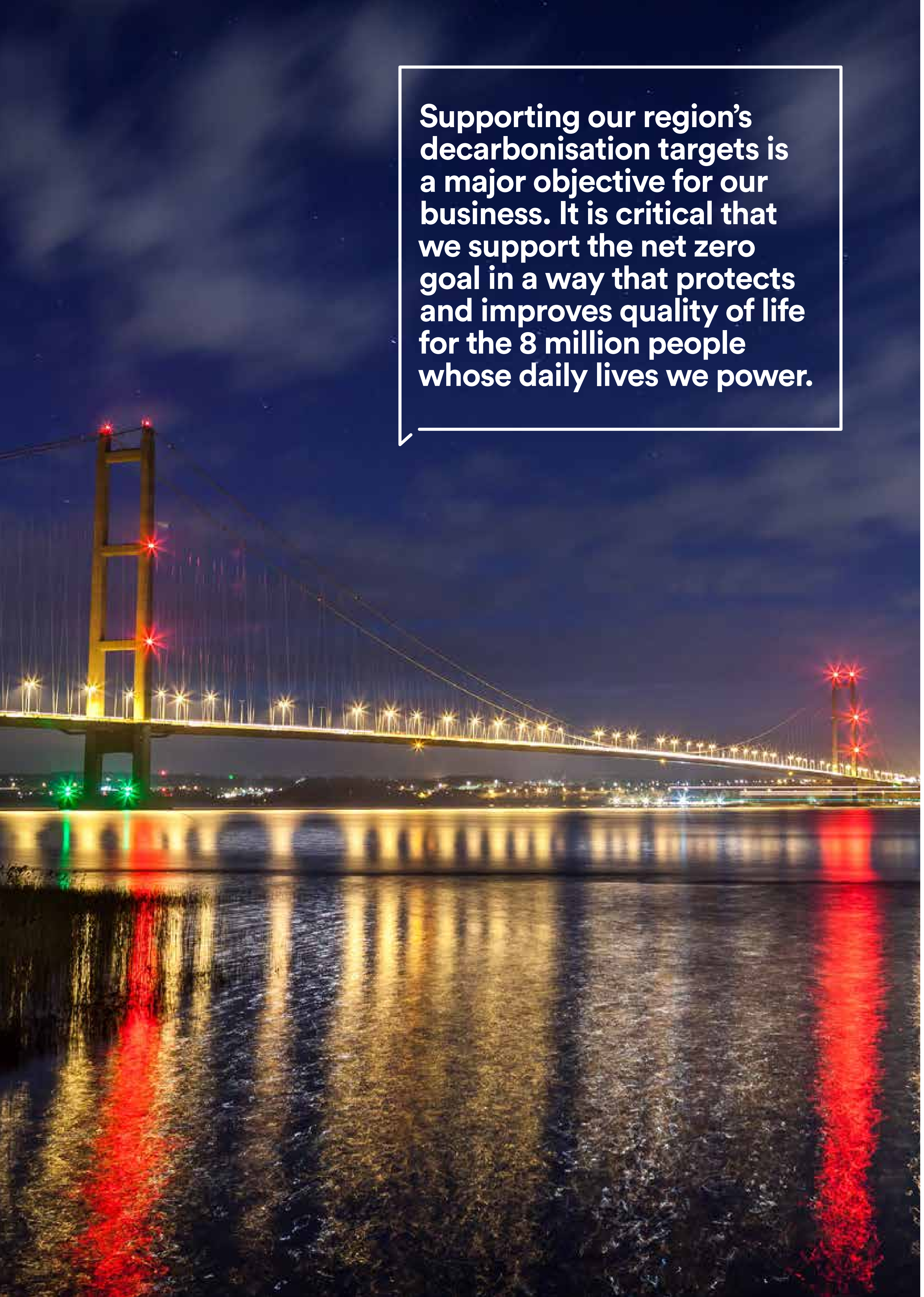
# Distribution Future Energy Scenarios

Mapping net zero locally

May 2021


Supporting our region's decarbonisation targets is a major objective for our business. It is critical that we support the net zero goal in a way that protects and improves quality of life for the 8 million people whose daily lives we power.



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# Introduction

## Foreword

**Energy networks have a central role to play in achieving decarbonisation. As the energy landscape transforms to achieve net zero carbon emissions by 2050, we are presenting our Distribution Future Energy Scenarios (DFES) for 2020.**

Building on National Grid's four national scenarios, we have modelled five scenarios demonstrating how we envision energy use might change in our region up to 2050. They set out a range of credible decarbonisation pathways, titled 'Leading the Way'; 'Consumer Transformation'; 'System Transformation'; 'Steady Progression'; plus 'Net Zero Early' allowing for a scenario when we see our region decarbonise faster than the national average.

In addition to the potential ways our customers' energy practices could change, we also set out the ways the network could be impacted in order to prompt our investment in services and infrastructure in coming years.

Using an open data approach, we are inviting our stakeholders to engage with the scenarios and seeking feedback to help us support your zero carbon ambitions through future network planning.

**2020 has been a year like no other. The COVID-19 pandemic has dominated every aspect of our lives, and it has impacted our already transforming energy landscape, surfacing new trends on how we engage with electricity and insights on how the network can be enhanced in the future.**

As a direct consequence of the initial mid-2020 nationwide lockdown, power demand fell in our region. As a result the share of renewable generation in our energy mix has increased. Our local picture is replicated nationally, with renewables securing the highest ever share of energy generation.[1,2] Across the UK demand fell by up to 20% compared to 2019, allowing the country to experience its longest period without coal-fuelled electricity since the industrial revolution.[3]

Energy policy has been uncertain in the last decade, but in the last quarter of 2020 a clearer picture has started to emerge. Ambitions are being converted into plans. The UK Government announced its Ten Point Plan for a Green Industrial Revolution, pledging to ban the sale of internal combustion engine (ICE) cars and vans by 2030 and targeting the installation of 600,000 heat pumps every year by 2028.[4] The Energy White Paper – 'Powering our net zero future' – added further clarity at the close of 2020.[5]

Our region has also accelerated decarbonisation commitments this year. Newcastle became one of 88 cities to make the CDP's (formally the Carbon Disclosure Project) 'A List' of global cities leading on climate adaptation. This is thanks to plans to reduce energy use in homes by 30%, and install solar panels on 30% of homes and 60% of non-domestic properties.[6] Newcastle City Council is also installing 250 heat pumps in homes across the city.[7]

The industrial cluster of Humberside is also pioneering leading green innovation through The Zero Carbon Humber Partnership, which plans to create 49,000 green jobs by 2027 and Associated British Ports' completion of the UK's largest rooftop solar array at 6.5MW atop the Port of Hull.[8,9]

Combined local and national action has not gone unnoticed in the public eye. The phrase 'net zero' has increased in public recognition from 52% to 66% in just six months, a likely outcome of the high-level announcements and increased local decarbonisation activity.[10]

Enabling customer deployment of new technologies is key to our decarbonisation strategy. In the next decade, electric vehicles, heat pumps and battery storage systems will increasingly become the norm in households and businesses. Our role as a Distribution Network Operator (DNO) is changing to reflect this shift. We are transitioning to implement functions of Distribution System Operation (DSO) and with this, will take a more active role in managing our network in real-time to balance demand and supply locally. This will optimise our system to deliver low carbon energy at the lowest cost to customers.

1 UK Q1 renewable energy share at 47%: https://www.theguardian.com/business/2020/jun/25/renewable-energy-breaks-uk-record-in-first-quarter-of-2020
2 UK Q2 renewable energy share at 44.6%: https://www.current-news.co.uk/news/renewables-near-50-of-generation-share-in-q2-as-records-continue-to-be-broken
3 Coal Free for 67 days: https://www.businessgreen.com/news/4016627/uk-record-coal-power-free-run-67-days
4 Ten Point Plan for a Green Industrial Revolution: https://www.agov.uk/government/news/pm-outlines-his-ten-point-plan-for-a-green-industrial-revolution-for-250000-jobs
5 Energy White Paper: https://www.gov.uk/government/publications/energy-white-paper-powering-our-net-zero-future
6 Newcastle CDP's 'A List' cities: https://www.edie.net/news/6/Which-UK-cities-are-leading-on-climate-action---and-how-/
7 Newcastle City Council heat pump scheme: https://www.newcastle.gov.uk/heatpumps
8 Yorkshire net zero industry hub to create up to 49,000 jobs: https://www.businessgreen.com/news/4023552/drax-yorkshire-net-zero-industry-hub-create-49-jobs
9 ABP Hull completes UK's largest rooftop solar array: https://www.yorkshirepost.co.uk/business/associated-british-ports-unveils-uks-largest-solar-panel-set-3041001
10 Public recognition of phrase 'net zero': https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/934647/BEIS_PAT_W35_-_Key_findings.pdf





At the same time, we are developing our business plan for the next regulatory period (2023-28). We have already released our emerging thinking on our business plan and through extensive customer engagement are seeking to determine how the electricity network can support net zero ambitions through a series of key questions;[11]

- **How electric:** will electric heating be in every home or will we see major investment in hydrogen?
- **How local:** will trends towards decentralised energy continue?
- **How flexible:** do our customers have appetite for selling capacity or generation as flexibility services to help manage supply and demand?
- **How fast:** do those living in our region want net zero by 2050, or do they want us to strive to get there earlier?

The scenarios outlined in this report will inform active network planning, and enable us to develop our role as the cornerstone of an energy system that enables an exciting transformation, combats climate change and builds a more sustainable future for the next generation.

This publication consists of this summary document, alongside raw open data and interactive data visualisation.[12]

It outlines our five forecasting models and gives key thematic analysis of the data and scenarios that we have used to determine the potential impact of different decarbonisation pathways.

The scenario-based method as exhibited in this document will inform our investment plan for the network and future planning for the region. By taking a data-driven approach to network planning alongside detailed and meaningful stakeholder engagement, we are ensuring that we are all prepared to accelerate along the pathway that will deliver net zero carbon emissions for every community that we serve.

**Jim Cardwell**
Head of Policy Development

11 Our business plan 2023-2028: engage.northernpowergrid.com/planning-for-2023-28/welcome
12 Data and visualisation: https://odileeds.github.io/northern-powergrid/2020-DFES

# About Northern Powergrid

**Northern Powergrid is responsible for the electricity network that powers everyday life for 8 million customers across 3.9 million homes and businesses in the North East, Yorkshire and northern Lincolnshire.**

Our team of around 2,700 colleagues operates 24 hours a day, 365 days a year to maintain a safe, reliable and efficient electricity supply. From pandemics to pouring rain, heat waves to hailstones, we work around the clock for our customers – no matter what the circumstances.

We're responsible for over 96,000 kilometres of overhead power lines and underground cables, spanning c. 25,000 square kilometres and more than 63,000 substations:

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

We are committed to being a strong anchor organisation that can serve our communities as a force for good.

A proportion of the money our customers pay as part of their electricity bill comes to us to cover the cost of operating the network and paying our dedicated team members. This works out at approximately £85 per year for each household.

The amount of revenue that we recover from our customers is defined by Ofgem through a price control review process. The current eight-year price control period is called RIIO-ED1, and lasts from 2015 to 2023.[1]

A new price control will start in 2023 and run until 2028. This is called RIIO-ED2 and we have already begun planning for this. In 2020 we issued our emerging thinking about how we will best support our region's power needs as the country seeks to meet net zero targets by 2050.[2] We will also continue our transition to performing the functions of a Distribution System Operator (DSO) – driving regional decarbonisation by operating a more active and flexible local electricity system.

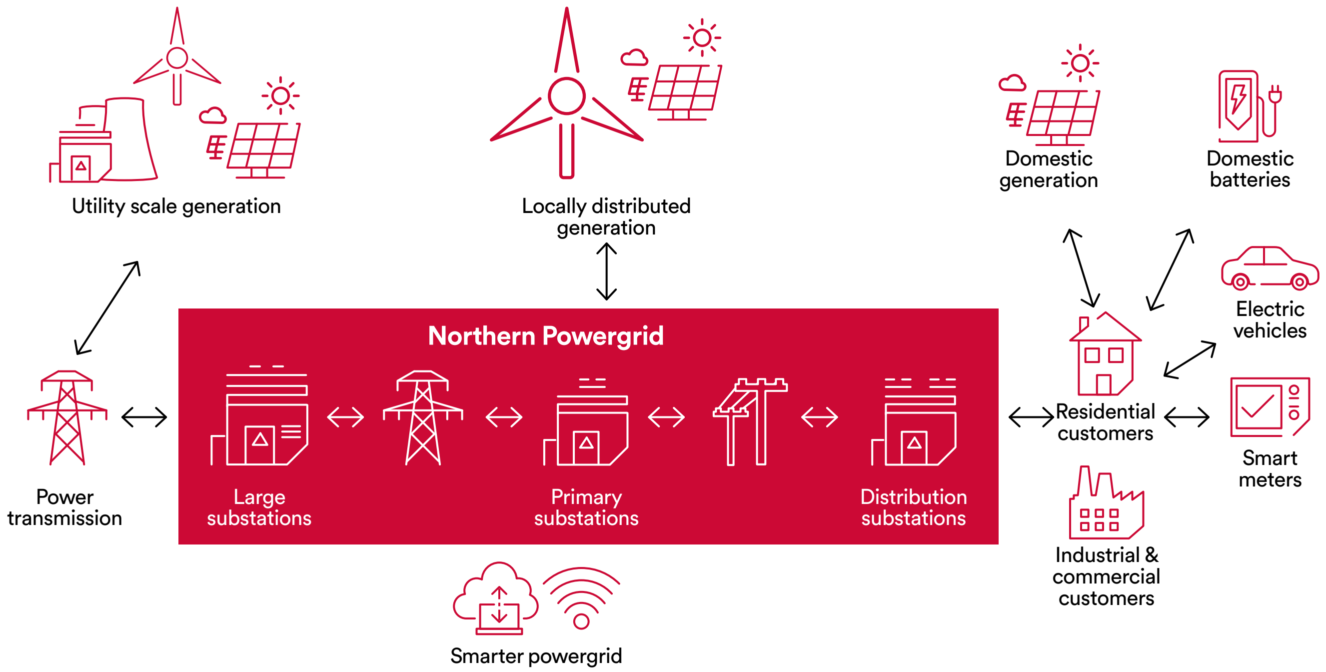
**We live and work here. Our business is made up of local teams that support their communities.**

1 Ofgem, RIIO-ED1 network price control: ofgem.gov.uk/network-regulation-riio-model/riio-ed1-price-control

2 Our business plan 2023-2028: engage.northernpowergrid.com/planning-for-2023-28/welcome








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


**Our regional structure enables our teams to best serve the local needs of our customers.**

# Purpose of this publication

**Scenario-based forecasting 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.**

## Background

As more action is taken to support the drive for net zero at a local, national and political level we are seeing huge changes, including:

— a boom time for electric vehicles, with public awareness and adoption rates unforeseen five years ago;
— a government-mandated push for electric heating that will accelerate heat pump installation; and
— a rapidly growing installed capacity of energy storage.

With the Government strengthening its commitments to tackle climate change and achieve net zero carbon by 2050, most recently with the Prime Minister's Ten Point Plan for a Green Industrial Revolution and the Energy White Paper, the UK is seeing a surge of interest in new energy-related projects. We now need networks to support this transition to zero carbon and also ensure maximum cost efficiency for every customer in all corners of the communities we serve.

To do this, your plans to help meet the UK's legally-binding net zero greenhouse gas emission target, and accompanying data, must be accounted for in our scenarios. We need to play our part in making your plans a reality.

Many of our regional stakeholders are currently firming up their plans. Big business, community energy schemes, agricultural entrepreneurs and others are responding to the climate emergency declared by most local authorities in our area.

We need to know where to expand capacity on our network through the use of customer flexibility, network flexibility or new capacity in the form of network reinforcement. We must work collectively across the energy system with our regional stakeholders as getting to net zero requires significantly co-ordinated action.

## 2021: a year of collaboration

Working collaboratively and harnessing joint data will help to mitigate uncertainty and enable us to consider several realistic scenarios in order to determine and model the range of future potential network impacts.

