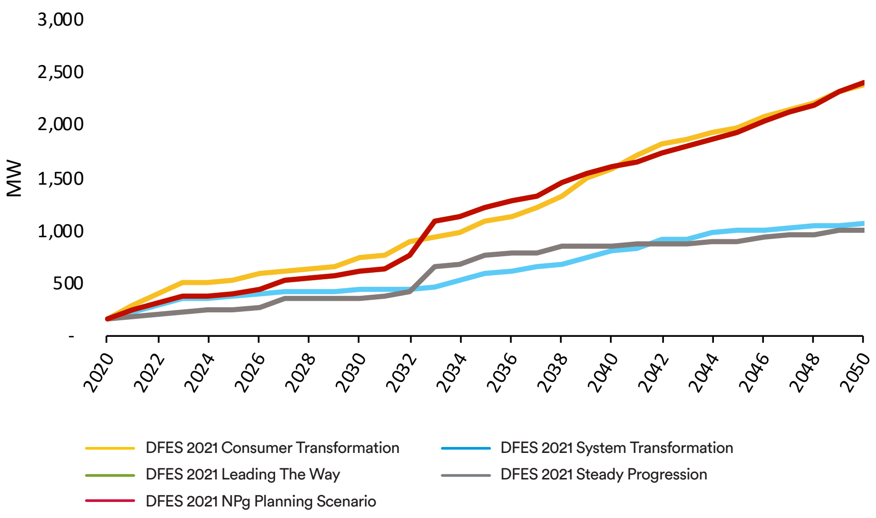
For the remaining three scenarios, DG capacity is expected to be more than 14 GW. Each scenario shares broadly similar mixes of generation types, however, it is notable that in the Consumer Transformation scenario, less large-scale solar capacity is expected with a greater proportion of the DG mix coming from onshore wind.

In our Planning Scenario, the DG mix is set to undergo significant changes over the next three decades. At present, the highest proportion of generation comes from non-renewable sources and onshore wind. During the 2030s, our Planning Scenario accounts for around 3 GW of non-renewable DG but predicts large increases in large-scale solar generation and domestic solar PV capacity of around 2 GW each.

By 2040, the volume of non-renewable generation falls to well below 2 GW, despite total capacity increasing by more than 3 GW. This is thanks to a 4 GW increase in domestic PV, large-scale solar and onshore wind. By 2050, only 248 MW of non-renewable DG is forecast to be connected to our network, with large increases in onshore wind and domestic solar capacity driving another 4 GW increase in renewable generation, bringing the total to 14.5 GW of DG connected to our network.

Forecast outputs: storage and flexibility

Figure 26: Storage Capacity



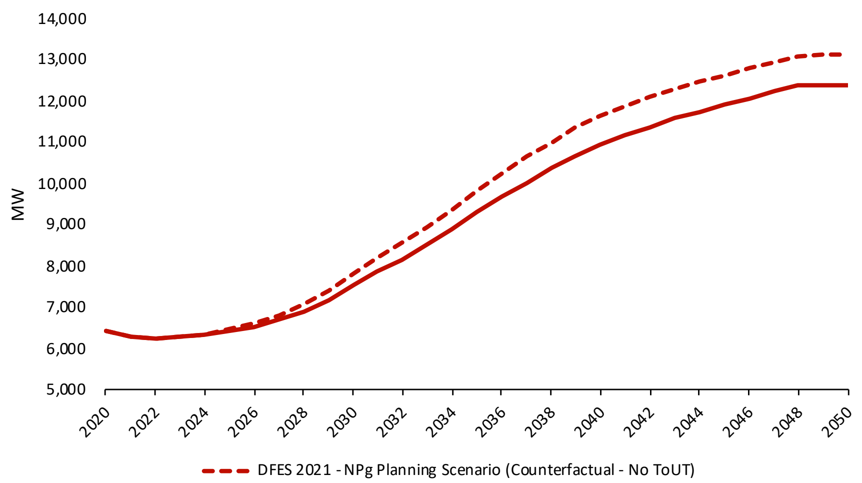
In all five scenarios, electrical energy storage, including domestic and large scale capacity increases steadily until 2050. Please note that for electrical energy storage our Planning Scenario and Leading The Way both forecast the exact same uptake.

Storage capacity is expected to follow the same trajectory as many LCTs, mirroring the expected uptake of those such as EVs, heat pumps and domestic solar PV. The falling price of battery storage is predicted to be the main driver of storage uptake. In all scenarios electrical energy storage will provide better grid flexibility and more options for commercial and domestic energy management.

Consumer Transformation, Leading The Way and our Planning Scenario anticipate over 2 GW of energy storage in the late 2040s. One reason for this is likely to be the co-installation of storage with large wind and solar PV projects to help store the intermittent energy for use at times of Peak Demand. This logic also applies at a smaller scale and many consumers with domestic solar PV arrangements may also consider investment in domestic battery storage to improve their home energy management.

The System Transformation scenario shows steady growth in storage capacity until 2030, which slows during the 2040s as advances in hydrogen technology displace the flexibility services provided by electrical energy storage in the more ambitious scenarios. Steady Progression expects slower uptake of storage capacity overall; this is related to low build-out of renewable energy generation.

Figure 27: Gross Peak Demand in MW (Planning Scenario includes Customer Price-driven Flexibility (ToUT))



Flexibility, shown in figure 27, is demonstrated by the Gross Peak Demand for our network in MW. This graph only shows our Planning Scenario because it is our best view scenario and contains the higher-certainty local assumptions that can be tailored for the flexibility changes in our region.[1]

A high adoption of Time of Use Tariffs (ToUT) by residential and industrial energy (as shown in figure 27, Northern Powergrid Planning Scenario) will lower Gross Peak Demand because customer price-driven flexibility through ToUT will help distribute power away from times of peak demand. For example, EV smart charging technology with a ToUT will determine the best time to charge assets such as EVs, to both avoid constraining the network at times of high demand and enable customers to take advantage of cheaper electricity prices at times of low demand.

The dashed line shows a counterfactual view where the customer price-driven flexibility that we are expecting to become embedded in the network does not materialise.

The impact of customer-owned flexibility on Gross Peak Demand shifts the curve down from the counterfactual view, lowering the Gross Peak Demand by nearly 1 GW to around 12 GW. While the demand is still substantial, this impact would significantly improve our ability to manage demand on the network.

Customer price-driven flexibility

Customer price-driven flexibility refers to network flexibility that is derived from energy supply contracts and ToUT. There are three kinds of ToUT that we refer to in this definition:

- Domestic ToUT (for example with smart appliances such as washing machines switching on automatically at times of low demand)
- I&C ToUT (supplier contracts that apply ToUT to I&C operations)
- EV smart charging (smart chargers that optimise EV charging to avoid consuming energy at times of high demand)

Customer price-driven flexibility does not include flexibility that we would procure in our DSO role from our customers by offering financial incentive. E.g., Demand Side Response.

1. We cannot show the impact of flexibility on the FES-aligned scenarios because our assumptions about flexibility are related to different needs compared to National Grid ESO, and therefore our modelling for flexibility would be incompatible with National Grid ESO's assumptions.

Conclusions

The next few decades

We hope you have enjoyed reviewing our 2021 scenarios. They are, of course, just showing a snapshot in time – our best thinking and modelling about how the world may look in the future based on everything we know now.

However, after modelling these numbers over successive years there are some very clear conclusions we can draw.

Firstly, that we will see a region, a nation and a world that is more reliant on electricity. While some energy vectors may influence exactly how much electricity we need as a society (hydrogen take-up, for instance), we can be confident that use will increase.

Secondly, the major step change to a more bidirectional nature of electricity use on the local grid – such as the one we operate – as we see more and more 'pro-sumers', localised storage and peer-to-peer trading in the decades to come.

Thirdly, an enduring conclusion. Once again, the DFES show us the importance of collaboration across our region. Understanding what the users of our network are doing today, plan to do tomorrow and aspire to do in the future is critical to our planning and investment. Ultimately, the further forward we investigate the future, the more uncertain everything becomes, and only good planning and agile reaction can ensure resilient networks for our customers – ready for whatever the future holds.

2020s

The 2020s are a fascinating decade from a load profile perspective, because we see an escalation of behaviour change on our region's roads as the switch to EVs maintains momentum (a momentum that has already – just a year into the decade – surpassed expectation), which would normally incur a major uplift in electricity demand. However, technology advances are not only taking place under the bonnet but in the fabric of our buildings and the quality of our appliances. The EV surge of the early part of the 2020s will be largely offset by improvements in energy efficiency. This is something we see across all scenarios.

The end of the decade will see a different picture starting to emerge. While e-mobility will gain traction in the front end of the decade, the behaviour change of the late decade will belong to heating, with three consumer-led scenarios (Consumer Transformation, Leading The Way, Planning Scenario) seeing heat pump uptake accelerating and the Planning Scenario and Leading The Way showing a higher uptake of heat pumps in the 2020s.

In the late 2020s all scenarios also see the maturation of heavy EV technologies and the subsequent charging infrastructure, placing more electric buses and electric HGVs on our region's roads.

On the generation side, the scenarios collectively show a small increase in non-renewable DG, which suggests that fossil fuel phase-out will not happen in this decade. But, over the 2020s, renewable DG will rise steadily – in the case of the Planning Scenario, ending the decade with around three times the current capacity. The increase in renewable DG capacity will largely be due to early investment this decade in residential PV solar and I&C large-scale solar PV as homes and businesses take advantage of cheap prices.

Similarly, energy storage is set to steadily increase throughout the 2020s in the Consumer Transformation, Leading The Way and our Planning Scenario, which indicates that, as the cost of storage technologies fall, uptake increases.

This means that it is imperative that we use the remainder of this decade to ensure that the network is ready for change. Our 2023-38 business plan does exactly this. The plan is based on delivering the outcomes of our best view "Planning Scenario" and sets out to unlock £3.3bn of investment to help prepare our network and support our customers on the road to net zero emissions.

2030s

The 2030s are a decade of great change. In all scenarios, the 2030s show the steepest increase in electrical energy consumption and Gross Peak Demand. Customers will either now own one or more LCTs, and many will be preparing to invest in them once legacy technologies such as gas boilers and petrol/diesel cars cease to work. From 2030 in the UK, all new car sales will now be electric.

The 2030s also sees the phase-out of fossil fuels. Apart from Steady Progression, all scenarios see non-renewable DG fall and in the case of the Planning Scenario, non-renewable DG hits a low of below 500 MW in 2035, then very slowly continues to decline. The rapid fall though happens between 2030 and 2035.

Renewable capacity continues to increase throughout the 2030s but in all scenarios, this change happens largely at the same rate as in the 2020s – this is probably because renewable generation technologies such as solar and wind are mature in comparison to demand technologies and have likely already had their "acceleration" moment in the 2010s and are now on a steady growth trajectory.

The expected uptake of energy storage also increases at a steady rate rather than in a burst of acceleration, however, this could be due to this storage being seen as an accessory that complements other LCTs, rather than a crucial part of a household the way heating (heat pumps) or transport (EVs) are.

Ultimately, in all scenarios the 2030s is when change happens and happens fast. It is critical that we steer our customers, stakeholders, and network through this change with early investment in flexibility, capacity, and education, and ensure that we are on hand to help our customers accept and adjust to the transition.

2040s

The change we see in 2030s continues into the 2040s as climate targets draw closer.

Gross Peak Demand accelerates in the 2040s, most noticeably in our Planning Scenario, due to the impact of the increase in electric HGVs and buses on the network requiring large amounts of power to charge. It is also due to the impact of large industries switching their fuel sources to electricity.

