WESTERN POWER DISTRIBUTION

OPENLV

OPENING UP THE SMART GRID

SDRC 2.2

TARGET NETWORKS, MARKET POTENTIAL & TRIAL DESIGN

ea technology

RIIO NIC NETWORK INNOVATION COMPETITION

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Contents

Glossary

Term	Definition
ACRE	Action for Communities in Rural England
API	Application Programming Interface
CI	Customer Interruption
CML	Customer Minutes Lost
CSE	Centre for Sustainable Energy
DNO	Distribution Network Operator
DTR	Dynamic Thermal Rating
GMT	Ground Mount Transformer
HV	High Voltage
LV	Low Voltage
LV-CAP™	Low Voltage Common Application Platform
NIC	Network Innovation Competition
NOP	Normally Open Point
OHL	OverHead Lines
PMT	Pole Mount Transformer
PV	PhotoVoltaics
RTTR	Real Time Thermal Rating
SDRC	Successful Delivery Reward Criterion
WPD	Western Power Distribution

Executive Summary

Background

The technology to be trialled as part of the OpenLV Project provides a new, open and flexible solution that will not only provide the Distribution Network Operator (DNO), community groups and the wider industry with data from the LV network, but will also enable these groups to develop and deploy software applications on hardware (the OpenLV Platform) within LV substations. The OpenLV Project is seeking to prove the technology and assess how the provision of LV network data and the ability to develop and deploy software applications can provide benefits to the DNO, community groups and the wider industry.

Three Methods will be used to trial the OpenLV Platform:

- **Method 1 – Network Capacity Uplift:** The Project team will deploy software applications, on OpenLV Platforms, to increase the capacity of existing LV assets through the application and implementation of Dynamic Thermal Rating of the LV Transformer and through meshing LV Feeder(s) on the LV network.
- **Method 2 – Community Engagement:** The Project Team will engage with and sign up Community Groups to either, make use of the LV network data provided by the OpenLV Platform, and/or develop and deploy software applications on OpenLV Platforms.
- **Method 3 – OpenLV Extensibility:** The Project Team will engage with and sign up 3rd parties to either, make use of the LV network data provided by the OpenLV Platform, and/or develop and deploy software applications, on OpenLV Platforms.

Further information on the overall project can be found in the Full Bid Submission, which is available on the OpenLV project website: https://openlv.net/.

Purpose

In this report we present the results from:

1. Identifying the target networks for the capacity uplift trials (Method 1);
2. An update to the results previously published regarding testing the market to assess the level of interest from communities and third parties in participating in trials as part of the OpenLV project (Methods 2 and 3); and
3. The detailed trial design for the capacity uplift, community and OpenLV Extensibility trials (all Methods).

The key findings from the work completed to date are broken down under the following headings:

- **Community Engagement Trials – Testing the Market:** Provides an overview of the community engagement that has been completed to date and the market potential for community groups to utilise LV network data and/or develop software applications to be trialled as part of the Project;

- **OpenLV Extensibility Trials – Testing the Market:** Provides an overview of the engagement work that has been completed to date to assess the market potential for the wider industry to utilise LV network data and/or develop software applications to be trialled as part of the Project; and
- **Detailed Trial Design:** Provides an overview of the detailed trial design for each of the 3 Methods outlined in the Full Bid Submission: 1) Capacity uplift, 2) Community and 3) OpenLV Extensibility. This also includes the work completed to identify the target networks for the capacity uplift trials.

Key Findings

Community Engagement – Testing the Market

Overall, 51 community groups showed interest in taking part in the Community Engagement trials. This resulted in 45 app ideas ranging from public energy consumption displays to developing an evidence base to feed into local planning documents.

Market research established that there was a good enough level of interest from community organisations across the WPD network area to begin the full recruitment process. CSE's assessment showed that almost half (22) of the ideas had a high degree of potential relevance for further development in the trial.

In total, 10 applications to take part in the trials were received. CSE staff reviewed the 10 applications received and shortlisted eight groups for interview. CSE and Regen interviewed the 8 applicants and selected 7 community groups to take forward to trial.

A total of 10 OpenLV platforms are available to support the OpenLV Community Engagement trials; 6 community groups have been allocated a single OpenLV platform and 1 community group has been allocated 4 OpenLV platforms. The group that has been allocated 4 units is an isolated rural settlement that has 'energy island' planning potential that could prove very useful for a large number of other community groups.

The key learning points from testing the market are as follows:

- **Community groups engagement:** Community groups have required a tailored engagement approach in terms of imagery and style of communications. This has been critical to engagement success in terms of understanding the appetite from community groups to take part in the project;
- **Number of units:** One group were interested in the project but did not put an application form in as the project could not supply enough units. Their idea was to develop an app that would help identify the impact that an energy local club would have on peak shifting and peak flattening. However, the group hadn't realised that there would be so many substations within their area of interest. This shows there is clearly more potential if LV-CAP™ was rolled out at scale;

- **Community group interest:** There are enough groups with individuals who have an interest in data and electricity, combined with a drive to benefit the community they represent, to have met demand for this project; and
- **Technical complexity:** This is a technically complex project that includes talking to community energy groups about software programming and getting them to think about LV network data and its uses. The selection process was further complicated by screening out applications that included Pole Mount Transformers (PMTs) and those with poor mobile signal strength. The technical complexity along with no direct funding support has meant that only the most committed groups have made it through the selection process.

CSE are currently working with the 7 community groups to progress the project trials.

OpenLV Extensibility – Testing the Market

Overall, 79 organisations showed interest in taking part in the OpenLV Extensibility trials submitting a total of 74 ideas on how LV electricity network data could be utilised to develop new software applications and/or how LV network data could be utilised in research. Of the 79 organisations 60 (76%) were classed as Businesses and 19 (24%) were classed as Academic.

In total, 23 applications were received from organisations that wanted to take part in the OpenLV Extensibility trials. Overall, this represents a conversion rate of 29% (23 applicants out of a total of 79 organisations that showed interest in the project trials).

A total of 10 OpenLV platforms are available to support the OpenLV Extensibility project trials. The project team reviewed the applications and sought to work with as many organisations as possible to maximise learning on the project. In total, 17 of the 23 applicants (74%) were selected to take part in the project trials. This included 12 business applicants (71%) and 5 academic institutions (29%).

Of the 17 organisations, 8 are seeking to develop and deploy a software application on the OpenLV platform, 6 are seeking to get LV network data via a server-to-server link and 3 have requested EA Technology to provide LV network data to them directly (i.e. offline).

The key learning points from testing the market are as follows:

- **Engagement:** We have had good engagement for the Method 3 trials with a total of 79 organisations showing some level of interest in taking part and 23 organisations applying to take part. Given the lack of funding to take part in the trials this is a significant level of interest. The Marketing and PR completed on the project certainly helped drive this level of interest;

- **Workshop:** A dedicated workshop was held 2 weeks prior to the end of the formal application process. This workshop was attended by 39 people from 24 organisations and provided all the information the organisations needed ahead of completing the application form. The workshop also included an "application clinic" to ensure organisations could ask questions regarding the completion of the application form to take part in the project trials. Holding this workshop helped to maximise the number of applications received;
- **Funding:** The lack of direct funding for third-party participation was an issue for a number of potential applicants which limited the number of applications received; and
- **Resourcing/Business Case:** A number of companies were interested in taking part in the trials but could not justify re-allocating resource from fee paying work or had concerns regarding publication of their idea. This limited the number of applications received.

EA Technology are currently working with the 17 organisations to progress the project trials.

Detailed Trial Design – Network Capacity Uplift Trials

The purpose of this trial is to demonstrate how control actions can be carried out on LV networks via a highly distributed architecture.

At the time of writing 50 of the 60 sites for the Network Capacity Uplift trials have been selected in line with the Full Bid Submission criterion. At bid stage the approach was to target 6 geographic areas in WPD's Licence areas with up to 20 OpenLV platforms installed in 3 geographic areas. Following the selection of trial sites for the Network Capacity Uplift trials, the OpenLV Project has, at the time of writing, installed 50 OpenLV platforms in 9 geographic areas.

It is confirmed that the Network Capacity Uplift trials have been designed in line with the trial approach outlined in the Full Bid Submission. The 50 Stage 1 sites that will test the OpenLV platform with monitoring and control software applications without actuation have been selected and were installed by the end of May 2018. A total of 30 potential sites have been short-listed to install the 10 Stage 2 sites that will test with actuation, e.g. operation of switchable devices on the LV network.

OpenLV platforms are scheduled to be installed at the final 10 Method 1 sites by the end of July 2018. The network capacity uplift trials will be executed over an 18-month time period as defined in the Full Bid Submission. It is confirmed that the detailed trial design has been completed for this Method.

Detailed Trial Design – Community Engagement

The purpose of this trial is to establish the market for community or customer driven software applications. EA Technology has appointed the Centre for Sustainable Energy (CSE) and they have engaged with community energy groups to promote the availability of the OpenLV platform and associated LV network data. EA Technology has also appointed Regen to assess the longer-term potential / economic impact for the use of the OpenLV platform and to develop enduring tools to assist communities in their engagement with the distribution network. This meets the requirements of the trial approach as outlined in the Full Bid Submission.

It is confirmed that CSE and Regen have engaged with community groups and housing associations to select the groups to take part in this trial. This is in line with the trial selection approach outlined in the Full Bid Submission.

In addition, it is confirmed that the deployment of the 10 trial units is in line with the approach outlined in the Full Bid Submission. In total, 7 community groups have been selected to take part in the trial. The 10 LV substations where the OpenLV platforms will be installed have been surveyed and are currently scheduled to be installed by the end of June 2018.

This will enable the community engagement trials to be executed over a 12-month time period. It is confirmed that the detailed trial design has been completed for this Method.

Detailed Trial Design – OpenLV Extensibility

The purpose of this trial is to exploit the flexible/open nature of the OpenLV platform to enable companies to develop innovative algorithms and applications. EA Technology has developed the 'third party developer Application Programming Interface (API)' and shared this with organisations that have shown an interest in taking part in this trial. In addition, EA Technology has developed further documentation/support tools that were not identified as part of the trial approach in the Full Bid Submission to support the project trials.

It is confirmed that EA Technology has tested the market and selected 17 organisations to take part in this trial. These organisations are a mix of large corporates, SMEs and academic institutions. The organisations selected meet the trial selection criterion outlined in the Full Bid Submission. In addition, EA Technology, has maximised the learning on the project by working with interested parties to understand how they want to utilise LV network data. This approach has enabled the project team to work with 17 organisations using 10 OpenLV platforms.

In terms of trial deployment EA Technology is currently working with the 17 successful applicants to agree where the 10 OpenLV platforms will be deployed. At the current time, 3 of the 10 LV substations have been selected and surveyed. It is expected that the 10 OpenLV platforms will be installed by August 2018. This will enable the OpenLV Extensibility trials to be executed over a 12-month period. It is confirmed that the detailed trial design has been completed for this Method.

Overall

The market potential for the Community Engagement and OpenLV Extensibility trials has been assessed. Significant interest has been shown in developing software applications and utilising LV network data from community energy groups, businesses and academic organisations.

The project team has completed the detailed trial design for the 3 Methods in accordance with the proposed trial design in the Full Bid Submission. The LV substations for the 60 Method 1 units have been identified and installations are currently on-going. Participants for the Method 2 and Method 3 trials have been selected and the 20 OpenLV platforms that will be used to execute the trials have been allocated to organisations that meet the selection criterion outlined in the Full Bid Submission.

The learning from deploying the overall OpenLV solution will be provided in SDRC-3 that is scheduled to be delivered in February 2019. The learning generated from the trials for all Methods will be reported in SDRC-4, which is scheduled to be delivered in January 2020.

1 Introduction

1.1 Document Purpose

In this Successful Delivery Reward Criteria (SDRC) report we present the results and learning generated from:

1. Identifying the target networks for the capacity uplift trials (Method 1);
2. An update to the results previously published regarding testing the market to assess the level of interest from communities and third parties in participating in trials as part of the OpenLV Project; and
3. The detailed trial design for the capacity uplift, community and wider industry (OpenLV Extensibility) trials.

This report has been structured to meet the SDRC evidence criterion outlined in the OpenLV Project Direction [Ref. 1]. The requirements for key project deliverables, as part of Network Innovation Competition (NIC) Governance, are defined as SDRCs and each SDRC has associated evidence criteria as defined in the Project Direction. It is confirmed that the SDRC and associated evidence requirements have been met and this is supported by the compliance matrix provided in Table 1.

Table 1: SDRC Criterion & Evidence Compliance Matrix

Successful Delivery Reward Criterion	Evidence	Criterion Met	Section(s)
Assessment and identification of the target areas of the LV Network to maximise learning for Method 1.	Sharing the technique(s) used to identify target LV networks.	Yes	Section 2
An assessment of the market potential for Community Engagement (Method 2).	Final Report: Sharing the results from assessing the market potential for sharing LV network data with and providing an open platform to communities that want to be part of a smarter grid.	Yes	Section 3 & 5

Successful Delivery Reward Criterion	Evidence	Criterion Met	Section(s)
An assessment of the market potential for OpenLV Extensibility (Method 3).	Final Report: Sharing the results from assessing the market potential for sharing LV network data with and providing an open platform to academics and companies (including non-energy companies).	Yes	Section 4 & 5
Detailed trial design for all methods.	Detailed trial design for all methods.	Yes	Section 5 & Annex 1

The OpenLV project will trial a new open and flexible Solution that will be installed in Low Voltage (LV) substations. This Solution will provide enhanced monitoring of the LV network and enable the industry to develop Applications or Apps to provide benefits to:

- Individual customers;
- Community energy groups;
- Distribution Network Operators (DNOs); and
- The wider industry.

Further information on the OpenLV Project can be found in the Full Submission Pro-forma (FSP) [Ref. 2].

1.2 Background

Great Britain has about 1,000,000 Low Voltage (LV) feeders; these have largely been designed and operated on a fit-and-forget basis for the last 100 years, but things are set to change. LV networks are expected to see radical change as we, as customers, alter our behaviour and requirements, stemming from the vehicles we drive, to the generation and storage devices we put onto and into our homes.

The technology to be trialled as part of the OpenLV Project provides a new, open and flexible solution that will not only provide the DNO, community groups and the wider industry with data from the LV network, but will also enable these groups to develop and deploy apps within LV substations. The OpenLV Project is seeking to prove the technology and assess how the provision of LV network data and the ability to develop and deploy apps can provide benefits to the DNO, community groups and the wider industry. These Methods are outlined below sub-sections.

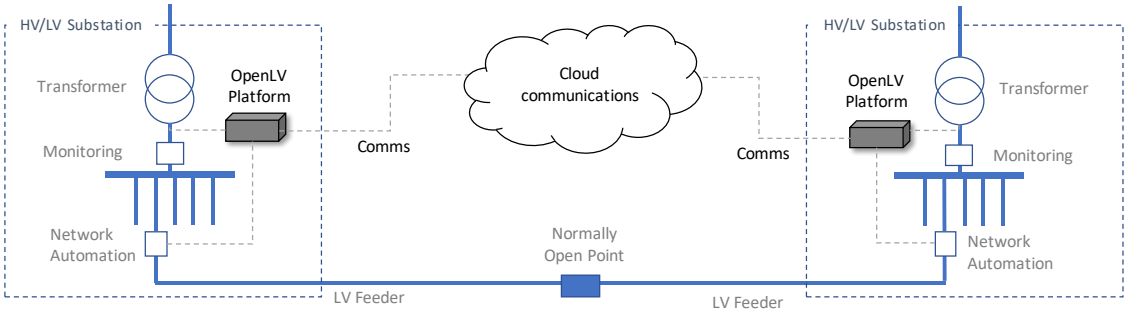
1.2.1 Method 1: Network Capacity Uplift

Figure 1 provides an overview of the systems architecture that will be deployed to complete Project trials for Method 1 – Network Capacity Uplift.

As part of the Project trials for Method 1 apps will be used to increase the capacity of existing LV assets through the application and implementation of Dynamic Thermal Rating of the LV Transformer and through meshing LV Feeder(s) on the LV network.

Dynamic Thermal Rating is a method whereby the rating of an asset (e.g. cable or transformer) can be temporarily increased due to previous favourable conditions (e.g. colder weather or the asset is currently cool due to light loading).

Meshing (connecting LV network areas together) can share spare capacity between two networks to prevent cable or transformer overloads.



What

- Check network capacity against thermal rating of transformer; when breached, close two radial circuits to mesh the LV network
- Deploy two proven techniques
  - 'Dynamic Thermal Ratings App' and
  - 'Network Meshing App'.
- Together with a 'Network Control App' to operate/configure the network

How

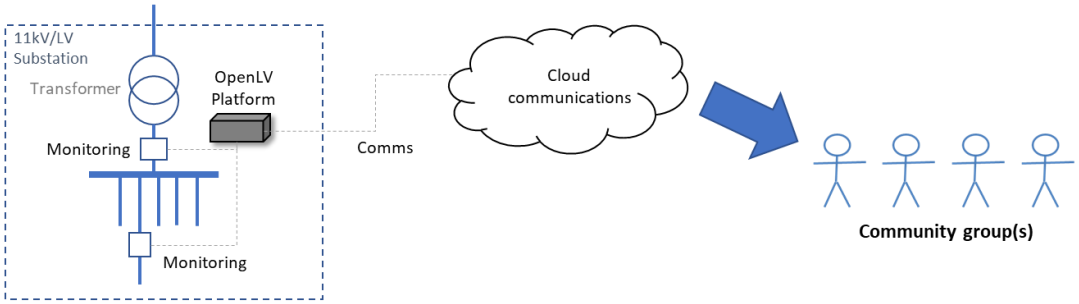
- Assess WPD's network to identify candidate circuits
- Deploy LV-CAP™ to 60 substations
- Monitor how the solution would operate over several months
- Install actuators on 5 circuits (2 ends each) to prove end-to-end control
- Assess and report on performance

Figure 1: Method 1 – Network Capacity Uplift

1.2.2 Method 2: Community Engagement

Figure 2 provides an overview of the systems architecture that will be deployed to complete Project trials for Method 2 – Community Engagement.

As part of the Project trials for Method 2, Community Groups will either, make use of the LV network data provided by the OpenLV Platform, and/or develop and deploy apps to provide benefits to individual Communities.



What

- To work with key community groups to understand whether Apps can be developed and installed on the platform
- Identify funding sources that customers / communities can use to develop specific Apps

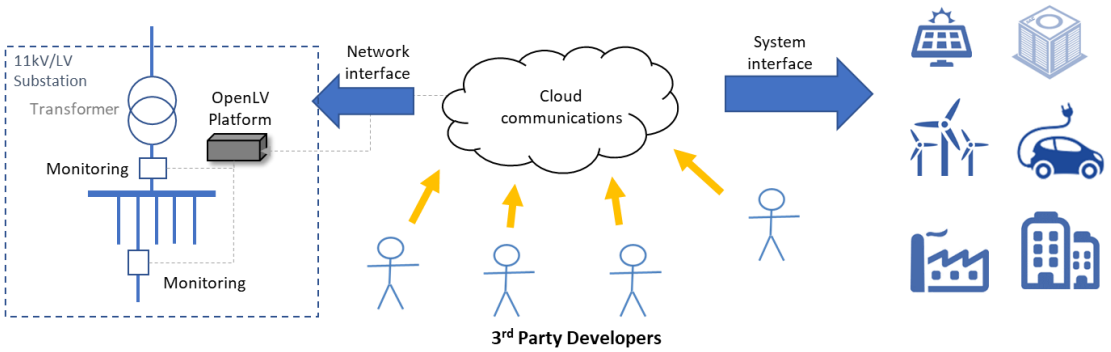
How

- Community engagement to promote availability of platform / LV network data
- Make available 10 LV-CAP™ units for deployment
- Provide communities access to relevant data
- Funding to develop specific Apps to be raised outside of the project budget, e.g. public funding / private sector

Figure 2: Method 2 – Community Engagement

1.2.3 Method 3: OpenLV Extensibility

Figure 3 provides an overview of the systems architecture that will be deployed to complete Project trials for Method 3 – OpenLV Extensibility. As part of the Project trials for Method 3, the Wider Industry will either, make use of the LV network data provided by the OpenLV Platform, and/or develop and deploy 'apps' to provide benefits to: DSOs, Platform Providers, 3rd Party Developers and Customers.



