SP Energy Networks | DSO

Network Visibility Strategy for RIIO-ED2

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1. An introduction

Scope

Visibility of network demand, generation, and power flows is important to help us efficiently and safely plan and operate the network to meet our customers' needs. Network visibility helps us make more targeted and coordinated intervention decisions, enables smart solutions that depend on data, and helps us support the use and growth of flexibility markets. We currently have good visibility of our HV[1] and EHV network, enabled by extensive monitoring at these voltage levels. However, there is very little monitoring or visibility of the LV network, as there hasn't historically been a need.

The distribution network is on the front line of the changing energy system. Decarbonisation means that customer power flows will increase, and the rise of customers actively engaging with markets means that power flows will become more dynamic. We also expect a surge in notifications, connection applications, and customer enquiries to connect low carbon technologies. These changes are going to require significant investment in the network, our operational capabilities, and our internal processes. These changes primarily impact the LV network, where we currently have the least visibility.

Without better visibility of our network, especially at LV, this investment would be less efficient and less timely, leading to higher costs and a poorer service for our customers. We therefore need to increase our network visibility in RIIO-ED2. We will primarily to this through increasing LV network monitoring and using smart meter data.

The purpose of this document is to share with our stakeholders why we need to increase network visibility and how we will deliver it in RIIO-ED2. Whilst it covers the whole network, the primary focus is on improving LV network visibility as we already have good visibility on the HV and EHV networks. It is a supporting strategy to our main DSO Strategy.

Navigating this document

- **Section 1:** explains existing levels of network visibility and why there is very limited monitoring on the LV network.
- **Section 3:** why we need more network visibility in RIIO-ED2 and beyond – the use-cases and benefits that greater network visibility will enable.
- **Section 4:** how we will increase network visibility by increasing LV network monitoring coverage, using more smart meter data, and using data from other sources.
- **Section 5:** how this increased network visibility will inform our network planning and operational decisions, including our use of flexibility services.
- **Section 6:** fault level monitoring is a specialist activity which we are leaders in – we were the first DNOs in the world to use both real time fault level measurement and active fault level management. The use-cases and benefits are different to the network visibility covered in the rest of this document, so we have covered this in a standalone section.
- **Section 7:** the increased data we will be able to share with customers and stakeholders as a result of increasing our network visibility.
- **Section 8:** summary.

[1] LV (low voltage) is all voltages up to and including 1kV; HV (high voltage) is all voltages above 1kV up to and including 22kV; EHV (extra high voltage) is all distribution voltages greater than 22kV.

Key highlights

In RIIO-ED2 we will:

1. Invest £28.3m to deliver LV monitoring at 14,102 secondary substations[2] rated at ≥200kVA (baseline scenario). When added to the 2,438 LV monitors we are delivering in RIIO-ED1, by the end of RIIO-ED2 52% of secondary substations rated at ≥200kVA will have LV monitoring. This will extend LV monitoring coverage from 14% to 76% of customers.
2. Deploy as business as usual our RIIO-ED1 fault level monitoring innovations through delivering active fault level management at 3 sites and real time fault level measurement at a further 38 sites, saving our customers £42.7m.
3. We will build smart meter data into our data fabric and our planning and operational analytical tools, so that it directly informs our planning and operational decisions.
4. Deliver our new Engineering Net Zero (ENZ) Platform. This is the main network analytical tool in RIIO-ED2 which we will use to inform planning and operational decisions. Automatically and continually inputting network monitoring data and smart meter data into the ENZ Platform means all our planning and operational decisions will be informed by network visibility.
5. Increase historical, near-time, real-time, and forecast data sharing with our customers. This data share will help promote transparency and efficient, coordinated, and competitive flexibility markets.

Benefits

We will invest £28.3m in LV network monitoring to deliver £32.2m of direct customer benefits. Increasing our visibility of the network will enable us to:

1. Get more out of existing network assets by safely operating closer to limits – delivering more value from assets customers have already paid for.
2. Make smarter and more coordinated network investments, by better knowing where, when, and how we need to intervene – pre-empting constraints, enabling decarbonisation, and reducing customer costs and disruption by making the right interventions.
3. Facilitate flexibility solutions and increasing the pool of providers and competition – helping defer more costly and disruptive interventions.
4. Facilitate smart interventions that need real-time network data to work, such as automation.
5. Respond to network faults more quickly – delivering a more reliable supply for our customers.
6. Automate LV connection offers – reducing overheads which are paid for by customers.
7. Manage network losses – reducing the cost and carbon impact of our networks.
8. Deliver the baseline DSO roles and activities that are required by Ofgem and needed to support the changing energy system.
9. Encourage innovation, by sharing data with third parties.
10. Increase competition in connections, by enabling ICPs and IDNOs to better serve customers.

Customer and stakeholder input

Over the course of preparing our RIIO-ED2 plan, we have engaged just over 19,000 customers across a range of customer segmentation groups and stakeholders. We've used this engagement to understand their priorities for RIIO-ED2 and so inform our approach and ambition. From this, we know that our customers prioritise four main things in their electricity supply: reliability, safety, cost-efficiency, and the capacity they need to decarbonise (domestic customer especially do not want to be constrained). We also had very specific stakeholder feedback that they expected to see greater LV monitoring capability and enhanced forecasting and

[2] A secondary substation is a HV/LV transformer and associated equipment.

modelling, especially where this delivers a better understanding of near-time network capacity, and the data is shared with network users and service providers. This has been supported with our specific introduction of a monitoring commitment for RIIO-ED2.

These priorities and feedback align well with our approach that is collated within this Network Visibility Strategy.

Delivering our plan

The main deliverability outputs from this plan are:

- LV monitors. Experience from our RIIO-ED1 Enhanced LV Monitoring project, which will deploy LV monitors at 2,438 secondary substations across our two licence areas by the end of RIIO-ED1, has helped inform the deliverability of our RIIO-ED2 LV monitoring deployment. Specifically, it has helped us understand what LV monitor specifications we should be using, develop our supporting data systems that analyse and share LV monitoring information, and inform our understanding of what is involved in delivering a large-scale rollout of monitors.
- The systems needed to incorporated smart meter data and to feed data streams from network visibility through to our planning and operational tools. The deliverability of these are covered in our IT and Digitalisation Strategy (Annex 4C.1) and our Data Strategy (4C.2) and their supporting Engineering Justification Papers.

Signpost for Ofgem's business plan requirements

The table below sets out Network Visibility Strategy requirements from Ofgem's Business Plan Guidance.[3] The requirements in baseline expectations 1.1.2 and 2.1.2 are very similar, so have been combined in this table for ease of reference.

Ofgem BP Guidance No	Page Number
4.19 A DSO Strategy must include a specific network visibility strategy in order to meet the baseline expectations on network visibility and monitoring. This strategy may be published as an associated document.	This document is our Network Visibility Strategy. It is a supporting document to our main DSO Strategy.
4.25 There should be an overall strategy to increase network visibility; this strategy should include a clear demonstration of how increased network visibility will be used to inform network operations, and be made available to third parties.	Section 4 explains how we will increase network visibility through rolling out LV monitors and increasing use of smart meter data. Section 5 explains how we will use the data to inform network planning and operations. Section 6 explains the data share with customers that is supported by increased network visibility.
Appendix 4, baseline expectation 1.1.2 and 2.1.2 combined: The network visibility strategy should cover the use of all sources of network data including direct measurement from monitoring roll-out, smart meter data, data analysis and modelling, and any other third party data sources.	Section 4 covers direct measuring from monitoring, smart meter data, and secondary internal and third-party sources. Section 5 covers data analysis and modelling.
Appendix 4, baseline expectation 1.1.2 and 2.1.2 combined: The strategy should: • explain how network monitoring for planning and operational purposes will inform planning and	Section 5 explains how network visibility will inform planning and operational decisions, including the

[3] Published 30 September 2021. Available at: https://www.ofgem.gov.uk/publications/riio-ed2-business-plan-guidance

operational decisions, including enabling the management, delivery, and use of flexibility;	use of flexibility. Also see Table 1 in Section 3.2 for a summary of planning and operational use-cases.
• clear justifications for where and when monitoring is rolled-out, including explanations of any targeting for equipment deployment;	Section 4.3 explains how we identified where and when to deploy more network monitoring.
• specifications of equipment, including detail on the data captured, frequency of polling, and the mode of communicating data.	Table 2 (in Section 4.1) and Section 4.2 explain the data captured, frequency of polling, and mode of communication data.

2. Where we are now – existing network visibility

This section explains existing levels of network visibility and why there is currently very limited monitoring on the LV network. The primary method to-date of providing network visibility is through network monitors. Network monitors measure, record, and collect data about our network. This data is how we understand what is happening on the network. This data helps us efficiently and safely plan, develop, and operate the network to meet our customers' needs. Network monitors range in capability from rudimentary maximum demand indicators (MDIs) that only produce one reading a year and must be manually read, through to monitors which provide granular near real-time data directly to our control room. All our EHV network and almost all our HV network is monitored using network monitors. However, there is very little network monitoring on the LV network, as there hasn't historically been a need. To a lesser extent, network visibility is also provided by:

1. Customer half hourly (HH) meter data. Businesses and larger customers usually have a HH meter. This records kWh import and export and kVArh import and export at a 30-minute resolution. We can use this data to calculate peak import and export from these customers. We receive this data from Elexon via the D38 process. There can be up to a month lag before we receive it, so we can't use this data for operational measures. Where customers with HH meters are connected to the HV and EHV network this provides little additional visibility to the network monitors we already have.
2. We are increasingly using smart meter data to provide visibility of the LV network (Table 2 shows the metrics recorded and Section 4.1 explains the granularity of data received). However smart meter coverage is still far from complete (the roll-out programme is due to complete mid- 2025) so they do not currently provide wide coverage of the LV network. As the penetration of smart meters increases, we will increasingly be able to use these as a source of LV network data.

2.1 LV network monitoring to-date

The LV network is the 'last mile' of network that runs from local secondary substations into our customers' properties. The great majority of a DNO's customers are connected to the LV network – 3.5m domestic and small business customers in our case. Our LV network is over 48,000km long, equating to 46% of our total distribution network length. A typical section of LV network consists of a secondary substation supplying a number of LV circuits. LV customers are connected to these LV circuits. Pole-mounted transformers are mainly in rural areas, usually supplying one LV circuit. Ground-mounted transformers are mainly in urban areas; they typically supply 1-5 LV circuits and can support a greater number of customers. Figure 1 shows a ground-mounted transformer supplying two LV circuits.

