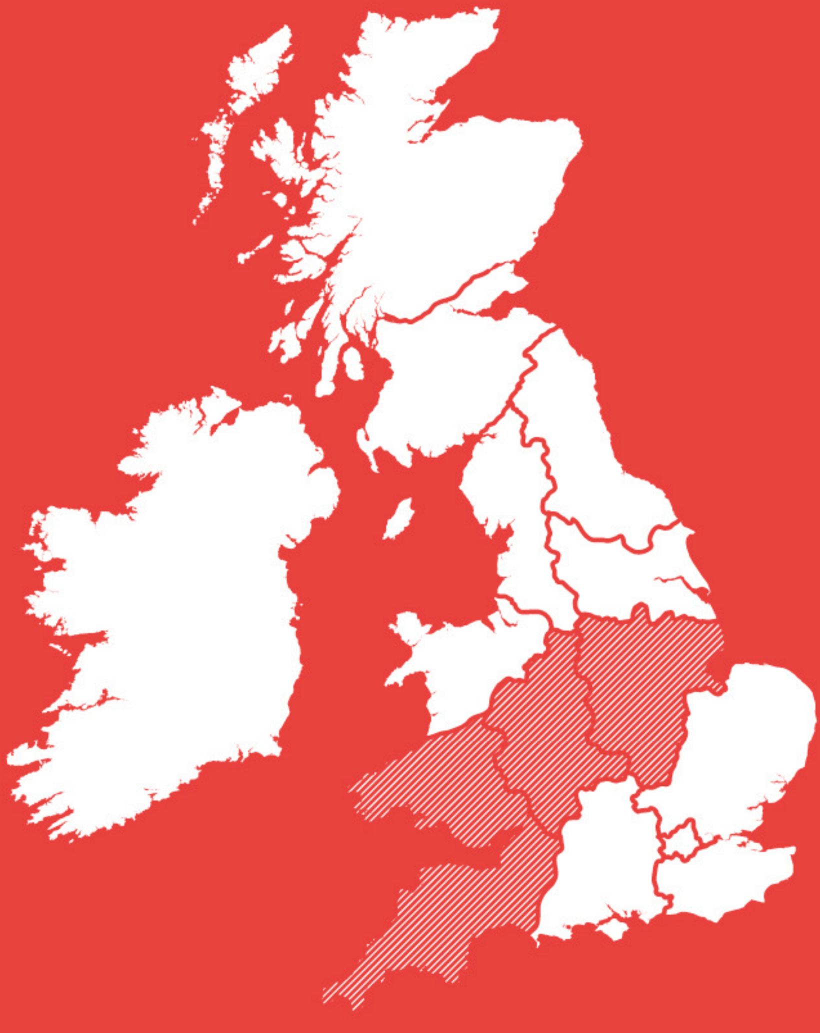
WESTERN POWER DISTRIBUTION

OPEN LV

OPENING UP THE SMART GRID



Network Innovation Competition (NIC Bid) 2016
WPD/EN/NIC/02

NON-CONFIDENTIAL

ea technology

RIIO NIC NETWORK INNOVATION COMPETITION

1. Project Summary

1.1. Project Title	**OpenLV**
1.2. Project Explanation	The **OpenLV** Project will trial an open, flexible platform that could ultimately be deployed to every LV substation in Great Britain. Through three key Methods, the Project will demonstrate the platform's ability to provide benefits to the network, customers, commercial entities and research organisations.
1.3. Funding licensee:	**Western Power Distribution (WPD) West Midlands on behalf of EA Technology**
1.4. Project description:	***1.4.1. The Problem(s) it is exploring*** The decarbonisation of heat and transport through the wide scale customer adoption of heat pumps and electric vehicles will increase demand on LV networks. Under current business practice this would result in a large amount of conventional LV reinforcement, at significant cost and disruption to customers, to accommodate this increase in demand. New solutions are becoming available, but each delivered on separate, proprietary platforms. ***1.4.2. The Method(s) proposed*** The functionality delivered by the **OpenLV** Solution will be proven via three complementary Methods: • **Method 1:** LV Network Capacity Uplift; • **Method 2:** Community Engagement; and • **Method 3: OpenLV** Extensibility to 3rd parties. ***1.4.3. The Solution(s) planned by applying the Method(s)*** The **OpenLV** Solution includes the following key components: 1) Intelligent substation devices that can support software Applications or 'Apps' from multiple vendors on a single device. Providing a low cost hub that, once deployed, can act as a hub for many more functions; 2) A secure platform that enables the intelligent substation devices to be remotely managed; and 3) A secure platform that provides LV network data to community groups and third party organisations. This will facilitate non-traditional business models by opening up network data to third parties to understand the network and deploy solutions. The roll out of the overall Solution proposed across GB will support the Low Carbon Plan and uptake scenarios presented in the UK Government's Fifth Carbon Budget by minimising the impacts of low carbon heating and transport on the LV network, therefore removing this as a barrier to customer adoption where it is applied. This has significant potential to deliver environmental benefits and cost savings to future and existing customers by negating and/or deferring the need to reinforce the LV network.

1.5. Funding

1.5.1 NIC Funding Request (£k)	*£4,855*	***1.5.2 Network Licensee Compulsory Contribution (£k)***	*£545*
1.5.3 Network Licensee Extra Contribution (£k)	*£0*	***1.5.4 External Funding – excluding from NICs (£k):***	*£463*
1.5.5. Total Project Costs (£k)	£5,908		
1.6. List of Project Partners, External Funders and Project Supporters	Project Lead: EA Technology Ltd Project suppliers include Nortech and Lucy Electric GridKey. Additional, project collaborators, service providers and equipment suppliers will be selected using a competitive tendering process. Project supporters include Bristol City Council, Bristol University, University of Reading and the University of Oxford. Letters of support are included in Appendix F.		

1.7 Timescale

1.7.1. Project Start Date	January 2017	***1.7.2. Project End Date***	April 2020

1.8. Project Manager Contact Details

1.8.1. Contact Name & Job Title	R Potter, Senior Consultant, EA Technology	***1.8.2. Email & Telephone Number***	Richard.Potter@eatechnology.com 0151 347 2243 07805 772243
1.8.3. Contact Address	EA Technology, Capenhurst Technology Park, Capenhurst, Cheshire, CH1 6ES		

Section 2: Project Description

2.1. Aims and objectives

2.1.1. Overview

OpenLV will trial and demonstrate an open, flexible platform that could ultimately be deployed to every HV/LV substation in Great Britain (GB). The Project will use three Methods to demonstrate the platform's ability to provide benefits to the network owner, customers and innovative service providers.