As an organisation we are now creating the business plan that will lead us through some of the most important years of flux in the energy system (2023–2028: our RIIO-ED2 price control period).

The decisions we take around network investment over the next few years will have a direct impact on the pace in which our network can facilitate decarbonisation in the communities we serve.

Feedback on our 2020 Distribution Future Energy Scenarios (DFES) will inform our 2021 planning for the RIIO-ED2 business plan. In turn, this planning will help to futureproof our investment decisions. We urge stakeholders to come to us early with their plans, so we can create a robust, reliable, cost-effective and smart power network on which everyone can power their futures.

## What are DFES and why have we published them?

Our DFES present a number of pathways for the decarbonisation of power generation, transport and heat. We update and publish DFES annually.

They present our underlying assumptions and potential network impacts. To maximise access and regional collaboration, we have published the DFES in an open data format, facilitated by the Open Data Institute (ODI) Leeds.

The full DFES includes:

**1. This orientation document**

**2. An online interactive visualisation tool[1]**

**3. Downloadable datasets[2]**

1 Visualisation tool: https://odileeds.github.io/northern-powergrid/2020-DFES/
2 Downloadable datasets: https://datamillnorth.org/dataset/northern-powergrid-dfes-2020





## Who is it for and what are the benefits?

This document shares the data we have so far, and places it into the public domain so you can tell us if it supports your plans.

Ask yourself: 'are my plans reflected in this data?' No matter how big or small your plans are, irrespective of how early-stage or advanced, we need to know about them so we can design our network to meet your needs.

Anyone can give feedback on the DFES but we expect it will be of most interest to:

— local and combined authorities and Local Enterprise Partnership planners and energy teams;
— low carbon initiative co-ordinators;
— economic regeneration and recovery teams;
— low carbon technology developers and installers, across all disciplines from EVs to heat pumps; and
— housebuilders and developers.

## How to provide feedback?

Follow-up engagement events will be held to discuss your plans and opinions.

We are particularly interested in the following aspects:

— 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.

We invite qualitative and quantitative feedback and are keen to receive any information you can provide from your own forecasts.

# 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.

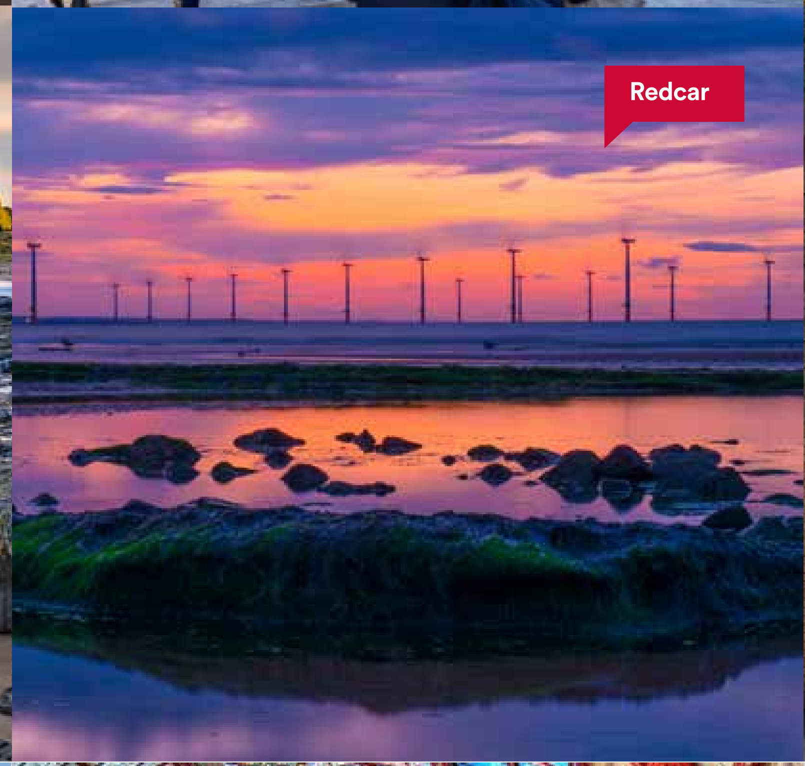

York: The Shambles


Leeds


Pennine Way

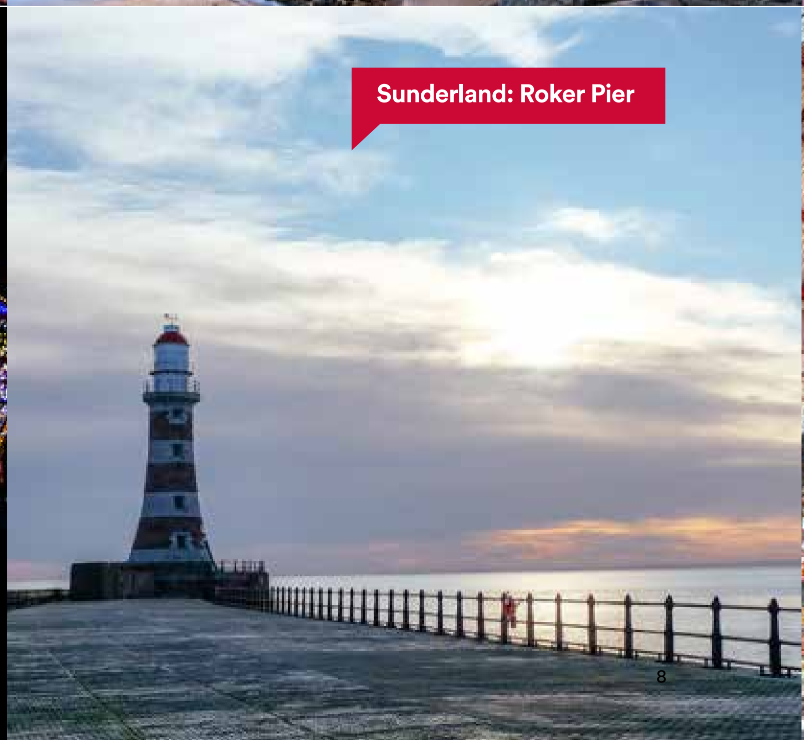

Whitby Harbour


Northumberland


Redcar


Sheffield: Hillsborough Stadium


Durham Lumiere Festival


Sunderland: Roker Pier


Newcastle Indoor Market


Kielder Water

# Distribution Future Energy Scenarios
## Our approach

**The Distribution Future Energy Scenarios outlined in this document model the range of potential and credible energy futures for our region.**

Your feedback on these is vital as it will guide our investment planning to ensure that we deliver a network that supports our customers. This year, it will also inform our business planning for the next regulatory period from 2023 to 2028 (known as RIIO-ED2).

> **The scenarios explore a range of credible futures. These are projections rather than predictions. Your feedback helps us to refine them. The knowledge we gain from this regional real-world modelling enables us to plan and deliver services and a network that supports the region's growth and decarbonisation ambition.**

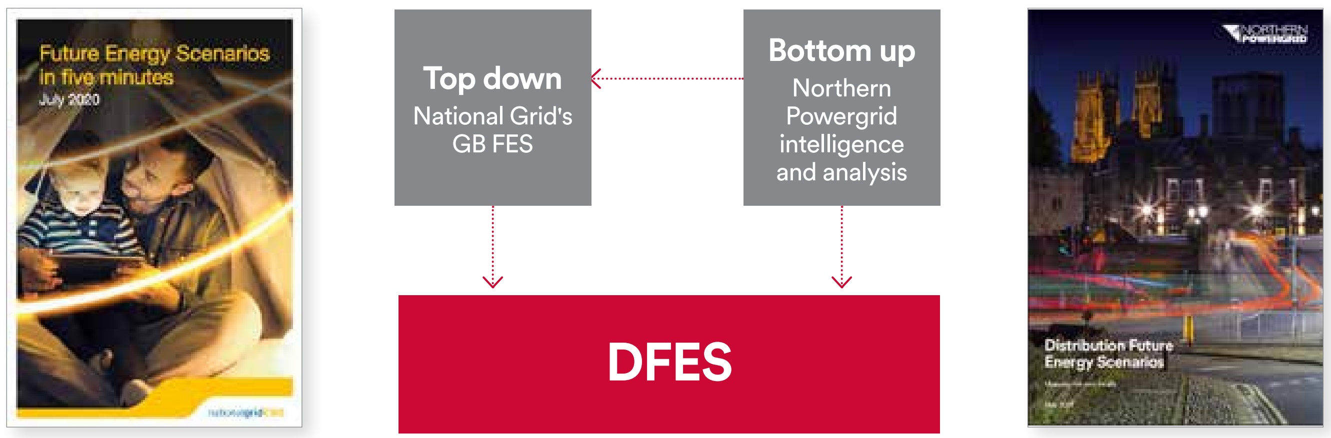
To foster strong collaboration, all of our DFES data is expressed in a common language and format.[1] It is open to public consultation and scrutiny.

Our regional data also contributes to national Future Energy Scenario (GB FES) projections via our ongoing collaboration with the Electricity System Operator (National Grid ESO) and other Electricity Distribution Network Operators (DNOs).

Our work with National Grid ESO means that regional views on decarbonisation may inform national exploration of future energy pathways and provides a central pillar in net zero discussions. Closer to home, this data is used in our DFES to:

- help us facilitate our region's net zero ambitions;
- give us a range of credible pathways that show the 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 which may need intervention or investment.

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




1 As agreed among the DNOs under the auspices of the ENA Open Networks Project Workstream1B Product 2 Whole Electricity System FES: https:/www.energynetworks.org/industry-hub/resource-library/open-networks-2020-ws1b-p2-july-update-(31-july-2020).pdf
2 IPPC 1.5 degree report: https://www.ipcc.ch/sr15/
3 National Grid FES Documents 2020: https://www.nationalgrideso.com/future-energy/future-energy-scenarios/fes-2020-documents





### Why five scenarios?

This year we are presenting five DFES scenarios. As with previous DFES, the first four scenarios interpret the GB FES with local data and represent the national assumptions at a regional level. The four scenarios, titled 'Leading the Way', 'Consumer Transformation', 'System Transformation' and 'Steady Progression' map four different routes to decarbonisation based on predictions about low carbon technology uptake and renewable energy generation.

The fifth scenario Northern Powergrid's 'Net Zero Early' was developed in response to stakeholder feedback as part of our emerging thinking development. Many of our communities and local authorities aspire to decarbonise before 2050. Some stakeholders are concerned that the FES scenarios are not consistent with a 1.5C world.[2]

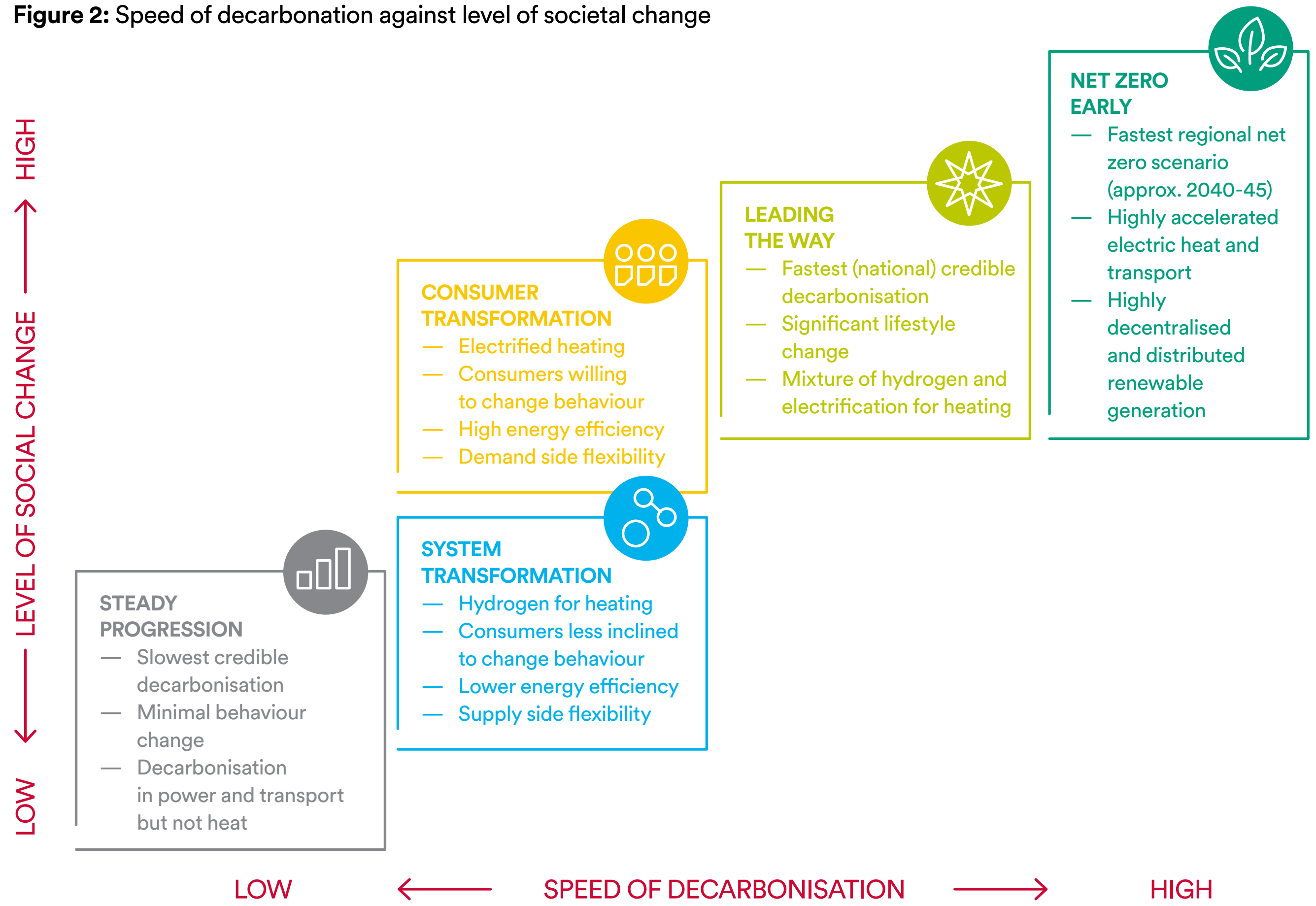
The new pathway that we have identified meets net zero in the 2040s. Our 'Net Zero Early' accelerates decarbonisation in our region faster than the national average and highlights the strides that we are taking as a region to progress green technology, infrastructure and planning. It reflects the interest by our stakeholders in exploring faster decarbonisation pathways. We are particularly interested in feedback on where it may be possible to go faster still 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.

A summary of the building blocks underpinning all scenarios can be found in Annex 1. More information about the GB FES scenarios and their underlying assumptions can be found in National Grid's 'Future Energy Scenarios' document.[3]

Our DFES present at a local level view for each of these scenarios, including:

- increased energy demand assumptions as a consequence of LCT uptake;
- increased energy generation assumptions;
- proactive grid management presented as:
  - increased energy storage;
  - impact of flexibility assumptions;
- impact on our electricity distribution network.

**Figure 2:** Speed of decarbonation against level of societal change



## Our method

Our load growth model produces a regional interpretation of the GB FES plus our 'Net Zero Early' 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;
- connection counts by customer type – i.e. Domestic or Industrial and Commercial.