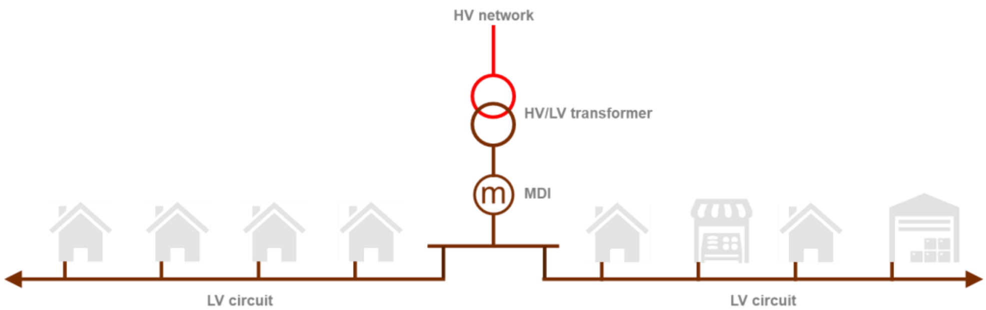


Figure 1: Example secondary substation and LV network

The loading on ground-mounted HV/LV transformers is recorded once/year using basic MDIs within the secondary substation. MDIs record peak current, from which we calculate annual peak demand. They are read manually as part of annual substation inspections. The peak current recording is not time-stamped, meaning we do not know when in the previous year it occurred. Pole-mounted HV/LV transformers have no MDIs or other monitoring. LV circuits have no network monitoring because the planning assumptions used to design LV circuits (average household maximum demand and customer consumptions profiles) have been predictable and stable for decades. Combined with a "fit and forget" approach[4] which meant that the LV circuits were able to accommodate all feasible scenarios, there has been little need for data-driven visibility of the LV network.

[4] LV circuits are built with sufficient capacity to supply the worst-case maximum demand scenario, and the HV/LV transformer tap changers (which set the LV circuit voltage) are set to ensure that voltage remains within statutory limits all the time.

3. The need for more network visibility in RIIO-ED2

This section explains why we need more network visibility, especially on the LV network, in RIIO-ED2.

3.1 Changes on the network

The energy landscape is changing, and the LV network is on the front line of those changes:[5]

1. **Decarbonisation means customer demand is increasing**. Net Zero legislation means that most customers' energy use will transition to electricity for all their needs – electric vehicles (EVs) for transport, electric heat pumps for heating, and electricity for all other consumption.[6] Our analysis shows that average household maximum demand could triple – this will materially increase the loading on LV circuits and HV/LV transformers. It also means we will need to process many more applications to connect low carbon technologies than in RIIO-ED1.
2. **Democratisation means customer consumption profiles are becoming more dynamic and less predictable.** Smart meters, home energy management systems, intelligent domestic storage and EV chargers, specialist service aggregators, new supplier tariffs – these are all increasing LV customer engagement in the energy system. This means power flows can become higher and more dynamic where a group of customers respond to the same price signal, and appear unpredictable when we don't have sight of the market signal to which they are responding.
3. **Decentralisation means generation is increasing.** This means that circuits may experience periods where demand is lower than ever before, which increases the challenge of keeping network voltage within statutory limits. It also means we will need to process many more applications to connect low carbon technologies than in RIIO-ED1.
4. **We and the electricity system operator (ESO) will increasingly rely on services from assets connected to the network**. This means we need to facilitate the ESO's access to service providers and coordinate it with our own service use. This means we need increased operability and control across the network.

These changes are well beyond what the LV network, our operational systems, and our internal processes are designed to accommodate.

3.2 The need for network visibility in RIIO-ED2 and beyond

These changes mean that we are going to have to significantly invest to increase network capacity, real-time operational capability, and internal design and connection offer processes. This investment is needed so we deliver the network capacity our customers and communities need, enable Net Zero, and ensure the continued safe, reliable, and efficient operation of the distribution network and wider energy system for all customers.

Many of these investments depend on network data and visibility. In some cases the absence of this would result in less efficient and timely investments, in other cases these investments won't be possible at all. Table 1 sets out the network visibility use-cases in RIIO-ED2 and beyond:

[5] This Section 3.1 is a summary of Section 2 of our DSO Strategy, which contains far more detail on the drivers of change and the impact on our network.
[6] In our two licence areas we forecast: up to 1m new electric vehicles (EVs) by 2028 (the end of RIIO-ED2) compared to 20,000 now, and up to 5.0m EVs by 2050m; up to 0.8m heat pumps by 2028, compared to approximately 1,000 now, and up to 3.8m heat pumps by 2050. These forecasts are from our DFES: https://www.spenergynetworks.co.uk/dfes.

Network visibility use-case	Customer benefit
1. Better utilising existing LV network capacity **Current situation:** we can't know exactly how much spare capacity there is on individual LV circuits. **With more visibility:** granular demand and voltage data means we can more confidently and accurately establish the spare capacity on LV circuits, and so allow customers to use that capacity. This means we can typically get up to 8% more capacity out of existing LV network assets.[7]	Gets more use out of existing network capacity that customers have already paid for. Defers the need for new investment, which keeps bills cost-effective for customers. Enables quicker and lower cost low carbon technology connections, which helps support decarbonisation.
2. Smarter network investment **Current situation:** for the LV network we have historically relied on rudimentary MDI readings, general planning assumptions, limited smart meter data, and connection notifications/applications to identify when and where we need to invest and to select interventions. This increases the risk of investment being reactive, reduces our ability to tailor solutions, and the assessment work is resource intensive. **With more visibility:** combined with our ENZ Platform (Section 5.1), we can accurately establish existing spare capacity and produce enhanced forecasts of future customer capacity needs. These mean we better know: • when existing capacity levels will be exceeded, helping us establish when and where we need to intervene. • the nature of the constraint (current or voltage) and how much additional capacity is needed, helping us to identify the best solution. • LV data also means network planning is less resource intensive as more of the assessment work can be done using automated modelling. We've calculated that it will help avoid the need for 21 new full-time staff, saving £8.7m in RIIO-ED2.	We only invest where it is needed, which keeps bills cost-effective for customers. We can intervene before the constraint occurs. This helps avoid delays for customers connecting EV chargers and heat pumps. Supports our customers' desire to be able to use EV chargers and heat pumps immediately and at full capacity. We use the right solution, which is more cost-effective and less disruptive for customers. We reduce the risk of over-specifying the solution (spending more than we needed to) or underspecifying the solution (not providing enough capacity). Having a better forward view of investments means we can coordinate network interventions. This is more cost efficient and reduces disruption to customers. We will reduce the overheads of LV network planning, saving our customers £8.7m in RIIO-ED2.
3. Facilitating flexibility services **Current situation:** limited data is a barrier to using flexibility services on LV constraints, and inhibits the participation of flexibility providers in HV and EHV flexibility markets as: • we have to use assumptions to define service windows. This can result in more onerous service windows, which reduces the number of participants. • we can't provide comprehensive market information that might enable providers to participate. **With more visibility:** • we can better forecast long-term flexibility need, enabling us to tender for flexibility. • we can more accurately define service windows. Where this results in less onerous windows, it can increase participation and free up providers to operate in other markets (resulting in greater whole system efficiency). • we can forecast near-term flexibility need, giving contracted providers near-time notifications we will dispatch them. This can increase the quality of the service we receive and market functioning.	Facilitating flexibility services helps increase competition and increase the pool of potential providers. These both bring costs down, resulting in more cost-effective bills for customers. Facilitating flexibility helps more LV customers participate in the energy system, directly benefiting those customers. Facilitating competition means we have more potential solutions at our disposal. We may be able to defer or avoid more costly and disruptive investment. Better knowing when we need flexibility frees up providers to operate in other markets. These other markets get the benefits of increased participation – there is a whole system benefit for all customers.

[7] Learning from our FlexNet innovation project.

• we can provide more comprehensive historical, near-time, real-time, and forecast network data, encouraging market growth.	
4. Facilitating smart solutions services **Current situation:** some smart network interventions require real-time data to work. The lack of this data prevents us from using them on the LV network, which will prevent us using the least cost solution in some circumstances. **With more visibility:** we can use smart network interventions on the LV network, for example: • LV Automatic Voltage Control – this is real-time regulation of LV network voltage at HV/LV substations. This requires real-time voltage data to operate. Having this data means we can use them on the LV network (we already employ AVC on the HV and EHV networks). • LV Network automation – this is real-time network reconfiguration to get the best use out of existing network capacity. It needs real time current and voltage data to work. This data means we can use this solution on the LV network (we already use it on the HV and EHV networks). • Power flow controllers (e.g. our solid-state transformer LV Engine) – these assess network needs in real-time to intelligently control LV voltage. They need real time current and voltage data to work.	Network voltage and current constraints can be a barrier to customers connecting EV chargers, heat pumps, and renewable generation, especially in rural areas where there are long circuits (which are more prone to voltage fluctuation). These smart interventions can: Get more use out of existing network capacity that customers have already paid for. Defer the need for new investment, which keeps bills cost-effective for customers. Enable quicker and lower cost low carbon technology connections, which helps support decarbonisation.
5. A more reliable supply for our customers **Current situation:** when there is a fault, we have to deploy field staff to reconfigure the LV network and restore supplies. This means our customers can be off-supply for some time. Depending on the customers affected, we deploy mobile generation and low carbon alternatives. **With more visibility:** • we can predict some faults before they happen using pre-fault criteria, meaning we can intervene before they arise. We estimate that we can reduce approximately 50% of repeat faults, avoiding up to £1.7m of CI and CML[8] costs. • combined with our LV network impedance model, we can identify where a fault occurs. Our field staff now know where to go, so don't have to spend as much time searching for the fault. • we can automate parts of the LV network, enabling them to self-heal after a fault. These all reduce how often and how long customers are off-supply for, and reduces the costs of managing faults.	Reducing the frequency and duration of power cuts is a key priority for our customers. This will increase in importance as our customers' dependence on electricity increases with decarbonisation. This is especially important for vulnerable customers and those on our Priority Services Register. Reducing the cost of managing LV faults will result in more cost-effective bills for customers.
6. Automating LV connection offers **Current situation:** all LV connection applications are processed manually. We will not be able to process the forecast surge in LV connection offers without implementing new tools – automation is essential. **With more visibility:** we can automate some of the processes behind LV connection offers using our ENZ Platform. This means: • we will be able to process the forecast surge in connection applications – this is not possible without automation. • we can offer self-serve solutions to some customers.	Processing these offers helps enable decarbonisation and maintain a safe network. Self-serve solutions will enable customers to proceed through the connection application process more quickly, so providing a better service. We will reduce the overheads of LV connection offers.

