Distribution Network Options Assessment (DNOA) Methodology

June 2023

First Edition

DSO DISTRIBUTION SYSTEM OPERATOR

UK Power Networks
Delivering your electricity

1. Executive Summary

We see our Distribution System Operator (DSO) being at the heart of facilitating the lowest cost transition to Net Zero, whilst supporting clean economic growth.

Our vision is of a dynamic distribution system, with electricity demand and supply flexing in response to distribution-level conditions and market signals. We will see market-based solutions which influence consumer behaviours, supplemented with traditional network investment that results in the lowest costs for consumers. This will lead to a smarter and more highly utilised distribution network, with faster and cheaper access for the Low Carbon Technologies (LCTs) we will need to achieve Net Zero.

We aim to deliver capacity at the lowest cost by focusing on two points:

1. Firstly, we will ensure that the existing network is optimally utilised.
2. We will consider where additional capacity is required setting a level playing field between network and market solutions. This will provide network capacity at the lowest cost. To deliver our plans, our DSO will run an open Distribution Network Options Assessment (DNOA) process. We will consult on scenarios for system needs. We intend to compare flexibility and whole system solutions sourced from the market with asset-based solutions provided by the Distribution Network Operator (DNO) (and in the future also by third party network operators). We will do this all the way down to the low voltage network to maximise opportunity for domestic level participation and cost savings for consumers. Figure 1 shows a simplified version of the process and we will provide further explanation in this document.

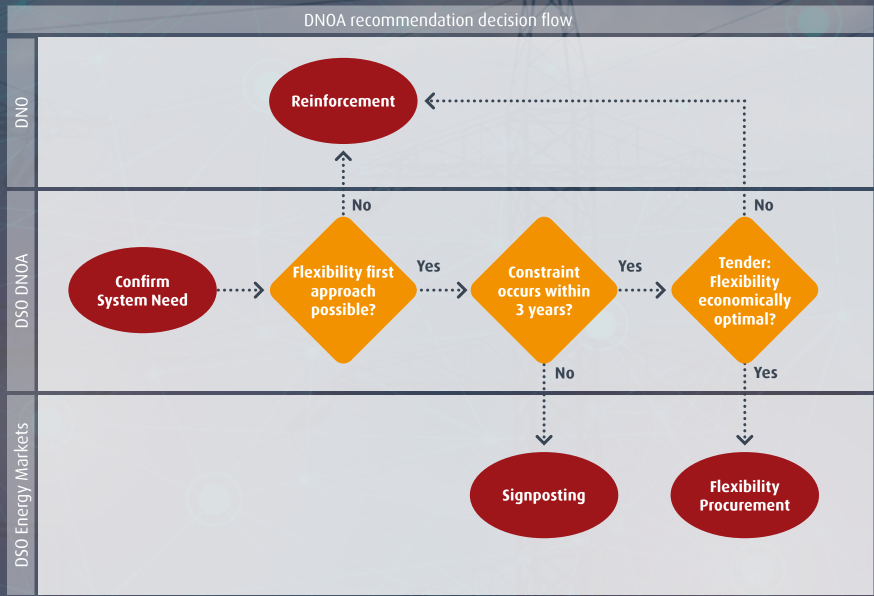

Figure 1 Simplified DNOA recommendation decision flow

Two of our commitments for RIIO-ED2 are:

Commitment DSO3

Our DSO function will deliver up to a £410m reduction in load related expenditure during RIIO-ED2 through increased competition and use of LV flexibility, including at the domestic level.

Commitment DSO4

We will keep our costs down by taking a "flexibility and energy efficiency first" approach over RIIO-ED2 and will "market test" all network needs before considering reinforcement. These needs will be procured through a range of long-term and short-term markets and products, which are inclusive by design and ensure no customer is left behind in the energy transition.

The DNOA process is an important tool to help us track and achieve both of these goals in a transparent manner. In this DNOA methodology document we explain how we base our system needs identification on the load growth predictions of our Distribution Future Energy Scenarios (DFES) and the capacity of the network. We present the different type of options (reinforcement, flexibility etc.) and how we source them from the DNO and DSO. We explain how we compare the different solutions by using the industry developed Common Evaluation Methodology (CEM) Cost Benefit Analysis (CBA). We also cover the decision logic to make the final recommendation. Finally, we explain how the output report for each scheme looks and what kind of information is shown on it. Our DNOA process is based on data we are making publicly available through work such as the Network Development Plan and our Flexibility Tenders that can be found in our Open Data portal as explained within the document.

The information provided in this document and the DNOA scheme reports will inform our stakeholders, such as Flexibility Providers (FPs), local councils, Ofgem, the Department for Energy Security and Net Zero and other interested parties about the developments on our network. Hence, it will inform FPs for upcoming opportunities to participate in the flexibility market, provide transparency to policy makers about our internal governance and facilitate other stakeholders' development plans towards Net Zero.

We are also progressing network reinforcement schemes to support our customers' needs for the Net Zero transition. We provide information about those schemes within our Long Term Development Statement (LTDS).

We are looking forward to receiving feedback on our approach and any suggestions that will help us improve this methodology and the DNOA process. Whilst this is not a formal consultation document, we welcome any questions, comments and feedback. We aim to complete a consultation round for our next methodology in the middle of 2023 so we can reflect feedback in the process to produce the DNOA reports for 2024. Please get in touch via email to DSO@ukpowernetworks.co.uk

2. Introduction

The Distribution Networks Options Assessment (DNOA) provides transparency to the industry on the decisions we are taking to meet the future capacity needs across our South East (SPN), London (LPN) and East of England (EPN) regions over the next few years. The DNOA methodology describes how investment decisions are informed by our DFES, and how we will then employ a cost benefit analysis approach to determine optimal investment across our networks.

This methodology document provides an overview of the process we will follow to establish an open and transparent decision making process, providing signals to Flexibility Providers (FPs) to ensure that we drive a flexibility and efficiency first approach to delivering future network requirements across our three regions. This process will describe how we develop our view on future capacity needs and use this to inform the marketplace to allow solutions to be brought forward into the evaluation process.

To improve transparency in how we reach decisions on flexibility procurement and the potential to delay conventional reinforcement, we will use the CEM CBA tool as established via the Energy Networks Association (ENA) Open Networks Project. This tool is used to assess the net benefit of flexibility against a baseline of conventional reinforcement for scenarios over a number of years and will be fundamental in assessing the viability of different options.

In our RIIO-ED2 submission we committed to publishing the framework for our DNOA process, the accompanying CBA methodology, and the resultant recommendations and rejected options on an annual basis. This document represents the first edition of our DNOA methodology. The methodology document will be updated annually to reflect any changes in our approach and share lessons learned from running the annual cycle. In addition, we will use customer feedback to make further improvements.

3. The DNOA Process

3.1 The DNOA timeline

The target publication period for the DNOA results will be the end of the first quarter of each calendar year.

The first half of the year is used to review and update the methodology capturing the learning points of the previous year and sharing it publicly.

Towards the middle of the calendar year, the DSO will complete the analysis of load data from the previous regulatory year (1st April - 31st March). Based on that, we will identify the system needs. In collaboration with the DNO, we will identify and cost the reinforcement options. If the DNO can identify operational solutions or other cheaper innovative solutions, they will be part of the comparison.

For the flexibility costs, we will use historic flexibility data and/or reinforcement costs to price the flexibility solutions for the initial CBAs. We will then market test the flexibility solutions in the next available tender events. Based on the information acquired, we will prepare CBAs for all the schemes.

Once all the CBAs have been completed, the option assessment is completed. A review cycle including internal review and an external Supervisory Board (SB) is then conducted. Prior to the final publication, a cross check will be done with the published Electricity System Operator Network Options Assessment (ESO NOA), to avoid conflicts and maintain whole system alignment.

This is our current view on the annual DNOA cycle. However, we expect to gain more lessons from doing the process. Therefore, the timeline shown in Figure 2 on the next page might be adjusted.