What

- To enable companies to develop innovative algorithms and applications for either the DNO, or it's customers

How

- Publicise the opportunity to 3rd parties
- Make available standard App 'container' for third parties to use for their development
- Make available 10 LV-CAP™ devices for substation deployment
- Funding to develop specific Apps to be raised outside of the project budget, e.g. private sector

Figure 3: Method 3 – OpenLV Extensibility

1.3 Report Structure

The structure of this report is as follows:

- **Section 2: Techniques for identifying target networks for Method 1 –** Provides an overview of the techniques used to select target networks for Method 1 trials, Network Capacity Uplift;
- **Section 3: Market Potential for Method 2: Community Engagement –** Provides an overview of the community engagement that has been completed to date and the market potential for community groups to utilise LV network data and/or develop Apps to be trialled as part of the Project. Further information is provided in 0;
- **Section 4: Market Potential for Method 3: OpenLV Extensibility –** Provides an overview of the engagement work that has been completed to date to assess the market potential for the wider industry to utilise LV network data and/or develop Apps to be trialled as part of the Project. Further information is provided in 0;
- **Section 5: Detailed trial design for all Methods –** Provides an overview of the detailed trial design for the overall Project. Further information is provided in Annex 1;
- **Section 6: Key Learning Points -** Outlines the key learning points recorded at this stage of the Project in relation to the specification, design, build and testing of the overall OpenLV solution; and
- **Section 7: Summary –** Outlines how the SDRC evidence will be utilised within the Project.

2 Techniques for Identifying Target Networks for Method 1: Network Capacity Uplift

The OpenLV Project will deploy 60 sets of trial equipment to undertake the Method 1 trials. These will comprise:

- 25-pairs (50 units) for Stage 1 Trials; and
- 5-pairs (10 units) for Stage 2 Trials.

Further details on these Stages are provided in Section 5.2.1.

2.1 Network identification

To trial the methodology proposed for Method 1, specifically utilising real-time monitoring of the LV network to inform an automated network meshing process. Selection of suitable LV networks is essential. Method 1 will include the use of Dynamic Thermal Rating (DTR) as an input to the implementation of the network meshing. However, DTR has been trialled before and is not therefore the purpose of these trials.

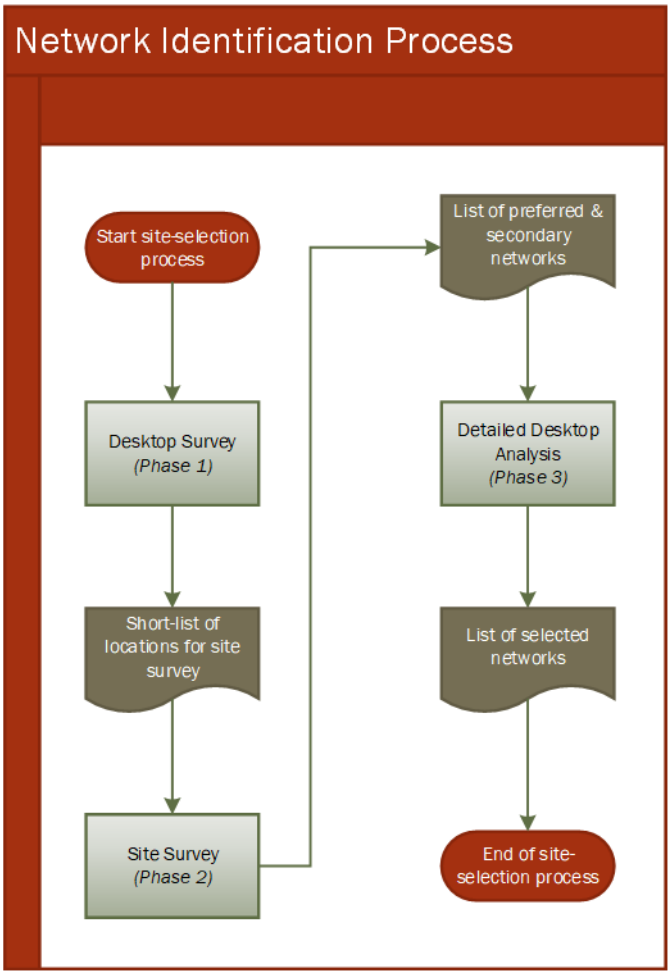


Figure 4: Overall LV Network identification process

2.1.1 Considerations for network selection

Identification of potential sites was undertaken utilising a combined desktop survey and on-site evaluation process. Sites shortlisted via desktop surveys were visually inspected before being subjected to a final, detailed network analysis. The overall process is depicted in Figure 4.

The considerations for network selection include technical and commercial requirements and are covered below, separated by the desktop survey and on-site inspection criteria.

The following sub-sections provide further detail on each of the three Phases:

- Phase 1 – Desktop Survey;
- Phase 2 – Site Survey; and
- Phase 3 – Detailed Desktop Analysis.

2.1.2 Desktop survey (Phase 1)

The flow diagram for Phase 1 is located in Figure 5: Desktop survey (Phase 1) process.

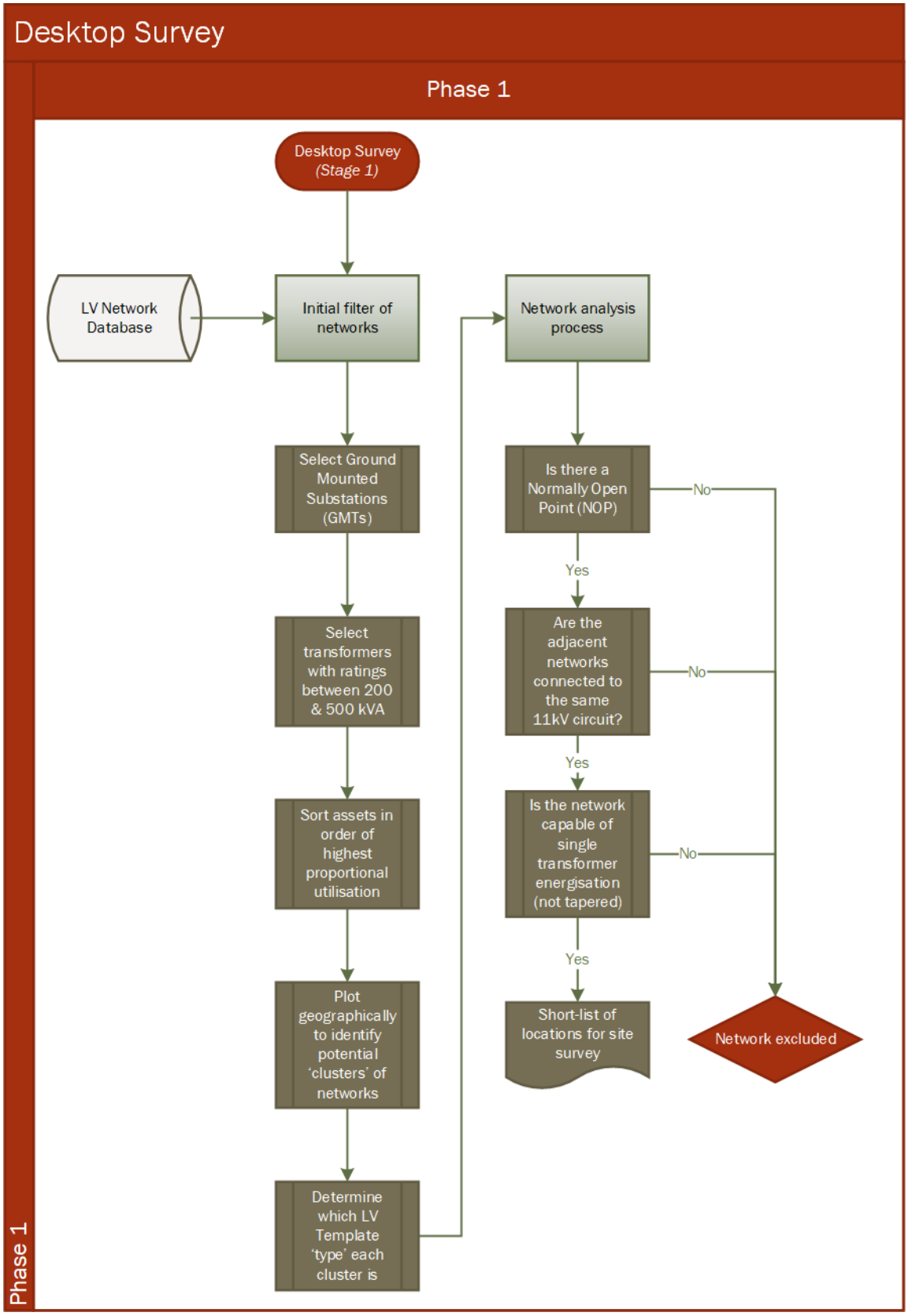


Figure 5: Desktop survey (Phase 1) process

Each of the below sub-sections provides details on the factors that influenced the site selection process during Phase 1.

WPD provided EA Technology with details of their LV substations, including actual and predicted load profile data to utilise.

Network locations

The project has been given network data to allow identification of potential networks to be undertaken.

The range of geography and customer profiles within the four licence areas has ensured the OpenLV Project could select the best networks for use in the trials, thus maximising the opportunity to gather a rich data set from across the networks available to the Project.

Figure 6: Map of WPD's 4 licence areas

Transformer type

Whilst it is a business-as-usual practice to deploy Smart-Grid enabled equipment at pole-mounted substations, for the purposes of the OpenLV Project, only ground-mounted substations will be utilised.

This decision was based on:

- Simplification of installation for the trials:
- The same work crews would be able to install the necessary equipment in all trial locations;
- The range of required mounting arrangements will be limited, minimising variations to equipment and method statement requirements.
- Equipment can be accessed without specialist equipment / training.

Any network locations identified as part of the process that consist of either overhead-line mounted transformers or private network transformers will be disregarded as will any transformers supplying less than 10 customers.

Furthermore, preference will be given to indoor substations to provide additional security and protection from the elements to the trial equipment. Indoor substations are also more likely to have capacity for the installation of ALVIN Reclose™ devices on the fuse board in the latter stages of Method 1.

Transformer rating

The ALVIN Reclose™ equipment will be utilised in Method 1 to demonstrate automatic control of network assets by an LV-CAP™ platform.

The desktop survey stage will initially disregard any transformer with a kVA rating that does not fall between 200 and 500 kVA to provide a more manageable list of potential sites. This does not preclude identified sites connecting to a substation with a larger transformer rating. If enough suitable sites were not identified from the first desktop survey, then expanding the search criteria to include higher rating transformers would have been undertaken to increase the number of potential sites.

This requirement applies to both transformers at either end of the potential 'link' to be established under Method 1.

Ratio of transformer rating vs loading

The OpenLV Project has been provided with a significant volume of LV network data from previous projects undertaken by WPD. The data, implemented in 'Distribution Substation Estimates', ranges across all four of WPDs licence areas although it does not include every network that exists.

This data relating to the transformers, includes 'Name Plate' details, whether it is a pole or ground-mounted and information relating to the loading.

Comparing the Name Plate details with the loading of the asset provides a loading ratio for the asset. The OpenLV Project is focussing on locations where one asset is operating, proportionally, at a greater loading than the other to have a level of load reliability from day-to-day.

Clustering

Logistically, it is more efficient to install, commission, maintain and decommission the trial hardware if the selected locations are in reasonable proximity, reducing reduce travel costs and installation time. Regardless of this, sites have been selected based on the learning potential, with clustering of installations a secondary consideration.

Network arrangement

There are several considerations for the specific arrangements of each identified network.

1. The presence, or otherwise, of a Normally Open Point (NOP). If there is no NOP that could conceivably be 'closed' to link adjacent networks, then the network has been removed from consideration at this stage. It has been assumed at this point that the NOP can be closed if required, although this will require verification at the site-survey stage.
2. The two adjacent networks must be energised from the same HV network to avoid the potential for an inadvertent connection between HV circuits through the LV network; if not then they have been removed from consideration.
3. The network cables on either side of the NOP must be capable of sustaining the energy transmission if the entire length were to be energised from a single transformer at one end or the other. Therefore, where a network is tapered, initially it has been removed from consideration; if additional networks are required, potential sites disregarded at this stage will only be reconsidered following network analysis to determine the network is capable of safely maintaining the load.

Network type

It was confirmed within the OpenLV Project Bid Submission that network selection would include consideration of the similarity to LV Network Templates, previously developed by WPD. Of the ten templates identified, two (Industrial Flats and Streetlighting) are inappropriate for the OpenLV Project and the demonstration of the LV-CAP™ platform's capabilities and consequently any networks of this type have been disregarded as part of the identification process.

At least three of each network type will be selected across the project to provide an indication of the benefits each of the methodologies implemented within the project for that network type.

2.1.3 Site surveys (Phase 2)

The flow diagram for Phase 2 is located in Figure 7: Site survey (Phase 2) process.

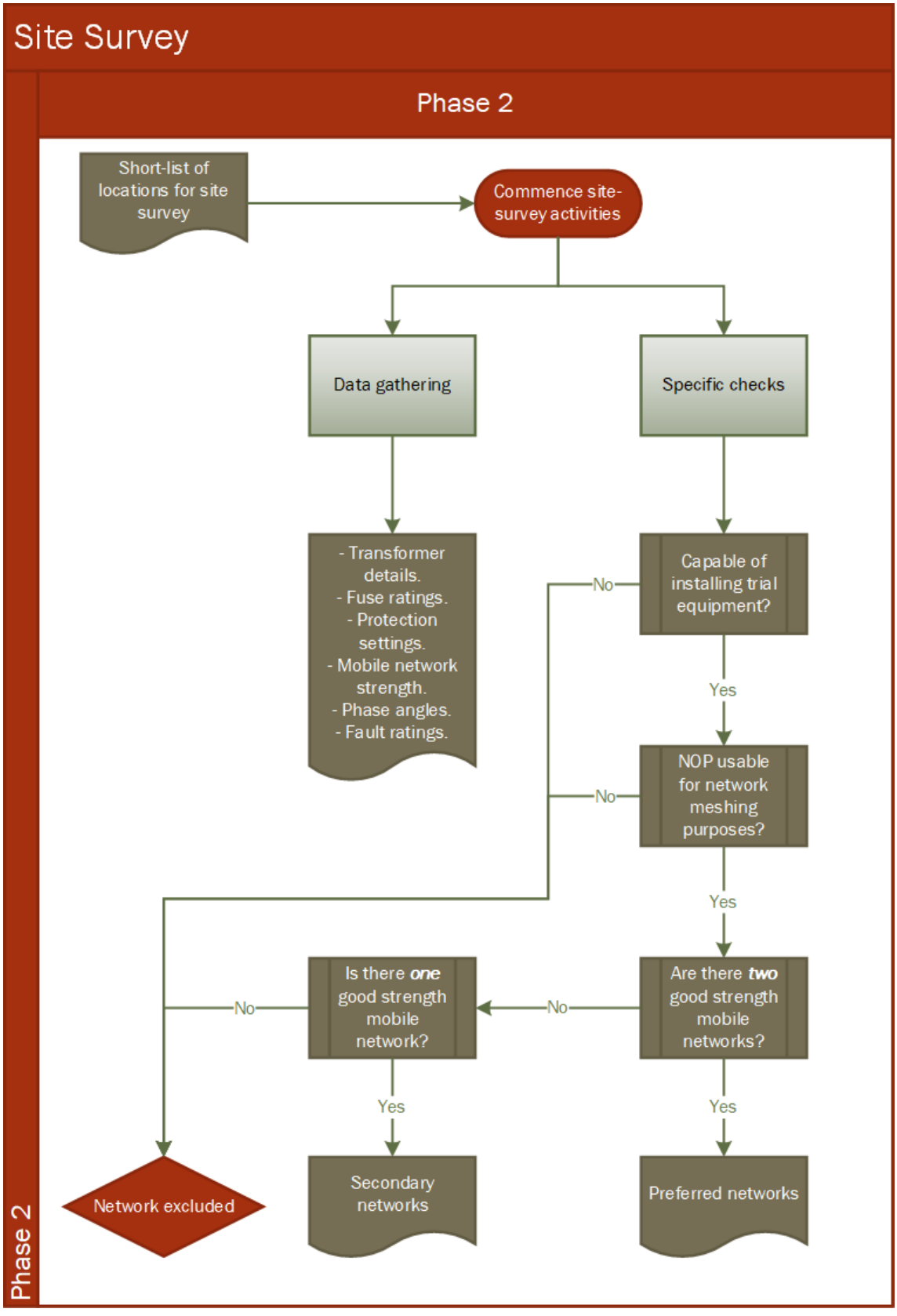


Figure 7: Site survey (Phase 2) process

The purpose of the Site Surveys was to determine if each pair of substations visited were capable of being outfitted with the OpenLV Project trial equipment.

Where possible, this involved capturing of data relating to transformer and fuse ratings, protection settings and mobile network strength. If WPD staff were present, they were also queried about any known network issues in the local area that may influence or be affected by the project trials.

Specific checks were undertaken relating to the ability to install the trial equipment in the substation; due space, power and cable routing requirements for the equipment to be installed.

The below sub-sections detail each area for investigation during the site-surveys.

Space to install OpenLV trial equipment

The ability to install the project's equipment within the specific substation is a critical factor that can only be verified via a site inspection. Consideration must be taken of available space to safely install a cabinet containing the LV-CAP™ platform within the substation, and connection of the monitoring devices (current transformers to bus bars, temperature probes to the transformer).

Where there was insufficient space to safely mount the necessary equipment, the site was disregarded for the purposes of the trial.

Fuse ratings

The ALVIN Reclose™ equipment to be utilised in Method 1 to demonstrate automatic control of network assets by an LV-CAP™ platform, can only replace fuse ratings of 315A and 400A.

Fuse board

The ALVIN Reclose™ devices are larger than a standard fuse and consequently a fuse board capable of having them fitted will be essential and any locations where this is not possible will be flagged at the site survey stage and taken into account during the final selection process.

Some LV enclosures will require retro-fitting of deeper doors to the LV enclosures if deemed suitable for use.

Furthermore, the presence of an unused set of fuse sockets on the fuse board is preferred to make connection into the LV network by the LV-CAP™ platform and monitoring equipment significantly easier to achieve.

Normally Open Point & Phasing

Verification of the NOP is required and will be checked during the site-survey stage to confirm the links can be physically closed.

