Department for
Business, Energy
& Industrial Strategy

Net Zero and the power sector scenarios

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Contents

This report accompanies EEP2019 and shows two illustrative net zero electricity demand and generation scenarios. Unlike the projections in EEP2019, they go beyond what we can expect to happen under current policies.

There are numerous paths to net zero. These scenarios represent a range of net-zero consistent scenarios and are not a forecast nor do they indicate a preferred outcome.

Given the pace of innovation in the market, we cannot confidently forecast what electricity generation mix in 2050 best delivers very low emissions and reliable supply, at the lowest cost to consumers. While the scenarios presented are not forecasts nor an expression of government policy, they do illustrate the mix of properties required for a Net Zero consistent power system. The scenarios will be used as a counterfactual in power sector analysis to assess the impact of policies against a baseline consistent with reaching net zero by 2050.

The 2050 electricity demand scenarios were developed using the UKTIMES[1] model. The generation and capacity mix outputs were produced using BEIS's Dynamic Dispatch Model (DDM)[2].

1.Methodology

We undertook the electricity supply sector modelling in March 2020 using BEIS' Dynamic Dispatch Model (DDM) supplemented with assumptions from the UKTIMES Model (UKTM). Most assumptions were kept the same as in the EEP Reference Scenario with the primary changes in electricity demand, technology mix and carbon price.

Our understanding of what the electricity sector will need to do to support delivery of net zero emissions will change over time. This will be informed by what we learn about the costs of decarbonising other sectors of the economy and by the costs and availability of negative emissions technologies such as Bioenergy with Carbon Capture & Storage or Direct Air Carbon Capture & Storage.

We used the Department's version of UKTM to identify two different scenarios for the UK. These each support reaching Net Zero emissions across the whole economy by 2050. To create them, we varied assumptions about the abatement potential in sectors other than the power sector. We ran several other UKTM scenarios, varying technical assumptions to ensure the range was consistent with a range of possible decarbonisation pathways e.g., with greater or lesser use of hydrogen and electricity for both transport and heat. The electricity demand scenarios used in this analysis illustrate the range of possible electricity demand levels in GB[3]

[1] UKTIMES is a UK whole energy system optimisation model developed by University College London and BEIS
[2] A model of the whole UK energy and greenhouse gas system. The model allows us to explore different possible decarbonisation scenarios by considering the availability, performance, feasible build rates, and costs of existing and new technologies. See background information on the DDM
[3] Note that UKTM models at a UK level whilst the DDM models at GB level. Demand outputs from UKTM were adjusted to be for GB only before being used in the DDM. All power sector results presented here are at GB level

modelled – they are neither forecasts nor bounds on what demand might be in 2050. Table 1 below shows the differences between the scenarios.

Table 1 – Power sector demand levels consistent with meeting net zero across the whole economy.

Scenario	2050 power sector demand (TWh)	Narrative
Net Zero Lower demand	575	More abatement potential outside the power sector. Road transport mostly electrified with some hydrogen used for LGVs and HGVs. Substantial electrification of heat but with hydrogen also playing an important role particularly for industry.
Net Zero Higher demand	672	Less abatement potential outside the power sector. Road transport nearly all electrified with minor use of hydrogen HGVs. Hydrogen use is restricted leading to higher levels of electrification across homes and businesses though it still has an important role in decarbonisation of industry.

In both demand scenarios, UKTM showed that lowest cost solutions for net zero across the whole economy implied very low emissions for the power sector – an emission intensity level of around 5gCO2/kWh by 2050.

Using the single-year version of the DDM[4], for both higher and lower demand levels, we explored different technology deployment mixes for the electricity system in 2050 that met the emissions intensity level from UKTM. More detail on this method and results from it can be seen in the Modelling 2050: Electricity System Analysis report[5] that is published alongside the Energy White Paper. From these results, we identified two balanced technology mixes to use as deployment levels for our primary low carbon technologies (Nuclear, Gas Carbon Capture, Utilisation and Storage (CCUS), Wind and Solar[6],[7]). These mixes were within the 10% lowest total system costs for the power sector to contribute to the decarbonisation levels we need for Net Zero. Uncertainties over the timing of hydrogen deployment mean we have not included

[4] Using a running mode whereby the DDM can explore a large number of capacity mixes in the year 2050
[5] This paper outlines Electricity System analysis for 2050 using the DDM in more detail.
[6] We do not consider Biomass with Carbon Capture and Storage (BECCS), which can provide negative emissions, in this analysis. This is because both the amount of biomass that will be available and the sector in which it would be used most efficiently to meet Net Zero are highly uncertain.
[7] Other technologies that can produce low carbon electricity may have a future role to play in the UK. We have focused on those technologies that are currently cost competitive and have significant growth potential in the UK. This does not mean other technologies will not be needed but we expect the primary technologies to make up the bulk of our future generation

hydrogen-fired generation in these scenarios although hydrogen may have a role to play in the power sector in future. The Modelling 2050: Electricity System Analysis report explores the possible role of hydrogen in the power sector in 2050 in more detail.