2.1.2. The Problem to be resolved

The UK's decarbonisation targets are clear, and remain firm, even in a post-Brexit Britain. The climate change agreement made in Paris in 2015 is legally binding for all nations. The UK has clear aspirations and its own legislation to drive towards a low carbon economy. Energy, and specifically electricity, has a key role in assisting this transition as generation decarbonises, and then through supporting heating and transport demands as these shift towards electricity. Great Britain has about 1,000,000 LV feeders; these have largely been run on a fit-and-forget basis for the last 100 years, but things are set to change. The 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.

We've seen the start of this transition over the last five years, with new solutions, supported through mechanisms like the LCN Fund, starting to appear on these otherwise passive LV networks. However, each solution is built on a different proprietary platform. As each substation has slightly different needs, there is a risk of lots of competing systems being deployed, each addressing its own, highly specific purpose.

This will result in inefficiency, both in terms of capital and deployment costs, and can ultimately lead to a raft of stranded assets as the new needs of the network outstrip the pace of change of the infrastructure that supports it.

2.1.3. The OpenLV Solution

The **OpenLV** Solution (LV-CAP™) is a software platform, operating on off-the-shelf commodity hardware. It will sit as an interface between the HV/LV substation assets and the customers it serves.

This Solution is analogous to a smartphone. In the case of a smartphone, the development and rapid acceleration seen in applications (Apps) has been provided by a wide variety of organisations, covering a huge array of services (Figure 1).

The growth in smartphone Apps, shows the importance of: 1) having an open Operating System (OS) that can be deployed on multiple vendors' hardware and 2) the ability to have a central system or store to deploy Apps and make them available to new users. Whilst the platforms are common, the Apps used are highly tailored to suit the unique nature of a user's own needs – no two phones are identical, as no users are identical.

This project, **OpenLV**, will trial a similar, open platform, but for a substation.

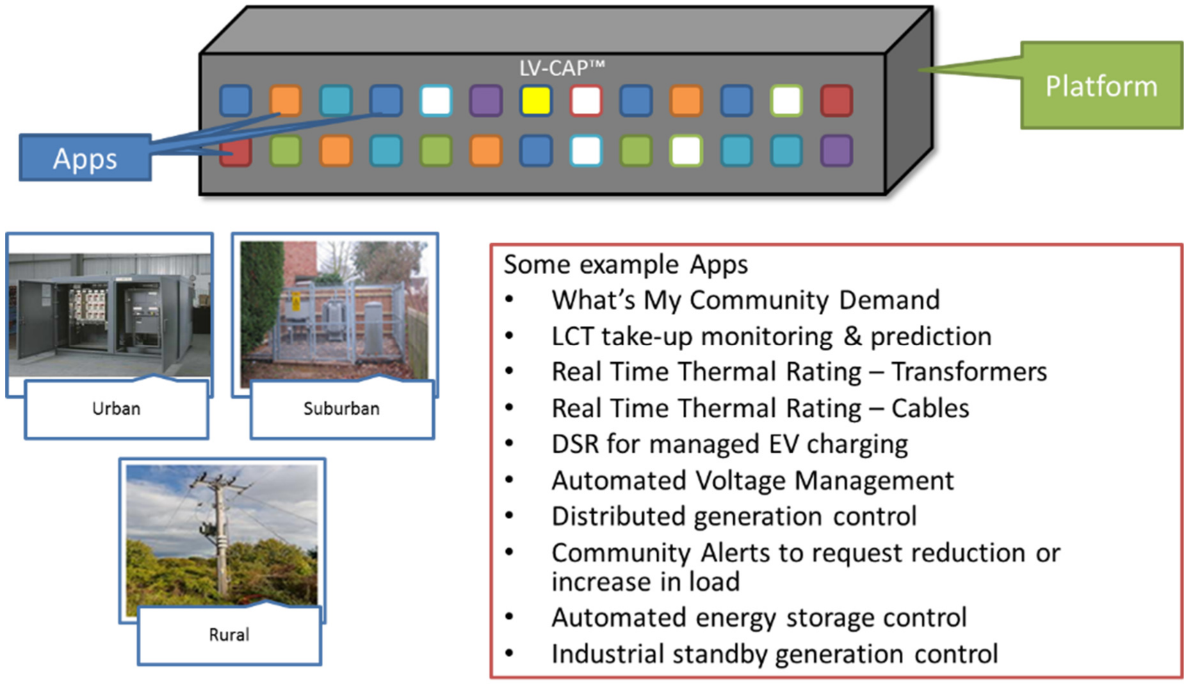


Figure 1: Illustration of the LV-CAP™ platform containing a range of relevant Apps

OpenLV builds on Background IP brought by EA Technology and its partners from a £0.5m co-funded InnovateUK project (Appendix M). Crucially, the LV-CAP™ software architecture has been built to allow different Apps, from a diverse set of developers (large corporates, to sole traders / community groups), to operate together.

With target hardware costs in the low £hundreds, the ultimate aim is for this platform to be deployed in many of GB's HV/LV substations, each with a tailored set of Apps. In doing so, it will act as a flexible bridge to suit the needs of the local network and, once in place, its local community.

2.1.4 The Demonstration being undertaken

Taking the lead from smartphone development, it would not be feasible nor possible for any one developer to produce all of the potential Apps, nor to launch them from day one. However, it is critical to test the key features that would be common for the future platform. With this in mind **OpenLV** aims to demonstrate the LV-CAP™ Solution by:

- **Proving the platform:** It builds on an existing development project to deploy a workable open substation platform for both monitoring & control of the LV network;
- **Creating an Eco-System:** It will provide third parties, such as community groups, access to network data; and
- **Stimulating a Market:** It will facilitate a common platform with low cost to entry for a range of new App developers.

