transition

Moving to a smart future

In partnership with LEO Local Energy Oxfordshire

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TRANSITION

Network adaptation for trial deployment

Scottish & Southern Electricity Networks

Contents

1 Introduction

1.1 Background

The GB network continues to evolve, and there is a clear need for networks to adapt, become more flexible, enhance network operations and allow new market models such as peer-to-peer trading to emerge. The 'fit-and-forget' approach of traditional network operation relied on predictable energy use and production that matched that use. The transition to a DSO (Distribution System Operation) has the potential to bring significant benefits to customers; it also brings a range of new complex challenges, unintended consequences and risks for market participants, new entrants and the network licensees.

The ENA Open Networks Project (ON-P) is focussed on defining the DNO (Distribution Network Operator) transition to a DSO model and has been endorsed by the UK Government's Smart Systems and Flexibility Plan.

TRANSITION is an Ofgem Electricity Network Innovation Competition (NIC) funded project. Led by SSEN in conjunction with our project partners ENWL, CGI, Origami and Atkins.

TRANSITION, based on the outputs of Open Networks, will inform the design requirements of a Neutral Market Facilitator (NMF) and Whole System Coordinator (WSC), develop the roles and responsibilities within the marketplace, develop the market rules required for the trials, and implement and test the concept of the systems by means of trials in Oxfordshire.

The TRANSITION NIC project gained Ofgem funding as part of a collaboration agreement between TRANSITION (SSEN), EFFS (WPD project) and FUSION (SPEN project), known in the industry as T.E.F.

In addition, the project is also closely collaborating with the Local Energy Oxfordshire (LEO) project, a UK Industrial Strategy funded project. Both TRANSITION and LEO have objectives that are closely aligned and when combined significantly enhance the overall learning.

As well as physical trials within Oxfordshire, where SSEN owns and manages the electrical distribution network the project will also undertake simulated trials within the Electricity North West Ltd (ENWL) licence area.

1.2 Purpose

The purpose of this report is to provide an update of how TRANSITION is preparing for the trial deployment phase of the project. SSEN owns and manages the electrical distribution network for a large part of Oxfordshire where trials will be conducted. Specifically, the report details:

- The site selection process undertaken to identify parts of the network suitable for service trials.
- The LV monitoring which will be installed for the project, the equipment specification, secondary substation identification, installation training and installation plan.
- HV monitoring equipment which will be installed as part of the project, the equipment specification and purpose.
- The connectivity model being developed by SSEN and the inter-project co-ordination with TRANSITION.
- The Common interface model (CIM) module for Sincal (power system analysis tool)

- The simulated trials being undertaken by Electricity North West Ltd (ENWL) in conjunction with TRANSITION.

2 Site Selection

2.1 Background

The site selection methodology which is explained in this section built upon the trial strategy developed by Atkins. The Oxfordshire Programme Trial strategy Report was published in January 2020 and is available in the document library on the TRANSITION website (URL https://ssen-transition.com/). An initial phase of site selection was undertaken at the outset of the project. This work established primary substations in Oxfordshire which would be unsuitable for the TRANSITION service trials. It then scored the remaining primary substations deemed suitable using a number of high-level criteria to establish a starting point for site selection. An internal report was produced in June 2019 detailing the process undertaken at that time and results it produced. The site selection process description which follows is the second phase of site selection which refined the work conducted in the initial phase. It establishes primary substations suitable for service trials which will be used for the project.

2.2 Site Selection stage 2

2.2.1 Introduction

The initial ambition for the second stage of site selection was to identify circa 10 primary substations within Oxfordshire suitable for both the LEO project and the TRANSITION project trials.
There are a number of essential criteria which are required by TRANSITION and additional considerations to make best use of the collaboration with LEO partners. The detailed analysis required to establish primary substations that give the best coverage of the site selection criteria is covered in the following sections.

2.2.2 Site selection essential criteria

The areas selected within Oxfordshire must be capable of fulfilling the service trials which are to be conducted by TRANSITION over the next phase of the project.

Criteria include but are not limited to:

- The two DSO services, constraint management and peak management
- The two peer to peer services, Import/export trading and offsetting
- A mix of low carbon technologies (LCTs) including generation and demand assets
- A mix of underground and overhead networks
- Assets connected at 33kV, 11kV and Low Voltage
- The areas selected must also accommodate the identification of suitable secondary substations for LV monitoring installations.

2.2.3 Site selection additional considerations

In addition to the essential criteria for service trials already outlined, the following additional considerations were identified to accommodate LEO partner requirements.

- Primary substations electrically feeding assets identified as core to the LEO project should be included in selection
- The total number of identified assets by LEO partners electrically fed from the selected primary substations should be as high as possible.
- The network areas covered by the primary substations should consider recruitment of new assets to the LEO project and give as broad a scope as possible to fulfil further recruitment.
- A Geographical spread across the county ensuring equality between rural and urban communities, demographics and low-income areas.

2.3 Identification of LEO partner assets

2.3.1 Central Asset Register template

The first phase of the site selection was completed in June 2019 as introduced in section 2.1. A list of potential assets for trials in Oxfordshire was provided by LEO partners at that time and the analysis conducted produced an initial shortlist of potentially suitable primary substations.
The data held required cleansing for format issues, duplication and to ensure information was up to date. A central repository with a consistent format of assets was therefore required called the Central Asset Register. This repository would be populated with new up to date information collected from the LEO partners.
A template of the Central Asset Register was produced by SSEN which identified 26 data categories that were required about specific individual assets. The full list of all 26 data categories are given in Appendix 8.1.

The template was then disseminated to each of the LEO partners to complete with details of all known operational and prospective flexibility assets. Seven of the data categories were mandatory for completion with a further four that if known should be also completed but were optional. These categories are shown below:

Mandatory categories to be completed by LEO partners

1. Asset Name
2. Asset Owner
3. Asset Reference
4. Priority (Core, high, Med, Low) as perceived by the LEO partner providing.
5. Nearest Postcode
6. Asset stage (operational/prospective)
7. Technology type

Additional optional categories (If known) to be completed by LEO partners

8. Meter Point Administration Number (MPAN)
9. Commissioning date
10. Flexibility confidence
11. Authorised supply capacity (if applicable)

Note, meter point administration numbers (MPAN) are considered personal information under GDPR. SSEN databases hold personal information which can be identified by the MPAN. For this reason, MPANs collected during this process would only be available to SSEN to identify network connections

They would not be included in the public version of the Central asset register available to the LEO partners.

2.3.2 Central Asset Register

In collaboration with the LEO partners TRANSITION collated the information provided into a single Central Asset Register spreadsheet. From the initial screening process the number of potential assets identified by the project was circa 250 across Oxfordshire (Jan 2020). A breakdown by project partner is provided below.

- Low Carbon Hub – 64
- Oxford City Council – 48
- Oxford County Council – 16
- Nuvve – 3
- University of Oxford – 121
- Oxford Brookes University – 4

An asset ID was assigned to each asset to ensure they were individually identifiable. The other data categories (shown below) were then completed by SSEN where data and connectivity information was available. The completion of this information was prioritised according to the Priority level identified by the partners which was one of the mandatory data categories (Core, High, Med, Low):

- Eastings, Northings and grid reference number (GRN)
- Where a meter point administration number (MPAN) was given Authorised Supply Capacity (ASC) was obtained if applicable.
- Network reference number (NRN), connection voltage and HV and LV network feeding arrangement (where identifiable)

The Central Asset Register spreadsheet is updated and maintained as the single source for information for LEO partner assets. It is available to view for all project partners and is maintained by SSEN with support from the LEO partners.

2.4 Oxfordshire primary substation areas

2.4.1 Primary substation area map

A map showing the geographical area supplied by the Oxfordshire primary substations in SSEN's region was produced, shown in figure 1. By using the grid reference number (GRN) of secondary substations and plotting them by which primary substation they are fed from, a geographical area could be established. This process does not take into account the low voltage network supplied from those secondary substations. The areas map should therefore be understood to give a good indication of the geographical area covered by a primary substation but there may be some variance at the boundaries.

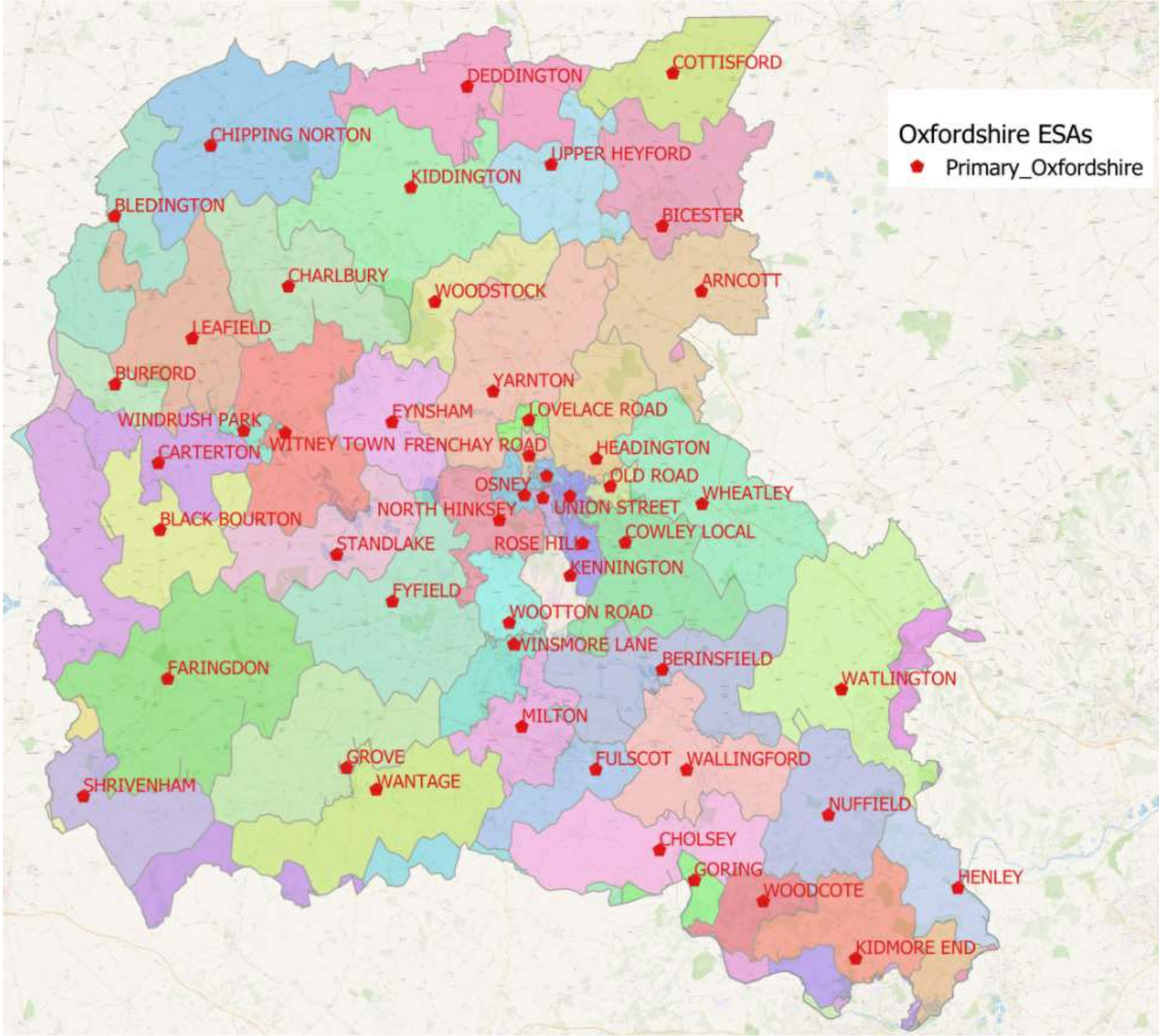


Figure 1 – Oxfordshire primary substation electricity supply areas (ESAs)

2.5 Establishing the primary substations for trials

2.5.1 Initial process

The initial selection process to establish the primary substations for the trials followed the below steps.