At this point it was also necessary to confirm that the adjacent networks were 'in-phase' to each other and consequently, can be connected through closure of the links in the NOP.

Communication capabilities

The final consideration for each network location considered is communication viability. Trialling the platform necessitates a reasonable communication capability for monitoring, over-the-air updates if needed and minimising site-visits as far as possible.

Consequently, the final stage of site selection shall be an evaluation of the mobile signal strength across all available networks at each short-listed location.

If there is not a sufficiently strong signal strength across ***two*** mobile network providers, but has met all other requirements, then the network shall be considered a lower priority potential site. If there is not a sufficiently strong signal strength across even ***one*** mobile network, then the site shall be disregarded entirely.

Fault history

It is anticipated that the site crews from each of the relevant WPD depots will be able to identify networks under consideration that have a history of fault occurrence. It is preferred that the OpenLV Project avoids utilising networks that are known to experience faults due to the impact this may have on the project findings.

2.1.4 Fault level analysis (Phase 3)

Post-successful site-survey, a detailed fault analysis will be undertaken on networks still under consideration, including calculation of recommended protection settings for the networks if automated network meshing were to be implemented.

Only sites where meshing will not cause problems for the network's protection settings can be considered for deployment of the ALVIN Reclose™ devices for the autonomous meshing trials.

18-pairs of substations have been shortlisted for Phase 3 – Detailed Desktop Analysis and this is currently underway.

Undertaking this analysis requires the creation of a network model for the LV network being considered and determination of the fault level for each potential scenario if the Alvin Reclose™ units were installed as planned within the project. These scenarios are:

1. Full length of feeder energised from Substation 1;
2. Full length of feeder energised from Substation 2; and
3. Full length of feeder energised from both Substation 1 & 2.

The flow diagram for Phase 3 is located in Figure 8: Detailed desktop analysis (Phase 3) process.

Once sufficient networks (5-pairs), are identified as being suitable for implementing the network meshing, no further networks will be analysed as part of the OpenLV Project.

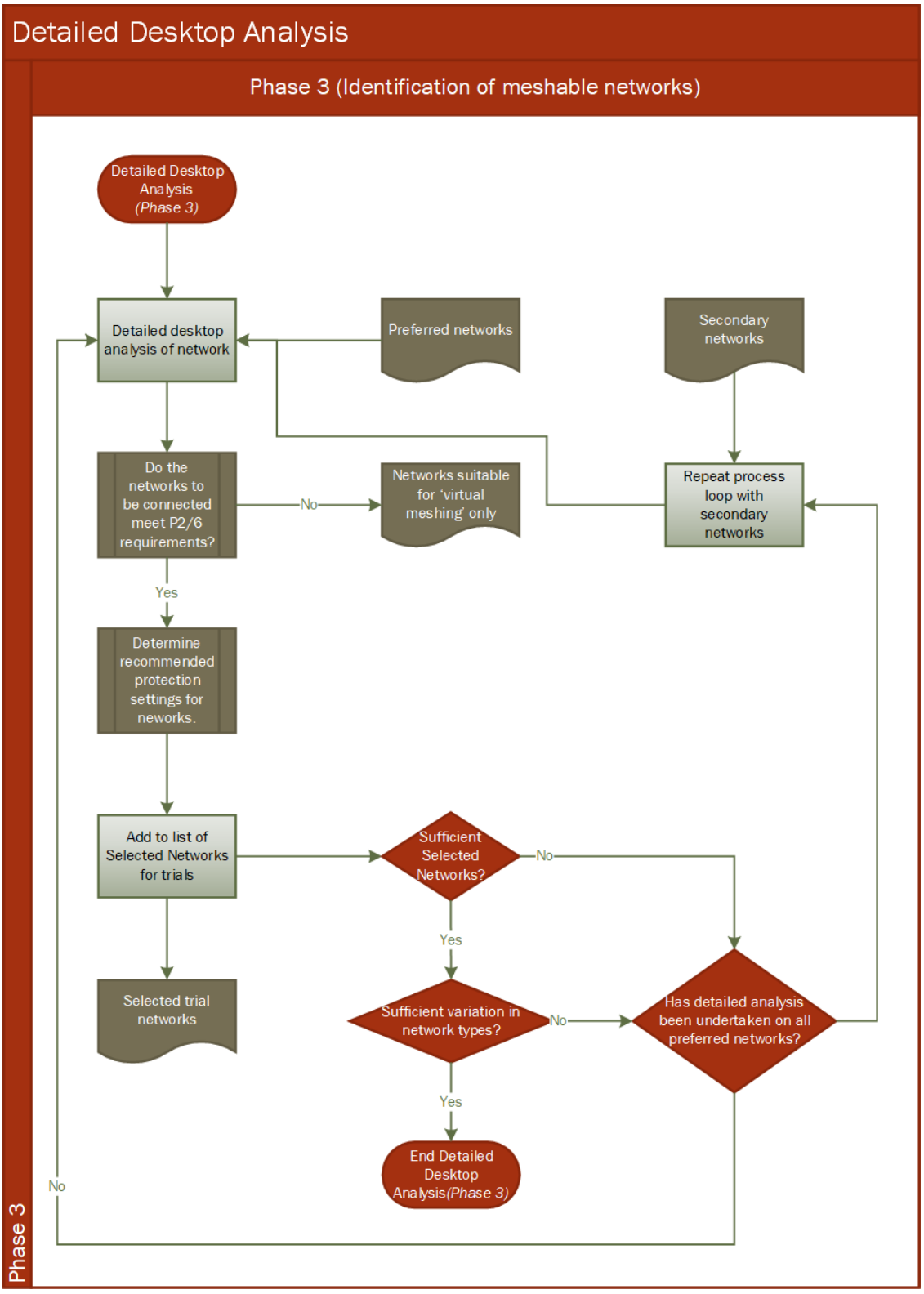


Figure 8: Detailed desktop analysis (Phase 3) process

3 Market Potential for Method 2: Community Engagement

3.1 Introduction

SDRC 2.1: Community Engagement Plan and Testing the Market [Ref. 3] explored the initial phase of the Centre for Sustainable Energy's (CSE's) engagement with community groups and determined that there was sufficient interest to commence the requisite number of trials under Method 2. Section 0 provides:

- **A recap on the initial findings in SDRC 2.1:** Community Engagement Plan and Testing the Market;
- **Community engagement**: An update on the market potential for LV-CAP™, by following the journey of community group engagement from the analysis of engagement at expression of interest stage (as covered in SDRC 2.1), to interviews and site surveys, to recruitment of successful community group applicants into the trial programme; and
- **OpenLV extensibility**: An assessment of the ideas generated by the community groups, further to that in SDRC 2.1.

3.2 Market Potential for Method 2: recap on initial findings

3.2.1 Community Engagement – Testing the Market

As reported in SDRC 2.1, 51 community groups responded to a survey that was open for 28 days. This resulted in 45 distinct app ideas ranging from public energy consumption displays to developing an evidence base to feed into local planning documents. Overall the market research at this initial stage established that there was sufficient interest from community organisations across the WPD network area to begin the full recruitment process.

3.2.2 Community Engagement – Market Assessment Review

The number of responses to the community engagement survey suggested considerable interest in LV substation data. As noted in section 3.2.1, the project received 51 responses from community groups, that when evaluated, produced 45 distinct software application ideas. Some of these had multiple potential benefits and consequently, 59 separate use cases were identified from the responses.

The ideas for using LV substation data presented by the groups showed a good breadth and range of objectives, from connecting new renewable projects to informing local plans and policies, indicating that LV substation data has the potential to provide multiple benefits for communities. It also provides a good starting point from which to identify ideas that have the most potential to be financially viable and replicable.

Overall, Regen's early assessment was that almost half (22) of the ideas had a high degree of potential relevance for further development in the trial.

A range of seven different sources of value were identified at this early stage, which provided some confidence that it would be possible to identify viable and replicable business models for community software applications using data from LV substations. Each of the 22 ideas had at least one potential source of value associated with it. However, there was still uncertainty about whether a community would be able to secure the income or saving, especially in relation to local flexibility markets and innovative models of supply, many of which do not exist yet. Individual ideas will need to be assessed for their potential risks, costs and benefits.

As the community groups under Method 2 progress towards trial stage, consideration will need to be given to commercial issues, such as the cost of new technologies and whether new markets will emerge within the required timescale. Furthermore, ideas will need to be assessed against criteria related to public acceptance and policy traction to test if they are likely to come up against political or community resistance.

3.3 Community engagement: the developing market potential

This section provides a progress update on recruitment under Method 2, along with details of the interview and selection process, survey, site selection and next steps.

3.3.1 Recruitment process

Following the market testing survey in the summer of 2017, and the development of the Community Engagement Plan, CSE launched the open call for applicants to Method 2 in December 2017, with a closing date set for 22nd of January 2018.

Potential applicants were able to call during this open period, and request information on the substations in their proposed project areas. CSE provided maps of substation locations to seven potential applicants, with more detailed feeder maps also provided by EA Technology on specific substations.

Separately, CSE promoted the OpenLV project to housing associations and parish councils, both by phone and by email. The National Housing Federation circulated the information via their internal regional newsletter, and CSE staff followed up with the regional offices. This resulted in the West Midlands and South Wales regional offices promoting the project further with their member housing associations.

Action for Communities in Rural England (ACRE), an umbrella body providing support services to rural community councils across England, also promoted the scheme through their newsletter. CSE staff also made calls and promoted the scheme via email to rural community councils in the WPD area, and the opportunity was circulated to parish councils already on CSEs mailing list.

An extended closing date and simplified application form was made available to housing associations and parish councils. CSE provided substation and feeder maps to two housing associations and one parish council. At the closing date, CSE received two applications from housing associations (both of which were taken forward for interview), but none from parish councils.

Anecdotal feedback from parish councils spoken to suggested that the OpenLV project was viewed as extremely technical and not close enough to the core business of a parish council to represent an attractive offer, particularly since it did not come with grant funding. Although one town council expressed an interest and discussed a proposal at some length with CSE staff, they did not submit an application in the end, citing lack of staff capacity as the main reason.

3.3.2 Interview and selection

Applications were received from ten community energy organisations at the closing date. Of these, eight were taken forward for interview. Of the other two, one was discounted for technical reasons once the application had been assessed, and the other was discounted as the application was substantially incomplete.

Based on the submitted applications and further information gleaned at interview, CSE staff summarised the range of app functionality described across the range of projects shortlisted for interview, shown in Table 2.

Table 2: Method 2 Community Groups Shortlisted for Interview

Group / project details	Exeter Community Energy	Marsh field	Owen Square Community Energy	Bath and West	Ambition Lawrence Weston	Tamar Energy	WHG Group	Rooftop Housing
Functions of the web app (public facing)								
Substation data (and aggregations)								
Web based visualisation of LV-CAP consumption/demand data over time	✓	✓	✓	✓	✓	✓	✓	✓
Web based visualisation of national stats on carbon intensity of grid electricity	✓	✓		✓	✓	✓		✓
Local Tariff modeller (for building a business case for selling locally generated energy directly).	✓	✓		✓	✓	✓		
Use reactive power and harmonics data to show the level of local generation as a proportion of substation load				✓				
Imported data (i.e. external sources)								
Web based visualisation of output from own generation assets (solar/wind etc), including household level PV	✓	✓		✓	✓	✓		
Grid carbon intensity (national grid)	✓	✓	✓	✓	✓	✓	✓	✓

Group / project details	Exeter Community Energy	Marsh field	Owen Square Community Energy	Bath and West	Ambition Lawrence Weston	Tamar Energy	WHG Group	Rooftop Housing
Weather data (wind, sun etc) - e.g. to predict renewables output		✓		✓	✓			
Alerts								
Relating to peaks in local energy generation (use now/it would be cheaper right now if we had a local energy tariff)	✓			✓	✓	✓		✓
Relating to peaks in demand at the local substation (stop now)				✓	✓	✓	✓	✓
Relating to peaks in carbon intensity of grid electricity					✓	✓		✓
Relating to existing tariffs, particularly E7 and E10							✓	✓
Reverse alerts - people using the app let the central server know that they are doing/not doing something	✓			✓		✓		✓
App data for modelling and business plans								
Battery storage - model services from aggregated data or encouraging uptake in general				✓		✓	✓	

There was considerable overlap between the proposals. A Key feature of interest from all applicants was the ability to visually represent the demand on the local substation to the local community. Other functionality such as text alerts and assessing the potential to connect renewable generation to the grid were also common to the majority of proposals.

This aligns with the findings of the market research survey, where features such as 'understanding community energy demand' and 'connecting low carbon technologies to the LV grid' and 'community alerts' were favoured by over 70% of respondents.

Each applicant group attended an interview with CSE and Regen, either in person or by Skype. Applicants were given the opportunity to explain their app ideas in more depth, and to understand the level of support that CSE is able to offer. After the interviews, the proposals were ranked in order of the likely impact, replicability and learning that could be gained from them, taking into account the relationship between the applicant groups and the proposed community of interest, the technical fit between their app idea and the data that the OpenLV platform provides, and the number of homes that could be monitored with the available devices.

The number of OpenLV platforms available was insufficient to provide for the needs of all of the original proposals. Several applicants had originally envisaged monitoring more than one substation, usually because they wished to create some sort of 'control' or 'comparison' set of households. CSE's research team advised them that it would not be possible to discern statistically significant differences on the data from two separate substations, due to the variations in demand patterns across the small numbers of households (sub-500) connected to each substation. In all cases where this was part of a proposal, the group agreed to slim down the project to one substation only.

Seven communities have been selected to go forward towards trial. Further information on both the groups and their ideas, may be found in section 5.3.

One of the interviewed groups will not progress to the full trial. The application was principally focused on developing a business case for offering voltage management services to the DNO after the construction of a community owned wind turbine. Although there were some associated fuel poverty and awareness-raising activities, the wind turbine project would be better achieved through accessing data at the primary substation. OpenLV platforms installed at only a small number of secondary substations would not give the level of data needed to achieve the goals of the Community Group.

Consequently, this submission will not progress on the basis that it is not a good technical fit with the OpenLV project.

3.3.3 Next steps

In addition to the final survey work and the installation of the OpenLV platforms, CSE will undertake the following work with each of the seven finalist groups over the next few months:

- Agree and sign a memorandum of understanding with each group;
- Agree and sign a Data Share Agreement with each group;
- Assign each group a named contact person at CSE for communications from here on;
- Set up and run a combined app design workshop for all groups (late May 2018);
- Run a bespoke app design session for individual projects where needed;
- Hold initial community consultation events and / or focus groups in each community;
- Finalise app proposals, logic models, and detailed project plans with each group, including full community engagement plans;

Provide app development services to groups without detailed in-house capabilities.

4 Market Potential for Method 3: OpenLV Extensibility

4.1 Introduction

SDRC 2.1: Community Engagement Plan and Testing the Market [Ref. 3] explored the initial phase of EA Technology's engagement with businesses and research organisations. It determined that there was sufficient interest to begin trials under Method 3. This section provides an update on the market potential for Method 3, OpenLV Extensibility.

As per SDRC 2.1, the market sectors that may be interested in participating in the trials to prove the OpenLV platform are shown in Figure 9. This shows that, many market sectors, some with direct links to the energy industry but others who have less established links, were identified as potentially being interested in LV network data or the services that could be provided by apps manipulating LV network data. The Figure shows that the market for the OpenLV Platform is broad.

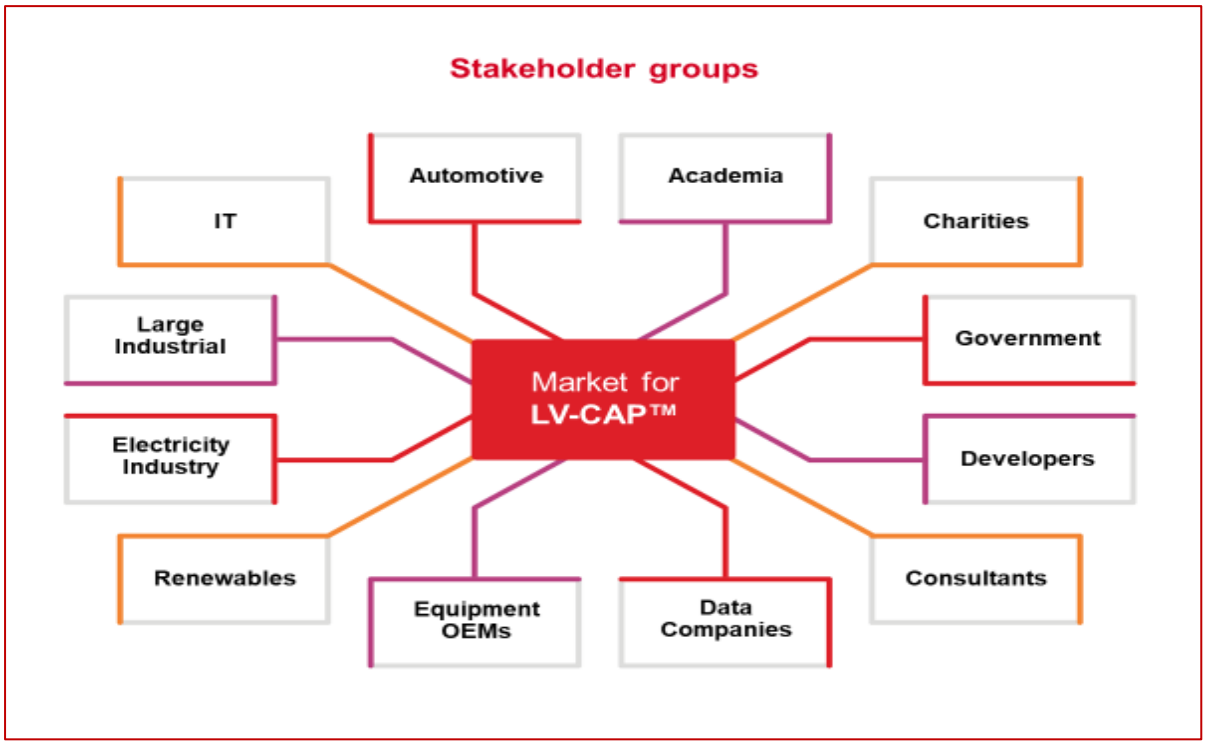


Figure 9: Method 3 Stakeholder Groups

4.2 Market Engagement

In order to meet the SDRC reporting requirements a three-stage process was utilised. The three stages were as follows:

- **Stage 1:** Assessing the market potential;
- **Stage 2:** Inviting applicants to take part in the trials; and
- **Stage 3:** Assessing trial applications and selecting trial participants.

As part of Stage 1: Assessing market potential, to establish the level of interest from potential stakeholders to provide evidence for SDRC 2.1 the following methods were utilised:

- An online survey was utilised. This survey was published on the OpenLV website and was live between 15th September 2017 and 12th February 2018.
- In conjunction with this survey the project team used direct email to publicise the online survey to potential trial participants.
- The project team also utilised a telephone market research company to contact relevant companies within the stakeholder groups and held face to face meetings with a number of organisations to provide further information on the project.
- In addition, the project team published a leaflet providing an overview of the Method 3 OpenLV Extensibility trials on the project website and utilised this leaflet to promote the project at industry events.

Further information regarding Stages 2 and 3 inviting applicants and assessing applications is provided in Section 5.4.

4.3 Overall level of interest

Overall 79 organisations showed interest in taking part in the OpenLV Extensibility trials submitting a total of 74[1] ideas on how LV electricity network data could be utilised to develop new software applications and/or utilised in research.

