NETWORKS

Local Network Visibility Multiyear Plan

NATIONAL NETWORK, LOCAL CONNECTIONS PROGRAMME

DOC-230921-GYO

Updated following consultation in Q4 2021

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Glossary

2 GLOSSARY

TERM	DEFINITIONS
ADMS	Advanced Distribution Management System
AI	Artificial Intelligence
AMI	Advanced Metering Infrastructure
CRU	Commission for Regulation of Utilities
DER	Distributed Energy Resources
DPO	ESB Data Protection Officer
DSO	Distribution System Operator
EPRI	Electric Power Research Institute
GDPR	General Data Protection Regulation
GIS	Geographical Information Systems
IOT	Internet of Things
IP	Ingress Protection
LCT	Low Carbon Technologies
LTE	Long Term Evolution
LV	Low Voltage
MPRN	Meter Point Reference Number
MV	Medium Voltage
NN,LCP	National Network, Local Connections Programme
NTC	ESB Networks National Training Centre
OH	Overhead
OMS	Outage Management System
OVM	Operational Visibility Mapping
PLTE	Private Long-Term Evolution
PQQ	Pre-Qualification Questionnaire
PR5	Price Review 5
QA	Quality Assurance
THD	Total Harmonic Distortion
TSO	Transmission System Operator
UG	Underground

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Background

The core objective of the National Network, Local Connections Programme is to bring together changes in how we are generating electricity, and how we are using it, enabling all electricity customers and communities to play an active role in climate action, by using or storing renewable electricity when it is available to them locally. To deliver this, we will need "visibility" of the network, and of demand and generation on the network, down to the most local level. This document sets out the "Local Network Visibility Multiyear Plan" – the plan to secure and share this visibility of the network by mapping, modelling, and monitoring the electricity network down to the local, low voltage networks.

In Q4 2021, we consulted on the Local Network Visibility Multiyear Plan as part of the wider consultation on the National Network, Local Connections Programme. Through this process, the value that stakeholders place on securing network visibility was clear, though there was little specific feedback on the technical and technological approaches set out in this document.

3 BACKGROUND

Throughout the consultation period, the Local Network Visibility Multiyear Plan was progressed further through a combination of design, analysis, and field work. The result is this updated Local Network Visibility Multiyear Plan which is now being adopted as the Local Network Visibility Multiyear Delivery Plan.

For more information on the stakeholder feedback received, ESB Networks' response to this and how this feedback has been incorporated into the National Network, Local Connections Programme delivery plans, please refer to the Consultation Core Response Paper available on the National Network, Local Connections Programme website.

The decarbonisation of Irish society relies on fundamental changes to how energy is generated and consumed. To enable these changes at the right pace and the right price, we will rely on the electricity network, and we need to make the connection between how renewable energy is generated, and how we use or store it. Every Irish home, farm, community, and business is being called on to play a part. The National Network, Local Connections Programme has been established to work with, and for, customers to make this possible. ESB Networks serves, and is funded by, all electricity customers.

To support Ireland's 2030 Climate Action Plan targets, ESB Networks has committed to:

1. **Facilitate people in Ireland adopting up to 936,000 electric vehicles and 600,000 heat pumps.**
2. **Connect up to an additional 10 GW of renewable generation at transmission and distribution level, so that we can charge our cars and heat our homes using renewable electricity.**

Much of the change needed to achieve these targets will happen at the most local or low voltage (LV) level on the electricity system. With heat pumps, electric vehicles, and microgeneration connecting at homes and businesses across the country, and the introduction of localised demand side flexibility as a core strategy to increasing the renewable energy consumed, there is a growing need for "visibility" of these local networks.

"Network visibility" means having an accurate picture of the electricity network, and the demand and generation on it, at any given point in time. Network visibility will play a critical role in allowing customers to become active participants in the electricity system, in a secure and coordinated manner. To build up this picture, we need accurate maps, electrical models, and monitoring of the system. Today we have this visibility of the high and medium networks, but we do not yet have an accurate view of demand and generation patterns on the LV system or how this varies by time of day, month, and season.

3 BACKGROUND

Currently, ESB Networks estimates how loaded MV/LV substations are, for example by aggregating traditional metering data, however the network model data and customer referencing used to do this is sparse and not always accurate, and a range of approximations and assumptions are needed. While this has met network development needs to date, it is not of the quality needed for operational purposes and to enable, customers on the low voltage system securely participate in flexibility services.

Increased visibility will allow ESB Networks, our customers, and emerging energy companies, to improve how we use and manage the low voltage system. It will allow ESB Networks to introduce new solutions to help provide the capacity and reliability needed at this most local level, by incentivising customers to use or store renewable energy on the network when it is local and available, and to spread out localised peaks to support the integration of low carbon technologies such as electric vehicles and heat pumps.

To enable this, ESB Networks has been mandated to drive out programmes of work including low voltage mapping and monitoring. Using these increased levels of visibility, ESB Networks will need to manage and monitor the network more actively down to the most local level and empower domestic and small business customers to become “flexible” or “active customers”. We are working toward a target of 50% mapping/modelling visibility of the network by the year 2025, in addition to retrofit monitoring on the low voltage side of 10,660 MV/LV distribution substations by the end of 2025.

The purpose of this document is to outline the work delivered in 2021 and to provide a roadmap for the approach and detail in relation to the programme management by ESB Networks in relation to reaching our target of 50% mapping/modelling by the end of 2025 and the installation of monitoring devices on the LV network throughout PR5. It also provides details in relation to procurement of monitoring devices, resourcing requirements for the operational visibility and mapping work programme, safety procedures, training, validation, installation, and commissioning. The success of the programme will require that certain milestones are met between now and the end of 2025 as detailed in Section 6 of this document.

4

Programme Delivery Approach

4 PROGRAMME DELIVERY APPROACH

The National Network, Local Connections Programme is responsible for delivering low voltage visibility on a phased basis, based on efficient and effective technical and delivery roadmap. The roadmap focuses on the following three pillars:

1. **Delivery readiness and sourcing.**
2. **Securing visibility.**
3. **Sharing visibility.**

4.1 DELIVERY READINESS AND SOURCING

Delivery readiness and sourcing can be broken down into the following four key activities:

1. **Definition.**
2. **Telecoms delivery readiness.**
3. **Delivery model and sourcing.**
4. **Network model formats and QA.**

ESB Networks' delivery readiness milestone for 2021 involved the delivery of comprehensive delivery readiness activities addressing technical, technological, and practical dependencies, and ensuring business readiness. This includes investigation and testing of a range of solutions, and business readiness for the delivery of the solutions which best fit different operating contexts for each aspect of the roadmap for operational visibility.

A key aspect of this was the definition of specific sourcing requirements (addressing labour and technology needs), and to commence sourcing of the delivery solutions selected. ESB Networks has identified the need to deploy a team of network technicians for the installation of the LV monitoring devices upon completion of the procurement of these devices.

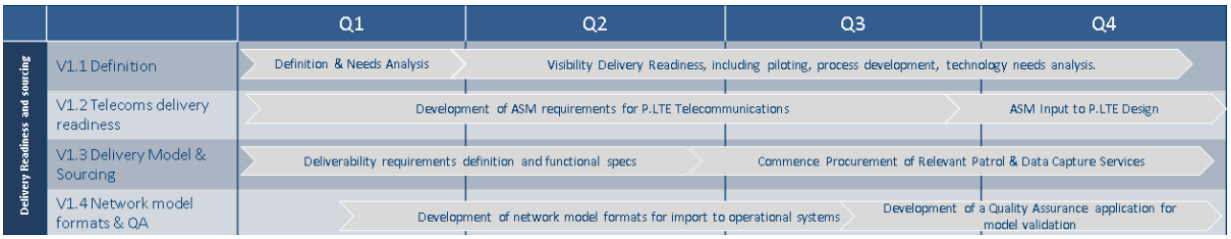
The final part of the delivery readiness programme involves the definition of a suitable LV network model for import to an ADMS system as detailed in Section V1.1 Definition – Model data requirements, and the development of a quality assurance for model validation. The quality assurance process will involve a validation exercise of the results of the low voltage mapping tool. This tool, currently under development by the Electric Power Research Institute (EPRI) will use linear regression modelling of smart metering voltage data.

4 PROGRAMME DELIVERY APPROACH

4.1 DELIVERY READINESS AND SOURCING continued

The QA process will also involve "boots on the ground" validation to be undertaken by suitably qualified and approved network technicians. Procedure documentation for this validation exercise has been drafted, will be adhered to throughout the QA exercise, and will be updated where appropriate based on piloting and field experience. This documentation will be signed off once training for validation commences in 2022. Further detail on this is set out below in Section V1.1 Definition – Delivery documentation. The work programme for resourcing of the validation exercise in 2022 was signed-off by ESB Network's programme delivery team at the end of 2021.

The graph below, submitted to the CRU in January 2021 as part of its annual target setting process, gives a detailed breakdown of the plan taken to reach our delivery readiness objectives for 2021.



V1.1 DEFINITION

To meet its 2021 targets with respect to definition, ESB Networks undertook comprehensive delivery readiness activities addressing technical, technological, and practical dependencies, and ensuring business readiness. This included requirements analysis, identification of delivery models, piloting and development of processes and procedures as required.

Resourcing Definition

To progress recruitment and selection of the resources required to deliver this work over the life of the PR5 programme, and to refine programme cost estimates, a multiyear resourcing plan was developed. This includes the plan setting out the field staff resources required to complete the installation of monitoring devices and the validation of the mapping / modelling visibility of the LV network. This plan has been approved by ESB Networks' programme delivery team and the required resources are included on the work programmes for 2022.

With regards to the validation of the maps / network models delivered by the EPRI tool, our current estimate is that on average, it will require 2 appropriately qualified network technicians for 1 day per MV/LV substation to carry out this task. The basis of this estimate is achieved from lessons learned on the Dingle Project and from the experience of network technicians who have previously delivered this type of work. This will be validated in the field from April 2022 onwards.