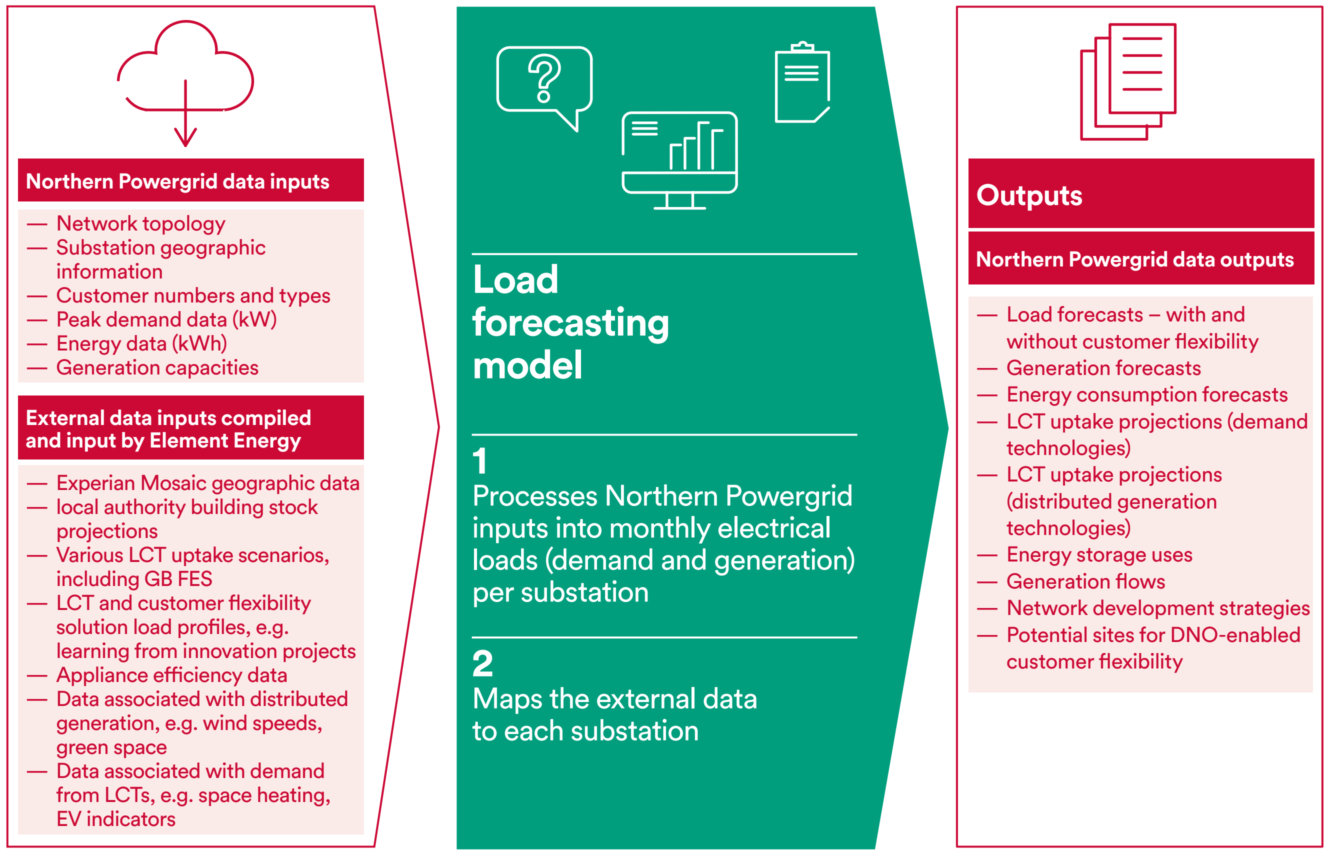
As a starting point for our analysis, we allocate the regionalised total quantities of energy uses such as numbers of electric vehicles (EVs) and heat pumps, and capacities of connected distributed generation across our substation population. These regionalised totals are provided to us from the preceding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

The modelling process is informed by a range of data sources to show the growth rates for the relevant regional building blocks, and to distribute the GB FES values, as well as our 'Net Zero Early' values. 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 project and emerging thinking 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 Leeds ODI website.[1]

**Figure 3:** Our modelling process

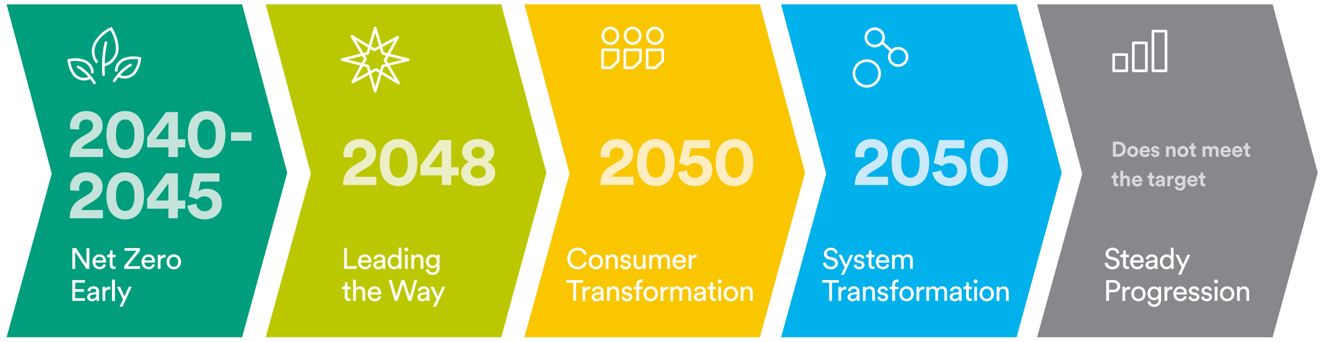



1 Leeds ODI website: https://odileeds.github.io/northern-powergrid/





# Net Zero




## Achieving net zero

Supporting our region's decarbonisation targets is a major objective for our business. It is critical that we support the net zero goal in a way that protects and improves quality of life for the 8 million people whose daily lives we power.

We must be the facilitator of our region's net zero ambitions.

We must make ample power safely available when and where it is needed.

And we must ensure that the delivery of this power is via a network that can withstand the pressure of extreme weather events.

Of the five feasible scenarios in this document (four based upon the GB FES and one from our own modelling), 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.

Over the past 12 months the mandate to focus our business operation on decarbonisation has been strengthening. From government announcements to customer feedback, the message is clear.

However, what is also clear is that net zero will require a multitude of solutions and collaboration across a range of parties. Every viable technology is being called upon to contribute and every section of society may undergo behavioural shifts as part of the transition.

What we are doing now is making robust decisions to ensure our network meets the needs of any scenarios that come to fruition.

This may be:

- working with suppliers to facilitate time-of-use tariffs;
- developing smart charging incentives;
- deploying flexibility services from distributed energy resources;
- targeted low voltage monitoring and network reinforcement; and
- targeted reinforcement of the high voltage and extra high voltage networks.

What is clear is that our local knowledge will come to the fore like never before.

The impacts on different substations will vary, depending on the demographics and size of the connected customer base, and the activities of the local authorities. Both factors will have an impact on the rate of uptake for LCTs or both green and blue hydrogen (for transport and heat respectively, with the latter needing CCUS).

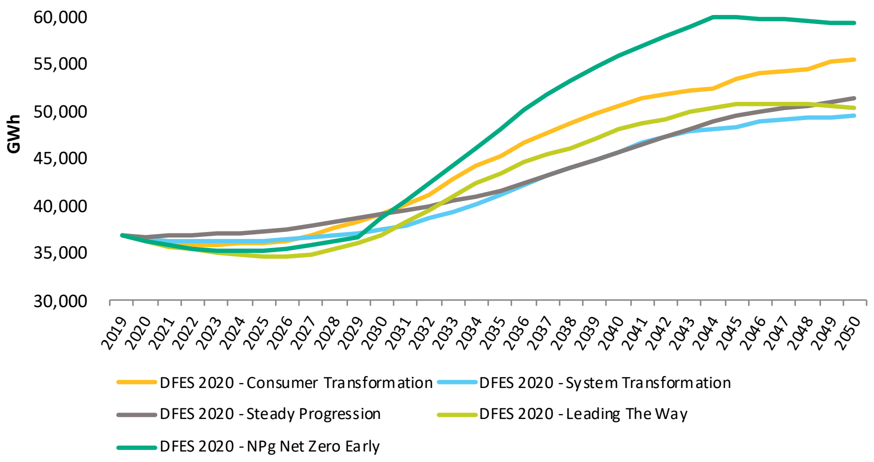
Our role as the local electricity distribution network operator is central to the region playing its part in the bigger picture of global decarbonisation. We can and will play a leadership role in supporting the North East, Yorkshire and northern Lincolnshire to achieve net zero, supporting a green industrial revolution and economic recovery 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 and with National Grid to continuously improve scenarios that provide a pathway to net zero. We are seeking our regional stakeholders' views on their plans and expectations, particularly on any new initiatives being proposed to achieve net zero.

# Forecast overview

## Demand

**Figure 4:** Electrical Energy Consumption




All five forecasts predict that over the 2020s energy consumption will remain at a relative net constant. However, there is far more activity on the network than this picture may indicate. Substantial improvements in energy efficiency are expected to outweigh the load growth from early uptake of low carbon technologies (figures 5 & 6). 'Net Zero Early' and 'Leading the Way' scenarios in particular demonstrate this, with total energy consumption actually decreasing throughout the 2020s.

However, from 2030 the ever-increasing uptake of LCTs will eventually outstrip such improved energy efficiencies. In all scenarios, the 2030s are assumed to be a decade of substantial societal change, resulting in the considerably increased acceleration of low carbon technology uptake across our region and leading to an increase in overall energy consumption by 44% (figure 4).

All five scenarios demonstrate this shift, but none more so than our own 'Net Zero Early' scenario. Under this assumption we expect to reach peak energy consumption by the mid-2040s as we reach a saturation point of low carbon technologies. We expect this to then fall slightly by 2050 as once again, improved energy efficiency measures result in the net reduction of total electrical energy consumption (figure 4).





**Figure 5:** Electric Vehicles

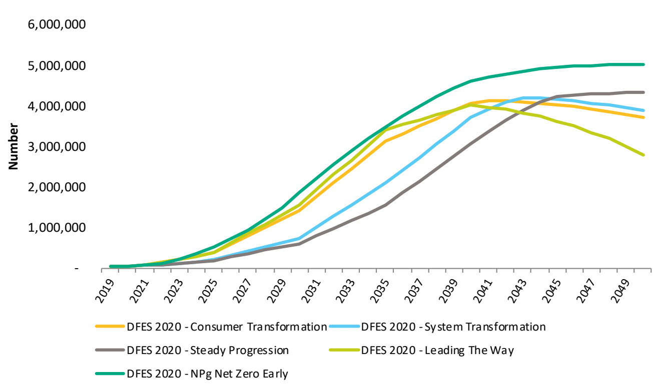
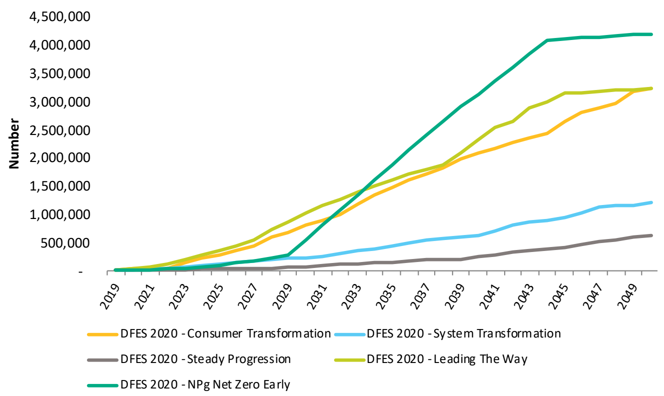



**Figure 6:** Total Heat Pumps




LCT growth will begin in the 2020s, but in line with overall energy consumption, the 2030s will be the decade of accelerated uptake of LCTs across the majority of the DFES (figures 5 & 6). From 2030 the sale of internal combustion engine (ICE) vehicles will be banned, driving a sharp increase in EV ownership alongside the expected fall in price of EVs in this same time period (figure 5).

Heat pump uptake is more varied across the scenarios, however under the 'Consumer Transformation' and 'Leading the Way' scenarios, and our own 'Net Zero Early' modelling, we will see a substantial uptick in the adoption of such heating technologies (figure 6). There is uncertainty however, about when heat pumps will start replacing gas boilers, as shown by the differences between the FES models, and our own assumptions.

In the 'System Transformation' scenario, the trend for heat pump uptake is demonstrably lower as this scenario assumes a hydrogen heating uptick, whereby gas boilers are powered by hydrogen, rather than switching to electrical heat pumps (figure 6). In parallel we are projecting a large increase in hydrogen producing electrolysers in the 'System Transformation' scenario.

**Figure 7:** 'Net Zero Early' – Energy Consumption included in our scenario

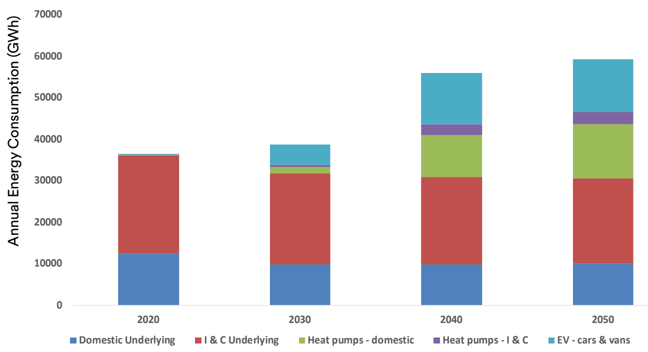
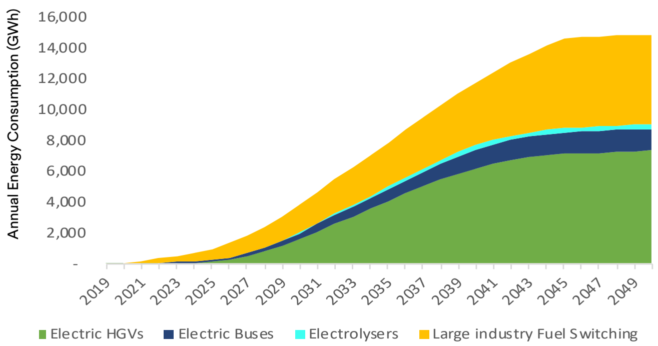



**Figure 8:** 'Net Zero Early' – Sensitivity for additional energy consumption uses




Increases in EVs and heat pumps are the most prolific contributors to the increase in energy consumption and in our 'Net Zero Early' scenario, we see their share of the consumption breakdown increase rapidly between 2030 and 2040 (figure 7).

Under our 'Net Zero Early' scenario, we demonstrate a slower 2020s increase in heat pumps as a result of the technology increasingly going into new build houses. The 2030s rapid increase will be as a result of end-of-life gas boiler replacements with heat pumps.

We also expect that EV ownership will accelerate in this time frame as a result of the 2030 ICE vehicle ban. This, alongside the removal of financial barriers to entry and a change in the zeitgeist towards EVs and heat pumps will drive the behaviour change needed to bring these predictions to life.

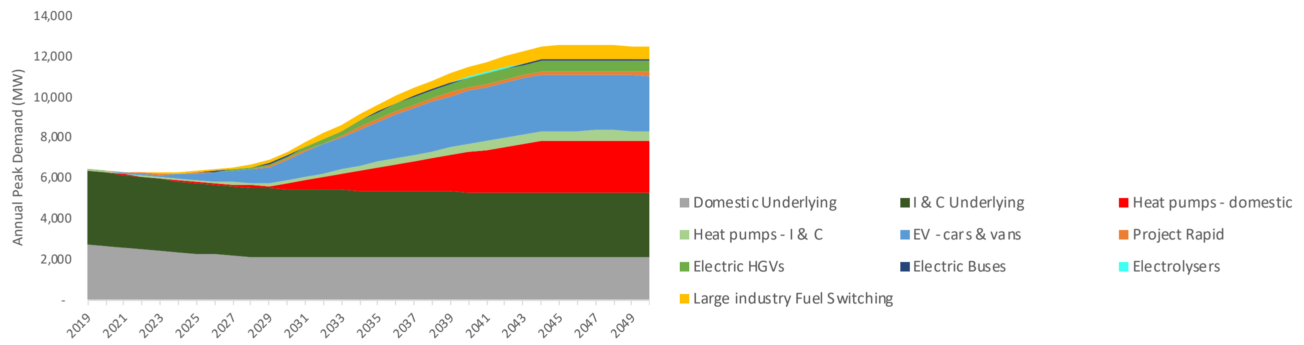
### Industry switching and electrolysers

Electricity consumption is also impacted by industry switching from fossil fuel power to electricity. Over the next two decades, industry fuel switching will drive a noteworthy increase in energy demand (figure 8). Improvements in industrial energy efficiency, as well as behavioural changes and the ability to earn additional revenue by contributing to demand side response and flexibility markets will drive this shift. Energy demand from electrolysers will also increase during this period, in particular between 2040 and 2050. This will likely be as a result of the maturation of hydrogen production and storage technologies that will unlock the so called 'last mile' of decarbonisation and offer green solutions to the remaining industries reliant on fossil fuels.

