Annex 4: Network Visibility Strategy

Detailing our plans as we provide visibility from the data collected for the planning and operation of our networks

December 2021

Executive Summary

Our strategy will deliver 100% network visibility coverage at all voltage levels in RIIO-ED2 and details our plans for providing 100% visibility based on the data collected for the planning and operation of our networks.

The data needed to provide a granular view of the operation of all the network voltage levels will come from a combination of smart meters, third-party sources, the installation of new permanent LV and HV monitoring equipment, and the use of derived data from techniques such as state estimation.

We have chosen to supplement the data gathered from smart meters and other third-party data sources as we are able to economically install new monitoring equipment on LV feeder heads to provide data on the operation of each LV network and aggregate this data to provide a distribution substation wide view. Our chosen monitoring solution is also able to provide the harmonic distortion measurements, as it uses a high sampling rate. It also monitors the neutral conductor current which is a crucial factor in assessing the thermal capacity because neutral conductors are typically half the cross-sectional area of a phase conductor.

Our approach for the installation of new monitoring equipment is to target the most populous ground distribution substations; these are likely to be in urban conurbations where the uptake of low carbon technologies, particularly Electric Vehicles, domestic Heat Pumps and residential PV is greater. By the end of RIIO-ED1 we will have installed monitoring on the LV network supplying electricity to 43% of all connected customers; and this will be extended in RIIO-ED2 to around 95% of all connected customers. We expect to obtain data for the network supplying the remaining 5% of customers from smart meters, or if this is not available due to the issues with the rollout and acceptance of smart meters, we will model these networks using actual data from similar networks. Where modelling is judged not to be sufficient we will install additional monitoring as required.

In the earlier years of RIIO-ED2 we will use the raw data to create a range of heatmaps that show capacity headroom and constraints, sharing both the raw data and heatmap information. We will deliver enhanced heatmaps for the HV network by the end of RIIO-ED1 and publish heatmaps for the LV network by 2025. The raw data will also be used in our ATLAS forecasting methodology and network simulation modelling to identify future network constraints across all voltage levels. Early signposting of network needs across all voltage levels will enable providers of energy efficiency and flexibility services to come forward to propose solutions for the identified network needs. It is important that the data we share, and the format meets the needs of all stakeholders and we will use our DSO Stakeholder Panel together with ongoing stakeholder engagement to enable us to identify and guide the development of our data sharing and visualisation.

We will consider how to provide the data in operational timescales with the aim of sharing the data by the middle of the RIIO-ED2 period to enable the management and delivery of flexibility services solutions.

The following documents are referenced in this Annex:

Annex 2: DSO Transition Plan	Annex 3: Load Related Investment Programme, Parts A & B	Annex 21: Data Strategy
Annex 25: Digitalisation Strategy and Action Plan	Annex 27: Workforce Resilience	LRE EJP 9: LV Network monitoring
Smart Metering Investment Proposal	Data, Analytics and Integration Platform Investment Proposal	

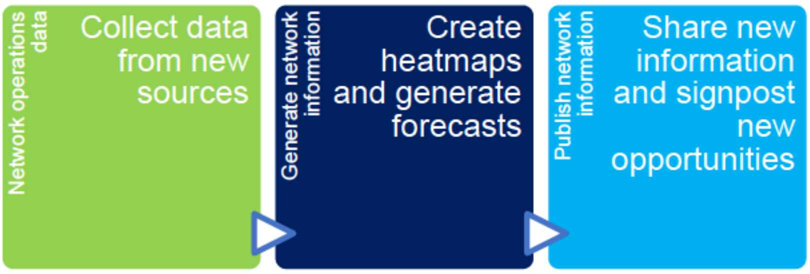
Contents

1. Introduction

Our aim is to strengthen the systems, processes and techniques that enable us to collect and manage the data needed to reveal how the whole of our networks is operating. Our innovation work within previous price controls has shown that we can release significant capacity in our HV and LV networks when we know more about how they are being used by our customers. This capacity released through improved visibility has already been paid for by customers and is therefore the most efficient means of meeting the early capacity needs expected as our customers connect more Low Carbon Technologies (LCTs) as part of the transition to Net Zero.

Increased visibility creates the opportunity to generate information and insights. The simple three step process shown below in Figure 1.1 shows how we can use the data to generate information and insights which when shared with customers and stakeholders can open opportunities for them, as well as for Electricity North West.

Figure 1.1. High level process showing transformation of data into information



For example, having granular data on the operation of the LV network enables us to produce improved LV heatmaps as well as enhance the existing HV heatmaps that we use to signal to our customers and stakeholders the hosting capacity and available headroom by network asset. This information will not only assist customers to minimise the costs of connection to the network but also maximise their income through opportunities for flexibility services or energy efficiency programmes to assist in deferring or removing the need for asset-based network capacity.

Figure 1.2. DSO data hub enabling whole system outcome and managing conflicts of interest