During this decade, we see the rapid uptake of many LCTs begin to slow down as they reach saturation. The notable exception will be for heating: we expect heat pump uptake to continue to accelerate well into the late 2040s.

The 2040s are where flexibility management starts to come into its own. By this point, it is expected that most of our cars and heat sources will be electric, our heavy industry will be switching to be powered with electricity, and DG renewable generation will be steadily rising. This is a lot of additional capacity from both a supply and demand side that we need to manage.

In our Planning Scenario, customer price-driven flexibility shows maximum impact in lowering the Gross Peak Demand curve, and new bi-directional and smart technologies will enable us to utilise data to manage the flow of electricity so that our customers become both consumers and suppliers of power. Our flexibility-first approach, outlined in our **business plan**, explains in more detail how we envision this future.

2050

Four out of the five scenarios demonstrate how by the end of 2050, our region will have reached net zero carbon. The notable exception is Steady Progression – showing that societal behaviour change (which is limited in this scenario) is critical for meeting net zero in time to meet targets.

By the time we reach this decade our electricity system will be fully smart and flexible. It will be powered by renewable electricity and consumers will be empowered to engage with it in a way that improves their lives.

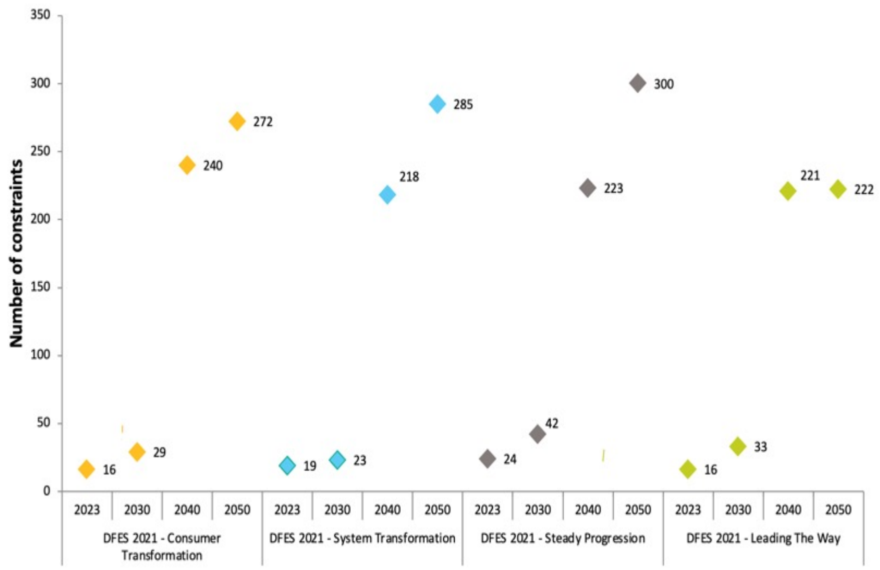
Hydrogen will be powering heavy industry. In some scenarios it will also be powering our heating – and in other scenarios, electric or hybrid-powered heat pumps will be keeping us warm.

On the roads of our region, people will be driving EVs, going to school in electric buses and having their bins collected by electric HGVs.

Thousands, if not millions, of homes will have solar PV on the roof, and large-scale solar PV and wind generation will be supported by on-site storage, to make the most of the intermittent technologies.

DFES 2021
Impact on our network

Figure 28: Primary and Major Substation Constraints (for each FES aligned scenario)



All FES-aligned scenarios predict that huge increases in electrical energy consumption will lead to increases in Gross Peak Demand, and all scenarios also predict increases in distributed generation across our region. We must prepare our network to deliver these significant changes for our region to transition to net zero.

Figure 28 shows how, in all the FES-aligned scenarios, as we move through the decades to 2050 and LCT uptake increases, so too do the number of constraints on our network. The largest jump in number of constraints on our network happens between 2030 and 2040. This is to be expected, as this decade has the largest uptake of LCTs and is predicted in all scenarios to be the decade in which our society and our network undergoes the most visible change.
This is something that we must manage to avoid becoming a blocker to this low carbon future, and flexibility-first is strategy that we intend to employ to do so.

6. Visualisation tool: https://odileeds.github.io/northern-powergrid/2021-DFES/
7. Downloadable datasets: https://datamillnorth.org/dataset/northern-powergrid-dfes-2021/

Figure 29: Primary and Major Substation Constraints (with and without customer price-driven flexibility) - for our Planning Scenario

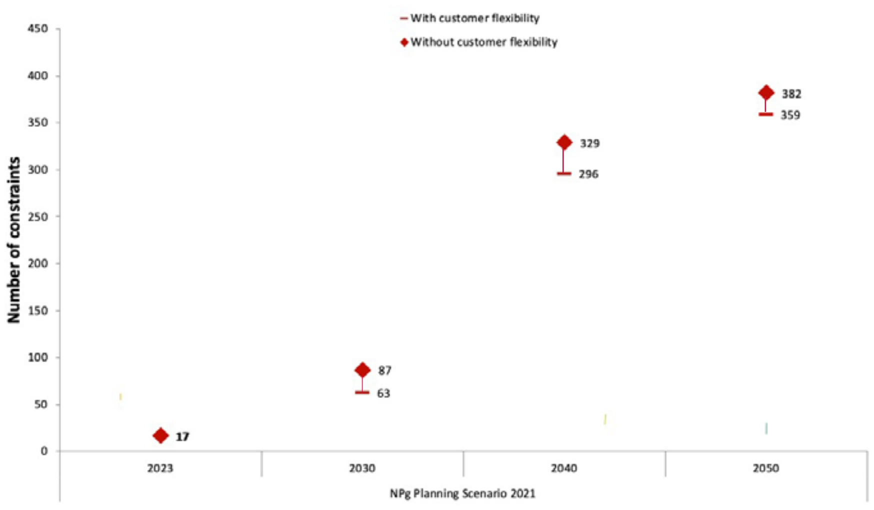


Figure 29 shows that our Planning Scenario expects the same trend in the increasing number of constraints over the decades. It also shows the expected constraints on our network for the Planning Scenario with and without price-driven customer flexibility.

Customer price-driven flexibility (see page 32) will help manage demand on our network. For example, customers utilising smart charging technologies that would automatically forego charging their EVs at times of high network demand. This would conserve power on the network to be used elsewhere. The customer would benefit by avoiding high costs of peak demand electricity and the network would benefit from the capacity.

Figure 29 shows the impact of this customer price-driven flexibility. The upper levels of constraints in each decade are marked as “without customer flexibility”. This demonstrates a counterfactual view, where the customer price-driven flexibility that we are anticipating becoming an embedded function of our network does not materialise. Figure 29 demonstrates how for the Planning Scenario, flexibility drives down the number of constraints to 254 (2040) and 323 (2050), in comparison to the counterfactual view.

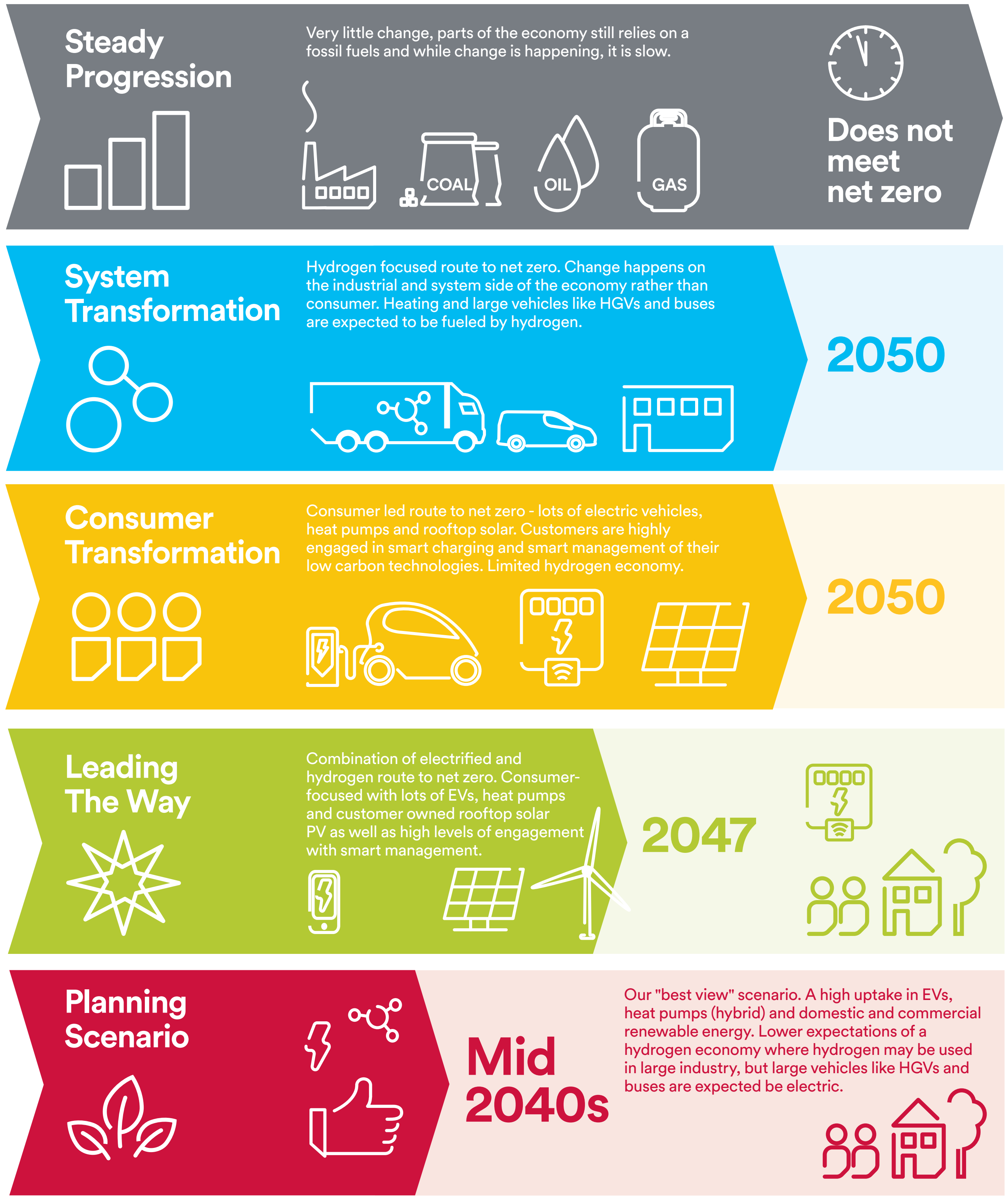
The DFES is a forecasting tool that we use to map out what our network will look like over the next 30 years. Data such as this helps us prepare the network for expected changes, and charts such as figure 29 give us an indication of what impact this will have, which allows us to set strategies and invest in measures to ensure that we can deliver this future.

To resolve the remaining constraints on our network, we have outlined our flexibility-first approach to network management in our business plan for 2023-28. This approach involves Northern Powergrid evolving further DSO capabilities, employing increasingly smart, and data driven technologies to procure flexibility and managing the network in a way that encourages our customers to utilise their assets to support our network operation.

1. We cannot show the impact of flexibility on the FES-aligned scenarios because our assumptions about flexibility are related to different needs compared to National Grid ESO, and therefore our modelling for flexibility would be incompatible with National Grid ESO's assumptions.

The roadmap to net zero

From 2021/22 to net zero by...



Engaging with our scenarios

Access to the datasets

Your feedback and collaboration are critical to ensuring that we have the most up-to-date data and insights to inform our modelling.