1. Of the 256 assets identified by the LEO partners circa 70 had been classified as core, high or medium priority for the project. The network feeding arrangements of these 70 sites were established manually using the SSEN SIMS, Electric Office and Power On systems. An overview of these systems is provided below
    - SIMS is a customer and network management system which holds customer information including MPANs.
    - Electric Office is a Geographic Information System (GIS) which displays the network layout at all voltages.

- Power On is a network management and control system which contains asset information at 11kV and above.

2. For these 70 assets, which the electrical feeding arrangements had been established, a count of the assets under each primary substation was made. The primaries were then ordered from highest to lowest based on the number of assets supplied by them.
3. The individual asset IDs were identified and ratified to ensure there was no duplication from the different LEO partners.
4. The top ten scoring primaries from this second phase of site selection were checked against the phase 1 site selection data described in section 2.1. None of those identified had been categorised as unsuitable for trials in phase 1 and all were in the top 32 of the scoring criteria from that phase 1 analysis.
5. Additionally, data from work identifying Electric Vehicle hot spots form another SSEN project was overlaid for comparison. This was done to establish any overlap which may provide areas of interest.

This process identified the below primary substations as potentially suitable for the trials. This list was not definitive or exhaustive but gave a starting point which could be refined.

- Rose Hill – 6 assets – scored 1st in phase 1 – 4 EV hotspots
- Cowley Local – 5 assets- scored 27th in phase 1 – 3 EV hot spots
- Osney – 5 assets – scored 14th in phase 1 – 0 EV hot spots
- Union Street – 5 assets – scored 32nd in phase 1 – 2 EV hot spots
- Old Road – 4 assets – scored 21st in phase 1 – 2 EV hot spots
- Yarnton – 4 assets – scored 6th in phase 1 – 2 EV hot spots
- St Ebbes – 4 assets – scored 15th in phase 1 – 0 EV hot spots
- Eynsham – 4 assets – scored 7th in phase 1 – 0 EV hot spots
- Frenchay Road – 3 assets – scored 18th in phase 1 – 4 EV hot spots
- Charlbury – 3 assets – scored 13th in phase 1 – 1 EV hot spots

2.5.2 Site Selection Workshop 1

In order to develop the site selection process TRANSITION held a two-day workshop with the LEO partners on 30th and 31st January 2020.

Photo of the site selection workshop held at the HVDC centre in Cumbernauld 30th & 31st January 2020

The purpose of the workshop was to present the services to be trialed by TRANSITION and understand the landscape and recruitment process of flexibility assets. The Central Asset Register and the initial work completed to establish primary substations for the projects as described above was presented, along with the areas map. Time was spent discussing this approach and qualifying each of the primary substations identified. Input from all the LEO partners and their knowledge of current assets and future development plans allowed conclusion to be draw on the suitability of each primary substation. Some changes were made to the list of substations identified during the initial process based on the discussion with the LEO partners. The outcome of the two-day workshop was the identification of ten primary substations which are preferred for use for the duration of the project, shown below.

- Rose hill
- Kennington
- Yarnton
- Eynsham
- University Parks
- Osney
- Deddington
- Milton
- Bicester
- Bicester North

Appendix 8.2 shows the break down and individual reasons behind each primary selected.

A further outcome of the workshop was the identification of 10 criteria by which to score each primary substation, shown below.

- Urban/Rural, Oxford/Oxfordshire
- Heat Networks
- Fuel poor/vulnerable
- Demographics
- Number of Leo Assets
- LEO technologies
- DSO service capability
- Peer to peer service capability (P2P)
- Voltage
- Regen Priority

2.6 Oxfordshire site selection stage 2 matrix

2.6.1 Site selection matrix and explanation sheet

Following workshop 1 SSEN created a matrix of the of the ten identified primaries and the ten scoring criteria. An explanation sheet to detail each of the criteria was also produced and the matrix and explanation sheet circulated to the LEO partners. Four of the criteria were to be completed by the LEO partners namely, 1) Urban/Rural, Oxford/Oxfordshire, 2) Heat Networks, 3) Fuel poor/vulnerable, 4) Demographics. The remainder were to be completed by SSEN. This allowed the following Gap analysis to be completed.

2.6.2 Gap analysis

Once partner responses were received all the assets identified in the Central Asset Register that are electrically fed from the 10 primaries were identified. This included assets which had not previously been assessed as described in section 2.5.1. The bulk supply points (BSPs) for the primary substations were identified and the SSEN Long Term Development Statement [(1)] and generation heat maps[(2)] were used to establish connected generation associated with those BSPs and primary substations. Suitability for DSO and peer to peer services (P2P) was assessed and 11kV and 33kV connected assets established. From this analysis all 10 primary sub stations were deemed suitable and a further two which would be of interest to TRANSITION were identified, Berinsfield and Wallingford. These two primaries were added, giving a total of 12 primary substations selected.

The GAP analysis process established the generation connected at 11kV under all 12 of these primary substations. It also established upstream generation connected at 33kV between the 12 primary substations and the BSP feeding them. Generation that has been accepted by SSEN but not yet connected was also assessed. A range of generation technology types were identified in the areas including photo voltaic, battery storage, gas, diesel and energy from waste. Though the owners of these generators have not yet been approached it was necessary to ensure there was a sufficient number of assets with sufficient capacity on the circuits fed by the 12 primaries and on the circuits feeding the 12 primaries capable of partaking in trials. The capacity of connected generation also needed to be significant enough to be meaningful for trials, where flexibility events could be monitored to see the impact on the network. In addition, generation connected at 33kV on other circuits fed from the same BSPs was established. These will be of interest in later TRANSITION trials.

Appendix 8.3 shows an example of the connected and accepted generation for the 12 primary substations as shown in the Long-term development statement. The type and capacity of all relevant generation was recorded.

2.7 Primary substations selected

2.7.1 Final selection

The final list of Primary substations selected for TRANSITION and LEO following this analysis are shown below:

- Rose hill
- Kennington
- Yarnton
- Eynsham
- University Parks
- Osney
- Deddington
- Milton
- Bicester
- Bicester North
- Berinsfield
- Wallingford

Figure 2 shows the areas supplied by these substations, produced using the same method described in section 2.4.1.

Note the area for Bicester and Bicester North shown in figure 2 is not fully accurate. Bicester North is a new Primary substation recently installed and data showing geographic connectivity of secondary substations had not been established at the time of producing this image. The area shown is the historic area for Bicester primary, some of this will now be fed by Bicester North and there are likely other changes to the connectivity of these two primary substations. A new version of this image will be produced once the data for Bicester North is available. The connectivity model explained in section 5 will help to improve the time lag of this process.

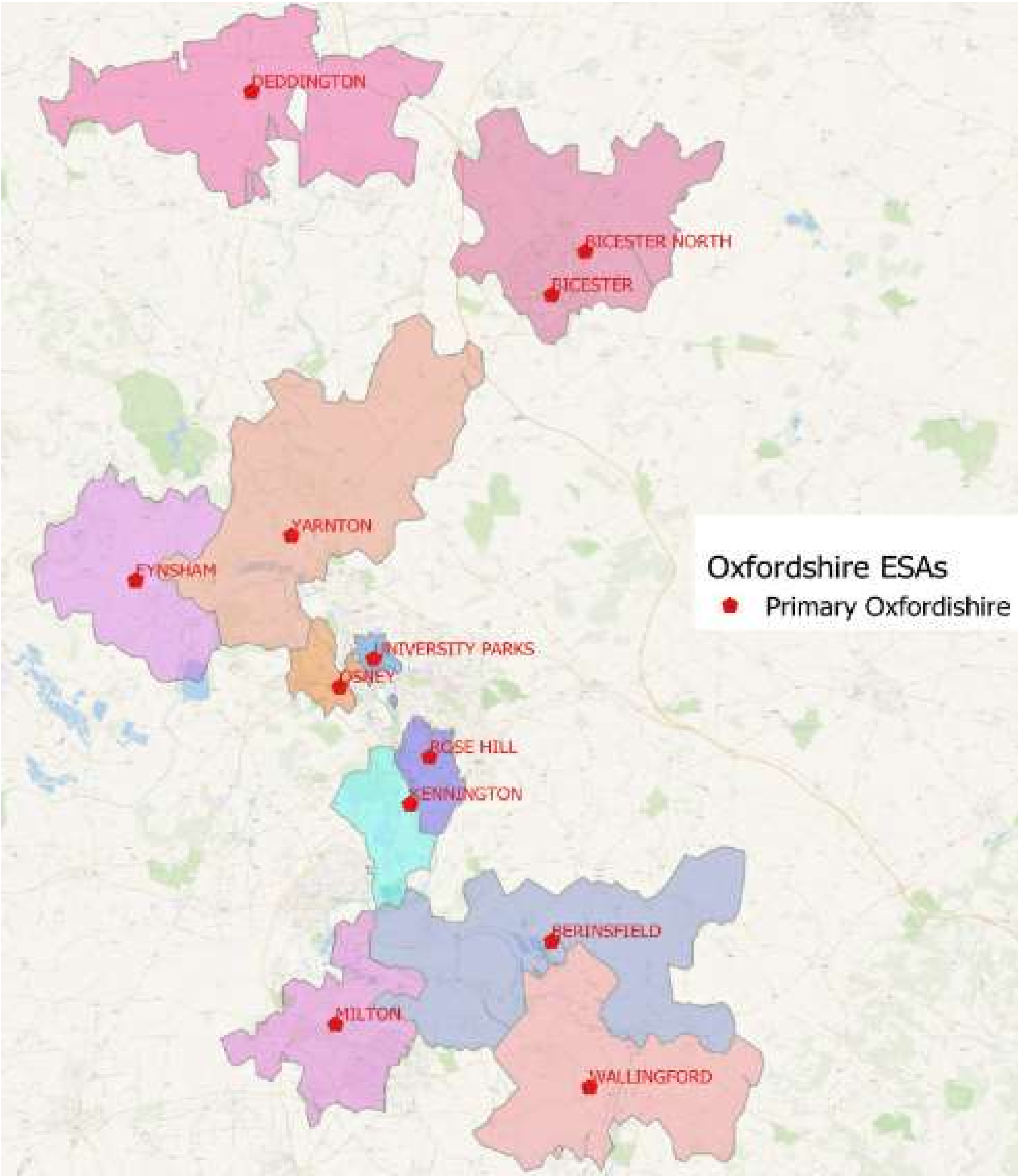


Figure 2 – 12 selected primary substation electricity supply areas

2.7.2 BSP's and Zones

The primary substations were grouped into zones by which BSP they were fed from as shown in figure 3. The select 12 primaries and BSP zones are spread across Oxfordshire and include different types of network and demographics. The types of networks and connections combined with the connected generation which had been identified by the gap analysis allowed zones to be classified. The type of trials each zone was likely to be able to fulfil could then be assessed. Further work is required to develop and refine the suitability of each zone to fulfil the different aspects of the service trials. The potential suitability that has been identified at this early stage is shown in figure 3