4 PROGRAMME DELIVERY APPROACH

4.1 DELIVERY READINESS AND SOURCING continued

Resourcing Definition continued

The skills and approvals needed to complete this work include:

1. NTW- PI1, PICW on LV Overhead Network
2. NTW-PI10, PICW on LV Underground Network
3. NTW-PI9, PICW on LV Service Cables fed from Ground Mounted Plant or OH Source
4. LWOH01, Preparing for Live Work and Application of Shrouding on OH Networks
5. LWOH05, LV Live Work - Make and Break 1Ph connections on OH Networks
6. LWOH10, LV Live Work - Make and Break 1Ph & 3Ph connections on OH Networks
7. LWUG01, Preparing for Live Work and Application of Shrouding on UG Network
8. LWUG15, LV Live Work - Make and Break connections at an LV Panel
9. PNTC, Person Nominated to take Charge
10. ID-LIVE10, Identify Live LV Cables using Twist Field methods
11. BSC-ID01, Identify LV Single Phase Cables using Physical Trace Methods
12. BSC-ID05, Identify LV Cables using Physical Trace Methods

With regards to the installation of monitors, our current estimate is that on average, it will require 1 appropriately qualified network technician 1 day to install 3 monitoring devices. The basis of this estimate is achieved from lessons learned on the Dingle Project and from the experience of network technicians who have previously delivered this type of work. The installation of monitors in the field will commence upon completion of the procurement process for the purchase and supply of the monitoring devices. The skills and approvals needed to complete this work include:

1. NTW- PI1, PICW on LV Overhead Network
2. NTW-PI10, PICW on LV Underground Network
3. NTW-PI9, PICW on LV Service Cables fed from Ground Mounted Plant or OH Source
4. LWOH01, Preparing for Live Work and Application of Shrouding on OH Networks
5. LWOH05, LV Live Work - Make and Break 1Ph connections on OH Networks
6. LWOH10, LV Live Work - Make and Break 1Ph & 3Ph connections on OH Networks
7. LWUG01, Preparing for Live Work and Application of Shrouding on UG Network
8. LWUG15, LV Live Work - Make and Break connections at an LV Panel
9. PNTC, Person Nominated to take Charge

4 PROGRAMME DELIVERY APPROACH

4.1 DELIVERY READINESS AND SOURCING continued

Resourcing Definition continued

Under certain conditions, tasks will need additional time and resources to complete for example:

1. **Access to MV/LV substation and equipment. For example if a pole had dense vegetation within its surrounds, if a ground mounted MV/LV Substation was inaccessible – e.g. Parked car blocking door, or behind locked gate.**
1. **Age, condition and model of certain low voltage assets may need extra time and resources to safely install monitors and to safely carry out validation of EPRI mapping model.**

The resourcing requirement for the delivery of the installation of monitoring devices and the validation of the mapping / modelling visibility of the LV network will be kept under review and updated as appropriate for future years within PR5 based on lessons learned during 2022.

Throughout PR5, the National Network, Local Connections Programme will centrally guide, oversee and assure the deployment of a team of network technicians who carry out both the installation of devices and the validation of LV maps. This centralised team will resource the ongoing ownership and application of the LV mapping tool, including any data cleanse, data transfer and further quality assurance checks required.

The definition process involved close collaboration between experts within and beyond our organisation, to address the range of complex challenges that may arise throughout the life cycle of the project. This included collaboration with:

1. **The Electric Power Research Institute (EPRI) to develop a proof-of-concept approach to low voltage mapping using linear regression modelling of smart metering AMI data.**
2. **ESB Networks Programme Management team to align our work programme with other work programmes being delivered by Networks Customer Delivery, Networks Project Delivery, and contractor resources in the field.**
3. **ESB Networks Customer Delivery Team (NCD) for the delivery of our work programme within PR5.**
4. **ESB Networks Programme Management to develop weekly progress reports planned over the course of PR5 on the delivery of the work programme.**
5. **ESB Networks Procurement and Legal specialists to provide guidance on the drafting of the PQQ documentation and associated technical specification prior to the commencement of the procurement of LV monitoring devices.**

4 PROGRAMME DELIVERY APPROACH

4.1 DELIVERY READINESS AND SOURCING continued

Resourcing Definition continued

6 **ESB Cyber Security and Solution Architecture teams to ensure proposed technical specification were cyber security and NIS compliant and to provide guidance on the appropriate processes for data management and storage.**

7 **ESB Networks Data Protection Office to assist with the drafting of Data Protection Impact Assessments to gain access to the appropriate smart metering data fields to build out the LV network model and to provide guidance on the appropriate processes for data management and storage.**

In this manner, we have built a detailed the multiyear programme for the remainder of PR5 to deliver the full scope of operational visibility and mapping required.

Delivery documentation

Prior to the validation of the EPRI Model and procurement and installation of monitoring devices, documentation defining the necessary procedures and protocols for field staff to carry out this work must be drafted and approved. During 2021, the necessary documentation has been drafted using ESB Networks' OneSource Procedure Development Policy, a standardised approach introduced in recent years as part of our organisational safety system. The suite of documentation developed or in development at the time of writing includes:

PROCEDURE DOCUMENT SET NAME	DOCUMENT DESCRIPTION	COMPLETION/FORECAST DATE
Installation of LV Monitors for National Network, Local Connection Programme	1. Installation and commissioning Procedure document for field staff. 2. Safety Risk Assessment Document for installation task 3. Business Impact Assessment document (BIA)	First draft complete. Finalised by July 2022.
Validation of EPRI results for National Network, Local Connections Programme	1. Procedure document for Validation of low voltage Mapping output results from EPRI Model and the recording of updated data. 2. Safety risk assessment document for validation for field staff.	First draft complete Finalised by April 2022

4 PROGRAMME DELIVERY APPROACH

4.1 DELIVERY READINESS AND SOURCING continued

Delivery documentation continued

The procedure documents focus on field staff activities for example the installation and commissioning of monitors and the field validation of the network models/maps developed through a linear regression model as described later in this document in Section 5.2.2 – EPRI Model approach.

The development and update of the requisite delivery documentation will continue as an on-going process into 2022 and beyond. This documentation will need to be added to or adapted to account for example for:

1. **Process improvement opportunities identified year on year.**
2. **To support any new methods emerging.**
3. **To support the introduction of additional delivery models.**
4. **To support any new or additional technology or devices introduced for field staff.**

Model Data Requirements

The definition process involved ESB Networks clearly defining the specific assets and attributes that will need to be mapped, captured in electrical models and/or monitored to meet the project specification. This was completed with the contribution of power system specialists, GIS and Smart Metering subject matter experts. The key assets and attributes are as summarized in the table below.

ATTRIBUTE	DESCRIPTION
Assets	The location of the following: • MV/LV substation • LV conductor (inc. OH, UG and service) • Mini pillars • Service poles • Meter point (location only)
Connectivity	• LV conductor to MV/LV substation • Mini pillar to LV conductor • Service cable to mini pillar • Customer MPRN to mini pillar i.e. service cable
Electrical characteristics	• Impedance • Conductor length estimation

4 PROGRAMME DELIVERY APPROACH

4.1 DELIVERY READINESS AND SOURCING continued

Monitoring Locations

ESB Networks' target is to have 10,660 monitoring devices operational, gathering real time monitoring of the LV network by the end of 2025. These 10,660 monitoring devices will consist of pole mounted and ground mounted installations on MV/LV substations. The procurement for the purchase and supply of monitoring devices from a preferred vendor will complete in 2022, including training and completion of preparation for the works and the monitoring devices will be installed over the years 2023-2025.

A two-phase approach is being adopted to select the locations for installing monitors. In both phases, data science approaches are being adopted. The first 2,000 monitor installation locations are selected based on the following criteria:

1. **MV/LV substations fed from 110kV stations which have been identified as within the top 10 candidate areas for piloting, based on technical assessment as per the 2030 Power System Requirements analysis.**
2. **From the above, individual substations whose utilisation factor is greater than 75% of MV/LV capacity.**
3. **Finally, MV/LV substations with highest numbers of customers connected.**

More advanced data science techniques will be used for the selection of locations for installations later in 2023 through to the end of 2025. At this point, we will seek to develop a selection strategy premised on the identification of strata or groups of substations with similar characteristics, and representative samples of substations monitored from each, to allow profiles to be extrapolated with a greater degree of confidence for those substations which are not currently monitored.

The locations selected for monitoring are identified in an online dashboard, to support various stakeholders' and partners' ease of access and review as presented in Figure 1: Power BI Dashboard showing MV/LV substations in Section V1.2 - Telecoms Delivery Readiness.

4 PROGRAMME DELIVERY APPROACH

4.1 DELIVERY READINESS AND SOURCING continued

Market Research

The approach taken involved market research to ensure that a range of options were considered in the development of technical specifications. As part of this, ESB Networks engaged with several domestic and international device vendors to review the products available on the market and build a deeper insight into the functionality available for pole mounted and substation mounted monitoring devices. Vendors offered a range of insights into the associated software, grid analytics and dashboards available, amongst other factors. Some of the key findings and learnings are;

1. **Functionalities of their devices including the vendors methods for measuring voltage and current**
2. **Commissioning and installation procedures**
3. **Materials used in construction of device**
4. **Communications methods used by device**
5. **Interfaces of device with backend cloud-based software**
6. **Cybersecurity**

4 PROGRAMME DELIVERY APPROACH

4.1 DELIVERY READINESS AND SOURCING continued

V1.2 TELECOMS DELIVERY READINESS

In PR4, ESB Networks secured the spectrum needed to deliver a "smart grid" telecommunications network based on private LTE (P.LTE) technology. This network is being developed during PR5. This connectivity offers a secure and efficient solution for the continuous gathering of real time LV monitoring data. As such, ESB Networks' target with respect to telecoms delivery readiness in 2021 was the development of technical requirements for the use of the P.LTE telecommunications network to support LV monitoring devices.

The key tasks involved:

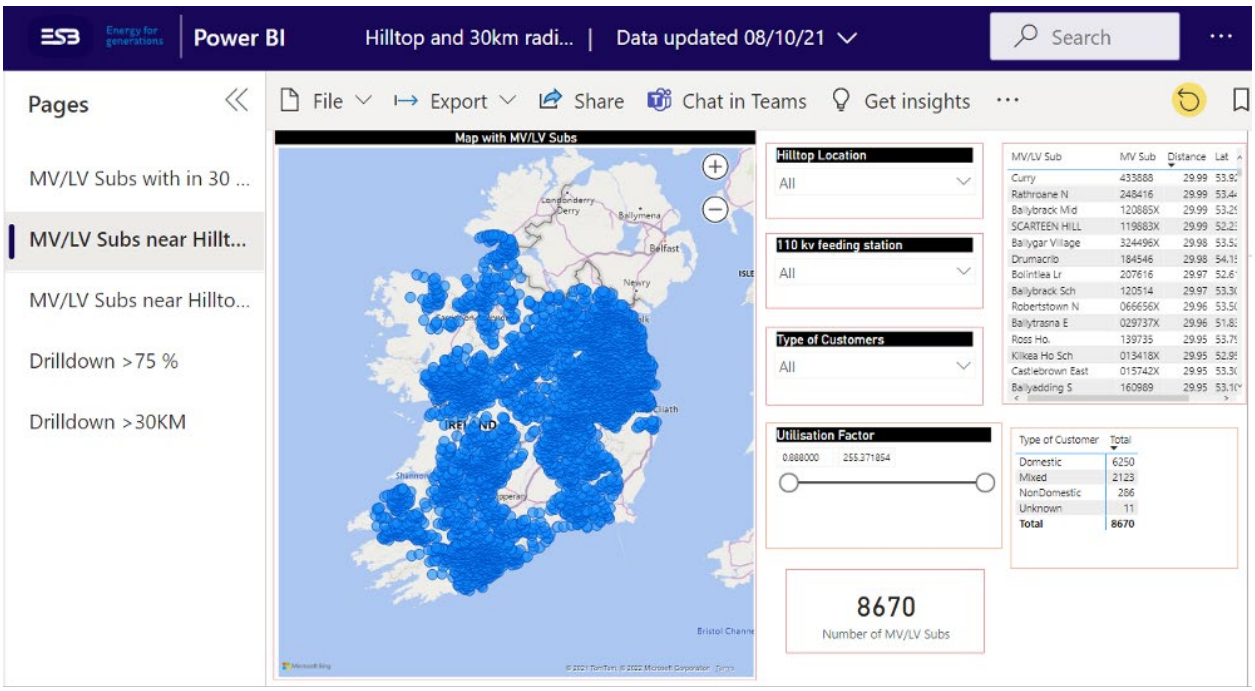
1. **Provision of technical and functional requirements for the establishment of National Network, Local Connections Operational Visibility telecommunications at MV/LV substations via P.LTE sending current, voltage, power (active, reactive) and harmonic distortion data from the network to operational systems with initial focus to be for locations where low carbon technologies are likely to be installed. These requirements were used by ESB Networks Telecoms to inform their requirements for tender of a partner to work with them in their design and build of the P.LTE network.**
2. **Development of a data analytics dashboard showing geographical coverage of the proposed P.LTE network based on ESB Networks Telecoms' confirmation of the initial 30 hilltop locations for the P.LTE rollout. ESB Networks Telecoms provision of this information allowed us to map the P.LTE coverage and overlay it on the locations of all MV/LV substation locations. In this manner, it was possible to select the initial 2,000 substation locations for monitor installations, applying the criteria set out above (as per V1.1 Definition) but also cognisant of the need for telecommunications coverage.**
3. **Development of a strategy for the rollout of monitors using 4G telecommunications technology initially while the P.LTE network is being designed and built.**
4. **Reaching a design decision on having the telecommunication technology built into the monitoring devices, rather than fitting a standalone communications device for each monitoring device. The benefit to this approach is that there is only a single device to be installed on site at MV/LV substations thus improving the efficiency of installations.**