We have a long-running DFES partnership with Open Innovations in Leeds (formerly ODI Leeds) to provide an interactive visualisation tool that explains the DFES data in a meaningful way.

The data is regionalised to local authority boundaries and presented in geospatial maps that can be viewed by each DFES parameter. For example, you can use the tool to see how many EVs could be on the streets of Leeds every year between now and 2050, and how the different scenarios impact this number. Likewise, you could also view the expected increase in rooftop solar PV in Northumberland, and how that changes with each scenario.

The datasets are published on Data Mill North, including in raw data form if you wish to take our data and use it for your own purposes.

For ease of reference, we have produced MS Excel workbooks which show the forecasts on a local authority level alongside substation level data.

We understand that different stakeholders may wish to explore the data with a varying degree of granularity. We have therefore provided several datasets that will suit these various needs.

Alongside providing forecasts for key locations on the distribution network (such as primary substations or grid supply points), we have published datasets that display DFES at a local authority level. These include MS Excel workbooks with charting tools, which could be useful for viewing the data behind different LCT forecasts.

If you would like to view the data behind the geospatial map, substation level data can be found in CSV files, provided separately for each parameter and scenario combination.

A full description of datasets and documents published on Data Mill North can be found in Annex 3.

Have a parameter suggestion?

We can break down our data in many ways. We encourage you to get in touch with ideas for new parameters we could add: npg.system.planning@northernpowergrid.com

Definitions of each parameter have been provided at the end of this document in Annex 4.

Download the underlying data for each parameter: https://datamillnorth.org/dataset/northern-powergrid-dfes-2021/

More information about Northern Powergrid's regionally led scenarios: https://odileeds.github.io/northern-powergrid/2021-DFES/

Data user guide

Clicking within the substation or local authority boundary will reveal the data relevant to that geographic area.

You will see:
- the total value of the parameter selected (e.g., the total number of EVs) in the local authority area; and
- a bar chart with the breakdown for each of the relevant Northern Powergrid primary substations in the area (e.g., EV charging supplied by each substation).

New for 2021: zoom in to local data access with our postcode search function

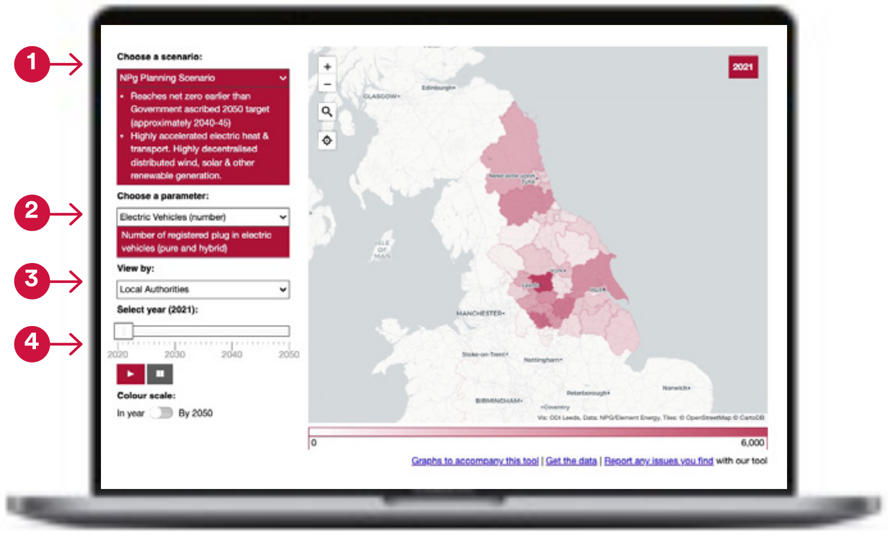
A new feature of our 2021 DFES is the postcode search function. When viewing the data, you can now add in postcodes to zoom in to data at street level.

The geospatial map includes a sliding bar for selecting the reference year and allows users to adjust the key variables, as follows:

1 Scenario:
- Regionalised view of National Grid ESO's FES:
  - Steady Progression
  - System Transformation
  - Consumer Transformation
  - Leading the Way
- Based on Northern Powergrid's accelerated decarbonisation pathway:
  - Planning Scenario

3 View by:
- Local authority areas
- Primary substations
- Primary substations (with local authority boundaries)

4 Scale:
- By 2050 – shades the map areas by reference to the maximum value (number or MW) in 2050 for the parameter within the boundary being viewed (substation or local authority)
- In year – shades the map areas by reference to the maximum number in the year being viewed



2 Parameters, including;
- Electric car, bus and heat pump numbers
- Domestic photovoltaic installed capacity (MW)
- Large solar generation installed capacity (MW)
- Wind generation installed capacity (MW)
- Total renewable generation installed capacity (MW)
- Energy storage installed capacity (MW)
- Domestic underlying energy consumption (MWh)
- Industrial and commercial underlying energy consumption (MWh)
- Total energy consumption including electric vehicles and heat pumps (MWh)
- Peak demand at primary substations (with and without customer flexibility)
- Peak utilisation at primary substations (with and without customer flexibility)
- Industrial fuel switching (including electrolyser use for hydrogen)

Engaging with our scenarios
Hope Valley Climate Action case study

Harnessing data for climate action

Our DFES data is part of a suite of resources that helps us to make long-term investment decisions about the network. It is also an open data tool that all stakeholders across our region can benefit from. All scenarios (except for Steady Progression) will have transformational effects on our energy system, and we encourage our stakeholders and customers to use our open data to ensure their decarbonisation plans are aligned with the changes that are taking place.

Hope Valley Climate Action (HVCA) is a grassroots climate action group in North Derbyshire. The organisation's goal is to drive climate action across travel, land use and energy in the Hope Valley area and community. With the support of our DFES 2020 open data, the group recently published its **Future Domestic Energy Demand report**, an insight into the future of household energy consumption and the benefits of tackling climate change.

What HVCA needed from us

The report's authors planned to complete their research by focusing on three scenarios for future domestic energy demand in the Hope Valley region. To undertake this research specific to the local area, HVCA planned to produce its own modelling to inform and support the findings of its research. To produce these models, the authors needed data.

After getting in touch with our DFES team, HVCA utilised the Open Innovations platform where stakeholders can access our DFES data in a visual and easy-to-use map format. As a DNO, we gather and interpret huge amounts of data, and we know how valuable this is to our stakeholders. So, when HVCA reached out to request our data, it was already available in an accessible format.

Dawn Ward, one of the authors of the report, said: *"Our research required detailed modelling of the future of energy demand in the Hope Valley region and for this, we needed as much data as possible. Northern Powergrid's data played a key part in our modelling, and it was extremely helpful to have it presented in an accessible format."*

Accessing our open data

All our DFES data from 2019 onwards is openly available on the **Open Innovations website**. HVCA was able to access our demand forecasts for Hope Valley and, alongside data from other sources, was able to complete its modelling to produce a comprehensive and insightful report on the future of domestic energy demand. Furthermore, HVCA offered valuable feedback on our DFES tools which we have taken onboard to improve stakeholder experience for DFES 2021.

HVCA's report will help drive awareness of the clean energy transition in the local community and demonstrates how our stakeholders and customers can take advantage of our open data to develop decarbonisation plans.

The future

We take pride in our DFES data and encourage our stakeholders from all sectors to consider how the data we provide openly can support their low carbon ambitions. HVCA's grassroots climate leaders have harnessed our data to produce the Future Domestic Energy Demand report to support their community and help deliver a local energy transition. Whether you are a car dealership planning your strategy for electric vehicle sales or a local authority seeking to plot heat pump uptake in your communities, our DFES team and open data is here for you.

To find out more about what our DFES data can do for you, get in touch via **npg.system.planning@northernpowergrid.com**

Engaging with our scenarios
We want to talk to you

The energy requirements of our region for 2050 are uncertain. Therefore, we must remain agile in our planning. As we emerge from a seismic year for net zero ambition, underpinned by COP26 and major Government announcements on heating and transport, decarbonisation is at the forefront of our stakeholders thinking.

This DFES is yours

Electric vehicle numbers are growing, heat pumps are replacing gas boilers and more solar panels are appearing on our roofs. It is you, our stakeholders, whose plans are driving our regions' net zero ambition.

The DFES for 2021 form an important part of our planning and for us, it is crucial it reflects your needs.

We want to hear more about your plans

We need to continually improve baseline planning forecast, which helps us plan investment based on the future energy needs of our region. To ensure our forecasts are as accurate as possibtle, we want to understand our stakeholders' plans.

So, whatever your plans, we're interested. From the installation of a single heat pump to the construction of a distribution centre with hundreds of EV chargers.

That is why we are proactively engaging with stakeholders, to understand your views and inputs into our range of scenarios. These will help us manage uncertainty and plan cost-effective and decarbonisation-enabling investments that keep the power flowing for 8 million people and support our region's transition to net zero.

Harnessing our data

While we will use your feedback to refine our DFES and support effective network planning, we want to ensure you can utilise the wealth of data we hold about the future of our region's energy system.

Our DFES 2021 data is published in an open data format so that you can use this information to support your ambitions and plans. Stakeholders are already using DFES data to progress their goals and as part of our DFES 2021 engagement, we will proactively seek to support others to understand the value of our open data and the best way to harness this information to achieve their goals.

How to talk to us

We are happy to receive your feedback in whatever format and encourage engagement from our stakeholders all year round.

To share information with our team, you can send an email anytime to: **npg.system.planning@northernpowergrid.com**

And while we are always here for you to come and talk to us, we will be reaching out to you in 2022 with a proactive campaign to learn more about our stakeholders' plan and ambitions. You will have the opportunity to talk to us via:

— Online surveys;
— Events (virtual and in person);
— Polling via our social media channels; and
— 1-to-1 meetings.

Getting your data into our DFES is important to us. That is why we are reaching out to you, to make it as easy as possible for your plans to be included in our forecasts so that we can make investment decisions

Glossary

Bioenergy with carbon capture and storage (BECCS): the process of extracting bioenergy from biomass and capturing and storing the carbon dioxide.

Biomass: Organic matter that can be used to generate electricity e.g., wood, forest residue, plant materials.

Carbon capture, utilisation and storage (CCUS): The process of capturing carbon dixoide to be recycled for further usage.

Climate Change Committee (CCC): Independent, statutory body that advisors the UK and devolved governments on reducing greenhouse gas emissions (GHG) and adapting for climate change impacts.

Decarbonisation: The reduction, and ultimately elimination, of GHG emissions.

Decentralised energy system: A system where small-scale energy generation units, connected to the distribution network, deliver energy to local customers.

Demand Side Response (DSR): Changes in the power consumption of an electric utility customer to match the demand for power with the supply. Often supported with financial incentive.

Digitalisation: Focused digital and technology agenda that supports the integration of digital technologies to improve Northern Powergrid's everyday business activities.

Distributed Energy Resource (DER): Smaller-scale power generators and controllable loads (like electric vehicles) that are connected to the local distribution network.

Distributed generation (DG): Embedded and distribution connected generation; these are generators connected to the distribution system, rather than the transmission system.

DNO: Distribution Network Operator – DNOs own, operate and maintain the electricity distribution networks.

DSO: Distribution System Operation – Secure operation and development of an active distribution system comprising of networks, demand, generation and other flexible DER.

Electrolyser: A device that splits water into hydrogen and oxygen using electrical energy.

ESO: Electricity System Operator – National Grid ESO is the electricity system operator for Great Britain, managing national electricity flows to ensure that supply and demand are balanced.

EV: Plug-in electric vehicle, conventionally powered by a lithium ion battery.

EHV: Extra high voltage – electricity supplied at 33,000 volts and above.