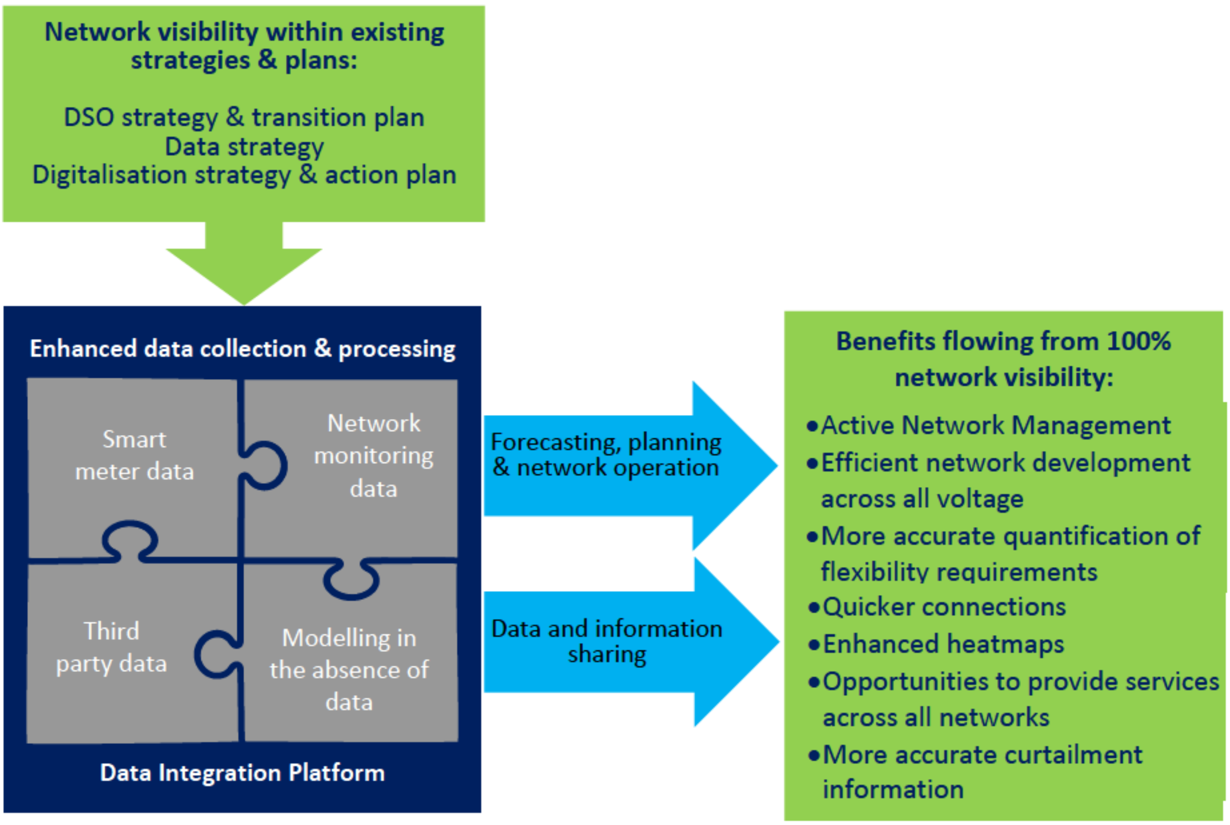
The DSO Transition Plan (Annex 2) details how data is a key enabler for the transition to distribution system operation and Figure 1.2 illustrates how DSO data is vital for the efficient operation of the DSO functions ensuring that whole system outcomes are achieved, and real or perceived conflicts of interest are being managed. Our Data Strategy (Annex 21) reaffirms our commitment to fully meeting the Energy Data Task Force's recommendations as we will ensure that all data is open, unless after triaging it is classified as confidential or commercially sensitive. In ED2 we will periodically re-publish the Digitalisation Strategy and Action Plan (Annex 25), regularly updating them as required and we will make available a wide range of planning and operational data that meets the expectations of the Data Best

Practice guidance. Data accessibility and visibility is at the core of our DSO commitments and essential for enabling a smart and flexible distribution system, delivering network capacity for use by customers at the most efficient price.

2. Network visibility strategy

Our vision is to create 100% network visibility across all voltage levels in our distribution network by the end of RIIO-ED2 and the strategy and actions to deliver that vision are embedded across a range of Annexes and Investment Proposals in the ED2 Business Plan submission. Figure 2.1 shows the whole network visibility strategy and details how by accessing and processing a range of data sources we can deliver significant benefits from the creation of 100% network visibility.

Figure 2.1. High level process describing how we derive benefits from 100% network visibility

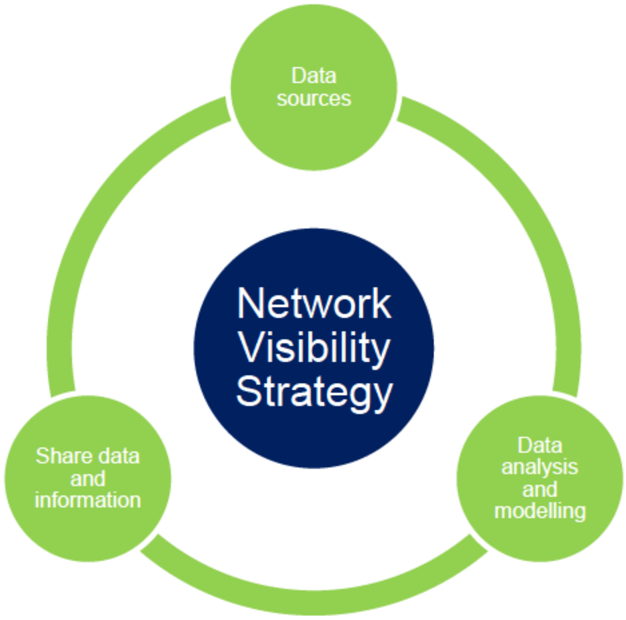


In the following sections of this strategy document we pull together the actions to deliver the strategy, we highlight the benefits derived from having 100% network visibility and we describe the data sources. These sections draw together, in one place information on systems, processes and techniques described in other parts of the RIIO-ED2 Final Submission and where useful we signpost to the relevant elements.

3. Action plan

This section outlines our commitments for delivering network visibility based around the three themes, namely data sources, data analysis and modelling and data sharing, shown in Figure 3.1. We also highlight how we will engage, consult and work with our customers and stakeholders within each of these key themes.

Figure 3.1: Three key themes of the network visibility strategy



Data sources: We will utilise data from smart meters, both consumption data and alerts for planning and operational purposes. This data will also be supplemented with data from third parties, where appropriate. In our Data Privacy Plan, approved by Ofgem in April 2021, we detail our plans for accessing household smart meter consumption data laying out the measures to retrieve, aggregate and anonymise smart meter data for the benefit of managing the safety, efficiency and cost-effectiveness of our electricity distribution network. We will continue the tactical deployment of monitoring equipment across the distribution network where is required to provide data on how the network is operating. At LV we continue to target the distribution substations with the most populous numbers of connected customers; further information on the proposed LV network monitoring solution is contained in LRE Engineering Justification Paper 9 – LV Network Monitoring and the technical specification of the equipment is detailed in Appendix 7.1. At HV we will target the installation of monitoring equipment on the longest circuits with the most variable loading, and at EHV we will upgrade the monitoring equipment when we intervene to retrofit or build new assets. Where further information is required to understand the harmonic content of the current and voltage waveforms on EHV and HV networks we will install power quality metering; noting that the proposed monitoring solution for LV includes power quality measurement capability.