[8] Customer interruptions (CI) and customer minutes lost (CML) are two metrics for the reliability of customers' supply.

• we can avoid significant levels of additional recruitment.	
7. Managing network losses **Current situation:** we struggle to identify exactly which LV network assets are highly loaded (a source of technical losses), and where electricity is being illegally abstracted (non-technical losses). **With more visibility:** • we will know which areas of the network are heavily loaded. Combined with the asset data in our ENZ platform, we can identify technical losses hotspots. This helps identify where and how we should be making losses-driven interventions. • combined with smart meter data, we can identify illegal abstraction by identifying areas where billed energy from smart meters is materially different to energy flowing through the network. This will also help identify unregistered unmetered supplies.	Decarbonising to Net Zero will naturally increase technical losses – better visibility and management of them is in our customers' interests: Losses are paid for by our customers, so managing technical and non-technical losses saves our customers money. Managing technical losses can free up existing network capacity for customers. Managing technical losses reduces the carbon footprint of the distribution network.[9] Managing technical losses reduces total system peak demand, and so reduces the amount of GB generation capacity needed.
8. Delivering DSO roles, activities, and baseline expectations Ofgem prescribes three DSO roles, five DSO activities, and 23 baseline expectations for DNOs to deliver in RIIO-ED2.[10] Most of these will be enhanced or enabled with greater network visibility, for example: new forecasting, simulation, and modelling capability (BE 1.1.1); efficient network planning and development (role 1); improving identification of and sharing of operability constraints (BE 2.1.1); and greater data share (multiple BE).	Delivering baseline DSO roles will help us meet our customers' evolving needs, deliver Net Zero, and ensure the continued safe, reliable, and efficient operation of the distribution network and wider energy system for all customers.
9. Encouraging innovation **Current situation:** we have limited LV network data to share with third parties. **With more visibility:** we can share more data with third parties and innovators.	The development of new innovations and solutions which may reduce customer bills, improve the service customers receive, and facilitate decarbonisation.
10. Increasing competition in connections **Current situation:** independent connections providers (ICPs) and independent distribution network operators (IDNOs) rely on us for all information relating to LV networks. **With more visibility:** we can publish LV network data. This means ICPs and IDNOs aren't as reliant on us (reducing our resourcing overhead), can better serve their own quotation offers (levelling the playing field), and can better audit our decisions (increasing transparency).	Measure to support ICPs and IDNOs will increase competition in connections. This should drive higher standards and reduce costs for customers.

Table 1: Network visibility use-cases

[9] This could be through avoiding the need for larger network conductors (embodied carbon saving) and avoiding wasted energy generation (primarily up until 2035, at which point power generation will be carbon free; beyond 2035 there will still be some carbon savings from the avoided embodied carbon of building generation to supply network losses).
[10] These are defined in Ofgem's Business Plan Guidance, dated 30 September 2021. Available at: Published 30 September 2021. Available at: https://www.ofgem.gov.uk/publications/riio-ed2-business-plan-guidance

4. Increasing network visibility in RIIO-ED2

This section explains how we will increase network visibility in RIIO-ED2 by increasing LV network monitoring coverage, using more smart meter data, and using data from other sources. This section focusses on the LV network as there is already extensive monitoring at HV and EHV.

4.1 Assessment of options to increase network visibility

There are three broad options to measure, record, and collect LV network data:

1. Use the existing MDIs already on the LV network – the baseline option.
2. Use smart meter data (by mid-2025 the great majority of LV customers will have a smart meter).
3. Install LV monitors on LV circuits (installed on the LV circuit ends in the secondary substation).

Table 2 compares the capabilities of these options, with red/amber/green colour coding to indicate their ability.

	MDI	Smart meter data	LV monitors
Metrics provided	Peak demand	Demand profile kWh Export profile kWh Voltage profile	Demand profile kVA Demand profile kW Demand profile kVAr Export profile kVA Export profile kW Export profile kVAr Voltage profile Phase angle Phase imbalance Harmonics
Metric time granularity	One reading per year	Up to one reading per 30 minutes (see box below)	Up to one reading per second
Metric locational granularity	Secondary substation group, per phase	Varied (see box below)	LV circuit, per phase
Time lag to receive metrics	Up to one year	Weeks	Near real-time (within 10 seconds)
Are the metrics time stamped?	No	Yes	Yes
Near real-time alarms	None	Under voltage Over voltage Loss of supply Restored supply	Under voltage Over voltage Loss of supply Restored supply Phase imbalance Harmonics Pre-fault activity Thermal overload Fuse blowout
Remote reading	No (site visit required)	Yes	Yes
Accuracy / error	Can give false readings[11] & be prone to human error[12]	-2% to +3.5%[13]	± 1%

Table 2: Capabilities of LV network data collection options

[11] Some types of fault current are erroneously recorded as load current, false implying that peak demand is higher than it is.
[12] Errors recording and uploading the reading, and errors resetting the MDI.
[13] The difference in the accuracy of smart meters and LV monitors may seem insignificant, but it makes a material difference as we have to operate within tight capacity and voltage parameters. For example, we have to keep voltage within -6% and +10%; a 3.5% error margin is therefore significant.

The granularity of smart meter data, and why it's important

DNOs are not sent all smart meter data – we received an aggregated and collated view from SmartDCC (the Ofgem regulated organisation responsible for smart meter data). We receive:

- Half hourly voltage readings for every customer. This is very useful, as we will understand much better the voltage profile along a LV circuit. This is beneficial to customers as voltage constraints are a key driver of LV network investment. We don't get this information from LV monitors.
- A total monthly energy consumption reading for every customer. This will be useful when combined with representative customer consumption profiles (which are developed using LV network monitoring).
- Half hourly demand/export readings, aggregated together for groups of customers to protect individual customer privacy. Where these customers can be aggregated by LV circuit the data will be useful, as it represents the LV circuit. However there are limits to the aggregation: it cannot react to temporary LV circuit reconfiguration (e.g. if we temporarily move some customers to another LV circuit, the aggregation no longer represents the LV circuit); it will not be possible to aggregate by circuit phase until we know what phase every customer is connected to; and it may not accurately represent complex interconnected LV networks (such as urban centres). As we evolve our LV network management, Ofgem may need to facilitate more granular aggregation by approving changes to our smart meter privacy policy. This would increase the customer benefits from smart meter data.

Based on the capabilities in Table 2 and the smart meter data we receive, we assessed the ability of these three network visibility options to deliver the Table 1 use-cases – this analysis is show in Table 3. For smart meter data, we have assumed we can't depend on aggregated demand/export data given the shortcomings of the aggregation method.

Use-case (from Table 1)	MDI	Smart meter data	LV monitors
1. Better use of existing network capacity	No: doesn't record voltage; we can't determine true peak demand as no demand profile.	Medium: the voltage data is very useful; the demand data is less useful due to the aggregation method. Higher error margin than LV monitors, no harmonic assessment.	Yes: granular high accuracy demand, export, harmonics, and voltage profiles for each phase. The high grade visibility means we can safely operate nearer limits.
2. Smarter network investment	No: doesn't record voltage; we can't determine true peak demand as no demand profile.	Medium: the voltage data is very useful; the demand data is less useful due to the aggregation method. Customer monthly energy consumption means we may be able to infer EV and heat pump uptake, and so produce better forecasts.	Yes: granular high accuracy demand, export, harmonics, and voltage profiles for each phase. The high grade visibility means we can better forecast constraints and assess and target interventions.
3. Facilitate Flexibility services	No: doesn't record demand and voltage profiles needed for defining service windows. Can't provide dispatch warnings.	Medium: we can produce better service windows for voltage constraints, but less so for thermal constraints given aggregation method. We can't give dispatch warnings due to time lag.	Yes: granular high accuracy demand, export, and voltage profiles means we can define windows. Real-time element means we can provide near-time dispatch notifications.

4. Facilitate smart solutions	No: doesn't provide the real-time data needed for automatic voltage control, automation, or solid state transformer solutions.	No: doesn't provide the real-time data needed for automatic voltage control, automation, or solid state transformer solutions.	Yes: provides the real-time data metrics needed to enable smart solutions. Increases our toolbox of interventions.
5. Increase supply reliability	No: it's not real-time.	Medium: real-time alarms help locate faults, but insufficient data to support pre-fault analysis or self-healing networks.	Yes: data granularity supports pre-fault prediction; real-time data enables LV network self-healing.
6. Automate LV connection offer processes	No: insufficient metrics to do this.	Yes, we could automate LV connection offers better than we can now, but there would be concerns about their accuracy due to demand data aggregation. We can use voltage to make demand estimations.	Yes: granular high accuracy demand, export, harmonics, and voltage profiles for each phase.
7. Managing network losses	No: we can't determine true peak demand as no demand profile.	Medium, as the usefulness of the demand data is limited by the aggregation method. Potentially very useful for identifying non-technical losses when combined with LV monitors.	Medium: good for identifying technical losses, but insufficient to identify non-technical losses unless combined with smart meter data.
8. Deliver baseline DSO functions	No: only records one data point per year for one metric.	Medium: much more data than MDIs, but less than LV monitors. The time lag will inhibit its usefulness for some flexibility and market functions.	Yes, lots of granular data for a wide range of metrics means we can better fulfil these roles and activities.
9. Encourage innovation	No: only records one data point per year for one metric.	Medium: much more data than MDIs, which has led to innovations with phase identification, constraint estimation, and neutral faults. However needs to be complemented with an LV monitor reference.	Yes, lots of granular data for a wide range of metrics means we have more data to share. This will help spur innovation, especially when combined with smart meter data.
10. Increase competition in connections	No: only records one data point per year for one metric.	Medium: much more data than MDIs, but less than LV monitors. The voltage data is useful; the demand data is less useful due to aggregation method.	Yes, lots of granular data for a wide range of metrics means ICPs and IDNOs are more likely to have the data they need.