GB FES: Future Energy Scenarios for Great Britain. The Energy System Operator's scenarios outline four different credible future of energy pathways for the next 30+ years. GB FES considers energy demand and supply on a wholesystem basis.

Flexibility: The ability to increase or decrease the production or consumption of energy at a given or requested time in order to support the wider electricity network and optimise capacity available for customers.

Fuel poverty: A household is considered to be fuel poor if they live in a property with a fuel poverty energy efficiency rating of band D or below and, when they spend the required amount to heat their home sufficiently they are left with a residual income below the official poverty line.

Geospatial mapping: Spatial analysis techniques that typically employs software capable of rendering maps, processing spatial data, and applying analytical methods to terrestrial or geographic datasets, including the use of geographic information systems.

Gross Demand: The total energy demand of a given region. It represents the quantity of energy necessary to satisfy consumption within the designated geographical region.

GW: Gigawatt – one thousand megawatts (million kilowatts) of electrical power.

GWh: Gigawatt hour – a measure of electrical energy equivalent to a power consumption of one thousand megawatts (million kilowatts) for one hour.

Heat pump: An electrical device that transfers heat from a local source (air, ground or water) to the space to be heated. Typically uses three to four times less electricity than direct electrical heating due to the availability of heat from the local source. As the electricity system decarbonises, so does this sort of heat supply.

HEV: Hybrid electric vehicle that combines a conventional internal combustion engine (ICE) with an electric propulsion system powered by a battery. May plug-in to charge the battery or work on fuel only.

HGV: Heavy goods vehicle – any truck with a gross combination mass of over 3,500 kg.

HV: High voltage – electricity supplied between 1,000 and 20,000 volts.

Hydrogen: a fuel produced by separating hydrogen from other molecules using one of a number of processes.

ICE: Internal combustion engine – a heat engine in which the combustion of fuel occurs to power a vehicle. Traditionally run on petrol or diesel fossil fuels.

I&C: Industrial and commercial (sector).

Industrial fuel switching: The process of switching from traditional fossil fuels to low carbon fuels like biomass, hydrogen and clean electricity to power industry.

kW: Kilowatt – one thousand watts of electrical power.

kWh: Kilowatt hour – a measure of electrical energy equivalent to a power consumption of one thousand watts for one hour.

Low carbon energy system: An energy system which uses energy sources that do not produce carbon dioxide emissions during operation, such as solar and wind.

Low carbon technologies (LCTs): Technologies that have the ability to reduce carbon dioxide emissions traditionally associated with energy consumption (e.g., electric vehicles, electric heat pumps, solar panels).

LV network: Low voltage network – network less than 1,000 volts.

MW: Megawatt – one thousand kilowatts of electrical power.

MWh: Megawatt hour – a measure of electrical energy equivalent to a power consumption of one thousand kilowatts for one hour.

Net zero: Legally binding greenhouse gas emissions target which requires UK to reduce nearly all of its GHG emissions by 2050 (compared to 1990 levels).

Network constraints: Areas of the network where the demand or generation exceed the designed network capacity, voltage or fault level limits

Peak demand: The greatest amount of electricity used on the network within a given time period (typically a year).

RIIO-ED1 or ED1: The current price control period for electricity distribution network operators which runs from 1 April 2015 to 31 March 2023.

RIIO-ED2 or ED2: The next regulatory price period, set by Ofgem, which runs from 1 April 2023 to 31 March 2028.

Smart grid: An electricity network including two-way digital communication technology that enables advanced network management techniques along with wider and more effective use of DERs and LCTs.

Solar PV: Solar photovoltaics – solar panels.

Time-of-use tariff: Tariff that reflects the true cost of electricity based on the time, i.e., higher at peak times and lower at times when the demand is low relative to the supply.

ULEV: Ultra-low emission vehicle – low emission vehicle that emits 75g/km carbon dioxide or less.

Annexes
Annex 1: Assumptions and building blocks

In this annex, we describe the five modelled regional scenarios:

1. Regionalised view of the National Grid Future Energy Scenarios (FES) Steady Progression that is incompatible with net zero by 2050.
2. Regionalised view of the FES System Transformation that meets net zero by 2050 with a major shift to hydrogen.
3. Regionalised view of the FES Consumer Transformation that meets net zero by 2050 with an increased reliance on electrification.
4. Regionalised view of the FES Leading the Way that delivers net zero earlier by 2047 through more ambitious changes.
5. Northern Powergrid Planning Scenario that meets net zero even earlier, by the mid 2040s, with some even more urgent decarbonisation actions and assumptions.

Steady Progression

Does not meet the net zero carbon target in 2050.

— Energy demand: UK misses clean growth strategy target to improve business and industry energy efficiency by 20 per cent by 2030. Slow progress with energy demand reduction as heat and industrial processes become more efficient. Low fuel prices.
— Electricity demand: No major shift in demand as consumers buy similar appliances to today. EU targets missed.
— Gas demand: No strong mandate from public for strong decarbonisation drive and thus no step change in policy. Pilot projects on clean heat solutions do not scale and incentive schemes are not extended. Heat networks are not decarbonised and remain largely unregulated.
— Generation: Slow transition to decarbonisation however progress is still likely to be substantial as generation switches to low carbon sources.
— Gas supply: Traditional sources of supply continue to be used.
— Hydrogen: Low hydrogen levels. Hydrogen demand is not significant enough to justify imports.
— Flexibility: Limited customer flexibility. Low consumer and industry and commercial (I&C) engagement in smart systems, vehicle–to–grid adoption levels remain low, and we see slow growth in the demand side response (DSR) market.
— Transport: Consumer resistance and other barriers mean slower uptake of electric cars and limited at-home charging. Gas seen as a viable way of decarbonising heavy goods vehicles (HGVs) and buses. Low growth in public transport usage.
— Support mechanisms: Carbon taxation remains low. Unpopular, difficult, uncertain or expensive decisions delayed or not taken at all.

System Transformation

Meets the net zero carbon target in 2050.

— Overall: High usage of hydrogen for heating and other energy demands.
— Energy demand: I&C energy efficiency improves by 20 per cent by 2030. All credible industrial processes to be considered for a switch to hydrogen fuel source.
— Electricity demand: Good progress in efficiency but UK still misses EU 30 per cent target. Consumers move towards smaller or more portable appliances and heat and industrial processes are moved to hydrogen where credible. Cars may use hydrogen after 2030.
— Gas demand: A self-sustaining hydrogen economy develops at a national scale. Industrial processes are moved to hydrogen where credible. Hydrogen boilers in commercial settings. Domestic heat networks switch to mainly hydrogen and electricity-based solutions adopted in new build properties.
— Generation: Major development of renewable technologies but are geared slightly towards larger, more centralised projects.
— Gas supply: High demand for hydrogen, carbon capture and storage (CCS) rolled out at scale. Low electrification.
— Hydrogen: High levels of hydrogen usage for heat, I&C and transport. Multiple steam methane reforming (SMR), autothermal reforming (ATR) and carbon capture, utilisation and storage (CCUS) plants around the country meet the bulk of demand initially. Some electrolysis projects are developed. High levels of hydrogen storage. Stable government framework and support for capital investment.
— Flexibility: Medium consumer and I&C engagement in smart systems, vehicle-to-grid (V2G) adoption levels are low, and we see moderate growth in the DSR market.
— Transport: ultra-low emission vehicles (ULEVs) uptake requires further policy support. Growth in public transport is lower due to limited consumer willingness to switch from private transport. Hydrogen is the fuel of choice for HGVs and a larger proportion of the bus fleet than in other scenarios. Consumers somewhat engaged in smart charging however adoption of V2G is slowed by technology concerns.
— Support mechanisms: High carbon tax. Key political decisions made in the mid-2020s. Clear effective policy/pricing creates clarity for zero carbon technologies.

Consumer Transformation

Meets the net zero carbon target in 2050.

— Overall: Pathway has a relatively high consumer impact.
— Energy demand: I&C energy efficiency improves by at least 20 per cent by 2030. All credible industrial processes will be electrified.
— Electricity demand: UK meets EU 30 per cent target. Consumers rapidly move towards smaller or more portable appliances. Heat and transport are mostly electrified.
— Gas demand: Industrial processes are electrified where credible. Sustainable hydrogen economy does not to materialise. Heating is largely electrified using a combination of building level technologies and district heating.
— Generation: High level of development in renewable technologies. Geared slightly towards smaller, more decentralised projects.
— Gas supply: High electrification levels leads to low demand for gas.
— Hydrogen: Medium/low levels of hydrogen produced via electrolysis, used in transport, I&C and some heating. Hydrogen used for peaking plant.
— Flexibility: High consumer and I&C engagement in smart systems, V2G adoption levels are low, and we see strong growth in the DSR market.
— Transport: Consumer demand accelerates private EV adoption. Buses are predominantly electric, and a larger proportion of HGVs are electric than in other scenarios. Consumers highly engaged in smart charging and V2G and charging predominately happens at home.
— Support mechanisms: Stable government and regulatory policy/legislation. Key political decisions made in the mid-2020s, creating clarity for zero carbon technologies. High carbon taxation.

Leading The Way

Meets the net zero carbon target in 2047.

— **Overall:** This scenario shows the earliest credible date when the net zero target is met.
— **Energy demand**: I&C energy efficiency improves by at least 20 per cent by 2030. I&C decarbonises early through electrification (~first 15 years) followed by hydrogen when it becomes available.
— **Electricity demand:** EU residential electrical efficiency targets enhanced. Consumers rapidly move towards smaller or more portable appliances. Heat and transport are mostly electrified.
— **Gas demand:** Aggressive emission targets set by communities and local and regional authorities drive faster adoption of low-carbon technologies. Strong emphasis on speed of progress. Solutions are a mix of electrification and hydrogen for heating.
— **Generation:** Highest levels of renewable/low carbon generation to support hydrogen production from electrolysis. A stronger push to develop new projects.
— **Gas supply:** Rapid uptake in hydrogen usage is needed to expediate decarbonisation.
— **Hydrogen:** Medium levels of hydrogen used in transport, industry and some heating.
— **Flexibility:** High consumer and I&C engagement in smart systems, V2G adoption levels are low, and we see strong growth in the DSR market.
— **Transport:** Targets to end sale of petrol, diesel and hybrid cars and vans are the most ambitious. V2G is pushed to enable more renewable generation. Charging happens in a wide range of forms (home, rapid, destination, etc.).
— **Support mechanisms:** Stable government and regulatory policy/legislation. Key policy decisions made in the mid-2020s, creating clarity for zero carbon technologies. Very high carbon taxation.

Planning Scenario

Meets electrification-driven net zero by mid-2040s while keeping all pathways open.

— **Overall:** This scenario is highly ambitious, enabling an electrification-driven decarbonisation strategy to reach net zero by the mid 2040s, while keeping all other credible decarbonisation pathways open.
— **Electricity demand:** Rollout of hybrid heat pumps at an early stage, allowing the heat pump market to build gradually through the mid to late 2020s ahead of the steep increase in roll-out rate required from 2030. By the mid-2040s, all high carbon heating systems become obsolete. Moderate uptake of consumer driven technologies such as domestic solar PV and batteries.
— **Gas demand:** Demand decreases through the decades.
— **Generation:** The incentivisation of renewable generation continues and offshore wind generation grows rapidly. The roll-out of CCS technologies is also successful and from the early 2030s and onwards, both gas CCS and bioenergy with CCS (BECCS) play a significant role in the generation mix.
— **Gas supply:** The gas grid still exists but at a reduced capacity relative to current levels and by the mid-2040s it is entirely converted within the Northern Powergrid region to delivering low carbon hydrogen serving customers on hydrogen hybrid heat pumps.
— **Hydrogen:** Becomes an important part of the mix after 2035, especially in hybrid heat pumps.
— **Flexibility:** A flexibility-first approach is taken, with high levels of customer engagement.
— **Transport:** Sector undergoes deep electrification. A ban on all internal combustion engine (ICE) vehicles as well as hybrid vehicles takes effect in 2030 resulting in the phase-out of fossil fuel-powered vehicles in the mid-2040s.The electrification of transport also extends to commercial fleets with buses and HGVs transitioning to electric power trains before 2050.
— **Support mechanisms:** Early and bold action from Wthe government is supplemented by intensive investment in LCTs.