Our RIIO-ED2 commitments within the data sources theme are:

Data sources – commitments		
Install monitoring equipment	**Access aggregated smart meter data and alerts**	**Working with our stakeholders**
• We will install of LV monitoring equipment at [redacted] distribution substations, increasing the network visibility to 95% of connected customers • We will install HV monitoring equipment on [redacted] of the longest with highly variable loaded • We will install four quadrant metering in new and retrofit EHV substations when we develop the network and for ANM zone implementation • We will install harmonic monitoring metering where necessary to ensure quality of supply is maintained	• We will access smart meter consumption data to target 100% LV network visibility • Where this is no smart meter data we will generate assumed load profiles (from similar consumer types) to model the network • We will use alert information for managing network events linking the alerts into the Network Management System (eg voltage, power outages etc)	• We will engage with our customers and stakeholders to source third party data eg weather data, local authority planning data, Future Energy Scenarios, Distributed Energy Resources etc • We will consult with our stakeholders to determine what data we utilise for improving network visibility

Data analysis and modelling: In our DSO Transition Plan we highlight that to deliver the new and enhanced DSO functionality, as prescribed by Ofgem, we will enhance our existing world leading ATLAS forecasting methodology to incorporate the proposed new data sources to generate granular forecasts. This granular forecast data will act as one version of the truth for the generation of our LTDS, DFES and NDP reports data. We will also adapt our Future Capacity Headroom model to accept this new granular forecast data to generate future constraints data opening the opportunity to increase significantly the number and range of flexibility services and energy efficiency tenders in RIIO-ED2. In Parts A and B of Annex 3, our Load Related Investment Programme we highlight how the use of the proposed new data sources enable the implementation of the strategic vision. We also have set out in our DSO Transition Plan that we will publish a planning methodology statement to give transparency and consistency throughout the connections process.

Real time network management: As the number of LCT connections increase, LV and HV feeders real time power flows will need to be managed to avoid network limits being exceeded. Traditional planning techniques use peak power flows or average seasonal power flows to determine the acceptable volume of demand and generation that can be connected. It is of note that without accurate power flow measurements, then these techniques result in conservative operation of the network and hence available capacity being denied to customers. With the rollout of accurate monitoring down to LV network level, we will implement the capability to monitor actual feeder flows and utilise this data in our Active Network Management (ANM) systems to enable real-time optimisation of LCT and customer usage of networks.

Our ANM system has been specifically designed to operate down to the LV feeder level, enabling the real time dispatch of smart EV controllers, heat pumps and other enabled customer devices. This dispatch may be direct or via a third party such as an aggregator or vehicle manufactures or via any other commercial model. The combination of sensors coupled with accurate feeder rating data and ANM enables us to truly optimise the ability of the network to deliver customers' needs. For example, the ANM can dynamically move LV and HV open points altering feeder loadings in response to customer needs. It can also use sensor and smart meter data to identify voltage constraints and alter network voltage set points or configuration to resolve these issues.

Our RIIO-ED2 commitments within the data analysis and modelling theme are:

Data analysis and modelling – commitments		
Data analysis and modelling	**Generate information and insights**	**Working with our stakeholders**
• We will carry out data hygiene checks so that only good quality data is used • We will use the data to create granular sub-feeder level heatmaps for all voltage levels • We will use the data in our ATLAS methodology as the basis for forecasts for all voltage levels • We will use network simulation with granular forecast data to generate future constraint data • We will monitor the health of our network to inform preventative maintenance or investment decisions	• We will create LTDS and DFES annually and NDP biannually • We will forecast future constraints • We will refresh heatmap data initially quarterly, moving to monthly • We will tender for flexibility services biannually and include early signposting specifically for energy efficiency • We will use our information and insights in network planning, investment and network operation processes	• We will engage with our stakeholders to share our data analysis and modelling activities • We will use external experts to support the development of enhanced data analysis and modelling activities • We will support our regional partners to develop local area plans (ie whole [energy, transport, heat] system)

Sharing data and information: Within our Data Strategy and Digitalisation Strategy and Action Plan Annexes we reaffirm our commitment to delivering the ETDF's recommendations and within the Data, Analytics and Integration Platform Investment Proposal we lay out our proposed solution and expenditure requirements to deliver the required IT infrastructure. Included within our investment proposals are enhancement of the data portal, developed in RIIO-ED1, and the addition of an online visualisation tool. The data portal will be adapted to enable machine to machine (eg through APIs) data sharing for example with third party data sharing/platform services providers that wish to access our data. We will continue to be active and collaborative participants in the Open Networks project and industry working groups, such as LTDS Form of Statement review, working on the development of enhanced data sharing requirements; and we will always deliver compliance and frequently exceed requirements.

Our RIIO-ED2 commitments within the sharing data and information theme are:

Sharing data and information – commitments		
Data portal with visualisation	**Open access**	**Working with our stakeholders**
• We will provide a data portal for sharing data, information and insights created when delivering the DSO functions and activities • We will provide means (eg APIs) for other data sharing services to access or data and information • We will provide data visualisation tools as part of the data portal to enable parties accessing our data to visualise it	• In line with the EDTF's recommendations we will presume all data is open, unless otherwise triaged • We will offer open and transparent sources of data, information and insights (eg LTDS, DFES, NDP, heatmaps etc) to allow stakeholders and other industry parties (eg DNOs, IDNOs and ESO etc) to make informed decisions	• We will engage with our customers, stakeholders and other industry parties to confirm the required datasets, their format and access method • We will work with the DSO Stakeholder Panel to enhance our data access policies and procedures over time • We will tailor the data, information and insights to specific types of customer/stakeholder, wherever possible

4. Benefits of network visibility strategy

The key benefit of network usage data is understanding the current utilisation of our assets as it enables us to better identify and signal available capacity in our networks as well as manage constraints.