Table 3 shows that of the 79 organisations 19 (24%) were classed as Academic and 60 (76%) were classed as Businesses.

Table 3: Type of Organisation

Company Type	Number	Percentage
Academia	60	76%
Business	19	24%
Total	**79**	**100%**

Table 4 and Figure 10 show the breakdown of each organisation that showed interest in participating in the OpenLV Open Extensibility project trials by sector.

[1] Note a number of organisations registered interest in the project but did not provide any specific ideas on how to utilise LV network data. In addition, a number of organisations submitted multiple ideas on how to utilise LV network data.

Table 4: Level of Interest - Organisations by Sector

Sector	Number of Organisations	Percentage
Academia/Research	25	32%
Energy Consultancy/ Technology Development	23	29%
Manufacturer	9	11%
EV use sector	8	10%
Community Interest Company	7	9%
Energy Supply	2	3%
Local Government	2	3%
Building Services	1	1%
Generator	1	1%
Networks owner/operator	1	1%
Total	**79**	**100%**

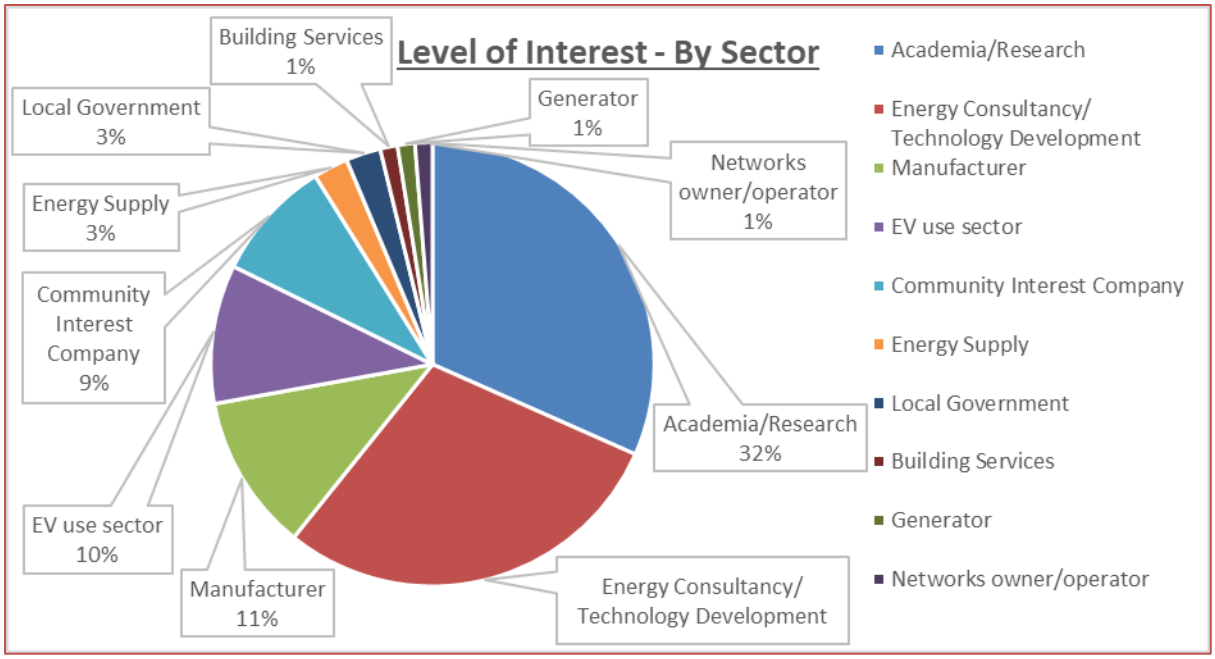


Figure 10: Level of Interest - Organisations by Sector

Each of the proposed ideas was classified to provide a high-level overview of the proposed ideas. Each idea was classified under the titles outlined in Figure 11.

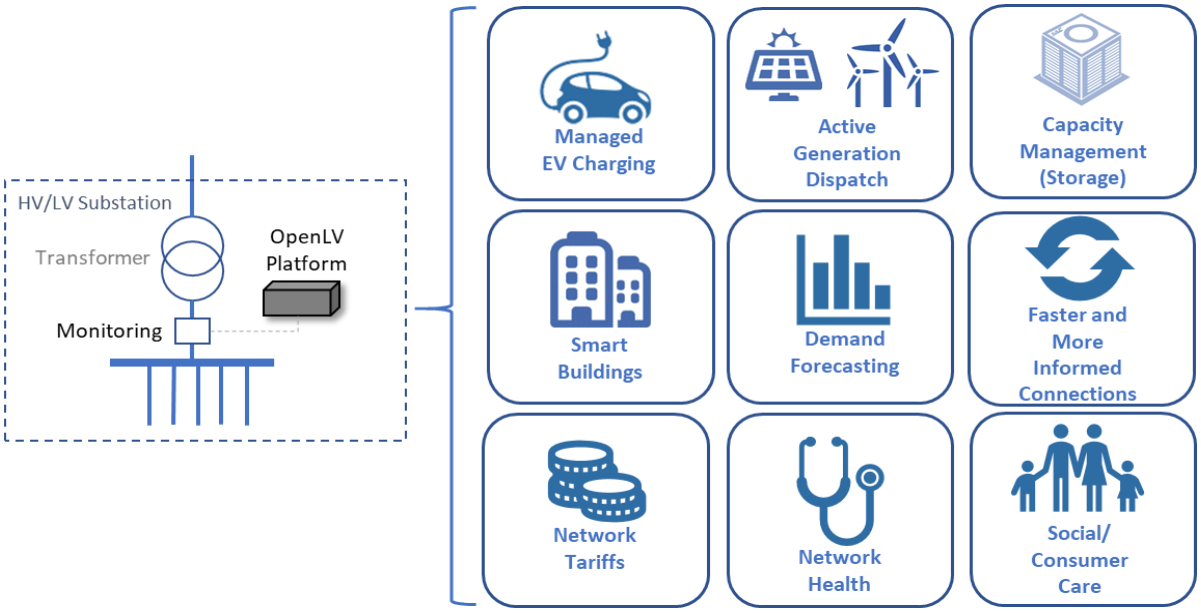


Figure 11: High-level grouping for the ideas proposed

Table 5 and Figure 12 show the high-level classification of each idea proposed by each interested organisation.

Table 5: Level of Interest - High-level classification of each proposed idea

High Level Idea Classification	Number	Percentage
Network Health	26	35%
Capacity Management	16	22%
Managed EV Charging	9	12%
Social/Consumer Care	7	9%
Network Tariffs	6	8%
Demand Forecasting	5	7%
Faster more informed connections	2	3%
Smart Buildings	2	3%
Active Generation Dispatch	1	1%
Total	**74**	**100%**

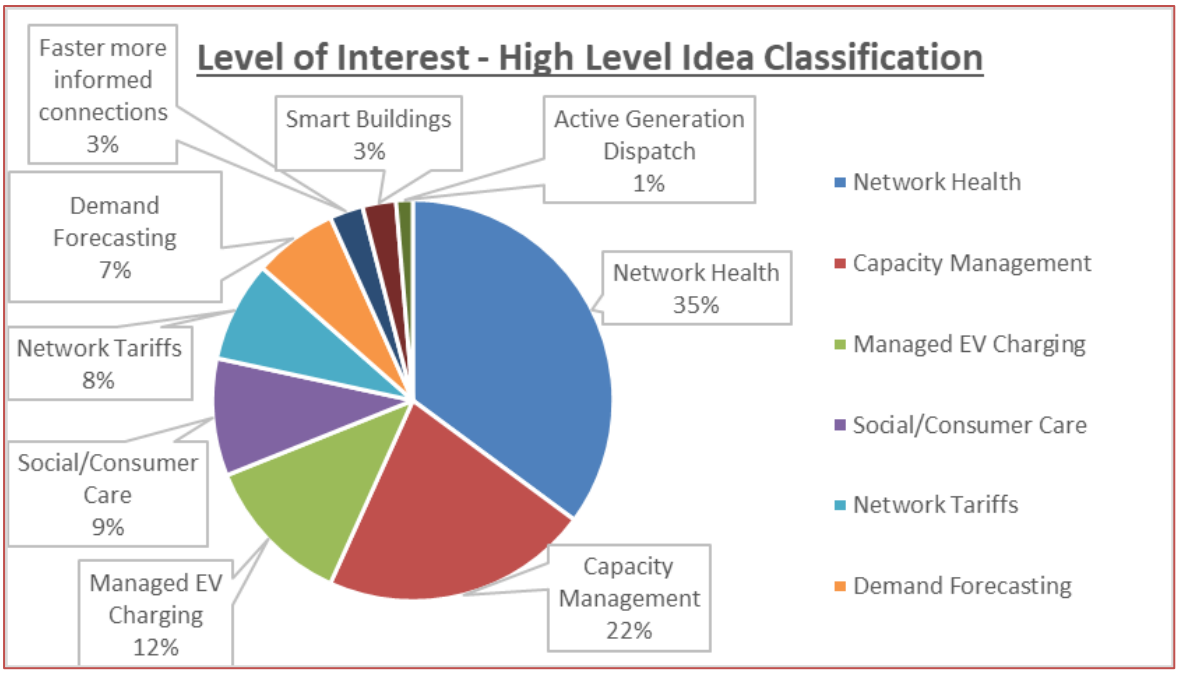


Figure 12: Level of Interest - High-level classification of each proposed idea

4.4 Applications received

In total, 23 applications were received from organisations that wanted to take part in the OpenLV Open Extensibility trials. This included 16 businesses (70%) and 7 academic institutions (30%), putting forward a total of 37 ideas. A total of 27 ideas were submitted by the 16 business applicants and a total of 10 ideas were submitted by the 7 academic institutions. This represents a conversion rate of 29% (23 applicants out of a total of 79 organisations that showed interest in the project trials).

Table 6 and Figure 13 show the breakdown of each organisation that applied to participate in the OpenLV Open Extensibility project trials by sector.

Table 6: Applications – By Sector

Sector	Number	Percentage
Energy Consultancy/Technology Development	8	35%
Academia/Research	7	30%
Manufacturer	3	13%
EV use sector	2	9%
Community Interest Company	1	4%
Energy Supply	1	4%
Generator	1	4%
Total	**23**	**100%**

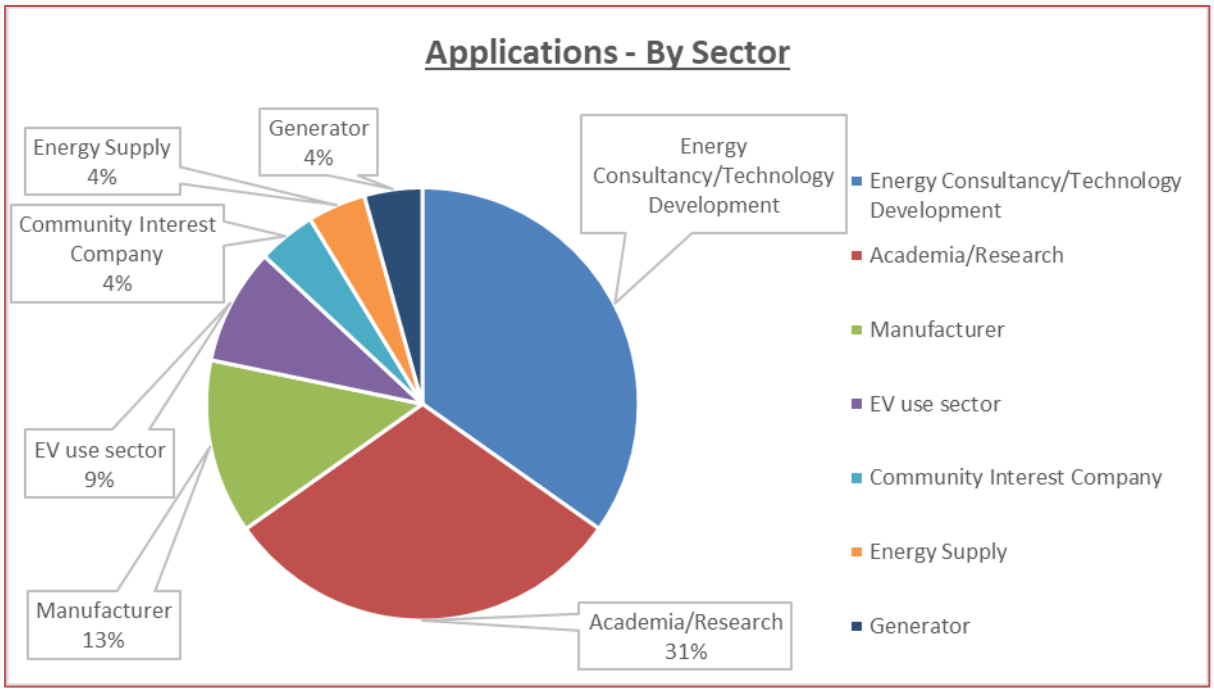


Figure 13: Applications – By Sector

Table 7 and Figure 14 show the high-level classification of each idea proposed by each organisation that completed an application to take part in the OpenLV Extensibility trials.

Table 7: Applications - High-level classification of each proposed idea

High Level Idea Classification	Number	Percentage
Capacity Management	7	30%
Network Health	7	30%
Managed EV Charging	3	13%
Network Tariffs	2	9%
Social/Consumer Care	2	9%
Active Generation Dispatch	1	4%
Demand Forecasting	1	4%
Total	**23**	**100%**

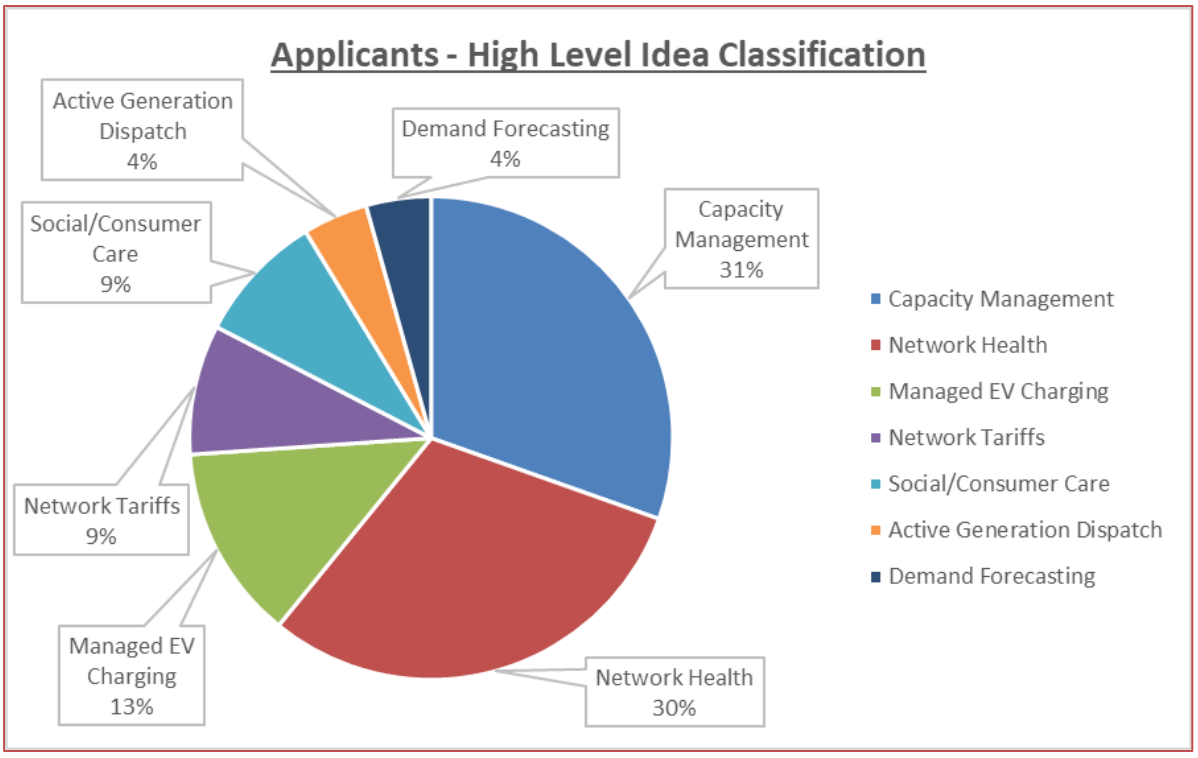


Figure 14: Applications - High-level classification of each proposed idea

4.5 Summary

A good level of interest was received in the OpenLV Extensibility trials, with a total of 79 organisations showing interest in the project. This led to a total of 23 organisations applying to take part in the project trials. Further information on the applicants selected and taken forward to trial is provided in Section 5.4.

5 Detailed Trial Design for all Methods

5.1 Introduction

As outlined in the full bid submission [Ref. 2] the core aim of the project is to prove the open nature of the platform through three core Methods:

1. Network Capacity Uplift;
2. Community Engagement; and
3. OpenLV Extensibility.

These Methods are outlined below and the detailed trial design for each Method is provided in Sections 5.2 to 5.4. Further information on the OpenLV platform can be found in SDRC-1 Detailed design of the overall OpenLV solution [Ref. 4].

5.2 Method 1: Network Capacity Uplift

This Method will demonstrate the core capabilities of LV-CAP™ as a viable distributed intelligence platform, through the use of two separate techniques, that will be trialled independently and simultaneously to provide network capacity uplift.

Each technique is known to provide network benefits, the use of LV-CAP™ seeks to demonstrate the effectiveness of automating their use, and combining the outcomes to mutual, increase benefit.

Thermal Rating of the Transformer

Existing equipment ratings are based on either the assumption that the peak load is continuously delivered over a prolonged period, (the static rating), or that a variation in load occurs over the course of each day, (the cyclic rating). These ratings are set to ensure the transformer does not exceed a maximum recommended operating temperature.

Once an asset exceeds this value, its condition begins to deteriorate at a significantly greater rate than previously, shortening the effective life of the asset. However, the assumptions made to set the static and cyclic ratings are known to be conservative; a reasonable approach in the absence of real-time monitoring of the LV network.

Due to the thermal capacity of transformers, they heat up and cool down in response to variations in load with a time-lag in the order of hours rather than minutes. Consequently, a transformer can be utilised to provide power in excess of either the static or cyclic rating for a relatively short period of time without incurring increased damage to the asset.

Thermal rating of the transformer within the OpenLV Project will utilise the historical load experienced by the asset to determine the temperature likely to be experienced by the transformer over the next several hours.

This will allow the system to determine the extent to which the transformer is approaching the recommended temperature threshold, rather than relying on an arbitrary load value.

Meshing the LV network

Implementing meshing of LV networks originally designed to be operated separately, with Normally Open Points in place between the two, has been successfully demonstrated by previous LCN Funded projects[2].

The OpenLV Project will implement autonomous meshing, utilising the dynamic thermal rating of the transformer as the control input, seeking to demonstrate that sharing load between transformers to alleviate overheating issues can provide network benefits.

5.2.1 Approach

The strength and wider potential of the OpenLV platform rests on the ability to deploy, adapt and remove applications on a case-by-case basis, enabling the system to be reconfigured remotely.

EA Technology have utilised the approach outlined in Section 2, to identify more than 30-pairs of linked substations, across WPD's licence areas for use in the Method 1 trials. Implementation of Method 1 is considered as a two-stage process.