Table 3: Assessment of LV network data collections options to deliver RIIO-ED2 use-cases

Some of the smart meter 'amber' ratings would be improved if Ofgem agreed to a more dynamic aggregation method which ensured that demand data was always aggregated by LV circuit.

In summary, the key findings are:

1. **MDIs don't provide the visibility we need**. MDIs don't provide the metrics or granularity we need to deliver any of the use-cases in Section 3.2. They only provide one reading per year for one metric, so they give very little insight.
2. **Smart meters provide some valuable visibility, but they have limitations.** Smart meters provide visibility that can usefully support some use-cases; particularly the voltage information, which is superior to what LV monitors can provide. Their usefulness in other use-cases is inhibited by their error margin, time lag, and aggregation method (we can't be sure it is a true representation of LV circuit demand).
3. **Network monitors provide nearly all the visibility we need, and so will be essential to increasing network visibility.** They provide network visibility in real-time, at a low error margin, for each circuit phase. They can deliver all the use-cases in Section 3.2, with the exception of non-technical losses identification (for that they must be combined with smart meter data).
4. **Customers get the most benefit when LV monitoring data and smart meter data are combined as they are complementary – we should use both to increase network visibility.** For example, LV monitors can help get more out of an existing LV circuit (use-case 1), but we can do this even better if we can combine them with smart meter voltage data. Similarly, we can only identify non-technical losses if we combine LV monitoring data with smart meter data – neither data set can do it on its own. LV monitoring data can provide a valuable reference point for smart meter data.

Based on this assessment, in RIIO-ED2 we need to:

1. install LV monitors on LV circuits as they are essential for providing the LV network data that's needed for the Net Zero electricity system. Sections 4.2 and 4.3 explain how we will do this.
2. increase our use smart meter data as their penetration increases; this will be especially valuable where we don't have network monitors. Section 4.4 explains how we will do this.
3. have planning and operational tools which combine network monitoring data and smart meter data together to increase the benefits to customers. Section 5 explains how we will do this.

4.2 LV monitoring specification

To ensure customers get the full benefit from LV monitors, they will meet the following specification:[14]

1. They must be able to meet the network monitoring specification in Table 2.
2. They must be capable of being installed on live assets – we do not want to have to isolate LV circuits to install these as that will disrupt customers.
3. They will be based on open platform hardware and operating systems, to allow third-party applications to run on the operating system. This also ensures that we are not tied in to one provider, and allows us to develop edge intelligence by pushing some analysis functions to the monitor.
4. They will provide standard secure communications to control and analysis systems and facilitate remote configuration. This will be more cost effective and ensures that cyber security can be managed.
5. The LV monitoring equipment must be flexible and scalable, given the many different types of LV distribution equipment that we have on our networks.
6. They must be capable of being deployed in both indoor and outdoor locations.

Each LV monitor will have an inbuilt SIM card modem, to communicate the data to our enterprise-level monitoring data management system. This data management system will enable different applications to utilise the data. These applications include our NAVI platform, in which the data can be used to enable real-time LV network management and combined with smart meter data, and our data visualisation platform (shown in

[14] We are currently part way through the procurement process for LV network monitors and so have purposefully not published our full tender specification within this document. More detail is included within Appendix I of LV Network Monitoring Engineering Justification Paper (ED2-NLR(O)-SPEN-001-MON-EJP), and if more specific details are required we are happy to accommodate a bi-lateral discussion to answer any questions that Ofgem may have.

Figure 2, against a traditional MDI for comparison). Section 5.1 shows the data communication architecture for network monitoring and smart meter data.

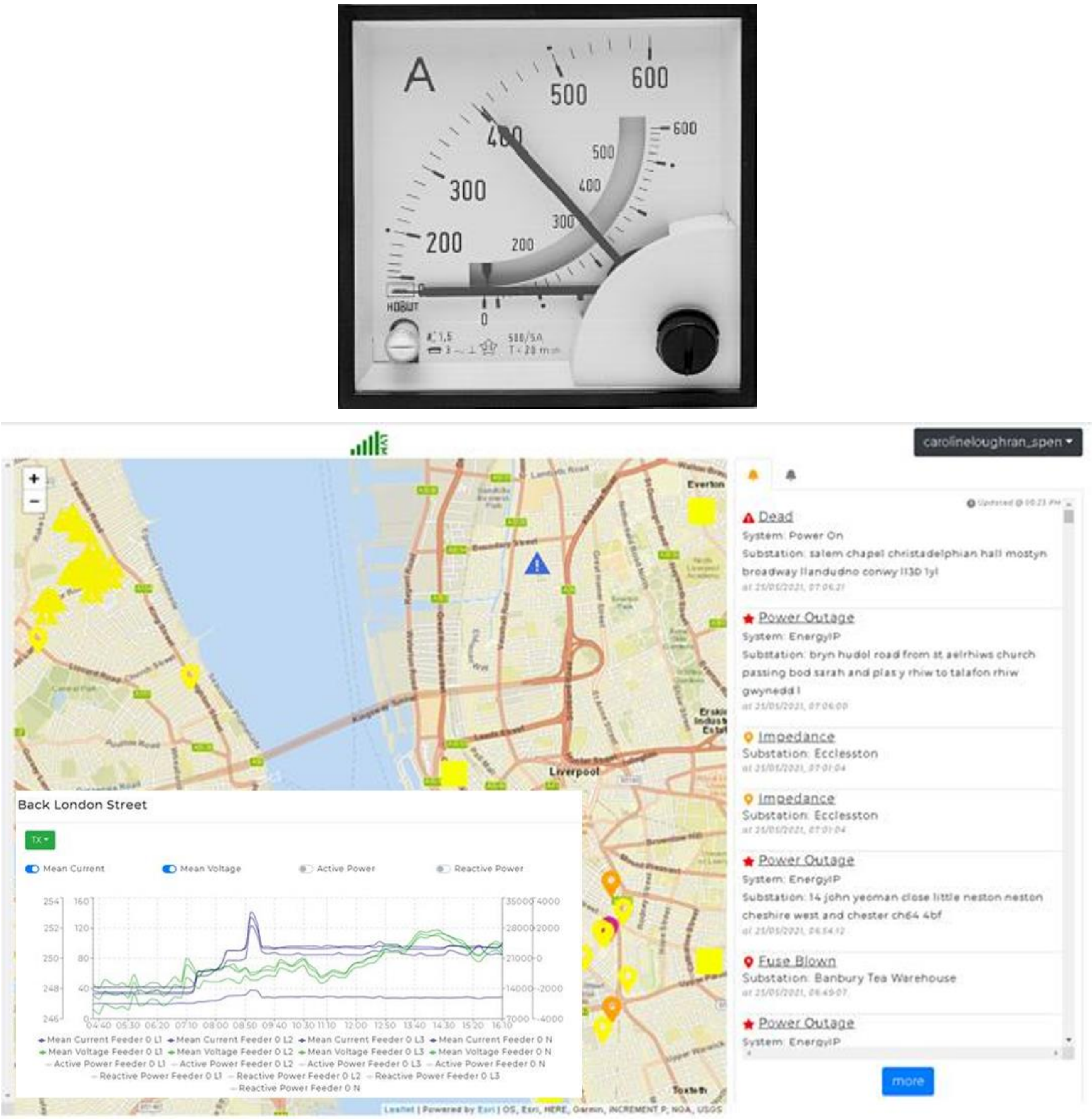


Figure 2: The old (MDI, top) and the new (LV monitoring data in a visualization platform, bottom)

The average cost for installing LV monitoring at a secondary substation that has five LV circuits is £1,970.[15] This cost does not include any capital or operational costs for central data systems.

[15] A cost breakdown for this (showing monitoring components, labour, and sim card data charges) is available within the supporting LV Network Monitoring Engineering Justification Paper (ED2-NLR(O)-SPEN-001-MON-EJP). We have not included this breakdown within this document as we are currently part way through the procurement process for LV network monitors.

4.3 Identifying where we need LV monitors in RIIO-ED2

Having identified the need for LV monitors and their minimum specification, we had to establish how to roll them out in RIIO-ED2 to deliver the best investment for customers.

4.3.1 Which types of secondary substation to target

We first considered whether all LV circuits and secondary substations should be considered for LV monitoring. We decided to rule out LV circuits supplied from small (<200kVA) secondary substations as the benefits were limited compared to the costs:

1. **We already have more data for small secondary substations:** small secondary substations nearly always supplies only one LV circuit, and they are located in rural areas with lower population densities. These two factors mean we can infer LV circuit loading and HV/LV transformer loading from smart meter data. We can't do this for larger substations as they supply multiple LV circuits (as explained in Section 4.1, there are limitations to aggregating smart meter data by LV circuit). This means that network monitors provide less benefit for <200kVA secondary substations than for ≥200kVA secondary substations.
2. **For small substations the costs of failure are low compared to the costs of LV monitoring:** if a small pole-mounted transformer fails it costs ~£8k to replace. Given what we can infer from smart meter data (point 1 above), LV monitors costing ~£2k do not sufficiently reduce the risk of failure to justify their cost.
3. **The customer coverage is lower:** <200kVA secondary substations supply fewer customers than ≥200kVA secondary substations, yet the costs of installing network monitors at each are comparable. This means that targeting network monitors at ≥200kVA secondary substations delivers disproportionately greater customer coverage (and benefits).[16]

Given these factors, LV monitors at small (<200kVA) secondary substations are not justified in RIIO-ED2. Therefore our RIIO-ED2 intervention plan only targets LV monitors at ≥200kVA secondary substations and their associated LV circuits. In total we have 31,808 of these secondary substations:

	SP Distribution	SP Manweb	TOTAL
Ground-mounted	16,471	11,575	28,046
Pole-mounted	1,764	1,998	3,762
TOTAL	18,235	13,573	31,808

Table 4: SP Energy Networks secondary substations ≥200kVA

4.3.2 Our RIIO-ED2 LV monitoring intervention plan

There are two options to roll-out monitoring to the 31,808 ≥200kVA secondary substations:

1. a targeted roll-out, where monitoring is only deployed in RIIO-ED2 where it is likely to deliver customer benefits in the foreseeable future (we used 2030 as the end-date).
2. a full roll-out, targeting deployment at all 31,808 secondary substations within RIIO-ED2.