Throughout our DSO Transition Plan we have declared our commitment to openly share data and Figure 1.1 showed earlier how we intend to collect data, how we use the data to create insightful information on the future needs of the network, and what we will do to promote this to encourage third parties to come forward and offer solutions to the network's needs. This is brought to life in

Figure 4.1: Processes for delivering flexibility first

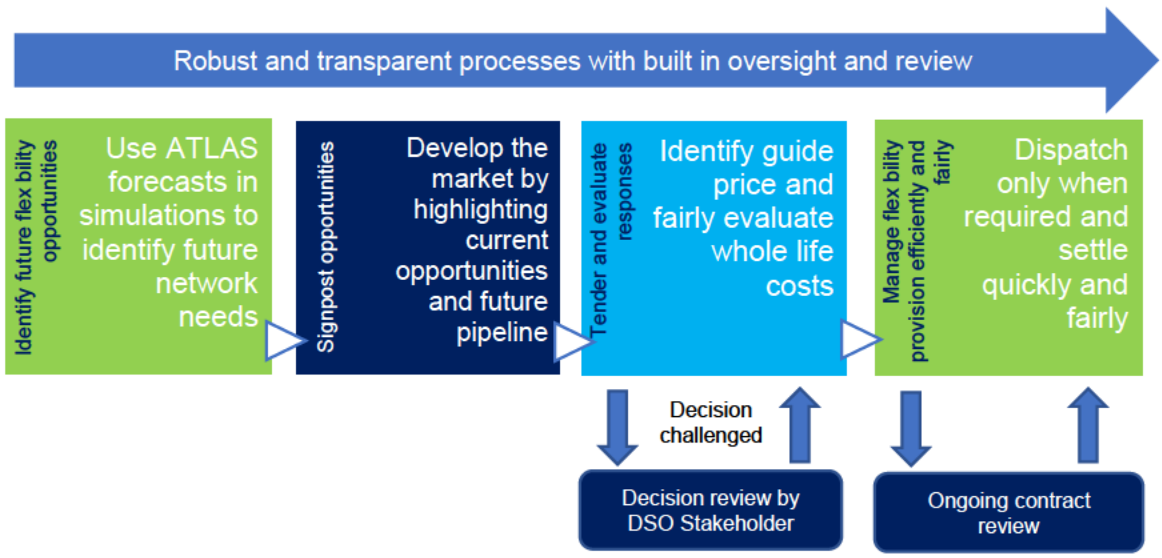


Figure 4.1 where we show how in RIIO-ED2 we will use the data to signal opportunities to flexibility providers of the network's needs.

In the DSO Transition Plan we also highlight that the combination of smart metering, third party data and new network monitoring equipment provides data on the operation of our networks, giving the outcomes and benefits shown in Figure 4.2.

Figure 4.2: Summary of the actions, outcome and benefits of greater network visibility

Action and outcome	Benefits
1. Create and share heatmaps showing utilisation and available capacity at all voltage levels, enhancing existing heatmap creation processes.	• Enhanced heatmaps with granular information enabling: • showing hosting capacity for potential connectees reducing connection times, • signalling constraints for potential solution providers aiding market development.
2. Generate forecast information on utilisation, capacity and potential constraints by enhancing world class forecasting methodology, ATLAS.	• Granular long-term forecasts enabling: • detailed network impact assessments, including potential use of ANM, • signalling areas with future network needs for quantifying potential intervention volumes, • signposting of future constraints developing the markets for energy efficiency and flexibility services, especially on the LV network.
3. Seek solutions from third parties to solve network constraints and promoting energy efficiency and flexibility services market development.	• Comprehensive tender requirements enabling: • targeted cost-efficient responses reducing the tender process costs for all parties, • a wide range of tender responses from across the technological spectrum developing the market for solutions provision.
4. Better inform operational network decision making and facilitate the utilisation of increased network automation to maximise the potential benefits of flexibility and unlock existing underutilised network capacity.	• Granular operational data enabling: • better understanding of the network risk, especially at LV where we can identify power flows, voltages or power quality outside limits, loading imbalance across the phases, excess current flows within the neutral conductor, reverse power flows, etc, • full utilisation of existing network capacity whilst maintaining a secure and resilient supply of electricity, • accurate operational decisions in our NMS, ANM and applications such as Smart Street based on actual data, • accurate week, day ahead and in day forecast requirements for flexibility services.

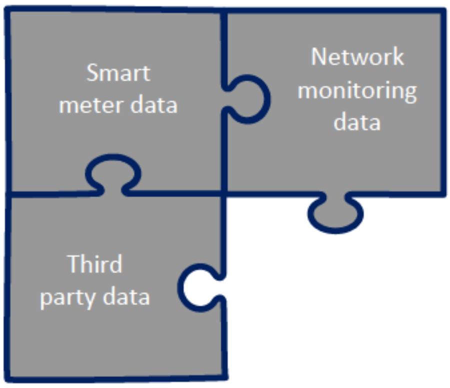
In Parts A and B of Annex 3, our Load Related Investment Programme we reiterate that the delivery of the strategic vision is enabled using data collected from a range of sources, but specifically measurement data from network monitoring equipment and smart meters.

By the installing monitoring equipment on selected HV and LV networks in RIIO-ED2 we will release capacity for use by our customers through improved understanding the of utilisation of our current assets. With significant increases in demand forecast during the RIIO-ED2 period, this is critical for our continued efficient network development saving DUoS customers money through deferred or avoided reinforcement.

5. Data sources

As shown in Figure 5.1 the three primary sources of data for deriving 100% network visibility are smart meter data, network monitoring data and third party data; these are described in more detail below.