4 PROGRAMME DELIVERY APPROACH

4.1 DELIVERY READINESS AND SOURCING continued

V1.2 TELECOMS DELIVERY READINESS continued

FIGURE 1
POWER BI DASHBOARD SHOWING MV/LV SUBSTATIONS WITHIN 30KM OF P.LTE HILLTOP SITES WHICH HAVE A UTILISATION FACTOR OF > 75%



The monitoring locations dashboard developed (as per V1.1 Definition) was shared with the telecommunications specialists responsible for the delivery of the P.LTE network, along with the precise MV/LV coordinates selected for installation of monitoring, to facilitate their planning provision of the requisite telecommunications coverage.

These monitoring locations were also confirmed to ESB Networks Programme Delivery in order that the installation of these monitoring devices was added into their work programmes.

4 PROGRAMME DELIVERY APPROACH

4.1 DELIVERY READINESS AND SOURCING continued

V1.3 DELIVERY MODEL & SOURCING

In preparation for work commencing on the ground in 2022, the Delivery Model and Sourcing target for 2021 was the definition of sourcing requirements and commencing sourcing of the delivery solutions identified.

The key sourcing requirements included:

1. **Identification of the delivery model for each aspect of the programme**
2. **Identification of the sourcing approach for each delivery model**
3. **Setting out clear technical and other requirements to be met through sourcing**
4. **Competitive procurement (where necessary)**
5. **Procedural documentation for field staff**
6. **Working with ESB Networks Programme Delivery and with field delivery personnel from ESB Networks Customer Delivery to ensure work programme items are resourced and delivered.**

Sourcing Monitoring Devices

A competitive tendering process is required to source LV monitoring devices for installation on the network. Subject to the targets set by the CRU for the rollout of the programme, a formal procurement process will commence in Q1 2022. In preparation for this, technical specifications for LV monitoring devices have been developed for use in this procurement process. The specification developed has been informed by:

1. **Market research and meetings with manufacturers to assess the technical capabilities of products on the market has informed this specification.**
2. **The lessons learned regarding LV Monitoring from the Dingle Project.**
3. **Engagement with ESB Networks procurement specialists.**

Key aspects of the technical specification developed include:

1. **Measurement of voltage and current on MV/LV substation low voltage outlets.**
2. **Calculation of power and power flows of low voltage outlets on MV/LV substation.**
3. **Inclusion of the telecommunications devices within the monitoring device housing.**
4. **Data transfer to IT systems through 4G / P.LTE telecommunications.**

4 PROGRAMME DELIVERY APPROACH

4.1 DELIVERY READINESS AND SOURCING continued

V1.3 DELIVERY MODEL & SOURCING continued

Sourcing a mapping / modelling tool

As set out in our publication of Q4 2021 and described more fully in Section 5.4 of this document, rather than a pure "boots on the ground" field staff approach like that used in the Dingle Project, ESB Networks has adopted an innovative approach to low voltage mapping / modelling. This involves the use of data science to derive the low voltage network model from a combination of data sources, including ESB Networks' existing GIS, and data gathered from smart meters (including geospatial coordinates and voltage profile data).

As this is not a standard solution available on the market today, the sourcing approach adopted is a research collaboration with EPRI, who have relevant expertise and related research is underway. As such, in December 2020, EPRI was commissioned to develop a Mapping / Modelling tool to map out the LV distribution network using data analytics. This work commenced in March 2021. Their approach is and will use data from datasets from ESB Networks' GIS system and from smart meters.

ESB Networks' target is for 50% visibility of the LV network by the end of PR5. Applying analytics-based approaches as the primary strategy, c. 10% of the modelled network will be validated by field staff using a "boots on the ground approach" confirming the accuracy of the mapping / modelling generated by the EPRI solution. Throughout 2021, 113 functional locations (substations) were selected for this validation exercise in 2022, with the number of functional locations increasing in 2023. ESB Networks' National Network, Local Connections Programme Operational Visibility and Mapping (OVM) team is currently working with EPRI to select a mobile solution that will be appropriate to support this "boots on the ground" validation by field staff exercise. Procedure documents for the "boots on the ground" validation by field staff have been drafted and are due to be signed off once training for validation commences in 2022. The programme for resourcing the validation exercise was signed-off by ESB Network's Programme Delivery team in December 2021.

4 PROGRAMME DELIVERY APPROACH

4.1 DELIVERY READINESS AND SOURCING continued

V1.3 DELIVERY MODEL & SOURCING continued

Sourcing Installation and Model Validation Resources

A resourcing approach is needed for completing the model validation activity set out in the previous section. The resources secured will be required to undertake the following steps involved in the validation of the EPRI Model:

1. **Field staff will receive the output data from the EPRI solution via a mobile solution/app showing the attributes and connectivity of the low voltage network including:**
   a. Meter location and electrical phasing of meter,
   b. Low voltage service from meter location to mini pillar/service pole,
   c. Low voltage mains conductor from mini pillar/service pole to MV/LV substation and
   d. Low voltage circuit number from MV/LV substation.
2. **Field staff with the skills and approvals for cable tracing and identifying, and working live on low voltage networks, will be expected to carry out this task.**
3. **Cable tracing and identification will be carried out on-site using both approved equipment already in use by ESB Networks and new devices sourced by the National Network, Local Connections Programme Operational Visibility and Mapping team in collaboration with ESB Networks' Tools and Equipment team. Training will be provided for the use of any new equipment in collaboration with ESB Networks' National Training Centre.**
4. **Any discrepancies between what the field staff discover on site, and the output data from the EPRI model will be adjusted and corrected on the mobile solution. This data will be returned to the OVM team and any corrections will then be updated within ESB Networks' GIS system and ESB Networks SAP IS-U system.**

4 PROGRAMME DELIVERY APPROACH

4.1 DELIVERY READINESS AND SOURCING continued

V1.3 DELIVERY MODEL & SOURCING continued:

Sourcing Installation and Model Validation Resources continued

A resourcing approach is needed for the installation of LV monitors as set out in the previous section. The resources secured will be required to undertake three different types of installation methods to suit our variety of MV/LV substations. Outdoor ground mounted, indoor ground mounted, and pole mounted. The steps involved in the installation and commissioning of low voltage monitoring devices by field staff are:

1. **For outdoor ground mounted MV/LV substation, the monitor will be installed on the internal side panel of the outdoor ground mounted MV/LV substation using high performance magnets. Current measurements will be obtained by installing Rogowski coils around each electrical phase on each low voltage circuit within the MV/LV substation. Voltage measurements will be obtained by connecting onto each electrical phase and neutral on the low voltage distribution panel within the MV/LV substation.**
2. **For indoor ground mounted MV/LV substation, the monitor will be affixed to the inside concrete wall. Current measurements will be obtained by installing Rogowski coils around each electrical phase on each low voltage circuit within the MV/LV substation. Voltage measurements will be obtained by connecting onto each electrical phase and neutral on the low voltage distribution panel within the MV/LV substation.**
3. **For pole mounted devices, the monitor will be pre-wired in an ingress protection (IP) rated and electrical insulated rated cabinet and pre-wired in a workshop. When on site the cabinet will be affixed to our MV/LV substation pole at low voltage level. The current measurements will be obtained by placing Rogowski coils around each electrical phase and neutral and voltage measurement will be obtained by a connection onto our overhead network using an insulated piercing connector onto each electrical phase and neutral.**

4 PROGRAMME DELIVERY APPROACH

4.1 DELIVERY READINESS AND SOURCING continued

V1.3 DELIVERY MODEL & SOURCING continued

Sourcing Installation and Model Validation Resources continued

Field staff carrying out these installations will require low voltage live working approvals including the use of low voltage insulated tools.

Field staff carrying out commissioning of the monitors will do so under existing procedure documents for 'Commissioning of the LV Network'. They will confirm telecommunications commissioning and connectivity of the device via their mobile device by log-on to the relevant web browser while on-site. The procedure document for telecommunications commissioning and connectivity will be developed in conjunction with the successful monitoring device vendor in 2022.

To support efficient delivery of the monitoring device installations work programme, engagement with ESB Networks' Programme Delivery team to integrate this work with other work programmes ensuring that where possible this work can be done as part of normal maintenance work undertaken at the relevant assets. We are also engaging with respect to the range of resourcing and delivery models which may be utilised. (Note: The potential for integrating this work into other work programmes touching the same asset may be relatively limited. For example, the units which require monitoring may not otherwise be on the work programme in a given year, or the skills required to complete this work may not be aligned with the skills needed to complete other work on the asset).

4 PROGRAMME DELIVERY APPROACH

4.1 DELIVERY READINESS AND SOURCING continued

V1.4 NETWORK MODEL FORMATS & QA

Our fourth target with respect to Delivery Model and Sourcing in 2021 was the definition of a suitable network model format for import to an advanced distribution management system (ADMS) and the development of a quality assurance application for model validation. An important aspect of this was the definition of the process and "data journey", and the requirements relating to the development of the interfaces between the systems involved in this process/journey, including ESB Networks' geographical information system (GIS), outage management system (OMS), ESB Networks' customer information system (SAP IS-U) and applications within the advanced distribution management system (ADMS). These have been developed through extensive engagement with ESB Networks' GIS, Mobile Delivery and Dingle Project management in 2021.