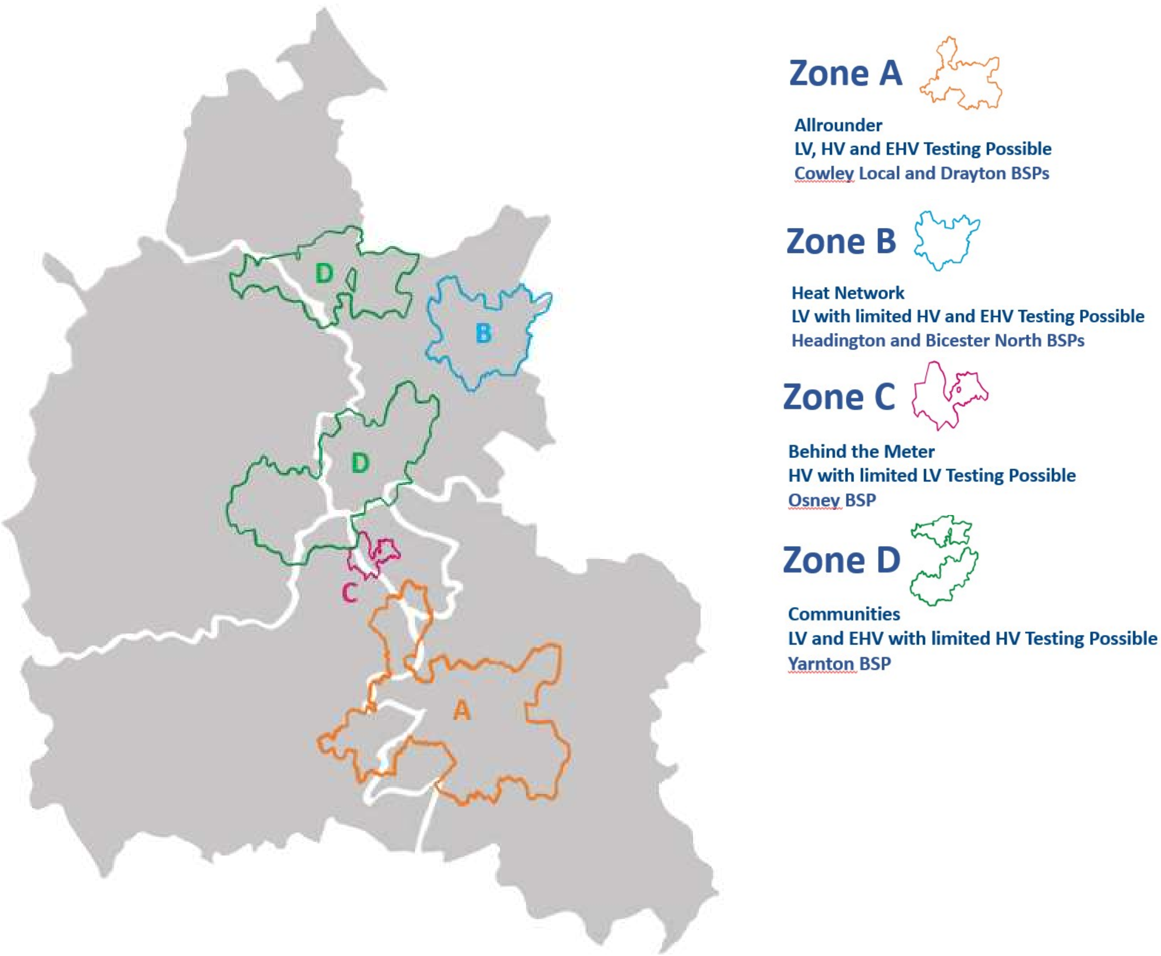


Figure 3 – Service trial zones and potential testing available

2.7.3 Site Selection Workshop 2

A second site selection workshop was planned for the 20th March 2020. Due to the ongoing challenges of COVID 19 the workshop was successfully held via online video conference instead of face to face. One purpose of this workshop was to present back to the LEO partners the final 12 primary substations, the areas supplied by them and the BSP zones. Other work which had been completed around services and trials plan was also presented to the partners and sessions to establish next steps undertaken, this is not covered in this report as it does not relate to network readiness.

2.8 Site Selection stage 2 conclusion

The work undertaken to identify the 12 preferred primary substations will allow the trials to be appropriately focussed. The selected primaries cover a broad range of network types and best fulfil the criteria outlined in section 2.2.2. Having areas of focus not only ensures assets already identified as potentially partaking in trials are accommodated within the areas fed by the primary substations, but also that future recruitment of assets can be specifically targeted.
It should be noted that the list of 12 primary substations is not definitive. As the TRANSITION and LEO projects develop it may be necessary to make changes by adding or removing primary substations. Decisions to adjust the areas of focus will be dependent on the direction of the project and available assets. The advantage and disadvantage of making any change would need to be carefully considered.
The work undertaken from the project initiation where Oxfordshire was selected through to the selection of the 12 primary substation areas and trial zones, has demonstrated very good engagement and agreement with the LEO partners.

3 Low cost low voltage monitoring

3.1 Introduction

In order to collect network data and aide service trials for the Oxfordshire area, the project investigated possible monitoring solutions. The monitoring units are to be installed at secondary substations identified in Oxfordshire to support both LEO and TRANSITION. They will gather baseline data from the network and will also be installed at points on the network feeding flexibility assets which form part of the trials. This will provide insight into the current activity on the network and the impact of the trials. One hundred low voltage monitors were procured for use on the project, see section 3.2 for further information.

3.2 Low Voltage monitoring equipment

The Low voltage monitoring equipment procured for TRANSITION are 5th generation EWS DTVI units manufactured by Eneida, an innovative Portuguese SME founded in 2012. For full specification sheet see appendix 8.4 Low voltage monitors can be safely installed on the vast majority of low voltage pillars in ground mounted secondary substations and will collect data on individual low voltage circuits. The monitoring units cannot be installed on LV networks fed from pole mounted transformers (PMT). PMTs have low voltage fuses mounted directly on the pole and so installing low voltage monitoring is not physically possible.
SSEN has produced an internal approved work instruction detailing the installation process, safety precautions and operational protocol for installing equipment. The work instruction covers the installation of Eneida units as well as Low voltage monitoring equipment from other manufacturers.

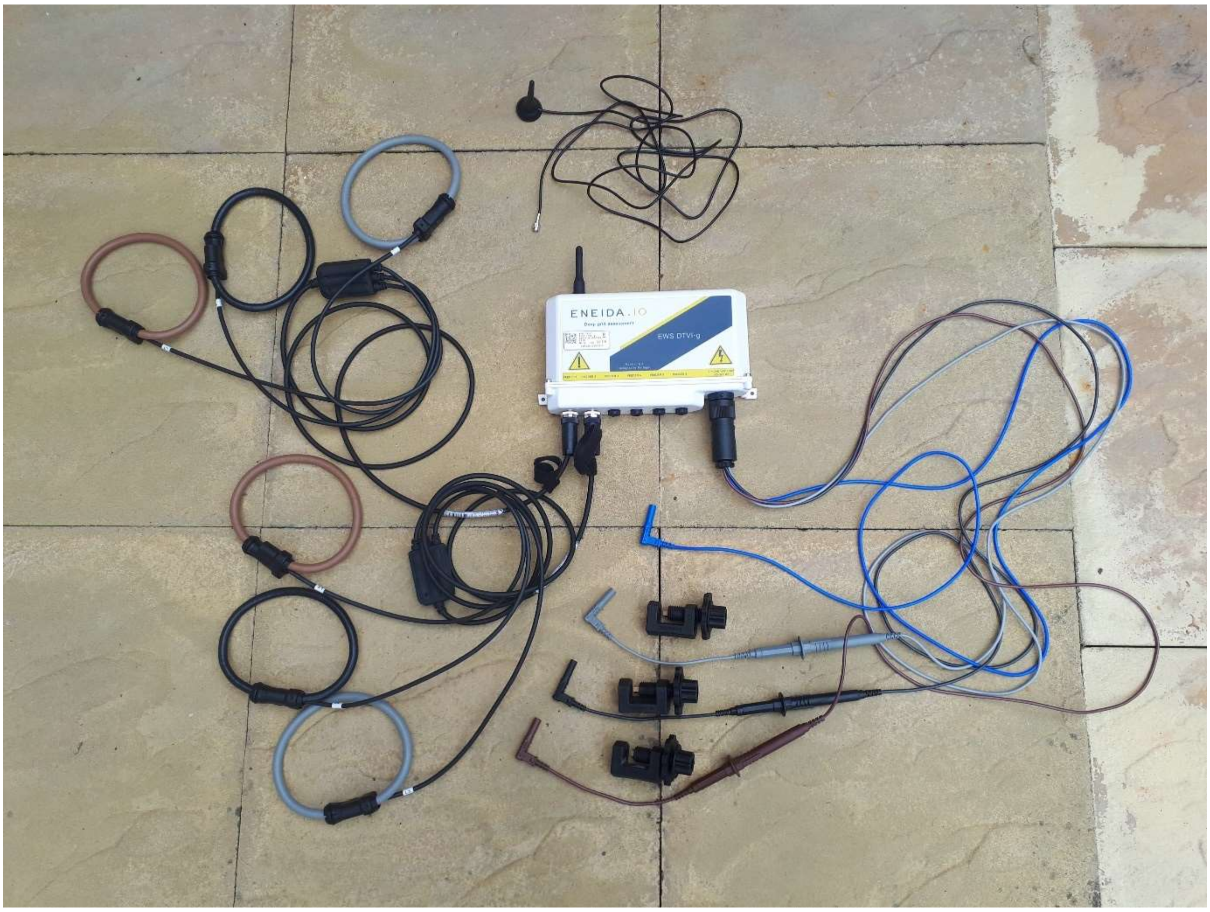


Figure 4 – Eneida EWS DTVI low voltage monitoring- showing Rogowski coils for two feeders, voltage connectors, bus bar G clamps and extendable aerial

3.3 The Eneida Deepgrid portal

The data that is collected by and returned from the low voltage monitoring will be hosted on the Eneida Deepgrid Portal. The portal is currently hosting the data for numerous other low voltage monitors that SSEN has installed on its network in other regions. Monitors installed in Oxfordshire as part of TRANSITION will be given a unique marker which identifies them specifically on the portal. Numerous reports can be viewed and downloaded and substation data can be seen down to individual feeder by phase. Logins to access the portal can easily be created giving TRANSITION and LEO project partners access to network data for analysis. Logins for LEO partners will be set up by the TRANSITION project engineer. The data sharing agreement which has been signed by all parties allows the sharing of this network data. The unique marker applied to the monitors installed by the project means logins can be restricted to only view these data only. Please see figures 5 and 6 for sample screenshots from the portal.