Assumption name	Steady Progression	System Transformation	Consumer Transformation	Leading The Way	Planning Scenario
Heat Pump	Low	Medium	High	High	High
Battery Electric Vehicles (BEVs)	Low	Medium	High	High	High
Wind (onshore)	Low	Medium	High	High	High
Solar generation (plant greater than 1 MW)	Low	Medium	Medium	High	High
Medium duration electricity storage	Low	Medium	Medium	High	High
Solar generation (plant smaller than 1 MW)	Low	Medium	High	High	High
Home thermal efficiency levels	Low	High	High	High	Medium
Appliance models: residential electrical energy efficiency	Low	Medium	Medium	High	Medium
Smart appliances	Low	Medium	High	High	High

Annex 2: LCT uptake scenarios and their network impacts

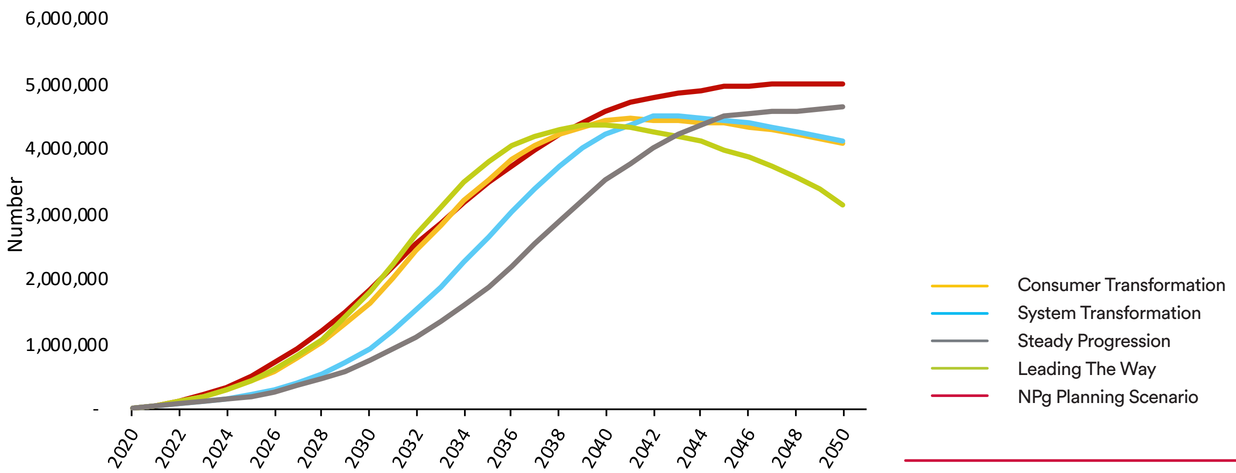
Demand

The following charts and tables show the Northern Powergrid forecast for the potential uptake of electric vehicles, heat pumps and other low carbon technologies that consume energy. We have provided the underlying data on the Open Innovations website with disaggregation down to local authority and primary substation level.

Electric Vehicles

	2020	2030	2040	2050
Consumer Transformation	37,328	1,655,344	4,431,205	4,086,045
System Transformation	37,328	951,624	4,226,193	4,133,725
Steady Progression	37,328	747,496	3,517,763	4,636,643
Leading The Way	37,328	1,812,382	4,363,767	3,160,521
Planning Scenario	37,328	1,851,101	4,596,745	5,021,138

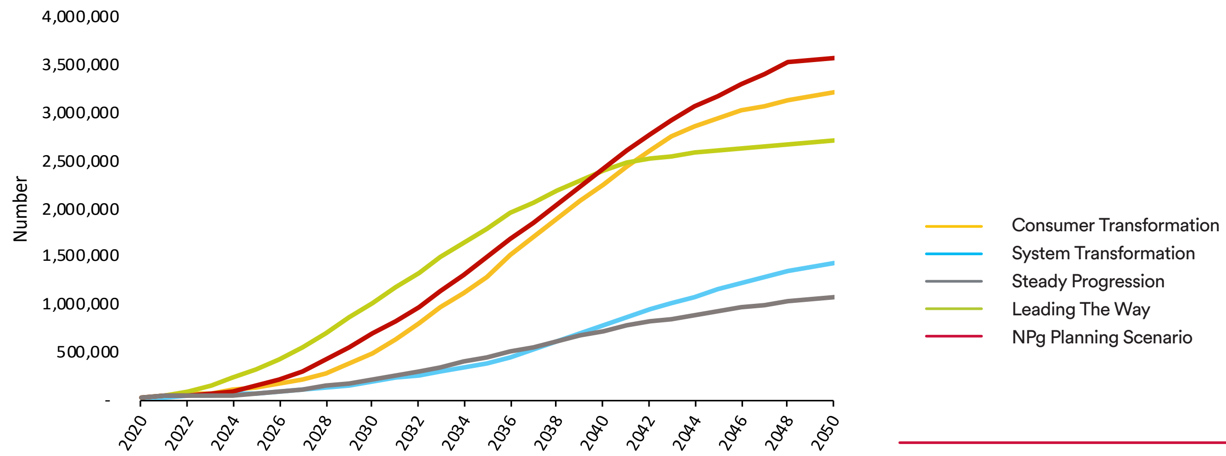
Figure 30:
Electric vehicle uptake forecast



Heat pumps

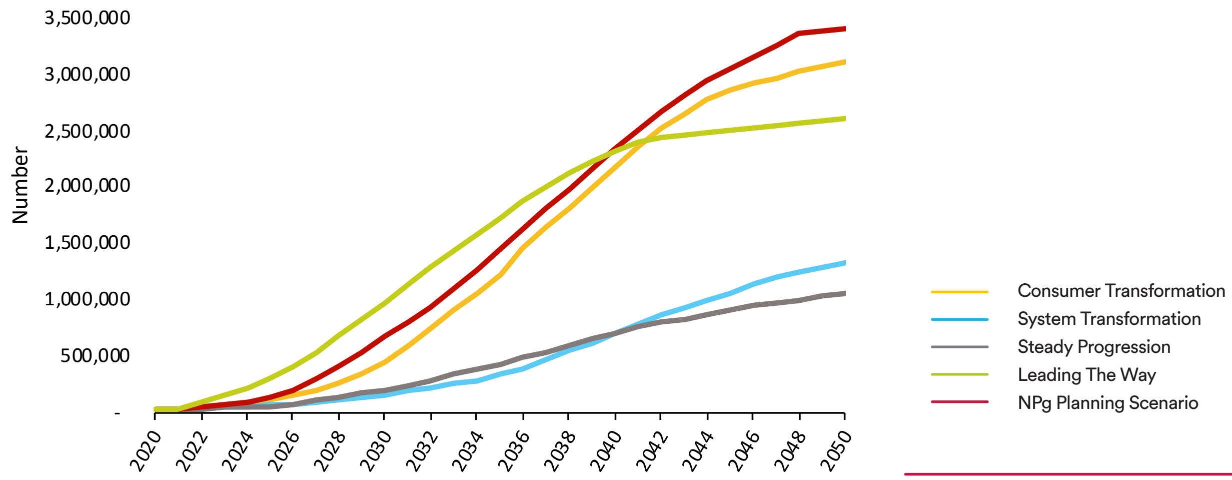
	2020	2030	2040	2050
Consumer Transformation	31,599	485,977	2,259,490	3,221,876
System Transformation	31,599	186,343	772,118	1,428,566
Steady Progression	31,599	213,754	726,622	1,084,341
Leading The Way	31,599	1,010,954	2,397,681	2,710,280
Planning Scenario	31,467	693,031	2,411,229	3,570,195

Figure 31:
Total heat pump uptake forecast



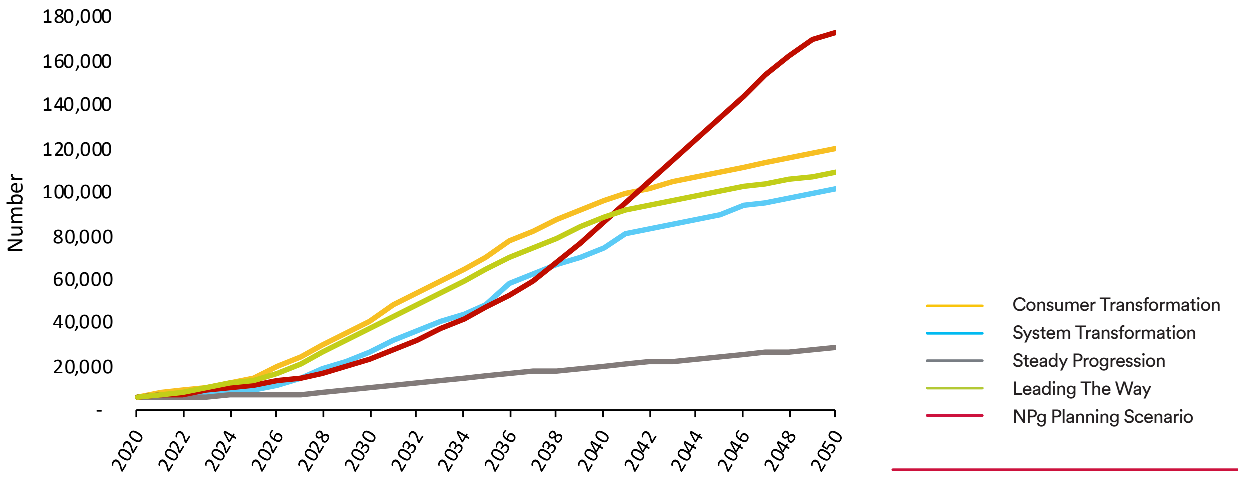
	2020	2030	2040	2050
Consumer Transformation	25,115	445,612	2,163,798	3,101,857
System Transformation	25,115	160,115	697,271	1,327,221
Steady Progression	25,115	203,806	706,467	1,055,584
Leading The Way	25,115	973,489	2,309,390	2,601,661
Planning Scenario	25,115	671,255	2,327,316	3,396,774

Figure 32:
Residential heat pump uptake forecast



	2020	2030	2040	2050
Consumer Transformation	6,483	40,366	95,700	120,019
System Transformation	6,483	26,227	74,847	101,345
Steady Progression	6,483	9,948	20,155	28,757
Leading The Way	6,483	37,464	88,291	108,619
Planning Scenario	6,483	23,759	85,896	173,421

