ESB NETWORKS

Visibility Multiyear Plan

NATIONAL NETWORK, LOCAL CONNECTIONS PROGRAMME

DOC-100223-GYO

Updated following consultation in DOC-230921-GYO

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1 ADDENDUM-1

SL. NO	POINTS OF DIFFERENCE	SEPT 2021 VERSION	JAN 2023 VERSION	MAPPING/MONITORING
1	Target for renewable energy	70% or more	80%	NA
2	Deployment of field resources (boots on the ground) to validate the data analytics model	No reference to start date	Commence in Q1 2023	Mapping
3	Electric Power Research Institute (EPRI) to develop the data analytics model	Not reference to start date	Currently at testing phase, commence in Q2 2023	Mapping
4	AI Image recognition approach	Under discussion	In discussion with third party vendors for development and scalability of the application	Mapping
5	LV monitoring Device's installation targets	Under discussion	2023 planned for installation of nearly 30% of monitors in various sub-stations across the country	Monitoring
6	LV Monitoring devices installation numbers	2887 monitors for each year 2022, 2023,2024,2025	3554 monitors for each year 2023,2024,2025	Monitoring
7	Availability of the LTE network required for procurement and the rollout of LTE monitors on the LV network.	NA	The P.LTE rollout is currently at the phase of the procurement process. Will be finalised in Q2 2023 and go live in Q3 2023	Monitoring

SECTION	DESCRIPTION
BACKGROUND	This section describes the overall nn, lc program and how ovm will play role in reaching the enduring solution.
WHAT THE PLAN IS DELIVERING	This section provides detail in relation to ESB Networks incentivised targets set out by the regulator.
PROGRAMME DELIVERY APPROACH	This section details how ESB Networks plan to deliver on each of the incentivised targets
VISIBILITY MILESTONE PLAN	This section provides more granular detail in relation to year-on-year targets
DEPENDENCIES	This section outlines the key external stakeholders that will be required to deliver the programme delivery approach
IMMEDIATE NEXT STEPS	This section outlines the public consultation roadmap for 2023

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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
LVND	Low Voltage Network Discovery
MPRN	Meter Point Reference Number
MV	Medium Voltage
NN, LCP	National Network, Local Connections Programme
NTC	ESB Networks' National Training Centre
OCA	Operational Control Architecture
OH	Overhead
OMS	Outage Management System
OVM	Operational Visibility Mapping
PLTE	Private Long-Term Evolution
PQQ	Pre-Qualification Questionnaire
PR5	Price Review 5
PSR	Power System Requirements
QA	Quality Assurance
RFT	Request for Tender
SMDH	Smart Metering Data Hub
THD	Total Harmonic Distortion
TSO	Transmission System Operator
UG	Underground

3

Background

3 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 (LV) networks.

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, Irish electricity 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 c. 10 GW of renewable generation at transmission and distribution level, so that we can charge our cars and heat our homes using 80% renewable electricity**

Much of the change needed to achieve these targets will happen at the most local or 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.

Increased visibility of the LV Network means that as we operate the low voltage electricity system, ESB Networks will have accurate and timely visibility of what is happening on the network. This includes

1. **Accurate and up to date data about the exact locations of customers on the network, and of larger demand like electric vehicle (EV) charging points, heat pumps, batteries, solar panels and other low carbon technologies.**
2. **Accurate and up to date data about how the network is connected, and the capacity and other attributes of its components (for example, how much capacity each wire and transformer has available for additional demand or generation)**
3. **Real time and forecast data about electricity flows on the low voltage network, as a result of customers' individual and aggregate demand on each local network**

ESB Networks' ability to use this information in network planning and operations is critical to enabling small customers 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 accurate monitoring of the system.

3 BACKGROUND

Today we have the 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. Currently, ESB Networks' estimates how heavily loaded MV/LV substations are, 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 LV system to 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 LV system. It will allow ESB Networks to:

1. **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**
2. **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 LV 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 end of 2025, in addition to retrofit monitoring on the LV side of 10,660 MV/LV distribution substations by the end of 2025.

The purpose of this document is to update the multiyear plan by setting out our detailed plan for the period 2023 – 2025, and a high-level plan for 2026 – 2027. Where relevant to this forward-looking plan, we outline elements of the work delivered throughout 2021 and 2022 and to provide a roadmap for the approach to the programme management by ESB Networks in relation to reaching our targets mentioned above.

This document also provides detail in relation to procurement and planned installation of monitoring devices, resourcing requirements for the operational visibility and mapping work programme up until 2025, safety procedures, training, validation, installation, and commissioning. The success of the programme will require that certain milestones will continue to be met between now and the end of 2025 as detailed in Section 6 of this document.

At the beginning of Price Review 5 (PR5) one of the incentivised targets under the Operational Visibility Mapping workstream was to develop Platforms and Dashboards to enable customers to visualise the growth, penetration and DERs/renewable energy in their local network. However, ESB Networks believes that the creation of such dashboards would fit better under the flexibility workstream and form part of the flexibility incentive under the "Robust transparency" objective.

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What the Plan is Delivering

4 WHAT THE PLAN IS DELIVERING

4.1 INTRODUCTION

The Operational Visibility and mapping workstream will deliver two main pieces of work i.e., Increased levels of network mapping and increased levels of network monitoring.

Accurate network mapping will include accurate referencing of customers to substations and circuits, and the topology and electrical parameters of the LV circuits themselves. In cases where there are already records of the LV 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.

ESB Networks are also targeting the installation of 10,660 monitors in the MV/LV sub-stations to gather real time monitoring of the network by the end of PR5. The monitoring devices will be installed over the years 2023-2025 and will comprise of both ground mounted and pole mounted devices. Once installed that will allow ESB Networks to measure certain electrical parameters including both voltage and current in up to 6 LV circuits in the MV/LV substation. Such measurements will be then used to calculate active and reactive power, power factor, power flow direction, and power quality total harmonic distortion (THD) at the monitored location, once fed back to the control room this will result in ESB Networks having more control of the LV network (further detail in **Appendix F**).

4.2 LV NETWORK MAPPING (50% BY THE END OF PR5)

Mapping Capabilities

ESB Networks is developing accurate maps/models of the low voltage system using and correcting existing Geographic Information System (GIS) data, Advanced Metering Infrastructure (AMI) data, data analytics and field spot checks.

The mapping solutions that have been developed and will continued to be developed throughout 2023-2025 include:

1. **GIS Geospatial Validation (further detail in Appendix A)**
2. **Electric Power Research Institute (EPRI) Tool (further detail in Appendix B)**
3. **LV Network Discovery (further detail in Appendix D)**
4. **Artificial Intelligence (AI) Mapping (further detail in Appendix E)**
5. **Other solutions – we will continue to seek and develop potential solutions as they arise**

Each of these solutions has different requirements and different strengths in terms of the kinds of network to which they are best suited. By efficiently deploying these solutions in combination across the network, we can secure accurate visibility of the network as a whole.

4 WHAT THE PLAN IS DELIVERING

To achieve the 50% target by the end of PR5, the GIS Geospatial Validation will continue to be deployed in additional planner groups throughout 2023, 2024 & 2025. This will target the correction and validation of the LV network associated with 50% of the customer base, by the end of PR5.

As the GIS Geospatial validation work is completed in each planner group and more AMI data becomes available, it is planned that the outputs from the EPRI tool and LV Network Discovery will be layered into the GIS model to give a full picture on customer referencing and phasing.

4.2.1 GIS GEOSPATIAL VALIDATION

GIS geospatial validation has been deployed since Q4 2022, which involves correction of connectivity within the GIS model.

The GIS geospatial validation runs a logical model trace from a customer's Meter Point Reference Number (MPRN) back up to the MV/LV substation, assessing 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 model.

ESB Networks' GIS experts have also devised a method which can link the geospatial coordinates of an MPRN to the LV network based on physical distance from the LV network. Currently not all MPRN coordinates are recorded in GIS, however this information is being gathered as part of the smart metering programme. Further details on the GIS geospatial validation can be found in **Appendix A.**

4.2.2 EPRI TOOL

From market research including several utilities worldwide coupled with the current availability of AMI data, a data analytics-based approach has been developed to map the Irish LV distribution system. ESB Networks understands if successful, this will offer a cost effective, resource efficient approach, and is therefore progressing this solution. AMI data will be used to test the effectiveness of this approach in Q1 2023. As this solution is dependent on AMI data the initial deployment will focus on the areas where the Smart Metering Programme has been rolled out.

Once the data is imported into the EPRI tool, it generates mapping results, customer referencing and customer phasing. ESB Networks will complete an appropriate level of validation of the generated mapping results on the ground. The EPRI tool will initially be deployed across 50% of the LV Network between now and the end of PR5, if successful it is envisaged that deployment will continue beyond PR5 into 2026 and 2027. It is anticipated that 10% of generated mapping results will be validated by a "boots on the ground" exercise between now and the end of PR5.

This validation will be carried out by ESB Networks' field staff deployed on the ground over a 3-year period up to the end of PR5 and the results will be imported into the GIS system with continued consultation with EPRI. Procedure and safety protocols relating to this validation were developed and have been approved by the ESB Networks' Safety Programme Implementation Group (SPIG) committee in Q4 2022. The training will continue to be provided in consultation with the ESB Networks' National Training Centre (NTC) to the required ESB Networks' field staffs. More details about this approach can be found in **Appendix B.**

4 WHAT THE PLAN IS DELIVERING

4.2.3 LV NETWORK DISCOVERY

ESB Networks is piloting an approach for mapping the LV Network by utilising substation data recorded by the network technicians on an internal portal (MyForms) along with "loss of supply" event data recorded on Smart Meters. A pilot will be conducted across 12 locations in Q1 2023 if the results from the pilot are positive, ESB Networks will explore the potential to roll this solution out across further locations. AMI data will be used for conducting pilot and various functionalities of the Smart Meter are being explored to co-relate the "loss of supply" event data with the sub-station data to correctly identify the phase, outlet and the sub-station information. For more details on the LV Network Discovery process, please refer to **Appendix D**.

4.2.4 AI MAPPING APPROACH

One of the largest gaps in ESB Networks' LV model data is the connection between the electricity utility pole to the customer premises. To address this, and to develop a potential alternative to the EPRI tool approach, an initial proof of concept study was undertaken in Q2 2022. The success of this study allowed ESB Networks' move into the second phase where pilots were conducted in Q3 2022. Through the initial pilots field trials the use artificial intelligence (AI) image recognition software was used to scan through street view images.

