BRIEFING

ELECTRIFYING INDUSTRY AND DISTRIBUTION NETWORKS:

CONSIDERATIONS FOR POLICYMAKERS

FEBRUARY 2025

Key findings

01 With a supportive policy environment, electrification of industry could deliver more than 40% of the greenhouse gas emissions reductions needed by industry to help reach the UK's net zero target.

02 Researchers from the University of Leeds have modelled such a scenario and implications for electricity distribution networks. In this scenario, industrial electricity use will **increase by 78% between 2024 and 2050**. Increased electricity demand from industry and other uses, such as heat pumps and electric vehicles, will put pressure on the distribution network.

03 Without further investment, **the network becomes significantly constrained from 2030**. This means industrial sites in many regions may not be able to access the electricity they need to decarbonise. By 2050 Yorkshire and the Humber is the only unconstrained region.

04

42% of large industrial sites are constrained in 2030, increasing to 77% in 2050. Most constrained sites are dispersed sites. The most affected sub-sectors are glass, iron and steel, non-ferrous metals and food & drink.

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Policymakers must ensure that the pattern of future industrial electricity demand is considered in analysis to inform distribution network strengthening and that anticipatory investment in networks is enabled. To inform network operator scenarios, the government needs to provide clarity on industrial electrification and the policies that will support it. Without policy intervention, network constraints could seriously hinder industrial decarbonisation.

Background

In 2024 the UK manufacturing industry[i] was worth £217 billion to the UK economy and directly employed 2.6 million people.[1] Industrial and manufacturing sectors underpin many of the high growth sectors identified in the government's 2024 Modern Industrial Strategy green paper. These include steel for clean energy technologies and chemicals for life sciences and advanced manufacturing. UK industry has a crucial role to play in achieving the UK government's growth mission.

Industry is also a major energy user and greenhouse gas emitter, representing 14% of the UK's total greenhouse gas emissions in 2023 (53 $MtCO_2e$).[2] As the UK progresses towards net zero, it is vital to reduce industrial emissions and support low-carbon industrial growth. In 2023, UK industry energy use consisted of 48% gas, 43% electricity, and 9% oil and coal.[3]

The UK government's 2021 Industrial Decarbonisation Strategy set out the ambition to reduce industrial emissions by 66% by 2035, and by more than 90% by 2050.[4] Government modelling included in the Strategy suggested that industrial decarbonisation would require a combination of resource and energy efficiency, significant deployment of low carbon hydrogen and carbon capture, utilisation and storage (CCUS) technologies, and the electrification of some industrial processes.

i. In this work, UK manufacturing industry is defined as the following sectors: iron and steel, chemicals, cement and lime, food and drink, glass, paper, other minerals (such as ceramics), non-ferrous metals, vehicles and other industry.

As the evidence base has evolved, electrification is expected to play a greater role in industrial decarbonisation than previously thought. Two of the three National Energy System Operator (NESO) Future Energy Pathways for industry, developed in 2024, suggest that industrial electricity demand will increase.[5] The Electric Engagement pathway presents a substantial 63% increase by 2050. The third pathway, Hydrogen Evolution, sees no overall increase in electricity demand for industry, as hydrogen is the main route for decarbonisation and the small increase in industrial electrification is offset by increases in energy efficiency.[6] The analysis in this brief suggests that, with a supportive policy environment, the increase in industrial electricity demand may be even greater.

Other sectors such as heat and transport are also electrifying, placing significant additional demands on electricity distribution networks. When a site electrifies, it may require upgrades or a new connection to the electricity distribution network. The time needed for an upgraded or new electrical connection is project-specific and depends on several factors. Research by the Industrial Decarbonisation Research and Innovation Centre found that the time taken for connections and upgrades ranged from around two years to ten years.[7] Understanding implications for the electricity network and anticipating future demand is vital to ensure an orderly expansion of grid capacity and timely connections for customers.

Aim of this brief

This policy brief presents an initial analysis of the extent to which the electricity distribution network will need strengthening to support industrial decarbonisation. The distribution networks have a certain capacity in terms of the volume of electricity they can carry. Without available capacity, new sources of supply or demand will not be able to connect, limiting the speed of decarbonisation. Box 1 provides more information on the distribution networks.