Figure 5.1: Sources of data use for deriving 100% network visibility

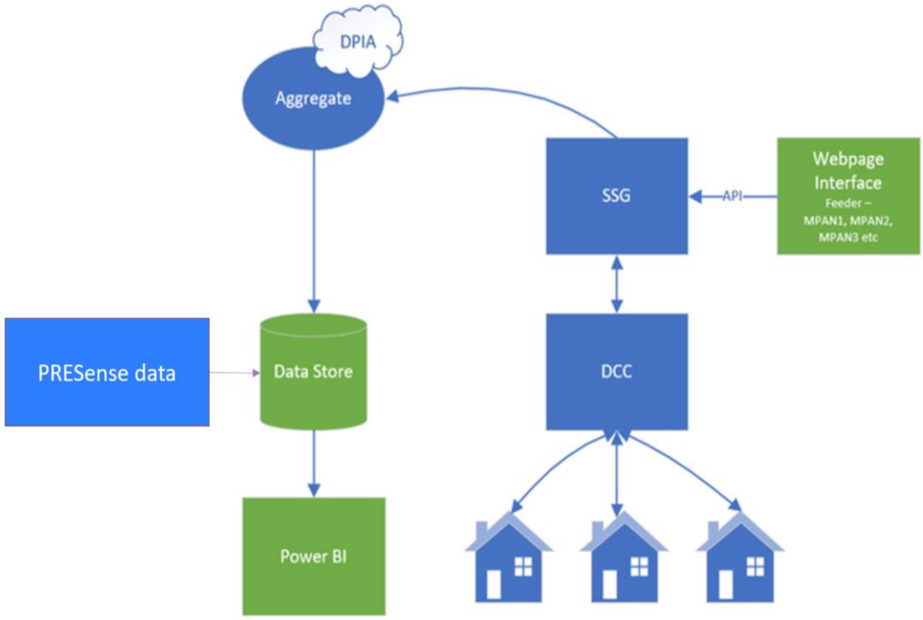


Smart metering: Throughout RIIO-ED1 we have been developing the systems and processes for interfacing with the Data Communications Company (DCC) to receive metered data and alerts generated by the meters. Due to the delays and issues in the national smart meter rollout we only expect to have up to 70% of our domestic customers with smart meters at the end of RIIO-ED1.

In early 2021 Electricity North West submitted a Data Privacy Plan and were granted permission to access domestic customers' smart meter consumption data in April 2021. The smart meter data will be gathered from the DCC, as shown in Figure 5.2. Connectivity data from our internal GIS and Network Management System (NMS) systems can show all MPANs connected to an LV feeder, secondary substation and HV feeders. Network connectivity data will feed, via a web interface (API), into the Smart Service Gateway (SSG); this is our corporate system that is used to communicate with all devices in the network. The SSG will then request to extract from the DCC the consumption, export, and voltage quality data (ie, alerts for under/over-voltages) from the associated smart meters for all MPANs on the specified secondary substations / LV feeders. Before being stored in our corporate system, the smart meter consumption data will need to be anonymised and aggregated.

Similarly, the voltage quality data will be processed to flag over/under-voltage issues per LV feeder / secondary substation. The anonymisation of the smart meter data will be in line with the Data Privacy Impact Assessment (DPIA) paper that has been approved by Ofgem. The aggregated and processed half-hourly smart meter data will be held in the data store.

Figure 5.2: System architecture for the collection and combined use of smart meter and LV monitored data



Measurements from the LV monitoring equipment on each secondary substation feeder will be also recorded and kept in the data store. Specifically; half-hourly averages of per LV feeder and per phase loading of active and reactive power, as well as currents and voltages, will be stored. These two forms of data are complementary and give a fuller picture as permanent monitoring provides harmonics and phase imbalance information enabling us to operate compliant networks and optimise use of existing assets.

We will utilise existing market ready data manipulation and presentation platforms (eg Microsoft Power BI) to not only visualise data, but importantly be the interface with planning engineers to access and process the data. This includes the extraction of datasets in formats (eg, csv/txt files) that can feed into the working tools of engineers and analysts to assess network impacts and select targeted, cost efficient interventions. Further information on the proposed investments in RIIO-ED2 related to:

- smart metering is included in out Smart Meter Investment Proposal and
- data analysis is included in our Data, Analytics and Integration Platform Investment Proposal.

Network monitoring: Our innovation work in DPCR5 and RIIO-ED1 has shown how monitoring and analysis can enable significant additional capacity to be released using the existing assets customers have already paid for; this was an innovation theme and is now embedded as business as usual. Our Connect and Manage approach adopted in RIIO-ED1 exemplifies this approach and shows how we maximise the use of existing LV assets for our customers. In Year 6 of RIIO-ED1 we have reported in Table E6 of the Environment and Innovation Report of our Annual RIGs submission that we had avoided over a million pounds of network reinforcement through this approach.

Knowing how valuable network usage data is for operating a smart and flexible network, in RIIO-ED1 we also took the decision to install monitoring on targeted areas of our overhead HV network and at high customer population distribution substations to obtain a clearer picture of how our networks are operating. Our primary aim is to obtain network usage data giving us a better understanding of how customers are using our networks, particularly for those circuits where LCTs are connected. Figure 5.3 shows that by the end of RIIO-ED1 we expect to have installed LV monitoring equipment on 15,000 LV circuits. We will be targeting those distribution substations with the most customers connected; we expect to collect data on the networks that supply electricity to around 1.024 million, or 43%, of all connected customers. At this point in time we only expect to have up to 70% of smart meters fitted and these will be randomly spread across the whole of the LV network.

Figure 5.3: RIIO-ED1 volume of customers covered by smart meters and network monitoring

	End of RIIO-ED1	Customer coverage
LV monitoring equipment	3,531 distribution substations or 15,000 LV circuits	1.024 million or 43%
Smart meters	Up to 1.68 million	Up to 1.68 million or 70%

We will continue using aggregated smart meter data to monitor the loading on the network, but we will also continue the strategic installation of HV and LV monitoring equipment in RIIO-ED2 to provide us with both greater visibility and additional data not available from smart meters with the aim of delivering savings to our customers. For LV network monitoring we aim to install equipment on another [redacted] ground mounted substations (covering a further [redacted] LV feeders), again selecting the most populous substations to ensure the widest coverage of monitoring across the connected customer population. This means that midway through RIIO-ED2 we expect to collect data on the networks that supply electricity to around 2.28 million, or 95%, of all connected customers. Alongside these monitors we estimate that there will be >95% coverage of smart meters, summarised below in Figure 5.4.

It is of note that network monitors fundamentally enhance the value that can be obtained from smart meter data; in that feeder monitors show accurate phase and neutral conditions whist smart meters show where the demand / generation is distributed along the length of feeders. This complementary data enables us to release additional capacity along the length of the feeder that would not be assessible with only feeder head monitoring. Similarly, the sensor data enables understanding of phase and neutral loadings versus associated limits as opposed to the less accurate probable 'average' loading visible through smart meters.