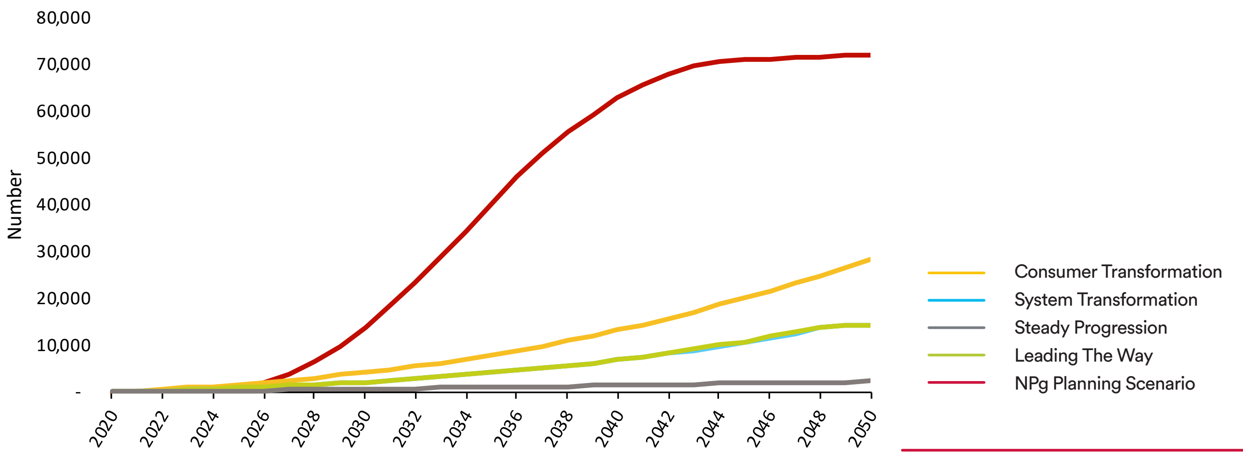
Figure 33:
I&C heat pump uptake forecast



Electric HGVs

	2020	2030	2040	2050
Consumer Transformation	128	4,322	13,312	28,250
System Transformation	128	2,230	6,910	14,395
Steady Progression	128	785	1,560	2,395
Leading The Way	128	2,301	7,023	14,451
Planning Scenario	13	13,677	63,038	72,029

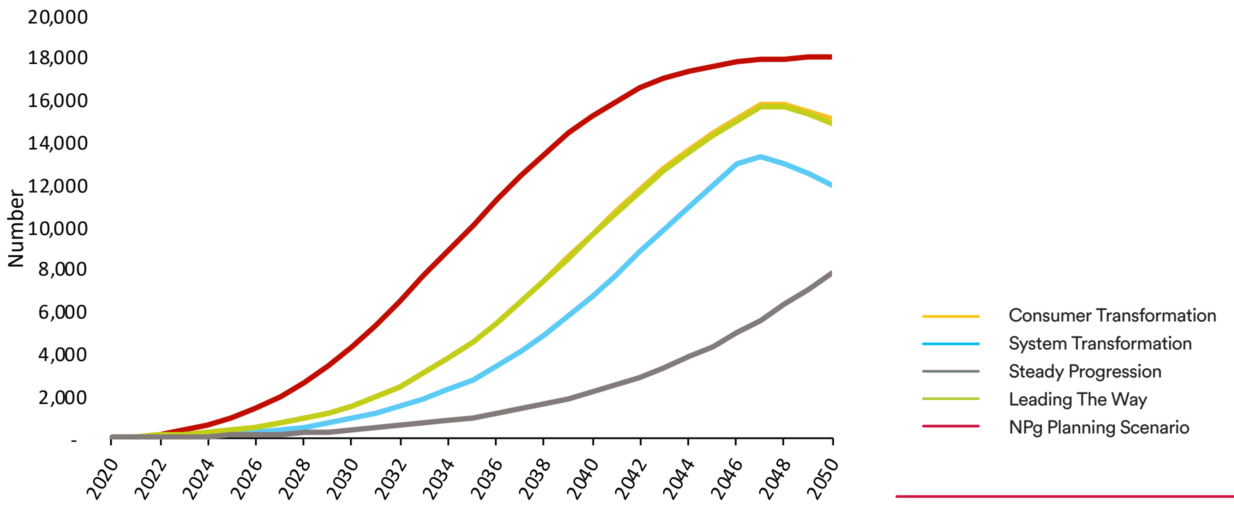
Figure 34:
Electric HGVs



Electric buses

	2020	2030	2040	2050
Consumer Transformation	69	1,604	9,706	15,172
System Transformation	69	974	6,778	12,043
Steady Progression	69	455	2,203	7,875
Leading The Way	69	1,604	9,655	14,962
Planning Scenario	19	4,405	15,299	18,048

Figure 35:
Electric buses



Generation

The following tables and charts show the Northern Powergrid forecasts for the potential increase in generation and storage capacity connected to the network. We have provided the underlying data on the Open Innovations website with disaggregation down to local authority level and also primary substation level.

Solar PV

	2020	2030	2040	2050
Consumer Transformation	429	1,620	3,437	5,139
System Transformation	429	928	1,750	2,637
Steady Progression	429	595	932	1,296
Leading The Way	429	1,576	3,334	4,967
Planning Scenario	429	1,576	3,334	4,967

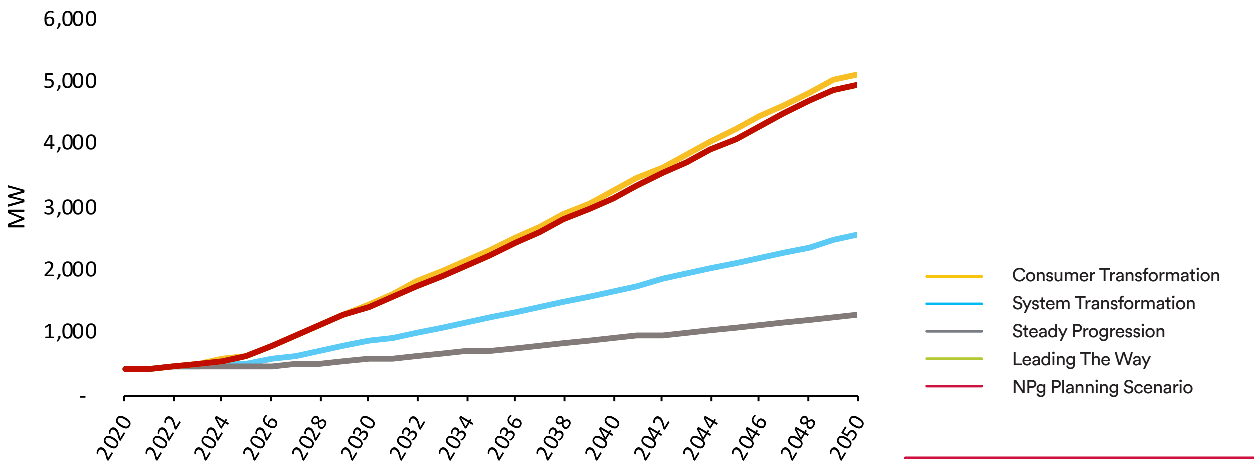


Figure 36:
Residential PV capacity uptake forecast (MW)

	2020	2030	2040	2050
Consumer Transformation	308	2,084	2,746	3,256
System Transformation	308	2,084	2,746	3,256
Steady Progression	308	861	1,183	1,417
Leading The Way	308	4,016	5,000	5,500
Planning Scenario	308	4,016	5,000	5,500

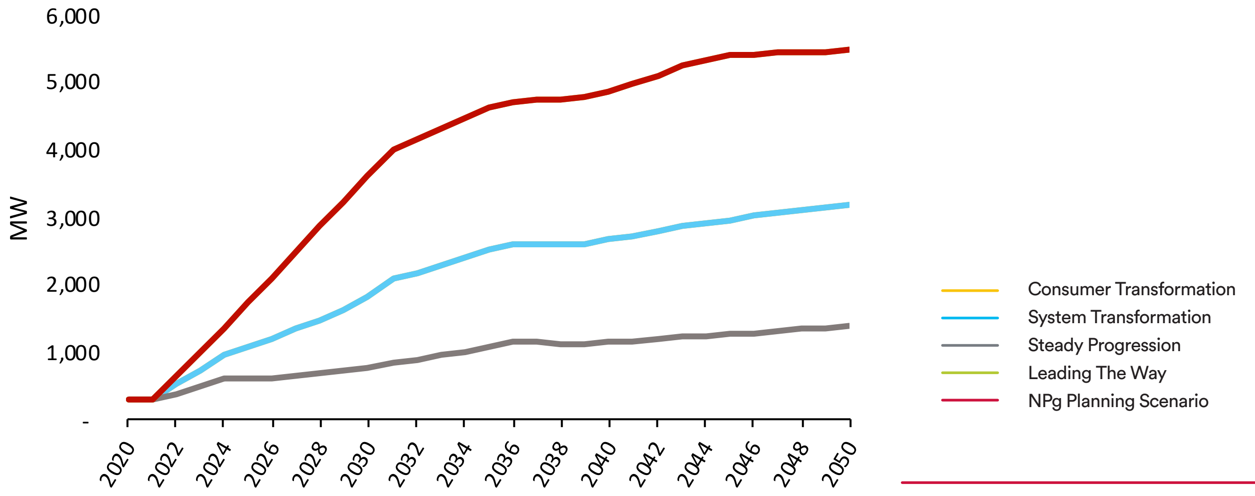


Figure 37:
Large scale PV capacity uptake forecast (MW)

Wind

	2020	2030	2040	2050
Consumer Transformation	1,322	1,817	3,320	5,011
System Transformation	1,322	1,426	1,707	2,052
Steady Progression	1,322	1,356	1,420	1,488
Leading The Way	1,322	1,655	2,658	3,884
Planning Scenario	1,322	1,655	2,658	3,884

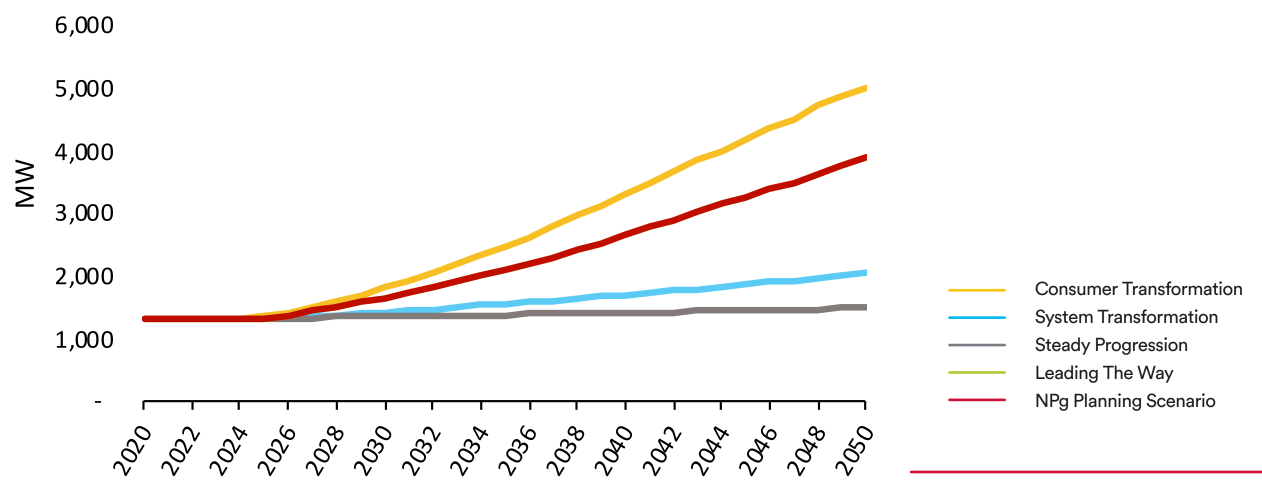


Figure 38:
Wind energy capacity uptake forecast (MW)

Energy storage

	2020	2030	2040	2050
Consumer Transformation	172	744	1,582	2,388
System Transformation	172	431	804	1,070
Steady Progression	172	363	859	1,009
Leading The Way	172	607	1,594	2,398
Planning Scenario	172	607	1,594	2,398