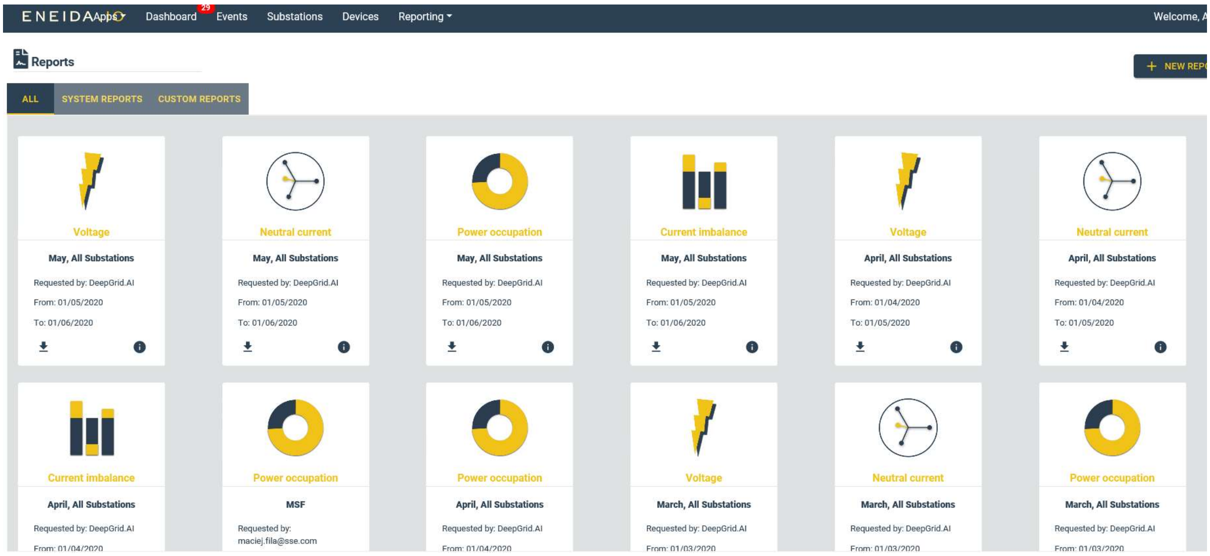


Figure 5 – Eneida portal screen shot showing reports available

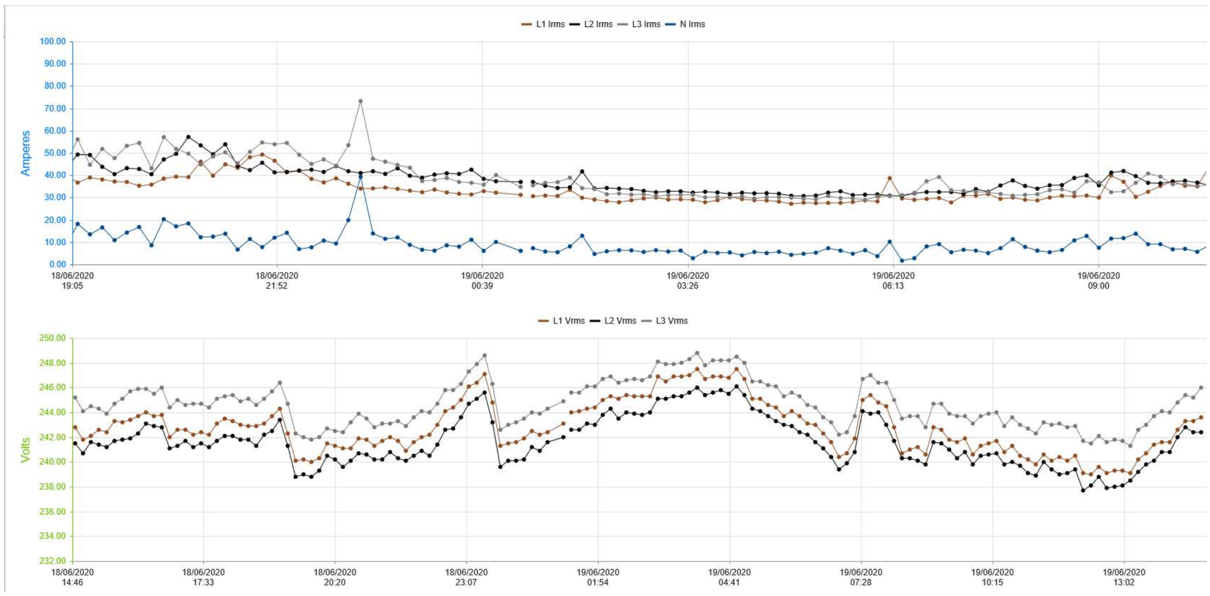


Figure 6 – Eneida portal screen shot example of phase current and voltage of an anonymised substation

3.4 Identifying resource to install low voltage monitoring

The preferred method for installing the LV monitoring was to use internal SSEN resource rather than contractors. This would be more cost effective and would allow SSEN develop the skills to install and maintain LV monitoring. Quotations for contracting the installations were obtained to ensure due diligence and the local SSEN operational region were approached. SSENs Inspection and Maintenance

Department for the Ridgeway region, which covers Oxfordshire were engaged and shown the equipment and deepgrid portal. The team were keen for the installations to be completed internally using the fitting teams and could see the many advantages of this approach. Safety, cost, development of understanding and the many uses for the data captured by the monitors were all realised. There would also be greater control and consistency of installation methodology by using internal teams. A program of installation would need to be carefully planned so as not to disrupt inspection and maintenance schedules, but it was felt that this was achievable. The decision to pursue this direction was therefore taken, the installations are to be undertaken using internal SSEN resource.

3.5 Low voltage monitoring equipment installation training

Following the site selection process carried out in early 2020, a two-day LV monitoring installation training course was arranged for the 1st and 2nd April. Six of SSEN Ridgeway region fitters were scheduled to attend along with two team managers and the TRANSITION project engineer. All attendees were operational staff and held the appropriate authorisations to be able to install the equipment after equipment training. Eneida were due to travel from Portugal to deliver the training which was classroom based for the first half day, then field based for the remaining time. Low voltage pillars on the live network were identified for installation during the training, this would give all in attendance the opportunity to safely install monitoring equipment on a range of LV pillars, whilst Eneida were on hand to answer any questions and provide guidance.

As the British response to the COVID 19 pandemic developed from mid-March, alternative arrangements were initially planned. These included reduced attendance and alternative trainers from Scotland in order to avoid international travel. Following the UK wide call to lockdown, SSEN's internal guidance mandated the training be cancelled until further notice.

With uncertainty over the duration of the lockdown, alternative ways to conduct the training were explored. SSEN's operational training centre for the south of England is located in Thatcham. Due to COVID 19 all training and assessments at Thatcham had been cancelled, meaning the facilities were not being used. Running technical training sessions using video conferencing is not practiced by SSEN. The training being delivered by Eneida was equipment familiarisation and installation guidance. It is not operational authorisation training subject to compliance with Model Distribution Safety Rules (MDSR) and SSEN's Operational Safety Rules (OSR). It was therefore deemed acceptable that a course could be designed using video conferencing as the medium of delivery. It was agreed that a demonstration of delivering the training in this way could be facilitated at the Thatcham training centre whilst it was not operational. This provided several key advantages to establishing whether video conferencing would be an acceptable delivery method.

- There were large class rooms with projectors and speaker systems which could be used whilst ensuring all social distancing methods could be maintained.
- There is an operational training and assessment facility with various types of LV pillars which could be used to practice installations. The training network can be made live or dead as required. Making dead during installation gave more scope to investigate the equipment and installation process fully in a completely safe environment. The network could then be made live to commission the equipment installed. WIFI is also available in the facility.
- Involving the training school in the development of the training provided the opportunity for valuable input and feedback from them.

Eneida developed several instructional training videos and a slide pack with detailed diagrams and photos of the equipment in preparation. A demonstration of delivering the training this way was arranged for the 12th May 2020. In attendance were an operational training instructor, the regional inspection and maintenance manager, the TRANSITION project engineer and the R & D engineer responsible for the LV monitoring procurement. The day was successful and went according to plan without any technical difficulties.

Some small amendments and changes were requested and the training was deemed acceptable for wider roll out to the fitting teams who will install the monitoring. Numerous other questions, challenges and suggestions to SSEN's internal installation protocol were also raised at the training day and are being addressed.

A date to conduct wider training rollout to operational teams has not yet been agreed. The success of this demonstration may be used to inform alternative training methods for the training school going forward.

3.6 Identifying secondary substations for installation

The disruption caused by COVID 19 delayed the identification of the first sites for LV monitoring installation and the scheduling of works. The site selection process covered by section 2 identified the primary substation areas where trials would take place. Assets in those areas could then be identified and may be suitable for LV monitoring to be installed. The first ten secondary substations requiring installation have now been identified and others will be identified as planning continues and once the full installation program begins.

3.7 Low voltage monitoring installation

The first two LV monitors were installed on the 23rd June 2020. This work was not completed by the fitting teams that have not yet received training. Installation was undertaken by the Inspection and Maintenance Manager and the TRANSITION Project Engineer. This allowed the full installation process to be evaluated and tools, methods and equipment requirements to be fully assessed. Figure 7 shows a completed installation.

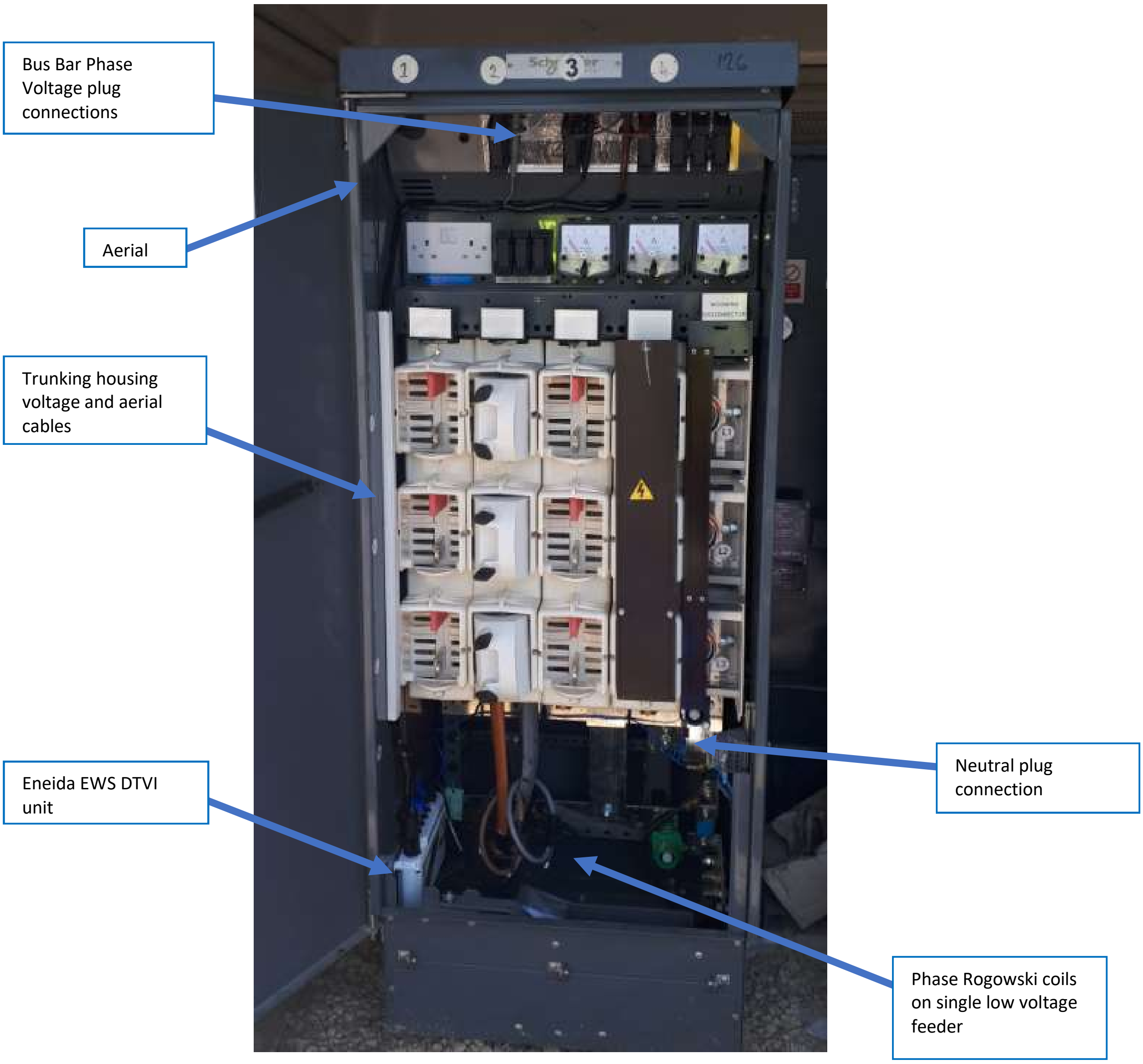


Figure 7 – Installed low voltage monitoring equipment at Rose Hill Community Centre S/S

3.8 SSEN Low Voltage Monitoring System

SSEN is running a parallel project to procure and install LV monitoring for fault finding and data acquisition. TRANSITION is working in collaboration with this project and sits on the project team in order to feedback learnings and maximise dissemination from the Oxfordshire trials. As part of this project five units will be installed to test transferring data back to SSEN's internal systems instead of the Eneida portal. The two projects are collaborating, and the five units will be installed in Oxfordshire on a network fed by one of the primary substations identified by site selection. This will ensure TRANSITION benefits from any learnings and creates the capture of further data for baselining purposes in the Oxfordshire trials.