The 'System Transformation' scenario strongly favours this pathway to decarbonisation.

## Motorway service area rapid charging

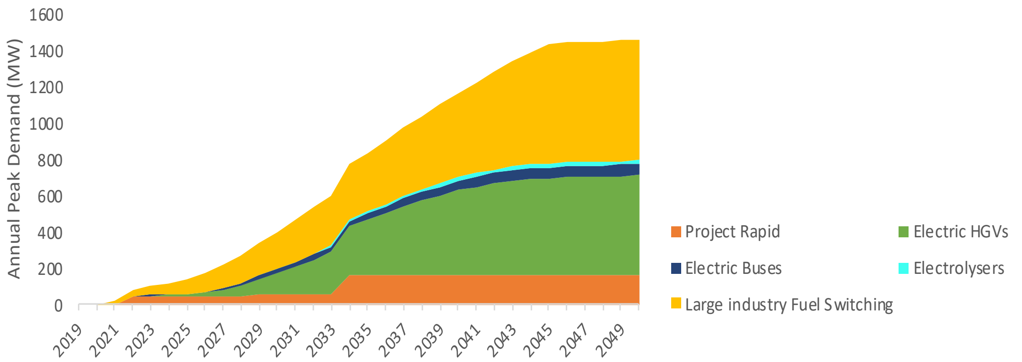
**Figure 9:** 'Net Zero Early' – Contributions to peak deamnd MW - NPg




The provision of Motorway Service Area (MSA) rapid charging is gaining public attention. "Range anxiety" has traditionally been a significant consideration in peoples' decisions to purchase EVs, and the ability to easily charge vehicles at speed (in a similar way to how they currently re-fuel their petrol or diesel vehicles) will help reduce this anxiety and encourage EV adoption.

A comprehensive network of rapid charging points has been under consideration at the Department for Transport (DfT), and Project Rapid (instigated by the DfT) has identified a number of potential MSAs that may be suitable for the installation of rapid chargers – including a number of MSAs in Northern Powergrid's region.

**Figure 10:** 'Net Zero Early' – Contributions to peak demand MW - Additional industry loads sensitivity




Whilst Project Rapid has not yet resulted in the building of any MSA rapid charging infrastructure in our region, there is a high likelihood that these will materialise over the coming years. The Project Rapid work has been interpreted by Northern Powergrid and the DfT's consultants to project the size (MW) of the connection to our network required for each MSA, as the numbers of rapid chargers increases at individual MSA sites.

Until more real-time specific details such as EV charging profiles together with peak charging times, days and seasons become clearer, there is insufficient data to model the impact of the demands on our network from the MSA rapid charging points. Therefore, where the DFES is concerned, we must treat every potential MSA site as new connection (i.e. point loads) and include them as a sensitivity as they are not yet agreed customer connections.

Figures 9 and 10 represent this sensitivity, and seek to identify the additional impact of the MSAs on our network in terms of the numbers of constraints and when we can expect them to occur.

We expect to be able to expand on this and provide further information to help inform future scenarios in our 2021 DFES.





## Energy Generation

**Figure 11:** Total Renewable DG Capacity

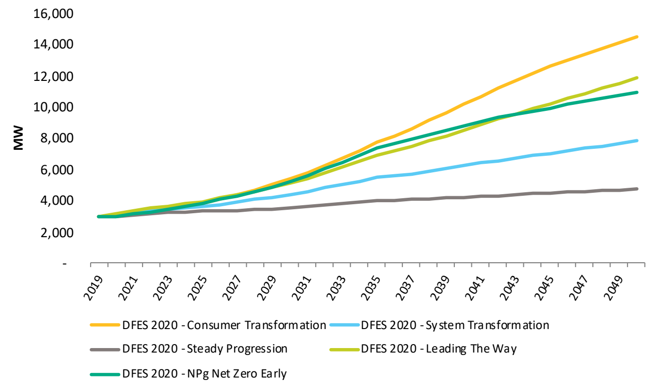
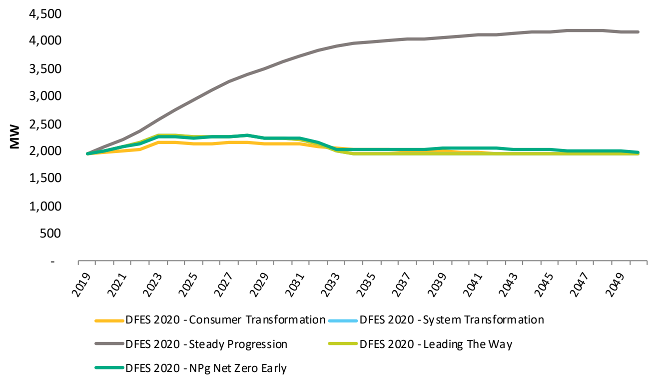



**Figure 12:** Total Non-renewable DG




The overall picture is that non-renewable distributed generation will flatline before the mid-2030s. In all scenarios except 'Steady Progression', this flatline occurs early in the 2020s and is supported by significant CCUS and industry fuel switching (figure 12). [1]

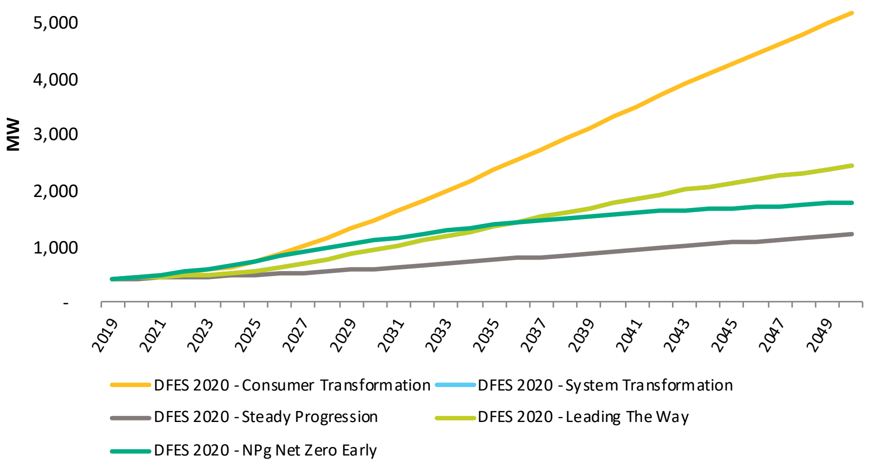
In the net zero target-missing 'Steady Progression' scenario, renewable distributed generation makes underwhelming gains from 3GW to around 5GW of installed capacity. In all other scenarios however, renewables boom from the middle of the 2020s, supported by early and robust government decision making bringing financial investment and stability (figure 11).

The greatest distributed renewable capacity increase would be achieved by following a 'Consumer Transformation' style scenario, driven by a huge increase in residential PV capacity.

Both 'Leading the Way' and 'Net Zero Early' see sizable increases in distributed renewable generation but stop short of the 15GW capacity seen in 'Consumer Transformation' due to an increased share for hydrogen use in the later years of these scenarios, and greater savings in appliance and building efficiencies (figure 11).

1 Whilst this figure shows non-renewable DG staying connected to the network, we assume that a fuel switch will occur in the future to low carbon fuel types.

**Figure 13 :** Residential PV Capacity




The PV sector (both domestic and large scale) shows some of the widest variations of DFES (figures 13 and 14).

Our 'Net Zero Early' scenario forecasts a significant increase in the early 2030s, as all available technologies are mobilised to hit carbon targets by the mid-late 2040s. Under this approach we see large scale PV level off in the early 2040s as hydrogen solutions mature.

**Figure 14:** Large Scale PV Capacity

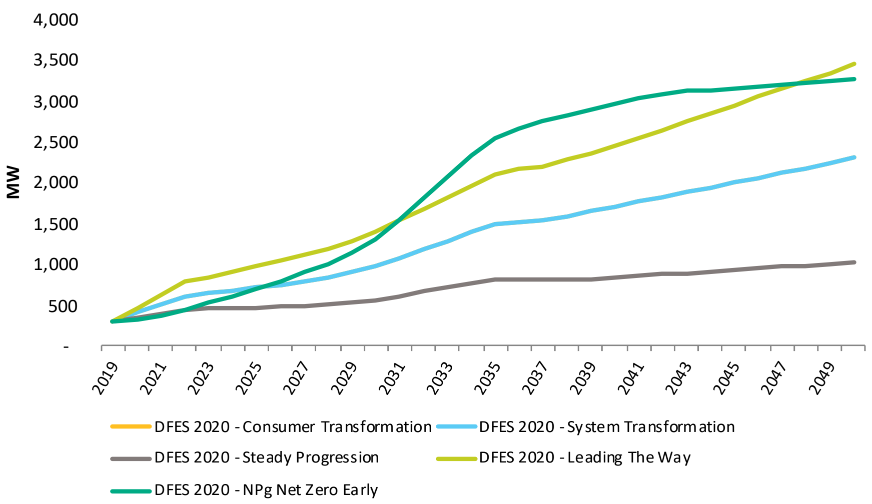
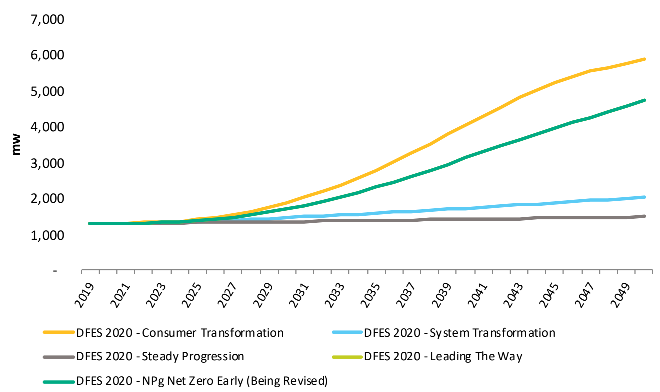







**Figure 15:** Wind Energy Capacity

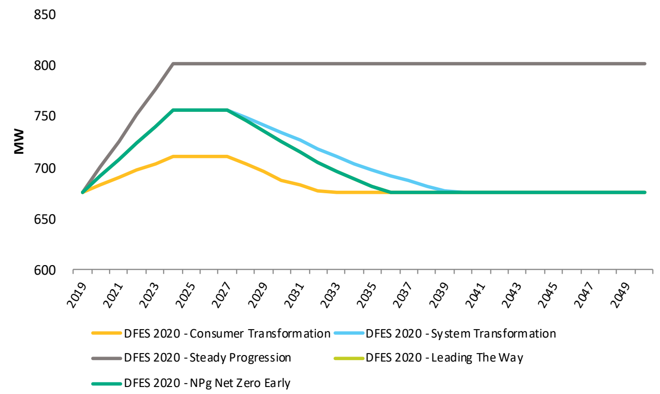



We assume that all future wind connected to our network will be onshore as offshore is higher capacity connections that typically suits a transmission interface. Our onshore connected wind generation displays yet more stark contrasts between scenarios.

Under the 'Steady Progression' and 'System Transformation' forecasts, we see minimal increases, with progress limited by societal preference for offshore turbines due to their smaller impact on land-use and visibility.

However, under the more progressive scenarios, customer appetite for onshore wind energy is expected to be higher and will drive government support, helping to facilitate a sizable acceleration of wind energy towards the end of the 2020s.

**Figure 16:** Total Biomass and Energy Crops DG Capacity




Flatline or decline is the forecast for biomass and energy crops.

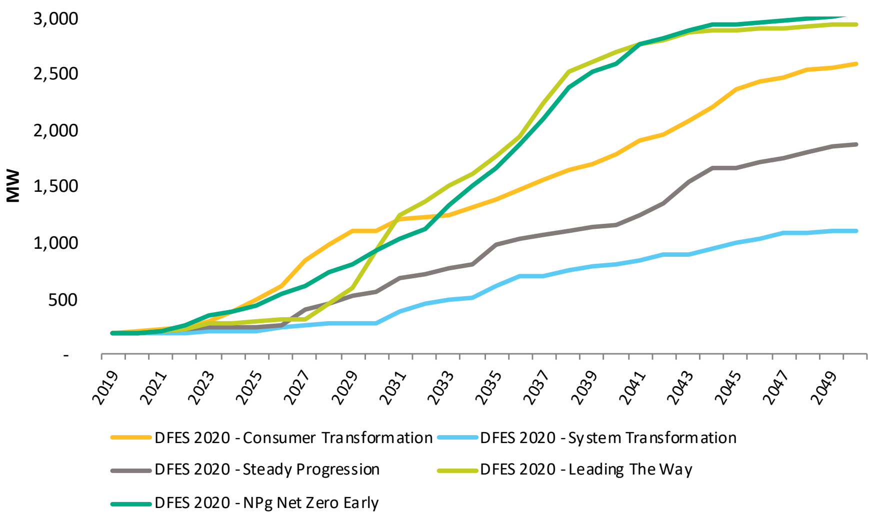
Under the 'Steady Progression' scenario, biofuels continue their sharp increase for the next few years but then flatline from the mid-2020s (figure 16).

In all other scenarios, including our own 'Net Zero Early', we see a decline of biomass over the 2020s before flatlining from the 2030s. A lack of immediately available and credible CCUS in the early years of the scenarios leads us to assume that this technology will be leapfrogged by others such as ready-to-go-solar.

# Proactive Grid Management

## Storage

**Figure 17:** Storage Capacity



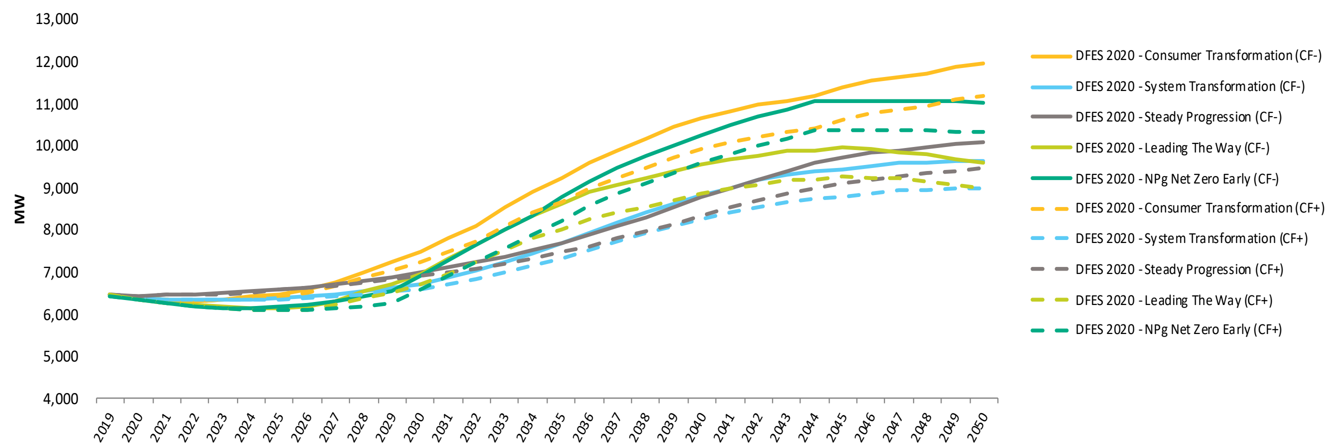

All five DFES forecast an increase in energy storage capacity across our region by 2050, with the most rapid rate of uptake occurring in the 2030s LCT boom (figure 17). For EVs, heat pumps and solar PV alike, the primary driver of this shift will be due to the falling costs of technology; and in the case of energy storage, the cost of batteries.