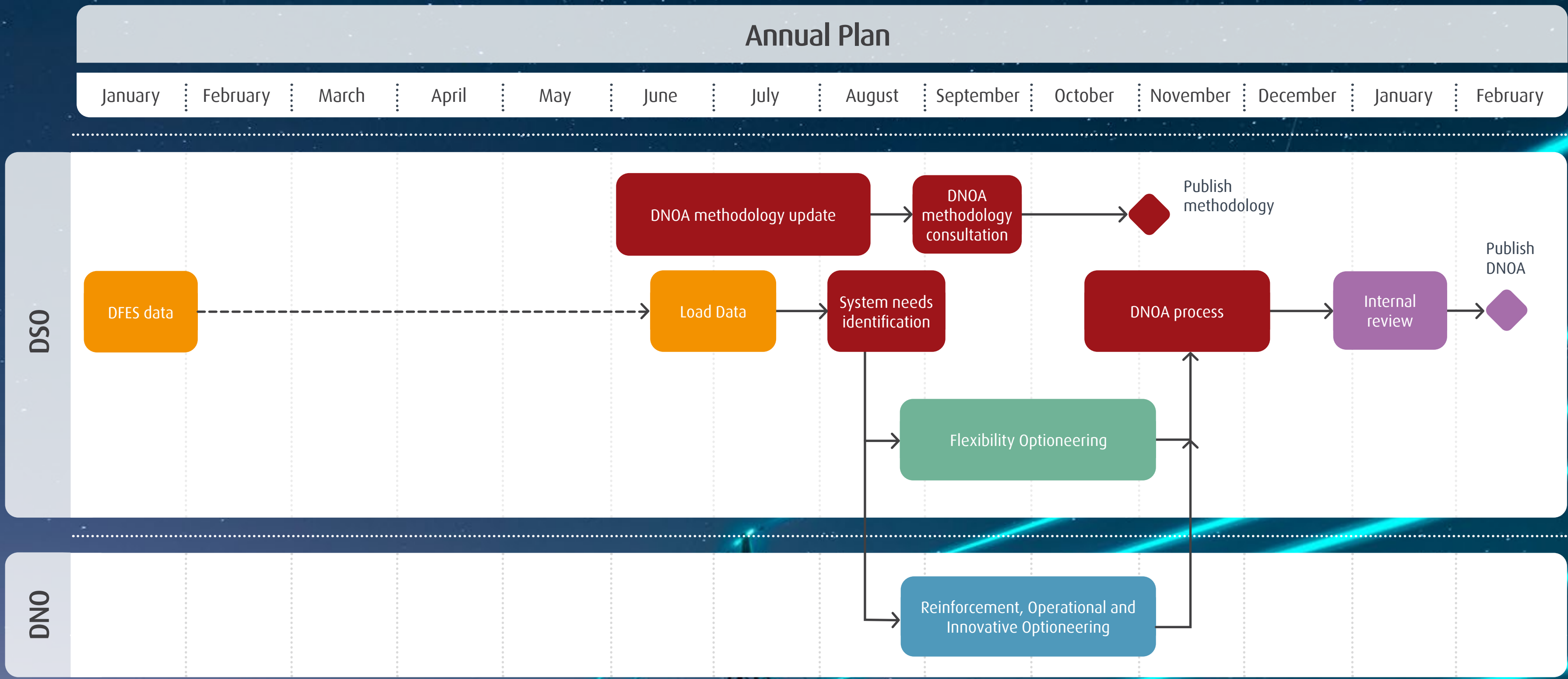

Figure 2 Annual DNOA production timeline

3.2 The Process

The development of the DNOA follows a clearly defined step by step process as shown below.

Figure 3 DNOA Process

Step 1: Identify the system needs

This can be accomplished by comparing the forecasted demand with the capacity of the relevant area of the network.

Step 2: Identify the potential options to address the needs

At this stage, we consider a range of market based and infrastructure solutions that could be employed.

Step 3: Cost the options

We establish the associated costs of each option.

Step 4: Carry out cost benefit analysis

We use the CEM tool by ENA to run a cost benefit analysis.

Step 5: Make recommendations

The end result of the CBA and options comparison is the selection of optimal solutions to address the predicted capacity shortfall.

Step 6: Publish outcomes

The final results of this process are compiled in a report and published.

3.3 Our approach at different voltage levels

The DNOA approach will be different based on the voltage level at which the intervention required to solve the system need occurs. Additionally, the value of the reinforcement scheme will change the level of effort on the individual scheme.

- For High & Extra High Voltage (HV and EHV) schemes with reinforcement costs above £1.5m, we will assess options for each individual scheme. We will base our decision on the CEM CBA.
- For High Voltage (HV) schemes where reinforcement costs are less than £1.5m and Low Voltage (LV) schemes, the schemes' options are assessed as an annual strategic plan, published as an appendix to the annual DNOA methodology, and managed by the DNO via an agreed policy.

3.4 Data provision

We present a list of input data used for the creation of the DNOA reports and the data sources in Table 1 below. Due to the differences in the publication date of databases and the DNOA, there can be differences in the published data. Links to all the resources can be found in the upcoming chapters in this document.

Table 1 Data sources for the DNOA

Data used in DNOA	Database Location
Load data from Long Term Development Statement	UKPN Open data portal
Substation Capacity Headroom data from Network Development Plan	UKPN Open data portal
Substation postcodes from "Key characteristics of active Grid and Primary sites" table	UKPN Open data portal
CEM CBA template from Energy Networks Association library	Energy Network Association portal
Flexibility Live or Previous Tender data	UKPN Flexibility Hub

4. Defining the System Needs

System needs are defined where the forecasted network load is larger or predicted to be larger than the capacity of the relevant area of network.

Load Forecast
Forecast future load based on network measurements and predictive models

Network Headroom
The difference between the forecasted load and existing network capacity

System Needs
Where, when and for what duration we need additional network capacity

In order to identify system needs, there is an intermediate step where we will establish the available network headroom. This task is carried out as part of the production of UK Power Networks' Network Development Plan (NDP).

The NDP consists of three components.

1. Network Development Report

Plans for infrastructure and flexibility services, updated every two years.

2. Network Scenario Headroom Report

Data tables for load and generation, updated annually – these show unused substation capacity, noting this capacity may be committed or contracted to customers.

3. Methodology

The methodology document for the NDP explains how the network headroom is produced.

All the NDP documents can be downloaded from the **UK Power Networks' Open Data portal.**

4.1 Forecasting

In order to calculate the available headroom, the first step in the process is to forecast the future demand.

This section explains how regional forecasts for each UK Power Networks area have been developed and describes the building blocks that underline the forecasting approach, covering the high-level aspects of how forecasts are created. Specifically, this includes what parameters are forecasted; the steps taken to create the forecasts; and how they are informed, alongside descriptions of the adopted scenarios. It details what differentiates a best view forecast from those which define the range of an uncertain future, in particular how policy, stakeholder engagement and local characteristics are considered.

We have worked together with our stakeholders and third party vendors to develop our Strategic Forecasting System (SFS) and to annually publish our DFES describing the evolution of demand and generation across our licence areas out to 2050. The scenarios modelled show that the greatest uncertainties relate to the extent and pace of decarbonisation of heating and transport. This matters because electrification of transport and heat results in significant load growth and it is key to ensuring there is sufficient network capacity, so the electricity network is not a barrier for the uptake of LCTs under any scenario.

Additionally, Local Authorities have a key role to play in delivering Net Zero, influencing over 80% of the UK's carbon emissions according to the Climate Change Committee. The majority of the decarbonising actions depend on the take up of Low Carbon Technology (LCT) solutions. To support Local Authorities with their Net Zero plans, UK Power Networks has established the Local Net Zero team responsible for engaging with Local Authorities on their regional or local climate change action plans. Through this collaboration, Local Authorities share their planned decarbonisation activities (e.g. deployment of electric vehicles). Making use of our Local Area Energy Planning (LAEP) framework ensures that we can be confident that a consistent level is met before any local climate change action plans are used to adjust our annually updated Distribution Future Energy Scenarios (DFES), supporting us to facilitate local Net Zero plans whilst investing with confidence.

An overview of UK Power Networks' Distribution Future Energy Scenarios

Our published DFES documents provide further information on the methodologies used to produce it. This version of the DNOA is using the data from the DFES published in February 2022. The SFS contains daily and seasonal profiles for assumed electricity consumption and generation. These are not simple profiles per kW installed. In the case of demand technologies, they also relate to the underlying demands for heat and transport energy (kWh) which are then converted to kW and assigned to the appropriate substation. These profiles are combined with the predicted volumes of new LCTs with appropriate diversity into additional electrical power flows. All existing accepted connections are also included in the forecast calculations.

The DFES framework includes four potential energy pathways to 2050, three of which reach Net Zero emissions by 2050. These pathways represent different positions on two main axes, speed of decarbonisation and level of societal change (Figure 4). We developed bespoke scenarios for each driver of demand and generation and constructed four overarching scenario worlds that align with the narratives of the pathways from National Grid ESO. By developing our own uptake scenarios with local knowledge, we are able to more accurately reflect UK Power Networks' region, the customers within this region and the current deployment of low-carbon technologies.

The four scenario worlds are structured as follows:

- **Falling Short:** General progress is made towards decarbonisation; however, this is the only scenario world that does not meet Net Zero by 2050;
- **System Transformation:** The 2050 Net Zero target is met by relying on hydrogen to decarbonise the more difficult sectors of heat and heavy transport;
- **Consumer Transformation:** The 2050 Net Zero target is met by a high degree of societal change as well as deep electrification of transport and heat; and
- **Leading the Way:** This is the fastest of the scenario worlds to achieve Net Zero, with the highest level of societal change, utilising both hydrogen and electric low-carbon technologies.