3.9 Low Voltage Modelling

Some of the Secondary substations identified for installation feed assets which are being developed by the LEO project. Modelling has been undertaken to identify the connectivity of one of these substations and establish capacity and voltage drop on the network. Once installed, low voltage monitoring will provide valuable insight into the accuracy of this type of LV modelling which is currently used during the new connections process. This excise will not be conducted at every installation site and is intended to simply gain understanding of the accuracy of the modelling.

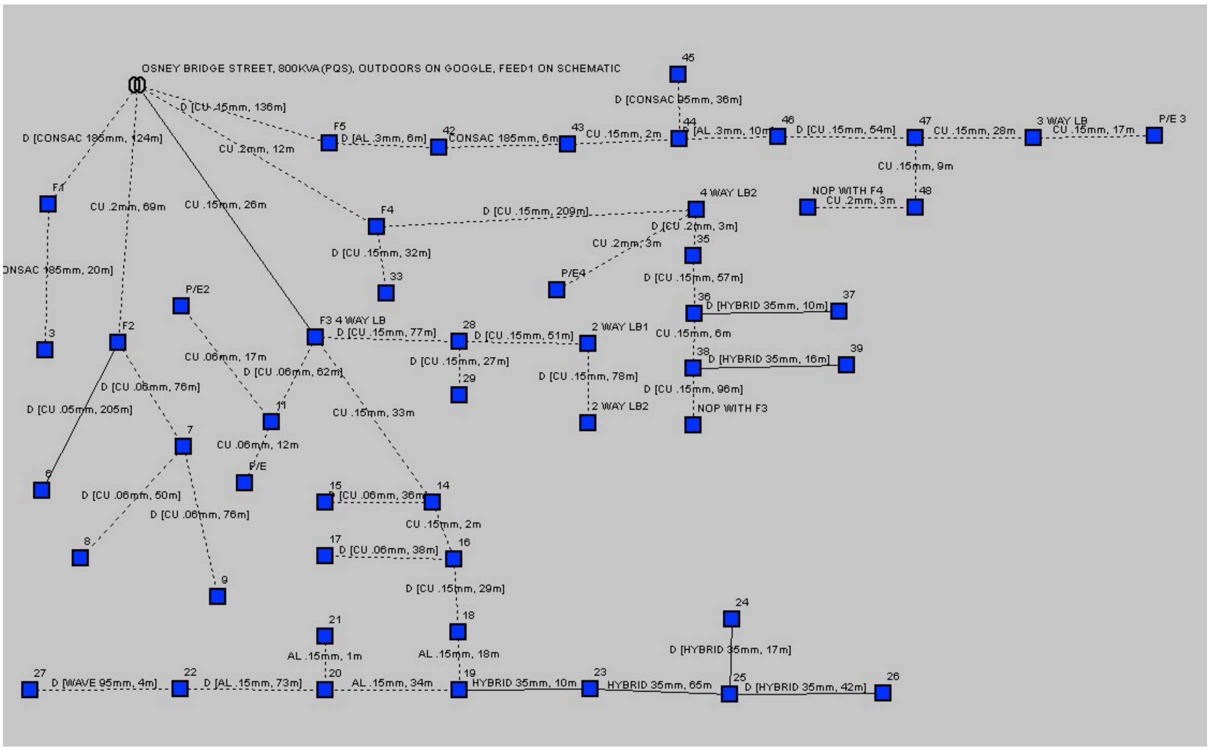


Figure 8 – Example of low voltage windebut modelling at Osney Bridge Street S/S

4 High Voltage monitoring

4.1 High Voltage monitoring equipment

TRANSITION is also procuring two sub.net monitoring units manufactured by Embedded Monitoring Systems (eMS). For the full specification sheet please see appendix 8.5. These units are portable and able to monitor 11kV as well as low voltage feeders and can be utilised as required during the project. As they are portable the sub.net devices will provide a flexible solution for LV monitoring on a short-term basis if specific trials require it. The ability to monitor at 11kV means they can be used to monitor any impact on the HV network from trials. This may be an 11kV connected asset or the combined effect of multiple low voltage connected assets. The devices can be placed at the primary substation using the 11kV Metering VTs and CTS.

TRANSITION is currently working with eMS and internal SSEN departments to establish the communication, data and reporting requirements of these devices.

5 Connectivity model

5.1 Overview

Below is an excerpt from Connectivity+ & GIS R2 Project Initiation Document[3]. It outlines the business requirements and plans to develop a comprehensive connectivity model.

The emergence of Distribution System Operators (DSO) will see data and the ability to use and share it as central to any success. An accurate Network Connectivity Model will be at the forefront of effective data use and underpin the DSO's key decision making

UK Distribution Network Operators already have customer connectivity models as they form the basis of reporting for IIS purposes. The Networks business currently hold its North and South models in the SIMS application in tabular format. They also have representations of their higher voltage level networks, often used for planning and operational purposes.

Moving forwards the business needs to move its connectivity model from SIMS to the new GIS platform. It will be central to Future Network Management, Customer Operations, System Planning and is a central enabler for the transition to becoming a Distribution System Operator (DSO) as well as ensuring improvements to services offered to customers through RIIO-ED2.

Creating the connectivity model will allow multiple views of the network through the use of different data sets, it would form the basis of a "digital twin" for analytical purposes which could be utilised for scenario-based forecasting or near real-time analysis.

The work required to achieve the model is not insignificant:

Focussing efforts on the new GIS application (Electric Office) will provide the business with the greatest opportunity to exploit data sets such as; - Network assets (fixed / linear), customer (Import/Export), Network load, environmental data (weather / flood forecasting). As a geospatial system the outputs can be readily visualised. This is an excellent fit with the "Digital Twin" concept for data analytics. This is also aided by GE's GSA product supplied alongside Electric Office to help visualise these diverse datasets.

For our data sharing requirements, the network model is an ideal vehicle to provide or exchange data between Distribution or System Operators, particularly if stored in an interoperable format such as CIM.

All this work underpins the move to Distribution System Operator and enables a Low Carbon economy.

As stated in the excerpt there is considerable work involved to create and populate a connectivity model. As the connectivity model project progresses priority circuits will be established which will be the first to be mapped. SSEN understands the importance of this model and the utility it would provide to the LEO and TRANSITION projects. It has been agreed that the Ridgeway region, which covers most of Oxfordshire, will be the first to undergo connectivity modelling to support LEO and TRANSITION. To collaborate with the project team as efficiently as possible TRANSITION will provide details of which HV and LV circuits assets are fed by and where LV monitors are located as trials develop. These circuits will be prioritised first where possible in conjunction with other business needs. A list of initial HV feeders, which are of priority to the project have been shared with the connectivity project team.
The connectivity model will hold the parameters of all cables, lines and plant items which in the future can feed into planning load, voltage and reliability models.

The process described in 2.5.1 which established the network feeder arrangement of LEO assets was completed manually by an engineer. It used several systems and cross-referenced data held in tabular form, geographic systems information and schematic connectivity system to establish these feeding arrangements. A full connectivity model will greatly reduce the time and expertise required to establish this information as the project progresses.

6 CIM module for sincal

6.1 Common Interface Model

Traditionally, simulations and Power Systems Analysis (PSA) have relied upon separate models of the 33kV system that are run periodically and 11kV models developed when triggered by a new connection or identified load growth. This approach has historically been robust but does not necessarily work in a DSO world with emerging local markets. The Whole System Coordinator (WSC) specified and to be built by the TRANSITION project will communicate with the existing PSA tools, PSSE and SINCAL, via a number of defined interfaces (as presented in Figure 9) to test requirements for the effective neutral facilitation of DSO and Non-DSO markets while maintaining security of supply on both the distribution and transmission networks.

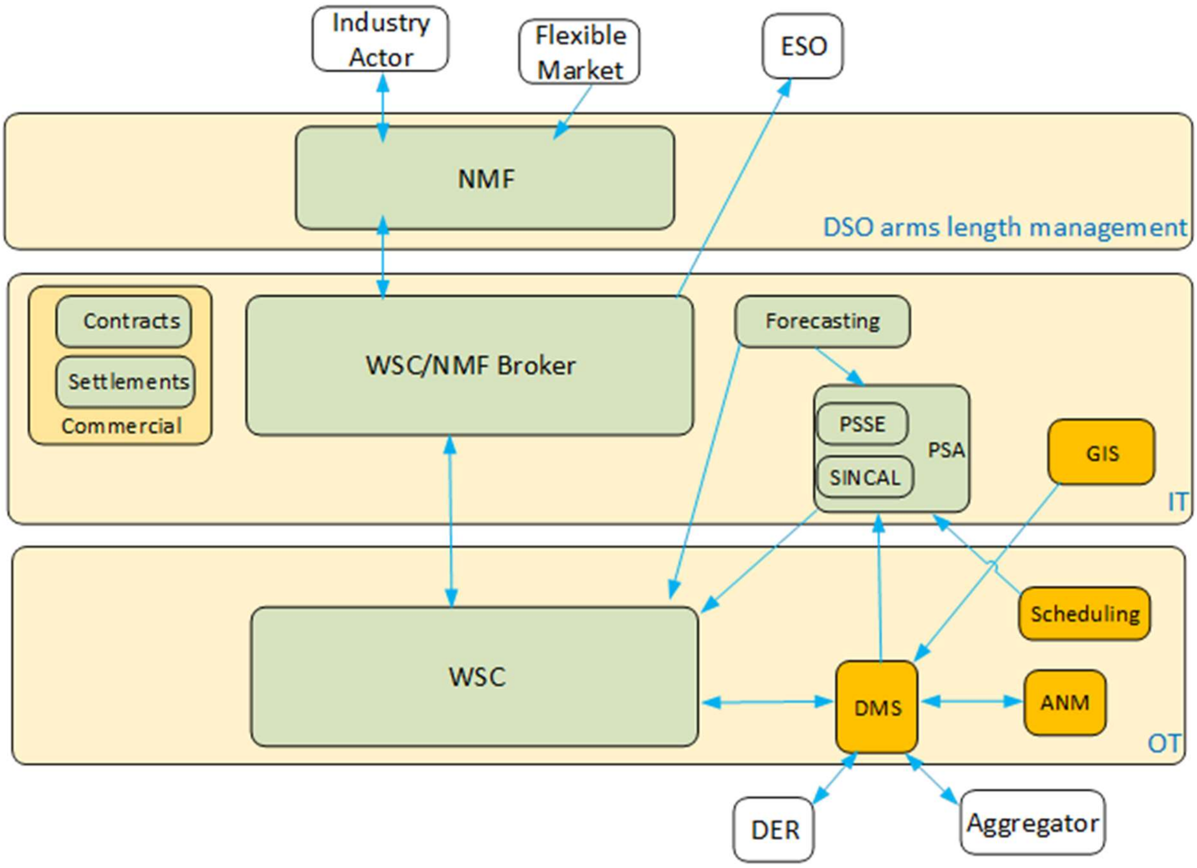


Figure 9 – Interfaces between existing PSA tools

For the defined interfaces presented in the "High Level Solution Design" to operate successfully, the PSA systems must be able to draw on the connectivity model data. While achievable manually at present, the timescales associated with the proposed trial markets render this approach unsuitable. A more automated process is needed to enable smart grid facilitation. The connectivity model itself is housed within the GIS Electric Office foundation system (drawing on the PowerOn Fusion master) which went live in late 2019. The GIS system and PSA tool SINCAL are both Common Interface Model (CIM) compliant, yet importantly not all CIM versions are compatible with one another. This is true for the systems in question, hence a conversion is needed before the GIS information can be used to generate a SINCAL model. CIM15 PSS®SINCAL v16 is a Siemens interface module designed to provide such a conversion, purchased by the TRANSITION project to enable the proposed trials from 2021. The SSE IT team is presently testing the module, alongside a SINCAL version upgrade, with full capability to be made available to the Oxfordshire Programme in the autumn.