Table 2 below shows the level of low carbon capacities in 2050 used in each scenario. The capacities used here are illustrative and are just two of many different possible pathways for the power sector. It is assumed all capacity is deployed through the Contract for Difference (CfD) mechanism[8] or, in the case of Gas CCUS, another support mechanism[9]. This does not indicate that this is BEIS' preferred method to deploy these technologies, more that this is a way to reflect that those technologies currently may require some support to deploy. All other technologies (except existing and planned plants) are built by the model's investment algorithm[10].

For the purposes of the modelling, we assume Nuclear and Gas CCUS deploy linearly from 2030 to 2050. We assume Offshore Wind reaches 40GW by 2030 and deploys linearly thereafter. Onshore Wind and Solar are deployed linearly from 2026 reflecting Pot 1 CfD auctions[11] being run in the 2020s[12]. As these technologies can respond quickly to market requirements, capacities used here should not be seen as targets. But we would expect 2030 capacity to be demonstrably above today's levels to make sure we are on a flexible pathway that allows us to deliver net zero. Deployment profiles are illustrative pathways of how the power sector could contribute to Net Zero and do not indicate a preferred trajectory for the power sector. For instance, the mix of renewables in 2050 may differ from that used for modelling purposes.

Table 2 – 2050 Capacities in GW used in the scenarios

Scenario	2050 Nuclear Capacity (GW)	2050 Gas CCUS Capacity (GW)	2050 Solar Capacity (GW)	2050 Onshore Wind Capacity (GW)	2050 Offshore Wind Capacity (GW)
Net Zero Lower demand	20	20	40	20	80
Net Zero Higher demand	30	20	40	40	80

[8] The Contracts for Difference (CfD) scheme is the government's current main mechanism for supporting low-carbon electricity generation.
[9] Gas CCUS is not deployed with a standard CfD in these scenarios. Other support mechanisms are being considered to ensure Gas CCUS dispatches in a mode as required by the system. https://www.gov.uk/government/consultations/carbon-capture-usage-and-storage-ccus-business-models
[10] Unabated technologies are mostly deployed through the capacity market in the model
[11] Pot 1 refers to CfD auctions is for established technologies such as onshore wind and solar PV
[12] Note this was announced post modelling of EEP so this is not included in the EEP Reference Case scenario

2. Summary of Projections

There are significant differences between the Net Zero scenarios and the EEP Reference Scenario with emissions in both Net Zero scenarios below 7gCO2/kWh by 2050 compared to 70gCO2/kWh in the EEP Reference Scenario. This is a result of the much higher levels of low carbon and renewable capacity in the former.

Figures 2.1 and 2.2 set out our projections of generation by technology for all power producers up to 2050 for both scenarios and show:

- The Net Zero scenarios require substantial **additional deployment** of most technologies compared to the EEP Reference Scenario in order to meet additional demand and ensure we reach low emissions. This includes 10-20GW more nuclear, 60GW more offshore wind and 20GW more Gas CCUS. Onshore Wind and Solar show similar levels of capacity to the EEP Reference Scenario. However, the Net Zero scenarios show average capture prices[13] are lower due to increased low carbon deployment, meaning these technologies can no longer deploy on a merchant basis and therefore need support to deploy.
- Over time, **low carbon generation** (renewables, gas CCUS and nuclear) increases. In both Net Zero scenarios, by 2050 low carbon generation makes up more than 99% of domestic generation. In 2030, low carbon generation is 88-90% of domestic generation compared with 76% in the EEP Reference Scenario.
- Generation from **renewables** rises significantly. By 2050, total renewable generation reaches 405TWh and 430TWh in Net Zero Lower and Higher electricity demand scenarios respectively - around double the 210TWh in the EEP Reference Scenario. From 2030 onwards renewable generation makes up around two thirds of domestic generation in both Net Zero scenarios.
- **Unabated Natural gas** generation falls throughout the modelled period. Natural gas generates less than 1% of total generation by 2050 with fleet average unabated gas load factors below 5% from 2035. Gas capacity increases from 37GW in 2018 to 75GW and 90GW in 2050 in the Net Zero Lower and Higher demand scenarios, respectively. This is to ensure that the system can still meet security of supply constraints. This suggests that there is likely to still be a need for a significant amount of 'peaking capacity' which provides short-term dispatchable generation to ensure reliable supply in peak periods. By 2050, low-carbon hydrogen or storage could satisfy this need, but some unabated gas may still be needed albeit running very infrequently.
- **Nuclear** generation increases from 2020 to 2050. Nuclear generation only rises above 2020 levels in 2035 in both scenarios due to existing plants closing and being replaced. By 2050, nuclear generation reaches 160TWh in the Net Zero Lower Demand scenario

[13] "Capture price" refers to the price an asset or technology achieves in the market – for example, because offshore wind generation is correlated across the country it can create periods of additional supply in the wholesale market. This depresses prices at that point and means average capture prices through the year may be below the average wholesale price

and 240TWh in the Net Zero Higher Demand scenario, a 75-155TWh increase on the EEP Reference Scenario.