Stage 1

EA Technology are in the process of deploying units to 25-pairs of substations.

These 25-pairs will be deployed with all core applications to enable network automation but will not be installed with the hardware necessary to enable actuation of the meshing.

Stage 2

Analysis of networks is underway to select the five-pairs at which Alvin Reclose™ units will be installed to provide network meshing capability. Selection of suitable sites requires consideration of both substation suitability and the impact on local fault levels.

These pairs of substations will be fitted with equipment identical to those in Stage 1, with the additional capability of network automation hardware through the provision of Alvin Reclose™ devices.

These devices will be controlled directly by the LV-CAP™ platform.

Modelling is performed within the LV-CAP™ platforms to inform decision making within the system. The actual responses of the Stage 2 sites to automated network meshing will be utilised to improve the off-line modelling and determine the ability of the system to provide capacity release for each of the Stage 1 sites.

[2] Customer-Led Network Revolution (NPg), Flexible Networks for a Low Carbon Future (SPEN), Flexible Plug and Play (UKPN), Low Carbon Hub (WPD), Flexible Approaches for Low Carbon Optimised Networks (WPD), Celsius (ENWL)

The achievable capacity release will be compared with the eight LV Network Template Types, defined in the LV Network Templates Project, being utilised in the OpenLV Project.

5.2.2 Outputs

The Method 1 element of the OpenLV Project seeks primarily to demonstrate and test the LV-CAP™ platform's ability to provide distributed intelligence services, and through doing so, deliver multiple learning outputs relating to the trial system, and for benefitting the distribution network.

This will be achieved by demonstrating that the system can:

- Record useful data from the LV network;
- Process this data to generate additional information;
- Make a decision based on this information;
- Share the decision, and pertinent data with another OpenLV platform;
- Paired OpenLV platforms can combine the pertinent data, and decision information with its own data and generated information, then act appropriately.

As part of the Method 1, multiple, discrete applications will be deployed, each providing a mix of learning specific to the application and when combined with outputs of others.

OpenLV platform

The OpenLV Project will demonstrate the capability of the OpenLV platform to operate as a distributed intelligence platform.

- The OpenLV platform will **monitor the LV network**, gathering voltage, current and asset temperatures for all monitored substations.
- The data will be processed by on-board applications, **generating additional data** to inform decision making processes within the platform.
- Specific applications will **determine the appropriate course of action** based on the gathered and generated data.
- This **data will be shared** between LV-CAP™ platforms to enable collaborative decision-making processes
- **Autonomous control** of the LV network will be implemented through direct control of Alvin Reclose™ devices by the LV-CAP™ platform.

The ability of the OpenLV platform to undertake the above will be considered as part of the process of assessing the potential for management of the LV network, using LV-CAP™ (or a similar distributed intelligence platform). Of specific focus will be the ability for the system to operate autonomously, with manual intervention only necessary by exception.

The LV-CAP™ platform contains a set of core software applications to enable remote monitoring, access and control from an authorised server, and the ability to store and share data to internal applications, and to other LV-CAP™ devices if required.

It will also be loaded with further applications, each designed to enable specific functionality to the deployed system. These applications are detailed below.

Specific applications

The strength and wider potential of the OpenLV platform rests on the ability to deploy, adapt and remove applications on a case-by-case basis, enabling the system to be reconfigured remotely. As part of the Method 1, multiple, discrete applications will be deployed to enable the testing of the distributed intelligence system.

Each of these, having a discrete output, will also have specific analysis undertaken against accuracy and performance.

Figure 15 depicts the range of software applications deployed to the platforms as part of the trials.

For reference, the applications were developed by different companies as detailed below:

- Blue - EA Technology;
- Orange – Lucy Electric;
- Red – Nortech Online;
- Purple – EA Technology utilising a thermal rating algorithm developed by the University of Manchester; and
- Green – Community Groups and 3rd Parties.

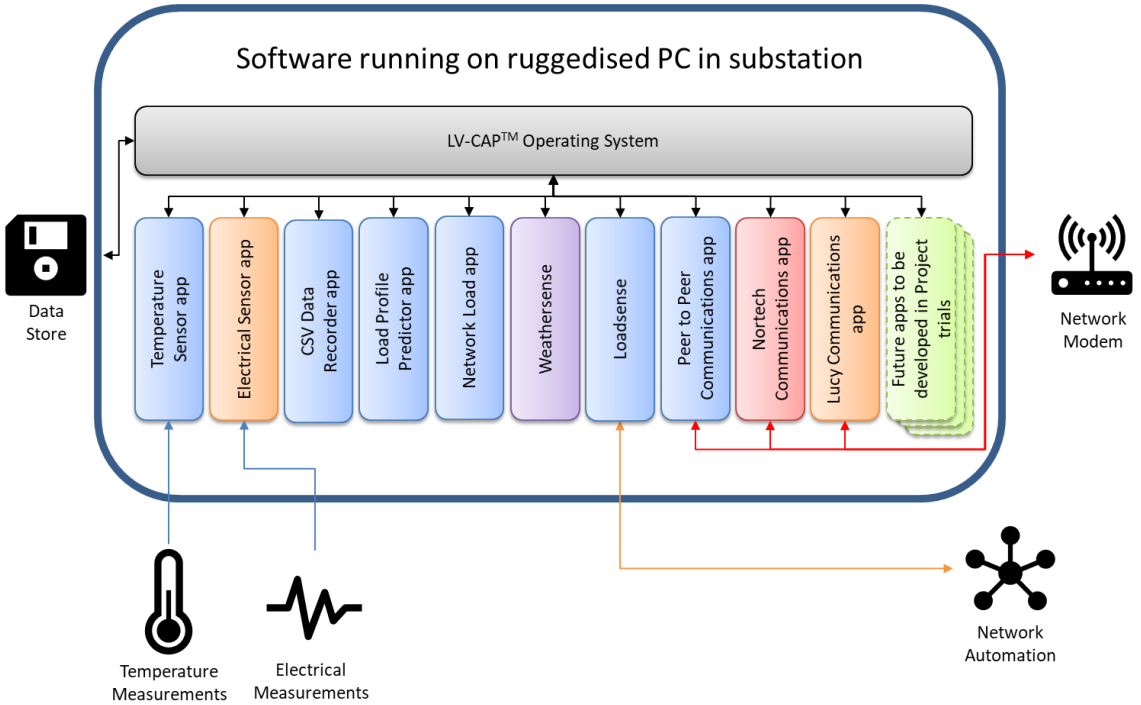


Figure 15: Overview of the OpenLV Platform

Load profile predictor application

The **Load Profile Predictor** utilises historical load from the connected substation and monitored feeders to generate a forward-looking load profile. This profile is used as an input to the dynamic, real-time thermal rating application (Weathersense).

The output generated by this profile will be compared against the subsequent 'actual load profile' experienced by the network to determine the accuracy of the prediction.

Real-time thermal rating application (Weathersense)

The **Weathersense** application embodies a revised RTTR algorithm developed by the University of Manchester as part of an InnovateUK project.

This application is implemented in two ways:

1. It takes the output from the actual (experienced) load and the monitored ambient air temperature, to calculate the current operating temperature of the transformer; and
2. It takes the currently calculated temperature and predicted load profile to predict the transformer temperature, in the future.

These outputs will be compared against the actual temperature of the transformer, (measured via the transformer oil pocket) to determine the accuracy of the algorithm's predictions.

Analysis will consider the range of transformer manufacturers, locations, and capacities and hence the overall potential of the Weathersense application.

This will include, comparing the total capacity of the transformer, as determined via the Weathersense application, with both static and cyclic load ratings.

LV network meshing control (Loadsense & Network Meshing Applications)

The **Loadsense** application, for the purpose of the OpenLV Project, contains a set of discrete logical rules, that trigger different states (meshed or unmeshed) in relation to the conditions of the two inter-connected substations.

Whilst all substation pairs will have the full range of software installed, only five pairs will be outfitted to enable actual meshing of the local LV networks through inclusion of the appropriate hardware (Alvin Reclose™ units).

The remaining sites will be virtually simulated, through manipulation of the recorded data to simulate the effects of network meshing being enabled in accordance with the encoded logic.

Testing will be undertaken to confirm the software operates as intended, but from a BAU perspective, it is expected that the logic will be adapted on an individual DNO basis.

This will include determining to what extent overall network capacity can be increased through the implementation of localised network meshing.

The operational logic embedded within the Loadsense application is detailed in Annex 1 and is developed by EA Technology for the project in collaboration with WPD.

When the Loadsense application determines that meshing is required, this will trigger a control signal from the **Network Meshing** application to the Alvin Reclose™ devices to close the breakers and mesh the adjacent networks.

Complete system

Simulation and operation of the paired networks will also allow determination of the total achievable capacity uplift from combining both Weathersense and Loadsense operations.

Due to the range of networks, (as defined by the LV Networks Templates project) this will be considered in terms of all trial networks, and specific network types.

Considering the overall trial operations, the project will determine which network types can best benefit from the deployment of LV-CAP™ platform.

Additional learning

The **accuracy of ambient temperatures forecast by the Met Office** in relation to the actual temperature recorded on-site will be determined. In the event that Met Office data is found to be sufficiently accurate, (within an acceptable margin of error), for the RTTR application then future trials or RTTR deployment may be able to dispense with local monitoring, if each distributed intelligence platform can download local forecasts directly.

5.2.3 Detailed trial design

Site selection process

The process outlined Section 2 has been followed and at the time of writing, 50 substations, (25-pairs) have been selected, with fault level studies underway to determine the final 10 (five-pairs) for the Method 1 trials from the current shortlist of 36 units (18-pairs). Figure 16 details the locations of the trial pairs selected at time of writing.

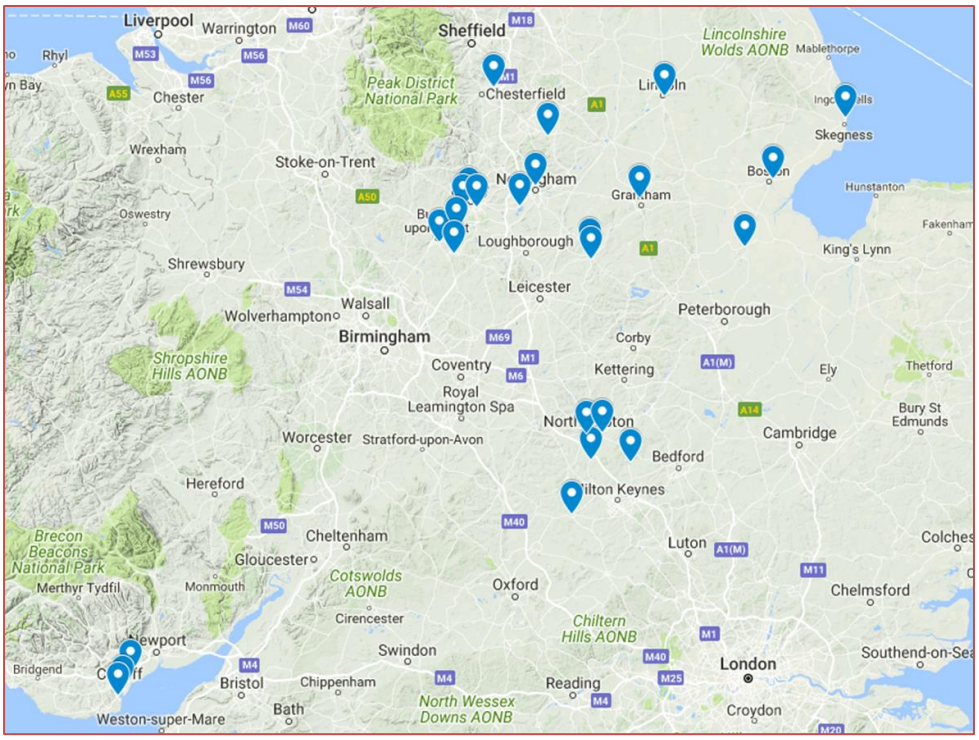


Figure 16: Selected trial locations (Method 1)

Selected substations

The OpenLV Project has ensured during the site selection process to utilise a range of network types as defined by WPD's LV Network Templates project. This project defined 10 LV network 'types' and developed a tool to provide guidance as to which type a particular network should be assigned to. The ten types are shown in Table 8.

Table 8: LV Network Template Types

Template Type	Description
1	High Industrial & Commercial Dominance
2	Modest Domestic Dominance (~60%) (Suburban)
3	Modest Domestic Dominance (~60%) (Urban)
4	High Domestic Dominance (~90%) (Modest Customer Size ~170)
5	High Domestic Dominance (~90%) (Low Customer Size ~70
6	Very High Industrial & Commercial Dominance (~90%)
7	Modest Domestic Dominance (~60%) (Rural)
8	*Industrial Flats*
9	Domestic Economy 7 Dominance (~65%)
10	*Lighting*

At the bid stage, network types 8 and 10 were excluded from the required networks, with a target of at least three networks of each required type being utilised in the project.

Of the 50 selected substations, the distribution of LV template types is shown below in Figure 17.

The data gathered by the project, relating to the dynamic thermal rating and from both simulated and actual network meshing will be utilised to identify the benefits applicable to each network type.

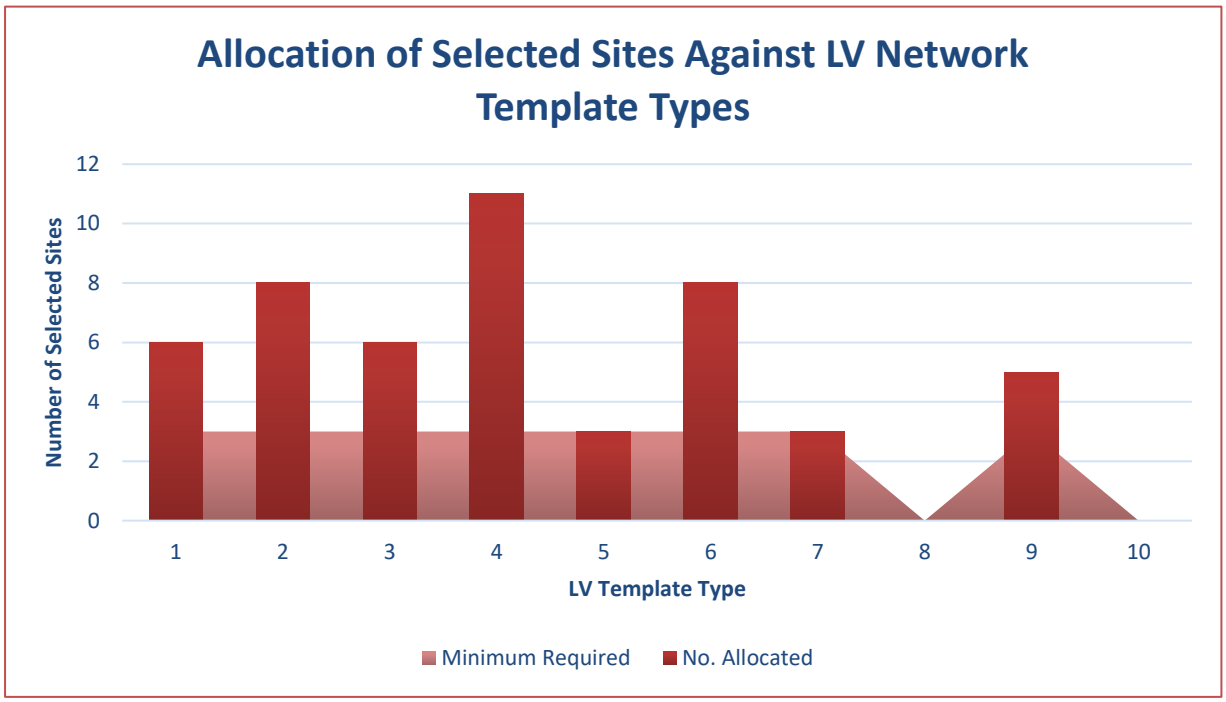


Figure 17: Distribution of selected sites against LV Network Template Types

Substations were also selected to provide a variety of installation types to ensure a varied dataset within the trials. The selected locations comprise a mixture of outdoor, indoor and GRP[3] enclosed substations, along a variety of transformers and LV board types and ages to verify the suitability of the trial equipment for use in all substations.

Equipment installation and commissioning

At time of writing, equipment has been successfully deployed and commissioned in 30 substations in accordance with the Project Method Statement for installation of the OpenLV platform.

[3] Glass Reinforced Plastic

Method 1 schedule

The current schedule for undertaking the Method 1 trials is detailed below in Table 9.

Table 9: Method 1 Planning

Stage	Status	Completion Date
Initial trial surveys	Complete	November 2017
Install OpenLV platforms at initial trial locations (x4)	Complete	December 2018
Main site surveys	Complete	March 2018
Install OpenLV platforms at remaining Stage 1 locations (x50)	Complete	May 2018
Select Stage 2 locations for network meshing (x10)	In progress	June 2018
Install OpenLV platforms at remaining Stage 2 locations (x10)	Planned	July 2018
Identify RTTR and meshing 'trigger thresholds' for all trial sites.	Planned	June – August 2018
Trials:	Planned	June 2018 – June 2019
Thermal Rating only		
Meshing Only ***(Simulated Meshing for Stage 1 and implemented for Stage 2)***		
Thermal Rating and Meshing ***(Simulated Meshing for Stage 1 and implemented for Stage 2)***		
Collation of trial data and ongoing trial analysis.	Planned	June 2019
Post-trial analysis.	Planned	September 2019
Quantify potential network benefits for all three scenarios.	Planned	November 2019
Collate learning points covering limitations with installation and implementation	Planned	October 2019
Undertake cost benefit analysis utilising Transform™ Model	Planned	November 2019
Report learning in SDRC 4	Planned	January 2020

Project data

All data gathered and generated within the trial system will be stored on each platform's internal storage and will be available to all applications for use as required.

The data gathered and generated within the LV-CAP™ platform can be considered to be in a particular Tier within the flow of project data.

- **Tier 1 – Captured Data:** Comprising unprocessed data, captured directly by the LV-CAP™ monitoring hardware.
- **Tier 2 – Information:** Comprising information, or additional data derived from performing calculations on Tier 1 data.
- **Tier 3 – Decisions:** A decision determined by the system, utilising any combination of Tier 1, 2, or 3 data.
- **Tier 4 – Actions:** A response enacted by the system following a decision or sequence of decisions.

Implementation of this full process as part of a wider system would be considered Active Network Management; Method 1 will demonstrate the ability of the LV-CAP™ to fill roles within such a system.

Additionally, all data gathered and generated by OpenLV platforms is permanently retained on the units. Periodically the system will compress and upload un-transmitted data to EA Technology servers to enable an ongoing process of data analysis throughout the project.

This data upload will contain all Tiers of data outlined above, included outputs from applications, and provides dual redundancy in the event of a failure of either at OpenLV platform or project server.