Researchers at the University of Leeds, working as part of the UK Energy Research Centre, have modelled a future industrial electricity demand scenario, and combined it with data on available capacity across distribution networks to identify the areas where network strengthening is needed. A high electrification of industry scenario was used to better understand the potential scale of constraints, given the increasing interest in the use of clean electricity as a decarbonisation option for industry. Box 2 describes the research and method in more detail.

This analysis considers the combined impact of increased electricity demand from industry and from other users (electric vehicles and heat pumps) on the electricity distribution network.

This brief focuses on distribution networks and considerations for industrial decarbonisation. It is important to note that a wider supportive policy environment is needed to enable industrial electrification, such as new business models, and this is not discussed in detail here.

BOX 1

Electricity distribution networks, network operators and the connection process

The electricity distribution network is the infrastructure that delivers electricity from the high voltage transmission network to businesses and homes. It is built and operated by Distribution Network Operators (DNOs). Smaller sources of electricity generation and flexibility, such a solar farms and batteries, also connect to the distribution network.

The electricity distribution network is split into defined geographic areas managed by different DNOs. The regulator Ofgem sets the outcomes that must be delivered and the revenues that may be collected by DNOs. The DNOs provide the infrastructure and separate electricity supply companies make use of the distribution network to supply electricity to consumers.

When a business chooses to electrify its operations further, its existing connection to the grid may not be able to service the significant rise in electricity demand. A new grid connection or upgrade is obtained by applying to the relevant DNO.[8] The DNO will assess the technical requirements against the capacity of the local grid to ensure they can accommodate the proposed electricity connection and place the project in a queue.

In cases where the newly proposed distribution connection is significant enough to impact the transmission network, the DNO engages with NESO on its customers' behalf and incorporates any transmission requirements into the connection plan offered to the business. In a small number of cases, projects may need to connect directly to the transmission grid and undertake a connection process directly with the NESO.

BOX 2

Methods

The findings presented are based on research from the University of Leeds for the UK Energy Research Centre.[9] The Net Zero Industrial Pathways (NZIP) model[10] (developed for the government and the Climate Change Committee (CCC) for the 6th Carbon Budget) was used to project the future spatially disaggregated electricity demand for industrial sites as they decarbonise.

A new "Max Electrification" industrial decarbonisation pathway was developed for this analysis. This scenario, called "High Electrification" in this brief, is designed to reflect a situation in which industrial electrification plays a significant role in decarbonising UK industry. Delivering such a scenario in reality would require a policy environment supportive of greater business investment in electrification than at present.

For industrial sites that are large point sources of emissions, electricity demand is projected by individual site. Electricity demand for other (smaller) industrial sites (non-point sources of emissions) is aggregated and projected by region. The current and future electricity demand headroom data was collected for substations across all DNOs in Great Britian.[11] Headroom is the gap between the ability of the electricity network to supply electrical demand, and the actual demand. The "Leading the Way" (or equivalent) scenario from the network development plans was used for future headroom data. This is an ambitious scenario that assumes net zero emissions is achieved earlier than 2050 due to the widespread use of electric and hydrogen technologies with significant consumer engagement. Data on network demand headroom and the additional electrical capacity needed by industrial sites (both point and non-point sources) were aggregated to 11 Regions in Great Britian (9 English regions, plus Wales and Scotland). These datasets were then compared to project the level of network constraints by region. Constraints are defined as the level of electricity demand that cannot be met by the distribution network.

As the location is known for industrial sites that are point-sources of emissions, spatial optimisation was used to find the nearest substation to each of these sites to minimise the likely cost of network upgrades (cables, etc.) and losses. The substation capacity is optimally allocated by allowing sites with small capacities to be accommodated first: this maximises the number of sites that can be connected within the headroom available at the substation, so represents a “best-case” scenario.

The percentage of sub-sectoral emissions associated with large industrial sites that are potentially constrained in 2050 was calculated as follows: 2030 emissions for large industrial sites divided by the total emissions for both constrained and non-constrained large industrial sites in the same year.

This analysis uses a single pathway for the future economic development of industry, based on that used by the CCC for the Sixth Carbon Budget. Overall future industry growth or that of the various industrial subsectors could be higher or lower than assumed here. In addition, the opening of new industrial sites that would also require a new electricity network connection is not considered.