The end-to-end data flow associated with the development of accurate LV maps / models starts with data inputted from the GIS system and from the smart metering data hub to the EPRI mapping / modelling tool, see Figure 2 – process flow for data transfer. The EPRI tool will develop the LV geographical and electrical models, and this new data will be outputted from the tool to the Project SharePoint site for validation and update of ESB Network systems. As per the process flow for data transfer, on completion of the mapping / modelling and when the "boots on the ground" validation by field staff exercise is complete, the corrected customer referencing will be updated into SAP IS-U and the new LV mapping updated into ESB Networks' GIS. Integrations between SAP IS-U and the new ADMS, and between the GIS system and the ADMS solution will also be developed, as per the National Network, Local Connections Operations Systems Roadmap (available here).

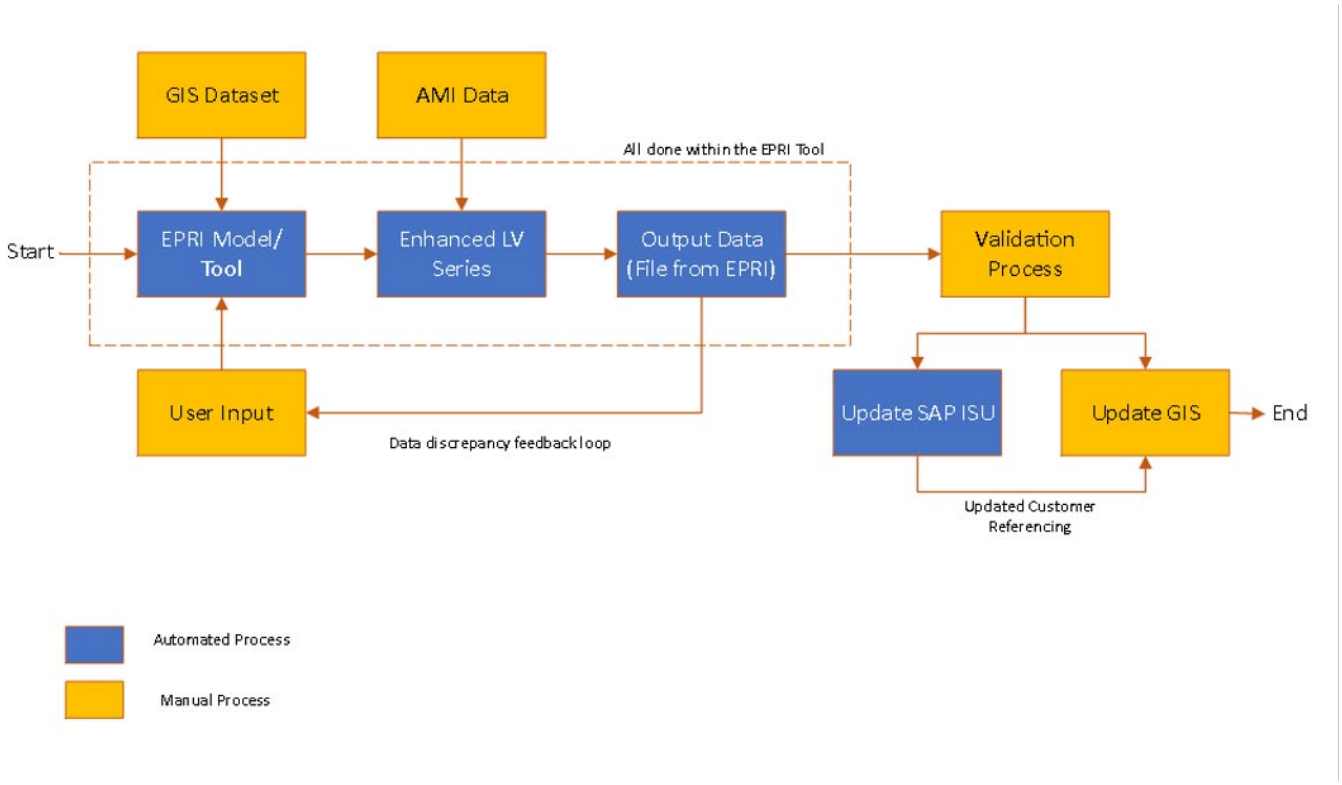
There has been extensive engagement with smart metering experts in ESB Networks, to define the data points to be used in this process, and with ESB data protection personnel to understand the implications of data sharing in relation to GDPR and to comply fully with these requirements. In the current build phase of the EPRI tool, ESB Networks has sent a sample set of data extracted from GIS and will send a second sample dataset extracted from the smart meter data hub. EPRI are using both data sets to develop the Mapping / Modelling tool. ESB Networks is due to receive the first beta version of the tool from EPRI in March 2022. After the tool has been developed it will be handed over to ESB Networks for "boots on the ground" validation by field staff of the output data. A data discrepancy feedback loop with EPRI for continuous improvement of the accuracy of the model output will be ongoing throughout the "boots on the ground" validation period. This feedback loop is currently planned to run until the end of 2023. EPRI have agreed that all data they receive will be deleted upon handover of the modelling tool, in compliance with GDPR regulations.

4 PROGRAMME DELIVERY APPROACH

4.1 DELIVERY READINESS AND SOURCING continued

V1.4 NETWORK MODEL FORMATS & QA continued

FIGURE 2 **PROCESS FLOW FOR DATA TRANSFER**



4 PROGRAMME DELIVERY APPROACH

4.2 SECURING VISIBILITY

"Securing visibility" refers to the development of operational quality, low voltage map and model information, by securing accurate referencing of customers to MV substations, and validation of information gathered on the LV network. This area of activity includes:

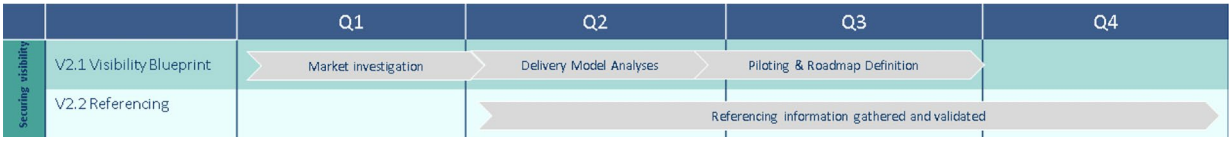
1. **Future visibility blueprinting with**
2. **Preliminary referencing.**

"Visibility blueprinting" involves the investigation and piloting of technical approaches and strategies to inform a blueprint of how we will accurately and efficiently map and develop operational quality models of the low voltage electricity network.

A customer being "referenced" to a point on the network means that there is a record of the network location where they are connected. At the beginning of PR5, as much as 4.5% of ESB Networks' customer base was not referenced to a connection point on the network and 12.3% of the customer base was referenced to an "unknown" LV feeder (i.e., a dummy feeder) on a secondary substation. A customer who is not referenced is effectively not "visible" to the system operator, and if a customer is not visible to the system operator, then it is neither secure nor safe to allow them to participate in any demand side response activities (either with the DSO, the TSO or any third party) until they are.

In 2021, ESB Networks' target was for 20% of all customers to be assessed for connection point reference and LV feeder reference. Our longer-term target for the end of 2025 is for those without a reference to be correctly referenced based on the use of AMI validation data. Those without a reference of this sample will have correct referencing assigned based on collaborative use of AMI validation data.

The graph below gives a breakdown of the approach to "securing visibility" in 2021.



4 PROGRAMME DELIVERY APPROACH

4.2 SECURING VISIBILITY continued

V2.1 VISIBILITY BLUEPRINT (LOCAL VISIBILITY PLAN)

Our target to develop a "Visibility Blueprint" refers to our investigating and piloting a range of technical approaches and strategies to inform the development of a blueprint for LV mapping and monitoring activity. This included market investigation, delivery model analysis and piloting and roadmap definition.

Applying the lessons learned through innovation projects

Since 2018 ESB Networks has worked with the local community in Dingle, Co. Kerry to deploy a range of new technologies as part of the development of a smart, resilient, low-carbon electricity network. Through this initiative, we installed a range of different LV monitoring devices to enable remote monitoring of the local networks.

The installation of these devices in Dingle is now being used as a learning platform for the Operational Visibility and Mapping workstream of the National Network, Local Connections Programme. The lessons learned which are now informing the LV Mapping and Monitoring programme of work include:

1. **A good deal of the technical specification for the monitors used on the Dingle project was used in the specification for the National Network, Local Connections Programme. This specification was taken from Project Winterpeak, which was part of the Dingle project.**
2. **The Dingle project recommended the use of a data protection impact assessment (DPIA) where processing of sensitive data is occurring. This recommendation has been implemented for the sharing of data with EPRI**
3. **It was recommended that ESB Networks be the data owners of data captured from the monitoring devices (as opposed to the device vendor). This has formed part of the technical specification for the monitors. ESB Networks will retain ownership of the data gathered from the monitors regardless of how it is processed.**

4 PROGRAMME DELIVERY APPROACH

4.2 SECURING VISIBILITY continued

V2.1 VISIBILITY BLUEPRINT (LOCAL VISIBILITY PLAN) continued

Leveraging collaboration with other utilities and organisations

ESB Networks is a member of the Electric Power Research Institute (EPRI). EPRI is a membership organisation that provides, industry expertise, and value to help the electricity sector identify issues and technology gaps. This is achieved through collaborative and collective research and development programs. EPRI's work encompasses research in technology, operations, systems planning and other areas that guide and support the development of new regulatory frameworks, market opportunities, and value to energy consumers. ESB Networks have been able to leverage such expertise in relation to the development of a multiyear plan in relation to LV mapping and monitoring.

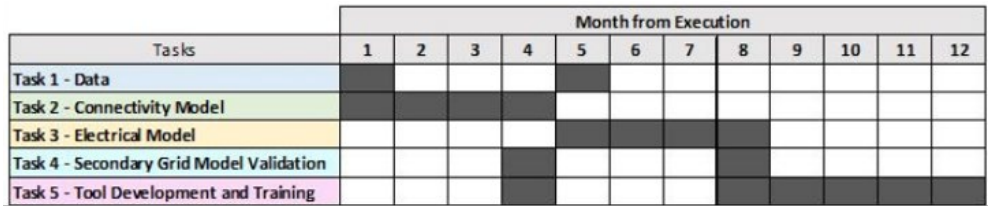
In late 2020, ESB Networks completed an end-to-end review of the EPRI research projects available which might support or inform our strategy for LV mapping and modelling needed. We discovered that EPRI was investigating the use of data analytics for network modelling purposes with another utility - Duquesne Light Company. In addition, EPRI have a programme P200e – Distribution Operations & Planning programme which aligns with the objectives of ESBN LV Mapping and Modelling requirements, hence our engagement with EPRI for the delivery of this solution.