2.1.5 The OpenLV Methods

In order to test these aims, three Methods will be applied, together with a common set of enabling works (Figure 2):

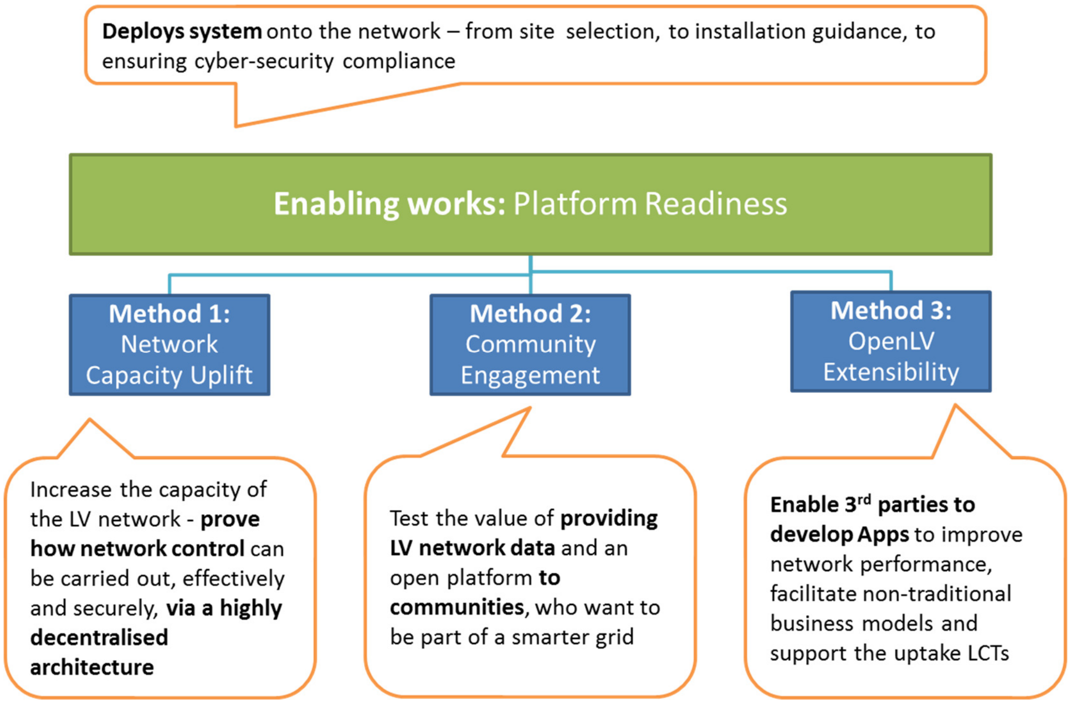


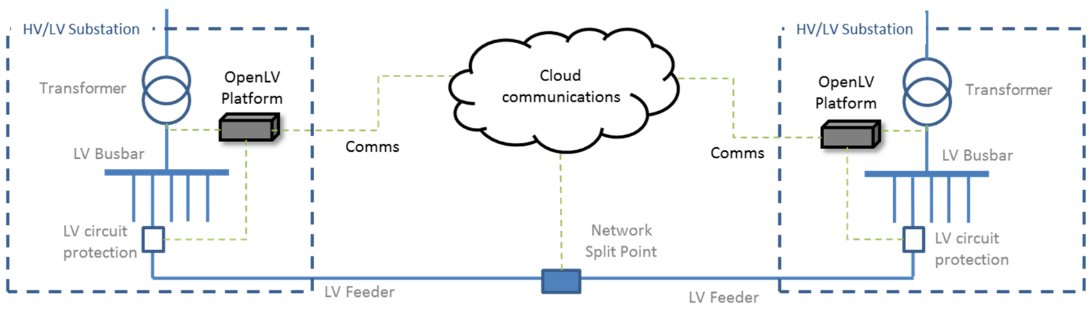
Figure 2: Overview of the three Methods being used in the project

2.2. Technical description of Project

The **OpenLV** platform (LV-CAP™) will be deployed in 80 HV/LV ground mounted substations in this project. This section provides an overview of each Method, and why they are innovative. Further detail is provided in Appendix H for the **OpenLV** platform and Appendix G for the Methods.

2.2.1. Method 1: LV Network Capacity Uplift

The Network Capacity Uplift Method will demonstrate the capability of the **OpenLV** platform to perform measurements and control from within a HV/LV substation (Figure 3).



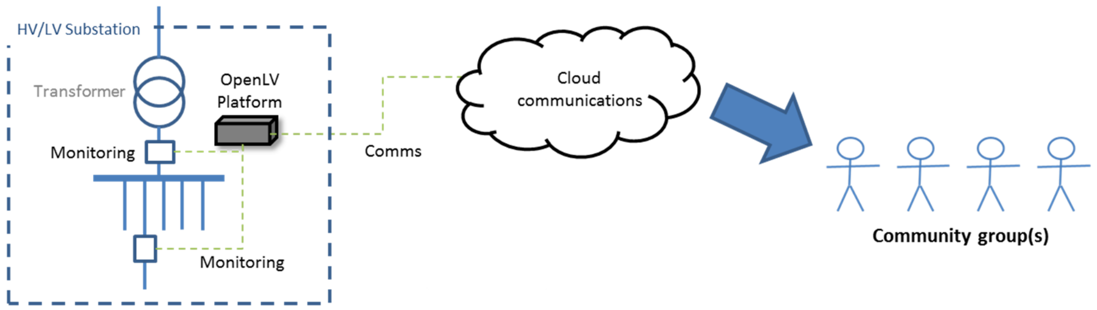
What	How
• Check network capacity against RTTR of transformer; when breached, close two radial circuits to mesh the LV • Deploy two proven techniques – 'Dynamic Thermal Ratings App' and – 'Network Meshing App'. • Together with a 'Network Control App' to operate/configure the network	• Assess WPD's network 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 3: Overview of LV Network Capacity Uplift (Method 1)

This Method is innovative as it will test the ability for control signals to be sent via a highly distributed architecture. It will also be the first NIC project to implement automated meshing of LV networks in conjunction with RTTR (Real Time Thermal Rating) of the local HV/LV transformer.

2.2.2 Method 2: Community Engagement

Once deployed, the **OpenLV** platform can be used to provide data to customers or groups of customers in communities. This Method will test how this could be promoted and achieved in practice (Figure 4).