Findings

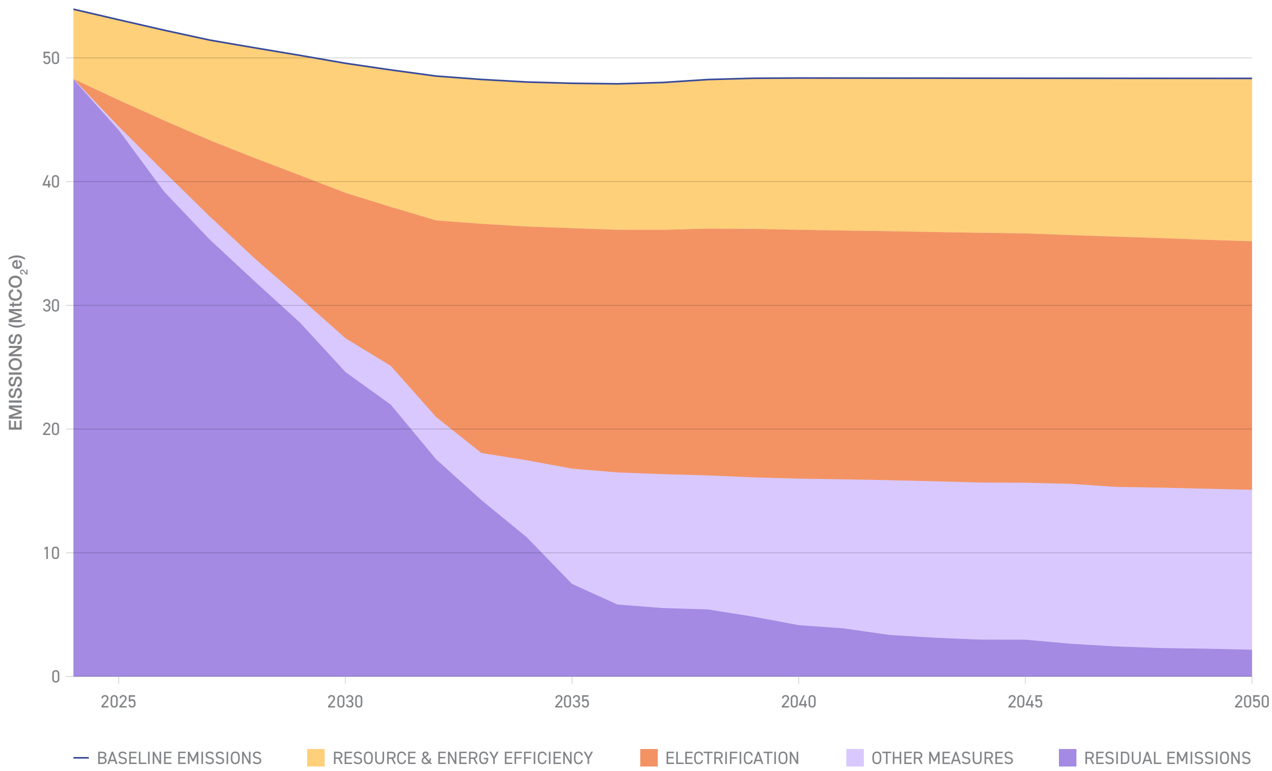
Industrial electricity demand under the High Electrification scenario

Industry decarbonisation will require a range of interventions and technologies including resource and energy efficiency (REEE), electrification, and other measures including hydrogen and carbon capture, use and storage. Under the High Electrification scenario used in this study, greenhouse gas emissions are reduced from 54 $MtCO_2e$ in 2024 to 2 $MtCO_2e$ in 2050, as illustrated in Figure 1. Electrification contributes the largest emissions reductions in 2050, representing 43% of total emissions reductions (20 $MtCO_2e$), while REEE and other measures contribute the remainder of emissions reductions (26 $MtCO_2e$).

In this scenario, industry electricity demand increases by 78% between 2024 and 2050, from 82 to 146 TWh. By 2050, the UK's industrial electricity use alone is projected to be equivalent to more than half of total electricity consumption in 2024. This increase is due to the deployment of both new industrial processes that use electricity (e.g. electric kilns) and other electricity-intensive decarbonisation technologies such as CCUS.