Following further discussion with EPRI, we commissioned a piece of collaborative development, to develop a mapping / modelling tool to map out the ESB Networks LV distribution network using data analytics applied to existing LV network and smart meter data sets. This will include voltage data from smart meters, geospatial coordinates confirmed during smart meter installations, and ESB Networks' existing GIS datasets.

The statement of work was signed in December 2020 and the development project commenced in March 2021. The initial 12-month project approach is as set out in the high-level plan in Figure 3 below. The work encompasses tasks relating to:

1. **Data development, initially of the existing ESBN GIS data and then of the AMI Smart Meter data,**
2. **Development of a connectivity model for the Geo-schematic LV Data,**
3. **Update of electrical model based on the provision of AMI Smart Meter data,**
4. **Secondary Grid model validation and**
5. **Finally, development of a software tool for LV modelling, and associated user training upon handover of the solution.**

FIGURE 3
HIGH LEVEL PLAN FOR EPRI TO DEVELOP THE MAPPING/MODELLING TOOL FOR THE LV DISTRIBUTION NETWORK



4 PROGRAMME DELIVERY APPROACH

4.2 SECURING VISIBILITY continued

V2.1 VISIBILITY BLUEPRINT (LOCAL VISIBILITY PLAN) continued

Practical delivery readiness piloting

As well as learnings from the Dingle project, additional programme-specific field trials were undertaken where necessary in 2021. To support of the EPRI Mapping / Modelling tool, it will be necessary to validate the outputted network models in a subset of locations. To be able to do this, alternative cable tracing devices were tested in the field throughout 2021. Existing approved cable tracing and identification equipment utilised by ESB Networks are:

1. SEBA LCI TX440
2. Low voltage 400volt GRUMBLER

These devices work by sending a DC pulse into the live conductor upstream of the supply, and a receiver, closer to supply, will pick up the signal on the live conductor.

Cable tracing and identification will be carried out on-site using both approved equipment already in use by ESB Networks and new devices sourced by the National Network, Local Connections Programme Operational Visibility and Mapping team in collaboration with ESB Networks' Tools and Equipment team. Training will be provided for any new equipment in collaboration with ESB Networks' National Training Centre.

Testing different applications of data analytics

In addition to the use of data analytics to develop initial LV network models, we are seeking to use data analytics for a wide range of use cases. With respect to LV monitoring, in 2021 data analytics was used to optimise the locations for installation of monitoring devices.

For this first wave of devices, a relatively simple analytics approach was taken, identifying MV/LV substations which are fed from 110kV stations identified as candidates for piloting based on network criteria and which have a utilisation factor of greater than 75% of MV/LV capacity. In this manner the first 2,000 sites for installation were identified, and their installation can commence upon successful completion of the procurement of the monitoring devices. Additionally, a dashboard was developed to deliver the locational analysis by parties collaborating with the programme.

Having successfully applied analytics in the selection of the first wave of monitoring locations, a more advanced analytics approach will be developed to determine the remaining locations for later in 2023 through to the end of 2025 in early 2022.

There have also been studies and piloting analytics approaches & strategies undertaken using AI image recognition approach and other alternative analytics approaches during 2021. This is discussed in more detail in section 4.5.3.

4 PROGRAMME DELIVERY APPROACH

4.2 SECURING VISIBILITY continued

V2.1 VISIBILITY BLUEPRINT (LOCAL VISIBILITY PLAN) continued

Delivering the Local Visibility Blueprint

The National Network, Local Connections Programme Operational Visibility and Mapping team have produced the Local Network Visibility Multiyear Plan blueprint for securing visibility of the low voltage system. This includes detailed activities and milestones in relation to each of the following:

1. **Resource recruitment and onboarding activities as agreed with ESB Networks Programme Delivery**
2. **Analytical advancements of the EPRI mapping tool**
3. **Piloting of devices and progression of redundancy options**
4. **Agreement of safety procedures and protocols**
5. **Location analyses and selection of locations for installation of monitoring devices up to 2025**
6. **Development of technical design and functional requirements for all devices**
7. **Procurement of devices and distribution for installation 2022-2025**

A more detailed view of this blueprint for 2022-2025 can be found in section 6 of this document.

4 PROGRAMME DELIVERY APPROACH

4.2 SECURING VISIBILITY continued

V2.2 REFERENCING PROGRESS TO DATE

At the beginning of 2021, as much as 4.5% of ESB Networks' customer base were not referenced to a connection point on the network and 12.3% of the customer base were referenced to an unknown LV feeder on a secondary substation. A customer who is not referenced is not "visible" to the system operator, and if a customer is not visible to the system operator, then it is neither secure nor safe to allow them to participate in any demand side response activities (either with the DSO, the TSO or any third party) until they are.

In response, ESB Networks' target for 2021 was to assess 20% of all customers for a connection point reference and LV feeder reference. What this meant in practical terms is that we considered 20% of customers and assessed if their substation and outlet reference was correct. Any that were found to be incorrect were corrected.

Meeting the 2021 target

At present ESB Networks has a customer base of 2.4 million homes and businesses, therefore in 2021, 20% equated to approximately 480,000 customers. To meet or exceed this target in 2021, ESB Networks checked 840,652 customer outlets on their connected substations verifying that 825,082 customers were referenced to the correct outlet while the remaining 15,570 were incorrectly referenced. Correct referencing for these 15,570 MPRNs has been identified and there is a plan in place to update the corrected referencing into all relevant systems in 2022.

In 2021, the National Network, Local Connections Programme checked and verified 840,652 customer outlets. The relevant substation references will be checked and verified in future years as the technical facilities required are delivered through the LV mapping and modeling programme.

DATA SOURCE	VERIFIED	IDENTIFIED CORRECTIONS	TOTAL
15/33 kVA Subs	667,129	5	667,134
50/100 kVA Subs	139,369	1,323	140,692
OMS	18,584	8,593	27,177
GIS		5,649	5,649
Total	**825,082**	**15,570**	**840,652**

4 PROGRAMME DELIVERY APPROACH

4.2 SECURING VISIBILITY continued

V2.2 REFERENCING PROGRESS TO DATE continued

Approach taken

The referencing of customers for 2021 was first split up into asset classes, starting with:

1. **15/33 kVA single-phase overhead substations**
2. **50/100 kVA three-phase overhead substations**

Each of these substations had their reference assessed to see if the outlet part of their reference is correct. This set of substations only have one outlet, so any that were not referenced in our information systems to outlet 01 were erroneous and had their reference corrected to outlet 01:

1. **667,134 15/33 kVA substations had their outlet checked.**
   - 667,129 were found to be correct
   - 5 were found incorrect
2. **140,692 50/100 kVA subs had their outlet checked.**
   - 139,369 were found to be correct
   - 1,323 were found incorrect

Then the operational management system (OMS) and graphical information system (GIS) were examined to identify evidence of incorrect referencing:

3. **A record of all 27,177 historic outage calls logged by customers was checked in OMS**
   - When a customer calls in an outage, the call is registered in OMS to the outlet which we know to be subject to an outage.
   - Where we identified that a customer has a different outlet reference in OMS to the faulted outlet registered on the call, the customers outlet reference is identified as incorrect.
   - 18,584 were found to be correct.
   - 8,593 were found incorrect.

4 PROGRAMME DELIVERY APPROACH

4.2 SECURING VISIBILITY continued

V2.2 REFERENCING PROGRESS TO DATE continued

Approach taken continued

4 **An in-depth examination of connection points in GIS was conducted:**

- 46,639 were found to have no reference.
- Of these, 5,649 corrections were identified.
- 40,990 connections points are still without a reference, but have been logged and will be corrected in 2022.
- The vast majority of these unreferenced connection points are unmetered supplies which would supply connections like traffic lights and streetlights.

In all cases where incorrect references or corrections to references have been identified, all the corrections required have been recorded. Whilst to date there has been no way in SAP to bulk update references, this functionality is now being developed currently and should be available in 2022.

4 PROGRAMME DELIVERY APPROACH

4.3 SHARING VISIBILITY

In 2021, ESB Networks developed, published (available here), consulted on and updated a roadmap for the delivery of both beta and production data exchange platforms and dashboards. These platforms and dashboards will enable customers and industry to engage with system operation, challenges and solutions, as active customers and communities, and participants.

V3.1 VISIBILITY PLATFORMS / DASHBOARDS ROADMAP

As part of the National Network, Local Connections Programme, ESB Networks will enable customers to visualise the growth, penetration, and output of renewable energy on their local and regional distribution system via an interactive customer dashboard. The proposals were developed based on desktop technical research, engagement with peer utilities, and customer and industry surveying. The published blueprint addresses:

1. **State of the art for DSO DER dashboards: Several key DSO energy platforms and dashboards across Europe and US were extensively researched and analysed. Each of the DSO portals display different functionalities and features that are highlighted based on the geographic landscape of the distribution network.**
2. **A functionality table with the key attributes to be considered for dashboards delivered in the National Network, Local Connections Programme: The resulting output of the research was a bespoke design taking the best and most applicable attributes from each of the DSO and TSOs. The functionalities indicated include (but not limited to) the distribution system consumption forecast, total share of the renewable energy injected into the network, the energy transition overview for different regions, heat pumps and demand response, community owned renewable energy projects portfolio, etc. Full list of functionalities can be obtained from the Platforms & Dashboards document available here.**
3. **Illustrative examples of proposed functional requirements: Some of the functionalities identified as basic requirements are illustrated. These are only an early development of the functionalities and will be further developed and built on from extensive studies, consultation, and feedback in 2022 and subsequent years during the different pilot phases.**
    i. Geographical Overview of the Existing DER Facilities in Ireland
    ii. Detailed Overview of Each of the DER Types
    iii. Overall Summary for Total Energy Injections DER
    iv. Projected Growth
    v. System Demand and Forecast
    vi. Market Flexibility Services
    vii. Smart Metering Data

4 PROGRAMME DELIVERY APPROACH

4.3 SHARING VISIBILITY

V3.1 VISIBILITY PLATFORMS / DASHBOARDS ROADMAP continued

The various functionalities represented will provide customers and communities with visibility of their local energy system. This will include consumption, demand, and the location specific or community specific views on the distribution network as well as projected DER growth and penetration on the distribution network.

Based on the blueprint developed in 2021, ESB Networks can progress into the development of dashboard and platform functionality in 2022, as per the National Network, Local Connections Flexibility Multiyear Plan.

The final blueprint document is published at link and forms the basis of ESB Networks meeting its 2021 target for sharing visibility.