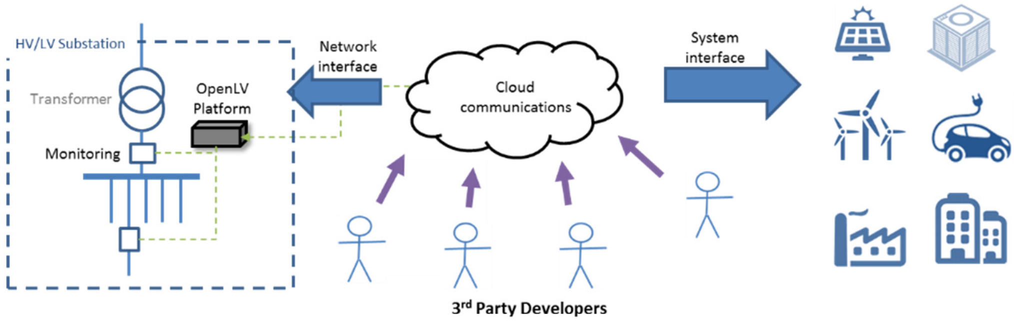
What	How
• To work with key community groups to understand whether Apps can be developed and installed on the platform • Identify funding sources that customers / communities can use to develop specific Apps	• Community engagement to promote availability of platform / LV network data • Make available 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 4: Overview of Community Engagement (Method 2)

This Method will promote innovation through active engagement of communities to provide organisations with direct access to LV network data through a secure third party hosted service. At the current time there are no solutions within the market place that provide this functionality. Data privacy, particularly for substations with a small number of customers, will be explored under this Method.

2.2.3 Method 3: OpenLV Extensibility

This Method will provide **OpenLV** as a secure platform to third parties for them to develop and release their own Apps offering new services to DNOs and customers alike (Figure 5).



What	How
• To enable companies to develop innovative algorithms and applications for either the DNO, or it's customers	• 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 5: Overview of OpenLV Extensibility (Method 3)

This will exploit the open nature of the **OpenLV** solution. This Method is innovative as it will seek to stimulate the market to develop and deploy new algorithms and/or Apps that ultimately benefit both Customers and DNOs through supporting the cost effective deployment of LCTs and facilitate the development of non-traditional business models.

2.2.4 How these Methods work together

The LV-CAP™ Operating System (OS) is the enabler for all three Methods. Ultimately each Method could be deployed in isolation, however it is envisaged that deployment will be initially DNO-led for DNO purposes (either LV monitoring or control). Once deployed, the DNO would have the opportunity to offer the data / platform up to third parties, who in turn can offer further value-add services on the same platform.

Implementation of the Operating System, allowing the deployment and hosting of multiple Apps is a significant project task. The system will be implemented and tested during the work associated with Method 1 using equipment and software in the direct control of EA Technology. Once deployed, the broad methodology will be shared and used in the implementation of Methods 2 and 3. The inclusion of engagement with communities (Method 2) and the supply chain including non-energy companies (Method 3), adds significant value to the project – showing a life beyond innovation funding.

2.3. Description of design of trials

This section describes how the project has been designed to ensure the results are statistically sound and sufficiently robust. It describes the overarching principles (2.3.1) before addressing specifics for each Method (2.3.2-2.3.4).

2.3.1 General Principles

The trials in **OpenLV** have been designed to strike an appropriate balance between testing in sufficient volumes to draw meaningful conclusions while ensuring value for money to customers.

Overall, 80 LV-CAP™ platforms will be deployed across the three Methods in the project: Method 1 – Capacity Uplift: 60 units; Method 2 – Community Engagement: 10 units; Method 3 – **OpenLV** Extensibility: 10 units.

Locations will be selected based on a combination of low-risk for deployment, alignment to the Method and replicability to GB. Across WPD's four distribution licences, there are over 65,000 ground mounted HV/LV substations, giving us very high confidence for being able to select suitable sites against these criteria.

The open nature of the overall Solution will be demonstrated by:

- Two suppliers providing communications back to separate back office systems (Nortech for Method 1[1] and Lucy Electric GridKey for Methods 2 and 3);
- Four suppliers providing software and algorithms developed for Method 1: EA Technology, Nortech, Lucy Electric GridKey and Manchester University; and
- The provision of a 'development skeleton App' that will provide standard code that can be used by 3rd parties to develop new Apps. Thereby reducing the development time for all new Apps that are provided by 3rd parties for Methods 2 and 3.

To ensure trials are robust and learning is captured, 'Learning Reviews' will be an agenda item at monthly project review meetings. The learning will be captured using the same robust methodology already employed on existing future networks projects in WPD's Knowledge Capture Log.

2.3.2. Method 1: LV Network Capacity Uplift

Trial Principle: This Method will use two techniques to release additional capacity by sending control signals to actuators on the network:

Thermal Rating of the Transformer: Existing equipment ratings are based on the conservative assumption that the peak load is continuously delivered over a prolonged period thus allowing time for the transformer to heat up to its maximum recommended operating temperature. In reality, particularly on networks supplying predominantly domestic customers, the load is at its peak only for a relatively short period each day. Real Time Thermal Rating systems use knowledge of the previous loading conditions, coupled with the heating and cooling characteristic of the equipment, to determine a new load (rating) that the equipment can safely supply without overheating. These new (dynamic) ratings are often significantly above the nameplate rating of the transformer for the actual period of peak load. Real Time Thermal Rating (RTTR), also known as Dynamic Thermal Rating (DTR), of the local HV/LV transformer have thus been shown to release additional capacity. In this Method RTTR of the local LV transformer will be provided by a 'DTR App' developed by Manchester University prior to this project.

Meshing the network: Meshing (joining together or interconnecting) LV substations originally designed to be run separately (with open points on feeders between them) has been successfully demonstrated in LCN Fund projects such as FUN-LV and Smart Street. These projects have shown that that meshed operation of the LV network could increase its capability to support higher penetrations of LCTs.

Whilst previous LCN Fund projects have tested dynamic thermal ratings and network meshing separately, this will be the first time that both dynamic thermal ratings and network meshing will be applied and automated on the same LV network.

[1] Whilst the Nortech Communications Container is being utilised for Method 1 it is also available for use by DNOs for Methods 2 and 3.

Trial Approach: The purpose of this Method is to demonstrate how control actions can be carried out on LV networks via a highly distributed architecture. It will be achieved via a two stage process:

- **Stage 1**: deployment of monitoring and control Apps, without actuation. This will be carried out for all identified sites under this Method.
- **Stage 2**: As Stage 1 with actuation, e.g. operation of switchable devices on the network as a consequence of decisions made by the Apps running on the **OpenLV** intelligent substation devices. Carried out on a limited selection of sites under this Method.