In the more ambitious scenarios like ‘Leading the Way’ and our own ‘Net Zero Early’, there will be a symbiotic growth between energy storage capacity and the increasing flexibility requirements of the region as the need for the latter, facilitates the growth of the former, and more customers discover the economic benefits of owning flexibility assets like batteries. Energy storage will also increasingly be co-located with renewable generation to maximise the benefits of the two technologies.



## Flexibility

**Figure 18:** Gross Peak Demand with (CF+) and without (CF-) Price Driven Customer Flexibility




Our fundamental role as a DNO is to manage gross peak demand to ensure that the energy needs of our communities are met when and where they are needed. As we transition to a DSO, and the network itself becomes more decentralised and multifaceted across all credible scenarios, we will play a more active role in managing the flow of energy to power our region.

We know that the electrification of heat and transport are going to change the network like never before and we are preparing to facilitate this evolution by championing a ‘flexibility first’ approach to manage the impact of LCT loads.

Figure 18 demonstrates how across all five DFES scenarios, price driven customer flexibility could ease the pressure on the network during times of gross peak demand. This is flexibility being offered by customers in response to regular price signals in their energy bills.

Flexibility will also empower our customers to take an active role in their energy futures and earn back on their LCT investments, or save money on their energy bills.

As we transition to this exciting new future, we expect energy suppliers will offer increasingly tailored and bespoke tariffs or other propositions that can account for all types of LCT. It will be our role as the DSO to ensure that these technologies and flexible tariffs work together, as well as make use of network tools like customer flexibility as additional energy procurement to avoid local network constraints and deliver clean energy to our communities.

# Impact and conclusions

## The next few decades

The coming decade is one of the most critical since the Electricity Boards were founded in the 1940s. To date, day-to-day operations and not the climate emergency have been the biggest driver of our investments.

That changes today.

No matter which of the scenarios presented in this document comes to fruition, we are already readying our network for significant change.

**2020s:** Whilst we will not see significant network constraints at our substations in the 2020s (as shown in figure 19) this is the decade that will dictate all the important decisions that influence the direction of the UK's net zero journey. Our task will be to monitor and respond to these decisions with network investment, including DNO connected customer flexibility, network flexibility and network development. The 2020s will also be categorised by responding to hyper-local, low carbon technology clusters that require capacity in the relatively few primary substations that will experience constraints. We remain committed to a 'flexibility first' approach during this time to support regional growth.

**2030s:** In this decade we will see the policy and investment decisions of the 2020s pay off nationally. In our region we will see more EVs as a result of the 2030 ICE ban and heat pump roll outs will be gathering pace. We anticipate that the capability of customer flexibility will start to be called upon more during this decade. This is especially true if a 'Net Zero Early' or 'Consumer Transformation' model is followed. We envisage that, with smart management, the number of major substation constraints will be kept comfortably under 100.

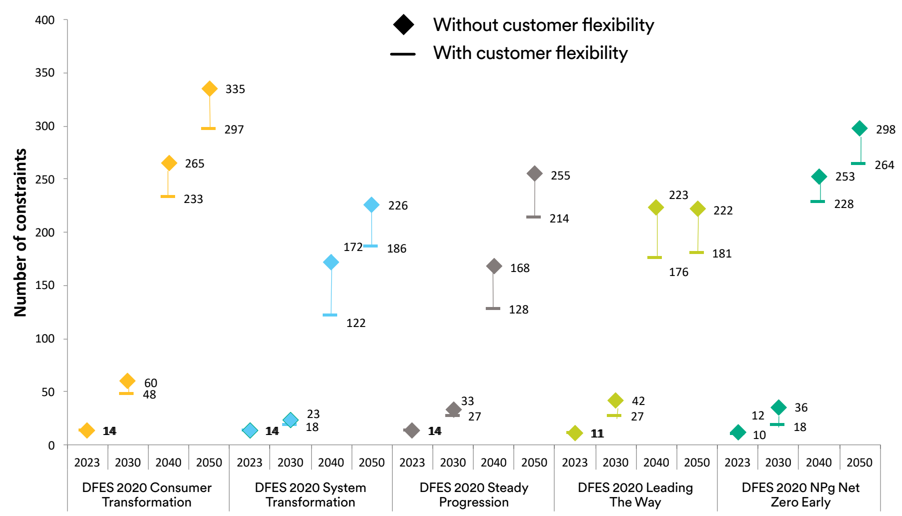
**2040s and 2050s:** These are the decades we must invest for now. Without customer flexibility, all models forecast a significant number of constraints at our primary substations. Without intervention (investment or customer flexibility incentive) the number of substations witnessing constraints are into the hundreds. The positive impact of 'flexibility first' can be keenly noted in figure 19. Under our own 'Net Zero Early' forecast customer flexibility could reduce the constraint management need for our customers by up to 13%, and under the 'System Transformation' model this is as high as 44%.

The following figures show the estimated number of substation constraints (i.e. where demand exceeds capacity) in 2030, 2040 and 2050 for each scenario, with and without the price driven customer flexibility assumed in the GB FES. The diamonds at the tail of the arrows represent the number of substations with potential capacity issues without customer flexibility. The line represents the significantly reduced number as a result of price-driven customer flexibility. As already mentioned, one of our solutions that we can deploy to deal with any constraints shown here is DNO contracted customer flexibility as an alternative to network investment – these solutions are not presented here.





**Figure 19:** The Impact of Price Driven Customer Flexibility on the Potential Number of Primary and Major Substation Constraints - for each Scenario

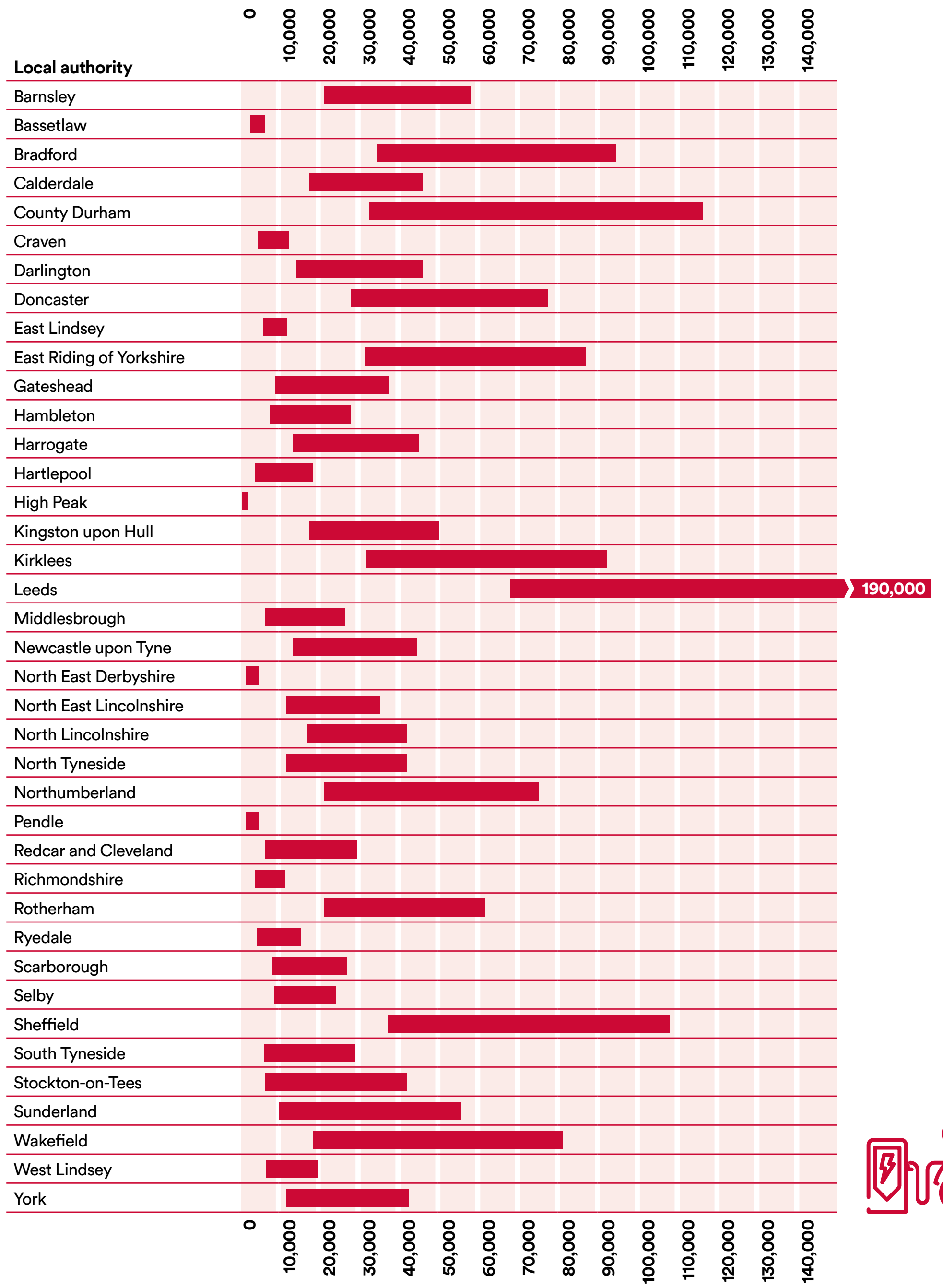



## Visibility of future network constraints

Figure 19 provides quantitative information on the number of substations potentially reaching full capacity under each scenario, across all of our network. You can access the detailed data by downloading the 'peak utilisation at primary substations (with or without customer flexibility)' spreadsheets from Data Mill North.[1] A utilisation rate of 100% for a substation means that the gross demand exceeds the declared capacity of the substation for a number of half-hour periods. The constraints shown are picking up substations at 99% utilisation rate. This does not necessarily signal the need to invest (in network or non-network solutions); it is an indication of the need to carry out a further assessment. For example, it may be possible to transfer the demand to an adjacent substation, or some of the peak demand might already be met by the generation connected to the network.

1 Datasets: https://datamillnorth.org/dataset/northern-powergrid-dfes-2020

**Figure 20:** Our Electric Vehicle Projections by Local Authority (2030)





**Our 2,700 colleagues are the heart of the UK's carbon reduction drive. Through our electricity distribution network, we will facilitate the net zero ambitions of our region.**

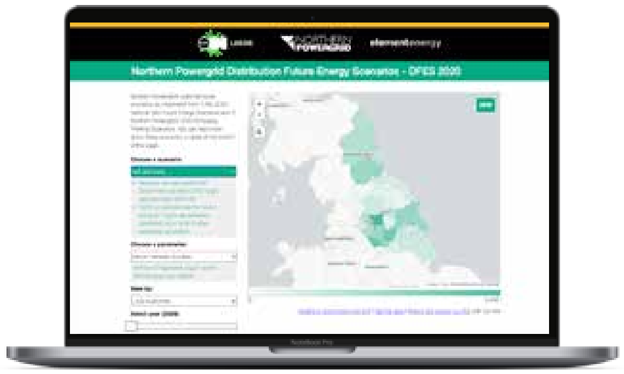
# Engaging with our scenarios
## Access to the datasets

**Our data modelling can only be valuable if we collaborate with you to get the best data and feedback for our region.**

As with last year's DFES, we have partnered with the Open Data Institute (ODI) in Leeds to provide an interactive visualisation tool that will make the DFES data more meaningful to you.

We have also taken the data from our forecasting tool, regionalised it to local authority boundaries and presented the key underlying variables in geospatial maps.

The datasets are published once again on Data Mill North, including in raw data form. This open data approach means you can take our data and use it for your own purposes.



**To view visualisations of the data specific to areas you are interested in:**
**https://odileeds.github.io/northern-powergrid/2020-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 2020**
Speed up data access with our new Local Authority search function.

When viewing the data by 'primary substations', you will see the total value of the parameter selected for each of these substations. 'Primary substations (with local authorities)' overlays this data with the local authority borders.

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

**Scenario:**
- Regionalised view of National Grid's FES.
  - Steady Progression
  - System Transformation
  - Consumer Transformation
  - Leading the Way
- Based on Northern Powergrid's accelerated decarbonisation pathway.
  - Net Zero Early

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

**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.

**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)

**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 a number of datasets which 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 which 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-2020**

**More information about Northern Powergrid's regionally led scenarios: https://odileeds.github.io/northern-powergrid/2020-emerging-thinking/graphs**





# We want you to talk to us

**The future energy requirements of the North East, Yorkshire and northern Lincolnshire are uncertain. We are bringing forward investment plans to manage this uncertainty, no matter what the future holds.**

A key part of dealing with uncertainty is to understand the range of credible pathways. We present these as 'book ends' or a range of credible outcomes. We do not know how future energy needs will outturn but it is likely that they will be in the range presented in our DFES.

As the country transitions towards net zero in 2050 (or sooner) and government policies – such as the push for heat pumps or the ICE vehicle ban – start to make an impact, more plans are being made.

Our local authorities are turning climate emergency declarations into climate action plans.

### You are making plans

You are deciding to push forward heat pump installations, you are buying and selling EVs, you are installing chargers, and you are trialling low carbon future fuels in factories.

### Please tell us what your plans are

We are seeking your input and views to arrive at a baseline planning forecast to inform our investment decisions for meeting the future energy needs of our region.

We're interested in plans that affect one building or street, right the way up to plans that impact the whole region or even the country.

### No plan is too big or too small to tell us about

As your network operator, we need to plan ahead to be ready to support anything that needs to happen in our energy future. We must make sure that the required interventions are delivered where and when they are needed to deliver best value for customers, whilst meeting their future energy needs. These interventions could be a mixture of procured flexibility services and network investments, which have longer planning timescales.

This is why we are consulting regionally to seek views on a range of scenarios to identify the most likely pathway over the next 10, 20, and 30 years.

### How to provide feedback

We welcome feedback in any format.

At any point you can email your view to: npg.system.planning@northernpowergrid.com.

In addition, we will be carrying out a proactive and interactive engagement campaign throughout 2021.

You'll be invited to share your net zero related ambitions with us via:

- virtual events
- easy polls on our social media channels
- interactive surveys
- 1-2-1 sessions.

This outreach is designed so we can review the scope and scale of your plans and reflect these insights in our DFES data, so that we can make the investment decisions needed to make your ambitions a reality.

# Next steps

**Your feedback, opinions and data updates will impact the investment decisions we take. These investment decisions include the flexibility services and network upgrades that may be needed to support your projects. Do not miss the opportunity to tell us what your plans are. We want to collaborate with, and support you.**

DFES is an annual publication; and this year it has some differences. We are in the process of preparing our plans for the next price control period, RIIO-ED2 (2023-2028) and your feedback will be instrumental in ensuring our business plan during this timeframe is able to meet your local near-term plans.

Our formal business plan submission to stakeholder groups and Ofgem is in 2021. We have spent this year engaging in meaningful conversations with stakeholders, developing our emerging thinking and beginning to form the basis of our RIIO-ED2 business plan.

This DFES document and your subsequent feedback will form a critical part of the next phase of our stakeholder consultation and engagement as we solidify our planning for RIIO-ED2 and network investment over this period.

## Timetable for DFES conversations

| 2020 | 2021 | | | | 2022 |
|---|---|---|---|---|---|
| December | Q1 | Q2 | Q3 | Q4 | Q1 |
| — Publish initial DFES 2020 document, interactive visualisation tool and data. | — Stakeholder consultation.<br>— January - February DFES assurance from our Technical Panel.<br>— February - March final DFES 2020 report.<br>— Use DFES 2020 to inform 2021 GB FES. | — Finalise and submit initial RIIO-ED2 plan. | — 2021 GB FES published by Electricity System Operator. | — Submit final RIIO-ED2 business plan.<br>— 2021 DFES published. | — Stakeholder consultation. |
| | | **Consult on draft business plan** | | | |
| | **Data collection and analysis** | | | | |





During January 2021, the initial DFES 2020 published outputs were scrutinised and accepted by our Technical Panel which provides technical assurance for our RIIO-ED2 business plan. Our audit function also assured reconciliation of the data to the GB FES. Externally, we have also run a stakeholder consultation exercise. We are now (Q2 2021) publishing this new updated version of DFES 2020 which is fully assured. The only changes from the previous version are the section on electric vehicle rapid charging and minor amendments to the non-renewable DG charts, tables and footnote.