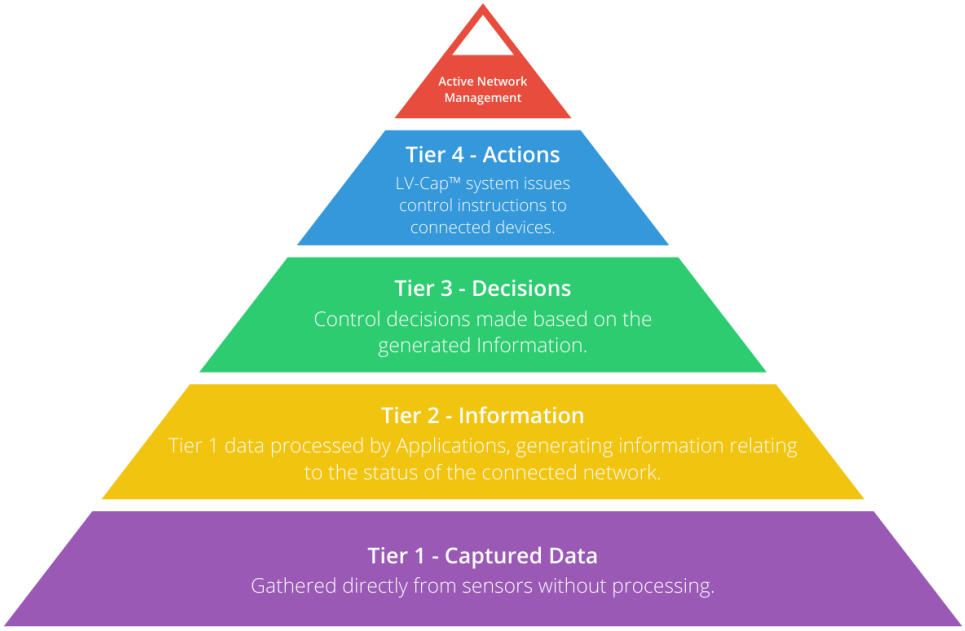


Figure 18: LV-CAP™ Data Hierarchy

Tier 1 – Captured Data

This comprises of:

- Busbar voltage (three phases);
- Total load on the transformer (three phases);
- Load (directional) on each monitored feeder (three phases);
- In some substations, all feeders are being monitored whereas in others it is just the inter-connecting feeder. This is dependent on the specific substation arrangement and varies on a case-by-case basis.
- Outside ambient air temperature;
- Indoor air temperature (if the transformer is located inside a building or GRP enclosure);
- Oil pocket temperature of the transformer.

Tier 2 – Information

This comprises of:

- Predicted load profiles for each scenario (detailed in the Loadsense report), generated by the Load Profile Predictor application.
- Calculated thermal profiles based on load profiles generated by the Weathersense application.

Tier 3 – Decision

The comprises of: The decision of whether implementation of LV network meshing is required or not, as determined by the **Loadsense** application. (Refer to Loadsense Operational Logic report for details.)

Tier 4 – Actions

This comprises the control signal from the **Network Meshing** application, triggered on receipt of the appropriate instructions from the Loadsense application.

Data gathered from other sources

The project will also gather weather data from the Met Office to enable comparison between the actual temperature's recorded on-site, the Met Office's forecast temperature and the Met Office's official 'recorded temperature'.

This data will be downloaded via the Met Office DataPoint portal and would constitute either Tier 1 or Tier 2 data, depending on the level of processing undertaken prior to being made available for download.

Implementing the trials

The referenced LoadSense report (Annex 1) details how the operational logic for determining when to implement meshing operates. In summary however, the network meshing shall only be implemented where an overall net benefit occurs to the local network.

During the trials, the project team will change the thresholds at which each substation in a pair will enable meshing to test the system operates as intended.

Determination of the released capacity is dependent on manipulation of the data gathered by the paired systems across the trials. As the networks are, in most cases not actually being meshed, neither are the transformers expected to be experiencing significant loading; analysis of recorded data, combined with extrapolation and repeated analysis to account for increased loading will be required.

This analysis will determine the following:

- Capacity uplift achievable from the implementation of Dynamic Thermal Rating application deployed by the Project;
- Capacity uplift achievable from the implementation of autonomous network meshing;
- Capacity uplift achievable from the implementation of Dynamic Thermal Rating and autonomous network meshing.

The assessment will consider the performance of the two solutions independently and together, before providing recommendations for their implementation with regard to any network factors identified as part of the analysis. If appropriate, this will include, but is not limited to the LV Network Template Types utilised within the OpenLV Project.

5.3 Method 2: Community Engagement

5.3.1 Approach

The approach for the Method 2 trials as defined in the full bid submission [Ref. 2] is as follows:

Trial Principle: This Method will establish the market for community or customer driven apps.

Trial Approach: This Method will work with external partners to ensure engagement in and beyond the project. It will:

- Appoint a specialist organisation to complete community engagement to promote the availability of the substation intelligence platform and associated LV network data; and

- Appoint an organisation(s) to assess the longer-term potential / economic impact for the use of the OpenLV devices, and to develop enduring tools to assist communities in their engagement with the distribution network.

Trial Selection: The appointed community engagement specialist will work with communities:

- That want to be part of a smarter grid to identify how the LV Network data could be utilised to benefit Community Engagement Schemes that cover aspects of collective action to reduce, purchase, manage and generate energy;
- To understand whether innovative algorithms and/or applications could be developed and installed on the low-cost substation intelligence to benefit Community Engagement Schemes; and
- To identify potential funding streams for community groups to develop innovative algorithms and/or applications.

Trial Deployment: Up to 10 LV-CAP™ devices will be deployed at specific ground mounted HV/LV substations to meet the communities' needs. Key attributes:

- Access to relevant data will be provided to communities via the Internet;
- WPD and the project team have contact with a number of potential groups, each with subtly different requirements;
- In Method 2 we will seek to work with a range of communities, ideally addressing different requirements, thereby broadening the replicability of provision of network information from the OpenLV platform to communities in GB; and
- The funding required to develop the specific apps will be raised outside of the project budget, for example, public funding or the private sector.

Post-trial: Review the performance of the community case studies, extrapolation to GB including the development of tools / materials to support broader adoption.

- Analyse the economic benefits identified at the outset of the trial;
- For the top three case studies, develop materials to support communication and sharing of learning to communities outside of the trial; and
- Test the learning tools with communities outside of the project trial to ensure they are fit for purpose.

The Outputs delivered by this Method are:

- A more detailed understanding of the appetite of communities in becoming a part of the smarter grid;
- Any learning generated from the development of community Apps, including an understanding of the types of services community groups value;
- Economic analysis of the deployed solution(s) effectiveness, documenting the replicability and providing materials in both a report and presentation format;
- Materials and tools to support the adoption of community benefits across Great Britain; and
- This learning will be collated in a report that will include an overall assessment of the process of engaging with communities to take advantage of the OpenLV platform and associated LV network data.

It is confirmed that the detailed trial design for the Community Engagement trials, as outlined in this document, conforms to the approach outlined in the Full Bid Submission.

5.3.2 OpenLV Community Groups: an assessment of the ideas

Prior to detailing the trial design under Method 2, it is worth giving an overview of the assessment of ideas generated by the seven community groups being taken forward into trial. This section focuses on the replicability and extensibility, as assessed to date, of those seven ideas under Method 2.

5.3.3 Replicability and types of community

An important part of replicability of the community projects will be the types of organisations that have applied and succeeded in obtaining access to OpenLV data. Of the seven successful projects, five were initiated by existing local community energy groups. The further two projects are housing associations serving urban areas and low-income residents. Six out of seven projects are in urban locations. Only one, Marshfield – run by a community energy organisation - is an isolated rural community.

5.3.4 Measuring engagement and behaviour change

Each community group has a particular geography, technology or focus that makes the project unique, for example interaction with solar/battery, micro-grids, local generation, schools etc. The diversity of the groups means that information and learning from Method 2 can be collected that will cover a good range of situations.

However, all the groups also share a desire to engage local people in the information and data coming through the OpenLV platform in the substation. Each group will undertake this in different ways. This shared objective should allow useful comparisons and lessons to be drawn about the most effective ways of presenting the information from OpenLV with different types of residents and communities.

A further shared objective for most projects will be to achieve some level of measurable change in behaviour at a household level. Capturing and quantifying the actual change in behaviour will be a key challenge for the evaluation process. In some projects data will be captured automatically and at a substation level. In Exeter changes should be captured mainly through a smart phone app. However, most projects will require manual recording of any changes or savings by individuals. The CSE /Group app development process will be looking at the feasibility of collecting information on behaviour change or action, for example through responding to text messages. If it can be collected automatically, this information will be important to gauge how effective various engagement methods have been. If an automatic system is not developed, then a manual system can also provide results, however these are likely to be less detailed and less accurate.

5.3.5 Community business cases

The Market Assessment report analysed a survey that showed there were around 22 community app ideas that had potential for further development. As the project has evolved from individual app development towards shared app usage, these business cases have evolved.

A key business case for the final seven projects is to achieve energy bill savings for residents by changing behaviours to use energy at different times of the day, either using Time of Use Tariffs (WHG Group) or matching local generation and demand which could help develop a local use tariff, e.g. Tamar Energy where the engagement will be focused around a sub-station and a school with PV installed.

Another business case is managing network constraints. Marshfield is keen to address existing local network constraints by using OpenLV unit to understand headroom at the substation. Another group, Owen Square, is anticipating future constraints because of heat electrification projects. OpenLV will help both communities plan for that eventuality or manage constraints to allow for expansion of low carbon technologies in the area.

Two projects are looking specifically at the potential for grid management services being offered by the community through installation of technology, Owen Square and Bath and West, could potentially use a virtual community battery made up of domestic solar and battery systems. The projects will assess grid impact of local technology to allow for future forecasting and whether communities could provide useful paid-for grid services.

The Exeter group is unique in that it is looking to develop a smart phone app to engage communities. This app could potentially be developed further or sold on to other communities if engagement can be proven effective and OpenLV is rolled out more widely.

Table 10 offers an initial assessment of the project ideas.

Table 10: Method 2 Initial assessment of project ideas

Group name		Project idea	Group features	Evaluation
1	Marshfield	An isolated community on 4 sub-stations – applicable to numerous smaller rural communities with constrained network wanting to understand usage and increase own generation.	Active and skilled local community energy group. Isolated communities have other potential non-energy groups (e.g. parish council)	Project likely to generate clear data picture from sub-station mapped with local generation. Also needs manual recording and evaluation of engagement and behaviours.
2	Bath and West	Project is installing solar and battery systems to half of homes (approx. 30/60) on a small urban sub-station to understand local grid impact of these systems.	Community energy group working with Moixa. Cost of installations presents a barrier to replicability, but urban location is typical, and results should help other areas with similar ideas.	Project will generate sub-station data – and data from individual systems to help evaluate pv/battery impact. Outreach staff member to record engagement and log behaviours (if not automated)
3	Rooftop Housing	Part of 18-month modernisation of low-income housing estate. Want to include information on carbon intensity and own renewables as information for residents to encourage behaviour change.	Project run by an engaged housing association, a highly replicable model. There is a dedicated estate manager on the ground who does community engagement along with active residents.	Housing associate are keen to be able to prove an impact and build a business case. Evaluation likely to be focus on manual recording of community engagement and behaviour change. Sub-station data may not show clear results.

	Group name	Project idea	Group features	Evaluation
4	WHG Group	Tower block low-income community with electric heating. Aiming to improve TOUT to reduce bills and potentially upgrade heating. Good replication potential of similar housing.	Housing association. Dedicated energy manager and team of energy champions likely to have good sense of time and cost to deliver and report.	Evaluation likely to be focus on manual recording of community engagement and behaviour change/cost savings. Substation data may not show clear results.
5	Exeter Community Energy	Sub-station area TBC Project are developing a smart phone app for users. Once technology is developed this has role out potential for any location.	Professional team and App developer costing around 10K. Team may be time-constrained.	Smart phone app and user profiles / engagement should provide automatically generated evaluation data, allow for testing of best gamification etc.
6	Owen Square	Urban community energy project working with residents on a Microgrid – looking to increase uptake of PV and storage.	A very engaged community group with strong history and technical understanding and existing technologies. Community is relatively unique.	Evaluation maybe difficult, particularly differentiating impact of OpenLV engagement from other activities of the energy group.
7	Tamar Energy	A substation within a community and linked to a solar school. Focusing on behaviour change - switch high usage equipment to off-peak hours/better correspond with local generation.	Strong community energy team with engagement expertise and 13 active volunteers.	Will generate some data through substation and local generation. Effective evaluation will also need manual recording of engagement and behaviours.

5.3.6 Detailed trial design

Seven community groups have been selected to be taken forward under Method 2, with the software applications scheduled to be rolled out for trial from early September 2018, with trials concluding at the end of June 2019. During this 10-month period[4], CSE staff will provide support to keep the trials on track, and each group will be assigned a CSE project mentor, whose role will be to ensure that progress does not fall behind schedule.

Table 11 gives an outline of key project activities and dates.

Table 11: Method 2 key project activities and dates

Activity	Dates
Selection of substations	February to April 2018
Development of project plans	April / May 2018
Initial app design workshops and bespoke design sessions (where needed)	May / June 2018
Community consultation events	May / June 2018
Detailed app proposals finalised	June 2018
Data sharing agreements in place	June 2018
LV-CAP™ units installed	May to July 2018
Engagement literature produced	July / August 2018
Trials of software applications	August 2018
Logic models finalized	August 2018
Full software development for software applications	From May 2018
App deployment and trial period	September 2018 to June 2019
Evaluation	July to September 2019

CSE will define the types of support and feedback mechanisms to be put in place to keep trials on track, for example:

1. A key point of contact with each group and a CSE team member.

[4] Note that it has been agreed between WPD, EA Technology and CSE that the trials under Method 2 could ostensibly run from June 2018 through to December 2019 in order to give the Method 2 participants 12 months' data or more.

2. Scheduled regular telephone catch up calls between CSE and the community contact, to check progress and develop solutions for any problems that arise.
3. CSE staff availability to help with wider community awareness-raising (where this is proving slower or less effective than the groups hope), and with press and communications activity.
4. CSE programmer availability for technical issues, to help with troubleshooting and liaison between WPD/EA Technology and the community groups.
5. Supporting Regen by identifying key community members who would be good candidates for interview/focus group work for evaluation purposes.

In relation to points 2 and 3 above, CSE will develop a data share agreement and support contract (a Memorandum of Understanding, or MoU) that the groups will have to sign up to at the point of being accepted onto the project. This will detail the circumstances under which support from CSE will be withdrawn and trials will be closed before the end of the trial period. The MoU is provided in Annex 2 and includes:

- Recruitment and participation targets for the community group to achieve before and during the trial period – number of households participating or signed up for alerts, for example;
- An agreed timetable of support and catch up phone meetings for the duration of the trial;
- Agreed service delivery standards and response times for all parties – for example, CSE committing to returning calls and emails within a certain time, and community groups understanding that a failure by them to report on progress against an agreed timetable will result in support being withdrawn; and
- A commitment from the participating group to provide Regen with data and participant contact details when required, and to respond to agreed requests for information relating to the evaluation and learning contract.

5.3.7 Applicants taken forward to trial

The seven community groups that have been selected for participation in the Method 2 trials are summarised in Table 12.

Table 12: Method 2 trial locations and overview

Name of group	Location	Brief project overview
Marshfield Village	Marshfield, South Gloucestershire.	Very limited local grid capacity is restricting attempts to develop community-scale renewable energy generation. The group want to develop a software application that will allow householders to see energy demand across the village, alongside data about grid carbon intensity. All four substations in the village will be monitored for the project, which will give a clearer picture of the real capacity on the local grid. It will also allow for the development of a village-wide energy strategy and business planning around time of use tariffs, EV rollout and potential storage solutions, to help the group develop their vision to be largely independent of the grid through careful balancing of local generation, storage and demand. All four substations serving the village will be fitted with LV-CAP™ units for the trial.
Bath & West Community Energy	Bath, Bath & North East Somerset.	BWCE hope to develop a software application to best utilise substation data for demand management, which they will combine with a domestic PV and battery offer that they have negotiated in conjunction with Moixa. The software application will enable homeowners to best use generation and storage and to adapt their energy use, it will encourage sharing of information in the community and applications of battery storage and solar PV for offering flexibility services to the grid operator. The trial will take place in a group of houses connected to a single substation in the Bear Flat area of the City of Bath, where the group already have a large number of local shareholders.

Name of group	Location	Brief project overview
Rooftop Housing	Cheltenham, Gloucestershire	The Rooftop software application will give residents in the trial area access to their community's real-time electricity demand. Via the software application and associated public meetings and awareness-raising events, residents will access this information alongside the equivalent carbon emissions increasing public awareness of their impact on the environment, and, in common with other software applications in the community trials, the housing association hopes to incorporate an alerts system, to study the effect of instantaneous awareness-raising at a particular moment. The project also aims to create community cohesion and a public approach to reducing peak demand on substations to reduce the associated carbon emissions. The trial will take place in homes connected to a single substation in the Bishops Cleeve area of Cheltenham.

Name of group	Location	Brief project overview
WHG Housing	Walsall, West Midlands	WHG is a social housing provider based in the West Midlands. Their software application will be developed for use in one of their tower blocks, to help them drive forward a heating retrofit project. The high electrical load puts a strain on the local substation, and WHG are aware that many of their tenants do not use their heating systems due to the expense of running them or not understanding the controls. WHG wants to raise awareness of energy usage and demonstrate how residents can save money on bills by shifting demand from peak times. The development of this software application will coincide with the installation of a smart heating solution for the tower block where the trials will take place. The smart heating solution requires customers to sign up to a special E10 type tariff and the software application will help them make the most of this tariff. It will be do this by alerting customers when peak and off-peak tariffs are in operation. They hope to also aid cohesion around energy in this very deprived community. The trial will take place in a single tower block in Walsall.

Name of group	Location	Brief project overview
Exeter Community Energy	Exeter, Devon	Exeter Community Energy (ECOE) is an innovative social enterprise that currently owns 8 renewable energy installations across the city. The software application developed by the Exeter group will give a visual representation of demand at the substation, which will be combined with data on local generation from assets owned by the group, as well as national grid carbon intensity. The group would also like to develop an alerts system, to let local households know when particular conditions are prevalent (e.g. high demand at the local substation), and functionality for householders to respond that they have taken action. Alternative local tariffs will be modelled as part of the project, to help build the case for local business models. Monitoring equipment will be installed in a single substation where ECOE already has active members, to help kick-start the engagement process.

Name of group	Location	Brief project overview
Owen Square Community Energy	Easton Ward, Bristol	Owen Square Community Energy cooperative is a member-based local energy supply company jointly operated by Easton Community Centre (ECC), local energy group Easton Energy Group (EEG) and Bristol-based microgrid developer Clean Energy Prospector (CEPRO). OSCE believes that the future of energy is local, renewable and all-electric. The Owen Square Community Energy project hopes to demonstrate the development of 'community microgrid' business, where a local supply company is setup based around a local substation. By installing new energy assets in homes (in lofts) and using these assets to supply low-carbon heat and power to those homes, they hope that the business will make money not only by selling energy to local residents but by capturing value from avoided energy transport costs and by orchestrating the new equipment as a coordinated grid asset providing flexibility services back to the grid. For the OpenLV project, the group will use the substation data from a single substation in the Easton ward of Bristol, to raise awareness of their offer to local households, and to help optimise the match between the PV and heat pump installations, so that local households will flex their demand in such a way that losses in the low voltage network are minimised.