ESB Networks are currently in conversation with third party vendors for potential collaboration and scaling of the AI mapping approach. Such an approach is explored due its cost effective and time efficient nature. The functionalities were explored throughout the first two phases and that will continue to be developed including the following:

1. **The tool takes existing LV maps from GIS as an input and uses the location coordinates to automatically iterate through street view. This allows the user find the images of electricity utility poles once AI image recognition is deployed it is possible to differentiate between electrical and non-electrical utility poles.**
2. **The AI image recognition selecting a particular utility pole can determine whether there is conductor connecting from the pole to a customer's premises.**
3. **Where this conductor is identified, the tool delivers the start-point and endpoint coordinates for this conductor it can then be updated into GIS as a service conductor layer**
4. **Once this information is known, it can be used along with GIS Geospatial validation 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. The initial results when testing this method were very positive as such ESB Networks is exploring the potential to collaborate with a third party to roll out this solution across multiple planner groups.**

4 WHAT THE PLAN IS DELIVERING

Once the functionality of this tool is proven, it may be expanded to look at more than just service conductor and pole locations:

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

This solution will allow ESB Networks' to fill in the gaps of missing O/H network data to help create a connected LV model. Further details on the AI mapping technique and different stages of the pilots can be seen in **Appendix E**.

A comparison of different mapping options are shown in the table below, with the strengths and drawbacks, and the training requirements for each of the different mapping options.

METHOD	STRENGTHS	DRAWBACKS	TRAINING REQUIREMENTS
GIS Geospatial Validation	- Data based exercise, can be completed largely without deployment of field resources - Resources who are already available can be utilised for running the model - Creates LV connected schematic	- Cannot be used in areas with no existing GIS records - Doesn't give phase info	Training for mapping resources to correct the GIS maps
AI Mapping	- Can be used in areas with no GIS records - Can be used with geospatial tool to connect MPRNs	- Does not indicate normally open positions, phasing or asset details - Overhead assets only	Dependant on decision to fully roll-out
EPRI Tool	- Geospatially maps customers	- In development, accuracy unknown - Without AMI data access, tool cannot be used	Training required for mapping resources to run the tool, once testing and development is complete
LV Network Discovery	- Produces accurate outlet & phase referencing for customers - Can be used to draw networks where no GIS records exist - Can be used to find Normally Open positions - No training required	- Not yet piloted - Results in momentary customer interruptions - Without AMI data access, tool cannot be used	Briefing required for network technicians
EPRI Field Validation	- Produces very accurate network schematics	- Manual and Labour intensive	Training required for network technicians

4 WHAT THE PLAN IS DELIVERING

The attributes that are required to be updated as part of the connectivity/ referencing are listed below.

1. **Phase info**
2. **Outlet info**
3. **Sub-station info**

Each of the different mapping options are compared in the table below identifying each of the attributes that can be captured using a particular technique (mentioned in appendix).

MAPPING OPTIONS	CONNECTIVITY/ REFERENCING ATTRIBUTES		
	OUTLET INFO	PHASE INFO	SUB-STATION INFO
GIS Geospatial Analysis	✓		✓
LV Network Discovery	✓	✓	✓
EPRI Field Validation	✓	✓	✓
EPRI Tool		✓	

4.3 LV MONITORING (10,660 INSTALLATIONS BY END OF PR5)

For ESB Networks to have an active, real-time view of the LV network, the installation of LV monitors on both ground mounted, and pole mounted MV/LV substations is required. Therefore, ESB Networks is planning to install 10,660 during the remainder of PR5. These devices will measure electrical parameters (voltage and current) of the sub-station and perform calculations on these measurements (active and reactive power, power flow direction, voltage total harmonic distortion). The data will be fed back to the cloud platform through ESB Networks' IT systems via 4G connection initially, and then through the private Long-term Evolution (LTE) network once it becomes available. Active and real LV monitoring of the LV network is necessary for ESB Networks to offer flexibility services to its customer base, and to enable their participation in all markets for flexibility.

In preparation for the procurement of the monitoring devices, technical and functional specifications for LV monitoring devices were developed, procurement is due to be complete in Q1 2023 with the commencement of installations in Q2 2023. ESB Network Telecoms are also in the final stages of 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 deployment of core and radio infrastructure will be finalised in Q2 2023 and the service go-live is scheduled for Q3 2023 and will continue to be rolled out across the network for the remainder of the PR5 period.

Further details on the installation of LV monitors can be found in **Appendix F**.

4 WHAT THE PLAN IS DELIVERING

4.4 INTEGRATION TO ADMS/ENDURING SOLUTION

ADMS Mapping

As part of the overall National Network, Local Connections Programme, ESB Networks is implementing an Advanced Distribution Management System (ADMS). Visibility of the LV network will be integrated into the ADMS which will give 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 Q2 of 2026. In the interim, the LV mapping data will be stored in ESB Networks' GIS system and used to support piloting and the development of initial dashboard functionality.

ADMS Monitoring

Once installed on the network, data from the LV monitors will be pointed to a gateway in an internet of things (IoT) hub environment. From here, ESB Networks will be able to import monitoring data from the 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 different functions (for example network asset managers and investment planners) for further analysis when required.

5

Programme Delivery Approach

5 PROGRAMME DELIVERY APPROACH

5.1 VISIBILITY BLUEPRINT (LOCAL VISIBILITY PLAN)

Our "Visibility Blueprint" refers to our investigating and piloting of 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 engaging with utilities worldwide to leverage collaboration.

Leveraging Collaboration With Other Utilities And Organisations:

ESB Networks has been able to leverage industry expertise in relation to the development of a multiyear plan for LV mapping and monitoring. Collaboration with multiple stakeholders including various Distribution System Operators (DSOs) in the US and Europe helped form the design, analysis, and development of the visibility blueprint. Information sharing sessions were held with Eredes, Iberdrola and Naturgy.

ESB Networks and each of these utilities presented on their current or proposed smart grid solutions and rollout and implementation of their work programmes were discussed. A particular focus was placed onto how network improvements have delivered benefit to their customer base.

Practical Delivery Readiness Piloting:

Programme-specific pilots were undertaken where necessary in 2021 and 2022. To support the EPRI tool, field validation of the outputted network models in a subset of locations will be carried out by the network technicians, this will commence in Q1 2023 and carry on until the end of PR5. To be able to do this, alternative cable tracing devices were tested in the field during 2022. Existing approved cable tracing and identification equipment utilised by ESB Networks include:

1. SEBA LCI TX440
2. LV 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.

5 PROGRAMME DELIVERY APPROACH

5.1.1 SECURING VISIBILITY

"Securing visibility" refers to the development of operational quality, LV 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" has involved the exploration of technical approaches and strategies for increasing the level of mapping of the LV electricity networks that are accurate and efficient. The future blueprint for increasing this level of mapping in PR5 will involve the continued rollout of GIS Geospatial validation across further planner groups. This process will correct any existing data issues found while also identifying areas where network information is inaccurate. Once GIS Geospatial validation is complete in a given planner group, ESB Networks will then run the EPRI tool and potentially the LV Network discovery option (dependent on the success of the pilot), allowing them to layer on additional information into their GIS system.

A customer being "referenced" to a point on the network means that there is a record of the network location where they are connected. Without the correct customer referencing it is effectively impossible for the system operator to have any visibility. As such customers will not be able to participate in any demand side response activities (either with the DSO, the Transmission System Operator (TSO) or any third party) until they are referenced correctly. At the beginning of PR5, 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 (i.e., a dummy feeder) on a secondary substation.

To achieve 50% LV network mapping / models by the end of 2025 will rely on ESB Network's having the corresponding customer base correctly referenced, as this is one of the core components of a fully connected LV model. This will be achieved by continuing our GIS Geospatial validation work and overlaying the outputs based on the use of the EPRI tool and the potential use of LV Network Discovery. As previously mentioned, both the EPRI Tool and LV Network Discovery solution will rely on access to AMI data as smart meters are rolled out.

5.1.2 DELIVERABILITY & READINESS

Procedures and Training

Specific procedures and training for the installation and commissioning of LV monitoring devices will need to be finalised 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 PROGRAMME DELIVERY APPROACH

5.1.2.1 DELIVERY DOCUMENTATION

Prior to the EPRI field validation 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.

Throughout 2022 similar procedure documents were also developed for the alternate mapping projects mentioned i.e., the Geospatial Analysis, EPRI field validation, AI mapping and LV Network Discovery further detail included in Appendix. Once the procedure documents are approved, they will be published in ESB Networks' OneSource documentation system, after which any training will take place for the field staff who are carry out the procedures.

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)	Targeting to complete in Q1 2023
EPRI field Validation results for National Network, Local Connections Programme	1. Procedure document for validation of LV mapping output results from EPRI tool and the recording of updated data. 2. Safety risk assessment document for validation for field staff.	Developed in May 2022 Approved in July 2022
Low Voltage Network Discovery	1. Procedure document for LV Network Discovery 2. Safety risk assessment document LV Network Discovery	Targeting to complete in Q1 2023
GIS Geospatial analysis	1. Safety risk assessment for Geospatial analysis	Developed in Q3 2022
AI Mapping	1. Safety risk assessment for AI mapping using image recognition technique	Targeting to complete in Q2 2023
LV Network Discovery DPIA	1. Data Protection Impact Assessment for the use of substation data recorded on the MyForms portal along with "loss of supply" event data recorded on Smart Meters	Developed in Q2 2022
EPRI Tool DPIA	Data Protection Impact Assessment for the use of smart metering power quality data and GIS data	Developed in Q1 2022

5 PROGRAMME DELIVERY APPROACH

The development and update of the requisite delivery documentation will continue as an on- going process into 2023 and beyond. This documentation will need to be added to or adapted to account for:

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

5.1.2.2 USE OF DATA ANALYTICS

Data analytics has been used in different areas of the programme to date, including the identification of locations for the installation of monitoring devices. ESB Networks has also used a data analytical approach to create a dashboard showing geographical locations of 10,660 LV monitoring devices between now and the end of PR5.

The key areas where further data analytics developments will be delivered between now and the end of PR5 are as follows:

1. **An IT script has been developed to validate and correctly reference MPRNs in the ESB Networks' SAP system, this script will be run on a regular basis as further errors are identified through our various mapping options i.e., EPRI tool output, GIS Geospatial validation and LV Network Discovery**
2. **GIS Geospatial Validation Script has been developed and will be deployed across each of the 34 planner groups as we complete our validation and corrections. The script will connect the MPRN back to the MV/LV substation**
3. **AI Mapping has the potential to determine LV overhead network that is currently not recorded in our GIS system therefore allowing us to build a more detailed schematic**
4. **EPRI data integration- data analytics will be used to effectively record and store various attributes (customer phase info, location coordinates, etc) that will be recorded by the network technicians during the field validation**
5. **LV Network Discovery data integration- Operational Visibility & Mapping (OVM) team will utilise data analytics techniques to streamline and simplify the process for extracting the outage event data from the Smart Metering data hub (SMDH), where the event data linked to the MPRN is stored**

5 PROGRAMME DELIVERY APPROACH

5.1.2.3 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 was substantively completed in Q4 2022. Training will be complete prior to commencement of installation in early 2023, monitor installations will continue throughout 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 were 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**

The second phase of monitoring location selection began in 2022 during which the development of a dashboard. The dashboard has enabled the selection of additional substation locations for the installation of LV monitors during 2023. The second phase involved expert cross-functional collaboration within the NN, LC Programme to enhance the analysis of candidate locations for piloting. Based on this, an additional 1554 locations have been selected and have been included alongside the initial 2,000 locations in the 2023 work programme.