Figure 5.4: RIIO-ED2 volume of customers covered by smart meters and network monitoring

	End of RIIO-ED2	Customer coverage
LV monitoring equipment	[redacted] distribution substations or [redacted] LV circuits	2.28 million or 95%
Smart meters	>2.3 million	>2.3 million or >95%

In selecting the type of monitors to install in our LV network, we have recognised the varied impacts of LCTs and the need to measure phase imbalance, neutral current loadings and harmonics as well as more common network voltage and phase current flow. This additional information in the phase and neutral conductors will supplement the consumption data from smart meters. Due to the delays and issues in the national smart meter rollout we only expect to have up to 70% of our domestic customers with smart meters at the end of RIIO-ED1. Aggregated smart meter data only shows the average current flows in the phase conductor and therefore provides a relatively coarse and simple view of phase conductor thermal loading. The current flow in the neutral conductor is often the factor that defines the maximum number of LCTs that can be safely connected to the network as its cross-sectional area is half the size of a phase conductor. It is of note that LCTs often produce highly unbalanced loading conditions, highlighting the importance of neutral monitoring. Installing advanced LV and HV network monitoring provides real and reactive power flows (i.e. four quadrant metrics) and network voltage. Further information on the LV network monitoring solution is contained in LRE Engineering Justification Paper 9 – LV Network Monitoring and the technical specification of the equipment is detailed in Appendix 7.1.

By the end of RIIO-ED1 we expect to have installed HV monitoring on 100 circuits on the overhead network, where the network loading is uncertain and highly variable. In RIIO-ED2 we aim to install equipment on another [redacted] overhead HV circuits again targeting those longest circuits with highly variable loadings. This additional visibility means that we will be able to understand how the networks are operating and when required we will be able to intervene with more accurate solutions derived from measurements rather than estimates.

Figure 5.5 below shows the data we intend to collect from the monitoring equipment.

Figure 5.5: Measurement information recorded by the monitoring equipment

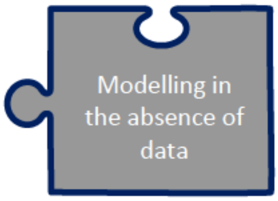
	Measurements*		
	Current	Voltage	General
LV monitoring equipment	Half Hourly phase current x 3 and Half Hourly neutral current	Half Hourly voltage x 3	Asset health measurement
HV monitoring equipment	Half Hourly phase current x up to 3	Half Hourly voltage x 1	Asset heath measurement, Low clearance identification, Volt drop alarm.

*Sampling rate of every second averaged over up to 30 mins

Third party data sources: In RIIO-ED1 we started engaging with IDNOs with the aim of two-way data sharing for network data, so that we could work together to develop a co-ordinated and efficient distribution network. As part of the data cleanse for the implementation of our new Network Management System we shared with our IDNO partners the data we held in our systems on the information about each embedded network's connection point and sought confirmation that the information was to update. This data exchange is now being formalised through a code modification and we expect that as we engage with our stakeholders throughout RIIO-ED2 we will find further opportunities for data sharing that we may wish to codify, so that there is consistency in approach across GB.

Managing and analysing the data to overcome observability issues

Figure 6.6: Managing data issues



The increase in data that DNOs will have in the future creates a significant challenge and our ability to manage this data challenge relies on us enhancing our existing skills and developing new skills in data analytics (see Annex 27 – Workforce Resilience on how we will upskill our existing colleagues and attract new colleagues with the necessary skills). Fortunately, we are not starting from a zero base as our current processes for forecasting, planning and managing the distribution network have provided us with the knowledge and experience of how to process large quantities of data and manage data gaps when they appear either temporarily or for significant time periods.

Temporarily missing metered data: Although we expect the data from smart meters and LV monitoring equipment to keep flowing, this is the real world and there are likely to be times when there are temporary glitches in the equipment or the transmission channel resulting in missing data. Intermittent loss of data is easily managed using estimation algorithms or machine learning techniques to replace the data with estimates where necessary. We currently use these techniques for missing data from our network monitoring equipment managed through our SCADA interface into our Network Management System. These techniques are also applied to the loss of large quantities of data ie several months if there is a reasonable history of data recordings that can be assessed. In addition, we have significant experience of data processing involving estimation and machine learning techniques from the development of the ATLAS forecasting methodology, which have been steadily improved since its introduction into business as usual in 2018.

Limited or no metered data: At the start of RIIO-ED2 we expect that there will be elements of our network where no monitoring equipment is fitted and there are very few smart meters fitted; this presents a challenge as there will be no telemetered network visibility. Of course, over time as the smart meter rollout continues and we install more monitoring equipment network visibility will increase but, in the meantime, we will develop the modelling capability and processes that enable us to infer the operation of those networks.

In the early years we will have numerous ground mounted and pole mounted substations that either have no data or limited data. This will be particularly the case where properties are fed from pole mounted substations. By targeting the installation of LV monitoring equipment on those substations with the highest number of customers, this means that the large majority of pole mounted substations will not have LV monitoring equipment fitted. To address this, we will create representative property models to estimate a demand and consumption profile for the properties. This enables us to generate aggregate LV feeder data in its entirety or plug gaps in the aggregated data as we know that less than 100% of properties on that feeder have a smart meter installed. We will rely on aggregated smart meter data and we will utilise the functionality of the DCC Gateway to identify the number of smart meters installed per feeder. Where there is missing smart meter data we will categorise the property type. Having identified information on the number and types of LCTs fitted; we will estimate a profile of demand and generation, based on similar representations to generate an assumed aggregated demand profile for that feeder.

Missing data – Low Carbon Technologies (LCT): Although we expect the installer or property owner to notify us of the installation of a new LCT or apply to connect to our network prior to the installation of a new LCT, our experience tells us that installers or customers sometimes don't, and we may have gaps in our data. Figure 5.7 below illustrates examples of how to fill the potential knowledge gap by talking to installers, other industry parties or third-party data providers.

Figure 5.7: Potential initiatives for managing missing LCT installation data

Data type	Target groups	Opportunities
EV charger(s)	Installers	Cross checking work programme
	Retail suppliers	Identify through tariff data or profile data
	Third party data source providers eg Zap Map	Cross checking with our GIS database
Heat Pump	Installers	Cross checking work programme
	Retail suppliers	Identify through tariff data or profile data
Solar PV	Installers	Cross checking work programme
	Retail suppliers	Identify through tariff data or profile data
	Third party data providers eg Satellite images recognition software	Cross checking with our GIS database

We will also look to employ machine learning algorithms combined with smart meter data to infer if an LCT has been connected and does not feature within our data records. An example of this would be utilising the smart meters export metering to infer that a customer has embedded generation installed within their property. A targeted follow up with the customer will help to update our own records and help to gather data on installers who are not following national guidelines for LCT installation so that appropriate education and enforcement action can be initiated. Filling in these data gaps helps to ensure that we can forecast and plan more effectively as well as helping to ensure that customers installations are safe and in line with national guidelines.