5

What This Plan Is Delivering

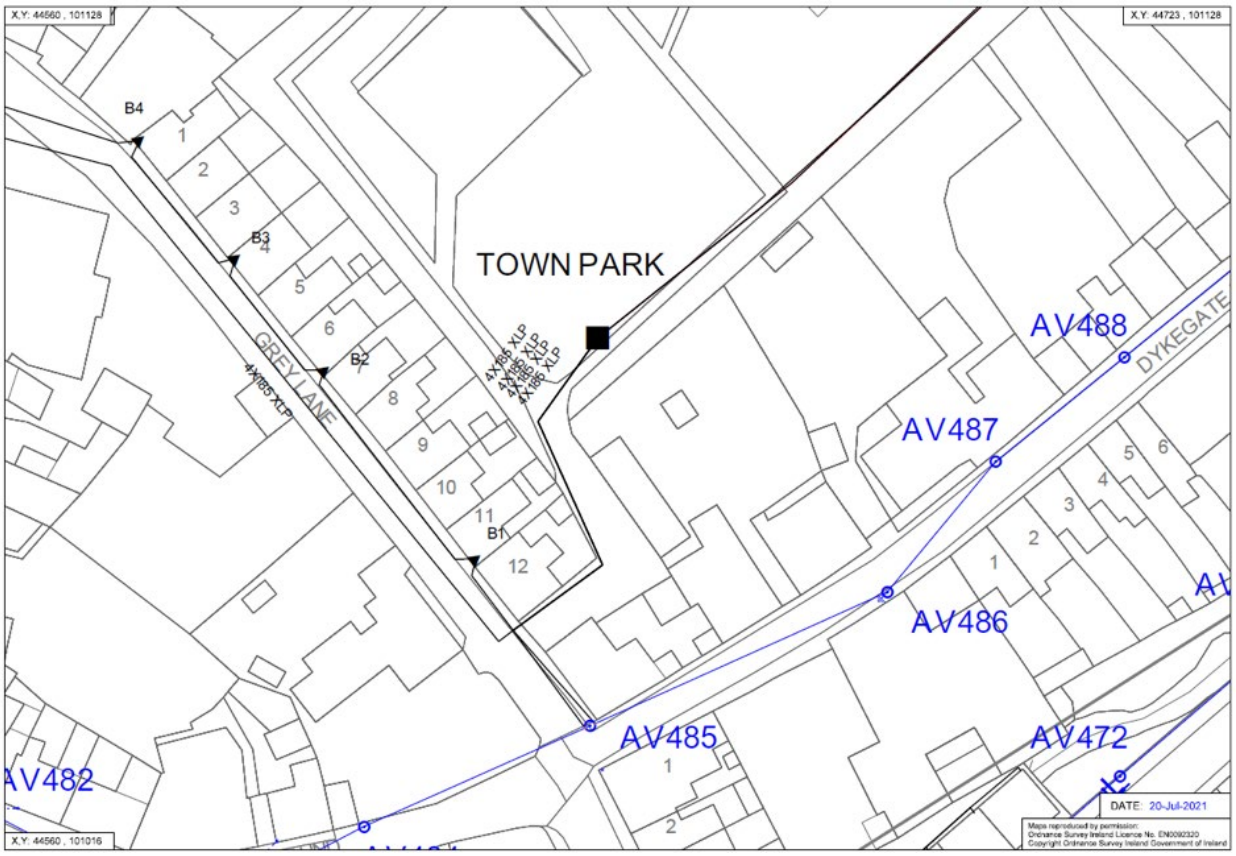
5 WHAT THIS PLAN IS DELIVERING

5.1 BACKGROUND

Accurate network models include accurate referencing of customers to substations and circuits, and the topology and electrical parameters of the low voltage circuits themselves.

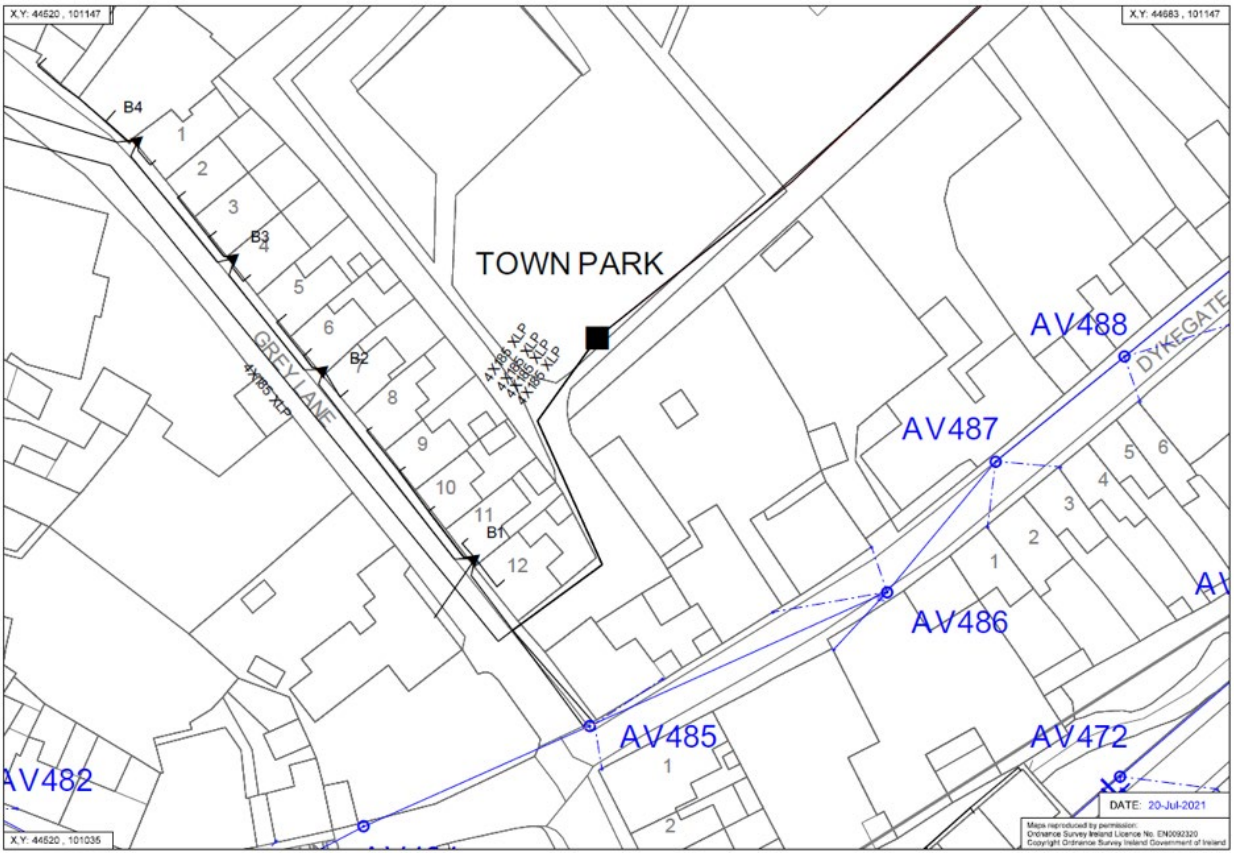
In cases where there are already records of the low voltage network, the information includes the LV network from the secondary substation down to the mini-pillar or pole outside a customer's premises. However, it does not include the overhead (OH) or underground (UG) lines that connects the customer's premises to the LV network. The existing maps are not always complete and there are gaps in the network which may leave some customers disconnected from the LV electrical model.

FIGURE 4 **LV MAP WITHOUT SERVICE CONNECTIONS**



5 WHAT THIS PLAN IS DELIVERING

FIGURE 5 **LV MAP WITH SOME SERVICE CONNECTIONS**



5.2 MAPPING CAPABILITIES

ESB Networks is seeking to develop accurate maps or models of the low voltage system using an approach that combines data analytics with field spot checks. This is an innovative approach which has not been piloted previously in Ireland but is delivering promising results in other jurisdictions.

To carry out this approach to mapping our LV distribution system, the key requirements are smart metering data and the deployment of field staff (boots on the ground) to validate the data analytics model. ESB Networks is partnering with the Electric Power Research Institute (EPRI) to develop the data analytics model required, based on its experience working with US utilities, some of whom have successfully implemented similar approaches. Upon completion of initial testing of the data analytics model, on the ground validation will be undertaken and pending its success, the results from the EPRI model will be fed into ESB Networks' GIS system.

ESB Networks is developing a documented and approved procedure for field staff to validate results. This procedure references ESB Networks' safety rules, policies, and protocols. Training will also be provided by ESB Networks to contractor field staff carrying out any validation exercises. This will be delivered under the control of ESB Networks' National Training Centre (NTC).

5 WHAT THIS PLAN IS DELIVERING

5.2 MAPPING CAPABILITIES continued

It is anticipated that 10% of results obtained during the development phase of this data analytics-based modelling approach will need to be validated to indicate the level of accuracy across the network. However, it will only be possible to confirm the accuracy of this assumption once initial model results are available. Due to challenges in relation to accessing smart metering data because of its falling within GDPR legislation, this has not been possible to date.

However, there is ongoing consultation with ESB Data Protection Officer (DPO) to secure access to this data.

Field trials are also required as part of the procurement of equipment and devices for the purposes of validation, including:

1. **Phase and feeder identification units.**
2. **Cable location units.**

5.21 AVAILABILITY OF SMART METERING DATA

As part of the increased visibility, customers without a reference point on the LV network will have correct referencing assigned, based on collaborative use of the smart metering validation data. To use this data analytics approach to LV mapping, there is a high dependency on smart metering data.

Smart metering data will be used to produce a model using voltage, current, active power, and reactive power. This will allow for LV mapping, and customer referencing to the LV outlet in the substation and the customer phasing (the phase that the customer is on in a three-phase system).

However, at present, smart metering data is not available due to GDPR (General Data Protection Regulation) constraints. Without access to smart metering data, voltage monitors will be required on each LV circuit in an MV/LV Substation to allow complete visibility of the LV Distribution system.

ESB Networks is in consultation with ESB DPO to resolve this issue.

5 WHAT THIS PLAN IS DELIVERING

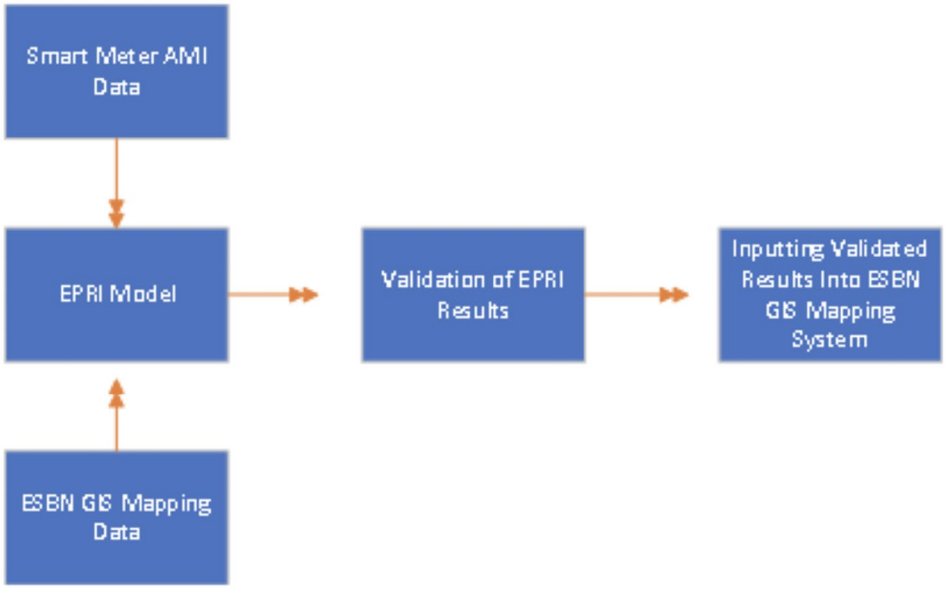
5.22 EPRI MODEL APPROACH

From market research including several utilities worldwide, and in anticipation of the availability of smart metering data, a data analytics-based approach is being developed to map the Irish LV distribution system. ESB Networks expects that this will offer a cost effective, resource efficient approach, and is therefore progressing a pilot prior to committing resources to any other mapping approach. The data analytics-based approach depends on the availability of smart metering data. As a result, the Programme will initially focus on the areas where the Smart Metering Programme has predominantly been rolled out including the greater Dublin and Cork regions.