5.1.2.4 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 2022 was the design and development of the P.LTE network.

The P.LTE rollout is currently at the latter phase of the procurement process. It is envisaged that the deployment of core and radio infrastructure will be finalised in Q2 2023 and the service go-live is scheduled for Q3 2023 and will continue to be rolled out across the network for the remainder of the PR5 period.

5 PROGRAMME DELIVERY APPROACH

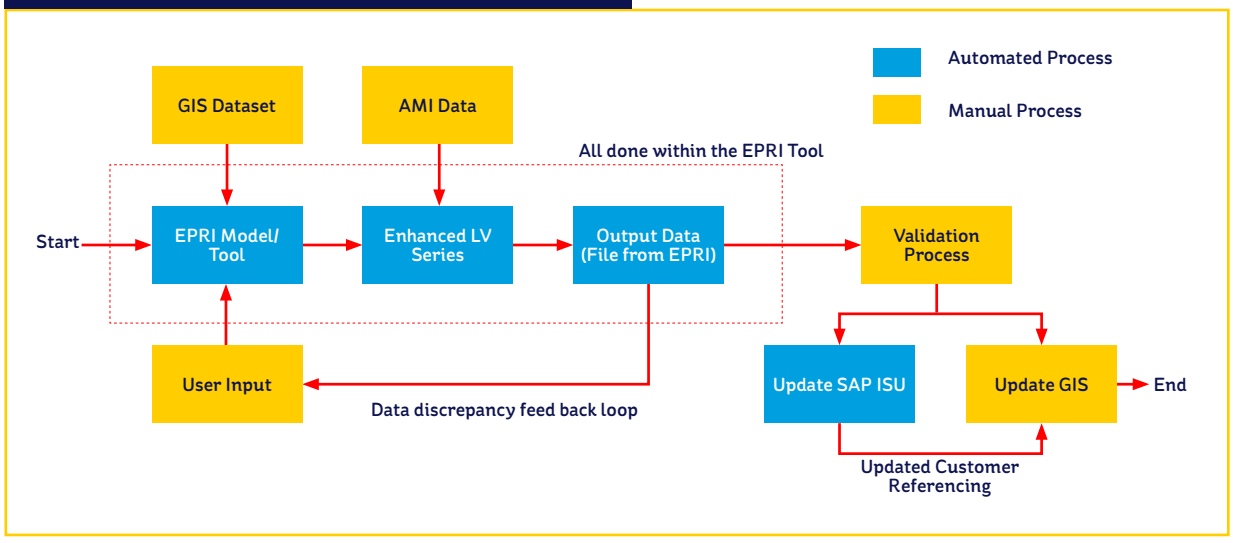
5.1.3 NETWORK MODEL FORMATS & QA

ESB Networks is working on the definition of a suitable network model format for import to an advanced distribution management system (ADMS) and the development of a quality assurance process for EPRI field validation. The EPRI field validation exercise is due to commence in Q1 2023, the locations were identified, and area briefings were conducted in Q4 2022.

An important aspect that required completion prior to the rollout of the ERPI tool was the definition of the "data journey". Throughout 2022 the requirements relating to the development of the interfaces between the systems involved in this process/journey were defined. These systems included 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). This predefined data journey will be adhered to throughout the remainder of the programme.

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 1 – 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 in 2023, 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 NN,LC Programme Operations Systems Roadmap (available here).

FIGURE 1 – **EPRI PROCESS FLOW FOR DATA TRANSFER**

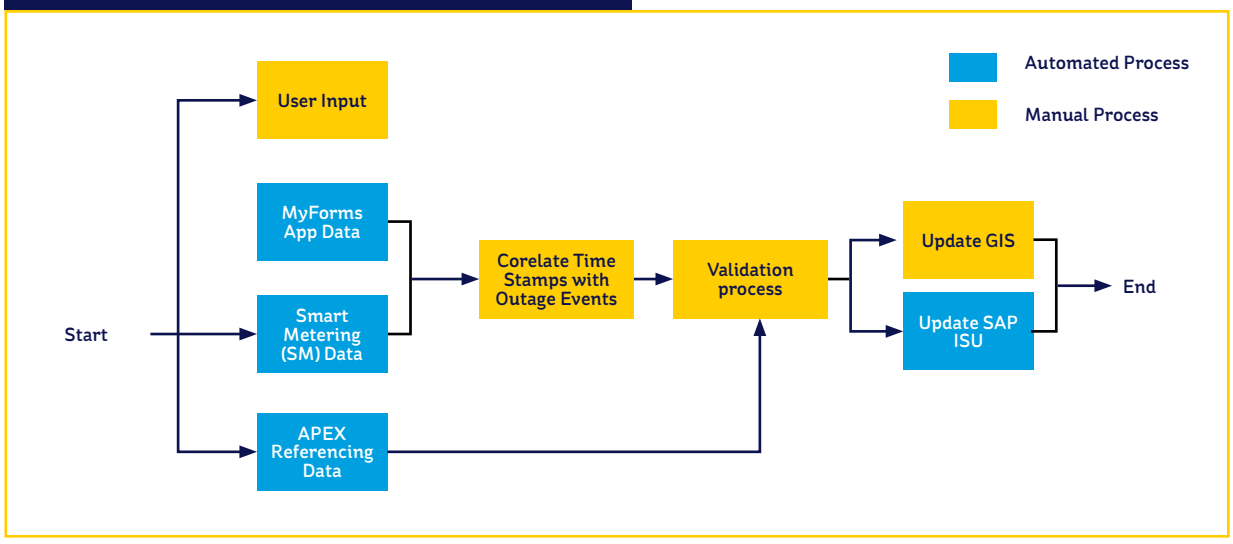


5 PROGRAMME DELIVERY APPROACH

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 General Data Protection Regulation (GDPR) and to comply fully with these requirements. ESB Networks are currently testing the beta version of the EPRI tool, ESB Networks have sent a sample set of data extracted from GIS to EPRI. EPRI has developed the mapping/modelling tool using these sample datasets from GIS and some extrapolated AMI data to develop and test the beta version. Once the full version of the tool has been developed, it will be handed over to ESB Networks for "boots on the ground" validation 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.

LV Network Discovery may be used as an alternative method to correct customer referencing in SAP IS-U and network data in GIS. This is due to be piloted in Q1 2023 (see Figure 2 for the LV Network Discovery pilot process). Network technicians will record data in the MyForms App as they complete the work in the field. Outage Event data will be extracted from the smart metering SM dashboard and the time from the outage events and time from the MyForms portal will be analysed to corelate outages caused by the network technician with outages recorded in the smart meter. This correlation will give us the correct customer network reference. This information will be validated against referencing data available in the APEX application. Updated customer referencing will then be uploaded into SAP IS-U. This reference data will also be used to update missing sections of our LV maps in GIS. A more detailed process is described in **Appendix B**.

FIGURE 2 – **DATA TRANSFER LV NETWORK DISCOVERY**



5 PROGRAMME DELIVERY APPROACH

The EPRI field validation safety and procedure documents were approved by ESB Networks' Safety Programme Implementation Group (SPIG) in July 2022 and were published in ESB Networks' OneSource document management system. The training for the on-the-ground validation exercise was carried out with teams nationwide in collaboration with the National Training Centre (NTC). The field validation is due to commence in Q1 2023. Several insight sessions were held with EPRI for delivering training on the EPRI tool, allowing ESB Networks to familiarise with the tool and its functionalities.

The procedure documents for alternate mapping projects- i.e., LV Network Discovery and the AI image recognition are currently under development and will undergo a similar process for approval. GIS geospatial validation analysis documentation has been developed, reviewed and has received the adequate approval.

5.2 SOURCING AND RESOURCING

ESB Networks' programme management and resourcing activities for 2023-2025 will see the advancement of our LV mapping strategy. This strategy will include the ramping up of our GIS Geo-Spatial validation, the commencement of the use of the EPRI tool for LV network modelling and its associated validation works. It will also see the introduction of the LV Network Discovery Pilot in Q1 2023.

Q2 2023 we will see the beginning of the installation of the initial 3,554 LV monitors, this will be followed by an additional 3,554 each year until the end of PR5. To achieve our PR5 milestones ESB Networks will continue to address all labour and technological needs as required. A key aspect of this is the onboarding of additional staff where required in relation to the various mapping solutions under development.

Throughout 2023 GIS Geospatial Validation will remain as our high priority mapping solution. There is a significant labour-intensive element to this solution due to the nature of the work as ESB Networks are validating and amending the existing network model in GIS. As such ESB Networks has identified the need for additional geospatial information system (GIS) mapping experts to be deployed within the OVM workstream from Q1 2023 until the end of PR5.

Once the GIS Geospatial Validation is complete geospatial scripts can then be run creating a fully connected LV schematic based on available & existing data. Further details can be found in **Appendix A** of this document.

The EPRI modelling tool (further detailed in **Appendix B)** and LV Network Discovery (explained in **Appendix D** of this document) solutions are interlinked with the Geospatial validation. Each of these solutions once implemented will be layered over this corrected and connected GIS network. Technological needs will include the continued development of various dashboards and applications that will assist with progress on both mapping and monitoring of the network.