These stages are essential in the demonstration of this Method to prove both the benefits (Stage 1) and show how the technology will operate in a real environment (Stage 2).

Stage 1 operation:

- The 'Network Control App' will assess the load on the LV network and automatically identify the need for additional network capacity. Once identified it will instruct the 'Dynamic Thermal Ratings and Network Meshing Apps' to provide more capacity.
- Network load data from the appropriate App will be collated along with the control instructions, provided by the 'Network Control App'.
- This information will be sent back to a central location, where the project team will then analyse this data to determine the number of times the device would have operated, thereby allowing an assessment of the level of capacity uplift that can be provided.

Stage 2 operation:

- Based on the performance of Stage 1, a subset of substations will be selected for closed loop testing[2], to maximise learning and minimise cost.
- The selection of sites for closed loop testing will be based on the number of times the Control App in Stage 1 has issued a request for further capacity – thereby focussing on those circuits where largest returns would be achieved.
- Actuators, by way of LV automation equipment will be deployed to demonstrate that signals can be securely sent over standard communications channels from the **OpenLV** platform to the field.
- Actuator status will be monitored and reviewed to confirm and validate operation in line with expectations.

Trial Selection: This Method will be trialled by installing LV-CAP™ devices on a number of candidate LV substations which are broadly representative of the population of GB networks that could benefit. These substations will be specifically selected to maximise the learning from the project trials by building on previous work.

Specifically, WPD's LV Templates and ENWL's LV Network Solutions have previously shown that there are a number of characteristic GB feeder types. We will seek to include the feeder types that will benefit most from the deployment of the **OpenLV** Method 1 solutions in our selection. This will be supported by discussions with DNO engineers to assist in the targeting of potentially suitable networks.

It is anticipated that in doing so, this will cover a broad range of underground and mixed circuits in GB, allowing the true scalability of the solutions to be quantified.

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[2] This is where the Apps, working together, recognise a capacity shortfall, determine the optimum strategy for meeting that shortfall and then autonomously execute that strategy using RTTR calculations and actuation of network switching devices.

Trial Deployment: The Trials have been designed to include a total of 60 LV-CAP™ devices based on an assumption of 30 pairs of HV/LV substations suitable for meshing. Each paired (adjacent) networks will be capable of being interconnected through a network split-point (e.g. a linkbox or LV pillar). Key attributes:

- WPD's LV Network Templates shows there are 10 network types. We will target 8 of the 10 network types as these are most likely to benefit from this Method.
- **OpenLV** will deploy 60 devices in 30 paired substations (see Figure 3). This will enable the Project to target a minimum of 3 examples of each network type (48 units on 24 LV circuits), whilst still providing a contingency of 20% (12 units 6 LV circuits) to account for any problems encountered in first-choice deployment.
- Stage 1 will deploy and monitor all 60 LV-CAP™ devices over an 18-month period.
- Stage 2 will later deploy 10 sets of switchable LV devices (actuators), one set at each end of 5 of the interconnector circuits between the paired substations selected for the closed loop trials.
- The project will target 3 geographic areas in locations that are part of the 'Smart Cities' programme and are in WPD's Licence areas: Bristol, Nottingham, Milton Keynes, Coventry, Stoke and Cardiff. Up to 20 LV-CAP™ devices will be installed in each geographic area.

The Outputs delivered by the Trials of this Method include:

- A detailed description of how LV networks can be assessed to identify which network locations would benefit from the installation of the 'Intelligent Substation Devices' (Section 9, SDRC-2);
- An assessment of how much additional capacity can be delivered by this Method. This will include Dynamic Thermal Rating in isolation, Network Meshing in isolation and both techniques combined (Section 9, SDRC-4); and
- An assessment of the costs and benefits of deploying the **OpenLV** platform against the traditional methods of reinforcing the LV network (Section 9, SDRC -5).

2.3.3. Method 2: Community Engagement

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.
- 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.

To ensure learning from this Method is maximised, relevant learning regarding customer engagement will be utilised from the following WPD projects: Sola Bristol, LV Templates and FALCON.

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.
- 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.
- 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;
- 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 (Section 9, SDRC-4 and SDRC-5).

The **OpenLV** project will provide a possible means of feedback by which community-led low carbon projects on monitored networks can determine their effectiveness. It will support community engagement by offering a vehicle for DNO and community collaboration on issues of concern to both. It will showcase a way in which access to network data can provide benefits to other interest groups.

The benefits from this Method are predominantly gained by the interested parties (e.g. customers and/or community groups) who are able to use this data to help achieve their aims.

2.3.4. Method 3: OpenLV Extensibility

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 HV/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 HV/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 10x 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 (Section 9, SDRC-4).

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.

2.4. Changes since Initial Screening Process (ISP)

2.4.1 The scale of the Project, funding required, other partners or External

Following detailed costing of the **OpenLV** Project, as part of the FSP process, the total cost of the project rose from £5,157,500 to £5,925,440 (£768k, 15%) and the NIC funding requested rose from £4,641,750 to £4,807,940 (£166k, 4%). The relatively small increase in the NIC funding request versus the increase in the total cost of the project highlights the significant level of in kind funding that has been committed to the Project by EA Technology (c10% of the NIC funding request).

The total number of distribution substations where the intelligent substation devices will be installed has been reduced from 100 to 80 locations. Following the development of the FSP it has been concluded that deployment of 80 units enables the generation of statistically sound and robust learning whilst delivering value for money to customers.

Following detailed planning, as part of the FSP process, the duration of the Project has been increased from 36 months to 39 months.

2.4.2 Cross Industry Venture (No changes)

2.4.3 IPR arrangements (No changes)

2.4.4 Ofgem feedback following the ISP

It is confirmed that this FSP document has been developed to address the feedback received from Ofgem following the submission of the ISP.

Section 3: Project Business Case

See Appendix A1: Financial Benefits Table, A2: Capacity Benefits Table, A3: Carbon Benefits Table and A4: Explanatory Notes.

3.1 Construction of the business case

The **OpenLV** Project is seeking to demonstrate several different areas of benefit via the three Methods described. These Methods vary considerably in their approach and as such the determination of the business case for each Method is different.