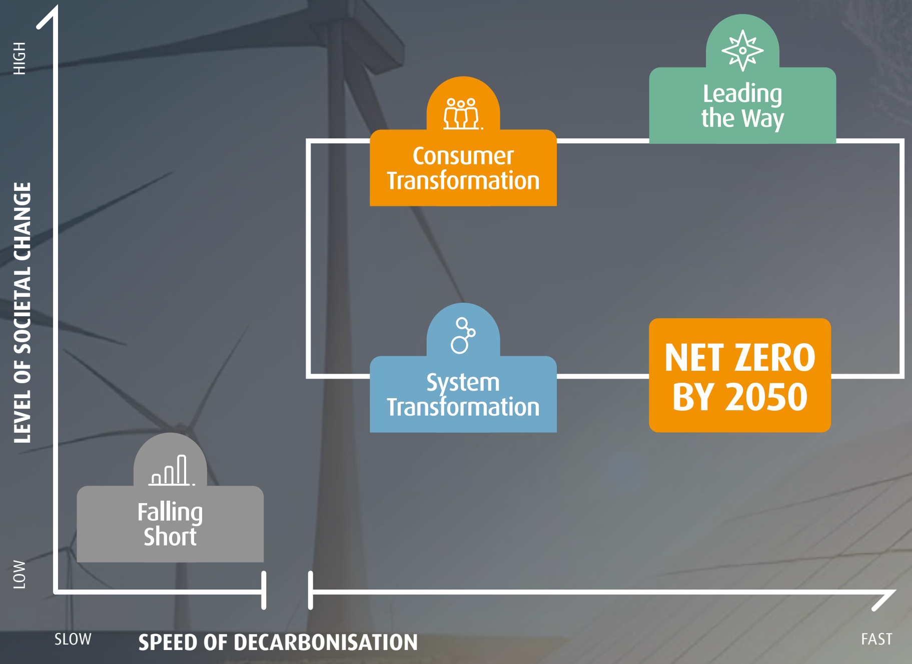

Figure 4 Scenario world framework overview

A simple overview of the annual timeline to produce the DFES is shown in Figure 5.

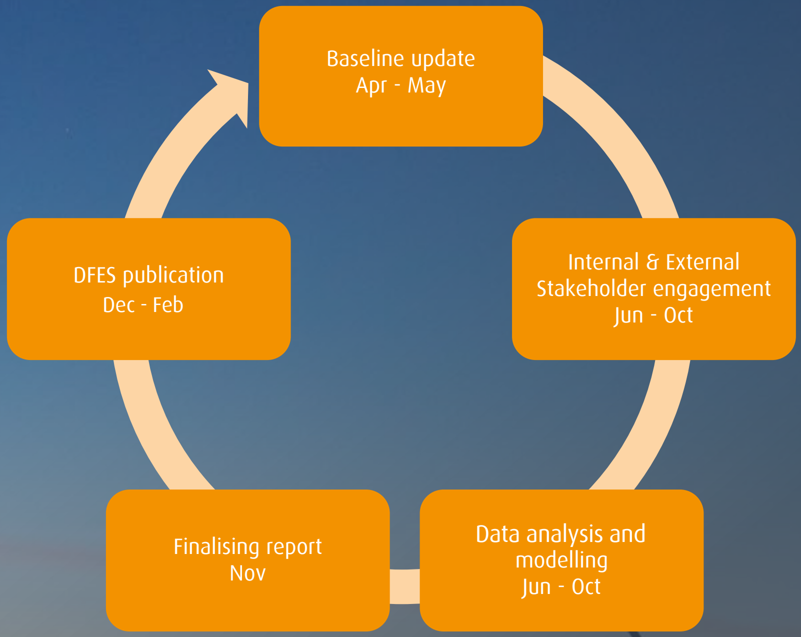

Figure 5 DFES annual timeline

Our Best View Scenario

Our high confidence forecast best aligns to the DFES Consumer Transformation. This would equate to delivering a Net Zero pathway with lower costs than alternative pathways we have modelled. The choice of best view scenario is based on justification criteria related to:

- **alignment with existing/announced policies**
- **alignment with stakeholder engagement inputs, and**
- **alignment with regional and local characteristic inputs.**

Therefore, for planning purposes we use the Consumer Transformation scenario as its best view scenario.

For each licence area, the best view scenario is shown in the UK Power Networks Long Term Development Statement (LTDS) for five years ahead. For example, Table 3A and 3B in the LTDS show grid and primary substation peak demand forecasts. LTDS for all licence areas are published on our Open Data Portal easily accessed by clicking the Long Term Development Statement (LTDS) and Network Development Plan (NDP) tile in the Feature links section. The LTDS also provides information on ongoing reinforcement schemes.

Forecasting Accuracy

According to the Ofgem DSO Incentive governance document: DSOs are due to report primary and secondary forecasting accuracy by 31 July each year in RIIO-ED2 as part of the RIIO-ED2 Regulatory Reporting Pack (RRP). The first submission will be 31 July 2024. This submission is not made public, however we intend to release some information from the accuracy metrics in an effort to promote transparency.

Converting the DFES assumptions to a substation loading

The information in the DFES scenarios is sorted on a regional level. In order to make substation specific predictions, we need to process the information further. The translation of the information from our DFES into peak and minimum load on a specific substation is carried out by the steps shown in Figure 6:

1. Development of use case profiles for each technology type
2. Validation of use profiles (data analysis and stakeholder engagement)
3. Development of bottom up modelling using insight data
4. Analysis and verification of modelling outputs

Figure 6 Conversion from DFES to substation loading

The load growth model within the SFS follows the general logic of first establishing the number of units (this would refer to customer connection counts, but also to LCTs). These are often resolved across different unit types, and we have a bespoke forecast for each unit for future years (considering growth/uptake scenarios from the DFES).

To assign the high level scenario data to smaller geographical regions we used Office for National Statistics (ONS) areas called:

- Middle Layer Super Output Areas (MSOAs); and
- Lower Layer Super Output Areas (LSOAs)

Our region is made up of about 2,200 MSOAs which in turn are made up of around 11,000 LSOAs. The average dimensions of MSOAs and LSOAs across England are given in Table 2 below.

Geography	Minimum population	Maximum population	Minimum number of households	Maximum number of households
LSOA	1,000	3,000	400	1,200
MSOA	5,000	15,000	2,000	6,000

Table 2 Average dimensions of MSOA and LSOA across England

The best available data is used to allocate units geospatially. The model is informed with LCT uptake at LSOA resolution, and the underlying distribution network topology resolves customer counts at LV Feeder level.

The annual consumption (or generation) is modelled for each unit, which is typically archetype specific and subject to additional scenario assumptions, such as changes in energy efficiency.

Once the annual consumption of a specific electricity consumer/generator is established, a profile shape is applied, which is characteristic for the diurnal load (customer behaviour throughout the day). Once the daily load is defined (for specific loading conditions and seasons), the peak load can be obtained. This peak load is corrected to reflect demand diversity, taking into account the phenomenon that a smaller number of customers will cause a higher per customer unit peak on the network than a larger number of customers. For further information on this please see Appendix A.

In summary, the DFES indicates the forecasted distribution of technology for each geographical region. For example, a scenario could say that 50 electric vehicles and 20 heat pumps are projected to be installed at an LSOA in 2026. After this information is validated, these units are then allocated to each LV feeder based on the customer distribution. We use the consumption profiles of all the LCTs and customers to build up the energy profile of an LV feeder. Then we keep building up and moving upstream all the way to our highest voltage substations.

4.2 Calculating the network headroom

The methodology used for calculating the network headroom is shown in Figure 7 below:

Figure 7 High-level approach to estimating unused capacity for demand per substation

[1]In mathematics, a time series is a series of data points indexed (or listed or graphed) in time order. Most commonly, a time series is a sequence taken at successive equally spaced points in time. Thus, it is a sequence of discrete-time data.

4.3 Understanding the duration of the constraint

Once it has been established that a site has a load constraint, the time of day and duration needs to be defined per season and per type of day. Seasonal (summer/winter) 24 hour profiles for working days and non-working days (total of four profiles for each site) are created. For each time-step (30min) in 24 hours, the seasonal loading profile is calculated as: mean + two standard deviations.