5 PROGRAMME DELIVERY APPROACH

ESB Networks has identified the need to deploy a team of network technicians for:

1. **MV/ the installation of the 10,660 LV monitoring devices between now and the end of PR5**
2. **for the validation of LV maps/models derived using an analytics-based tool developed in collaboration with the Electric Power Research Institute (EPRI) – hereby referred to as the "EPRI tool"**
3. **For the successful implementation of the LV Network Discovery (LVND) pilot –another alternative mapping / modelling solution - due to commence in Q1 2023**

The mapping options that will be continued to be developed throughout 2023-2025 include:

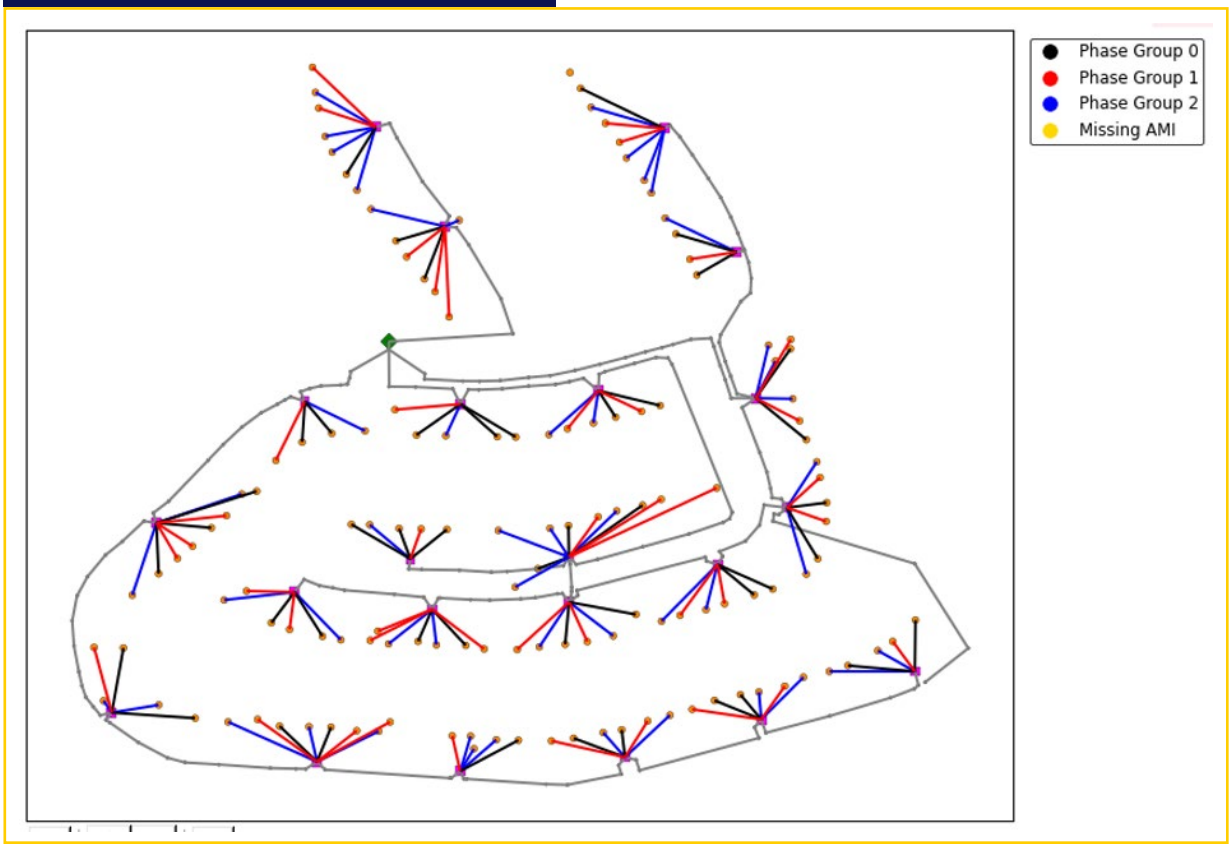
1. **GIS Geospatial Validation (further detail in the Appendix A)**
2. **EPRI Tool (further detail in the Appendix B)**
3. **LV Network Discovery (further detail in the Appendix D)**
4. **AI Mapping (further detail in the Appendix E)**

The current GIS Geospatial Validation will be deployed in additional planner groups throughout 2023 with a target completion of the network associated of 50% of the customer base, by the end of PR5. The programme management and resourcing pillar requires that ESB Networks define a suitable LV network model for import to an Advanced Distribution Management System (ADMS) system and the development of a quality assurance process for model validation. This quality assurance process will commence in Q1 2023 and will continue until the end of PR5 with the potential to be extended into PR6. The process involves a validation exercise of the results of the LV mapping tool. A beta version of the tool has been developed by the Electric Power Research Institute (EPRI) and is under internal review/testing at present. It is envisaged that the production version of the tool will be available for use in Q1 2023 once initial testing of AMI data is complete.

Once the production version of the tool is deployed into the ESB Networks' ecosystem it will use linear regression modelling using AMI data including voltage, current, active, and reactive power. This will allow for the development of 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). The images below are captured from the beta tool.

5 PROGRAMME DELIVERY APPROACH

FIGURE 3 – **PHASE ESTIMATION VISUALISATION**



The Quality Assurance (QA) process will commence in Q1 2023 using a "boots on the ground" validation to be undertaken by suitably qualified and approved network technicians. Procedure documentation for this validation exercise has been approved and will be adhered to throughout the QA exercise and will be updated appropriately. The end-to-end process for EPRI Tool field validation can be found in **Appendix B**.

A range of innovative data-based solutions will be required to achieve our overall visibility targets. Throughout 2022, ESB Networks explored various alternative options to the solution developed in collaboration with EPRI to account for the range of different network types and underlying data levels available. Various mapping options have been explored to identify range of efficient innovative solutions.

LV Network Discovery has also been identified as an alternative approach due to its ability to provide an unambiguous correction of customer referencing to phase (R, S, T), LV outlet and MV/LV substation. LV Network Discovery piloting is due to commence in Q1 2023, a decision to continue this process beyond a pilot will be made by the end of Q1 2023. More detail in relation to this process can be found in **Appendix D**.

5 PROGRAMME DELIVERY APPROACH

Throughout 2023-2025 ESB Networks will continue to explore and develop the AI mapping technique using Image Recognition. This process will utilise AI image recognition software to process the street view images. Once the images are processed this will allow ESBN to identify where overhead assets are located, data will then be translated and stored in GIS for use in LV electrical modelling. Further detail on this is set out below in **Appendix E**.

ESB Networks will continue to build upon what was achieved to date and will continue to deliver the approved work programme set out for the remainder of PR5. To date ESB Networks have begun to build out a team of mapping experts and have commenced the GIS Geospatial Validation in several highly populated planner groups. The procurement of the LV monitoring devices is currently at the Request for Tender (RFT) stage with the expectation that contracts will be signed in Q1 2023.

ESB Networks have drafted safety and procedural documentation in relation to LV monitoring installations and completed safety and procedural documentation in relation to both the EPRI field validation process and the LV Network Discovery pilot. Throughout 2022 ESB network technicians have been briefed in relation to the work packages for EPRI field validation and LV Network Discovery. Further briefings will continue throughout the remainder of PR5 in to the above and LV Monitor installations. In Q4 2022 a software script was tested and deployed to rectify incorrectly referenced MPRNs, data analytical approaches were used to aid with the selection of the sub-station locations for the installation of LV monitors and for the development of dashboards to see progress in relation to the LV mapping.

Throughout the remainder of PR5 ESB Networks will continue to onboard additional staff to carry out the required LV mapping and modelling work, we will develop additional procedural and safety documentation as required.

5.2.1 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 in 2022 this will be reviewed at regular intervals throughout the remainder of the programme. 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 of the LV network. The proposed work programme has been approved by ESB Networks' programme delivery team and the required resources have been included on the work programmes for 2023. Throughout 2023 we will work with the programme delivery team and human resources to define and finalise the resource requirements for the 2024 work programme.

Throughout 2022 ESB Networks began to implement delivery models, including commencement of additional resources for LV network mapping and modelling. With regards to the validation of the maps/network models delivered using the EPRI tool, our current estimates indicate that it will take two appropriately qualified network technicians one day per MV/LV substation to carry out this task. The basis of this estimate is the experience of network technicians who have previously delivered this type of work.

5 PROGRAMME DELIVERY APPROACH

Throughout 2022 ESB Networks began to implement delivery models, including commencement of additional resources for LV network mapping and modelling. With regards to the validation of the maps/network models delivered using the EPRI tool, our current estimates indicate that it will take two appropriately qualified network technicians one day per MV/LV substation to carry out this task. The basis of this estimate is the experience of network technicians who have previously delivered this type of work.

For the LV Network Discovery pilot our current estimate is that on average, it will take one network technician two hours to carry out the necessary work at each LV/MV substation. The LV Network Discovery pilot includes 12 different sub-station locations, taking a total of 24-man hours. This estimate is based on the analysis of experienced network technicians within ESB networks. This pilot is due to commence in Q1 2023.

This LV Network Discovery Pilot is applicable to Ground Mounted and Indoor MV/LV Substations in 12 MV/LV Sub locations only. The 12 locations were selected in areas with a high level of smart meters installed. The Pilot is proposed to be completed before the end of Q1 2023.

With regards to the installation of monitors, our current estimate is that on average, it will require appropriately one qualified network technician one day to install 3 monitoring devices. The basis of this estimate includes outputs from piloting of sample monitor devices and lessons learned from the Dingle Project along with 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 in early 2023. Under certain conditions, additional time and resources will be required to complete the work, 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**
2. **Age, condition, and model of certain LV assets may need extra time and resources to safely install monitors and to safely carry out EPRI field validation**

The resourcing requirement will be kept under review and updated as appropriate for future years within PR5 based on lessons learned as the installations are completed.

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

5 PROGRAMME DELIVERY APPROACH

The definition process to date has 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 LV mapping using linear regression modelling of AMI data from the smart meter**
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 Pre-Qualification Questionnaire (PQQ) documentation and associated technical specification prior to the commencement of the procurement of LV monitoring devices**
6. **ESB Cyber Security and Solution Architecture teams to ensure proposed technical specification were cyber security and Network & Information System (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 AMI data fields to build out the LV network model and to provide guidance on the appropriate processes for data management and storage**
8. **Develop an AI Image recognition model using pole imagery**
9. **ESB Networks GIS Team to explore the potential to develop a connectivity model using the AMI data**

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

5 PROGRAMME DELIVERY APPROACH

5.2.2 SOURCING MONITORING DEVICES

Sample monitoring devices are expected from the vendor post completion of the RFT stage in Q1 2023. These sample devices will be tested in a 3rd party laboratory and out in the field to confirm their suitability.

In preparation for the procurement process, technical and functional specifications for LV monitoring devices were developed. The specifications developed were informed by each of the following:

1. **Market research and meetings with vendors/manufacturers to assess the technical capabilities of products on the market has informed this specification**
2. **Review of the lessons learned regarding LV Monitoring devices from the Dingle Project**
3. **Engagement with ESB Networks' procurement specialists**
4. **Engagement with ESB legal and finance in relation to the procurement documentation**
5. **Engagement with both ESB Networks' Overhead and Underground assets teams**

Key aspects of the technical specification developed included:

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

Throughout 2023 we will complete the overall procurement of devices, place initial orders with the selected vendors, confirm locations for delivery of monitoring devices and commence installations.

For further details on the monitor installation, please refer to **Appendix F**.

5.2.3 SOURCING A MAPPING / MODELLING TOOL

As set out in our publication in Q1 2022 and described more detail in Appendix B 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 LV mapping/ modelling. This involves the use of data science to derive the LV network model from a combination of data sources, including ESB Networks' existing GIS system, 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, one sourcing approach adopted was to carry out research collaboration with EPRI. As a result of this research the approach for the remainder of PR5 will use data from ESB Networks' GIS system and the AMI data.. EPRI delivered a Beta version of the tool in Q2 2022, the tool is currently going through a test phase in Q1 2023, once the test phase is complete training will be provided to the team that will be working on the validation process.

5 PROGRAMME DELIVERY APPROACH

ESB Networks' target is to achieve 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 tool. Selection of 2023 locations for EPRI field validation was complete in Q4 2022 and they have been agreed upon and have been in included in the ESB Networks' work programme.