We selected a targeted roll-out as it delivers better value for customers, as it avoids installing LV monitors where there are minimal benefits.

Considering the potential use-cases of LV network data (Table 1), and the use-cases that can be supported by smart meter data (Table 3), we used two criteria to identify which ≥200kVA secondary substations to target in RIIO-ED2:

- is utilisation of the secondary substation transformer ≥75% at any time by 2030; or

[16] This is supported by the roll-out plan in section 4.3.2: our plan to expand network monitoring to 52% of ≥200kVA secondary substations will result in 76% of LV customers being covered by monitoring.

- is utilisation on any of the LV circuits connected to the secondary substation forecast to increase by at least 10% from current levels by 2030.[17]

We used these criteria as a secondary substation meeting either of these is likely to become overloaded in the near future. Increased network visibility will therefore deliver customer benefits, especially for use-cases 1-4.

To identify which secondary substations and LV circuits fulfilled either of these criteria, we analysed our entire LV network for our low, baseline, and high RIIO-ED2 forecast scenarios.[18] We started with a full connectivity model of the LV network[19], from where it leaves customers' properties up to and including the secondary substations – over 48,000km in total. We then fed in our low, baseline, and high scenarios, and the outputs from our EV-Up and Heat-Up enhanced forecasting tools, to forecast the consumption and generation of every one of our 3.5m LV customers for a range of scenarios. The model ran power flow analysis to systematically identify the current and future loading on every single LV network asset, and the location, magnitude, and timing of any constraints at secondary substations and LV circuits.[20]

This modelling was intensive. Each model run analysed over 175,000 iterations per network asset. We didn't have any computers powerful enough, so we had to use cloud-based servers. But this new, comprehensive forecasting and modelling approach means we have a higher degree of confidence where and when interventions are required. This results in a more targeted and efficient LV monitoring plan.

This overall process is shown in Figure 3.

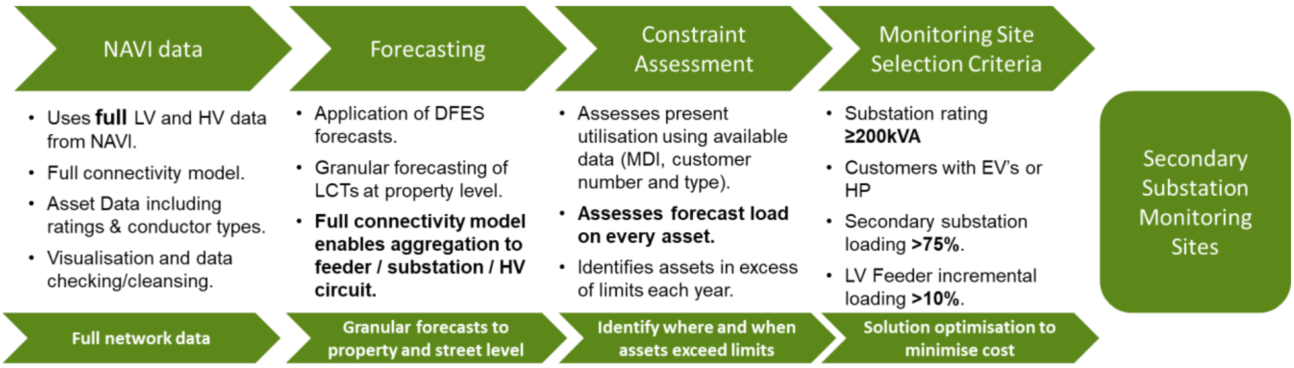
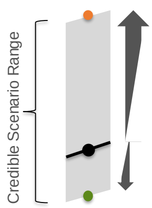


Figure 3: Process to identify secondary substations for LV monitoring in RIIO-ED2

Table 5 shows the volume of secondary substations that fulfilled at least one of the two assessment criteria. The high monitoring scenario equates to rolling out LV monitoring to all secondary substations ≥200kVA that will not have had monitoring installed in RIIO-ED1.



2028	SP Distribution	SP Manweb	TOTAL
High	16,547	12,823	29,370
Baseline	7,749	6,353	14,102
Low	7,431	6,353	13,784

Table 5: Secondary substation volumes which require LV monitoring in RIIO-ED2

[17] Where just one LV circuit within a secondary substation meets this criterion, we will install LV monitors on all the LV circuits within that secondary substation. This is because, considering the fixed costs of travel and the LV monitoring unit, there is marginal additional cost to monitoring all the other LV circuits within the secondary substation.
[18] Different DFES forecast scenarios will have different network impacts, requiring different levels of investment. So how do we know which one to plan for in RIIO-ED2? We considered the range of Net Zero compliant scenarios developed by us, the ESO, and the Climate Change Committee to develop a low, baseline, and high scenario. The low and high scenario mark the lower and upper bounds of this range of credible Net Zero pathways. The baseline represents the best approach for our customers assuming the appropriate regulatory mechanisms are in place. Please see Part 4A of our RIIO-ED2 Business Plan for more information.
[19] This was developed through our award-winning RIIO-ED1 Network Constraints Early Warning System (NCEWS) innovation project. Please see Section 3.4.1 of our DSO Strategy for more information.
[20] Section 3.1 of our DSO Strategy explains this process in more detail.

Based on this work and as our RIIO-ED2 Business Plan is developed to deliver the baseline scenario, we plan to deliver LV monitoring on the LV circuits in 14,102 secondary substations within RIIO-ED2. This RIIO-ED2 intervention plan builds on our current LV monitoring programme, which will have installed LV monitoring at 2,438 secondary substations by the end of RIIO-ED1. Combined, these programmes mean that 52% of secondary substations ≥200kVA will have LV monitoring by the end of RIIO-ED2, up from 8% at the end of RIIO-ED1. This will increase customer coverage from 14% to 76%.

Appendix A shows the locations of the secondary substations which will have LV monitoring by the end of RIIO-ED2.

4.3.3 Delivering LV monitors efficiently

To ensure an efficient roll-out programme, we will organise the roll-out programme considering:

1. Need – we will target those secondary substations and LV circuits which will be overloaded soonest. We will use our enhanced forecasting tools and ENZ Platform to identify this.
2. Geographical clustering – by minimising travel time between substations we can cover more substations per day and minimise travel overheads.

This means the LV monitors will be delivered efficiently and at the right time to deliver value for customers. Installation will be carried out by a two person team working according to live-line working practices.

4.4 Smart meters

The national smart meter roll-out programme will install smart meters at all homes and business by mid-2025, at which point there should be total coverage. This means the availability of smart meter data will increase through the first half of RIIO-ED2. In RIIO-ED1, we have received half-hourly aggregated smart meter data, which we have used in several projects including our NAVI connectivity model and our Engineering Net Zero (ENZ) Model. For RIIO-ED2, we are building on that foundation to ensure we have the enabling systems, tools, and processes. We will build smart meter data into our data fabric and our planning and operational analytical tools (see Section 5.1). This means smart meter data will increase our network visibility and inform our network planning and operational activities to meet our customers' evolving needs, enable Net Zero, and ensure the continued safe and reliable operation of the network for all customers. Our IT and Digitalisation Strategy and our Data Strategy explain how we will harness Smart Meter data to increase network visibility, support some of our innovative toolsets, and support network planning and operations. Section 5.1 explains how we will incorporate this data into planning and operational decisions. Our Smart Meter System Engineering Justification Paper (ED2-NLR(O)-SPEN-005-SMS-EJP) explains the systems infrastructure we will use to transfer this data from SmartDCC into our systems.

4.5 Secondary sources of network visibility

This document has so far covered primary sources of network visibility, i.e. direct sources of data that measure and record what is happening on the distribution network. There are also secondary sources of network visibility. These are typically less useful than primary sources as they don't provide direct data about the demand, generation, and power flows on the distribution network, but they are still useful as we can infer what is happening on our network based on what is happening elsewhere. These include:

4.5.1 Network asset condition data

In RIIO-ED1 we have fully digitalised our Network Asset Management System (NAMS). This collates multiple asset management metrics into a single database. These metrics can help provide network visibility. For example, if transformer oil readings show greater degradation than usual, and temperature readings for the same transformer are higher than usual, we can infer that this transformer has been more heavily loaded (i.e. subject to higher network demand and power flows).

In addition, we collect condition information related to the health and criticality of our assets. This is managed through our Condition Based Risk Management (CBRM) platform. Criticality is linked to asset loading, and so both informs[21] and is informed by[22] network visibility. We have an ongoing requirement to maintain an asset management Information Gathering Plan (IGP). This sets out our long-term strategy to collect accurate, timely,

[21] High areas of criticality will help prioritise areas that need increased network visibility.
[22] Criticality of our assets will be kept up-to-date and accurate through data from network visibility.

and meaningful condition data on our asset base. Appendix A of our Network Asset Risk Strategy is a full list of all asset condition data and how inspection metrics maps to condition data.

Section 5.1 explains how we will incorporate this data into planning and operational decisions.

4.5.2 Weather data

Weather is one factor that determines how much electricity domestic customers consume – customers typically consume more electricity during cold, dark, damp, windy days than during hot, light, dry, still days. In RIIO-ED1 we have developed a near-time forecasting platform (called PRAE) to give demand and generation forecasts for up to four days ahead. We use this to inform our operational actions, such as flexibility service utilisation. This has then been expanded and combined with our Weather Normalised Demand Analytics (WaNDA) project. This uses historical data, generation, and discretised weather data at a primary substation level, to help better understand the effects of weather on network power flows. By combining PRAE and WaNDA, we can better forecast network power flows and so increase our network visibility. Section 5.1 explains how we will incorporate this data into planning and operational decisions.