Name of group	Location	Brief project overview
Tamar Community Energy	Tavistock, Devon	Tamar Energy Community Limited is a Registered Society, which already owns a number of renewable assets across the Tamar Valley area. TEC's OpenLV project will centre around awareness raising and the development of local tariff models, by using substation data from a small part of Tavistock. Their app will give a visual representation of demand at the substation, which will be combined with data on local generation from assets owned by the group, as well as national grid carbon intensity. The group would also like to develop an alerts system, to let local households know when particular conditions are prevalent (e.g. high demand at the local substation), and functionality for householders to respond that they have taken action. Alternative local tariffs will be modelled as part of the project, to help build the case for local business models. The project will include households and a primary school (which already has a PV array) connected to a single substation in Tavistock.

5.3.8 Quantitative vs qualitative monitoring

The number of homes connected to each of the trial substations is relatively small, and it is therefore highly improbable that any observable changes in electricity consumption that could be confidently attributed to intervention activity will occur. Household energy demand fluctuates over the day and the standard 'morning and evening peak' pattern does not emerge predictably until around 500 or more households are monitored. Daily variation in consumption patterns will be expected because of the small sample sizes used in each trial (with approximately 100-200 homes on each substation). Many of the projects will be focused on intangible benefits during the trial period. This is because, in most cases, the proposals focus on a general awareness-raising campaign, combining local consumption data with data from groups' own renewable generation capacity, real-time national carbon intensity statistics, modelled local tariffs, or the load status of the local substation (and in some cases, all of these).

It will be important to capture the full range of benefits, both tangible and intangible, that could accrue as a result of the trial projects. We therefore intend to take an approach that establishes a theory of change for each trial, by completing a logic model (see Figure 19) with each of the communities at an early stage. The logic model will help define whether the data collected is quantitative (blue text) or qualitative (green text), which will guide the development of data collection processes. Once software application design and community input has been completed, the logic model will be reviewed and finalised for each community before the trials begin in September.

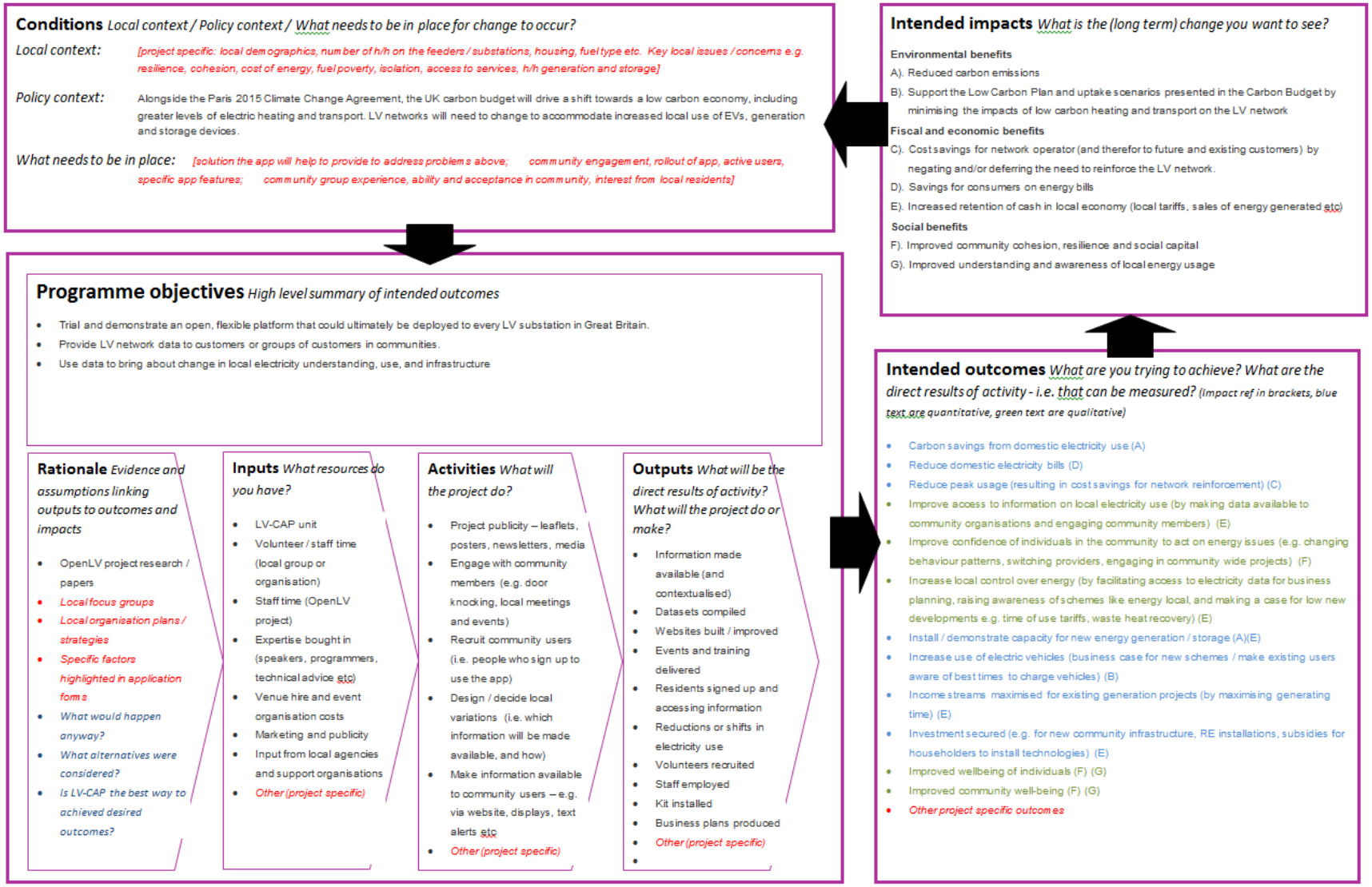


Figure 19: Method 2 – Trial Delivery Logic Model

5.3.9 Automated vs manual data collection

The software applications will be designed so that they can track user data, such as number of unique visitors in any given time period, as well as how long visitors spend interacting with the software application. We will also be able to analyse this data to assess whether there is an attrition rate, whereby individual users are initially regular users of the software application but then reduce their frequency of use over time.

Data collection systems will also be established to collect information on the real costs of the trials, in particular to track the number of volunteer hours contributed to the project, as well as income that the groups bring to the trials as match funding, such as the costs of installed generating equipment and displays, or venue hire.

During the trials, each community group will be assigned a key worker from CSE, with whom they will have a regular telephone catch-up. The aim of these calls will be to capture the project activity that cannot be measured by looking at the automated data, to understand whether trial progress has deviated from the planned activities, and any actions that can be taken to address such deviations. The experimental nature of the trials means that deviations are expected, and it is also likely that logic models will be reviewed during the trial period if trial re-designs are necessary in some cases.

5.3.10 Pre-trial activities

Between April and August 2018, the groups will be supported to develop their software applications and establish detailed project plans. The project plans will include a community engagement strategy tailored to each community, with support from the CSE community team included according to the needs and abilities of the different groups and their target communities.

The simplified Gantt in Figure 20 shows the pre-trial tasks that will be completed before the trials launch in September.

ID	Task Name	Start	Finish	Duration
1	Trial data requirements and data collection mechanisms developed	04/04/2018	13/04/2018	8d
2	Agree MoU with all groups	16/04/2018	04/05/2018	15d
3	Development of mock-up app functions	23/04/2018	18/05/2018	20d
4	Produce draft logic model for each group	27/04/2018	11/05/2018	11d
5	Detailed project plans approved	11/05/2018	17/05/2018	5d
6	RAMS produced for each community	21/05/2018	05/06/2018	12d
7	App design workshop (all)	21/05/2018	21/05/2018	1d
8	Bespoke app design sessions (where needed)	01/06/2018	26/06/2018	18d
9	Community consultation/focus groups	11/06/2018	21/06/2018	9d
10	Finalised App designs approved	25/06/2018	25/06/2018	1d
11	Full software development	25/06/2018	17/08/2018	40d
12	LV-CAP units installed	14/05/2018	29/06/2018	35d
13	Engagement literature produced	10/07/2018	10/08/2018	24d
14	User trials of apps in-community	13/08/2018	31/08/2018	15d
15	Final logic model approved for each group	27/08/2018	31/08/2018	5d
16	Trials launch	03/09/2018	07/09/2018	5d

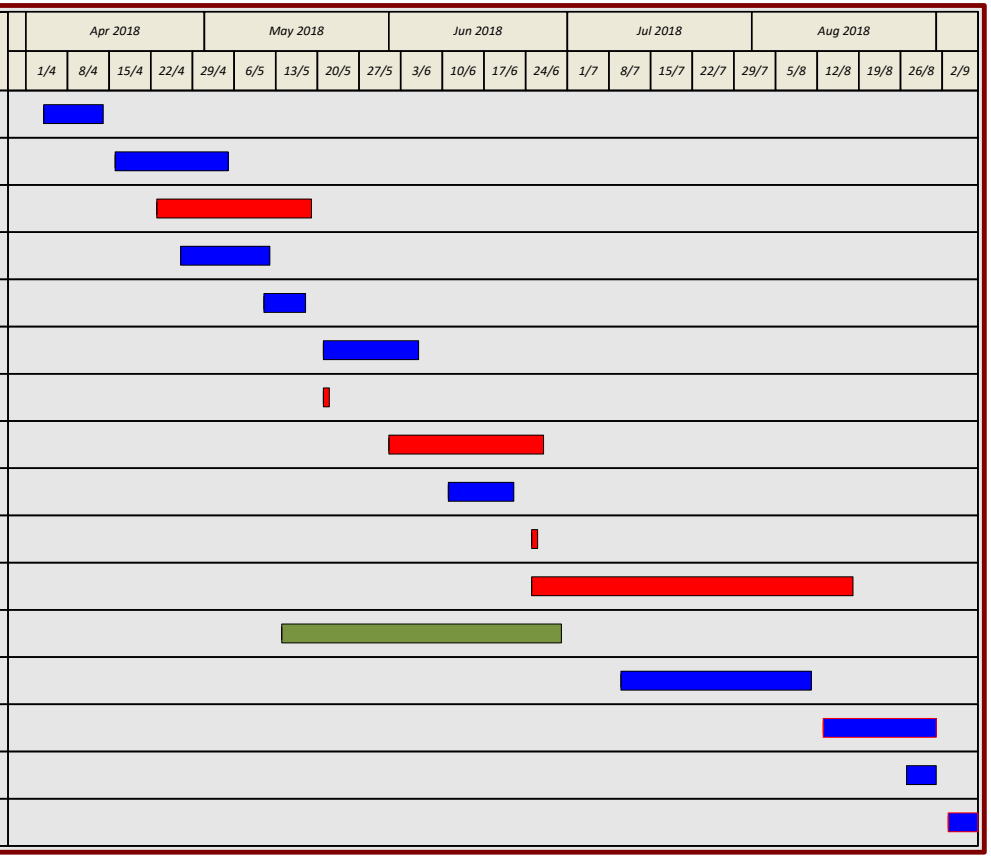


Figure 20: Simplified Gantt showing pre-trial activities

5.4 Method 3: OpenLV Extensibility

5.4.1 Approach

The approach for the Method 3 trials as defined in the full bid submission [Ref. 2] is as follows:

Trial Principle: We will use this Method to exploit the flexible/open nature of the OpenLV platform to enable companies (including non-energy companies) to develop innovative algorithms and applications.

Trial Approach: The 'third party developer API' will be shared, allowing interested organisations or individuals to develop their Apps on the common platform. This will be advertised to potential developers.

Trial Selection: Up to 10 LV-CAP™ devices will be made available in LV substations, for this purpose. The OpenLV project will seek to select a number of providers (large corporates, to sole traders, or academics) who can offer a broad range of services to the DNO and the DNOs' customers.

Trial Deployment: As above, up to 10 LV-CAP™ devices will be deployed at specific LV substations to meet the needs of developers. Key attributes:

- Specific App related data will be sent from the LV-CAP™ devices to a secure Internet based platform for developers to access;
- New Apps will be remotely downloaded to the LV-CAP™ devices for trial;
- The funding required to develop the specific Apps will be raised outside of the project budget, for example, via the private sector or academic funding.

The Outputs delivered by this Method are:

- A more detailed understanding of the appetite of innovative developers using this Solution;
- A revised API which will be shared with the developer community for future App development;
- Learning associated with App validation and verification;
- This learning will be collated in a report outlining how the OpenLV platform and associated LV network data can be used by 3rd Parties.

The benefits from this Method will depend on the Apps developed. They can flow to customers either via the DNO, as Method 1, or directly to the customer, as Method 2".

5.4.2 Detailed Trial Design

A three-stage process has been utilised to:

1. Assess the market potential;
2. Invite applications; and
3. Assess applications and select participants for trial.

This process is outlined in Figure 21.

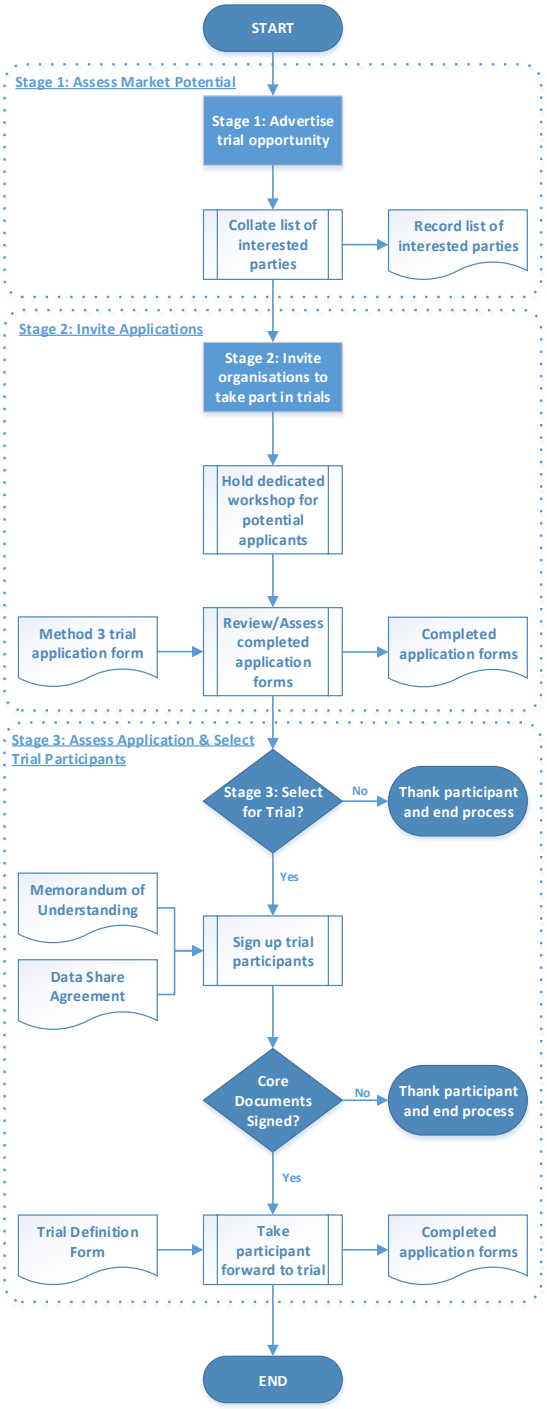


Figure 21: Method 3 – Trial Process

As part of Stage 2, the formal application to take part in the project trials. To convert the interest from potential organisations the project team:

- Opened the formal application process between 15th January 2018 date and 2nd March 2018.
- Published the application form for applicants to complete on the project website on 9th February 2018.
- Published guidance for applicants on the project website on 9th February 2018.
- Published the OpenLV Measurement Points document on the project website on 24th October 2017.
- Published the Public Application Programming Interface (API) for the OpenLV platform on the project website on 24th October 2017.
- Published a guide to developing software applications with the virtual machine, this virtual machine will provide the development environment for new software applications, on the project website on 8th February 2018.
- Arranged and held a workshop for interested parties on 13th February 2018 that was attended by 39 people from 24 organisations. The presentations from this event were published on the project website on 16th February 2018.

As part of Stage 3, assessing trial applications and selecting participants for trial. To maximise the learning from deploying 10 OpenLV platforms as part of the project trials, the project team:

- Held conference calls with the 23 applicants to review all the applications that were received.
- Assessed the applications made from all parties by looking at:
    - The quality of the idea;
    - Technical feasibility;
    - Level of commitment and interest (as outlined on the application form);
    - The ability to self-fund/resource software development/research;
    - The range of ideas (to maximise learning);
    - How replicable the proposed idea was; and
    - How willing the applicants were to share learning from the project trials.
- Developed and circulated a Memorandum of Understanding (MoU) document to be agreed by all applicants. This document outlines the responsibilities of both EA Technology and trial applicants. This document is provided in Annex 3.
- Utilised the Western Power Distribution (WPD) Data Share Agreement that covers how the data shared by the project team can be utilised.
- The applications received were assessed between 12th March 2018 date and 6th April 2018. Successful applicants were informed by 13th April 2018.

It is important to note that EA Technology are providing the infrastructure to enable organisations to participate in the OpenLV Extensibility trials. Organisations are not being funded to take part in the project trials.

As a result, the project team has limited control over the overall scope of each individual trial. This approach does enable organisations to keep ownership of any Intellectual Property (IP) they develop.

In order to formalise the participation of organisations in the trials as outlined above 3 key documents have been put in place:

1. the Memorandum of Understanding;
2. the data share agreement; and
3. the trial definition form.

All these documents form the core trial documentation.

At the time of writing the project team has selected organisations to take forward and is in the process of agreeing the core trial documentation with each organisation. It is important to note that the number of organisations selected may reduce throughout the duration of the project due to: 1) The core documentation set not being agreed and/or 2) Organisations pulling out of the trials at a later date. To mitigate against this and to maximise learning the project team has signed up as many organisations as possible to take part in the OpenLV extensibility trials.

5.4.3 Applicants taken forward to trial

A total of 10 OpenLV platforms are available to support the OpenLV Extensibility project trials. The Project team reviewed the applications and sought to work with as many organisations as possible to maximise learning on the project. In total 17 of the 23 applicants (74%) were selected to take part in the project trials. This included 12 business applicants (71%) and 5 academic institutions (29%).

5.4.4 Utilising LV network data

There are 3 options for organisations to source LV network data within the trials. These are:

1. **Software Application:** In this case the organisation participating in the project trial will develop a dedicated software application that will run on the OpenLV platform. The functionality to be provided by this software application will be determined as part of the detailed trial design.
2. **Server to Server Link:** In this example the organisation participating in the project trial will receive LV network data or an output derived from this data via an automated server to server link. The data or derived output to be provided will be determined as part of the detailed trial design.
3. **Data Only Request:** In this case the organisation participating in the project trial will receive LV network data from the project team. This is likely to be provided in a non-

automated fashion. The data to be provided will be determined as part of the detailed trial design

Figure 22 shows the above 3 options on a high-level architecture diagram of the overall OpenLV solution. Further information on the overall solution can be found in SDRC 1 Detailed Design of the Overall OpenLV Solution [Ref. 4].