In addition, there other potential initiatives using existing engagement processes or customer touchpoints that provide the opportunities for engaging directly with customers. Examples are:

- As part of a Priority Services Register (PSR) follow up ask whether our information on LCTs installed at their location is up to date.
- As part of the planned interruption notices ask whether our information on LCTs installed at their location is up to date, providing contact information for the customer to get in touch.

6. Data and information sharing use cases

We will use the half hourly current and voltage readings for each phase (and for LV networks only, the neutral conductor) from the monitoring equipment to provide information on the how the network is operating in real time and to generate insights for the planning and future development of the network.

1. Publish raw data

Real time network management

It is possible to publish the real time half hourly data collected from the monitoring equipment for the real time management of our network. However, we are unsure whether this would be useful and valuable to our stakeholders so we will be guided by the DSO Stakeholder Panel on how to publish this data.

We will collect current and voltage readings for each phase to monitor the operation of the network. Network management tools will manage the network flows ensuring that no parts of the network are overloaded; or when a fault occurs, the faulty section is isolated, and where possible the network is reconfigured and supplies to customers restored. The data collected populates a network connectivity model within the Network Management System and its applications; for example, techniques such as ANM, Smart Street, FLISR, CLASS etc are enabled by the provision of network usage data.

The smart network of ED2 and beyond will serve millions of LCTs monitored by thousands of sensors working together with smart meters and our ANM to always enable customers to maximise the use of the network.

Further, we envisage that the role of flexibility providers will be enhanced by only using those services when the network is unable to resolve issues through dynamic network ANM operation. Once the ANM has exhausted the network's capability it will efficiently dispatch flexible resources via industry market interfaces to resolve any remaining constraints. Accurate sensor and smart meter data enables such dispatch instructions to be only used when essential hence preserving the flexible capacity for other whole system uses such as system balancing. Our visibility strategy is fundamental to this network operation goal and central to ensuring the efficient use of flexibility.

We also anticipate that ESO dispatch requests alongside other commercial market operations will need to be closely monitored to verify that the modelled impact on the network and hence customers is as anticipated. For example, vehicle manufactures may act as balancing parties either directly or through aggregators dispatching EV demand / export in response to market signals. Network sensors will provide the direct real-time feedback ensuring that unintended consequences are avoided or quickly resolved by the ANM. For example, in high wind availability scenarios market participants may cause an increase in EV charging rates for flexible chargers or through real time tariff signals. Whilst many feeders will remain within limits, some may not, and the network sensors will immediately detect any constraint breaches enabling them to be resolved by the ANM before assets sustain damage or deterioration.

It is not possible to envisage all the ways in which network visibility will aid networks operations by our investment in sensors or smart meter data but ANM is designed to manage a whole host of scenarios enabling optimised operation of the network and flexible resources.

Opportunities	Benefits	Action
Unknown	To be determined	Seek guidance from DSO Stakeholder Panel in ED2

2. Generate loading information and publish heatmaps for efficient network use

Analysis for network development

In planning timescales, we will analyse the half hourly current and voltage readings for each phase (plus for LV networks only, the neutral conductor) and calculate specific information to understand how the network is operating over time. For example, we use the collected data to:

- Analyse and compare phase currents against the phase capacities to understand phase imbalance,

- Calculate minimum and maximum demands on the network with accompanying date and time stamps to understand operating range of the networks, and
- Compare with network capacity to calculate and publish available headroom in the form of a heatmaps to signal opportunity to connect or provide flexible services /energy efficiency.

Opportunities	Benefits	Action
1. Visibility of available headroom 2. Visibility of network constraints	1. Signal to developers connection opportunities; for quicker connections and reduced connection costs 2. Signal to aggregators/ flexibility providers opportunities; developing the market and reducing the cost of procuring flexibility services	Publish enhanced HV and LV heatmap information and accompanying data tables, updating quarterly, moving to monthly

Prior to the DSO Stakeholder Panel assisting us to decide whether to publish all the raw data, we will provide, on request, the half hour data for defined sections of network.

3. Publish information and insights to encourage efficient solutions

Analysis for network development

The analysis of the loading data generates additional information on the current usage of the network and potentially identifies network issues that may require rectification. In previous price controls an asset solution would have been developed from this analysis. As more granular data becomes available our approach will change where we will look to third parties to generate potential solutions, whilst we develop the asset intervention solution primarily as the counterfactual for the evaluation and solution selection stage.

For example, we could potentially find on LV and HV circuits:

- Power flows, voltages or power quality outside limits,
- Loading imbalance across the phases,
- Excess current flows within the neutral conductor,
- Reverse power flows, etc.

Publishing information on constrained parts of the network, via the NDP and flexibility services tenders, would encourage customers, other DNOs, embedded IDNOs, aggregators etc to come forward with as wide a range of potential solutions as possible to remedy the problem; and the solutions would be evaluated as normal using the Whole System CBA, CEM or ROCBA tools. This would aid our commitment to encourage participation in the operation of the network from as many individuals and organisations as possible.

Opportunities	Benefits	Action
Visibility of network issues	Signal opportunities for solution providers, reducing solution costs	Publish network problems and accompanying data tables, updating initially bi-annually

4. Publish forecast information and insights to encourage efficient interventions

In RIIO-ED2 we will run simulations on the HV and LV networks using the DFES loading forecasts, derived from the collected data and generated from the ATLAS methodology, to identify the volumes and locations of potential network needs for the next 10 years. This enables stakeholders to understand the range and scale of the potential network needs in the future, based on our current forecasts; these would be published in Long Term Development Statement and Network Development Plan formats.

Opportunities	Benefits	Action
Visibility of forecast network issues	Signal potential opportunities for solution providers; reducing solution costs.	Publish forecast volumes of network problems and accompanying data tables, updating initially every other year.