FIGURE 1

THE CONTRIBUTION OF DIFFERENT MEASURES TO REDUCE INDUSTRIAL GREENHOUSE GAS EMISSIONS UNDER THE HIGH ELECTRIFICATION SCENARIO. WITH A SUPPORTIVE POLICY ENVIRONMENT, ELECTRIFICATION COULD ACCOUNT FOR 43% OF INDUSTRIAL EMISSIONS REDUCTIONS BY 2050.



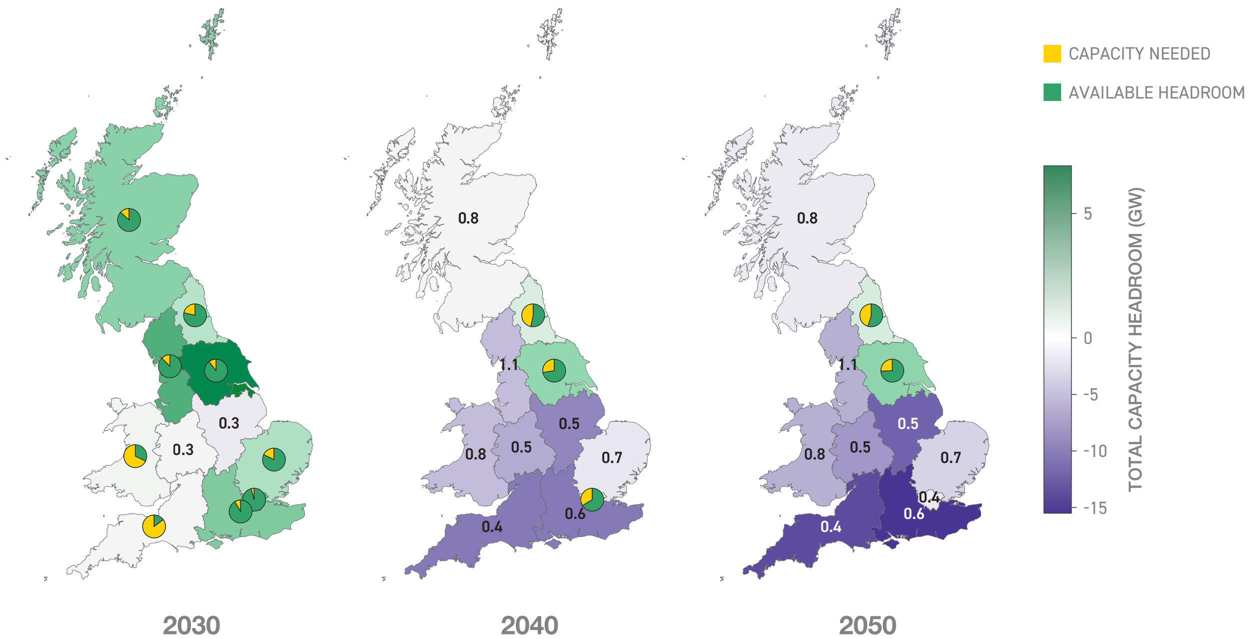
Network capacity needs for industrial sites and emerging network constraints

Increased demand for electricity from industry, combined with higher demand from other users, will put increased pressure on the electricity distribution network. Figure 2 shows that, in the short term, the available network headroom is sufficient to meet the extra electricity demand in nearly all regions in Great Britain. However, the decarbonisation of industry (and other sectors) accelerates after 2030, resulting in higher electrical capacity needs for 2040 and 2050, and regions become constrained.

Without further investment beyond 2030, the network would become significantly constrained in the central, south, and north-west areas of England, and Wales. By 2050, Yorkshire and the Humber will be the only unconstrained region. The reasons for the pattern of constraints that emerge is due to complex interactions between additional electricity demand and the capacity of the existing network in the different regions. However, typically higher demand growth is seen in areas of high population density (such as the south and central regions of England). Regions that were historically highly industrialised have more existing headroom.

FIGURE 2

CAPACITY NEEDS FOR INDUSTRIAL SITES AND NETWORK HEADROOM ACROSS GB UNDER THE HIGH ELECTRIFICATION SCENARIO. WITHOUT FURTHER INVESTMENT, DISTRIBUTION NETWORKS BECOME INCREASINGLY CONSTRAINED (PURPLE) ACROSS REGIONS FROM 2030.



NOTE: Pie charts represent the capacity needed by industrial sites (yellow) compared to the available headroom in a region. Correspondingly, where there is no headroom available, no pie charts are included. The numbers inside the regions represent the approximate extra capacity needed by industrial sites in GW when no headroom capacity is available. Green shading represents available capacity, and purple represents negative headroom (constrained capacity).