We are inviting early conversations with you to gather your views on the scenarios, discover any challenges you have on our assumptions and collect any new data insights.

In Q2 2021 we will also finalise our RIIO-ED2 initial business plan. This will be a culmination of extensive stakeholder engagement and development of propositions first shared in our 2020 emerging thinking. Over the course of 2021, we will continue with extensive stakeholder consultation regarding the RIIO-ED2 business plan, supported by this DFES 2020 and the initial plan that is expected to be submitted by July 2021.

In Q3, we will begin processing the data and information for our 2021 DFES which will take into account the 2021 GB FES and also contain the planning scenarios generated from our stakeholder outreach.

We complete our RIIO-ED2 final business plan in Q4 and will take on board all learning from DFES activity up to this date.

**We welcome your feedback at any time.**

Data collection and analysis is a fluid process and will be ongoing throughout the year, but please be mindful that the deadline for data to be included in Northern Powergrid's 2021 DFES is 30 June 2021.

# Glossary

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

**Carbon capture and utilisation storage (CCUS):** The process of capturing carbon dioxide (CO2) to be recycled for further usage.

**COVID-19:** An infectious disease caused by coronavirus 2 (SARS-CoV-2).

**CO2:** Carbon dioxide – the most common greenhouse gas.

**Decarbonisation:** The reduction, and ultimately elimination, of greenhouse gas (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 networks.

**Distributed generation:** 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 Operator – DSOs securely operate and develop 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.

**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 whole-system 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 have required fuel costs that are above average and, if they were to spend that amount, would be 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 one source to another.

**HEV:** Hybrid electric vehicle that combines a conventional internal combustion engine (ICE) system with an electric propulsion system powered by a battery.

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

**HV:** High voltage – electricity supplied at 11,000 volts.

**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, 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 emissions by 2050 (compared to 1990 levels).

**Network constraints:** Areas of the network where the demand or generation exceed the designed network capacity.

**Peak demand:** When the most electricity is being used on the network at any given time.

**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 based on digital technology that is used to supply electricity to customers through a two-way digital communication.

**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.

**ULEV:** Ultra-low emission vehicle – low emission vehicle that emits 75g/km CO2 or less.

# Annexes
## Annex 1 – Distribution Future Energy Scenario assumptions and building blocks

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

1. Regionalised view of the 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 2048 through more ambitious changes.
5. Northern Powergrid's Net Zero Early that meets net zero even earlier, by around 2045, 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% 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 I&C engagement in smart systems, Vehicle–to–Grid (V2G) adoption levels remain low and we see slow growth in the DSR market.
— Transport: Consumer resistance and other barriers means slower uptake of electric vehicles 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% 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% 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 utilisation and storage (CCUS) rolled out at scale for steam methane reformation (SMR). Low electrification.
— Hydrogen: High levels of hydrogen usage for heat, I&C and transport. Multiple SMR, Autothermal Reforming (ATR) and 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, V2G adoption levels are low and we see moderate growth in the DSR market.
— Transport: Ultra Low Emissions Vehicle (ULEV) 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% by 2030. All credible industrial processes will be electrified.
— Electricity Demand: UK meets EU 30% 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 2048.**

- Overall: This scenario shows the earliest credible date when the net zero target is met, at the national level.
- Energy Demand: I&C energy efficiency improves by at least 20% by 2030. I&C decarbonises early through electrification (~1st 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.

## Net Zero Early

**Meets the net zero carbon target by the mid-2040s.**

- Overall: This scenario presents a more ambitious pathway.
- 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 rollout 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 rollout of CCUS technologies is also successful and from the early 2030s and onwards, both gas CCUS and bioenergy with CCUS 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 the government is supplemented by intensive investment in low carbon technologies.

| Assumption name | Steady Progression | System Transformation | Consumer Transformation | Leading The Way | Net Zero Early |
|---|---|---|---|---|---|
| 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 1MW) | Low | Medium | Medium | High | High |
| Medium duration electricity storage | Low | Medium | Medium | High | High |
| Solar generation (plant smaller than 1MW) | Low | Medium | High | Medium | High |
| Home thermal efficiency levels | Low | Medium | High | High | High |
| Appliance models: residential electrical energy efficiency | Low | Medium | Medium | High | High |
| Smart appliances | Low | Medium | Medium | High | High |

# Annex 2 – LCT uptake scenarios and their network impacts

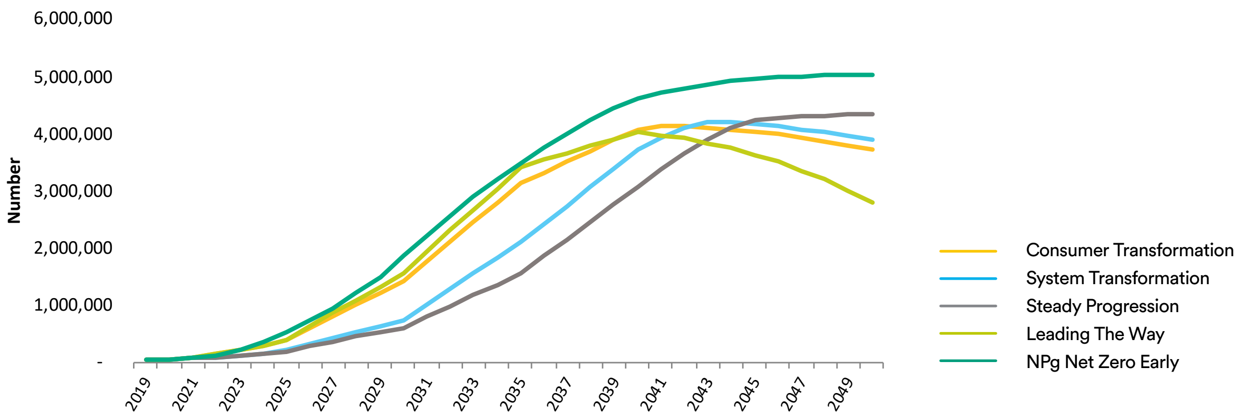
## Demand

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

## Electric Vehicles

| | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|
| Consumer Transformation | 48,816 | 1,405,387 | 4,066,804 | 3,699,764 |
| System Transformation | 39,495 | 742,307 | 3,706,800 | 3,894,709 |
| Steady Progression | 39,601 | 606,089 | 3,076,814 | 4,335,203 |
| Leading The Way | 48,674 | 1,553,169 | 4,018,157 | 2,777,407 |
| Net Zero Early | 36,956 | 1,850,729 | 4,596,373 | 5,020,767 |

**Figure 21:**
Electric vehicle uptake forecast



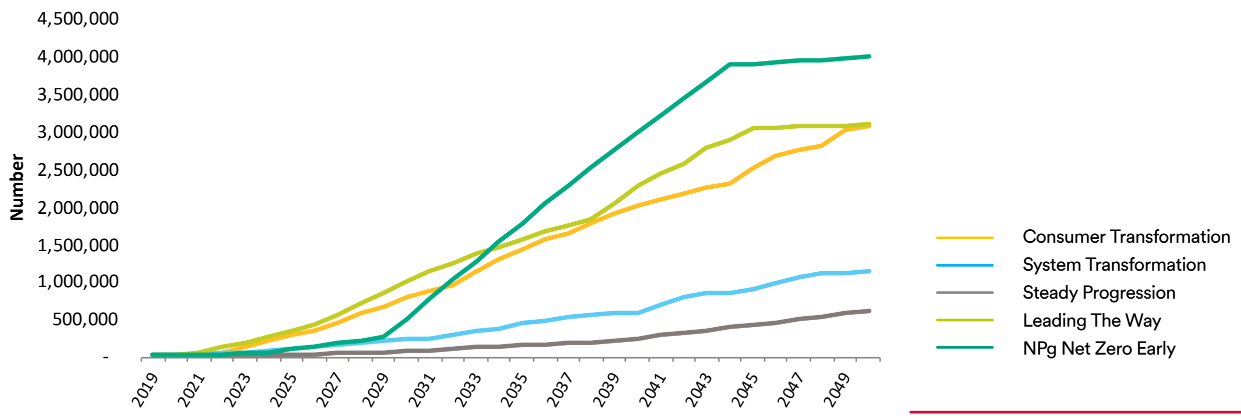





## Heat pumps

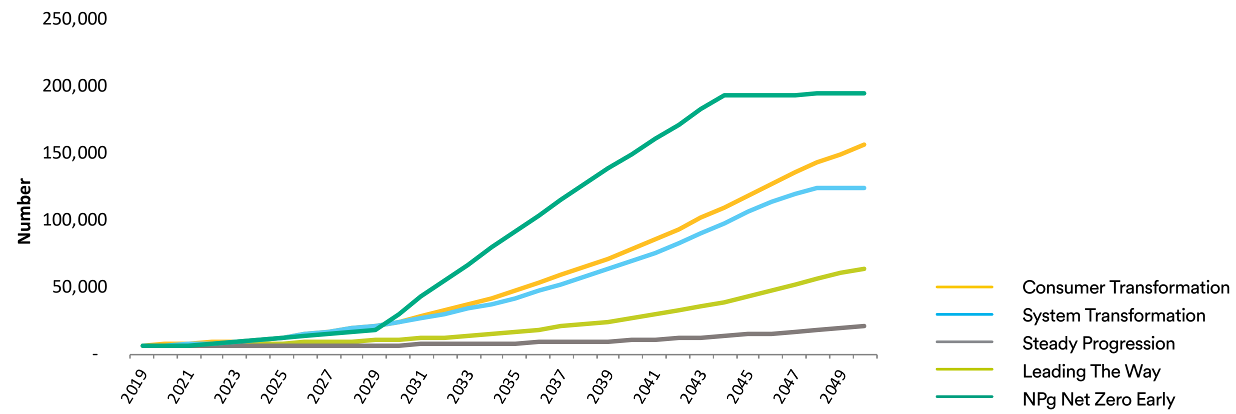
| | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|
| Consumer Transformation | 30,424 | 786,050 | 2,008,787 | 3,082,425 |
| System Transformation | 28,295 | 235,836 | 593,682 | 1,149,815 |
| Steady Progression | 23,203 | 73,266 | 241,773 | 616,248 |
| Leading The Way | 32,601 | 1,002,218 | 2,269,214 | 3,098,628 |
| Net Zero Early | 22,711 | 514,326 | 2,982,852 | 3,994,780 |

**Figure 22:**
Residential heat pump uptake forecast



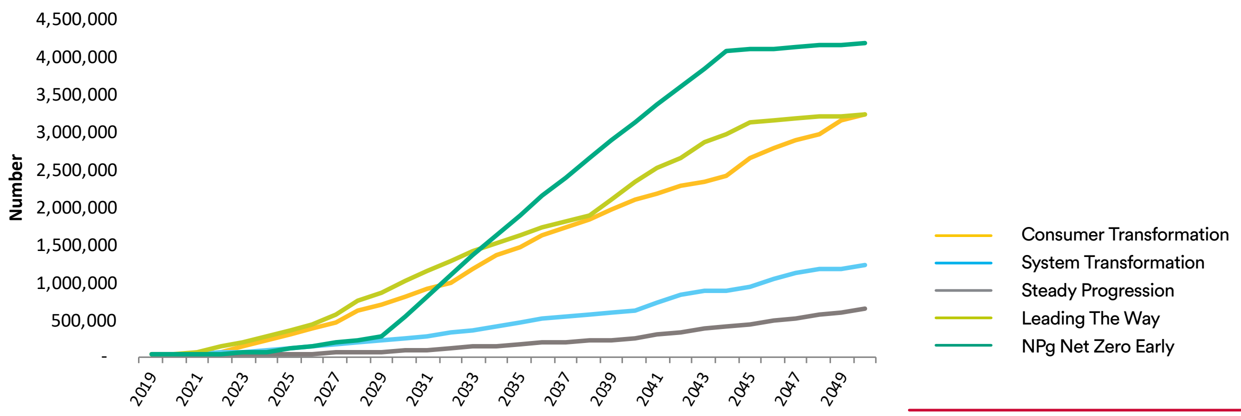

| | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|
| Consumer Transformation | 7,212 | 24,230 | 77,547 | 155,572 |
| System Transformation | 6,306 | 10,766 | 77,547 | 63,082 |
| Steady Progression | 6,143 | 6,683 | 77,547 | 21,010 |
| Leading The Way | 6,557 | 23,652 | 77,547 | 124,394 |
| Net Zero Early | 6,146 | 30,274 | 77,547 | 193,805 |

**Figure 23:**
I&C heat pump uptake forecast



| | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|
| Consumer Transformation | 37,635 | 810,280 | 2,086,335 | 3,237,997 |
| System Transformation | 34,601 | 246,602 | 619,881 | 1,212,897 |
| Steady Progression | 29,347 | 79,949 | 251,947 | 637,258 |
| Leading The Way | 39,158 | 1,025,870 | 2,338,055 | 3,223,021 |
| Net Zero Early | 28,858 | 544,600 | 3,132,171 | 4,188,585 |

**Figure 24:**
Total heat pump uptake forecast

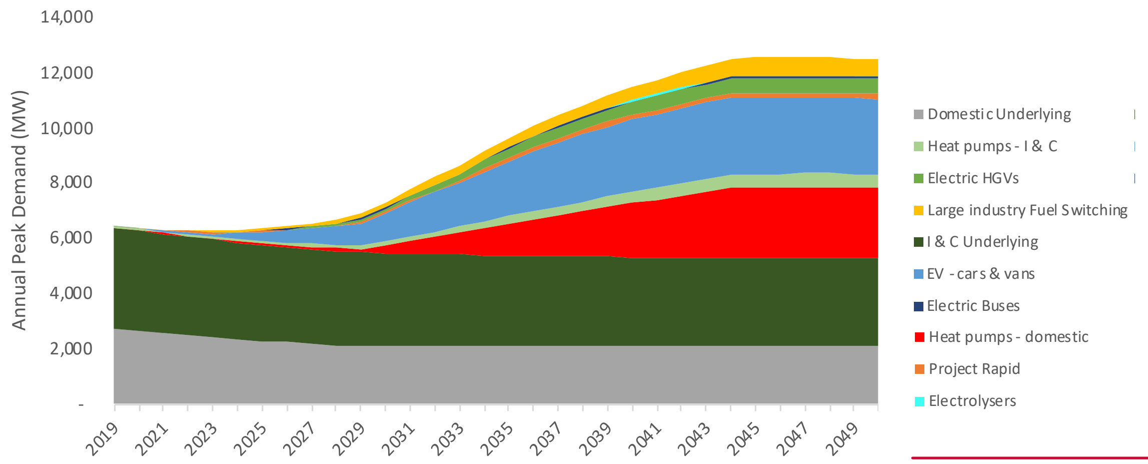







| Net Zero Early: Contributions to Peak Demand MW - NPg | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|
| Domestic Underlying | 2,635 | 2,083 | 2,089 | 2,112 |
| I & C Underlying | 3,637 | 3,363 | 3,219 | 3,146 |
| Heat pumps - domestic | 21 | 296 | 1,942 | 2,582 |
| Heat pumps - I & C | 45 | 125 | 395 | 476 |
| EV - cars & vans | 21 | 1,044 | 2,617 | 2,712 |
| Project Rapid | | 58 | 166 | 166 |
| Electric HGVs | 0 | 118 | 463 | 548 |
| Electric Buses | 0 | 17 | 52 | 62 |
| Electrolysers | 0 | 3 | 19 | 20 |
| Large industry Fuel Switching | 0 | 207 | 460 | 661 |
| Total demand | 6,359 | 7,316 | 11,422 | 12,487 |