7 ENWL simulated trials

7.1 Overview

Electricity North West Ltd (ENWL) are working with TRANSITION to run simulated services trials. The intention is for simulated trials to complement the physical trial which will take place in Oxfordshire. Because the trials are simulated there is potential for the number of trials conducted to be far greater than physical trials. The simulated trials will use forecasting and power system analysis models to produce data inputs for the Neutral Market Facilitator (NMF) and Whole System Co-ordinator (WSC).

Electricity North West Ltd (ENWL) like SSEN do not currently have a full connectivity model below 11kV. The simulated trials will focus on the 132kV network down to 11kV using networks in the ENWL area. The systems currently available are able to model to primary transformer bus bars with any 11kV asset modelled as point loads. Running simulated trials at 11kV and above up to 132kV compliments the physical trials which will focus on low voltage up to 33kV. The trials thereby have the potential to establish the benefits and constraints on the network from different perspective and facilitate different outcomes and findings.

The trials will help ratify the functionality of interfacing with the NMF and WSC and facilitate data exchange with the forecasting module.

8 Appendix

8.1 Central asset register data categories

The mandatory categories for LEO partners are highlighted green, optional if known are highlighted yellow.

1. Asset Name
2. Asset Owner
3. Asset Reference
4. Asset ID
5. Category
6. MPAN
7. Priority (Core, high, Med, Low)
8. Eastings
9. Northings
10. GRN
11. Nearest Postcode
12. Commissioning date
13. Asset stage (operational/prospective)
14. Flexibility confidence
15. Import kW
16. Export kW
17. Authorised supply capacity (if applicable)
18. Generation capacity
19. Voltage kV
20. Technology type
21. NRN
22. LV feeder (if known)
23. Secondary S/S
24. HV feeder
25. Primary S/S
26. BSP

8.2 Final list of primary substations and reasons for selection

Taken from site selection workshop notes and actions

- Rosehill (smart neighbourhood / PIPs/ limited headroom/ Low income area) Urban
- Kennington (Sandford Hydro and possible smart neighbourhoods / 11kv connection) Urban
- Eynsham (Future development and generation / longer legacy view / potential need for upgrade of the substation) Rural (EDF interest)
- Yarnton (Begbroke Science Park / development of solar farm / 33kv connected solar farm / possible connection of Cassington AD) Rural
- Osney (Smart Neighbourhoods and Hydro, Sackler Building) Urban
- Uni Parks (uni buildings and interesting re P2P) Urban
- Deddington (Very Rural, off gas network, planned solar farm and very different to other rural areas of Oxfordshire, potential for heat network) Rural
- Milton (south in the County, LCH projects, Didcot growth town, Science Parks and future demand)

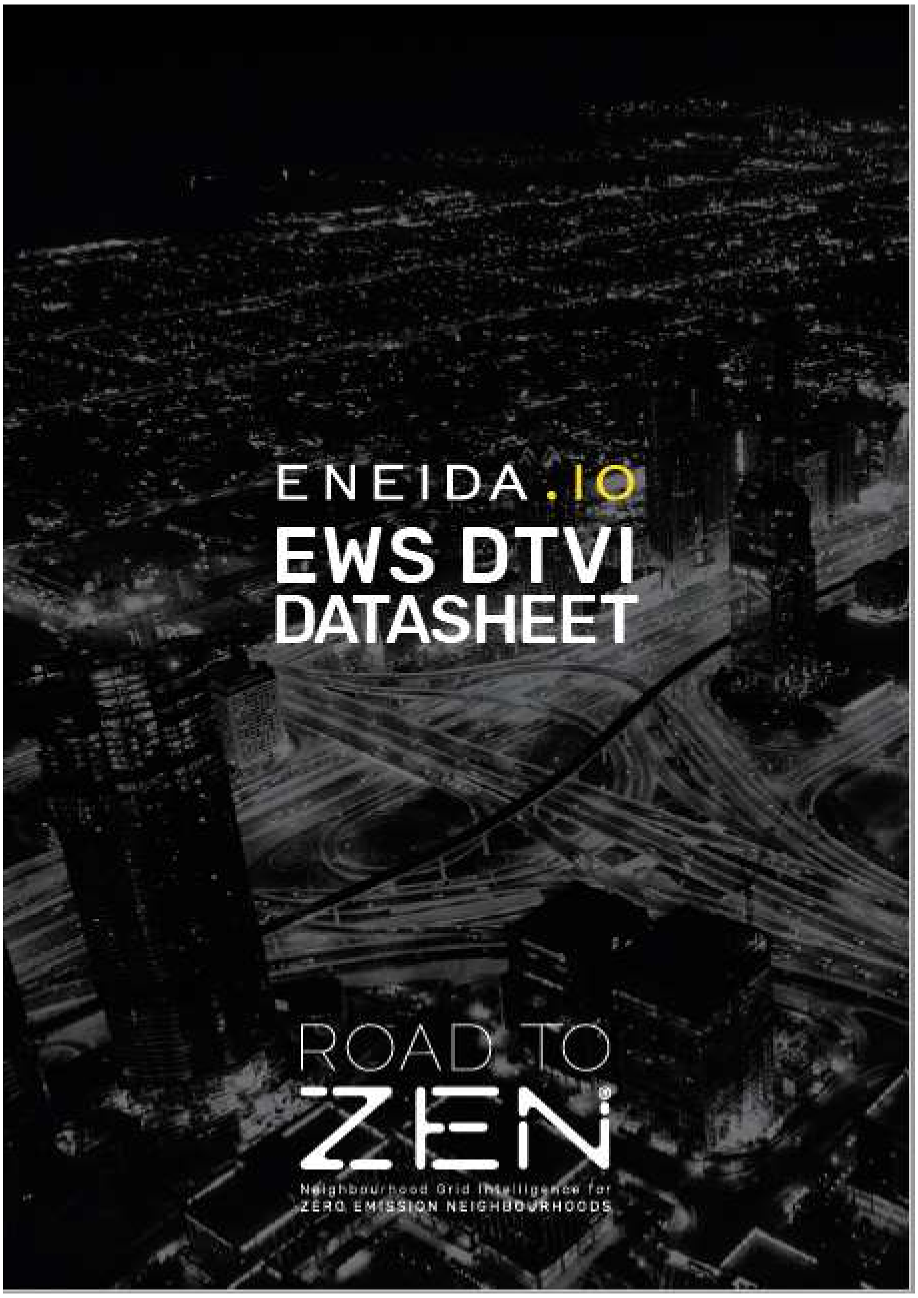
- Bicester & Bicester North (heat network) Urban (EDF interest)

8.3 Connected and accepted generation

Connected and accepted generation from the 12 primary substations -SSEN Long term development statement May 2020

GSP	BSP	Primary	Connection Voltage (kV)	Installed Capacity	Fuel Type	Connected / Accepted
COWLEY	HEADINGTON	BICESTER	33kV	26	WASTE TO ENERGY	CONNECTED
COWLEY	WITNEY & YARNTON	YARNTON	11kV	4.98	PHOTOVOLTAIC PLANT	ACCEPTED
COWLEY	COWLEY LOCAL RESERVE	BERINSFIELD	11kV	4.14	PHOTOVOLTAIC PLANT	CONNECTED
COWLEY	HEADINGTON	HEADINGTON	11kV	3.6	CHP - GAS TURBINE	CONNECTED
COWLEY	DRAYTON	MILTON	11kV	3.3	DIESEL	CONNECTED
COWLEY	HEADINGTON	BICESTER	11kV	3.169	CHP - GAS TURBINE	CONNECTED
COWLEY	COWLEY LOCAL RESERVE	WALLINGFORD	11kV	2.4	LANDFILL GAS	CONNECTED
COWLEY	COWLEY LOCAL RESERVE	BERINSFIELD	11kV	2	PHOTOVOLTAIC PLANT	CONNECTED
COWLEY	DRAYTON	MILTON	11kV	1.68	OTHER SYNCHRONOUS	CONNECTED
COWLEY	COWLEY LOCAL RESERVE	WALLINGFORD	11kV	1.36	PHOTOVOLTAIC PLANT	CONNECTED
COWLEY	DRAYTON	MILTON	11kV	1.25	DIESEL	CONNECTED
COWLEY	WITNEY & YARNTON	EYNSHAM	11kV	1	DIESEL	CONNECTED
COWLEY	HEADINGTON	BICESTER	11kV	0.899	PHOTOVOLTAIC PLANT	ACCEPTED
COWLEY	COWLEY LOCAL MAIN	ROSE HILL	11kV	0.8	CHP - GAS TURBINE	CONNECTED
COWLEY	COWLEY LOCAL RESERVE	WALLINGFORD	11kV	0.684	PHOTOVOLTAIC PLANT	CONNECTED
COWLEY	OXFORD	OSNEY	11kV	0.504	DIESEL	CONNECTED
COWLEY	DRAYTON	MILTON	11kV	0.45	LANDFILL GAS	CONNECTED
COWLEY	DRAYTON	MILTON	11kV	0.406	SMALL HYDRO	CONNECTED
COWLEY	COWLEY LOCAL RESERVE	KENNINGTON	11kV	0.4	SMALL HYDRO	CONNECTED
COWLEY	DRAYTON	MILTON	11kV	0.4	DIESEL	ACCEPTED
COWLEY	WITNEY & YARNTON	WALLINGFORD	0.4kV	0.05	PHOTOVOLTAIC PLANT	CONNECTED
COWLEY	WITNEY & YARNTON	DEDDINGTON	11kV	0.05	PHOTOVOLTAIC PLANT	ACCEPTED

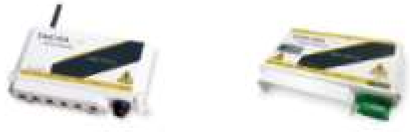
8.4 Eneida EWS DTVI data sheet



EWS DTVI DATASHEET

General Caracteristics

ENEIDA.IO



PHYSICAL	EWS DTVI-g	EWS DTVI-m
Dimensions (WxHxD)	250 x 135 x 45 mm	250 x 150 x 56 mm
Weight	600 g	655 g
IP Grade	IP 65	IP 20
Housing	ABS / PC	
Working Temperature	-20° to 55°C	
Working Humidity	up to 95%, non-condensing	
Mounting Options	Magnetic, Wall mount	Din-rails clip

POWER SUPPLY		
Nominal Voltage	240 VAC @ 50 Hz / 110 VAC @ 60 Hz	
Voltage Range	90 VAC to 264 VAC (from N and L1)	
Nominal / Max Power	5 W / 13 W, with GPRS On	5W / 5W
External Power supply	Yes as an option, 24 VDC	
Internal / External Backup	Last gasp / Yes as an option	

CURRENT INPUTS		
Connector Type	M12 A-code 8P Female M12 A-code 12P Female*	RJ 45 Socket RJ 50 Socket**
Signal Type	Rogowski coil output di/dt	
Current Range	up to 600A, other calibrations under request	
Input Range / Absolute Max	350 mVrms @ Full scale / 700 mVrms	
Accuracy	Class 1, when use Eneida's Rogowski coils	
Number of Channels	6	8
No. of Inputs per Channel	Standard: 3 / Option: 4*	Din-rails clip

VOLTAGE INPUTS		
Connector Type	RD 24 4P Male	Terminal Block
Voltage Range	10 to 264 VAC	
Accuracy	Class 0,5	

EWS DTVI DATASHEET

General Caracteristics

ENEIDA.IO

COMMUNICATIONS PORTS	EWS DTVI-g	EWS DTVI-m
Cellular	Yes, 2G or 4G	No
Cabled	No	Yes, Ethernet and RS-485
Local	Yes, Bluetooth for commissioning	
Protocols	HTTP / HTTPS FTP / FTPS	Modbus RTU Modbus TCP/IP HTTP / HTTPS FTPS

COMPLIANCE	
EMC	IEC 61326-1
safety	CAT IV 300V according EN 61010-1
Enviromental	IEC 60068-2
Product	PMD-SD according IEC 61557-12

CURRENT SENSORS	MICRO-*flex* ™	PRO-*flex* ™
Type	Tri-head Flexible Rogowski coils	
Probe Cabe Length / Diameter	160 mm / 6 mm	406 mm / 9,9 mm
Cable Aperture	50 mm	130 mm
Heads to splitter Length	0,5 m standard, other lengths under request	
Output Cable Total Length	1,5 m standard, other lengths under request	
Connector Plug	M12 A-code 8P Male or RJ 45 Plug	
Operating Temperature	-20°C to 60°C	
Operating Humidity	15 to 85% non-condensing	
IP Rating	IP 65 (heads to connector with M12 or just the heads	
Heads Colour	Standard: Brown, Black, Grey or Red, Yellow, Blue	
Output per kA @ 50 Hz	14 mV	65 mV
standard Calibration per Head	500A / 600 A / 1500 A / 3000 A	
safety standards	CAT IV 600V according EN61010-1, EN61010-2-032	

EWS DTVI DATASHEET

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Features

DATA PROVIDED

EWS DTVI can provide all relevant electrical parameters from the distribution network. All the inputs are sampled synchronously without gaps at 8kHz sampling rate. The refresh rate for voltage and current is half-cycle (10ms @ 50 Hz) and one second for all other parameters. Data is then aggregated and published at the configured periods. The Table below synthesises all the data that can be provided.