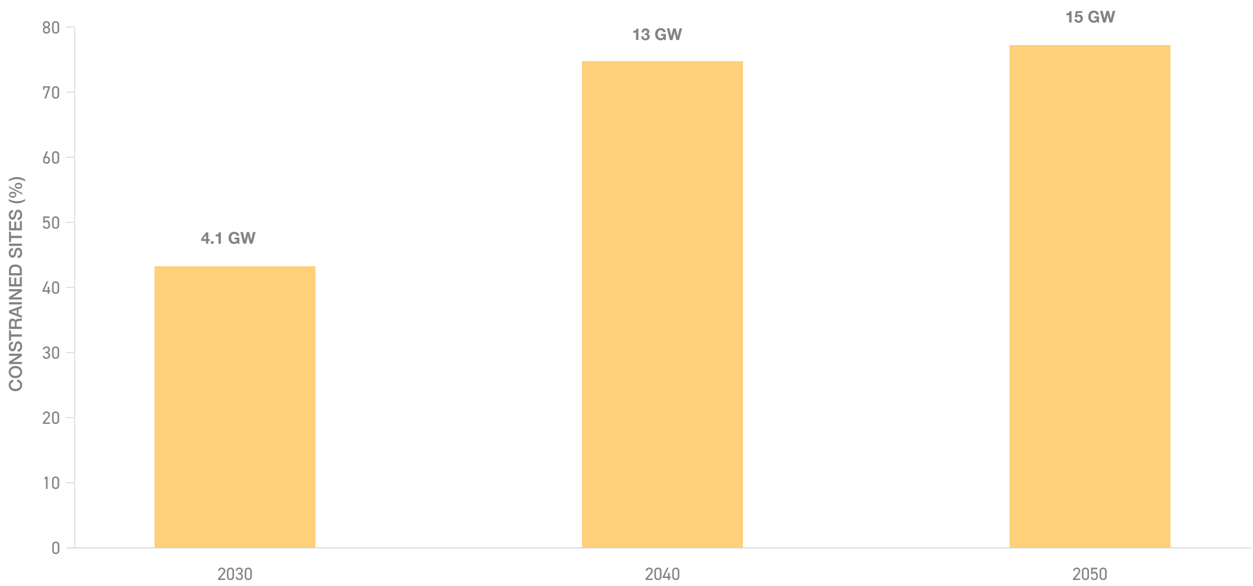
The amount of **additional** network capacity needed to alleviate the constraints for all users **rises to 71 GW in 2050**. For context, peak electricity demand today is about **58 GW**. Additional capacity is predominantly linked to the predicted increase in electricity demand from other users (e.g. heat pumps and electric vehicles), rather than the increase in industry electricity demand. Nevertheless, the additional electrical capacity needs from industrial sites over the period to 2050 is significant at around **8 GW**.

Focusing on **large industrial sites**, Figure 3 shows that, without additional network investment, **42% of large industrial sites would face electricity constraints in 2030. This rises to 75% by 2040 and 77% in 2050** under the High Electrification scenario. Around **three-quarters** of large industrial sites would be constrained due to the nearest substation being under demand pressure from other sectors. The remaining sites are constrained due to a lack of sufficient headroom at the nearest substation to meet the additional electricity demand from the industrial site.

These network constraints could have a significant impact on progress to reduce industrial emissions. The level of industrial emissions associated with **large industrial sites** that are constrained rises from 18 $MtCO_2e$ in 2030 to around 29 $MtCO_2e$ in 2050 (based on the 2024 emission levels for these sites), equivalent to 33% and 54% of total 2024 industrial emissions respectively.

FIGURE 3

PROPORTION OF LARGE INDUSTRIAL SITES THAT ARE CONSTRAINED AND THEIR TOTAL CONSTRAINED ELECTRICAL CAPACITY (NUMBERS ON TOP). WITHOUT NEW NETWORK INVESTMENT, BY 2050 MORE THAN THREE-QUARTERS OF LARGE INDUSTRIAL SITES MAY NOT BE ABLE TO ACCESS THE EXTRA ELECTRICITY THAT THEY NEED TO DECARBONISE.