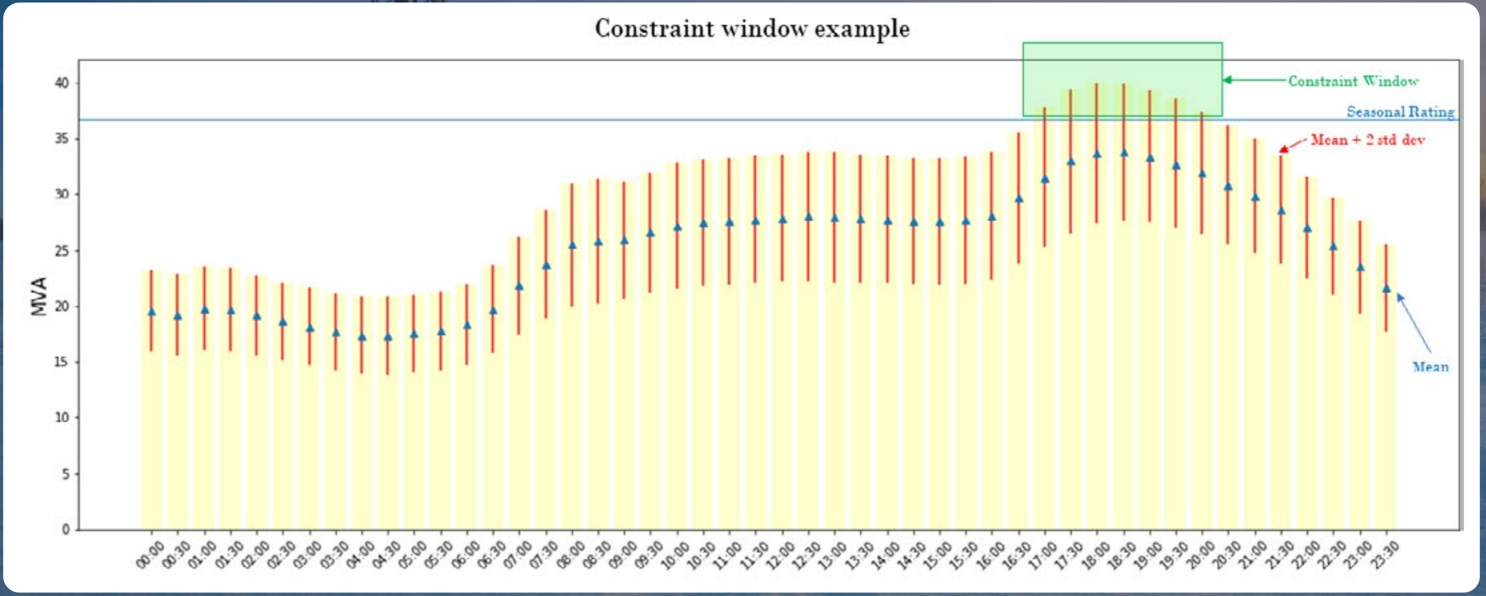

Figure 8 Constraint window example

A constraint window is defined when the seasonal profile exceeds the seasonal asset rating (summer/winter rating), as shown in Figure 8 above. We use our load growth forecasts and the seasonal profile to identify the future constraint windows.

4.4 Other needs drivers

There are occasions where system needs are identified by DNO Planning engineers. There can be various reasons why such a need could not be identified via the process described above. These can be triggered for example by new customer connections outside of the DFES refresh cycle. Another trigger event such as a regulatory change, for example the Significant Code Review (SCR), can also boost load growth and the DNOA process will need to be carried out. Additionally, there can be overloaded sites under specific conditions for example ENA Engineering recommendation P2 issues or other fault driven work. The DSO DNOA team will be collaborating with the planning team to make sure that on such occasions the most optimal solution is selected. In cases where the system need cannot be summarised in the DNOA publication page, there will be a more detailed explanation chapter in an Appendix of this document’s future versions.

5. Optioneering

5.1 Reinforcement options

Traditional reinforcement options to address system needs are a well-established approach in the industry. UK Power Networks has an internal process for the delivery of reinforcement solutions. In the DNOA process we focus on load related needs and solutions. Therefore, the need is usually triggered by network capacity exhaustion and the solution is to increase capacity. That can be achieved by building new substations and circuits or upgrading existing assets. When a load related need coincides with an asset health need, then an upgrade is the preferred economical solution. Another potential solution is network reconfiguration.

The reinforcement process uses a traditional project management phase-gate process. At the early stages, a system need is identified, and possible solutions are scoped. The asset engineers will study the network, produce high level costs and compare the solutions, choosing the optimum one (Stage A). In the following stage, the experts from the delivery teams will collaborate with the asset engineers to provide more accurate concept design costs (Stage B). At the next stage the delivery team is primarily involved in creating the delivery plan and producing detailed costs (Stage C). The final stage is delivery and project closedown (Stage D). For the large reinforcement projects, the stage A costing is done prior to the start of the regulatory period.

For the purpose of the DNOA, the expense for the reinforcement and the phasing of the costing is the main input to the process. Depending on the stage of the reinforcement process, the amount of detail available can be varied. The DNOA team will always use the latest data available. Please refer to chapter 7 in this document for further details.

On some occasions when the system need is identified far enough in advance of intervention, the reinforcement cost might not be available. On such occasions, average historic data will be used as an indicator.

5.2 Flexibility services

UK Power Networks has always used the flexibility inherent in the distribution network to provide economic and secure supply ahead of undertaking conventional reinforcement. For the past few years this has also included flexibility provisioned from the marketplace. This flexibility is procured via six monthly tendering rounds in areas triggering load related reinforcement. The contracts signed are longer than six months. Also, the reason for the frequency of tender events is to have opportunity to seek more flexibility capacity if the needs change.

Flexibility is a rapidly emerging marketplace for Distributed Energy Resources (DER) including generators, batteries, and demand side response to offer services to electricity networks. More specifically, DER can offer cost effective additional capacity on the network at peak times instead of the traditional method of building new infrastructure.

The Flexibility Roadmap, published in 2018 describes how UK Power Networks will communicate future flexibility needs to the market, allowing potential providers to assess the commercial opportunity, and to encourage them to participate in upcoming procurements for flexibility. Additionally we published in our consultation in 2022 our plans to scale up the procurement of flexibility.

In RIIO-ED2 we aim to continue our RIIO-ED1 practice to contract flexibility services ahead of the need to start reinforcement work. Therefore, we will allow time for multiple tender rounds to procure the required capacity. We have a number of flexibility products with different levels of commitment from providers. The flexibility services being procured fall under three categories from the standardised ENA flexibility products: Secure, Dynamic, Sustain. There are described in Table 3.

We consider Secure and Sustain appropriate alternatives to reinforcement for our best view DFES. For constraints identified for the other three DFES scenarios, we use Dynamic. Additionally, Dynamic is used for signposting, or in circumstances where we have a need for a backup. For our tender rounds we set a ceiling price according to the cost of reinforcement. FPs can compete below this price by submitting bids.

For further information on our flexibility products, please refer to Appendix B.

UK Power Networks has also pioneered the use of an online third-party platform to advertise information on upcoming system needs and allow DER to register their interest. We developed, trialled and are currently employing the UK's first GB-wide flexibility marketplace with Piclo, a single place for DSOs and more recently the ESO to source flexibility.

5.3 Other alternative solutions

Another traditional solution to manage a system need is via an operational solution, like network reconfiguration. This approach moves load to other areas of the network to decongest the constrained areas of network. This kind of solution is the first response to network constraints and is usually the most economic. However there is a limit to how long this can be done.

There are also occasions where a network constraint can be managed with an innovative solution such as our Distributed Energy Resource Management System (DERMS) or via an asset monitoring solution (Real Time Thermal Monitoring).

In certain scenarios it may also be possible to use hybrid solutions that combine a number of potential options. For example, it may be the case that an identified need is addressed partially by a flexibility service and the residual requirement through a small reinforcement scheme, or an operational solution.

	Secure	Dynamic	Sustain
Direction of flex required	› Demand turn-down (generation turn-up)	**Either:** › Demand turn-down (generation turn-up) OR › Demand turn-up (generation turn-down) As specified for each Flexibility zone	› Demand turn-down (generation turn-up)
Payment	**Availability and Utilisation Fee:** Payment for availability and energy delivered	**Utilisation Fee:** Payments for energy delivered	**Service Fee:** Payments for peak load reduction within Service Window
Capacity and price variation	FPs commit delivery and fees at contract sign	FPs specify Utilisation Fee and capacity available at day-ahead	FPs commit delivery and Service Fee at contract sign
Guarantee of revenue	Some revenue certaintly provided by the fixed Availability Fee and capacity*	**Pot 1** (demand turn-up): UKPN commit to minimum dispatch of 10hrs per year at full capacity **Pot 2** (demand turn-down): No committed minimum dispatch	Revenue certainty provided by fixed delivery and fee*
Timings	› Seasons & time windows specified in tender › Day-ahead dispatch	› No service windows › Day-ahead dispatch	› Seasons & time windows specified in tender › Scheduled dispatch
Level of connection	HV or LV connected assets		
Minimum contractable unit	Minimum (aggregated) 10kW threshold sustainable for 30 mins		

Table 3 Flexibility products

*Assuming delivery as per contract

6. Technical & Economic Assessment – CEM CBA

Through the ENA Open Networks project and in collaboration with Baringa Partners the first version of the CEM was developed and delivered. This tool allows the user to assess the viability of flexible vs non-flexible (i.e. conventional network reinforcement) options to meet their existing and future network needs. From April 2021 all DNOs committed to using the CEM to evaluate flexibility.

The CEM was well received by stakeholders and suggestions were made on how the tool could be further enhanced. This feedback was incorporated into the scope for 2021 and the outcome/deliverable being the publication of the second version of the CEM and tool in January 2022.

The tool has the ability to compare the costs under the different future energy scenarios. Where no pricing signal has been received from the market, i.e. at the very early stages of a system need identification, the tool can help identify a ceiling price for the flexibility prices to be viable. This information is important for the DSO during the flexibility tendering process. At the later stages of the scheme life when the market has indicated pricing, this information can be incorporated in the tool to measure the approximate benefits. Generally, we will continue to publish in our Flexibility microsite the available revenues for each flexibility area for every tender. This provides transparency to all stakeholders around the value of flexibility and how we develop and operate our distribution network.

For more information, please refer to the links below.

- **Statement for Common Evaluation Methodology for Network Investment Decisions v2.0**
- **Common Evaluation Methodology (CEM) and Tool v2.1- User Guide**
- **Common Evaluation Methodology Tool Version 2.2**
- **CEM Good Practice Guide**
- **Flexibility Hub**

7. Recommendation Process Summary

The previous chapters have explained the steps in the DNOA process. It is useful, however, to also understand how the above information is included in the DNOA decision process to reach the final recommendation and overall approach in decision making. Figure 9 below displays this decision process, however, it is crucial to note that this is a simplification as there are different possible scenarios and options to consider. The flowchart below aims to give a general insight to the logic.