ESB Networks will continue to develop an in-house mobile solution throughout 2023 to support the "boots on the ground" validation by field staff exercise. Procedure documents have also been developed and approved in July 2022 in relation to the validation exercise.

5.2.4 SOURCING INSTALLATION AND MODEL VALIDATION RESOURCES

A resourcing approach is needed for completing the model validation activities set out in the Appendices of this document. The resources secured will be required to undertake the following steps involved in the validation of the EPRI tool:

1. **Field staff will receive the output data from the EPRI tool via a mobile solution/app showing the attributes and connectivity of the LV network including:**
   - **a. Meter location and electrical phasing of meter**
   - **b. LV service from meter location to mini pillar/service pole**
   - **c. LV mains conductor from mini pillar/service pole to MV/LV substation**
   - **d. LV circuit number from MV/LV substation**
2. **Field staff with the skills and approvals for cable tracing and identifying, and working live on LV 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 tool 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**

A resourcing approach is needed for the installation of LV monitors as set out in Appendix F. The resources secured (i.e., the field staff) 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.

5 PROGRAMME DELIVERY APPROACH

Field staff carrying out the commissioning of monitors will adhere to current procedural documentation for 'Commissioning of the LV Network'. They will confirm telecommunications commissioning and connectivity of the device via their mobile device by logging-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 Q2 2023.

To support efficient delivery of the monitoring device installations, this work is being integrated with other work programmes so that where possible this work can be done as part of normal maintenance work undertaken at the relevant assets. There is ongoing review of the range of resourcing and delivery models which may be utilised to complete this work. (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). The resourcing requirements for LV monitor installations, EPRI field validation and LV Network Discovery have been reviewed with a view to their inclusion in ESB Networks' wider work programme for 2023.

5.3 MAPPING PROGRESS TO DATE

ESB Networks' full outturn performance in 2022 will be set out in ESB Networks' Visibility Outturn Report 2022, for submission to the CRU in April 2023. However in summary, throughout 2021 and 2022 it was found that a number of customers MPRNs were not referenced correctly. As such a SAP-ISU script for updating incorrect customer references in bulk was developed, tested and deployed into production in Q4 2022 to update the records in SAP-ISU and other relevant systems.

To date, ESB Networks have reviewed 37% of all MPRNs accounting for approximately 880,000 customers. Out of the 880,000 records, 10,000 erroneous records were identified. These 10,000 records for modification have been shared with the ISU development team and corrected. Ensuring that the customer bases is correctly referenced is one of the core components of a fully connected LV model. The recruitment process is underway for a dedicated mapping team to carry out various activities in relation to increased levels of mapping on the LV network. Once the full team has been onboarded, they will be responsible for the correction of records in GIS and the running of both the EPRI tool and GIS Geospatial validation tools, they will also assist with the LV Network Discovery Pilot and the AI mapping proof of concept project (explained further in Appendix E). Each of the aforementioned solutions will play a key role in connecting customers to the networks schematic and will provide ESB Networks with accurate LV schematics and customer referencing.

5 PROGRAMME DELIVERY APPROACH

5.3.1 AVAILABILITY OF AMI DATA

The availability of AMI data is critical to the success of the programme. The effectiveness of the GIS geospatial validation, EPRI tool and LV Network Discovery mapping methods are highly dependent on the availability of the AMI data.

As part of the increased visibility, customers without a reference point on the LV network will have correct referencing assigned, based on the use of the AMI validation data. AMI data is also required to produce the EPRI model using voltage, current, active power, and reactive power. The implementation of 'Push-All' functionality from the smart meter is required to develop the EPRI tool for modelling the network by assigning MPRNs to proxy phase groups and connection points using linear regression modelling. The AMI outage event data is also critical for the success of LV Network Discovery pilot to co-relate event data with the sub-station data when a network technician operates on the sub-station.

The table below shows the different mapping options and their associated requirement for AMI data:

METHOD	DEPENDENCY ON THE AMI DATA	FUNCTIONALITY/ DESCRIPTION	STATUS
GIS Geospatial Validation	✓	This method is used in combination with EPRI and LV Network Discovery for a complete connectivity model of the LV Network	In progress.
EPRI Tool	✓	SM data required to import into the tool to perform linear regression modelling and assign MPRNs to proxy phase groups and connection points	Currently at the test phase. Go-live Q2 2023
LV Network Discovery	✓	Outage event data for co-relation	Currently in Pilot phase. Expected to be complete in Q1 2023
AI Mapping		NA	NA

6

Visibility Milestone Plan

6 VISIBILITY MILESTONE PLAN

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 LV 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 life cycle 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, with substantial overlap between each year as part of a continuous, efficiently delivered programme of work. 2023 will see the completion of detailed procurement exercises, 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 complete in 2023.

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 2023 is to capture 25% off the LV network, 37.5% by the end of 2024, and 50% by the end of 2025. During 2023, 2024 and 2025, a central element of accurate LV maps / connectivity models will be the gathering and validation of reference information (i.e., mapping individual customers to the MV/LV substation which is feeding them). ESB Networks will also aim to install 10,660 LV monitoring devices on the network between 2023 and 2025.

The table below reflects the milestones from 2023 onwards.

YEAR	MILESTONES
2023	Capture of 25% of LV Network by the end of 2023, including by gathering and validating customer reference information 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, including by gathering and validating reference information 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, including by gathering and validating customer reference information 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.

6 VISIBILITY MILESTONE PLAN

6.1 SCORECARD PROPOSAL

Throughout PR5, the CRU is measuring the delivery of visibility using an annual balanced scorecard based on ESB Networks' development and execution of a plan to secure increased visibility, and monitoring) prior to the end of 2025. The scorecard focuses on the following three pillars, sourcing and resourcing, securing visibility, and sharing visibility.

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 for customers and market participants.

The balance scorecard we propose for 2023 as outlined below is based on progress against milestones for increasing the visibility of the LV Network, enabling a future outcome of ESB Networks actively managing the network to accommodate greater number of LCTs and manage capex reinforcements more efficiently.

ESB Networks propose that 30% of the weighted incentive is placed against the installation of monitoring devices, 40% against increased visibility, 20% against the use of data analytics and the remaining 10% against sourcing and resourcing.

The key milestones we aim to deliver upon to achieve for 2023 are:

1. **Installation of 3,554 retrofit monitoring devices in the LV network – 30%**
2. **Achieve 25% visibility of the LV Network - 40%**
3. **Use of Data Analytics to achieve the mapping and monitoring targets – 10%**
4. **Sourcing and Resourcing activities to address technical, technological, and practical dependencies – 20%**

VISIBILITY INCENTIVE	TASK	EVIDENCE PROPOSED	WEIGHTAGE
LV monitoring	Installation of 3,554 monitoring devices in the LV Network	Report on the progress made in relation to the total number of monitors installed in the MV/LV sub-station	30%
LV Mapping	Achieve 25% visibility of the LV Network	Report on the mapping and the customer referencing progress	40%
Use of Data Analytics	Application of data analytics for meeting the LV mapping and monitoring targets	Report on the use of data analytics across different work programme to achieve the mapping and monitoring targets.	10%
Sourcing and Resourcing	Sourcing and resourcing activities to address the technical, technological, and practical dependencies	Report on the activities undertaken to address the various requirements (people, processes, and technology) to meet the yearly targets	20%

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	ASSUMPTION	RISK
AMI DATA	There is a dependency on AMI geospatial and voltage data for use in the development of the LV mapping model in order to achieve the 12.5 % annual target of LV mapping from 2023 until 2025 inclusive.	The OVM team is working on the core assumption that the AMI data and various associated functionalities will be available to carry out various mapping projects including the EPRI tool, LV Network Discovery and GIS geospatial validation as set out in detail in the document in section 4.2	There is a risk that Smart Metering "push all" functionality may be delayed beyond Q1 2023. This would result in the programme being unable to add data to the EPRI LV Mapping Solution. The impact being that the LV Mapping Solution would be unusable, and the programme would be unable to conduct LV Mapping.
EXTERNAL RESOURCES	External resources – There may be a requirement to onboard external contractors for the rollout of each of the following: -Monitoring Device Installations - LV Model Validation -LV Network Discovery	It is expected that external resources will support with the delivery of work programme within the PR5 period	There is a risk of ESB Networks' customer delivery team unable to provide the required resources to conduct the various field activities such as EPRI field validation, LV Network Discovery and monitor installations which will impact the milestones and visibility incentive targets
PRIVATE LTE NETWORK AVAILABILITY	Availability of the LTE network required for the rollout of LTE monitors on the LV network.	The P.LTE rollout is currently at the latter phase of the procurement process. It is envisaged that the deployment of core and radio infrastructure will be finalised in Q2 2023 and the service go-live is scheduled for Q3 2023.	Risk of delay in the procurement of private LTE network that will impact the communication of the LV monitors with the ESB Network IT systems
CONNECTIVITY TOOL	A data analytics model is required to increase the level of mapping across the LV network.	The data analytics tool will develop the LV geographical and electrical models, and this new data will be transferred from the tool to the Project SharePoint site for validation of the LV network and subsequently updating the ESB Network systems.	Level of accuracy in connectivity model and electrical model (for EPRI model development) may not be sufficient for NN, LC Programme requirements. This is yet to be determined as the model progresses in development

8

Immediate Next Steps

8 IMMEDIATE NEXT STEPS

This document will be available for public consultation for a 4-week period from February 2023 whereby members of both industry and public can provide feedback. During this 4-week period ESB Networks will host a webinar to help with any questions or clarifications in relation to the public consultation documents. ESB Networks will also provide a list of questions with each publication on the areas they require input from the public.

The public consultations will continue to inform the direction of the programme, including for example who ESB Networks' will engage with, how they will engage and the speed and locations where the programme will be rolled out. ESB Networks' welcome your thoughts and encourage you to participate in our formal consultations. To register please email engagement@esbnetworks.ie. Once we have reviewed all feedback, we will submit a revised and updated report to the CRU in April 2023. We envisage that the CRU will respond with our updated 2023 incentivised targets by the end of Q2 2023.

In April of 2023 ESB Networks will submit our 2022 outturn report to the CRU in relation to the progress made against our 2022 incentivised targets. This will form the basis for renumeration received from the CRU in relation to the balanced scorecard published in 2022.

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Appendix

9 APPENDIX

A. GIS GEOSPATIAL VALIDATION

This is a functionality that is being developed in ESB Networks' GIS system. Once developed it will allow ESB Networks to check the physical distance between the geospatial coordinate of a customer's MPRN and the geospatial coordinate of the nearest piece of LV network or substation. Using these distances, ESB Networks can verify or correct the reference of a customer. This will work slightly differently for urban and rural customers:

If a rural customer is referenced to a substation that is 500m away from their geospatial coordinate and the tool determines that there is a substation that is only 40m away, then it is more likely that the customer is connected to the closer substation and their reference can be updated.