Method 1 is concerned with trialling equipment to release capacity on the LV network and hence the business case focuses on the amount of capacity that can be released and the relative costs of this action when compared to the alternative techniques. Initial analysis has been performed to gauge the likely number of networks across Great Britain that could benefit from such an approach to both determine the replicability of the Method, and also to confirm that there are significant savings to be made by deploying this technique across numerous LV networks. This analysis makes use of the Transform Model which is accepted by the industry as the leading tool to evaluate the merits of different innovative approaches and quantify the likely cost saving over time that these approaches could yield. The Transform Model was used by all DNOs as part of their RIIO-ED1 business plan development and the figures from this analysis were provided to Ofgem, who also have a copy of the Transform Model to evaluate such submissions. **The business case is therefore based on the tool accepted by both network operators and regulator as offering the best method to analyse scenario driven investment needs.**

Method 2 focuses on community engagement and allowing DNOs and community groups to work more closely together to better understand their electricity consumption and to allow them to develop local smart grids or low carbon communities. Over the past 2 years, WPD has engaged with approximately 528 community groups, 200 of these community groups have attended WPD events and are keen to explore the use of generation coupled with storage to reduce carbon emissions, or to try to develop non-traditional business models for local energy trading. The deployment of LV-CAP™ technology allows the implementation of 'Apps' that can be deployed to **assist communities in understanding their consumption and export, and allow them to optimise their demands with storage to minimise carbon emissions and/or energy bills.**

Method 3 looks at the way in which having an open, low cost platform provides flexibility to App developers and interested academic institutions to be able to offer services to the network operator and customers, or to use the available data to assist in furthering academic research. Here **the business case focuses on the anticipated cost of deploying such Apps against the deployment of additional, proprietary hardware to achieve the same result.**

3.2 Financial benefits

The most significant benefit of having the low cost LV-CAP™ platform is the extensibility that is provided in terms of being able to provide a range of services at a substation level, via just one piece of hardware. This is vital to the future of a smart grid as different areas will provide different challenges and hence require a range of different solutions.

The benefits deriving from the deployment of the LV-CAP™ platform are twofold. Firstly, the low cost nature of the hardware means it represents a significant cost saving against the installation of a bespoke solution at a substation level, instead allowing multiple solutions to be deployed in software onto the single platform. Once the platform has been deployed in a substation, the benefits that can then arise are concerned with the ability to utilise the platform to provide a multitude of different tools and solutions that will deliver value both to the DNO and also to customers.

At present, the costs and complex nature of installing new solutions in hardware act as a barrier to new entrants to the market. The **OpenLV** project will remove this barrier by allowing all potential developers of solutions to offer their product in a low-cost manner to a DNO.

We will now turn to each of the Methods in turn, but it is important to recall that within the context of the project, these Methods are designed to demonstrate the potential functionality and flexibility that the platform delivers. The enduring benefits are all predicated on the extensible nature of the platform to provide an open, market-led approach to managing LV networks.

Method 1: The financial benefits of deploying Method 1 nationwide have been calculated from using the Transform Model for Great Britain. These calculations have been performed with a target deployment price of £[redacted] assuming the solution is available from 2020.

The calculations have been performed for a range of options, looking at the highest and lowest scenarios for Low Carbon Technology (LCT) uptake (in line with standard industry practice, using the scenarios prepared by central government, i.e. Department of Energy and Climate Change for electrification of heat and uptake of generation and Department for Transport for electrification of transport) over the period to 2050 to show the range of savings available.

Several Transform Model runs have been carried out to quantify the benefit. The first, to establish a baseline, simulated the case where a full range of conventional and smart solutions are available to resolve network constraints, with the exception of the 'Uplift' solution being trialled in Method 1. This analysis shows necessary network expenditure of between £1,445m to £14,638m depending on the levels of LCT uptake (all figures in discounted totex terms).

Now by adding the Method 1 'Uplift' solution to the model with the parameters the solution is anticipated to have in terms of its costs and benefits, a second Transform Model run was performed for the same scenario range. The anticipated investment is reduced to £1,325m to £12,590m. In other words, the deployment of the solution is anticipated to **save between £120m to £2,048m over the period to 2050** depending on the LCT uptake scenario

Furthermore, the baseline Transform Model analysis revealed that of the approximately one million LV feeders in Great Britain, the number requiring some reinforcement due to LCT load growth between now and 2050 is anticipated to be approximately 133,000 in the low scenario, and 686,000 in the high scenario. **The 'Uplift' solution is shown to be applicable to a range of LV feeder types** and to provide a viable solution for a number of the load growth challenges that will be experienced. Indeed, it is seen from the second set of Transform Model analysis that the 'Uplift' solution is deployed on 16,000 feeders in the low scenario (12% of feeders requiring reinforcement) and 241,000 feeders in the high scenario (35% of feeders requiring reinforcement) over the period to 2050.

The deployments of the Uplift solution are found to be distributed between various feeder types that are found both in town centres and in residential areas, indicating a **high degree of replicability for the solution across significant portions of the network in Great Britain.**

The Transform Model analysis described above illustrated the number of feeders that could benefit from the Uplift solution. It is more difficult to quantify the precise number of substation installations that would be necessary as certain feeders that benefit may be supplied from the same substation. However, the types of feeders that have been shown to be suitable for the deployment of this solution, come from substations that supply an average of 3.3 feeders per substation. Therefore, dividing the number of feeders by 3.3 gives a realistic low-end estimate of the number of substation deployments.

This calculation shows that between **approximately 5,000 and 73,000 substations would be likely to have the LV-CAP™ technology installed by 2050.**

Method 2 is concerned with providing communities with greater levels of information regarding their electricity consumption and their interaction with the distribution network. We have considered that communities may wish to engage through understanding their collective demand and seek to negotiate a preferential rate through a collective purchase agreement for their electricity. The data transfer to facilitate such an arrangement could be provided via an app on the LV-CAP™ platform.

To quantify the benefits that could be realised from such an arrangement, it has been assumed that the average electricity bill is £592 (based on 2014 data) and an estimated customer saving of 10% has been applied, based on the fact that their increased buying power will facilitate a reduction in electricity prices from a supplier. Based on the fact that there are, on average, approximately 36 customers per substation, the benefit of applying this at a substation level have been calculated. Projecting forward the number of potential communities who will become involved in such schemes (growing non-linearly from 10 in 2020 to 20,000 by 2050), **the net present value of the benefit can be calculated to be £177m.**

It is important to note that the **benefits from Method 2 flow directly to customers**, and there is no direct benefit to the DNO. There may be secondary benefits as customers may make use of their increased visibility of their collective demands to make decisions regarding their loads and attempt to reduce them to both save money and avoid network upgrades, but any such benefit is excluded from the figure above.