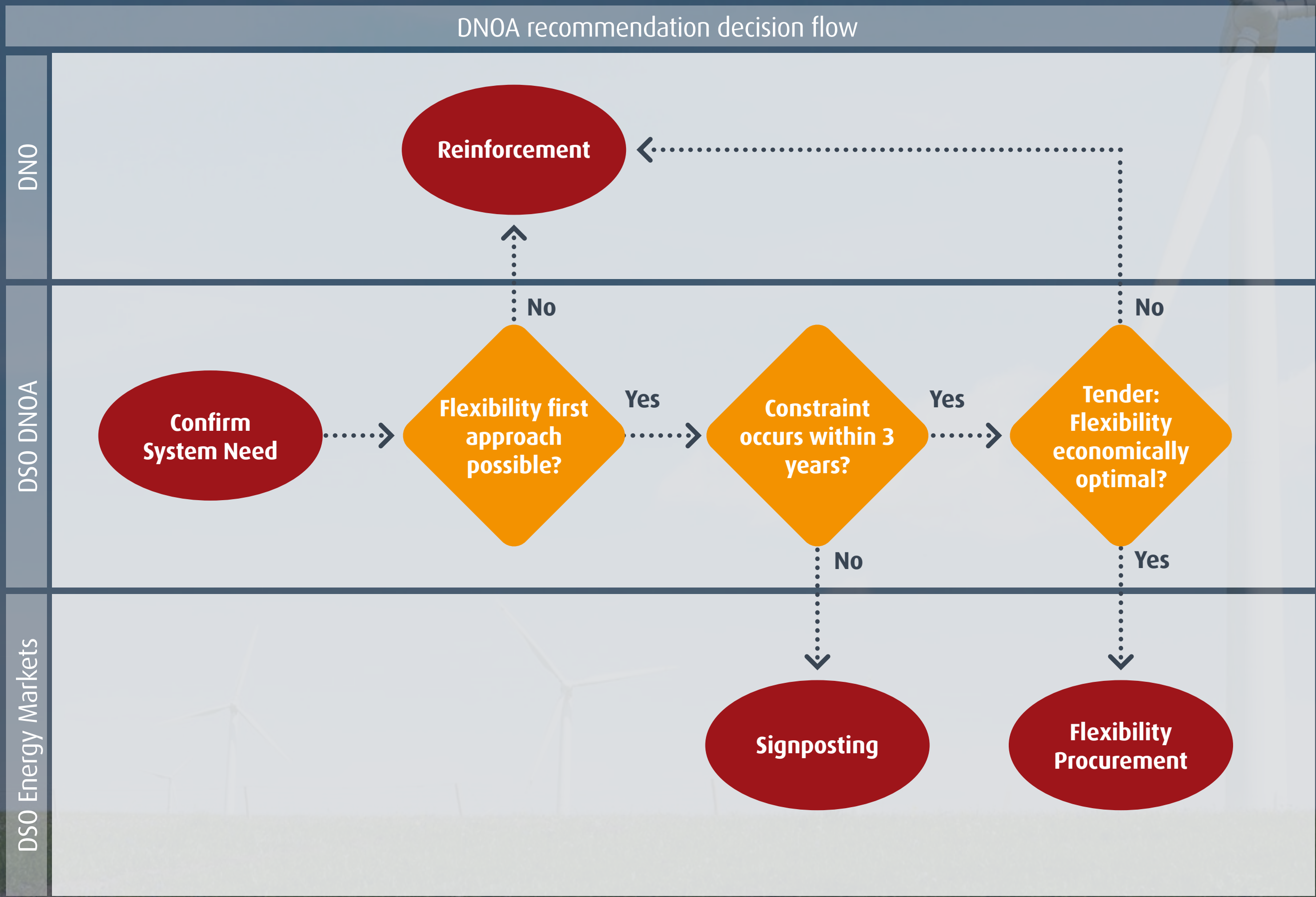

Figure 9 Simplified DNOA recommendation decision flow

The flowchart above is not meant to be completed in one annual cycle of DNOA. Depending on the lead time until the system need is realised, the process can pause, resume, and restart. This is especially affected by how far in the future the DNOA process is going to look.

1. Confirm system needs.

At the first year of RIIO-ED2, we identified system needs that will occur during this regulatory period i.e. the next five years. In the subsequent years we aim to expand into the RIIO-ED3 period.

We retrieve data for reinforcement schemes in the next 5 years from the DNO. The DNOA team will make a request to the DNO to prepare and cost reinforcement options for constraints appearing in more than 4-5 years in the future. This can also capture constraints that appear in non-best view scenarios.

2. Confirm flexibility is a viable option.

While we always want to have flexibility as our first option, there are occasions when flexibility cannot be used. As we have explained in our RIIO-ED2 submission, based on our experience of running flexibility tenders, when the level of capacity shortfall is more than 20MW or/and the duration of the capacity shortfall is longer than three or four hours, flexibility is unlikely to be secured or it is uneconomic to do so. However we aim to market test all schemes.

3. Lead time until constraint materialises.

The DNO should provide an indication of a lead time for the delivery of a reinforcement scheme. This essentially indicates a deadline by which the flexibility services need to have been procured by. On the other hand, the procurement of flexibility cannot start too far in advance of that deadline. The DSO Flexibility markets team can signpost the future need if we are a considerable time away from the constraint occurrence. When we are closer to the constraint occurrence, the DSO Flexibility markets team will begin the market testing. This time depends on the required time to deliver a reinforcement solution. For example, if a constraint occurs in four years and we know that we need two years to deliver a reinforcement solution, then we signpost the need now and market test next year. This will give the market one year to prepare and one year (or two flexibility tender rounds) for us to procure the required flexibility capacity.

4. Decide on the optimal solution.

Having concluded the market testing, we know if flexibility is the economically optimal solution. Therefore, the final decision on the best approach can be made. If we don't procure the total capacity required from flexibility, then we will explore the use of all available options as detailed in the Optioneering section, including the use of hybrid solutions that involve reinforcement, operational measures and flexibility.

The above steps can be progressed in one year's DNOA or multiple years.

The process is repeated every year in order to verify the system need's existence and that the solutions are appropriately sized and costed in order to verify the DNOA recommendation.

The progress of the status for a scheme is shown in Figure 10 below. Each vertical line indicates a possible pause in the process flow shown below.

Status:

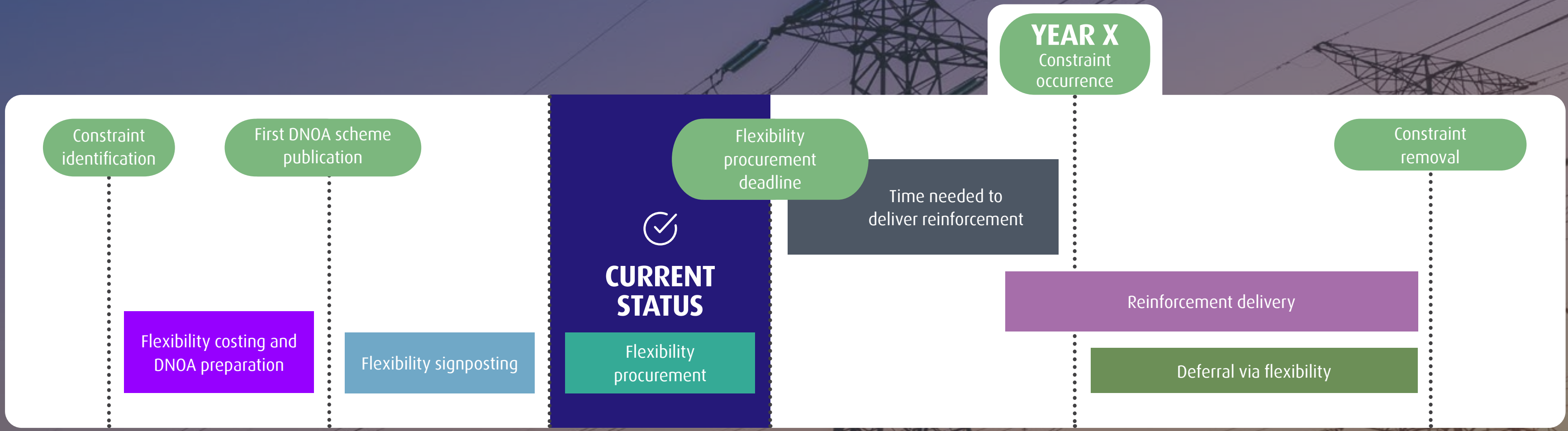

Figure 10 Simplified DNOA scheme progress

The above diagram assumes the flexibility required was procured prior to the deadline. In an alternative case when the procurement of flexibility is not successful by the deadline, the reinforcement delivery works will start to achieve the timely removal of the constraint.

The benefit of running the annual cycle of DNOA and confirming system needs, is that we can identify when a system need disappears which negates any further intervention. Overall, any reinforcement delivery would be required, only if the need persists past the period of the deferral through flexibility and in the absence of a more efficient option identified through DNOA.