7. Appendices

7.1. Technical specification for LV monitoring equipment

Technical Specification

<table>
<tr><td colspan="3">Environmental</td></tr>
<tr><td>Ingress protection</td><td colspan="2">IP54</td></tr>
<tr><td>Operating Temperature</td><td colspan="2">–25 ^{0}C to 60 ^{0}C</td></tr>
<tr><td>Operating Humidity</td><td colspan="2">Up to 95 % Non-Condensing at 20 ^{0}C</td></tr>
<tr><td colspan="3">Connectors</td></tr>
<tr><td>Voltage</td><td colspan="2">Bulgin 4000 series</td></tr>
<tr><td>Current</td><td colspan="2">5 off Bulgin 400 Series</td></tr>
<tr><td>Ethernet</td><td colspan="2">RJ45 connector</td></tr>
<tr><td>Antenna</td><td colspan="2">SMA</td></tr>
<tr><td>USB/Expansion</td><td colspan="2">Proprietary sealed USB A</td></tr>
<tr><td colspan="3">Communications</td></tr>
<tr><td>Wireless</td><td colspan="2">2G, 3G, 4G</td></tr>
<tr><td>Local</td><td colspan="2">Bluetooth</td></tr>
<tr><td>Direct Connect</td><td colspan="2">Ethernet</td></tr>
<tr><td colspan="3">Measurements</td></tr>
<tr><td>Load/Power Quality</td><td colspan="2">To EN 61000-4-30 Class S in general
Per Phase -
Voltage - Min, Max and Mean
Voltage Interruptions
Voltage Dips
Voltage Swells
Rapid Voltage Changes
Mains Signalling Voltage
Voltage Unbalance
Current – Min, Max and Mean
Current Unbalance
Frequency-Min, Max and Mean
Power Factor
Real Power
Reactive Power
Apparent Power
Power Unbalance
Total Harmonic Distortion (mean V and I)
Individual harmonics to 25th (mean V and I)
Interharmonics (mean V and I)</td></tr>
<tr><td>Capture Windows</td><td colspan="2">1 min, 10 min or 30 mins (10min default)</td></tr>
<tr><td rowspan="2">Voltage</td><td>Range</td><td>0 to 625 V a.c.</td></tr>
<tr><td>Accuracy</td><td>0.2 % of reading</td></tr>
<tr><td rowspan="2">Current</td><td>Range</td><td>10 kA rms input range</td></tr>
<tr><td>Accuracy</td><td>2% of reading</td></tr>
<tr><td rowspan="3">Standard Current Probe Set</td><td>Type</td><td>Rogowski</td></tr>
<tr><td>Sensors</td><td>3</td></tr>
<tr><td>Cable Length</td><td>3 m</td></tr>
</table>

7.2. Glossary

API	Application Programming Interface - a set of functions and procedures allowing the creation of applications that access the features or data of an operating system, application, or other service
ANM	Active Network Management – an application of the Network Management System that manages network constraints in real-time by using flexible assets and varying the import and/or export of DER
ATLAS	Architecture of Tools for Load Scenarios project which developed methodologies, prototype tools and specifications to develop detailed loading scenarios
CEM and Tool	The common evaluation methodology developed in the Open Networks Project in 2020 for evaluating a range of potential solution options, especially flexibility, against traditional reinforcement. An MS Excel Tool, based on the Ofgem CBA, was developed using the methodology for the assessment by DNOs in ED1
CIM	Common Information Model – a protocol for sharing electrical network data between parties
Connect & Manage	The approach, devised through an innovation trial, to allow a defined number of new Low Carbon Technologies to connect to the distribution network, without reinforcement. Once the defined number is achieved monitoring equipment is installed to provide accurate information on the operation of the network.
Data Best Practice guidance	Developed as part of the Modernising the Energy Data agenda this publication by Ofgem and BEIS defines their overarching expectations for how access to and the exchange of energy data between organisations is undertaken and how energy data is best used.
DER	Distributed Energy Resources - small-scale power generation and storage such as solar, wind and electric vehicles that operate locally and are connected to a larger power grid at the distribution level
DFES	Distribution future electricity scenarios – forecasting plans for a range of scenarios for how low carbon technologies will be taken up and how the network could respond. The scenarios inform our investment plans and provide visibility of flexibility opportunities
DNO	Distribution network operator - company licensed to distribute electricity in Great Britain by the Office of Gas and Electricity Markets (Ofgem)
DSO	Distribution system operation
EDTF	EDTF, Energy Data Task Force has developed a set of recommendations for how industry and the public sector can work together to facilitate greater competition, innovation and markets in the energy sector through improving data availability and transparency

ENA	ENA, Energy Networks Association – industry body which represents transmission and distribution network operators for gas and electricity in the UK and Ireland
EJP	Engineering Justification Paper
Flexible connection	A connection to the distribution network that has agreed flexible arrangements, generally the curtailment of import or export capabilities at given conditions.
Flexible/flexibility services	Distributed energy resources connected to our networks can increase exports (generate more) or reduce imports (consume less) when instructed by the network and receive payment in return
HH	Half hour
HV	High voltage
IDNO	Independent distribution network operator
LCT	Low carbon technology such as electric vehicles, electric heat pumps, solar and wind energy
LTDS	Long Term Development Statement – the requirement to publish network information, including the likely network developments across years 0 to 5, as detailed in standard licence condition 25 and the Form of Statement.
LV	Low voltage
National Grid ESO	National Grid Electricity System Operator
Net Zero carbon/Zero carbon	The achievement of balancing carbon dioxide emissions with carbon removal or eliminating carbon dioxide emissions altogether
Neutral Market Facilitator (NMF)	A transparent, neutral market for flexible services, providing attractive opportunities for customers of all scales to respond to requests for flexibility, allowing existing and new renewables to be fully utilised.
NMS	Network Management System – a electricity network control system
Ofgem	Office of Gas and Electricity Markets – the government regulator for gas and electricity markets in Great Britain
Open Networks Project (ONP)	Open Networks Project - a key industry initiative to deliver government policy that will transform the way our energy networks work and help deliver the 'smart grid'
Prosumer	A person who both consumes and produces a product, in this case electricity RIIO-ED1 Current electricity industry price control period, 2015-2023
PSR	Priority Services Register – a register of customers in vulnerable circumstances used by utilities to identify and provide additional support, when and where necessary
ROCBA	Real Options Cost Benefit Analysis – a tool for the financial evaluation of a set of intervention options, including the counterfactual of traditional reinforcement

RIIO-ED2	Electricity distribution price control period, 2023-2028
Whole System CBA	A costs and benefits tool, developed within Workstream 4 of the ENA Open Networks Project, that has been designed to evaluate the total costs and benefits for a range of parties across a range of interventions.