Method 3 addresses the open and flexible nature of the platform, demonstrating the way in which third party developers can offer solutions and services via Apps. The Project will trial a small number of these to demonstrate the extensibility and highlight the removal of barriers for a range of services to both the DNO and to customers.

The level of benefit associated with Method 3 will, in effect, become the enduring benefit of the LV-CAP™ platform as a range of offerings can be provided and the possibilities for these offerings is almost boundless. In order to provide a conservative view of what these benefits could be, we return to our Transform Model analysis from Method 1 which identified the number of LV feeders requiring reinforcement between today and 2050. As we do not know which of the government's LCT uptake scenarios that we have tested will manifest itself, we have taken the average number of feeders requiring reinforcement from macros the highest and lowest cases.

By doing this, and further assuming that the feeders are co-located, such that a minimum number of LV-CAP™ devices are installed, we can identify potential benefits to offering solutions to the DNO to assist in managing the demand on the network.

We have assumed that the cost of deploying bespoke solutions at a substation level is £[redacted] per solution, while the target cost of the LV-CAP™ platform is £[redacted].There is a further cost per App deployed onto the platform, which we have assumed to be £[redacted]. The average case shows that by 2050, just under 400,000 LV feeders require some reinforcement (once those already accounted for in Method 1 have been subtracted). Assuming these feeders are co-located, we divide this by the average number of feeders per substation (3.3) to ascertain that 119,000 LV-CAP™ platforms could be deployed to tackle these constraints, instead of deploying bespoke hardware at the 119,000 substations.

If we then assume that only a single app is required (i.e. all of the problems to be resolved are of the same nature) then **a benefit of £298m in NPV terms is calculated by 2050**.

If instead a range of different problems can be resolved by deploying multiple apps onto the LV-CAP[TM] platform then the benefit increases (as this replaces greater amounts of different hardware solutions) such that **if three apps were deployed per substation, the benefits are more than trebled to £927m in NPV terms to 2050**.

Hence using our conservative estimates, the benefits of the Project are as follows:

- Method 1: £120m
- Method 2: £177m
- Method 3: £298m
- **Total benefit: £595m**

3.3 Environmental benefits

The use of the Uplift solution in Method 1 facilitates uptake of LCTs by removing the need for reinforcement of between 16,000 – 241,000 LV circuits, which can instead be actively managed through the Uplift system. This has been calculated to provide a saving of 117,600 tCO_2 over the period to 2050. Additionally, the use of the LV-CAP[TM] platform will also facilitate the adoption of a range of other techniques to mitigate the need for network reinforcement (to be trialled through Method 3). Examining the number of LV circuits anticipated to require some intervention over the period to 2050, it has been calculated that there is a saving of approximately 2,892,901 tCO_2 available in avoiding conventional reinforcement through installation of cable.

Furthermore, the use of LV-CAP[TM] also promotes the opportunities for communities to become more engaged with the DNO and to assist them in their requests to become smarter, lower carbon micro-grids or offer them the opportunity to use collective purchasing power to gain a better deal on their electricity supply. Estimates have shown this could provide a carbon saving of 31,410 tCO_2 over the period to 2050 (see Appendix A for details).

Over the past two years, WPD has carried out extensive engagement exercises with community groups looking to manage their own carbon impact through the use of community generation, and potentially storage. A total of 528 such groups have met with WPD in the last year at a range of events. Increasingly, rather than solely focusing on being able to connect low carbon generation, these groups are interested in how they can contribute to the low carbon economy of the future and assist in reducing network costs.

For example, the use of variable tariffs to incentivise the consumption of electricity at times when local solar output is high can reduce reverse power flow issues and minimise electrical losses by co-locating the generation and demand. There is also the desire to investigate non-traditional business models (NTBMs) whereby local community groups could engage in energy trading and sell their generation export to, for example, nearby businesses, who could again benefit through reduced costs and electrical losses as opposed to drawing supply through the network.

The use of the LV-CAP[TM] approach can enable communities to more quickly identify the viability of using NTBMs or other innovative approaches. Historically, WPD has offered these groups a 1:1 meeting with an engineer to discuss connection options, and the time taken to host and attend these meetings could be significantly reduced if the data was already available to community groups pertaining to their own demand and generation output. This could accelerate the adoption of innovative low carbon approaches within the community, leading to carbon savings and improved air quality.

3.4 Value for money

In order to ensure that projects were identified that delivered the best value for money in solving the network issues faced by WPD, an extensive consultative exercise was undertaken.

WPD identified network challenges where a NIC bid would be considered. They opened this up competitively to all stakeholders on how their potential solutions could address these challenges. Having undertaken a thorough review of these concepts, WPD selected two that offered the best value to customers in providing solutions to the challenges; one of these was **OpenLV**.

By adopting this approach, WPD ensured that the net was cast sufficiently wide to capture a range of thinking from a range of existing/new partners and hence pursue the best ideas from a large selection of responses. Having established the best responses, and the approximate costs for these projects at an early stage, the proposals have then been refined and potential suppliers to the project identified.

In order to achieve this within the **OpenLV** project, EA Technology engaged with a range of potential suppliers via an RfI process using both the ENA portal and via social media to seek interest in supporting one of several roles within the project. The response to this was extremely positive with a number of respondents for each project role, enabling the approximate costs to be identified for each task and informing the specifics of each role to be better defined. The contract award for the majority of these areas will be conducted within the project via a competitive process with a well-defined scope following the RfI process.

Certain key project supporters have been identified at this stage rather than within the project as they offer key strategic input to the project success. These include the organisations that have been responsible to date for the development of the LV-CAP™ platform. This minimises the risk associated with the project and provides a degree of continuity in the process that has seen the platform develop within a laboratory environment to its successful roll out on the distribution network.

The project builds on the learning derived from a jointly funded InnovateUK project to develop the platform, which took the technology from TRL1 to TRL4.

It is now appropriate to further deploy the platform in a real substation environment and explore its additional functionality through the deployment of a variety of Apps. This is an innovative activity as it involves trialling an approach that has not previously been used and has the potential to deliver significant benefits to a range of stakeholders (including customers and researchers). It is therefore appropriate that this project be funded through the NIC mechanism.