Example scheme timeline

At this point we provide an example to make the above timeline easier to understand. Let's assume we identify a need occurring in 2027 and the reinforcement delivery is two years. This means we need to have procured the required flexibility services by 2025. We will signpost in 2023 to inform and cultivate the market. In Figure 11 below we assume that the economically optimum deferral period for this scheme was three years.

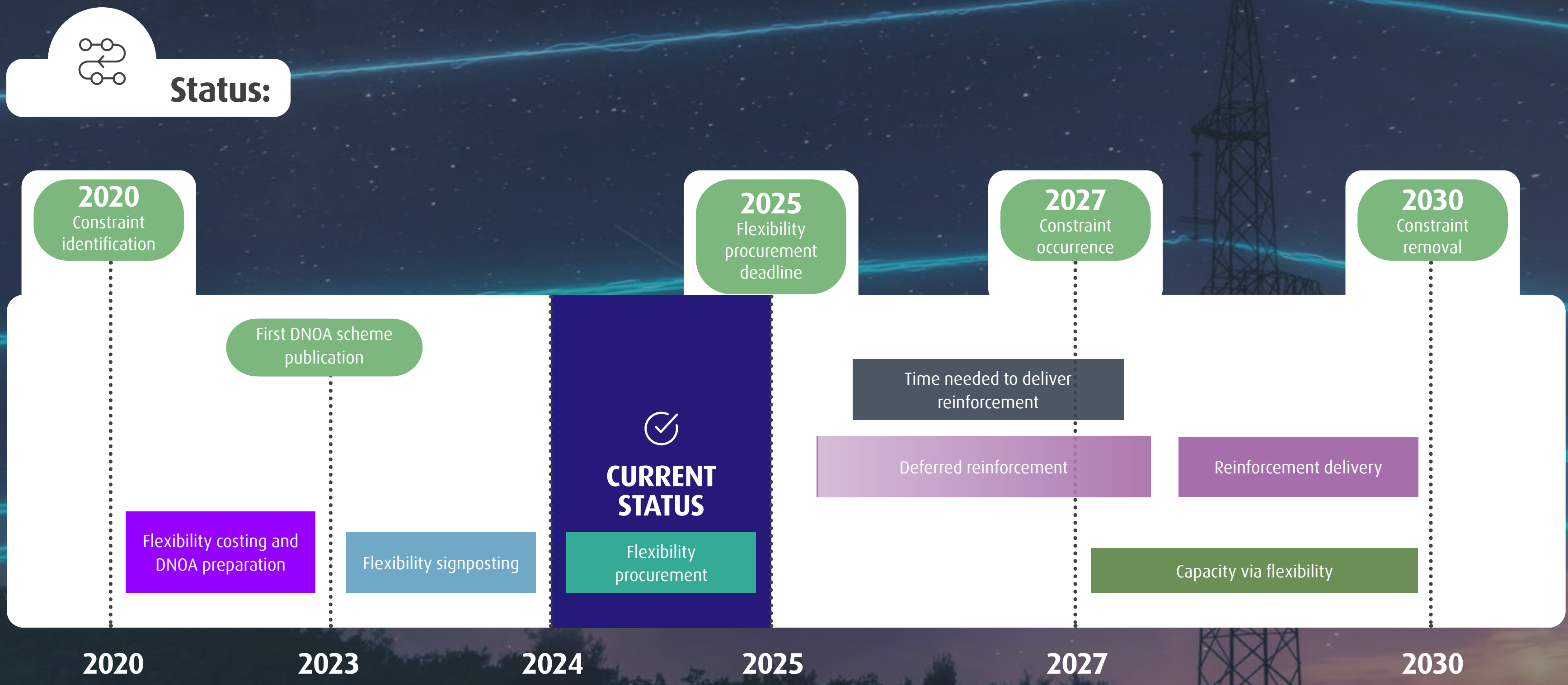

Figure 11 Example of scheme

8. Report Output Template

A common template for the reporting of every scheme has been developed. The template is shown in Figure 12 below.

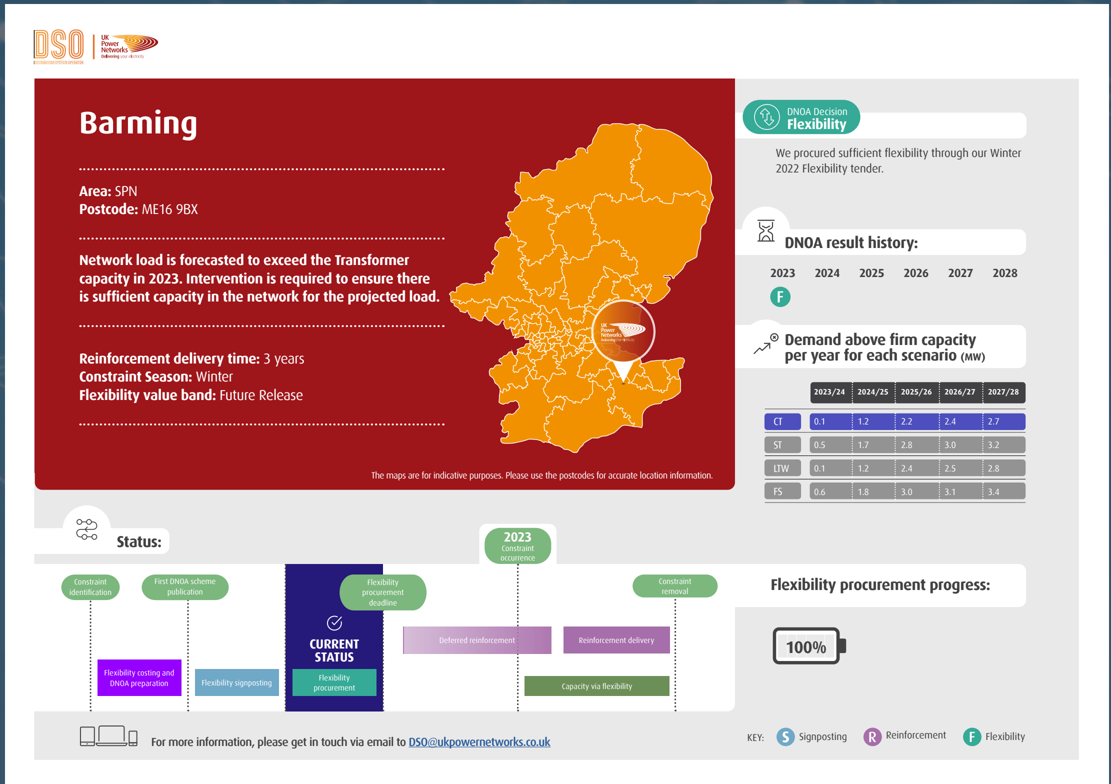

Figure 12 Scheme report page template

The report page is self-explanatory. An explanation of key elements is shown below:

- **Reinforcement delivery time:** Time needed to complete the asset works to increase capacity or remove the constraint. Depending on the stage of the DNOA, this can be unknown.
- **Constraint Season:** Season that the network experiences the constraint.
- **Flexibility value band:** We will give an indication of the value of the flexibility services. Depending on the stage of the DNOA, this can be unknown.
- **DNOA result history:** We will show all DNOA decisions in RIIO-ED2.
- **Flexibility procurement progress:** What percentage of the required flexibility capacity have we procured until now.

9. Stakeholder and Customer Feedback

This is our first publication of the DNOA methodology and results. We aim to evolve this document in order to best serve our customers.

We would kindly ask our customers or any readers of this document to provide us their views and ask questions by sending an email to DSO@ukpowernetworks.co.uk and use "DNOA" in the subject line.

Some of the areas that we would like feedback from our customers:

1. Did you find the DNOA report informative?
2. Is there any additional data or information that you would benefit from being included in future DNOA reports?
3. How could we improve the data presentation?
4. Is there any aspect of the DNOA process that you think needs to be more transparent?
5. Have you got any other general feedback on the latest DNOA report or the DNOA process?
6. How would you score the DNOA publication out of 10?

10. DNOA Results Summary

The results of the DNOA report are summarised in the three tables below, one for each area. The information in the tables is the same as the reports explained before but limited for the purpose of a summary.