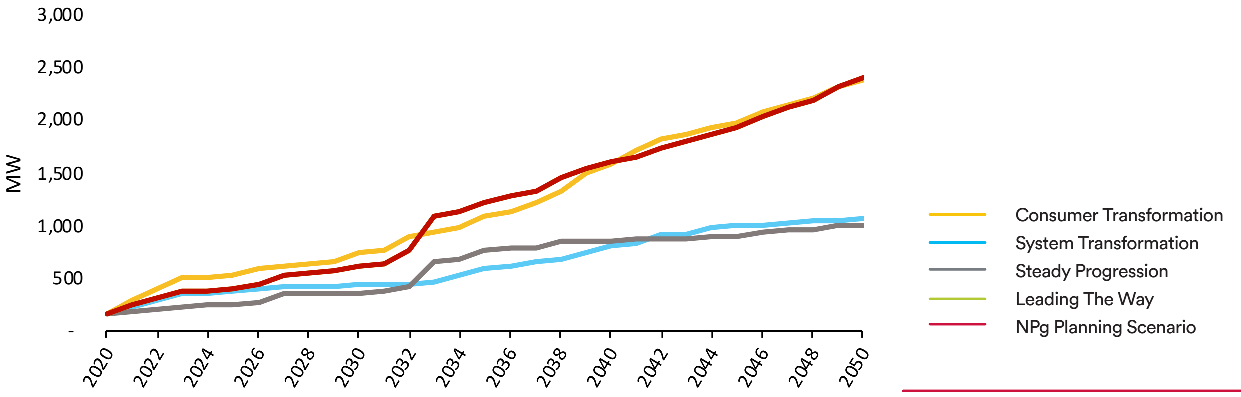


Figure 39:
Total storage capacity uptake forecast (MW)

Impact

Charts below show impact data on energy consumption and gross peak demand.

Energy consumption

	2020	2030	2040	2050
Consumer Transformation	36,768	38,349	54,177	58,941
System Transformation	36,768	37,301,	48,970	52,716
Steady Progression	36,768	39,556	48,937	54,871
Leading The Way	36,768	38,150	51,998	52,914
Planning Scenario	36,695	43,851	64,984	72,879

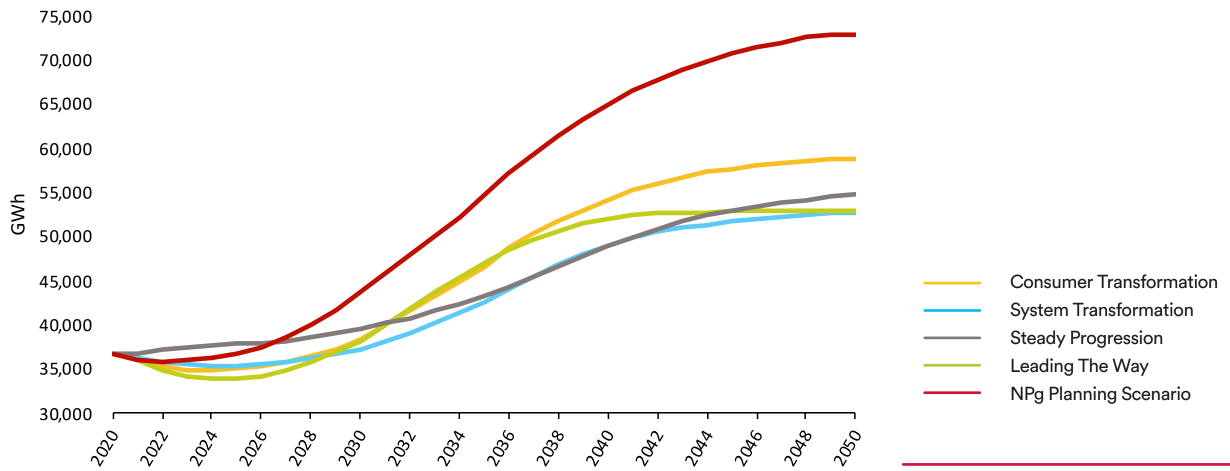


Figure 40:
Total energy consumption

	2020	2030	2040	2050
Consumer Transformation	6,436	6,839	9,860	10,639
System Transformation	6,451	6,716	9,565	10,682
Steady Progression	6,451	7,095	9,463	10,996
Leading The Way	6,436	6,808	9,484	9,602
Planning Scenario	6,420	7,536	10,923	12,389

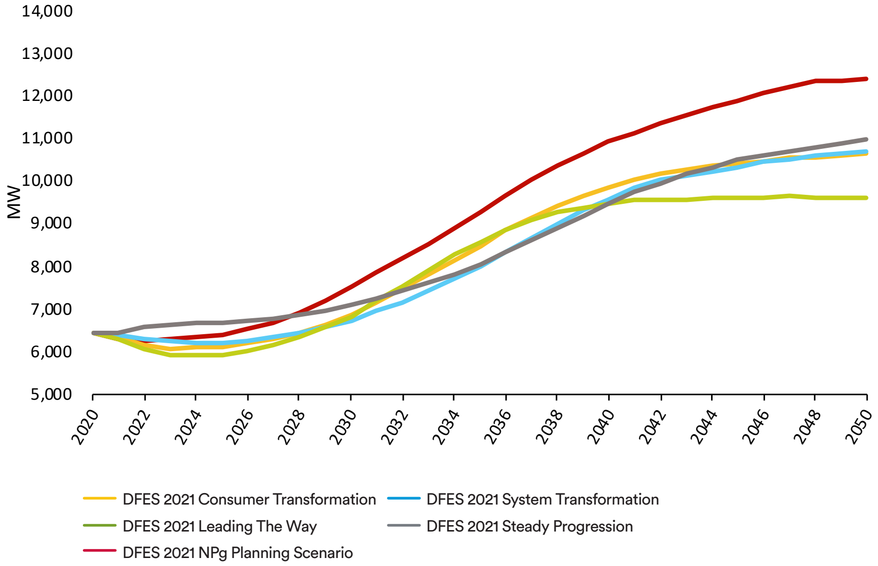


Figure 41:
Gross Peak Demand

Annex 3: Data sources

Our Distribution Future Energy Scenarios (DFES) 2021, and DFES from previous years, are available for to view on the Open Innovations (formerly ODI Leeds) website:

https://odileeds.github.io/northern-powergrid/2021-DFES/

The full DFES data is available to download on the Data Mill North website:

https://datamillnorth.org/dataset/northern-powergrid-dfes-2021/

To assist you in navigating the datasets, we have provided descriptions of the data in the chart below. The data is grouped and ordered as follows:

Data Sources	
Data	**Description**
Northern Powergrid level data	Data for the key parameters at Northern Powergrid level. This is a single MS Excel workbook bringing together all the parameters, each provided on a separate sheet (together with all the scenarios).
Local authority level data	Data for the key parameters at a local authority level. This is a single MS Excel workbook bringing together all the parameters, each parameter broken down further into separate sheets (one for each scenario).
Local authority charting tools	Data for the key parameters at a local authority level, grouped by technology. Several MS Excel workbooks providing useful tools for analysing the data, grouped by technology and by local authority, e.g., an electric vehicle (EV) workbook.
Metadata	A MS Excel workbook providing helpful information about the data, e.g., percentage splits of each primary substation across local authorities, the connectivity between primaries, bulk supply points and grid supply points.
Grid supply point level data	Data for the key parameters at grid supply point (i.e., connection points between the GB transmission network and Northern Powergrid's distribution network). A single MS Excel workbook bringing together all the parameters and scenarios, provided in flat format on one sheet.
Major site level data	Data for the key parameters at bulk supply point (i.e., connection points on Northern Powergrid network which are fed from the grid supply points and which supply the primary substations). A single MS Excel workbook bringing together all the parameters and scenarios, provided in flat format on one sheet.
Primary substation level data	A link to a series of over 50 files and links to the data shown in the geospatial Open Innovations visualisation tool – a separate file for each parameter and for each scenario combination. Also, a single MS Excel workbook bringing together all the parameters and scenarios, provided in flat format on one sheet.

Annex 4: Parameter definitions

We can add new parameters to our data visualisation at any point – we don't need to wait for next year's DFES.

If there is a parameter breakdown that would be valuable, please contact us and we will endeavour to make it available.

Parameter	Definition
Electric vehicles (EVs) (number)	Number of registered plug-in electric vehicles (pure battery electric and hybrid cars and light vans).
Electric buses (eBuses) (number)	Number of planned electric buses (pure battery electric and hybrid vehicles).
Electric heavy goods vehicles (eHGVs) (number)	Number of planned electric heavy goods vehicles (pure battery electric and hybrid vehicles).
Heat pumps (number)	Number of heat pumps in residential households and commercial properties, including from district heating schemes.
Domestic photovoltaic installed capacity (MW)	Installed capacity of solar PV panels on domestic roofs for installations less than 4kW.
Large solar generation installed capacity (MW)	Installed capacity of large-scale solar farms.
Wind generation installed capacity (MW)	Installed capacity of onshore and offshore wind farms.
Total non-renewable generation installed capacity (MW)	Installed capacity of all non-renewable generation including waste, combined heat and power plants, gas, other thermal generation.
Total renewable generation installed capacity (MW)	Installed capacity of all renewable generation.
Energy storage installed capacity (MW)	Installed capacity of electrical energy storage (predominantly batteries).
Domestic underlying energy consumption (MWh)	Annual energy consumption by residential households, excluding electric vehicle and heat pump consumption.
Industrial and commercial underlying energy consumption (MWh)	Annual energy consumption by industrial and commercial properties, excluding electric vehicle and heat pump consumption.
Industrial switching from fossil fuels to electricity (MW)	Impact of large industry changing from their existing fuel sources to electricity.
Electrolysers (MW)	Impact of increased electrolysers as a means of hydrogen production. Electrolysers are large energy consumers but will have a significant role in any future scenario that utilises hydrogen technology.
Total energy consumption, including electric vehicles (cars, light cans, buses and HGVs) and heat pumps (MWh)	Total energy consumption by domestic households and industrial and commercial properties, including electric vehicle, heavy electric vehicle and heat pump consumption.
Peak demand at primary substations (MW)	Peak half-hourly demand within the year.
Peak demand with customer flexibility at primary substations (MW)	Peak half-hourly demand within the year, if load is shifted by e.g., time-of-use tariffs and smart charging of EVs.
Peak utilisation at primary substations (%)	Peak half-hourly demand within the year as a proportion of primary substation capacity.
Peak utilisation with customer flexibility at primary substations (%)	Peak half-hourly demand within the year as a proportion of primary substation capacity, if load is shifted, e.g., time-of-use tariffs and smart charging of EVs.

Annex 5: Our best view scenario

Collaboration and supporting Open Networks

The way we engage with electricity is changing. As we strive to decarbonise the energy sector, our region's distribution network is being transformed by smart technologies that change the way we consume, generate and manage electricity. To ensure we are ready to facilitate a transition that benefits everyone, we are collaborating with our ENA partners on the Open Networks project.

The Open Networks project allows ourselves and ENA partners to work closely as an industry as we continue transform the GB electricity system to meet the needs of a net zero society. To ensure a cohesive approach that delivers decarbonisation benefits in the short-, medium- and long-term Distribution Network Operators (DNO) are sharing plans and forecasts with each other and stakeholders to facilitate the transition to a decentralised, flexible, and open whole electricity system.