For an urban customer, the underlying LV network first must be validated and any breaks in the network schematic must be corrected. Once completed, the customer's geospatial coordinates can be connected to the coordinates of the nearest connection point on the validated LV network (a pole or mini pillar). The tool can then determine the connection path back to the substation through the validated LV network, and the customer can be assigned a reference based on this substation path.

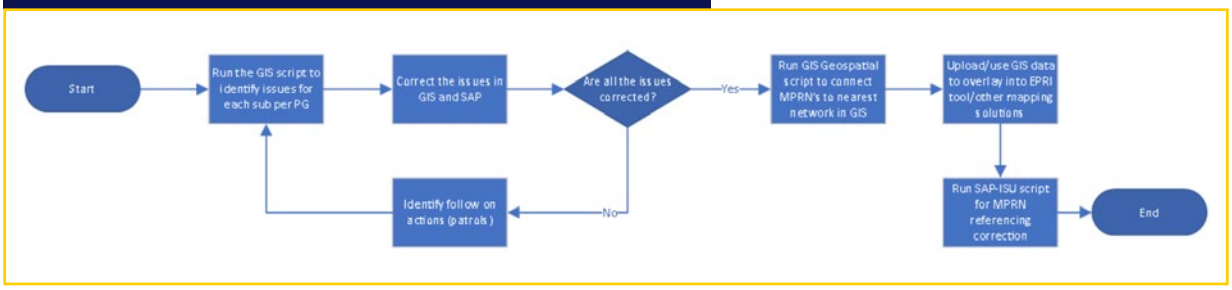
The first step in the GIS geospatial validation is the analysis of the GIS tool by running scripts to identify the issues across each sub in each planner group. Following this initial step and identified issues can be corrected in the existing GIS model and within SAP. This process is repeated until all identified issues are rectified in each planner group. Once validation and corrections are complete in both the GIS and SAP systems, the GIS geospatial validation script is deployed to connect the MPRNs to the nearest network in the GIS (as mentioned above) based on specific rules. The output is a fully connected LV schematic from the MPRN to the sub-station, based on which the referencing can be updated.

This process is undertaken for each individual substation across all 34 planner groups. Once complete, ESB Networks' will deploy other mapping solutions including the EPRI tool and the LV Network Discovery.

The MPRN referencing is corrected and updated in SAP-ISU using a script that can validate and update the MPRNs in bulk.

Once this process is carried out for a complete planner group, we will be testing the tool and further follow-on work will be identified and carried out. The process flow for the GIS geospatial validation is shown in the figure 4 below:

FIGURE 4 – **PROCESS FLOW OF GIS GEOSPATIAL VALIDATION**



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B. EPRI TOOL

ESB Networks, in collaboration with EPRI developed a beta version of the LV Network model tool in 2022. Once the tool is deployed into the ESB Networks' ecosystem it will use linear regression modelling of AMI voltage data. AMI data will be used to produce a model using voltage, current, active, and reactive power. This will allow for the development of 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).

The QA process will commence in Q1 2023 using a "boots on the ground" validation approach undertaken by suitably qualified and approved network technicians.

A high-level process flow has been defined for the capturing and updating of mapping & referencing for EPRI validation, see Figure 5.

The steps in this process are:

1. **Network technicians will complete the validation process in accordance with the procedure document**
2. **OVM Mapping resources will receive paper maps and data attributes from the network technicians as per the procedure document (which will be scanned and saved on OVM SharePoint)**
3. **OVM Mapping resources will extract existing GIS Data from GIS and will upload to the EPRI Tool**
4. **OVM Mapping resources will extract AMI data from smart meter data hub and will upload to the EPRI tool**
5. **The output from the EPRI tool will be generated and a comparative analysis will be carried out against the paper maps submitted by the network technicians**
6. **If the data taken from the EPRI tool is accurate, files will be prepared for both GIS and SAP and then uploaded with the correct/accurate network data**
7. **The SAP IS-U team will then update SAP with the correct network data**
8. **GIS will also be updated with the correct network data**
9. **If the data taken form the EPRI tool is inaccurate, the OVM team will revert to EPRI to refine the tool**

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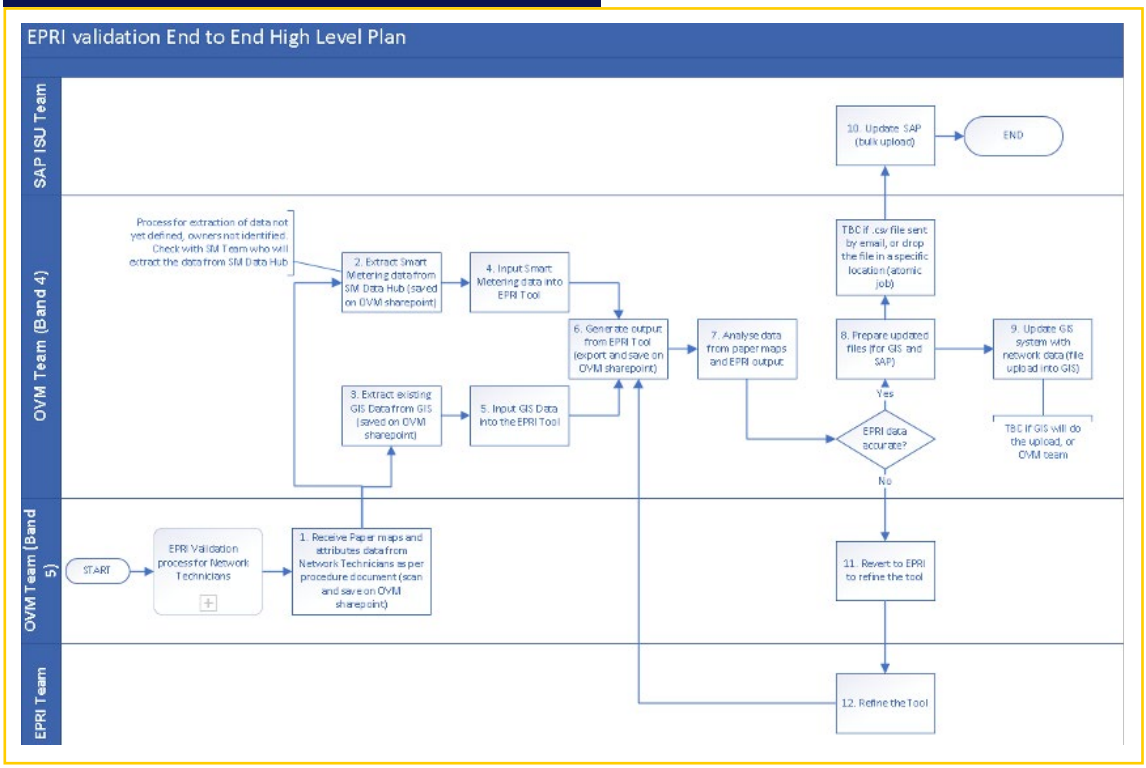
FIGURE 5 – **EPRI VALIDATION END TO END PROCESS**



C. NETWORK TECHNICIAN BRIEFING FOR THE 'VALIDATION OF EPRI LV MAPPING RESULTS

Training material has been developed to support the EPRI field validation results process. The validation exercise will take place on-site and will be performed by network technicians.

The area briefings aim to provide a broader context of the LV Visibility work to be carried out by the network technicians. Each briefing provides instruction on how to undertake LV circuit confirmation from the meter point to the feeding MV/LV Substation using the SEBA/MEGGAR TX440 CI kit on LIVE LV single phase and three phase circuits. It provides the networks technicians with the necessary skill set to record outcomes of on-site checks. Only network technicians with appropriate approvals and who have been briefed may carry out this task.

This briefing consists of below lessons:

1. **Lesson 1: Use of the SEBA/Meggar LCI TX 440 for LV Circuit Confirmation - Principle of operation of Seba/Meggar LCI TX 440 for LV Circuit confirmation**
2. **Lesson 2: LV Single Phase Circuit Confirmation - Confirm single phase O/H and UG LV circuit using Seba/Meggar LCI TX 440; Use of G-Clamp Connector for LV Circuit Confirmation**
3. **Lesson 3: LV Three Phase Circuit Confirmation - Confirm 3 - Phase O/H and UG LV Circuit using Seba/Meggar LCI TX 440**
4. **Lesson 4: Recording/Amending of GIS Mapping- Recording/amending data on GIS paper maps**

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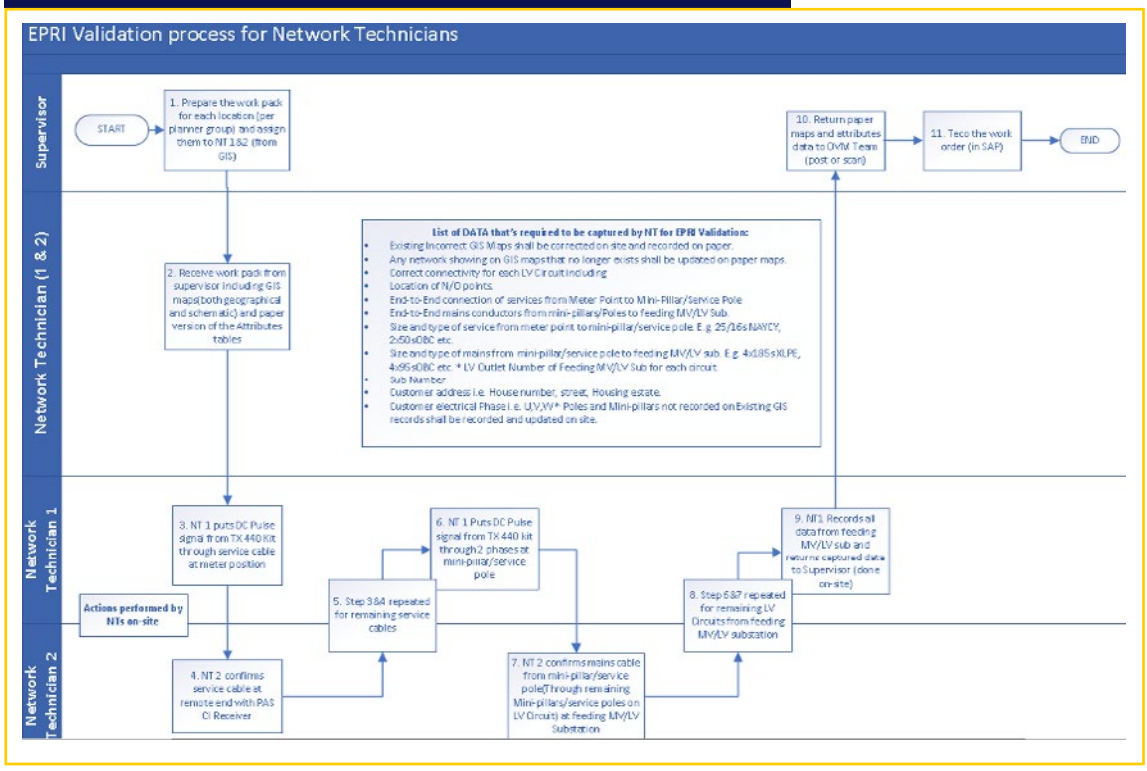
D. LV NETWORK DISCOVERY

To achieve the mapping/modelling objectives for LV Network, ESB Networks are also considering an approach called LV Network Discovery that would help to develop a complete connectivity model of all customers and fill in the missing information in relation to LV mapping. This process will be piloted in Q1 2023 across 12 locations the outcome of the pilot will determine if we roll this out to further locations on a programme wide basis. The end-to-end process is explained in figure 6 below.