Results summary table for SPN:

Scheme	Constraint Description	Year	DNOA Results	DNOA Stage
Barming	Transformer	2023	Flexibility	Flexibility procurement
Betchworth	Transformer	2023	Flexibility	Flexibility procurement
Capel	Transformer	2023	Flexibility	Flexibility procurement
Capel Switching Station	Circuits	2023	Flexibility	Flexibility procurement
Chatham West A	Switchgear	2023	Flexibility	Flexibility procurement
Cobham	Transformer	2024	Flexibility	Flexibility procurement
Cranbrook	Transformer	2023	Flexibility	Flexibility procurement
Dover	Transformer	2023	Flexibility	Flexibility procurement
Edenbridge	Interconnection	2023	Flexibility	Flexibility procurement
Guildford A	Transformer	2023	Flexibility	Flexibility procurement
Lewes Central	Transformer	2023	Flexibility	Flexibility procurement
Leysdown	Transformer	2023	Flexibility	Flexibility procurement
Little Chart	Transformer	2025	Flexibility	Flexibility procurement
Medway Grid	Transformer	2023	Flexibility	Flexibility procurement
Sittingbourne Grid	Switchgear	2023	Flexibility	Flexibility procurement
Smeeth	Transformer	2023	Flexibility	Flexibility procurement
Steel Cross	Interconnection	2023	Flexibility	Flexibility procurement
Townsend Hook	Transformer	2023	Flexibility	Flexibility procurement

Scheme	Constraint Description	Year	DNOA Results	DNOA Stage
Warehorne	Interconnection	2024	Flexibility	Flexibility procurement
Wingham	Transformer	2023	Flexibility	Flexibility procurement
Wrotham	Circuits	2024	Flexibility	Flexibility procurement
Chatham West B	Switchgear	2027	Signposting	Flexibility signposting
Dymchurch	Interconnection	2026	Signposting	Flexibility signposting
Guildford B	Switchgear	2027	Signposting	Flexibility signposting
Nutfield	Circuits	2027	Signposting	Flexibility signposting
Rye	Interconnection	2027	Signposting	Flexibility signposting
Sevington	Transformer switchgear	2027	Signposting	Flexibility signposting
South Orpington	Transformer switchgear	2028	Signposting	Flexibility signposting
St Peters	Transformer switchgear	2028	Signposting	Flexibility signposting
Staplehurst	Transformer	2026	Signposting	Flexibility signposting
West Weybridge 132/11	Transformer	2027	Signposting	Flexibility signposting
West Worthing	Circuits	2027	Signposting	Flexibility signposting
Weybridge	Transformer	2026	Signposting	Flexibility signposting

Results summary table for LPN:

Scheme	Constraint Description	Year	DNOA Results	DNOA Stage
Aberdeen Place B	Transformer	2024	Flexibility	Flexibility procurement
Back Hill	Transformer	2025	Flexibility	Flexibility procurement
Back Hill 132kV Group	EHV Circuits	2023	Flexibility	Flexibility procurement
Eltham Grid 33kV	EHV Circuits	2025	Flexibility	Flexibility procurement
Nelson Street	Transformer	2024	Flexibility	Flexibility procurement
Whiston Road Sub Group	EHV Circuits	2023	Flexibility	Flexibility procurement
Willesden	Interconnection	2023	Flexibility	Flexibility procurement
Blackhorse Lane	Transformer	2027	Signposting	Flexibility signposting
Bow	Transformer	2027	Signposting	Flexibility signposting
Bromley South	Transformer	2026	Signposting	Flexibility signposting
Eltham Grid 11kV	Transformer	2027	Signposting	Flexibility signposting
Exeter Road	Transformer	2027	Signposting	Flexibility signposting
Lithos Road	Transformer	2027	Signposting	Flexibility signposting
Sewell Road	Transformer	2026	Signposting	Flexibility signposting

Results summary table for EPN:

Scheme	Constraint Description	Year	DNOA Results	DNOA Stage
Aldreth	Switchgear	2025	Flexibility	Flexibility procurement
Ampthill	Transformer	2024	Flexibility	Flexibility procurement
Bramford Diss Thetford	Circuits	2023	Flexibility	Flexibility procurement
Brandon	Transformer	2023	Flexibility	Flexibility procurement
Brockenhurst Mill Hill	Transformer	2023	Flexibility	Flexibility procurement
Cockfosters	Transformer Tapchanger	2023	Flexibility	Flexibility procurement
Croydon	Interconnection	2023	Flexibility	Flexibility procurement
East Barnet	Transformer	2023	Flexibility	Flexibility procurement
Feltwell	Interconnection	2023	Flexibility	Flexibility procurement
Godmanchester	Interconnection	2023	Flexibility	Flexibility procurement
Guyhirn	Interconnection	2023	Flexibility	Flexibility procurement
Halesworth Primary	Transformer	2023	Flexibility	Flexibility procurement
Halstead	Transformer	2024	Flexibility	Flexibility procurement
Hilton	Interconnection	2023	Flexibility	Flexibility procurement
Kenninghall	Transformer Tapchanger	2023	Flexibility	Flexibility procurement
Kimbolton	Interconnection	2023	Flexibility	Flexibility procurement

Scheme	Constraint Description	Year	DNOA Results	DNOA Stage
Laxfield	Transformer	2023	Flexibility	Flexibility procurement
March Primary	Transformer	2023	Flexibility	Flexibility procurement
Waddesdon	Transformer	2025	Flexibility	Flexibility procurement
West Horndon	Transformer	2023	Flexibility	Flexibility procurement
West Letchworth Shefford Biggleswade	Circuits	2023	Flexibility	Flexibility procurement
Wiggenhall	Interconnection	2023	Flexibility	Flexibility procurement
Worstead	Interconnection	2023	Flexibility	Flexibility procurement
Willesden Grid	Interconnection	2023	Flexibility	Flexibility procurement
Alresford	Transformer	2026	Signposting	Flexibility signposting
Austin Canons Primary	Protection	2027	Signposting	Flexibility signposting
Barsham	Transformer	2026	Signposting	Flexibility signposting
Basildon Local	Transformer	2027	Signposting	Flexibility signposting
Bourn	Transformer	2027	Signposting	Flexibility signposting
Brington	Interconnection	2027	Signposting	Flexibility signposting
Brogborough	Transformer	2027	Signposting	Flexibility signposting
Caister	Transformer	2027	Signposting	Flexibility signposting
Central Harpenden	Transformer	2027	Signposting	Flexibility signposting
Chaul End	Transformer	2028	Signposting	Flexibility signposting
Coxford	Transformer Tapchanger	2028	Signposting	Flexibility signposting
Cromer	Switchgear	2028	Signposting	Flexibility signposting
Diss Grid	Transformer	2027	Signposting	Flexibility signposting

Scheme	Constraint Description	Year	DNOA Results	DNOA Stage
Elm Park	Switchgear	2027	Signposting	Flexibility signposting
Hartspring	Transformer	2027	Signposting	Flexibility signposting
Hendon Way	Transformer	2027	Signposting	Flexibility signposting
High Street	Transformer	2027	Signposting	Flexibility signposting
Ilmer Grid	Transformer switchgear	2027	Signposting	Flexibility signposting
Kimms Belt	Transformer and switchgear	2026	Signposting	Flexibility signposting
Leighton Buzzard	Transformer	2025	Signposting	Flexibility signposting
Lt Massingham	Interconnection	2027	Signposting	Flexibility signposting
Manton Lane	Switchgear	2027	Signposting	Flexibility signposting
March Grid	Transformer	2027	Signposting	Flexibility signposting
Milton Road	Transformer	2026	Signposting	Flexibility signposting
Rainbow Lane	Transformer	2027	Signposting	Flexibility signposting
Rickmansworth	Transformer	2027	Signposting	Flexibility signposting
Thorpe Grid	Switchgear	2027	Signposting	Flexibility signposting
Trowse Grid	Switchgear	2027	Signposting	Flexibility signposting

Appendix A. Further information on the forecasting process

In the forecasting chapter, we explained that the load growth model within the SFS follows the general logic of first establishing the number of units (this would refer to customer connection counts, but also to LCTs). These are often resolved across different archetypes, and we have a bespoke forecast for each unit for future years (considering growth/uptake scenarios from the DFES).

Some of the different archetypes distributed per geographical regions and affecting the forecasts are explained below.

Low carbon technologies

The load growth model within the SFS considers the uptake of heat pumps, district heating, air conditioning, EVs and solar PV as the most important growing technology segments. Heat pump uptake is modelled in a separate module and considers the various building archetypes separately. This module applies the uptake for each archetype as produced by the Element Energy Renewable Heat model in the DFES, which considers the business case and willingness-to-pay assumptions and evaluates the most suitable heating types for specific building archetypes. EVs are modelled in line with the Recharge the Future project conducted by us in partnership with Element Energy. This module has been enhanced since the project; it now considers a variety of additional transport segments, such as vans, taxis and motorcycles. A great number of vehicle types and charging behaviours are considered within each segment.

Generation

The model considers a table of known large generator sites (including near term forecast of the accepted connections pipeline). For these locations, the installation size (capacity), location and fuel type are defined and modelled accordingly. Small scale installations (typically solar PV) that connect behind the meter at LV level are distributed to LV customers. This is informed by uptake assumptions at LSOA level. The model also considers a range of storage installations, which mostly play a role in the constraints modelling.

There are a number of uncertainties which have been modelled based on the best available information, for instance discussions with water and wastewater companies have identified the potential for the reduction of generation output from some sites in order to divert fuels to power the company's fleet of vehicles, as green electricity can be purchased on a commercial basis, in so reducing CO_2 impact further.

EV charging

This sub section describes the key assumptions and process by which we have modelled EV related demand.

Our modelling has calculated what the EV charging annual consumption breakdown across our three licence areas will be. Figure 13 then shows our forecast of how EVs will be dispersed across our networks.