New for 2021: a Best View Scenario

The purpose of our DFES is to forecast the likely pathways for achieving net zero while accounting for the uncertainty associated with predicting what our energy system will look like in three decades time. In order to ensure that we can support our region's ongoing net transition, we are striving to offer higher levels of certainty in the shorter term to support our stakeholders plan and our own network planning.

This year, all DNOs are producing a Best View Scenario as part of our DFES, this best view being the single scenario that reflects the highest certainty over the next 1-10 year period. By offering a Best View Scenario, we hope to offer more clarity about demand and generation patterns regionally in the short term and to remove the complexities of multiple scenarios for stakeholders.

In developing our Best View Scenario, we are working to three justification criteria that ensure all network operators are aligned in their approach.

— alignment with existing and announced Government policies;
— consideration of stakeholder engagement inputs; and
— use of regional and local characteristics.

Introducing our Best View Scenario

Adhering to these agreed justification criteria and following the methodology used to create our DFES 2021 scenarios, we have adopted our Planning Scenario as our Best View Scenario.

Our Planning Scenario was developed during 2021 and has informed the investment decisions we have set out in our business plan for 2023-28. Because our Planning Scenario has been produced to support real investment decisions we are making in the short term, we carefully considered existing policies, inputs from our stakeholders and the local characteristics of our region.

Aligning with policy

Our Planning Scenario was produced following the Climate Change Committee's 6th annual carbon budget which was published at the same time as the Government's Ten Point Plan. In developing the Planning Scenario, we have considered all existing and potential policies that will impact our network in both the short and long term.

Policy commitments such as the ban on sales of new Internal Combustion Engine (ICE) vehicles by 2030 and policy ambitions such as those announced in October's Buildings and Heat Strategy are included within our assumptions to form the Planning Scenario.

The assumptions on latest policy can be seen in figure 42.

Figure 42: Assumption on latest policy

Key building block	Assumptions on latest policy
Electric vehicle uptake	— In line with the Government's Ten Point Plan, it assumes a ban on the sale of new ICE vehicles by 2030 and includes a ban on new hybrids by 2035
Heat pump uptake	— In line with the CCC's Balanced Pathway scenario, it meets the Government's Ten Point Plan targets of 600,000 heat pumps being installed annually in the UK by 2028 — It assumes a ban on the sale of new gas boilers for new homes from 2025
Energy efficiency	— Domestic thermal efficiency is assumed to be moderate. Appliance efficiency assumptions meet current EU targets for 2030 — I&C energy efficiency is aligned to EU energy efficiency targets
Renewable energy sources	— Solar PV assumptions based on high large scale solar uptake and high domestic PV take up, reaching 1013 MW by 2030 and 2146 MW by 2050 — Wind assumption supported by recent wind turbine sizes and behaviours reaching 748 MW by 2030 and 2015 MW by 2050

Stakeholder inputs

Our methodology for developing the Planning Scenario includes assumptions based upon our engagement with our stakeholders. This includes information gathered from our connections pipeline, surveys and 1-to-1 conversations we hold with our stakeholders.

Within all DFES 2021 scenarios, we have included 600 MW of recently accepted customer demand connections in our near-term forecasts. We have also considered 4 GW of accepted customer generation connections. This ensures that projects being undertaken by stakeholders, right now, are visible in our forecasts to provide the greatest clarity.

The accepted connections account for a wide range of customer activities, such as electric rail, park & ride EV charging, glass industry, warehousing growth, new units at industrial, manufacturing and business parks, and services like sewage treatment and waste. Also of note is that our Green Recovery scheme is now in progress, which creates the necessary capacity to support clean energy growth projects across our region, including regeneration and development at the Humber freeports, large scale solar and wind generation and rapid EV charging on motorways and trunk roads as identified in the Project Rapid report commissioned for the Department of Transport.

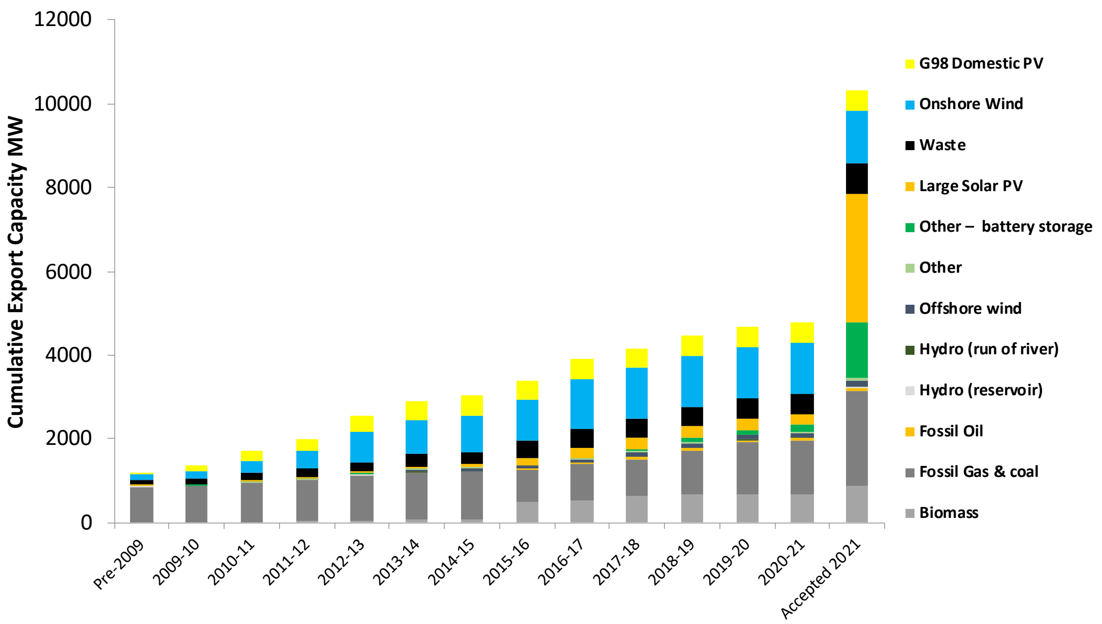
Stakeholder insights have also been gathered from surveys shared with key stakeholder groups as part of our DFES 2020 engagement campaigns, reaching out to groups including local authorities, LCT installers, car dealerships and large industry. These quantitative insights are supported by information gathered from 1-to-1 engagements our team has with stakeholders, whether that is speaking to local councils about their plans, or community groups such as the example of Hope Valley Climate Action.

Regional characteristics

Our region is unique, and we are careful to reflect locally specific characteristics in the assumptions for our Planning Scenario.

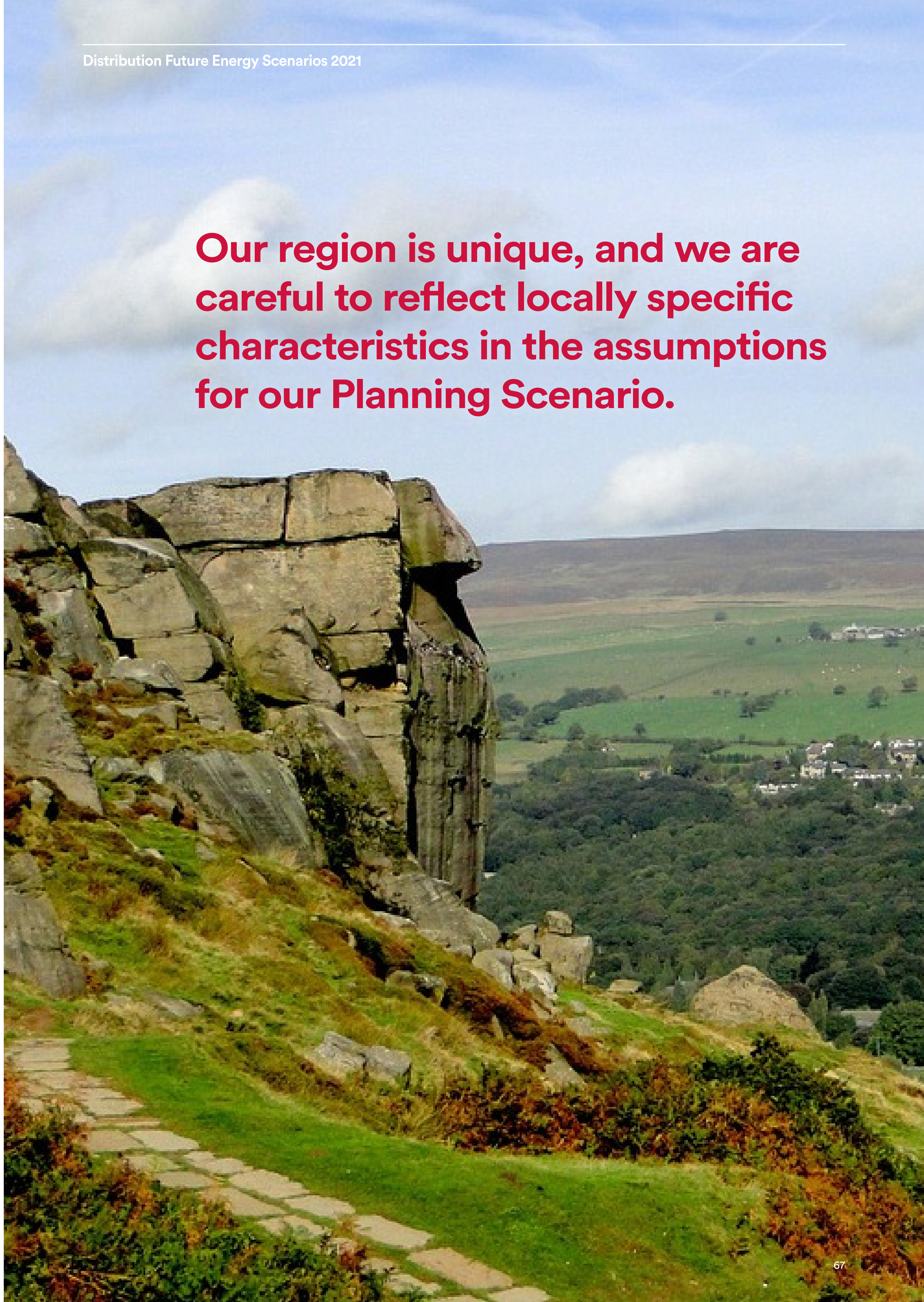
We have carefully monitored trends specific to our region to ensure our Planning Scenario is truly reflective of life in our local communities. For example, we have scaled up the uptake of large solar PV in our Planning Scenario to reflect the large pipeline of these projects expected in our region by 2030. Figure 43 shows the substantial increase in large scale solar PV projects accepted in 2021. For clarity, we do not expect all of these projects to connect to our network in 2021-22, this is simply a view of the forward pipeline.

Figure 43: Cumulative Generation trends at NPg



We have also modified our assumptions from those in the FES building blocks where we have new information to offer greater clarity on LCT uptake. For example, we have updated our assumptions for heat pumps to reflect what is believed to be a higher number already in our region and used data from the Driver and Vehicle Licensing Agency (DVLA) to improve the certainty of our EV projections.

Further to this, we have undertaken additional studies to reflect the specific impacts of our regions proud industrial sectors on our forecasts. The Humber region is aspiring to become one of the country's leading hydrogen clusters and we modelled for an increase in electrolysers contributing to the gross peak demand of our network in the future. Fuel switching for industrial stakeholders has also been studied as we expect electricity to replace fossil fuels in heavy industries.



Our region is unique, and we are careful to reflect locally specific characteristics in the assumptions for our Planning Scenario.

Contact us

Your feedback is important to us and should be sent to:
npg.system.planning@northernpowergrid.com

Please contact us if you have any questions.