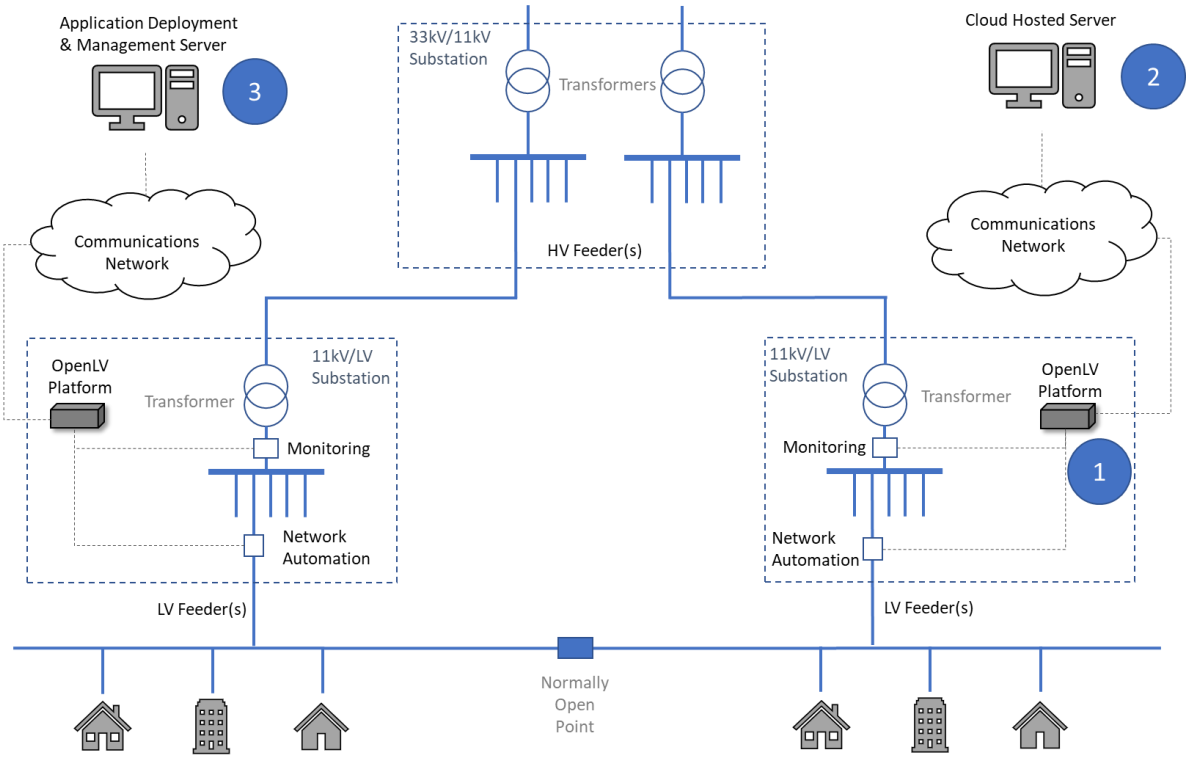


Figure 22: Routes for trial participants to utilise LV network data

Table 13 summarises the number of organisations that are expected to:

1. Develop software applications;
2. Implement a server to server link; and
3. Utilise LV network data within their research.

The OpenLV platforms have been prioritised for organisations that are seeking to develop software applications or implement a Server to Server link. The option shown in the "To Be Confirmed" category will either be a Software Application or a Server to Server link.

Table 13: How organisations will participate in trials to access LV network data

Option	Number of Applicants	Percentage	Number of OpenLV Platforms
Software Application	8	47%	6
Server to Server Link	6	35%	4
Data Only Request	3	18%	0
Total	**17**	**100%**	**10**

5.4.5 The way forward

The Project team are continuing to engage with the selected trial participants to:

- Ensure that the commercial agreements are put in place. This includes the Memorandum of Understanding and Data Share Agreements;
- Agree the technical details of the trial that will be completed with each organisation;
- Finalise the detailed trial design for each individual organisation; and
- Agree the success criteria for each trial.

The overall timeline for the Method 3 OpenLV extensibility trials is shown in Figure 23. The overall learning generated from this trial will be reported in SDRC4 – Learning Generated from the OpenLV Project Trials for all Methods. This SDRC is scheduled to be delivered in January 2020.

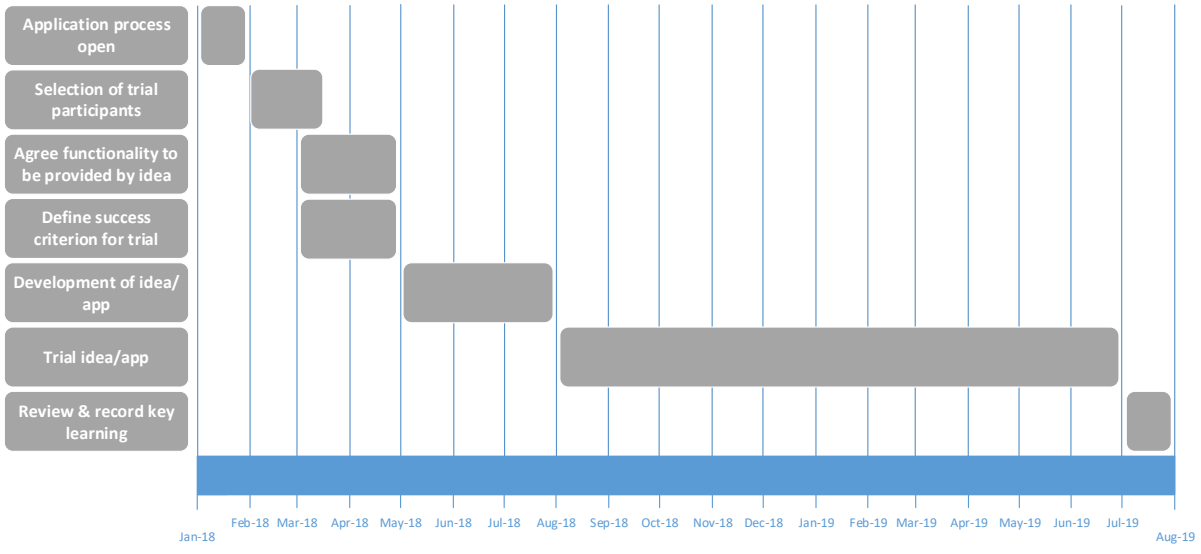


Figure 23: Method 3 OpenLV Extensibility Timeline

1. **Data Only Request:** In this case the organisation participating in the project trial will receive LV network data from the project team. This is likely to be provided in a non-automated fashion. The data to be provided will be determined as part of the detailed trial design.
2. **Software Application:** In this case the organisation participating in the project trial will develop a dedicated software application that will run on the OpenLV platform. The functionality to be provided by this software application will be determined as part of the detailed trial design.

5.5 Overall business case update

During the development of the OpenLV Project Bid, EA Technology utilised the Transform Model to generate a business case for the implementation of the LV-CAP™ platform on GB networks.

This approach will be replicated towards the end of the OpenLV Project, to take into account the following:

1. The Transform Model is updated periodically to reflect the changing status of GB networks, load profiles for properties and devices (e.g. electric vehicles), and anticipated uptake curves for low carbon technologies;
2. The learning generated by the three methods of the OpenLV Project will be considered, resulting in an update to the 'LV-CAP™ type solution' template within the Transform Model.

Running the Transform Model again in 2019, utilising up-to-date information will provide a meaningful comparison of the viability of an LV-CAP™ type solution against traditional reinforcement and other 'smart solutions' available to GB DNOs.

6 Key Learning Points

The key learning points regarding the techniques used for identifying target networks for Method 1, assessing the market potential for Methods 2 and 3 and the detailed design for all Methods, are outlined in the below sub-sections.

6.1 Method 1: Identifying target networks & detailed trial design

Key learning points at this stage of the project for **Method 1 - network capacity uplift** are detailed below. It is noted that currently, the project has been undertaking site surveys, and equipment installation and commissioning, a sequence of tasks common to innovation Projects and BAU activities, and as such, the below learning points relate to these areas of the project.

6.1.1 Principal learning points

The **unintended consequences of seemingly separate decisions** combined to limit the number of substation pairs suitable for use in the project.

- Decisions made during the initial project development stage combined with on-site restrictions to decrease the number of sites suitable for use in the trials.
- Each decision or requirement, added an additional, albeit small, restriction but these combined to rule-out a significant proportion of the network.
- These decisions were made for the right reason, in conjunction with necessary assumptions, but resulted in unintended consequences.
- Sufficient flexibility still remained to identify suitable locations, but the site selection process was more time consuming than expected for the eventual outcome.

The implementation of the project's trial system, utilising LV-CAP™ and Alvin Reclose™ devices is likely to be more difficult than deployment of other hardware mixes in the future.

6.1.2 Contributing factors (and the underlying rationale)

The above learning points arose from a number of indirectly connected criteria defined in the project bid documentation, resulting from hardware limitations, or subsequent design decisions taken during the initial project initiation phase.

1. Whilst the BAU implementation of an OpenLV platform will be smaller, self-contained unit, for the trials a modular system was determined as the most suitable approach.
   This was due to several reasons:
   - It was unknown at the time of specification and procurement what the requirements would be for Methods 2 & 3, and consequently, the system needed to be capable of communicating with as many different systems and devices as possible.

- A single-unit platform for the LV-CAP™ software, suitable for long-term deployment on the network, did not exist at the commencement of the OpenLV Project.
- It was deemed necessary in the event of equipment failure to be able to remove and replace any part of the system to minimise downtime within the trials.

3. This decision influenced the availability of substations suitable for installation.
   The project team elected not to utilise any Overhead Line (OHL) networks, specifically Pole Mounted Transformers (PMTs), within the project due to:
   - the additional complexities associated with installing and maintaining the equipment.
   - the size and weight of the equipment enclosure at such a location.
   - Connection to a Ground Mounted Transformer (GMT) enables easy access to the hardware if required.
4. In order to demonstrate the overall Distributed Intelligence capability of the OpenLV platform (detailed in section 5.2 above), a method of implementing a measurable network change, controllable by the OpenLV platform, was required.
   Whilst several alternative approaches were considered, the use of Alvin Reclose™ devices was considered to be the approach providing the best ability to deliver the project learning whilst minimising overall risk of delivery. However, this required consideration of:
   - The size of the Alvin Reclose™ units limited the substations that were suitable for implementation of the network meshing functionality; specifically, many of the LV enclosures surveyed did not have sufficient space to fit Alvin reclose units with the enclosure door closed. This problem was exacerbated as both substations at either end of the 'pair' needed to be compatible with the units so a single substation could block the pair from being suitable.
   - The use of Alvin Reclose™ units required that both substations in the pair were connected to the same HV network to prevent the possibility of a fault being back-fed along the inter-connected LV network.
   - WPD do not operate a meshed LV network under normal operating circumstances and consequently, significant evaluation of the networks proposed for deployment of the Alvin Reclose™ units was required.

   Alternative methods that were considered would not have experienced these restrictions but at a greater financial cost, and increased project risk through additional project suppliers being required.
5. Whilst the OpenLV platform is designed to be capable of operating autonomously with highly limited mobile data availability, during the OpenLV project trials locations of this type were actively avoided as far as possible.

This is solely due to the need for system data availability over the course of the project rather than only being available following system decommissioning.

6. It was stated that eight of the ten LV network types identified during WPD's LV Network Templates project would be utilised within the OpenLV Project, with at least three of each type utilised in Method 1.
   Some network types defined in the LV Network Templates project are highly specific, (e.g. Network Type 7 being defined as a rural setting). The other requirements above, combined to prevent some network types being significantly represented when the final shortlist was collated.
   For example, a significant proportion of rural areas are excluded by the combination of 'no OHL networks' and the requirement for a reasonable strength mobile network.

6.2 Method 2 & 3: Assessing the market potential

Key learning points for **Method 2 – community engagement** are as follows[5]:

- **Community groups engagement:** Community groups have required a tailored engagement approach in terms of imagery and style of communications. This has been critical to engagement success in terms of understanding the appetite from community groups to take part in the project;
- **App ideas:** Community groups proposing potential app ideas under the banner of "policy, planning and retrofit programmes" has been a surprise. This is not an area that was covered in the initial list of six potential app ideas when the survey was sent out. A total of five app ideas have been received under this title (11% of the total). An example includes, using the data to input to neighbourhood development planning;
- **Number of units:** One group were interested in the project but did not put an application form in as the project could not supply enough units. Their idea was to develop an app that would help identify the impact that an energy local club would have on peak shifting and peak flattening. However, the group hadn't realised that there would be so many substations within their area of interest. This shows there is clearly more potential if LV-CAP™ was rolled out at scale;
- **Community group interest:** There are enough groups with individuals who have an interest in data and electricity, combined with a drive to benefit the community they represent, to have met demand for this project;
- **Timescales – applications process:** A longer period of time between the launch of the application process and the deadline may have resulted in more applications. This would have given groups more time to work up their ideas;
- **Timescales – sites:** Allowing more time to assess suitability of substations before interviews would have been useful;

[5] Note that these are new learning points that have not been reported in SDRC 2.1.

- **Application form:** The length of the application form may have deterred some groups from applying, but all those that did were sensible proposals that met the brief, so it may have acted as a filter to unsuitable projects;
- **Type of community group:** There was good engagement from existing community energy groups and housing associations, but it was much harder to engage with Parish Councils;
- **Technical complexity:** This is a technically complex project, that includes talking to community energy groups about software programming and getting them to think about LV network data and its uses. The selection process was further complicated by screening out applications that included Pole Mount Transformers (PMTs) and with a poor mobile signal strength. The technical complexity along with the lack of funding has meant that only the most committed groups have made it through the selection process; and
- **Inability to install LV-CAP™ on pole-mounted transformers (PMTs):** One of the full proposals didn't make it to interview as all the substations in their hamlet were PMTs. Anyone from a small rural settlement who responded to the original survey would have come across the same problem when looking to complete their application, and this would have probably meant a fair number didn't complete a formal application to take part in the project trials.

Key learning points for **Method 3 – OpenLV Extensibility** are as follows[6]:

- **Guidance for Applicants:** A guidance document was drafted and published on the OpenLV website. This document gave organisations all the information they needed to know when applying to take part in the project trials;
- **Engagement:** We've had good engagement for the Method 3 Business & Academia trials with a total of 79 organisations showing some level of interest in taking part in the project trials and 23 organisations applying to take part. Given the lack of funding to take part in the trials this is a significant level of interest. The Marketing and PR completed on the project certainly helped drive this level of interest;
- **Workshop:** A dedicated workshop was held 2 weeks prior to the end of the formal application process. This workshop was attended by 39 people from 24 organisations and provided all the information the organisations needed ahead of completing the application form. The workshop also included an "application clinic" to ensure organisations could ask questions regarding the completion of the application form to take part in the project trials. Holding this workshop helped to maximise the number of applications received;

[6] Note that these are new learning points that have not been reported in SDRC 2.1.

- **Funding:** The lack of funding was an issue for a number of potential applicants which limited the number of applications received;
- **Resourcing/Business Case:** A number of companies were interested in taking part in the trials but could not justify re-allocating resource from fee paying work. This limited the number of applications received; and
- **Marketing & PR:** Marketing, PR and a good project website to host all the relevant documentation are key to getting the message out and providing the right information to potential applicants. The formal launch event at the WPD Balancing Act event was a great start.

6.3 Detailed trial design for methods 2 & 3

Key learning points for the detailed trial design for **Method 2 – community engagement** are as follows:

- **Approach and associated documentation:** The approach taken to signing up participants includes using the Memorandum of Understanding, Data Share agreement and trial design form. These documents provide a clear basis for the Method 2 trials
- **Length of trials:** All of the seven applicant community groups progressing to trial have expressed a need for at least 12 months' worth of data to make the trial viable. The flexibility of the project to install LV-CAP™ units from June 2018, and for them to remain in situ until December 2018 will be of significant benefit to the participating community groups under Method 2, and will support on-going extrapolation of learning and assessment of replicability and benefits going forward;
- **In-house app development:** The ability of CSE to provide in-house app development support will overcome one of the major barriers to community groups developing their own apps – i.e. access to funding.
- **Trial implementation and associated documentation:** A number of documents will enable the project team and applicants to design and implement the trials. This documentation is needed to ensure the trials are successful. Documentation includes: 1) OpenLV Point Measurement document, 2) Developing with the LV-CAP™ Virtual Machine, 3) The OpenLV Common Application Platform API and 4) The trials design form.

Key learning points for the detailed trial design for **Method 3 – OpenLV Extensibility** are as follows:

- Approach and associated documentation: The approach taken to signing up participants includes using the Memorandum of Understanding, Data Share agreement and trial design form. These documents provide a clear basis for the Method 3 trials;

- Telephone Interviews: Following receipt of applications, prior to selecting organisations to take forward, telephone calls were held with each applicant to review their application. This enabled the project team to get a better understanding of the proposed ideas and maximise learning on the project;
- Maximising Learning: Following receipt of 23 applications, the project team took the approach to work with as many organisations as possible to maximise learning, rather than just allocate a single OpenLV platform to each applicant;
- OpenLV Solution Architecture: The systems architecture of the OpenLV Solution enables 3rd parties to: 1) Develop/deploy applications to utilise LV network data, and/or 2) Implement server to server links to utilise LV network data and/or 3) Enables LV network data to be downloaded for offline use. This architecture has enabled the project team to maximise project learning; and
- Trial implementation and associated documentation: A number of documents will enable the project team and applicants to design and implement the trials. This documentation is needed to ensure the trials are successful. Documentation includes: 1) OpenLV Point Measurement document, 2) Developing with the LV-CAP™ Virtual Machine, 3) The OpenLV Common Application Platform API and 4) The trials design form.

7 Summary

This SDRC report has presented the results from: 1) Identifying the target networks for the capacity uplift trials (Method 1), 2) An update to the results previously published regarding testing the market to assess the level of interest from communities and third parties in participating in trials as part of the OpenLV project and 3) The detailed trial design for the capacity uplift, community and wider industry (OpenLV Extensibility) trials.

The project team has:

- Identified where the 60 OpenLV platforms will be installed to support the project trials for Method 1, Network Capacity Uplift. The 60 OpenLV platforms to support this trial will be installed in LV substations in WPD's licence areas by July 2018. Trials will be completed over an 18-month time period as defined in the OpenLV Bid document.
- Assessed the market potential for the project trials for Method 2, Community Engagement and has signed up 7 community groups to take part in the trials. The 10 LV substations, where the OpenLV platforms will be installed, have been identified and surveyed. Installations are currently scheduled to be completed by the end of June 2018.
- Assessed the market potential for the project trials for Method 3, OpenLV Extensibility and has signed up 17 organisations to take part in the trials. The 10 LV substations, where the OpenLV platforms will be installed, are currently being identified. Installations are currently scheduled to be completed by the end of August 2018.
- Completed the detailed trial design for all Methods in line with the Full Bid Submission.

The learning from deploying the overall OpenLV solution will be provided in SDRC-3 that is scheduled to be delivered in February 2019. The learning from the project trials for all Methods will be provided in SDRC-4 that is scheduled to be delivered in January 2020.

8 References

1. OpenLV Project Direction, 16th December 2016, https://openlv.net/wp-content/uploads/2017/08/Open-LV-Formal-project-Direction.pdf
2. OpenLV Full Submission Pro-forma, https://openlv.net/wp-content/uploads/NON-CONFIDENTIAL-OpenLV-NIC-Bid-2016-WPD_EN_NIC_02-RESUBMISSION-v1-1-Wit.pdf
3. SDRC-2.1, Community Engagement Plan & Interim Results of Assessing Market Potential (Methods 2 & 3).
4. SDRC-1, Specification, Design and Factory Testing of the overall OpenLV Solution.

Annex 1. Evidence - Method 1: Network Capacity Uplift

See separate document.

Annex 2. Evidence - Method 2: Community Engagement

See separate document.

Annex 3. Evidence - Method 3: OpenLV Extensibility

See separate document.