Again, considering just **large industrial sites**, exploring the location of the constrained sites reveals that the vast majority, around 80%, are dispersed sites (located more than 30 km from one of the large industrial clusters). While the current policy focus is on the infrastructure requirements of industrial clusters, this result shows that attention is also needed on dispersed sites given that they account for more than half of all industrial greenhouse gas emissions.

Different subsectors of industry are not equally affected by constraints on the distribution network as they are unevenly distributed across the country and will not have the same potential for electrification. To understand the varying impact, the share of industry subsector emissions associated with large industrial sites (based on 2030 emissions) that would be constrained in 2050 was analysed.

Emissions reductions most affected by electricity network constraints were in the glass, iron and steel, non-ferrous metals, and food and drink subsectors. For these subsectors, over 90% of 2030 emissions from large industrial sites would be difficult to reduce through decarbonisation options that require additional electricity. This includes direct electrification of industrial processes or the use of CCUS and green hydrogen (both of which require electricity). The shortfall reflects a combination of the lack of network headroom at the nearest substation and the increased demand for electricity from the decarbonisation options that would be implemented by the site. Subsectors with more sites in less constrained regions or where electrification is a less viable decarbonisation option, such as cement and lime, were less affected. More granular analysis would be beneficial to understand subsector-specific implications of network constraints.

The future network constraints indicated by this analysis would have economic implications. Together, the sectors most affected by such constraints account for more than 25% of the manufacturing industry's total contribution to the UK economy and include sectors where the UK has an existing competitive advantage, such as food and drink.[12,13] Many areas across the UK rely strongly on industry to support economic activity with industrial jobs paying more than the regional averages. 28% of total heavy industry Gross Value Added is in the North, with over 400,000 jobs.[14]

Policy implications

This analysis seeks to geographically quantify the additional electrical grid capacity Britain needs to support electrification (and therefore decarbonisation) in industry, while also taking account of electricity growth in other sectors. With increasing competitiveness and the drive to decarbonise globally, potential network constraints create uncertainty for businesses. If left unaddressed, this could result in lost opportunities and investment as businesses struggle to compete internationally or decide to relocate to countries with more policy certainty or support for electrification. New or reinforced connections and the wider strengthening of the distribution network will also carry a cost and there remains uncertainty on how these will be met and by whom.

Key considerations for policymakers are:

1. **Electricity distribution networks need to be strengthened to meet the increasing electricity demand from industry and other sectors.** The government is currently developing spatial energy plans, including the Strategic Spatial Energy Plan and the Regional Energy Strategic Plan. Industrial electricity demand and potential constraints must be considered and addressed as part of these plans. Historically, the scenarios used by DNOs to calculate headroom on the distribution network have not assumed significant increases in industrial electricity demand. Moreover, place-based, sectoral and temporal considerations are important when tackling network constraints as some regions, sectors and types of sites may be affected sooner than others by potential network constraints. As the government pursues the Clean Power 2030 Action Plan, it must ensure the energy system is set up to meet the developing electricity demands of all sectors beyond 2030.

2. **Anticipatory investment in distribution networks must be enabled to support decarbonisation of industry.** At present, regulation does not sufficiently encourage DNOs to invest in network capacity ahead of need. This analysis shows that the rapid increase in demand from different sectors cannot be met without additional capacity beyond 2030. The accessibility and ease of the connection process and the information available for businesses should also be improved.

3. **The government needs to provide clarity on industrial electrification and the policies that will help enable electrification. This will be valuable to inform DNO scenarios, wider energy system planning and investment in industrial decarbonisation.** The potential role of electrification for industrial decarbonisation may be greater than previously expected, but significant barriers remain, such as high industrial electricity prices and upfront capital costs. The government's upcoming Net Zero Strategy and Industrial Decarbonisation Strategy must consider the potential impact of electricity network constraints alongside other barriers or enablers for industrial decarbonisation. The government should also make updated data, modelling and assumptions available to key stakeholders – such as the DNOs – to inform their future investment decisions and planning.

4. **Better data on future industrial electricity demand is needed to develop an accurate understanding of where and when distribution network constraints will emerge.** Clearer demand data and modelling of potential future growth and industry demand is required. Labour's election manifesto commits the government to introduce mandatory transition plans for businesses. Transition plans may provide an additional data source to help inform electricity demand scenarios and DNO customer management strategies.

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