FIGURE 6 – **EPRI VALIDATION PROCESS FOR NETWORK TECHNICIANS**



Process Explained:

1. Each LV outlet has a single fuse protecting each phase. A fuse will be 'pulled' and 'closed' one at a time by the network technician on each outlet, where the time, outlet and the phase information will be recorded on the My Forms portal. Network technicians will follow the process as presented below (fig. 7)
2. The time of this interruption will create a "loss of supply" event (also called 'Power Off') and will be recorded in the customer's smart meter, and sent to the Meter Data Management System (MDMS)
3. Info loaded into the MyForms portal can then be accessed by the OVM team
4. The OVM team will extract outage event data from the Smart Metering Data Hub (SMDH) (data in the form of a Power BI dashboard). This file will contain event data linked to MPRNs. The file will be saved in OVM SharePoint site (restricted access to OVM team)

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Process Explained (continued):

5 **The OVM team will analyse the time from the outage events and time from the MyForms portal to corelate outages caused by the network technicians with outages recorded in the smart meter. The time the fuse was 'Pulled' would correspond with the 'Loss of Supply' event on the smart meter, therefore the MPRN can be aligned with the LV outlet and LV phase**

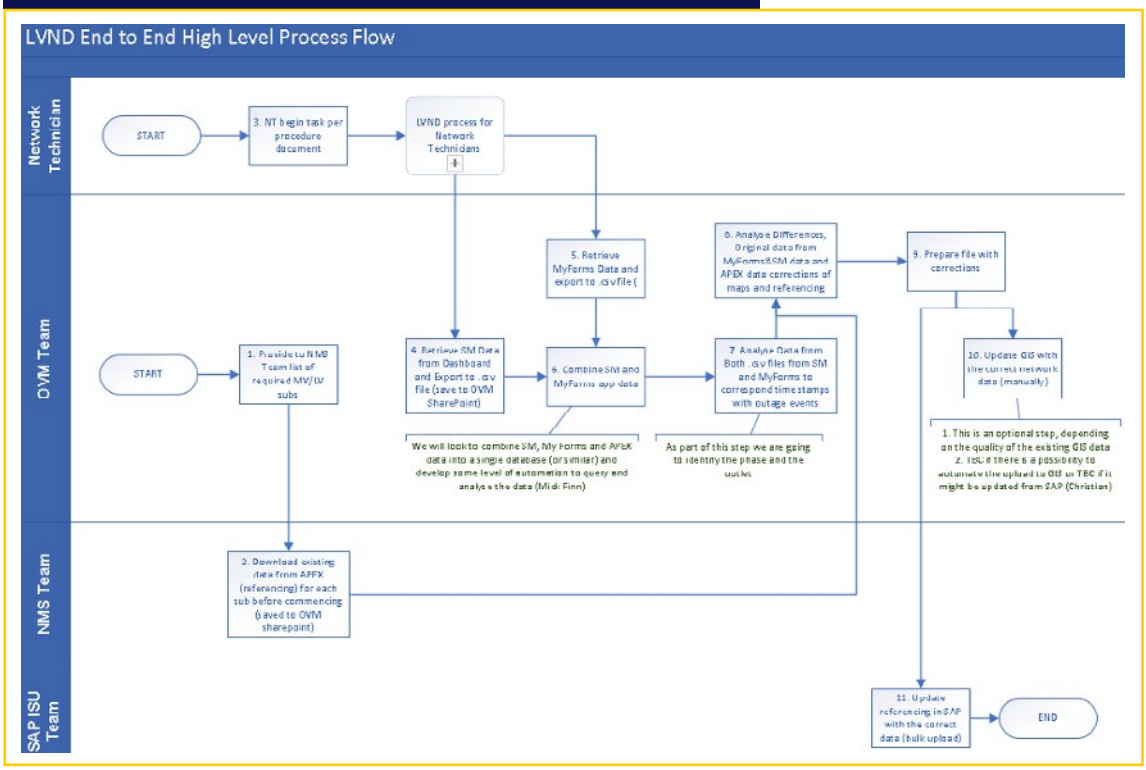
6 **This correlation will provide the correct customer network reference and identify which part of the network the customer is electrically connected to giving ESB Networks a complete customer reference to substation outlet and phase. Updated customer referencing will be temporarily stored on the OVM SharePoint site**

7 **The OVM team will then update the new customer reference on SAP IS-U in conjunction with the SAP IS-U team**

8 **The OVM team will also use the reference data to update missing sections of our LV maps in GIS**

The end-to-end process flow for LV Network Discovery is shown in the figure 7 below

FIGURE 7 – **LV NETWORK DISCOVERY END TO END PROCESS FLOW**



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E. AI MAPPING

This is a proof-of-concept project that aims to use AI image recognition software to process images to identify where ESB Networks' overhead network assets are located, and to translate this data into GIS. Once data is available in GIS, it can then be used in ESB Networks' electrical models. This proof of concept is being delivered in three phases as outlined below:

1 Pilot covering small area – complete in Q2 2022

This was conducted using a small data set of approximately 200 utility poles. The aim of the pilot was to assess if the AI image recognition software could be used for the purposes of identifying network. The initial result from the pilot was deemed a success and the pilot then progressed into phase 2.

This pilot was run using a twostep approach.

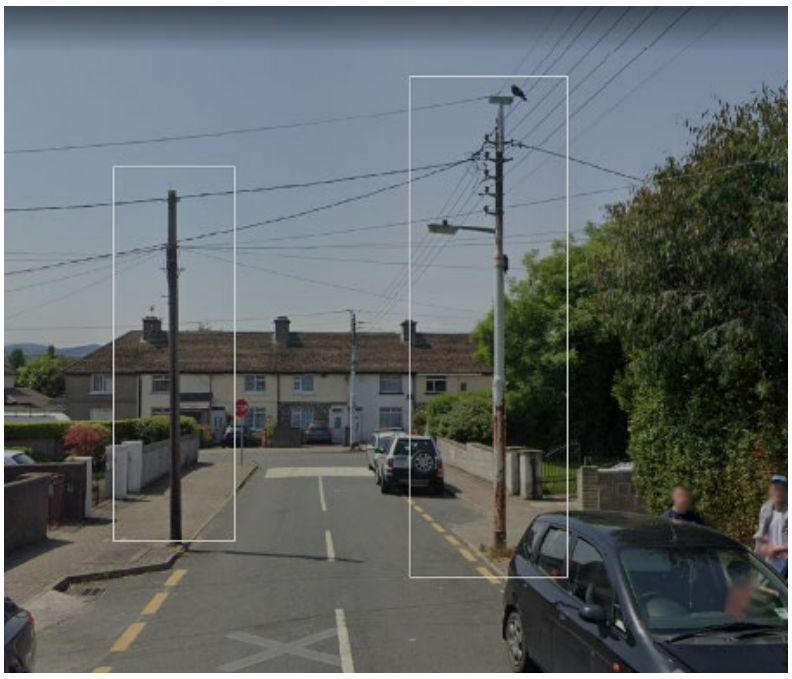
Step 1 was to train the AI model to recognise ESB Networks' poles.

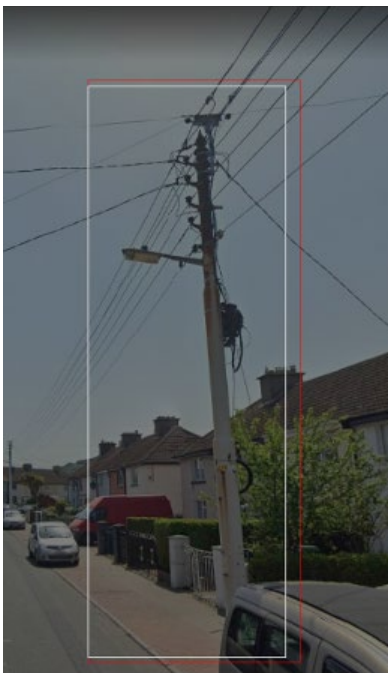
The model was trained by manually tagging ESB Networks' poles in images. Once trained the model was able to identify ESB Networks' poles independently and differentiate between ESB Networks' poles and telecom poles.

The image on the left below shows the AI model being trained to recognise the conductor by tagging the ESB Networks and telecom poles.

The image on the right below shows the output of the model. The white box indicates what was manually tagged in order to train the model. Red is what the model recognised independently.

FIGURE 8 – **AI MAPPING**





The output accuracy from the initial trail was high, which meant that the tool could be progressed to a pilot with larger area.

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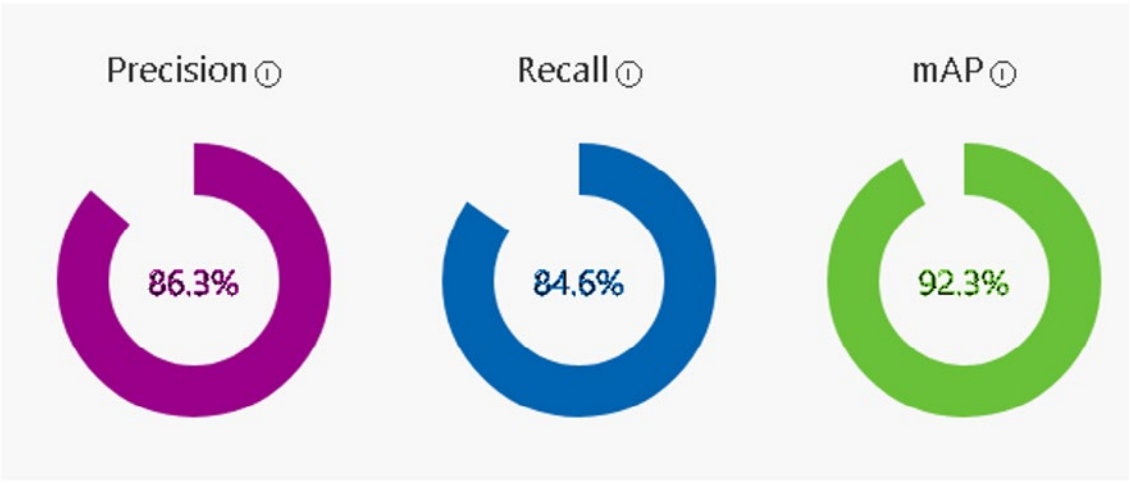
FIGURE 9 – **OUTPUT ACCURACY STATISTICS FOR THE INITIAL PILOT**