- From 2035 onwards, in both Net Zero modelled scenarios GB becomes a **net exporter to Europe** rather than a net importer. Net exports reach 48-54TWh in 2050. This is because the high level of renewables on the system allow GB to export cheaper energy to Europe more regularly.
- **Gas CCUS** generation increases significantly compared to the EEP Reference Scenario, reaching around 50TWh in both Net Zero scenarios by 2050. CCUS' load factors fall over time, as other low carbon capacity is deployed. However, analysis shows that its role in responding to periods of lower solar/wind output is crucial.
- Short term **battery** use increases in both scenarios, rising from 1GW in 2020 to 5 and 8GW in 2050 in the Net Zero Lower Demand and Net Zero Higher Demand scenarios, respectively.

Figure 2.1: Electricity generation by fuel source in GB, TWh – Net Zero Lower Demand Scenario

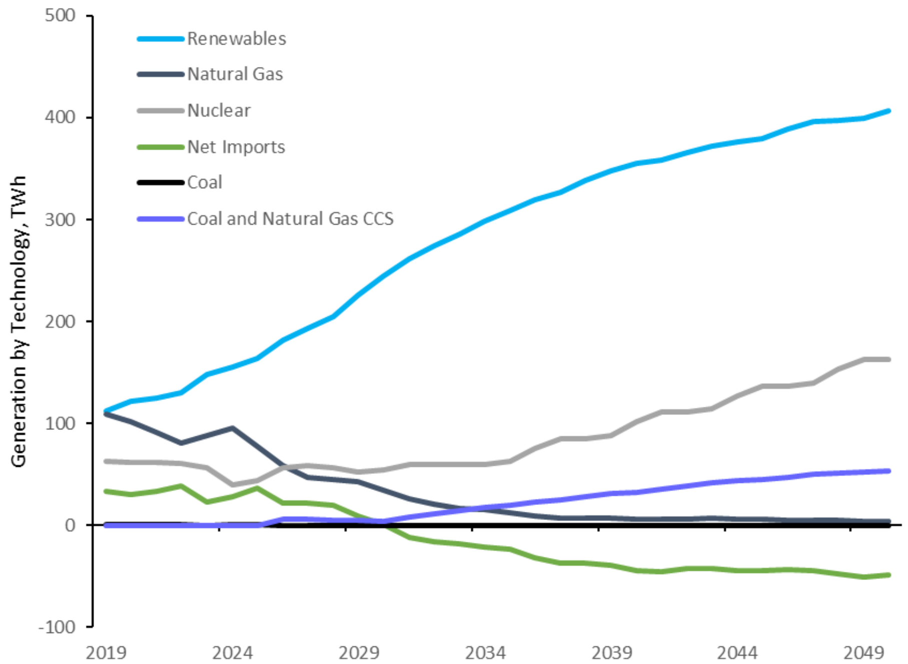
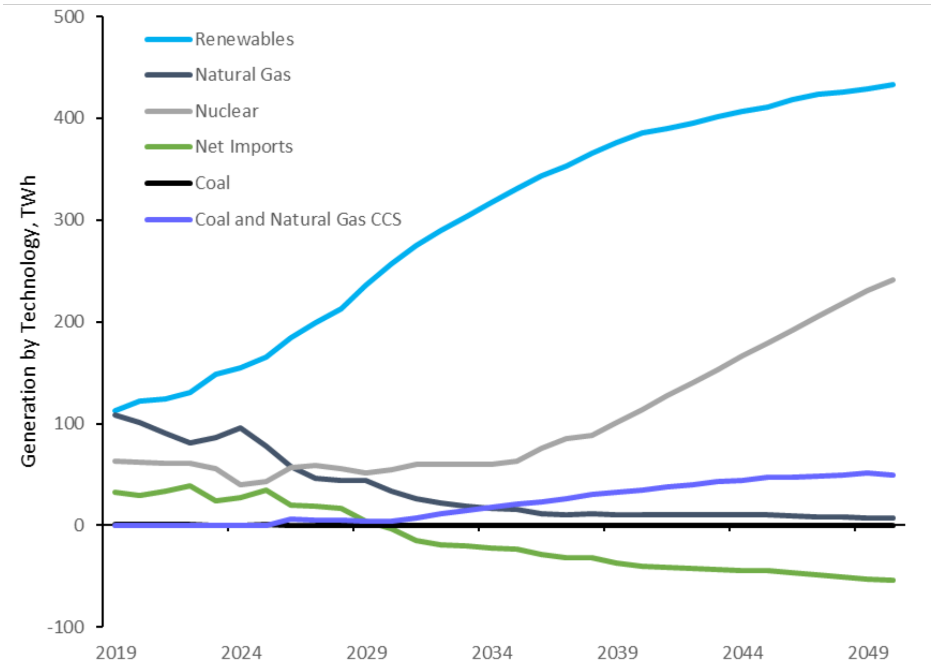


Figure 2.2: Electricity generation by fuel source in GB, TWh – Net Zero Higher Demand Scenario



This publication is available from: www.gov.uk/government/publications/updated-energy-and-emissions-projections-2019

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