**Figure 25:**
Net Zero Early: Contributions to Peak demand (MW)



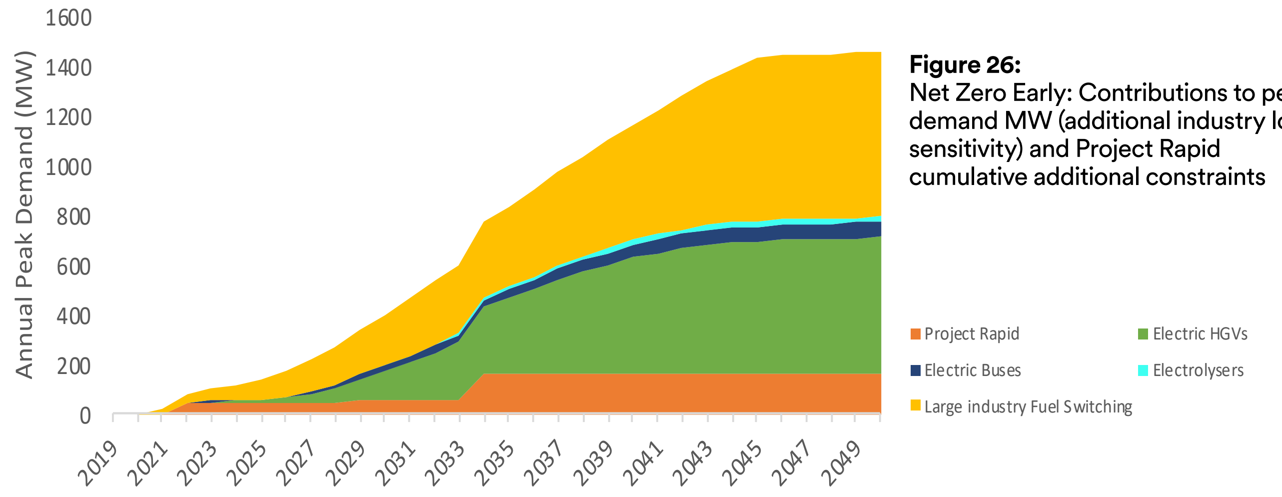




**Figure 26:**
Net Zero Early: Contributions to peak demand MW (additional industry loads sensitivity) and Project Rapid cumulative additional constraints

| NZE 2020 - Project Rapid Cumulative Additional Constraints | End of ED1 (2022/23) | End of ED1 (2022/23) | 2029/20 | 2039/40 | 2049/50 |
|---|---|---|---|---|---|
| Primary | 1 | 1 | 1 | 2 | 2 |
| Supply point | 0 | 0 | 0 | 2 | 2 |
| Total | 1 | 1 | 1 | 4 | 4 |

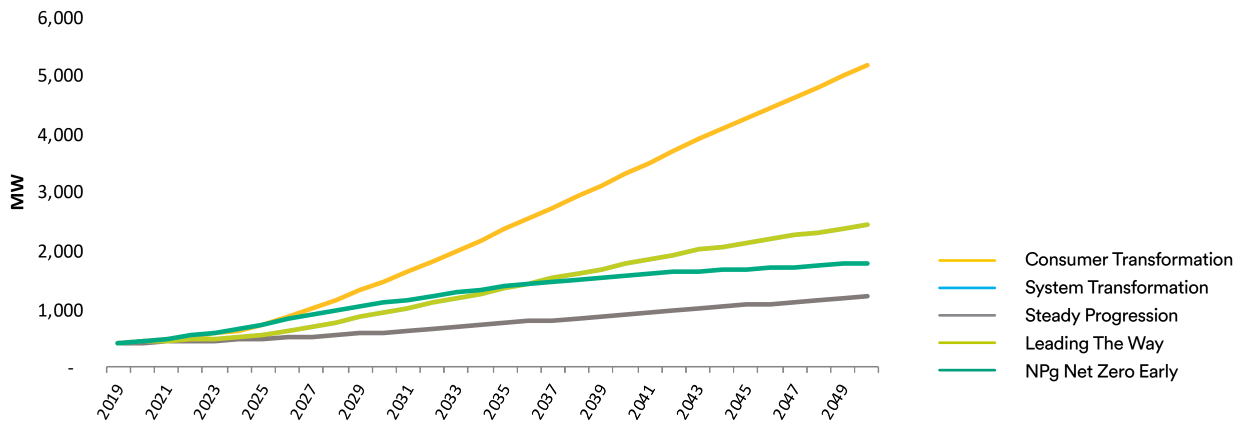
## Generation and Storage

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 ODI website with disaggregation down to local authority level and also primary substation level.

## Solar PV

| | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|
| Consumer Transformation | 446 | 1,479 | 3,315 | 5,189 |
| System Transformation | 438 | 944 | 1,777 | 2,442 |
| Steady Progression | 435 | 609 | 919 | 1,213 |
| Leading The Way | 438 | 944 | 1,777 | 2,442 |
| Net Zero Early | 456 | 1,109 | 1,582 | 1,788 |

**Figure 27:**
Residential PV capacity uptake forecast (MW)

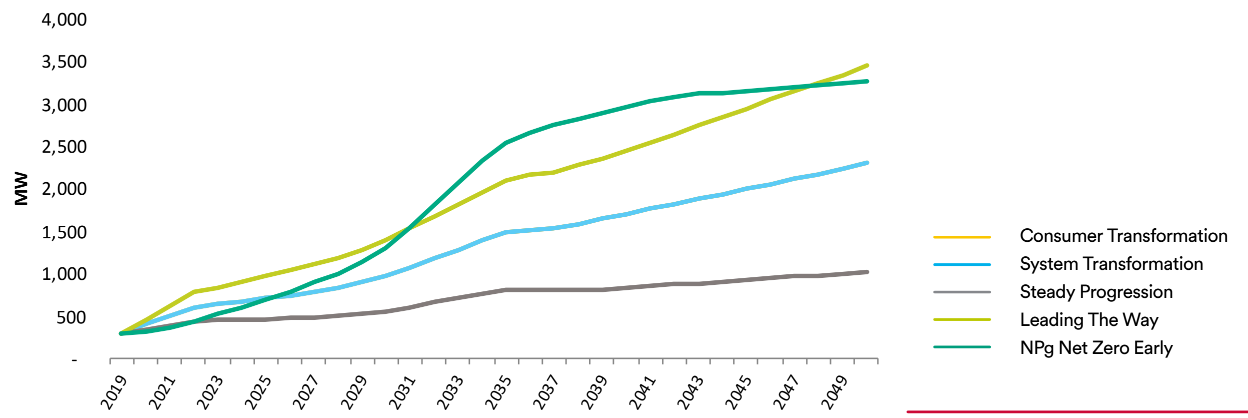







| | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|
| Consumer Transformation | 412 | 988 | 1,706 | 2,301 |
| System Transformation | 412 | 988 | 1,706 | 2,301 |
| Steady Progression | 356 | 571 | 843 | 1,025 |
| Leading The Way | 468 | 1,400 | 2,449 | 3,447 |
| Net Zero Early | 331 | 1,311 | 2,964 | 3,278 |

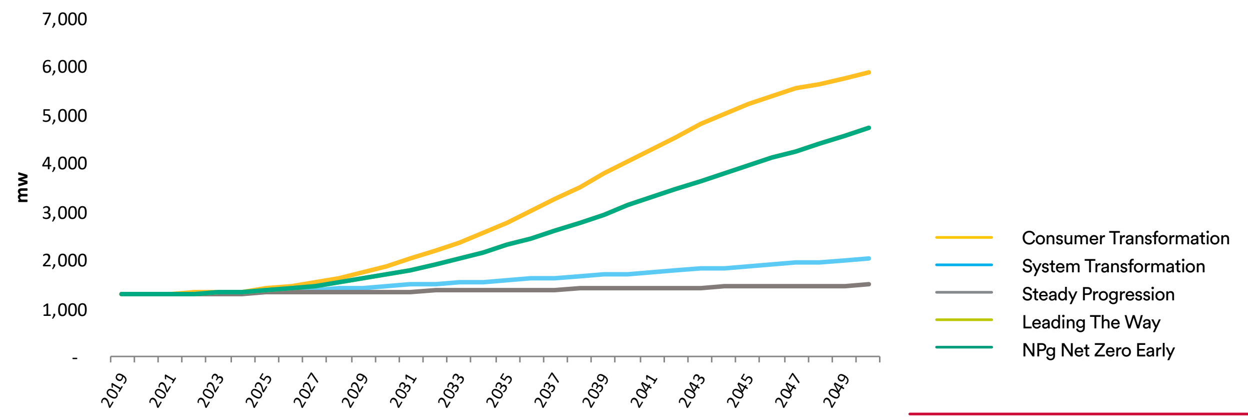
**Figure 28:**
Large scale PV capacity uptake forecast (MW)




## Wind

| | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|
| Consumer Transformation | 1,325 | 1,891 | 4,046 | 5,867 |
| System Transformation | 1,324 | 1,468 | 1,734 | 2,048 |
| Steady Progression | 1,323 | 1,362 | 1,426 | 1,492 |
| Leading The Way | 1,324 | 1,713 | 3,139 | 4,746 |
| Net Zero Early | 1,324 | 1,713 | 3,139 | 4,746 |

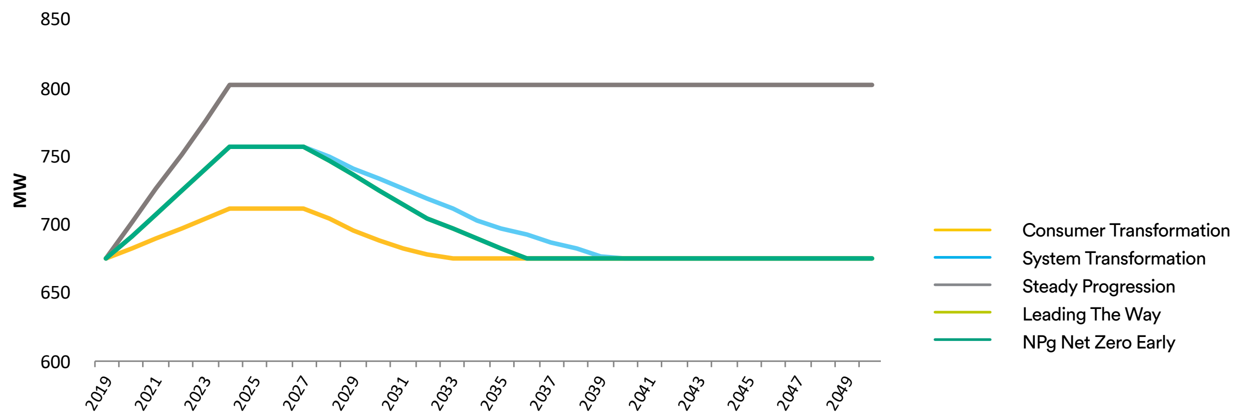
**Figure 29:**
Wind energy capacity uptake forecast (MW)



## Biomass

| | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|
| Consumer Transformation | 683 | 688 | 675 | 675 |
| System Transformation | 692 | 734 | 675 | 675 |
| Steady Progression | 701 | 802 | 802 | 802 |
| Leading The Way | 692 | 726 | 675 | 675 |
| Net Zero Early | 692 | 726 | 675 | 675 |

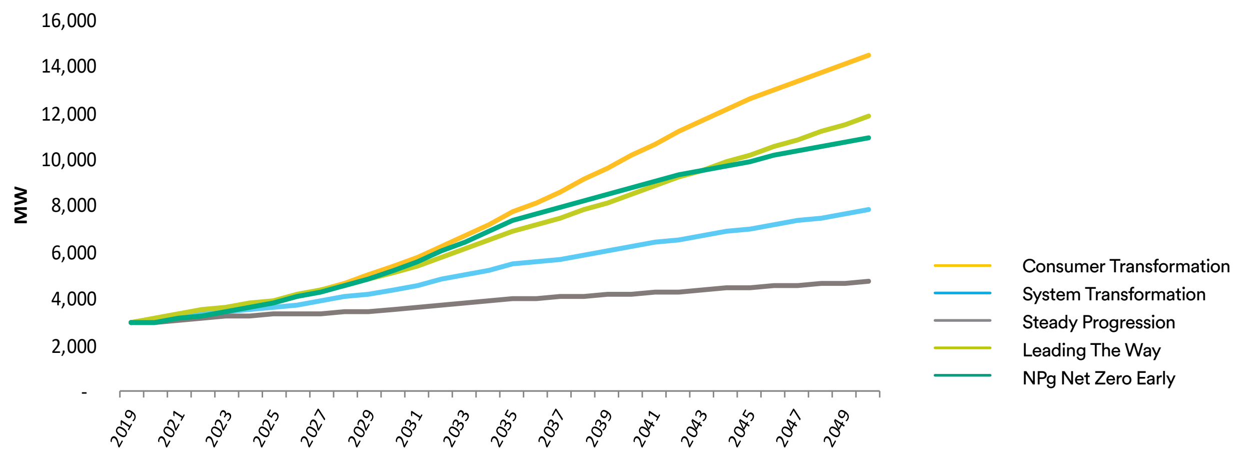
**Figure 30:**
Total biomass and energy crops distributed generation capacity uptake forecast (MW)




## Total generation

| | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|
| Consumer Transformation | 3,086 | 5,375 | 10,158 | 14,469 |
| System Transformation | 3,083 | 4,409 | 6,228 | 7,808 |
| Steady Progression | 3,028 | 3,564 | 4,224 | 4,768 |
| Leading The Way | 3,143 | 5,129 | 8,508 | 11,824 |
| Net Zero Early | 3,024 | 5,200 | 8,795 | 10,965 |

**Figure 31:**
Total renewable energy distributed generation capacity uptake forecast (MW)

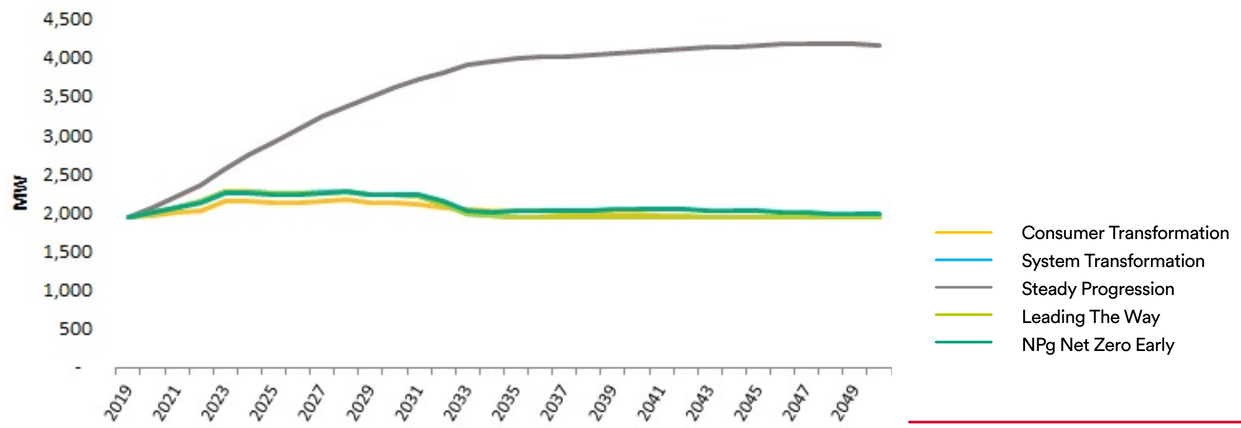







| | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|
| Consumer Transformation | 2,086 | 2,257 | 2,096 | 2,055 |
| System Transformation | 2,123 | 2,348 | 2,055 | 2,055 |
| Steady Progression | 2,186 | 3,729 | 4,197 | 4,278 |
| Leading The Way | 2,123 | 2,348 | 2,055 | 2,055 |
| Net Zero Early | 2,122 | 2,354 | 2,162 | 2,097 |

**Figure 32:**
Total non-renewable energy distributed generation capacity uptake forecast (MW) [1]

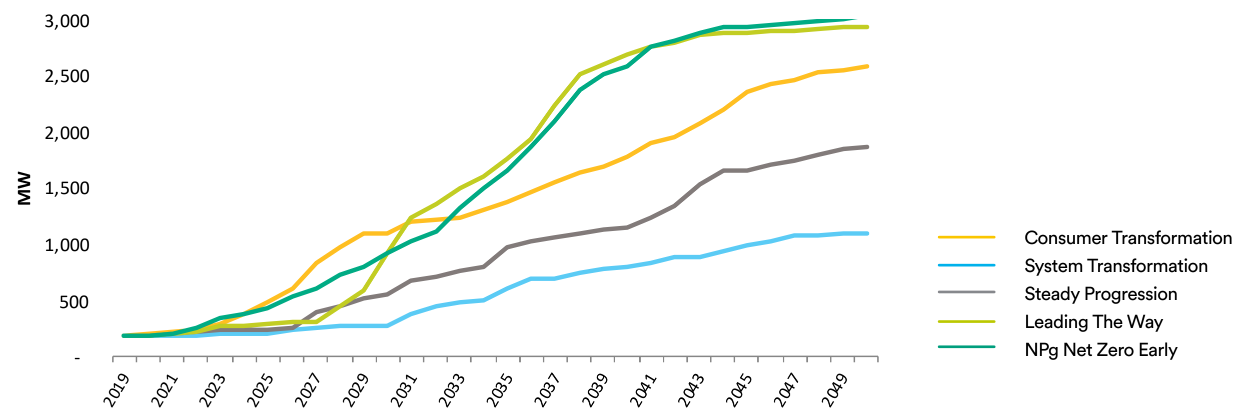



1 Whilst this figure shows non-renewable DG staying connected to the network, we assume that a fuel switch will occur in the future to low carbon fuel types.