PARAMETER	Feeder	Busbar
Voltage Ph – N		Yes
Ph Current	Yes	Yes**
N Current	Yes*	Yes**
+/- Phase Active Power	Yes	Yes**
+/- Phase Reactive Power	Yes	Yes**
+/- Phase Apparent Power	Yes	Yes**
+/- Total Active Power	Yes	Yes**
+/- Total Reactive Power	Yes	Yes**
+/- Total Apparent Power	Yes	Yes**
+/- Phase Power Factor	Yes	Yes**
+/- Total Power Factor	Yes	Yes**
Current THD	Yes	
Voltage THD		Yes
Current HD up to 40th	Yes	
Voltage HD up to 40th		Yes
+ Phase Active Energy	Yes	Yes**
- Phase Active Energy	Yes	Yes**
+ Phase Reactive Energy	Yes	Yes**
- Phase Reactive Energy	Yes	Yes**

* Neutral current can be measured or calculated ** The values are calculated over the feeder values

EWS DTVI DATASHEET

Features

ENEIDA.IO

SPECIAL FEATURES

EWS DTVI has a Bluetooth module that simplifies commissioning of each unit by the user seamlessly, guiding the user with all relevant information across the installation process, such us:

- Feeder name;
- Fuse / Circuit breaker nominal current;
- Transformer phase rotation and nominal power;
- Site ID and location.

The Mobile App also allows the user to validate the installation by running an installation check.

The other Bluetooth function enables communication with other sensors inside the substation such as:

- Flood level indicator;
- Ambient temperature and humidity;
- Transformer temperature;
- Intrusion (all of these devices are available from Eneida.IO portfolio).

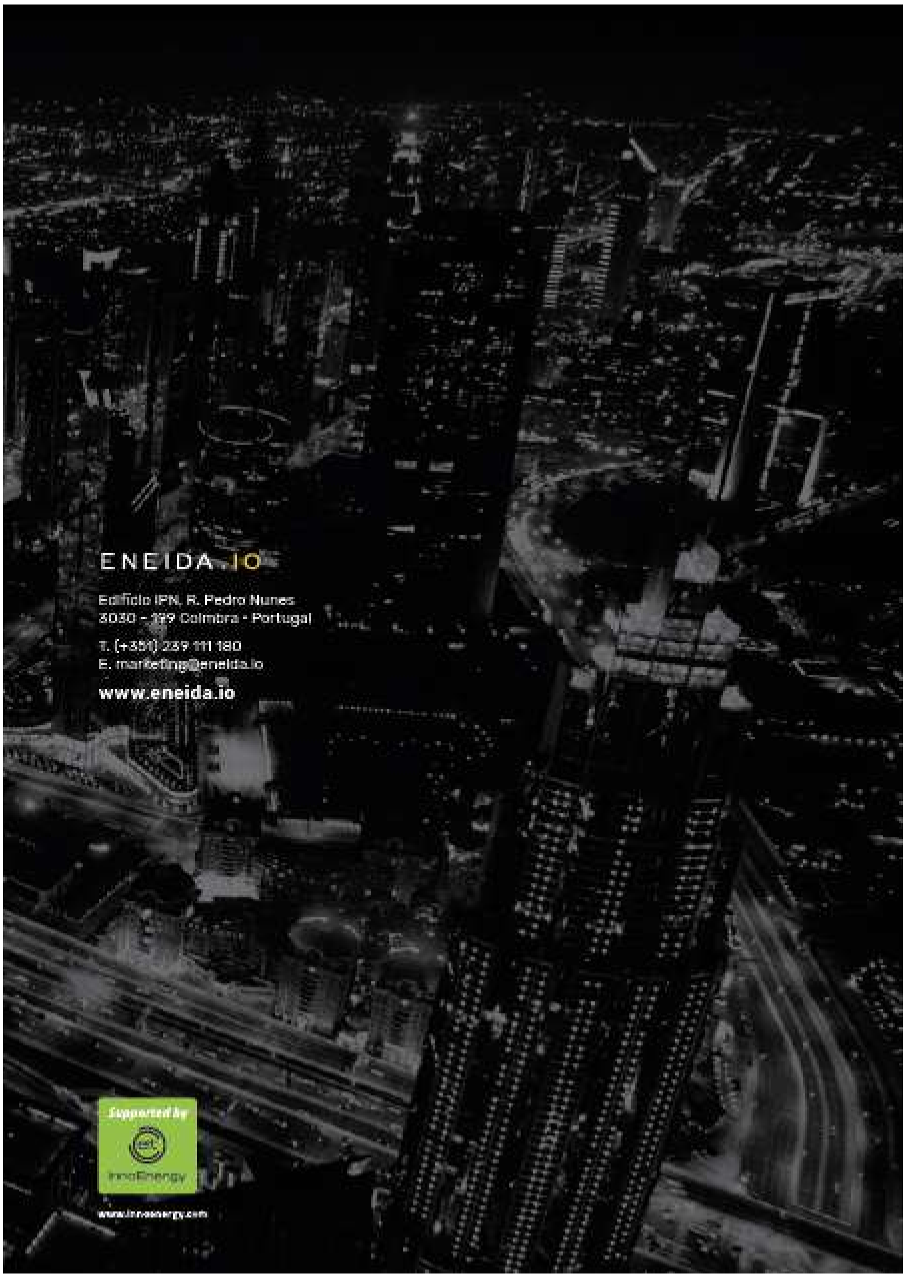
EWS DTVI is primarily self-powered by the voltage signals and has a small energy backup in order to alert the power fail. Additionally, it can be powered by an external power supply in the case a substation has secure DC power supply. Optionally, if the substation does not have a secure voltage and should EWS DTVI be required to continue work after a voltage interruption or any another abnormal event, a power backup module based in Supercapacitors can be connected to EWS DTVI.

EWS DTVI has the capability to remotely upgrade its firmware over GPRS or Ethernet port. It allows it be configured and benefit from data logger functions.

LV APPS

EWS DTVI allows DSOs the ability to run specific **Low Voltage Applications (LV Apps)**. These Apps can be remotely activated for a period of time or run indefinitely. All the Apps can run simultaneously with the standard mode avoiding loss of data. The Apps available from Eneida include:

- Current Fault Location (Incl. Fault Level Indicator),
- Dead Section/ MV Fault Location,
- Network Power Quality (according to IEC 61000-4-30, class S),
- Connection Tests and Energy Balance (Technical & Non-Technical Losses Monitoring and Location).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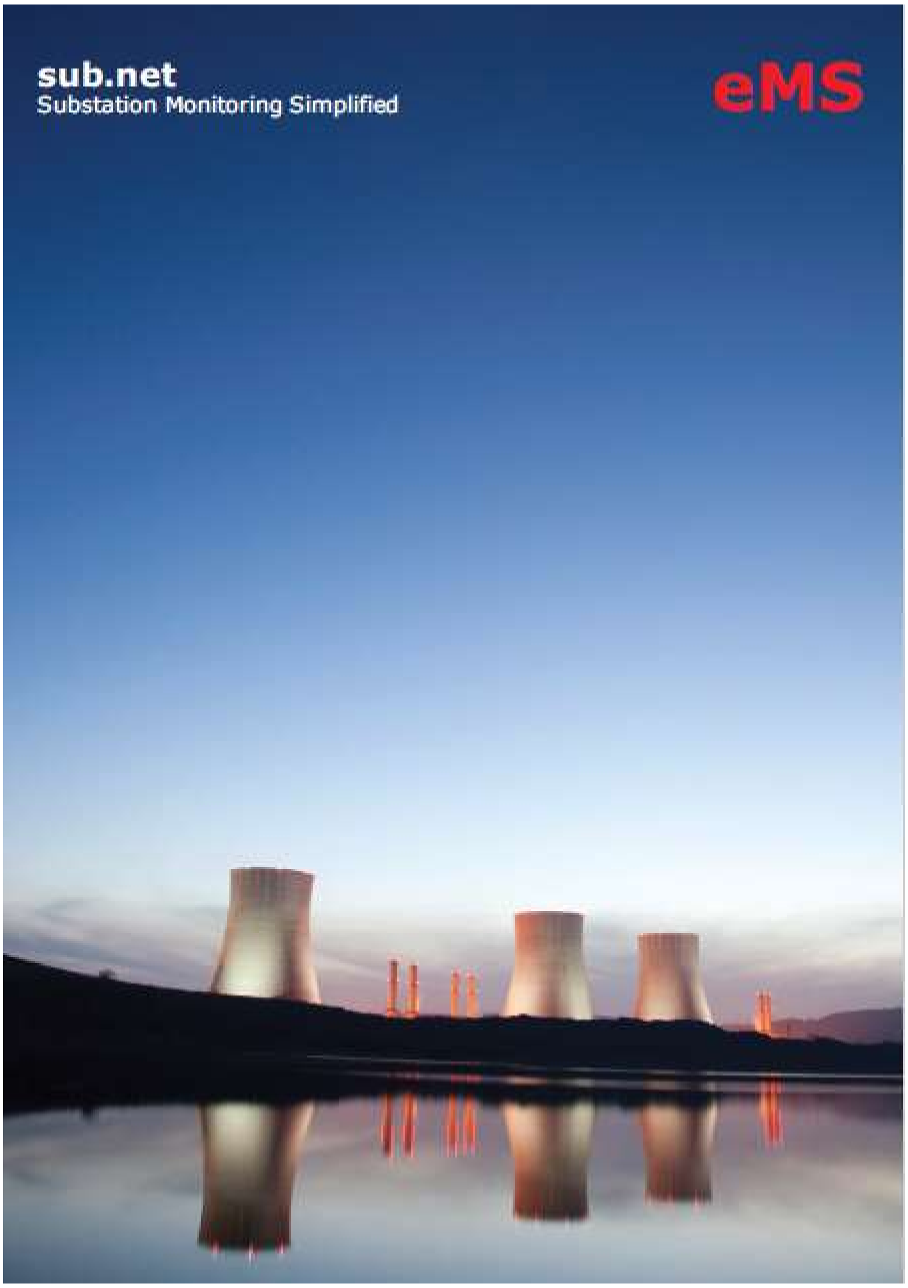
8.5 eMS Sub.net specification sheet