ESB Networks has commissioned EPRI to develop a model using a data analytical approach including both smart metering and GIS data. Once the data is imported into the model, it will generate mapping results, customer referencing and customer phasing. ESB Networks will complete an appropriate level of validation of the generated mapping results on the ground. It is anticipated that this validation will be 10% of the generated mapping results during 2022 and 2023.

This validation will be carried out by ESB Networks field staff deployed on the ground over a 2-year period and the results will be imported into the GIS system with continued consultation with EPRI. Procedure and safety protocols will be developed, and training will be required by all ESB Networks field staff in consultation with the ESB Networks' National Training Centre (NTC).

FIGURE 6 **EPRI MODEL PROCESS**



5 WHAT THIS PLAN IS DELIVERING

5.23 AI IMAGE RECOGNITION APPROACH

One of the largest gaps in ESB Networks' LV model data is the connection between the ESB Networks utility pole to the customer premises. To address this, and to develop a potential alternative to the EPRI model approach, a proof-of-concept project is under development to use artificial intelligence (AI) image recognition software to scan through google street view images.

The functionalities under development are as follows:

1. **The tool will take current LV maps from GIS as an input and use the locations to automatically iterate through google street view to find the images of ESB Networks' utility poles with AI image recognition.**
2. **The AI image recognition will be able to look at this utility pole and determine whether there is conductor connecting from the pole to a customer's premises.**
3. **Where this conductor is identified, the tool will be capable of delivering a start and endpoint for this conductor so that is can be drawn back into GIS as a service conductor layer.**
4. **Once this information is known, it can be used along with a geospatial analysis to build out an LV connectivity model by connecting customer's MPRN locations to the new service conductor layer.**

The advantage of this method is that it will give us a more accurate picture of how and where our customers are connected to the network, as we will have more precise location on where the service conductor starts and ends in overhead LV networks.

Once the functionality of this tool is proven, it could be expanded to look at more than just service conductor and pole locations. The National Network, Local Connections Programme Operational Visibility and Mapping team has consulted the asset managers responsible for the management of these network assets, along with the data analytics team to determine areas of future development, some of which are as follows:

1. **Categorise wooden and steel poles.**
2. **Determine OH conductor construction type (bundled or flat 4 construction).**
3. **Determine mini pillar locations.**

5 WHAT THIS PLAN IS DELIVERING

5.24 ALTERNATIVE APPROACHES

Alongside the model approaches under consideration as detailed above, there are alternative approaches under consideration, such as correction of connectivity within GIS system. However, such alternative approaches may also be highly dependent on smart metering data availability. As such any alternative will focus on the geographical areas where smart metering installation has been rolled out. We will continue to research alternative approaches to ensure that what we deliver is an effective approach and make best use of the resources available to us over the life of the programme.

The GIS team has come up with a method which can run a logical model trace from the customer's MPRN back up to the ESB Networks' substation which will assess if there are any breaks or problems with the LV connectivity model. Once these breaks and problems have been highlighted, they can be corrected within GIS.

The GIS team has also come up with a method which can link MPRN locations to LV network based on physical distance from the LV network. Currently not all MPRN locations are in GIS, but this will increase as the smart meter programme progresses as all meter points are being recorded as part of this project.

GIS alternative approaches can be implemented when the extra non-field resources are assigned to the OVM team.

5 WHAT THIS PLAN IS DELIVERING

5.3 MONITORING CAPABILITIES

5.3.1 LV MONITOR CHARACTERISTICS

For ESB Networks to have an active, real-time view of the LV network, the installation of LV monitors on ground mounted and pole mounted MV/LV substations is required. LV monitoring is necessary for ESB Networks to offer flexibility services to its customer base, and to enable their participation in all markets for flexibility.

Each device will measure voltage and current in up to 6 LV circuits in the MV/LV substation. The device will use these measurements to calculate active and reactive power, power factor, power flow direction, and power quality total harmonic distortion (THD). Initially each measurement and calculation will be communicated back to ESB Networks' IT systems via 3G/4G connection initially, however communication will be via ESB Networks' private LTE network once it becomes available. ESB Network Telecoms are finalizing a tender process for the procurement of a partner to work with them to design and build the P.LTE Network. It is envisaged that the design will complete in 2022 and initial P.LTE coverage rollout will commence in 2022.

Each device will have on-board memory which will be capable of storing measurements if the data signal is lost. These stored measurements will again be communicated back to ESB Networks once the data connection has been restored.

Devices will be powered off the LV network and will have a capacitor backup so that they can perform a last gasp communication in the event of power failure. The devices will be sufficiently rated to protect against weather conditions and requirements will specify IP55 for ground mounted substations, IP66 for pole mounted devices.

5 WHAT THIS PLAN IS DELIVERING

5.3.2 EXAMPLES OF LV MONITORS

The LV monitoring rollout builds on the results of successful innovation trials undertaken previously. The devices shown in this section were purchased and trialed by ESB Networks in Project Winterpeak, which formed part of the Dingle Project. These serve as examples only. Although the investigation undertaken through Project Winterpeak is informing the specification and design consideration, the devices rolled out within the National Network, Local Connections Programme will be identified through a competitive procurement process.

Further information relating to the Dingle project can be found below:

https://www.esbnetworks.ie/who-we-are/innovation/esb-networks'-dingle-project

https://www.esbnetworks.ie/newsroom/blog-post/2021/06/28/esb-networks-dingle-project-more-information

FIGURE 7 **POLE MOUNTED MONITORING DEVICE DEVELOPED BY MAC DEVICES**

FIGURE 8 **INSIDE POLE MOUNTED MONITORING DEVICE DEVELOPED BY MAC DEVICES**

FIGURE 9 **GROUND MOUNTED MONITORING DEVICE DEVELOPED BY DEPSYS**

5 WHAT THIS PLAN IS DELIVERING

5.3.3 PROCEDURES AND TRAINING

Specific procedures and training for the installation and commissioning of the LV monitoring devices will need to be developed once the procurement process is complete. These procedures will address:

1. **On-site safety risk assessment.**
2. **Installation of monitors using live working procedures.**
3. **On-site commissioning for the device, including telecommunications commissioning.**
4. **Repair and maintenance of the device.**

Upon completion of procurement process, ESB Networks will complete pilot installations of the selected devices in ESB Networks' National Training Centre (NTC). Installation procedures will be developed for field staff to install LV monitors, referencing ESB Networks' safety rules, policies, and protocols. Training will be provided by ESB Networks to field staff carrying out installation, with this training provided under the control of the NTC.

5.3.4 MARKET SCAN/RESEARCH

Market research was conducted by ESB Networks, including engagement with LV monitoring device manufacturers including MAC Devices, VTechnology, Depsys, Eneida, EA/Powerpoint Engineering and Haysis. Each of these manufacturers have extensive experience with large customers both nationally and internationally. This is not an exhaustive list of manufacturers of these types of devices, and all manufacturers that bid into the tender process will be given equal consideration.

In these sessions, the vendors shared information relating to:

1. **Functionalities of their devices including the vendors methods for measuring voltage and current**
2. **Commissioning and installation procedures**
3. **Materials used in construction of device**
4. **Communications methods used by device**
5. **Interfaces of device with backend cloud-based software**
6. **Cybersecurity**

For more detail on the key insights developed through these sessions, please see section 4. Each vendor session helped inform ESB Networks about the availability of LV monitors on the market and to what technical specifications/ level they can be developed. The sessions confirmed to ESB Networks that the technical specifications required for our solution are available in the marketplace. Whilst marketing material and technical documentation were shared by manufacturers, this documentation cannot be included in this document as it is commercially sensitive.

5 WHAT THIS PLAN IS DELIVERING

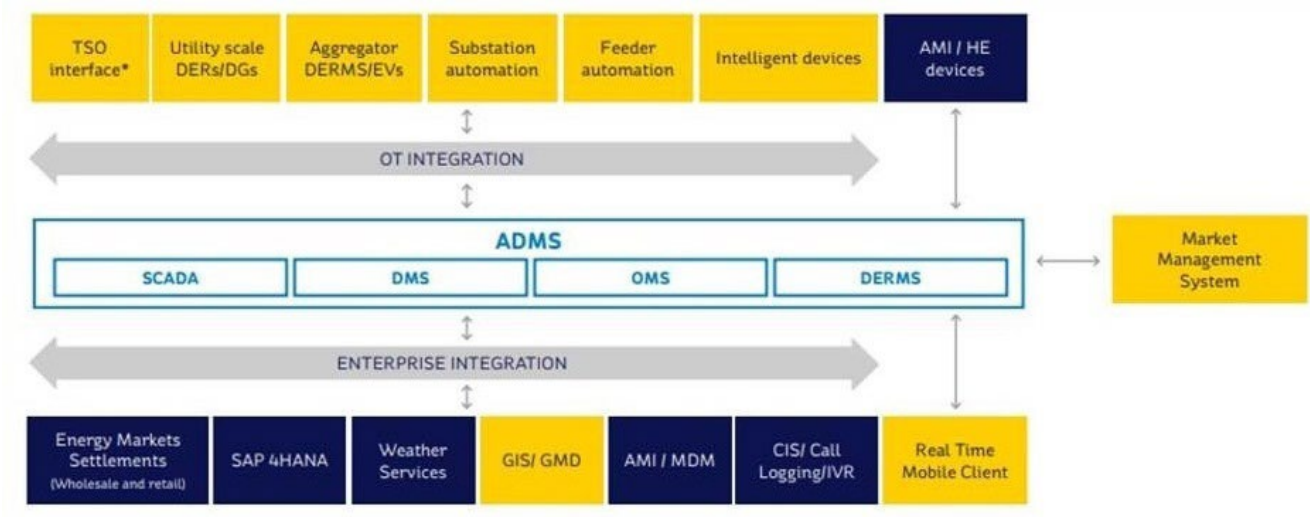
5.3.5 ADMS MAPPING

As part of the overall National Network, Local Connections Programme, ESB Networks is working towards implementing a fully integrated Advanced Distribution Management System (ADMS). Visibility of the LV network will be integrated into the ADMS which will give ESB Networks more operational control of the LV system. Pending the potential for programme adaptation based on conditions emerging over the coming years, this integration may be possible from Q1 of 2025. In the interim, the LV mapping data will be stored in the current ESB Networks' GIS system and used to support piloting and the development of initial dashboard functionality.