Performance Per Tag

Tag	Precision	Recall	A.P.	Image count
Utility Pole	88.9%	86.5%	94.0%	186
Telecom Pole	80.0%	80.0%	90.6%	72

Precision: If a pole is predicted, how likely is it to be right

Recall: Out of the poles that should be found, what percentage did the model find

mAP: Overall performance score (mean average precision)

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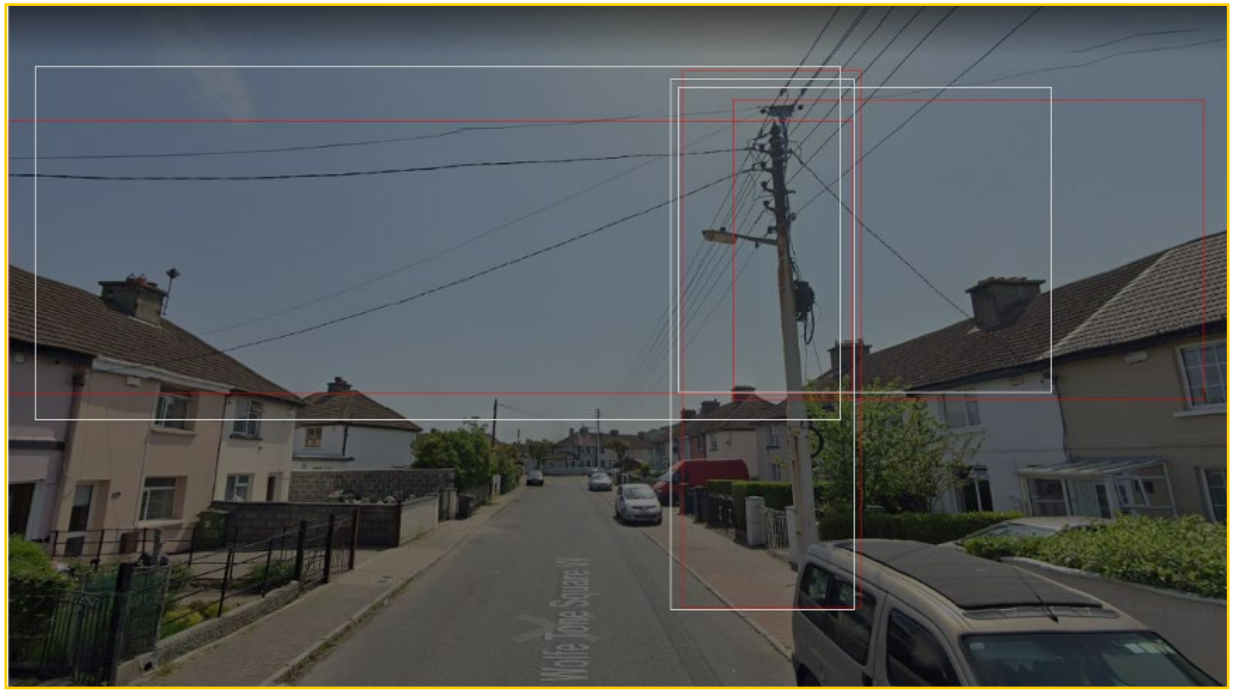
Step 2 of the initial trial involved training the AI model to recognise where there was conductor connecting a pole to a customer premises. The image below shows the AI model being trained to recognise the conductor.

FIGURE 10 – **AI MAPPING**

The image below shows the output of the model in red.



Again, the accuracy was high.

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FIGURE 11 – **COMPLETED TARGETS IN 2022**

Predictions

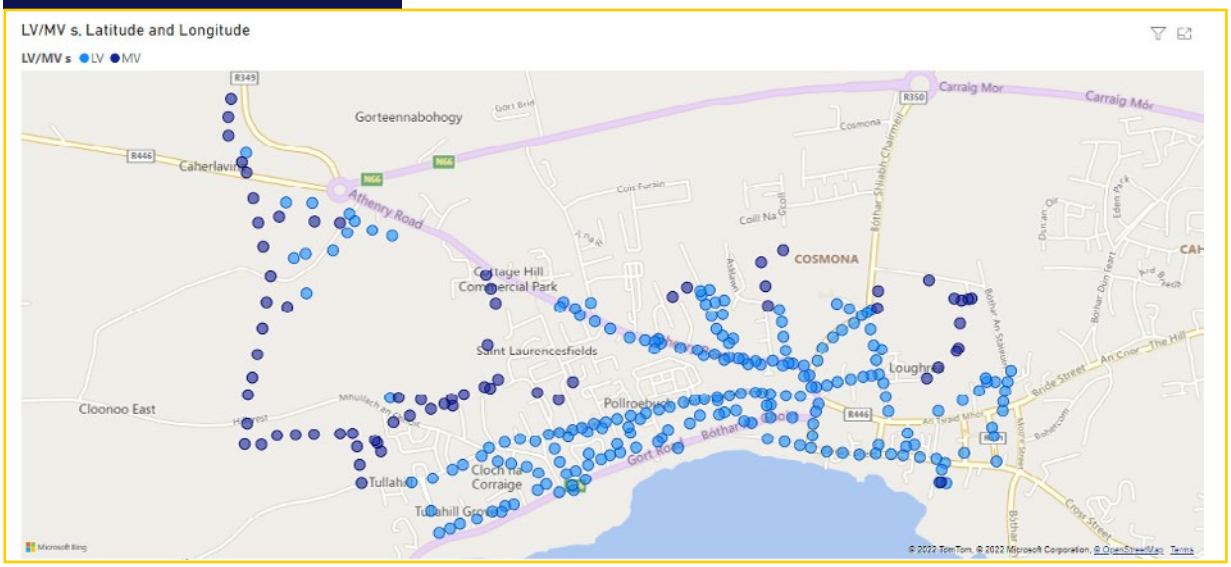
Predictions are shown in red

Tag	Probability
Utility Pole	99.9%
LV	96.3%
LV	94.1%

2. PILOT IN LARGER AREA- COMPLETED IN Q4 2022

The large pilot involved training the AI model on a known set of data from ESB Networks' patrols. This data is highly detailed and provides a good opportunity to check the accuracy of the AI model against known accurate data.

FIGURE 12 – **LV AND MV MAPS**



Below is a map of the pole data used for this pilot. Any MV pole and any LV poles that were not visible from the road were discounted from this pilot as it wasn't possible to get high enough resolution images of these poles.

The results from this trail were favourable:

1. 66% of all LV poles were found
2. 84% of LV poles visible from the road were found
3. 77% accuracy finding LV cable from pole to house

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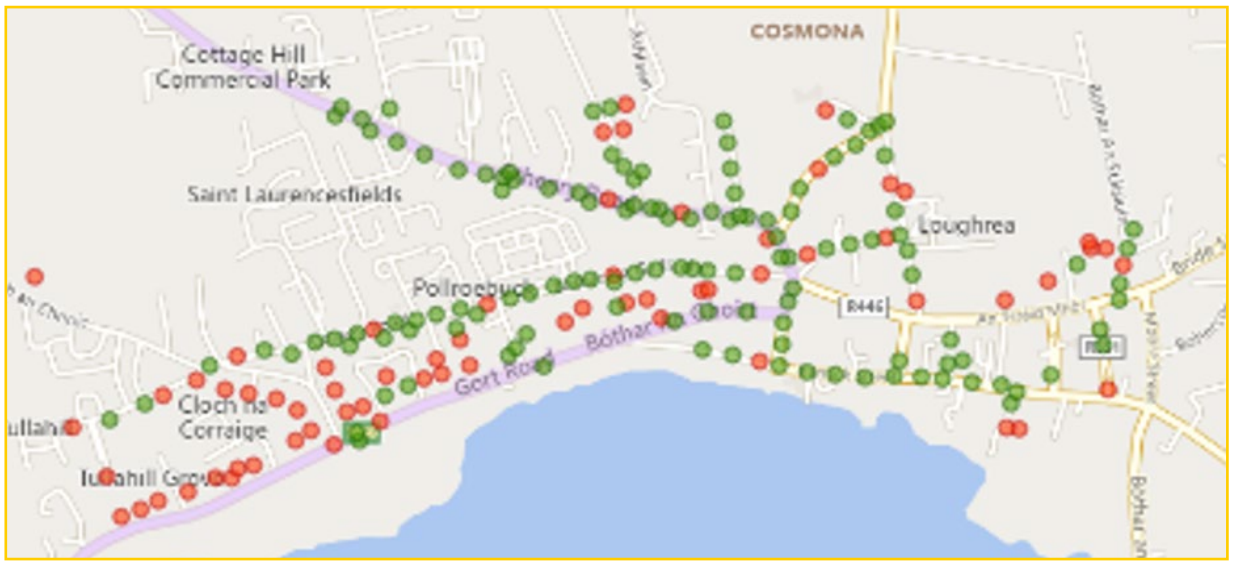

3. PILOT WITH DATA INTEGRATION- START Q1/Q2 2023

The pilot involves developing a script that can direct the AI model through an image set allowing data to be gathered automatically. There is also a software translation layer that will convert the data gathered by the AI model into a format that can be aligned to ESB Networks' GIS system so that the electrical models can be improved.

Once these developments are complete, it is proposed that the tool will gather data from a geographic area automatically and prepare it for import into GIS alongside validation and user intervention.

Initial functionality has been developed, but it is slow and requires a high level of compute power. ESB Networks are in discussion with a third-party vendor to assess if it is possible to access higher quality imagery data, and to see if there are any alternative technological solutions available to process the data once captured. Depending on the outcome of the conversations with third party vendors, this solution may be used in conjunction with aforementioned mapping options above.

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F. INSTALLATION OF LV MONITORS IN MV/LV SUB-STATIONS

ESB Networks is planning to install 10,660 monitors in both ground mounted and pole mounted MV/LV sub-stations during the PR5 period to have an active, real-time view of the LV network. 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 procured as per the specification that ESB Networks has put to market will measure voltage and current in up to 6 LV circuits in the MV/LV substation. The selected device will use these measurements to calculate active and reactive power, power factor, power flow direction, and power quality total harmonic distortion (THD) at the monitored location. Initially each measurement and calculation will be communicated back to ESB Networks' IT systems via 4G connection initially, however communication will be via ESB Networks' private LTE (4G) network once it becomes available. The data will be fed back to this cloud platform through ESBs Private LTE network. This cloud platform will have a web interface that can be used by ESB staff, and an API or FTP link so that the data can be accessed.

The device shall be actively powered from mains single phase or three phase electricity. The device shall be connected to the voltage leads through a removable plug, which shall have the ability to be locked onto the device.

ESB Network Telecoms are finalising 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 deployment of core and radio infrastructure will be finalised in Q2 2023 and the service go-live is scheduled for Q3 2023 and will continue to be rolled out across the network for the remainder of the PR5 period. 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, and IP66 for pole mounted devices.