4.5.3 Gas network data

Of our 3.5m customers, 2,806,293 (~80%) are domestic customers who are also served by the mains gas network (1,632,579 in SP Distribution, 1,173,714 in SP Manweb). For these properties served by both gas and electricity, the loss of one energy vector usually increases consumption of the other. For example, a property which uses mains gas for central heating and hot water will likely switch on their electric immersion heater to heat water and use electric heaters to heat their home if they experience a gas supply interruption. This means that an outage on the gas network affects power flows on our distribution network. This relationship is not theoretical – please see Section 5.2 of our DSO Strategy for a real example of gas network failure which increased network electricity demand by 2.7 times normal peak demand.

For this reason, we will seek increase data sharing with the three gas utilities (Cadent, SGN, and Wales & West Utilities) that serve our customers to increase our distribution network visibility. We would like this data exchange to cover both planned interruptions (e.g. maintenance outages) and unplanned outages. Planned outages are usually known about months in advance, so we may be able to incorporate this knowledge into our planning processes. Unplanned outages (or nearer-time planned outages) may occur without any warning, so we would incorporate knowledge of these into our operational activities.

4.5.4 LCT notifications

When domestic customers install low carbon technologies they should tell us, either via the connect and notify route for smaller low carbon technologies or via the connection application process for anything larger. [23] We can use this data to help understand where network power flows may increase. Section 5.1 explains how we will incorporate this data into planning and operational decisions. We do not always receive this information – we are committed to working with the rest of industry to improve the rate of LCT notifications.

4.5.5 Data from the ESO

The ESO will be increasingly use services from assets connected within the distribution network as their service needs increase and traditional service providers close.[24] This DER service use by the ESO affects power flows on the distribution network, and so overlaps with our responsibility to operate a safe, reliable, and efficient distribution network. Having visibility of ESO service use in near-time and real-time will give greater insight into network power flows and potential network constraints.

4.5.6 Data from flexibility market participants

The operation of flexibility markets can generate useful data that can be used, alongside suitable connectivity models and analytics, to infer anticipated network conditions and provide network visibility. Examples of flexibility market data include anticipated DER import/export profiles, and the D-prognosis reports (as part of the Universal Smart Energy Framework (USEF)) where flexibility market providers notify about their commitments and availability.

[23] For generation LCTs, connect and notify can be used where the total installed capacity is less than or equal 16amps/phase. For demand LCTs, connect and notify can be used where the new household maximum is less than or equal to 60amps.

[24] Section 2.3.1 of our DSO Strategy for more detail.

5. Informing our planning and operational decisions

This section describes how increased network visibility will inform our network planning and operational decisions across our whole network (i.e. at all network voltage levels). Section 5.1 describes the platforms and architecture to show how the data from network visibility is inputted to our planning and operational tools. Section 5.2 gives examples of how network visibility informs decisions across the planning and operational timeframe.

5.1 Network visibility architecture

Figure 4 sets out the architecture to show how primary and secondary network visibility sources feed through into our planning and operational tools (and so inform our planning and operational decisions).

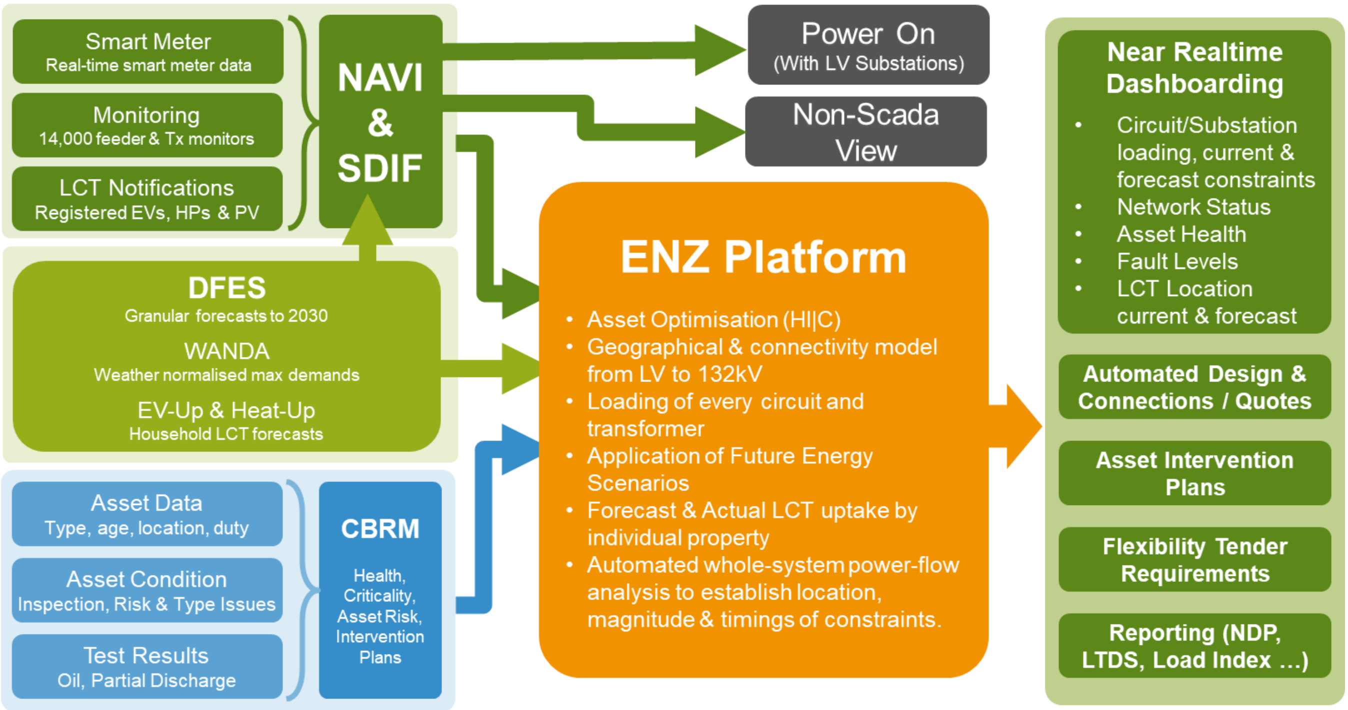


Figure 4: Network visibility architecture – RIIO-ED2 prototype

The main sources of network visibility are on the left of Figure 4. They are monitoring, smart meters, forecasts, and asset data (represented by the blue CBRM box). These network visibility sources feed into:

- **ENZ Platform.**[25] This will integrate four previously independent network visibility data sources (monitoring, smart meters, enhanced forecasting, and asset condition) with a full connectivity model of our entire distribution network.

  This will continually run automated power flow analysis for the entire network to create a whole network analytical platform and provide the master view of asset health, criticality, and risk. This will give us data-driven visibility of what is happening on the network right now, and what will happen in planning and operational timescales in terms of power flows and asset condition.

  We will also integrate our asset risk management tools (CBRM and Optimisation) within the ENZ Platform to enable holistic whole-lifecycle asset management operational and planning decisions. This will analyse asset inspection, testing, and measurement diagnostics using the CNAIM V2.1 risk modelling approach to inform investment planning decisions and ensure consistency with regulatory reporting. By embedding the asset Optimisation tools we have built for planning RIIO-ED2 within the ENZ Platform we will further unlock the ability to run real-time network planning optimisation, aligning intervention decision making with future planned reinforcements, connections, and ultimately even fault

[25] This will be delivered in RIIO-ED2 by building on the ENZ Model we have developed in RIIO-ED1. The ENZ Platform is a key component of our network planning and operational toolset in RIIO-ED2. See Section 3.4 of our DSO Strategy for more information.

repairs. This will allow us to deliver more efficiently on behalf of customers and realise long-term planning and cost-saving benefits. We are also able to track and meet our regulatory risk-outputs in near-real time – ensuring our interventions meet our RIIO-ED2 obligations, and that we prioritise interventions that provide maximum customer benefit.

The ENZ Platform will also embed and build on our network performance (reliability) models and forecasting tools. These models have been built to predict the potential customer impact arising from unplanned faults and interruptions on the distribution network. We are evolving from retrospective fault impact analysis to forward looking dynamic network performance models which can identify and detect network vulnerabilities and areas of network with the highest risk of customer impact. We will also trial the ability to use customer/network specific Value of Lost Load (VOLL) characteristics – recognising that for some customers (vulnerable, LCT owners, and those on the Priority Service Register) a loss of supply can be more impactful than for others (holiday lets, unmetered supplies, etc.). By incorporating these tools within our ENZ platform we will further optimise the deployment of new technologies to reduce fault impacts and refine our asset modernisation plans. We will also use the outputs of these risk assessment to inform operational planning and undertake contingency analysis considering fault response and restoration times.

These analytics mean we can make high-quality data-driven decisions directly informed by network visibility which improve the safety, reliability, and efficiency of the network for our customers. And we can better coordinate the range of load related, asset management, and DSO interventions, to reduce cost and disruption for our customers while delivering what they want.

Our ENZ Platform is the main network analytical tool in RIIO-ED2 which we will use to inform planning and operational decisions. Automatically and continually inputting network monitoring data and smart meter data into the ENZ Platform means all our planning and operational decisions will be informed by this data.

- **SDIF:** Smart Data Integration Fabric (SDIF) is, at its highest level, an enterprise service bus (a data highway for our internal systems). It has two core outputs so far: an integrated network model (the integration of various network models) and a workflow engine. The first use case of SDIF was to locate faults at 11kV using data from multiple systems (this went live in November 2020). One use case that is currently in development is to use smart meter data to support outage/customer management. SDIF is a key enabler for moving improved network visibility data between our systems and supporting the workflow management for multi-system analytics and modelling.
- **NAVI:** this is a platform which automatically creates a connected network model from our GIS data. This creates an "analytics ready" model which can be used as the basis for most types of network analysis (this is the network model that the ENZ Platform depends on). NAVI stemmed from our award winning NCEWS innovation project[26] but has now been implemented into our digital ecosystem as business as usual. NAVI will utilise increased network visibility to improve our connectivity model supporting our increasing requirement for analytics, modelling and simulation for RIIO-ED2.
- **CBRM.** Please see Section 4.5.1.
- **PowerOn.** This is our Network Management System (NMS) which provides the software platform for the safe and secure management and orchestration of our distribution network. Given the day to day operational importance of this system, providing improved network visibility can support improved operational planning and network action.