## Energy storage

| | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|
| Consumer Transformation | 204 | 1,107 | 1,793 | 2,590 |
| System Transformation | 190 | 285 | 810 | 1,111 |
| Steady Progression | 197 | 558 | 1,164 | 1,873 |
| Leading The Way | 197 | 930 | 2,692 | 2,950 |
| Net Zero Early | 185 | 926 | 2,600 | 3,045 |

**Figure 33:**
Total storage capacity uptake forecast (MW)

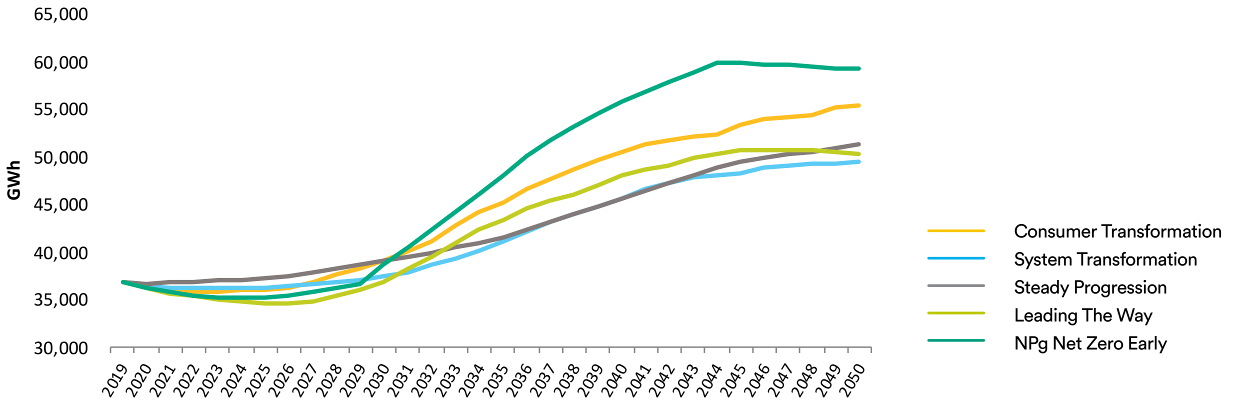


## Energy distributed

The total energy distributed (GWh) will increase as the number of LCTs such as electric vehicles and heat pumps increase, although the underlying consumption is expected to continue reducing with further improvements to energy efficiency. The table and chart below illustrate the total energy consumption for the five scenarios.

| | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|
| Consumer Transformation | 36,501 | 39,194 | 50,647 | 55,463 |
| System Transformation | 36,591 | 37,476 | 45,710 | 49,512 |
| Steady Progression | 36,737 | 39,106 | 45,659 | 51,269 |
| Leading The Way | 36,345 | 36,995 | 48,020 | 50,332 |
| Net Zero Early | 36,396 | 38,707 | 55,791 | 59,242 |

**Figure 34:**
Total annual electrical energy consumption projections (GWh)







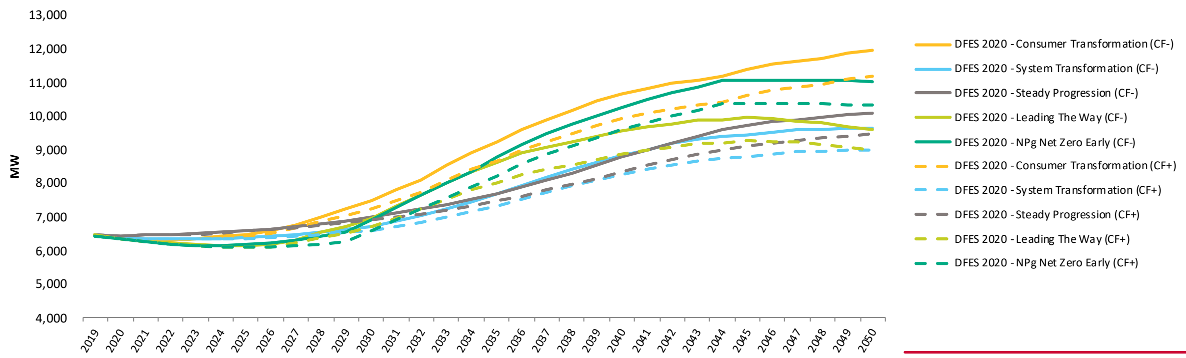

## Flexibility

Procuring flexibility from our customers will be an effective energy management technique as demonstrated in the below data. Flexibility services can involve shifting the time of energy usage, supporting the local network with generation at short notice, or offering up the ability to charge empty energy storage with excess power. These services are a vital part of local power grid operations and will increase in importance as more renewable energy is needed to support the uptake of low carbon technologies like electric vehicles and heat pumps consumption for the five scenarios.

| Gross Peak Demand - No CF (MW) | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|
| Consumer Transformation | 6,405 | 7,493 | 10,654 | 11,949 |
| System Transformation | 6,412 | 6,733 | 8,845 | 9,656 |
| Steady Progression | 6,437 | 6,997 | 8,782 | 10,107 |
| Leading The Way | 6,369 | 6,977 | 9,570 | 9,581 |
| Net Zero Early | 6,358 | 6,977 | 9,570 | 9,581 |

| Gross Peak Demand - With CF (MW) | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|
| Consumer Transformation | 6,403 | 7,247 | 9,916 | 11,175 |
| System Transformation | 6,411 | 6,612 | 8,276 | 9,011 |
| Steady Progression | 6,436 | 6,916 | 8,348 | 9,466 |
| Leading The Way | 6,367 | 6,711 | 8,862 | 8,997 |
| Net Zero Early | 6,358 | 6,587 | 9,596 | 10,334 |

**Figure 35:**
Gross Peak Demand projections (MW)



## Industry switching and electrolysers (sensitivities)

| | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|
| Electric HGVs | 0.217 | 118.275 | 463.484 | 548.453 |
| Electric Buses | 0.101 | 17.287 | 51.562 | 62.494 |
| Electrolysers | 0.047 | 2.621 | 19.152 | 20.417 |
| Large industry Fuel Switching | 0.000 | 207.499 | 459.672 | 660.720 |
| Total additional contribution | 0.365 | 345.682 | 993.871 | 1292.084 |

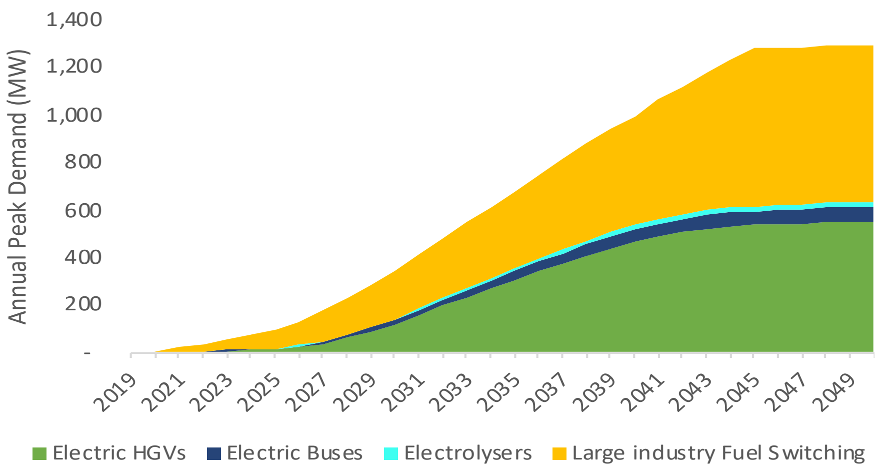



**Figure 36:**
Net Zero Early Peak Demand: Additional Industry Loads Sensitivity

| | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|
| Electric HGVs | 2.893 | 1576.890 | 6179.334 | 7312.166 |
| Electric Buses | 2.314 | 395.380 | 1179.307 | 1429.327 |
| Electrolysers | 0.709 | 39.949 | 292.001 | 311.454 |
| Large industry Fuel Switching | 0.000 | 1817.689 | 4026.729 | 5787.908 |
| Total additional contribution | 5.917 | 3829.908 | 11677.372 | 14840.855 |

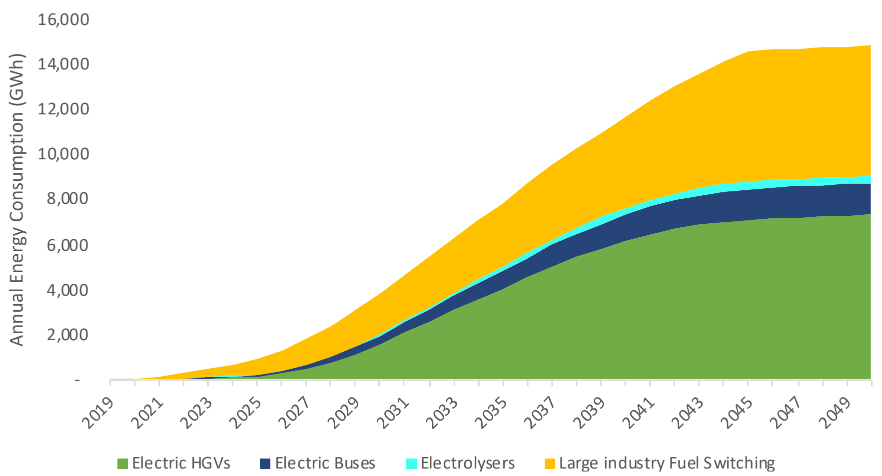



**Figure 37:**
Net Zero Early: Contributions to Energy Consumption GWh-NPg





# Annex 3 – Data sources

DFES data is available for download on the Data Mill North website: **https://datamillnorth.org/dataset/northern-powergrid-dfes-2020**

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 of 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 of the parameters, each parameter broken down further into four separate sheets (one for each scenario). |
| Local authority charting tools | Data for the key parameters at a local authority level, grouped by technology. A number of MS Excel workbooks providing useful tools for analysing the data, grouped by technology and by local authority, e.g. an 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 on separate sheets. |
| 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). Three MS Excel workbooks bringing together all the parameters and scenarios, provided on separate sheets. |
| Primary substation level data | A series of over 50 files and links to the data shown in the geospatial interactive visualisation tool – – a separate file for each parameter and for each scenario combination. |

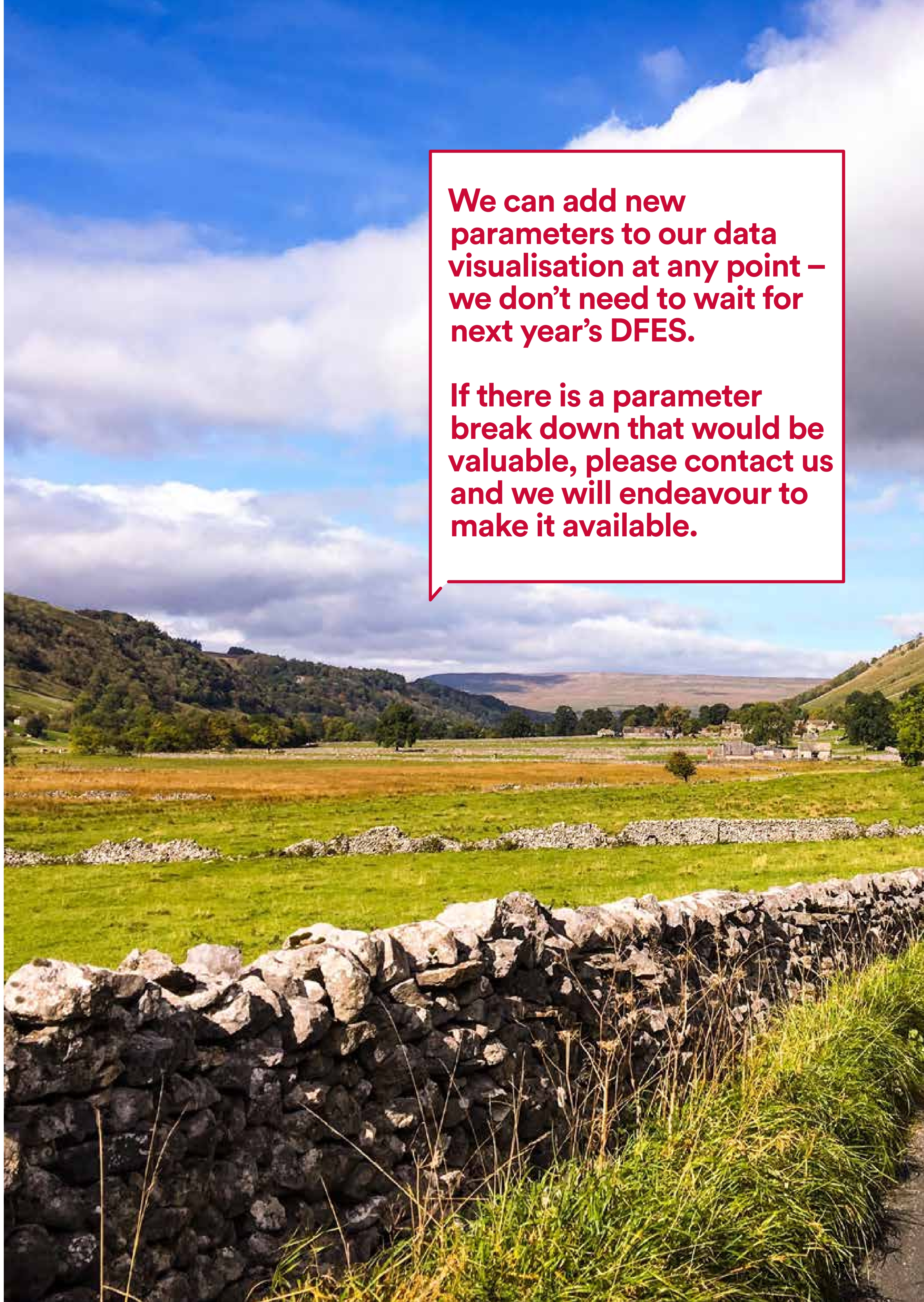
# Annex 4 – Parameter definitions

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 break down 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 vehicles). |
| **Electric transport (number)** | Number of planned electric transport vehicles in use. Includes EVs, HGVs, buses and wider feet vehicles such as bin lorries. |
| **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. |
| **Other generation installed capacity (MW)** | Installed capacity of all other generation including biomass, 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** | New parameter to provide information to large industrial customers relating to the impact on our electricity network of changing from their existing fuel to electricity. |
| **Total energy consumption, including electric vehicles and heat pumps (MWh)** | Total energy consumption by domestic households and industrial and commercial properties, including electric vehicle and heat pump consumption. |
| **Peak demand with customer flexibility at primary substations (MW)** | Peak half-hourly demand within the year. |
| **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, if load is shifted, e.g. time-of-use tariffs and smart charging of EVs. |





**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 break down that would be valuable, please contact us and we will endeavour to make it available.**

## 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.