5.3.6 ADMS MONITORING

Once installed on the network, data from the LV monitors will be pointed to a gateway in a Microsoft Azure internet of things (IoT) hub environment. From here, ESB Networks will be able to import monitoring data from the Microsoft Azure IoT hub into the new ADMS once available. Real time information will then be fed to operations/control room staff to assist with network performance. Real time and historical data will also be made available to ESB Networks staff for further analysis when required. The creation of platforms and dashboards and associated analytics will be developed in the Microsoft Azure IoT hub environment. This solution will be developed when our successful ADMS vendor is onboarded to the programme once procurement is complete.

FIGURE 10 **REQUIRED IT & ARCHITECTURE**



6

Visibility Milestone Plan 2022- 2025

6 VISIBILITY MILESTONE PLAN 2022- 2025

The objective of the National Network, Local Connections Programme Visibility Multiyear Plan is to outline the roadmap for increasing visibility of the network between now and the end of year 2025. In 2020, it was agreed that visibility will be tracked and incentivised year on year by the CRU, working toward a target of 50% visibility of the network by the year 2025.

As well as introducing increased levels of visibility through the development of accurate network models and customer referencing, ESB Networks will need to begin to monitor the LV network. Such monitoring will be achieved by deploying measurement devices on the low voltage side of the MV/LV distribution substations.

Each year of the visibility multiyear plan, we will build upon learnings from the previous year. Delivery phases will follow typical project delivery lifecycle phases of High-Level Design (HLD), Detailed Design (DD), Build, Test and Deploy. The target for monitoring is to have 10,660 monitors installed by the end of 2025. This will follow a waterfall methodology however there will be significant overlap between each year. 2022 and 2023 will see the completion of detailed procurement, data analytics with the engagement of EPRI, and data integration. 2024 will follow a similar path however procurement of both digital and private long-term evolution (PLTE) monitors will be completed in 2023.

As part of PR5, the CRU is introducing an annual balanced scorecard based on ESB Networks' development and execution of a plan to secure increased visibility (50% of the low voltage network), improved customer referencing (assessment of 20% of all customers for connection point reference and LV feeder reference, and correction of the assigned referencing for those that are not based on collaborative use of AMI validation data), and monitoring (10,660 monitoring devices on the LV network) prior to the end of 2025. The scorecard focuses on the following three pillars, delivery readiness and sourcing, securing visibility, and sharing visibility.

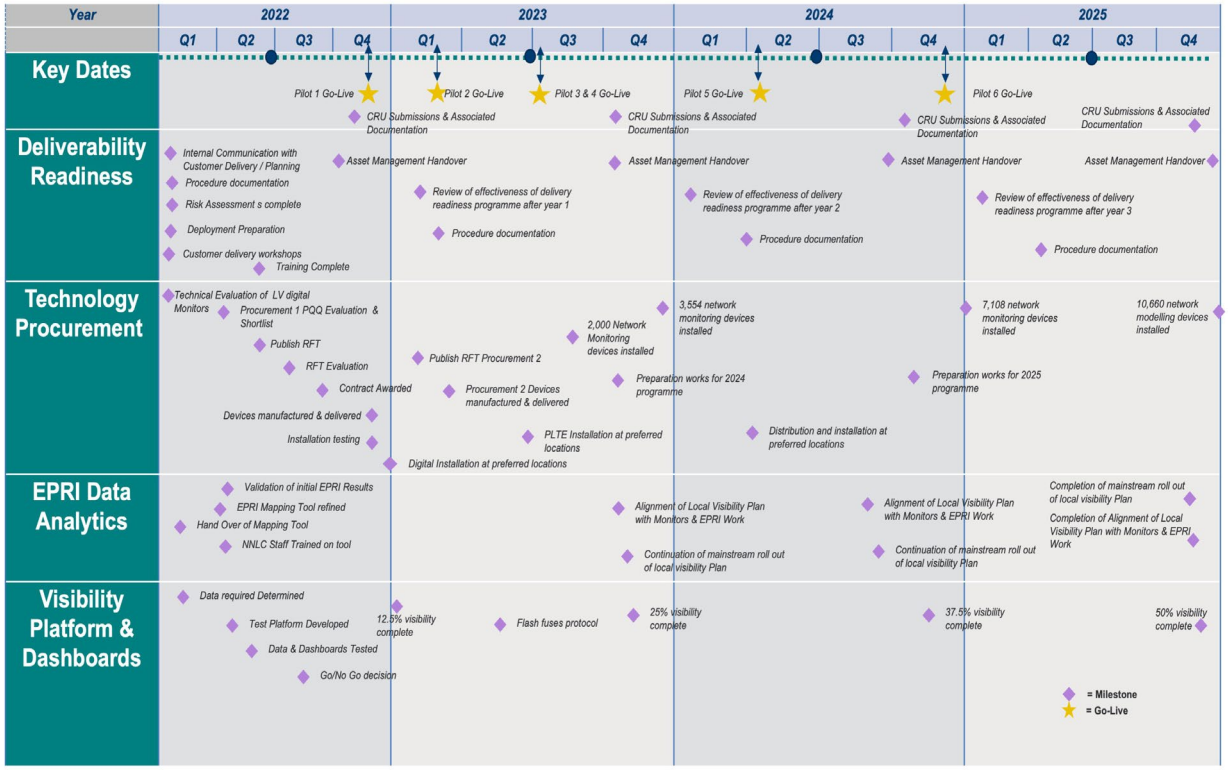
ESB Networks' performance will be scored on quality of plan & actions (20%), implementation (40%) and effectiveness (40%).

The scorecard is designed to reflect the need for better information and visibility of the LV Network, allowing the DSO to manage the networks more efficiently and deliver better outcomes and efficiencies for customers and market participants. This will require ESB Networks to gather and validate the reference information required to support the visibility of the LV network and deliver system interfaces required to enable visibility of the LV network. By the end of 2021, ESB Networks is required to deliver an LV visibility technical and delivery strategy roadmap. ESB Networks is also required to complete certain delivery readiness activities addressing technical, technological, and practical dependencies and develop a plan for the delivery of a beta data exchange platform.

6 VISIBILITY MILESTONE PLAN 2022- 2025

Please see the visibility multiyear plan for 2022-2025 below. This multiyear plan provides the basis of the proposed annual milestones to be used as targets in the PR5 Visibility Incentive.

FIGURE 11 **HIGH LEVEL PLAN ON A PAGE**



During 2023, 2024 and 2025, ESB Networks must also gather and validate reference information required to support the visibility of the network. The target for 2022 is to capture 12.5% off the LV network, this is to be expanded to 25% by the end of 2023, 37.5% by the end of 2024, and 50% by the end of 2025. During 2023, 2024 and 2025, ESB Networks must also gather and validate reference information required to support the visibility of the network. ESB Networks will also aim to install 10,660 LV monitoring devices on the network between by 2025.

Critical Path Milestones	2021 PR5	2022 PR5	2023 PR5	2024 PR5	2025 PR5	2026 PR6
Capture of 12.5% of LV Network		◊				
Capture of 25% of LV Network			◊			
Capture of 37.5% of LV Network				◊		
Capture of 50% of LV Network					◊	
LV Visibility Technical & Delivery Stage Roadmap	◊					
Development of plan for Data Exchange Platform (Beta Version)	◊					
Validate reference Information		◊	◊	◊	◊	
Procurement of monitoring devices		◊				
3,554 monitors installed on the LV Network			◊			
7,108 monitors installed on the LV Network				◊		
10,660 monitors installed on the LV Network					◊	

Legend
◊ Expected
◊ Complete
◊ Delayed
◊ Cancelled or Replaced

6 VISIBILITY MILESTONE PLAN 2022- 2025

The table below reflects the milestones from 2021 onwards.

YEAR	MILESTONES
2021	LV visibility: technical & delivery strategy roadmap. Readiness activities addressing dependencies. Sourcing of technical solutions. Development of a plan for the delivery of a beta data exchange platform. Commencement of gathering & validating reference information.
2022	Capture of 12.5% of LV Network by the end of 2022. Gather and validate customer reference information required to support the visibility of the LV Networks for 5% of all customers. Completion of the procurement of the monitoring devices.
2023	Capture of 25% of LV Network by the end of 2023. Gather and validate customer reference information required to support the visibility of the LV Networks for 5% of all customers. ESB Networks is working towards reaching a level of 3,554 monitors installed by 2023.
2024	Capture of 37.5% of LV Network by the end of 2024. Gather and validate reference information required to support the visibility of the LV Networks. ESB Networks is working towards reaching a level of an additional 3,554 monitors by 2024.
2025	Capture of 50% of LV Network by the end of 2025. Gather and validate customer reference information required to support the visibility of the LV Networks for 5% of all customers, delivering a total of 20% of all customers completed. ESB Networks is working towards reaching a level of an additional 3,553 monitors, delivering a total of 10,660 monitors, by 2025. Deliver system interfaces required to enable visibility of its LV network.

7

Dependencies

7 DEPENDENCIES

As with all transformation programmes, there are dependencies and constraints that require close and careful management to ensure the plan is delivered effectively. The key dependencies in relation to the Local Network Visibility Multiyear Plan have been captured below.

FOR	DESCRIPTION	YEAR	WHEN
GIS Data	GIS data to be extracted for EPRI – Connectivity information to be pulled for further support to the first two data sets.	**2022-2025**	**Annually Q1-Q4**
Smart Metering Data	There is a dependency that ESB Networks DPO will approve the use of AMI geospatial and voltage data which can be anonymised for use to develop the LV mapping model in order to achieve the 12.5 % Annual target of LV mapping from 2022 until 2025 inclusive.	**2022-2023**	**Annually Q1-Q4**
Customer Delivery	Customer delivery – Roll out installation team field staff for monitoring and validation of secondary model results and bridge gaps on data analytical model	**2022-2025**	**Annually Q1-Q4**
Network Telecoms	Availability of the LTE network required for procurement and the rollout of LTE monitors on the LV network.	**2022/2023**	**Annually Q1-Q4**
EPRI	EPRI required to build the data analytics model used in relation to increase mapping of the LV network.	**2022-2023**	**Annually Q1-Q4**

8

Next Steps

9 NEXT STEPS

1 **Procurement**
a). Monitor technical specification.
b). Tender process.

2 **Procedures**
a). Validation of mapping
b). Installation of LV monitors, including commissioning and risk assessments.

3 **Continue to develop the EPRI modelling tool.**

4 **Continue exploration of alternative mapping methods.**