Not shown in Figure 4 is the Operational IT and telecoms that network visibility depends on – this can be thought of the network's nervous system that is used to transfer data securely, reliably, and with low latency. See our Operational IT and Telecoms Strategy for more information on the operational IT and telecoms infrastructure we plan to deliver in RIIO-ED2 to enable network visibility.

5.2 Network visibility informing planning and operational decisions

Figure 5 shows examples of how network visibility informs decisions across the planning and operational timeframe. The data-flow mechanism for informing these decisions is set out in Section 5.1.

[26] This project won the prestigious Institution of Engineering and Technology (IET) and Engineering and Technology (E&T) 'Innovation of the Year' prize in November 2019.

Planning timescales

Making more targeted, efficient, and coordinated intervention decisions. More network visibility means:

- Earlier constraint identification, giving more time to intervene before constraints impact customers, and more opportunity to coordinate interventions (reducing costs and disruption for customers).
- More knowledge about the constraint characteristics, meaning we can better intervention decisions, or in some cases safely operate nearer the network headroom to avoid needing to make interventions.
- We can use smart interventions that need real-time data, meaning more solutions are available to us.
- Better identification of losses, meaning we can better plan interventions which manage them.
- More efficient planning of maintenance outages, and the actions we need to take to secure them.

What this means for flexibility:

- we can provide the market with more notice of network needs through flexibility tenders.
- we can more accurately define service windows. Where this results in less onerous windows, it can increase participation and free up providers to operate in other markets (resulting in greater whole system efficiency).
- we can provide more comprehensive information about our network, encouraging market growth.

Near-time

Near-time notifications to increase market efficiency & whole system coordination

Network visibility means we can identify what will happen in near-time timescales. This means we can send near-time notifications to flexibility providers, the ESO, and constrainable connectees:

- ‘Dispatch warnings’ will notify flexibility providers that they are likely to receive a dispatch instruction from us in a certain service window. This gives the service provider time to prepare.
- ‘No need notifications’ are the opposite of ‘dispatch warnings’ – they notify service providers that they are very unlikely to receive a dispatch instruction from us in a certain contracted service window. They operate more efficiently than if they’d been on standby for us.
- ‘Constraint warnings’ are notifications to customers who have a constrainable connection that we will likely need to constrain them for a certain window.

We aim to send these notifications before market gate-closure so that suppliers have time to manage any resulting imbalance. These notifications will increase the efficiency of the flexibility markets, wholesale markets, and whole system coordination. Sending these at LV depend on increasing LV network visibility.

Network visibility also helps predict some faults before they happen, allowing us to pre-empt faults, and respond to near-time data such as weather and gas network outages.

Real-time

Better LV fault identification and response to increase reliability for our customers

Smart meter and network monitoring alarms in the control room will alert to network constraints and faults. This means we can start responding more quickly than if we waited for customers to notify us.

Network visibility will enable greater understanding of location and nature the fault. Our field staff save time searching for the fault by knowing where they need to go to repair it, reducing the time our customers are off-supply.

Network visibility will enable us to automate some parts of the network, meaning they can quickly self-heal after a fault.

What this means for flexibility:

- we only dispatch flexibility when we know we need it, keeping network costs efficient for customers.

Post-event

Post-event analysis to increase network efficiency and reliability

Network visibility means we can better analyse network faults and other network incidents that impact our customers. By better understanding incidents, especially those that result in the loss of customers, we increase our knowledge and can work to prevent these events happening again.

What this means for flexibility:

- we increase our understanding of how flexibility performs in network faults, enabling us to refine its use in future events.

Figure 5: Network visibility informing planning and operational decisions

6. Real time fault level measurement

6.1 Work so far in RIIO-ED1

When there is a network fault, the local network experiences a ‘fault current’; these are orders of magnitude higher than normal network current. Generators are a source of fault current, so the increasing levels of DG needed for Net Zero will increase prospective network fault current. Switchgear are the assets which are designed to safely isolate network faults, and so are sized to cope with a certain level of fault current. Where connecting a generator would increase the network fault current above the rating of the switchgear, we’ve historically needed to replace the switchgear before that generator can connect. This is expensive for the customer and delays their connection.

Historically there has been no reliable way to measure a network’s prospective fault current; instead they’ve been calculated using computer models (governed by industry standards). These models need to be manually updated with network changes and they do not reflect the fault current fluctuations a network will experience during a typical day. The models are a representation of what the network is thought to look like at any one time and modellers rely on information supplied by transmission network companies, DNOs, and customers. This information is not always readily available. Given the safety importance of switchgear, and that these models involve no measured data, this modelling involves a safety margin to ensure real network fault currents aren’t likely to be higher than those calculated by the model.

The ability to measure actual real fault current in real-time would be a step change in industry’s understanding of network fault current.

In RIIO-ED1, we partnered with Outram Research Ltd to develop the world’s first real-time fault level measurement (RTFLM) device. For the first time for any DNO, this gives an accurate real-time understanding of prospective network fault level. The significance of this achievement was recognised with this project being awarded the “Best Electricity Network Improvement” Award at the UK Energy Innovation Awards 2019.

We combined this innovation with a network management scheme to create active fault level management (AFLM) – another first for any DNO. Together, these capabilities allow us to safely connect more generation customers without triggering fault level reinforcements. This is good for our generation customers, who can connect more quickly and at lower cost. It’s also beneficial for our wider customer base, who pay a portion of interventions to manage fault level.

6.2 Roll-out of RTFLM and AFLM in RIIO-ED2

Given the success of RTFLM and AFLM, we will roll them out as business as usual in RIIO-ED2; our baseline scenario includes AFLM at three sites and RTFLM at a further 38 sites. Together this will save our customers £42.78m in RIIO-ED2 by deferring switchgear reinforcements. In addition to lower connection costs for the connecting customers and lower socialised distribution costs for all customers, this will enable quicker connection of zero carbon renewable generation.

AFLM can only be delivered through constraint management zone (CMZ) infrastructure. Section 3.5.2 of our DSO Strategy provides detail on CMZs and where we will deliver them in RIIO-ED2.

7. Data sharing with customers and stakeholders

Increasing network visibility, supported by our planning and operational tools which use this data, means we will have more data and network insights. These will support and inform some of the data we plan to share with customers and stakeholders in RIIO-ED2, including:[27]

- Historical network data: network data showing what has happened on the network, including voltages, demand and generation levels, active fault level monitoring data, network topography, and fault rates (CI and CML). For areas of the network that have monitors, we will calculate network losses disaggregated to substation level. We will use this information to model losses in the areas of the network that don't have monitors. We will share this information as it develops over RIIO-ED2.
- Near-time and real-time operational data, such as constraint warnings and dispatch warnings, so that service providers, customers, and other network operators can get ready. These are enabled by greater network visibility. [28] Increasing network visibility also supports our objective of sharing a full network GIS from 132kV to LV, so that customers can map the data we publish.
- Network needs: we will tender for flexibility for all viable network constraints and provide the information and site-specific price signals that participants need to make an informed bid. More network visibility means we can given more notice of our needs, we may be able to more tightly define service windows, and we will have more network data to share to support flexibility market growth.
- The long-term development statement (LTDS) is a licensed DNO publication to inform and enable any customer to evaluate opportunities to enter into arrangements with the distribution licensee. This includes in the provision of flexibility services. The LTDS is being reformed to enhance the content and processes and will include aspects such as data sharing, common information model (CIM), and heatmaps. Increasing network visibility will support several areas of LTDS reform, including data provision, supporting the connection offer process, and facilitating flexibility services. Heat maps are included as part of LTDS reform and, while they are used to highlight network capacity, increased network visibility data will support more granular heat maps across a greater range of timescales.
- Our Distribution Future Energy Scenarios (DFES) are forecasts for key customer demand and generation metrics up until 2050. We develop these considering a range of sources, including network data. Improving network visibility will increase the network data that is available during the production of our DFES – this supports not only our forecasts but other network publications.
- Evaluation of network capacity is an essential part of a robust process for developing efficient and economical network interventions. We will publish a Network Development Plan (NDP) every two years to provide stakeholders with transparency on network constraints and needs for flexibility. The long-term demand and generation forecasts from our DFES are used to underpin network assessments that inform the NDP to provide the 'best view' of the planned asset based and flexible network developments over the five to ten-year period. As these network assessments are underpinned by our DFES, improving network visibility has a direct impact on the NDP.

Greater network modelling will improve the quality of our forecasts:

1. **We know the starting point.** Nearly all forecasts and models build up from the existing state of the network – that is the starting point of the model. The more network visibility we have the more accurately we can define the starting point, and outcomes of forecasting/modelling are more accurate.
2. **We can calibrate our tools.** In RIIO-ED2 we will introduce an annual calibration exercise for our forecasting and modelling tools, so they remain accurate. This will include comparing previous forecasts against the observed reality. More network visibility increases the accuracy of the observed reality. This should result in more accurate forecasting and modelling tools.
3. **We can improve the quality of the network asset data** that we hold by helping us identify incorrectly registered assets. This is especially relevant for the LV network, where records can be incomplete. For example, if we have incorrectly recorded the size and type of an LV circuit, then when monitoring data is combined with our network models there will be a discrepancy. This discrepancy is a flag that the records we hold may be incorrect. Increased network visibility helps ensure more accurate models and data share.

[27] This list covers the data share that will be supported by greater network visibility. Please see our DSO Strategy for the complete list of data that we plan to share in RIIO-ED2.
[28] Section 5.3 of our DSO Strategy provides more detail on these near-time notifications.

8. Summary

This strategy covers five main points:

1. We need to increase network visibility, especially for the LV network, in RIIO-ED2 and beyond (Section 3).
2. We plan to increase network visibility primarily through increasing LV network monitoring coverage, but also by using more smart meter data and data from other sources (Section 4).
3. This increased data collection will inform our network planning and operational decisions, including through our new simulation and modelling analytical ENZ Platform which will utilise data from monitors and smart meters (Section 5).
4. We will increase visibility of network fault current (Section 6).
5. Increasing network visibility means we can share more data and network information with stakeholders (Section 7).