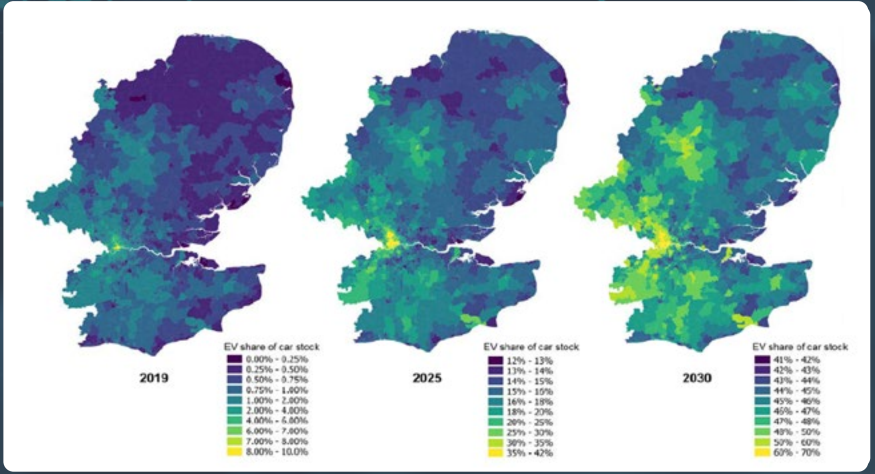

Figure 13 Heat maps showing the electrification of cars in Consumer Transformation and System Transformation at MSOA resolution in 2019, 2025 and 2030.

EV uptake forecasts at GB level are disaggregated geospatially using the best available deployment data. Over the shorter term we have forecast Plug-in Hybrid Electric Vehicles (PHEVs) and Battery Electric Vehicles (BEVs) registrations (modelled at GB level) and allocated to area units according to the historic uptake proportion using DfT and DVLA data. In the longer-term analysis, we then blend towards the distribution of car ownership. In the near term, hotspots form in areas that have a high proportion of early adopters in the baseline year (2019) and, as a result, we see high variation in the electrification between MSOAs in 2025, where anywhere from 12% to 42% of cars are electric. In 2030, EVs have reached the majority of the car stock in some MSOAs, but the hotspots are still visible. As the number of EVs grows, the difference in electrification between regions decreases and by 2050, the variation in electrification across MSOAs within our region is less than 3%.

The assumptions on LCT profiles that inform peak load estimates

As outlined in the previous section, the model determines an estimated annual consumption (or generation) for a host of customer types and technologies for each future year, scenario and at each network node. This annual consumption is then converted to a diurnal load profile. The load profiles from different technologies/customer types are stacked and the peak load is determined. This logic is repeated for each future year and network node.

The model considers profile shapes for each calendar month, and for min/average/max loading conditions. Furthermore, weekend and weekdays are distinguished where sufficient data is available.

Appendix B Further information on flexibility products

The need for flexibility

UK Power Networks will typically procure services to manage constraints on the network where high demand (or high generation) leads to exceedance of network limits for short periods. UK Power Networks' Flexibility Roadmap explains the different applications of flexibility for the distribution network. This includes deferring generation or demand-driven network reinforcement, manage planned maintenance, and unplanned interruptions. These Flexibility Services offer an alternative approach to traditional network reinforcement solutions such as upgrading network assets.

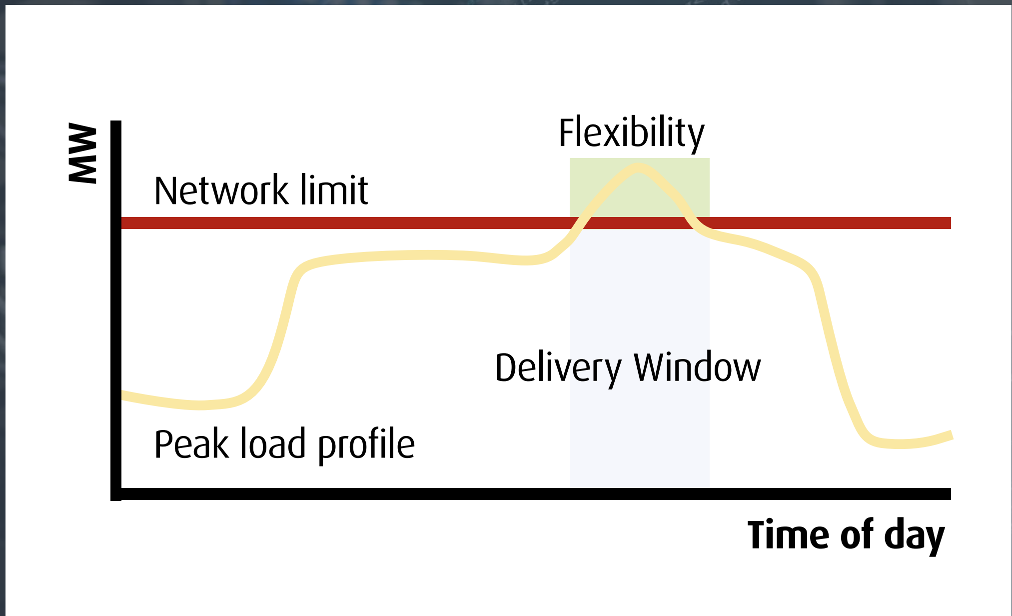

Figure 14 Flexibility Services targeting peak electricity demand at a substation

Flexibility Services can be provided by Distributed Energy Resources (DER), which is defined as a solution that can change its level of consumption or generation relative to its normal operations. Depending on the needs and product, this change can be through responding to dispatch requests, long term response, or even through enduring changes to demand (such as energy efficiency). The DER may be a generator, storage or demand asset, or a combination of these located at the same site.

A group of DER can be aggregated together into a single controllable unit called a Flexible Unit. A Flexible Unit is a notional DER that can be made up of one or more real DER located within the same zone. Flexible Units can be made up of existing and/or planned DER.

Secure Service

Under the Secure Service, Flexible Units are paid to be available during fixed service windows and only dispatched when needed to resolve operational constraints that occur within the service window. Specific months of the year and windows during the day are identified and the Flexibility Provider receives an Availability Fee (£/MW/h) in return for guaranteeing availability for the service periods. The Flexibility Provider is also paid a Utilisation Fee (£/MWh) for the energy delivered following instruction. Utilisation Instructions are issued at day-ahead. UK Power Networks is also exploring a notification at day ahead that will release a DER from providing availability during a service window to make it easier for the DER to participate in other flexibility services if there is certainty that the DER will not be required.

The service is ideal for business cases which require guaranteed cash flow.

Dynamic Service

Under the Dynamic Service, Flexible Units are contracted for close to real time service provision. The Flexible Provider is paid a Utilisation Fee (£/MWh) for the energy delivered when requested by UK Power Networks. It is a non-firm service so Flexible Providers can update the available capacity and Utilisation Fee at any time up to the day-ahead deadline to reflect their expected running or opportunity costs and can choose to accept dispatch requests from UK Power Networks. UK Power Networks intends to dispatch by a predefined day-ahead time in order to maximise the opportunity for Flexible Providers to also participate in other flexibility services.

This service is ideal for flexible solutions which can only commit to delivering flexibility on these short time scales, such as those participating in other energy or flexibility markets or those with variable flexible capacity (for example, demand reduction or intermittent generation reduction).

Sustain Service

Under the Sustain Service, Flexible Units are paid a Service Fee (£/kW/year) to reduce their peak demand (or increase their minimum generation) for the duration of the Sustain Service windows. It is a firm service which provides a fixed revenue in return for the agreed reduced peak load.

This service is ideal for flexible solutions that can provide a long-term reduction in peak load at a constraint during particular windows. This service could also be provided through enduring demand reduction programmes such as energy efficiency, if it can be demonstrated that the programme will have the required peak load reduction.

Appendix C. Definitions and acronyms

Term	Description
BEV	Battery Electric Vehicles
CBA	Cost Benefit Analysis
CCC	Climate Change Committee
CEM	Common Evaluation Methodology
CT	Consumer Transformation
DER	Distributed Energy Resources
DERMS	Distributed Energy Resource Management System
DFES	Distribution Future Energy Scenarios
DfT	Department for Transport
DG	Distributed Generation
DNO	Distribution Network Operator
DNOA	Distribution Network Options Assessment
DSO	Distribution System Operator
DVLA	Driver and Vehicle Licensing Agency

Term	Description
EHV	Extra High Voltage
ENA	Energy Networks Association
EPN	Eastern Power Networks
ESO	Electricity System Operator
ESO NOA	ESO Network Options Assessment
EV	Electric Vehicle
Feeder	Circuit leaving a substation
FES	Future Energy Scenarios
FP	Flexibility Provider
FU	Flexible Unit
GB	Great Britain
HP	Heat Pump
HV	High Voltage
LCT	Low Carbon Technology

Term	Description
LPN	London Power Networks
LSOA	Lower Layer Super Output Area
LtW	Leading the Way
LV	Low Voltage
MSOA	Middle Layer Super Output Area
NDP	Network Development Plan
NDR	Network Development Report
Network Planning team	The team responsible for planning reinforcement work in the DNO network
NSHR	Network Scenario Headroom Report
Ofgem	Office of Gas and Electricity Markets

Term	Description
ONS	Office for National Statistics
PHEV	Plug-in hybrid electric vehicles
PV	Photovoltaic
RIIO-ED2	The current electricity distribution regulatory period, running from 1 April 2023 to 31 March 2028
SB	Supervisory Board
SFS	Strategic Forecasting System
SP	Steady Progression
SPN	South Eastern Power Networks
ST	System Transformation
UF	Utilisation Fee
UKPN	UK Power Networks