Embedded Monitoring Systems

Features

- Multiple substation monitoring functions
- Embedded event classifier saves engineering time
- Event reports sent via email, fax and text message
- Concurrent and prioritised reporting from multiple units
- Embedded web pages for viewing reports, inputs and set-up
- No dedicated master station software required
- Four concurrent recording rates
- Recorded data available in COMTRADE format
- Compact DIN rail mounting enclosure
  Portable & wall mounting options
- Fully solid state design
- Embedded network, modem and GPS time sync.
- Low power consumption
- Ease of use

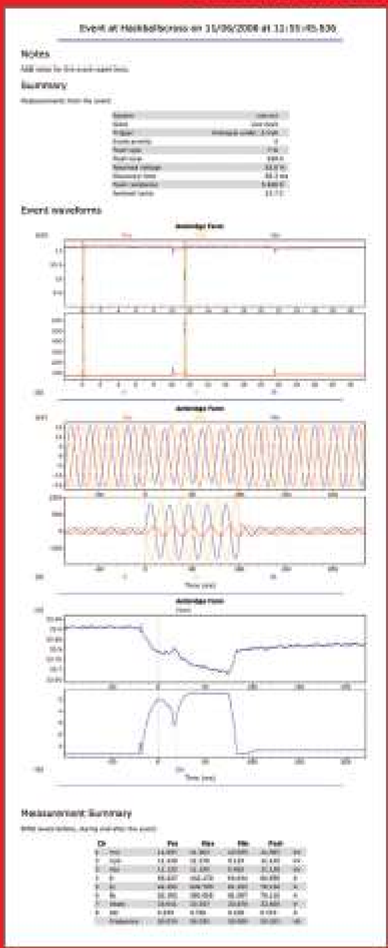
Applications

- Protection monitoring
- Quality of supply recording
- System stability monitoring
- Asset condition assessment
- Line fault location
- Power recording and submetering
- System planning
- Generator monitoring
- Grid code compliance
- Real time display
- Power quantities transducer
- Synchrophasor measurement
- Specialist applications -
  Capacitor bank switching
  Peterson coil monitoring

Locations

- Wind farms
- Generators
- Transmission sites
- Distribution substations
- Industrial plants

Protection Event Report



Embedded Monitoring Systems

Embedded software within sub.net provides automatic analysis of the recorded data resulting from system events and sends prioritised reports as email, fax or text messages. This enables rapid engineering assessments to be made and appropriate prompt actions to be taken. There is now no longer any need for large volumes of data to be retrieved from multiple instruments to a centralised master station before information can be made available to users.

Sub.net is a web enabled, multi-functional substation monitoring system incorporating wide ranging monitoring and recording functionality for use in the electricity supply industry and industrial plants. This makes sub.net ideal for use with Smart Grid where the internet is used to deliver useful information on the state of the energy network.

Sub.net continuously monitors and reports on protection operations, quality of supply, stability and other substation asset conditions. Real time monitoring and metering are other integral features.

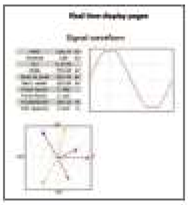
Sub.net is a completely new concept in substation monitoring, incorporating the very latest in software, hardware and communication technologies to meet the evolving needs and demands of the power supply industry. It will significantly reduce engineering fault analysis time, assist in network improvements, aid fault location and help reduce customer minutes lost (CML). Both installation costs and time are greatly reduced due to its very compact size.

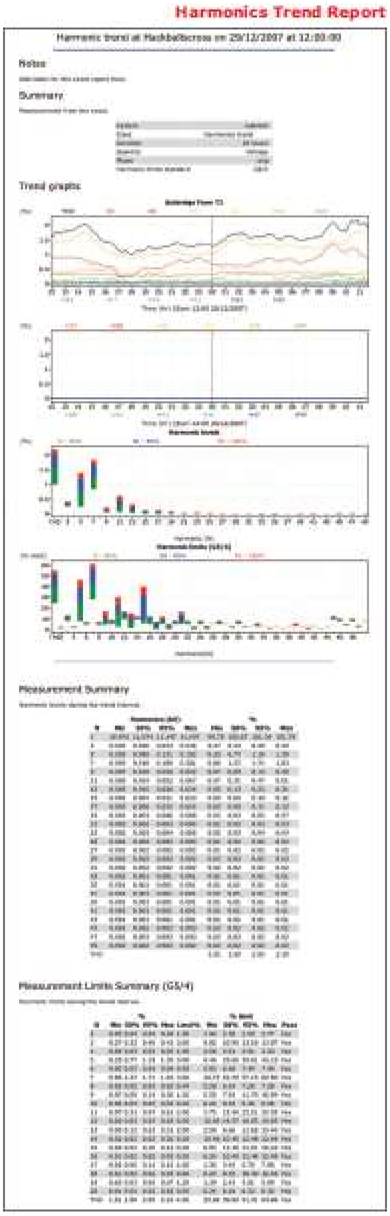
Remote communications are via LAN, PSTN or GSM connections. As event reporting is by email any number of sub.nets can process and transmit reports at the same time delivering timely information directly to user's desktops. Because sub.net works in this way a central master station application is not required saving time and money.

A web browser is all that is required to retrieve waveform and RMS files if signal data are required for further analysis. These files may also be sent as email attachments with the event report in COMTRADE format.

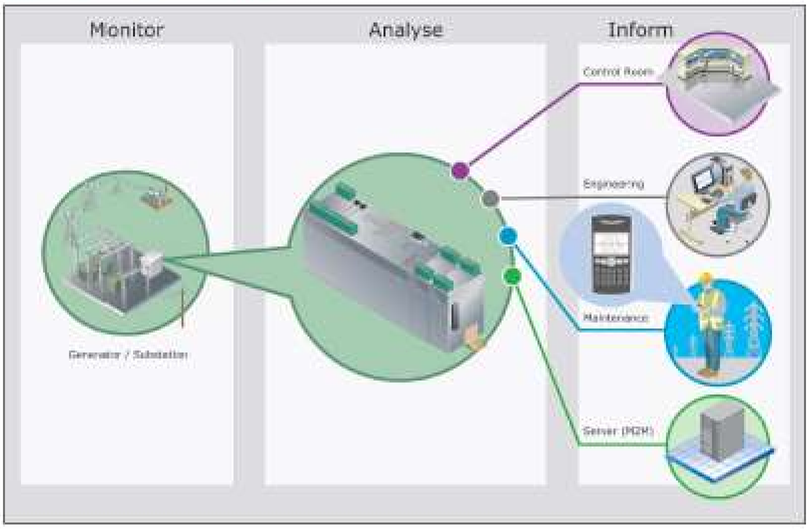
DIN rail mounting design enables rear panel fixing of the sub.net, close to the input connections. This, together with its very compact size, enables big reductions in both panel space requirements and wiring costs.

Sub.net uses field programmable devices and solid state storage to produce a high performance, flexible, low power instrument in a small enclosure. The low power consumption allows sub.net to be used in substations with older electromechanical protection.





sub.net Substation Monitor



sub.net substation monitor delivers visibility of today's ageing electrical grid, and tomorrow's smart grid, to maximise efficiency and reduce risk.

Sub.net introduces **automatic analysis** to the substation, monitoring and identifying problems throughout grid installations – reducing costs and saving time and money.

sub.net...

1. **monitors your network assets** for any faults 24/7 365 days a year.
2. performs **automatic fault analysis**, to verify performance of network assets.
3. e-mails ready analysed and prioritised event reports within moments, ensuring that the right people get **the right information right away**.

Manufacturing Options

Enclosure
- DIN rail mounting
- Portable case
- Wall / Pole mounting cabinet

Power supply
- 110/230V ac & 110/220V dc
- 30/50V dc
- 110/230V ac with external battery

Communications
- V90 modem
- GSM/GPRS modem
- PSTN router
- SCADA (Modbus RS485/TCP)
- Synchrophasor (IEEE C37.118)

Time sync
- GPS receiver
- GPS aerial and cable

Input modules
- 3x VT & 3x CT
- 6x CT
- 1x DC

Current transformers
- Wedding ring (toroidal)
- Split core
- AC clamp
- Hall effect DC clamp
- 3 phase Rogowski probe

sub.net Specifications

INPUTS

Analogue inputs	12. VTs, CTs or transducers
VT - input	150/300 Vac max. Phases isolated
- burden	24mW (500kΩ)
- isolation	2.5kV ac
CT - input	External interposing CT (clamp, toroidal etc.)
- range	Scaled for load or fault levels
Frequency response	30Hz - 3kHz (VT), DC - 3kHz (CT)
Sampling scheme	True synchronous sampling
Quantising resolution	16 bits (65535 levels)
Accuracy	Better than 0.1% of scale
Contact inputs	16
- wetting voltage	30, 50, 110 & 220V dc. Polarity independent
- debounce	0 - 10 ms

EVENT CAPTURE (DFR)

Waveform recording	
- sampling rate	128 samples per cycle. (6.4 or 7.68kHz)
- recording time	4-10 cycles pre event, 8-60 cycles post event
- records per event	up to 8
RMS/swing recording	
- channels	Up to 50 selected parameters. Voltage, current, frequency, apparent, real & reactive power, NPS, ZPS, etc.
- sampling rate	50 or 60 samples per second
- recording times	2-30s pre event, 10-60s post event

CONTINUOUS RECORDING

Trend recording	
- channels	~ 800 parameters. Voltage, current & frequency, apparent, real & reactive power, NPS, ZPS, power factor, imbalance, harmonics and flicker
- sampling rate	Max, min & avg every 10 minutes
- duration	26 weeks rotating buffer
RMS log recording (DDR)	
- channels	12 selected parameters (as RMS/swing)
- sampling rate	10 samples per second
- recording time	14 day rotating buffer

OPERATING LIMITS

Voltage	Maximum & minimum value, rate of change
Current	Rate of change
Frequency	Maximum & minimum value, rate of change

REAL TIME CLOCK

Crystal	Temperature compensated 32 kHz
Drift	Better than 4 ppm (~2s per week)
Synchronisation	GPS (optional)
GPS accuracy	Better than 1us

DATA STORAGE

Buffer storage	16Mbytes
Data storage	1024Mbytes flash memory

INTERFACE FUNCTIONS

User interface	Web browser (Internet Explorer, Firefox, etc.)
Event report delivery	Email, SMS or fax
Input data file format	COMTRADE (IEEE C37.111-1999)
Synchrophasor (PMU)	IEEE C37.118 (2005)

COMMUNICATIONS

Modem	
- baud rate	Up to 56 kbaud
- DTE rate	Up to 115 kbaud
- line isolation	3kV
- data protocol	PPP
- connector	RJ11
LAN	
- datarate	10/100 Mbps
- protocol	TCP/IP
- connector	RJ45
SCADA	
- Modbus	RS485/TCP
Network services	HTTP, SMTP

LEDs

Top panel	8 status, 2 LAN.

STATUS RELAYS

Status outputs	4
Contact rating	400V dc, 1A continuous
Surge current	5A for 1s
Isolation	3.75kV ac
Relay type	Solid state (IGBT)
Functions	System OK (N/C), Event (N/O), Attention (N/O)

POWER SUPPLY

Standard supply	110/230Vac 50/60 Hz and 110/220Vdc
DC supply (option)	30V or 50Vdc
Isolation	1.5 kVac
Battery back up (option)	External 12V gel cell
Battery support time	>2 Hrs (0.8Ah battery)
Power consumption	<4W

ENCLOSURE

DIN rail enclosure	
- size	315 x 110 x 75 mm
- weight	1.4 kg (3V & 9I)
Portable enclosure	
- size	406 x 330 x 174 mm
- weight	5.2 kg
Wall mounting cabinet	
- size	400 x 300 x 210 mm
- weight	11.5 kg

ENVIRONMENT

Operating temperature	-5 to 60 Deg C
Relative humidity	up to 95%

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