Decarbonisation, decentralisation, and democratisation are driving changes to the electricity system. These changes are going to require significant investment in the network, our operational capabilities, and our internal processes. These investments depend on greater network data and visibility, especially on the LV network. In some cases the absence of network data would result in less efficient and timely investments; in other cases investments won't be possible at all.

We considered three main solutions to get this data: existing MDIs, smart meters, and LV monitors. We found that:

- MDIs don't provide the visibility we need.
- Smart meters provide some valuable visibility, but they have limitations (mainly due to their error margin, time lag, and aggregation method).
- Network monitors provide nearly all the visibility we need, and so will be essential to increasing network visibility
- Smart meters and network monitors are complementary; customers get the most benefit when they are combined so we should use both to increase network visibility.

Based on this approach, to increase network visibility in RIIO-ED2, we will:

1. Invest £28.3m to deliver LV monitoring at 14,102 secondary substations in RIIO-ED2 (baseline scenario). When added to the 2,438 LV monitors we are delivering in RIIO-ED1, this means that by the end of RIIO-ED2 52% of secondary substations rated at ≥200kVA will have LV monitoring (up from 8% at the end of RIIO-ED1). This will extend LV monitoring coverage from 14% to 76% of customers. This will deliver £32.2m in customer benefits.
2. increase our use smart meter data as their penetration increases; this will be especially valuable where we don't have network monitors.
3. use monitoring and smart meter data to directly information our planning and operational decisions. This will primarily be done though our ENZ Platform. This means we will be making high-quality data-driven planning and operational decisions in RIIO-ED2.

Separately from standard network visibility considerations, we have been world leaders in the development of real time fault level measurement and active fault level monitoring in RIIO-ED1. In RIIO-ED2 we will deliver active fault level management at three sites and real time fault level measurement at a further 38 sites, saving our customers £42.7m. This will enable generators to connect more quickly and at lower cost, so helping the transition to Net Zero.

Increased network visibility will mean that we have more data we can share with our customers and stakeholders. In RIIO-ED2 we will increase historical, near-time, real-time, and forecast data sharing with our customers. This data share will help promote transparency, innovation, and efficient, coordinated, and competitive flexibility markets.

9. Appendix A – LV monitoring substation locations

We are installing LV network monitors at 2,438 secondary substations in RIIO-ED1 and 14,102 secondary substations in RIIO-ED2 (baseline scenario). Figure 6 and Figure 7 show the locations of these 16,540 secondary substations.

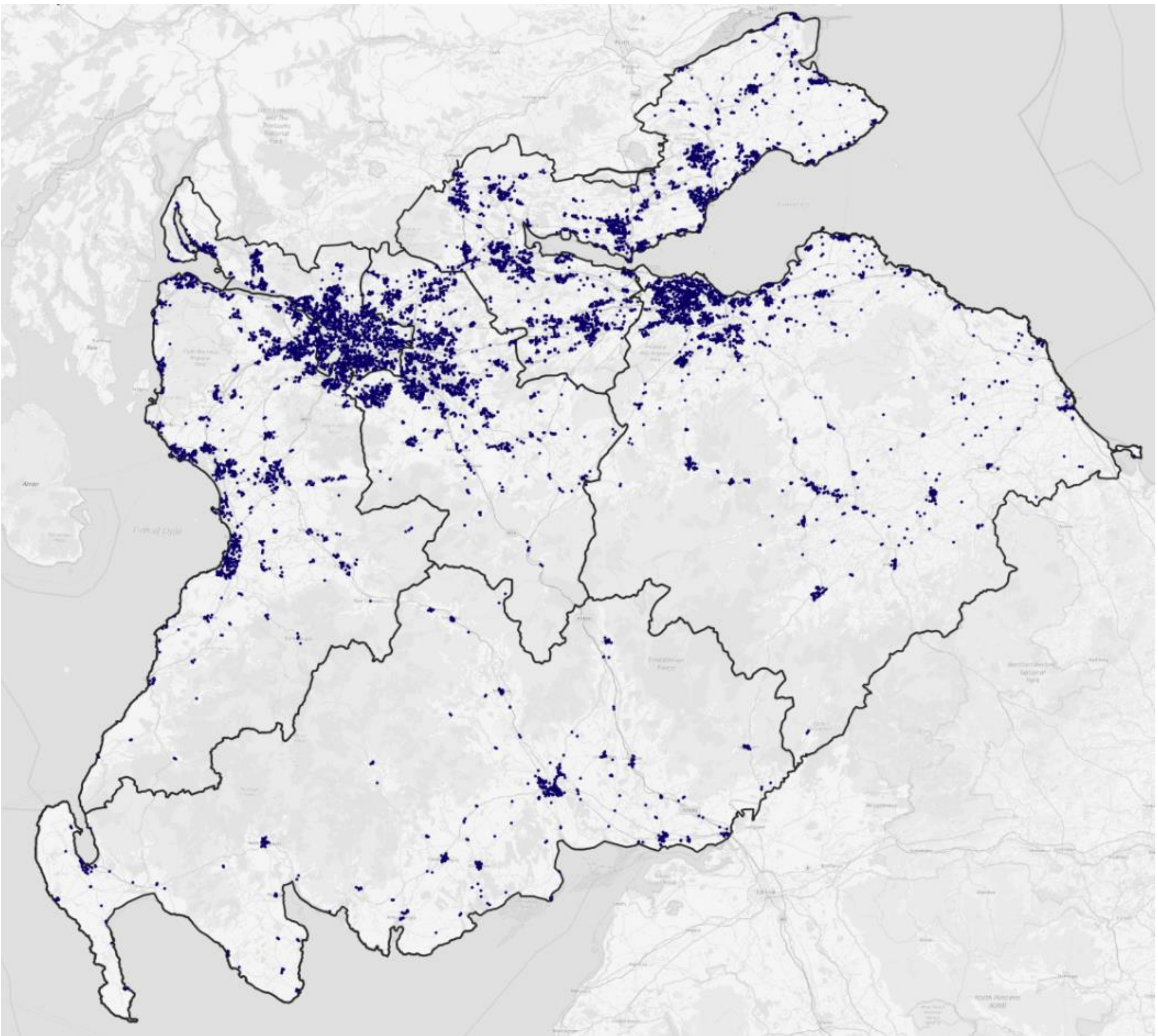


Figure 6: SP Distribution secondary substations that will have LV monitoring by the end of RIIO-ED2

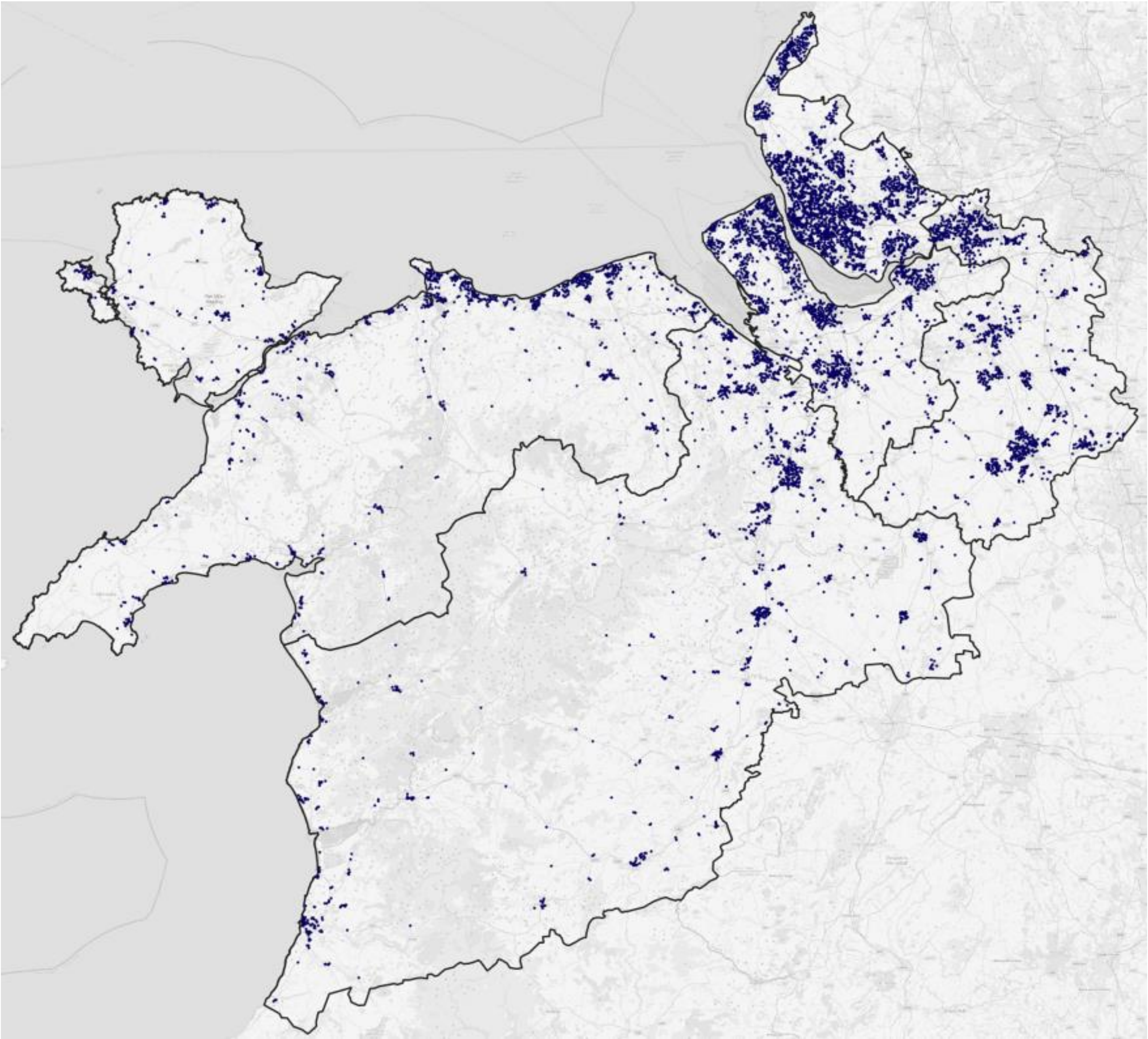


Figure 7: SP Manweb secondary substations that will have LV monitoring by the end of RIIO-ED2

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