3.5 OpenLV business case

In future, there will be considerable benefit associated with having a more open and flexible way to facilitate access to the LV network both for research purposes, but more crucially, for various parties to be able to provide services to customers and network operators. If each individual potential solution provider required proprietary hardware to be installed, then this would become unmanageable from a network operator perspective and also uneconomic.

Instead, the ability to deploy a single, low cost, open solution into substations that then acts as a platform that the wider market can access to offer solutions to (in the form of software Apps) then this will provide far greater value. It will allow network operators to access the best solutions from a wide range of providers without being tied in to individual companies owing to the bespoke nature of the equipment used. It will therefore facilitate competition in this sector and will also allow customers access to a wider range of services. This could include ways in which they can obtain information regarding their local network (amount of electricity being generated by their community versus amount consumed, for example) in real time. It could also act as an enabling technology towards customers becoming engaged in energy balancing and trading through having this increased visibility and the appropriate Apps to allow them to participate.

All of the above should contribute to customers being more engaged, while also being able to benefit from savings to their bill. These savings could come directly through having more control and influence on their energy consumption needs with respect to local conditions such as generation or energy storage availability, and indirectly through the network operator being able to deploy solutions in software at low cost, making savings against the alternative of individual hardware deployments that are passed on to customers.

3.6 Impact on DNO business plans and future price control reviews

The adoption of the **OpenLV** approach is entirely in keeping with WPD’s wider strategy regarding the smart grid.

It endeavours to provide a solution which is not complex, easy to replicate across the entire network and is incremental in nature. In other words, it can be applied as part of a wide-scale roll-out but the benefits can be realised from the first installation, rather than requiring full coverage of a network.

It can also be updated and improved (through the remote addition of new Apps) as and when required, meaning that further marginal benefits can be realised throughout the lifetime of the LV-CAP™ deployment.

It is also worth noting that the approach of using the LV-CAP™ platform facilitates further customer engagement (as will be demonstrated through Method 2) and is fully cognisant of the fact that when engaging with customers there is not necessarily a ‘one-size-fits-all’ approach that can be taken. The ability to utilise different Apps for different situations and different customers is aligned to WPD’s philosophy regarding customer engagement.

Section 4: Benefits, timeliness, and partners

4.1 Criterion (a): Accelerates the development of a low carbon energy sector and/or delivers environmental benefits whilst having the potential to deliver net financial benefits to future and/or existing Customers

The Carbon Plan aims to deliver carbon emission cuts of 34% on 1990 levels by 2020. This national target is devolved, in part, through local government carbon emission reduction targets as set out in their strategy planning documents. The Carbon Plan sets out ways to generate 30% of the UK's electricity from renewable sources by 2020 in order to meet the legally binding European Union (EU) target to source 15% of the UK's energy from renewable sources by 2020.

The Low Carbon Plan states that the sector accounts for 27% of UK total emissions by source. By 2050, emissions from the power sector need to be close to zero. These targets are especially challenging given that the potential electrification of heating, transport and industrial processes, average electricity demand may rise by between 30% and 60%.

The UK Government has identified the adoption of electric vehicles and heat pumps as key aspects when meeting the UK's carbon emission reduction targets. **OpenLV** supports the uptake of LCTs by enhancing visibility of LV network and therefore facilitating effective network management.

The overall Solution provided by the proposed Methods will facilitate the Carbon Plan as follows:

- **Low Carbon Heating & Transport:** The decarbonisation of heat and transport through the wide scale consumer adoption of heat pumps and electric vehicles will increase demand on LV networks. Under current business practice this would result in a large amount of conventional LV reinforcement, at significant cost and disruption to customers, to accommodate this increase in demand. The deployment of new innovative techniques in Method 1 will facilitate the uptake of low carbon heat and transport by increasing the capacity of existing assets and enabling active management of the LV network. This will facilitate the adoption of LCTs by Customer's;
- **Low Carbon Electricity:** Community Engagement and **OpenLV** Extensibility (Methods 2 and 3) will increase visibility for customers and third party providers of local LV network performance. Through the use of local technologies such as renewable generation and storage it will be possible for community groups to maximise the potential of these assets whilst minimising the impact on the LV network. The use of local low carbon generation, balanced with local demand, coupled with a reduction in network losses arising from less power being drawn through the grid results in lower carbon electricity for customers.

The roll out of the overall Solution proposed within the **OpenLV** bid across GB would **support the Low Carbon Plan and uptake scenarios presented in the Fifth Carbon Budget Report**, ratified by HM Govt. on 30th June 2016, by minimising the impacts of low carbon, heating and transport on the LV network. This has the potential to deliver environmental benefits and cost savings to future and existing customers by negating and/or deferring the need to reinforce the LV network.

In addition, **the Methods will facilitate the development of the low carbon energy sector**, in line with criterion (a) by engaging with communities and technology providers to facilitate access to the data required to stimulate the market to develop Apps that will improve understanding and the performance of the LV network.

The Future Power Systems Architecture (FPSA), commissioned by DECC and published by the IET in July 2016, outlines four core evolutionary pathways for power sector evolution over the next 15-20 years[3]. Two of these pathways are:

- **Community Empowerment:** the power sector expands its facilitation role, empowering smart cities and energy communities with local markets and peer-to-peer trading; and
- **Customer Empowerment:** the power sector becomes a facilitator empowering the emergence of new commercial parties, new business models, and new services.

Methods 2 and 3 align directly to the above pathways. **OpenLV** will provide a technological Solution that will enable the goals of these pathways to be realised.

The roll-out of the proposed Methods has **significant potential to facilitate the uptake of LCTs across GB**. The Methods could provide new solutions that have not been identified yet, for DNOs to overcome the barriers to delivering the Carbon Plan.

As described in Section 3, the **total financial benefit** of **OpenLV** is **£595 million**. This is made up as follows and shown in Figure 6:

- The financial benefit of the Capacity Uplift Method is **£120 million**;
- The financial benefit of the Community Engagement Method is **£177 million**; and
- The financial benefit of the **OpenLV** Extensibility Method is **£298 million**.

Further details of the financial benefits of **OpenLV** (including a breakdown of the Base Case Costs and Method Costs) are provided in Appendix A.

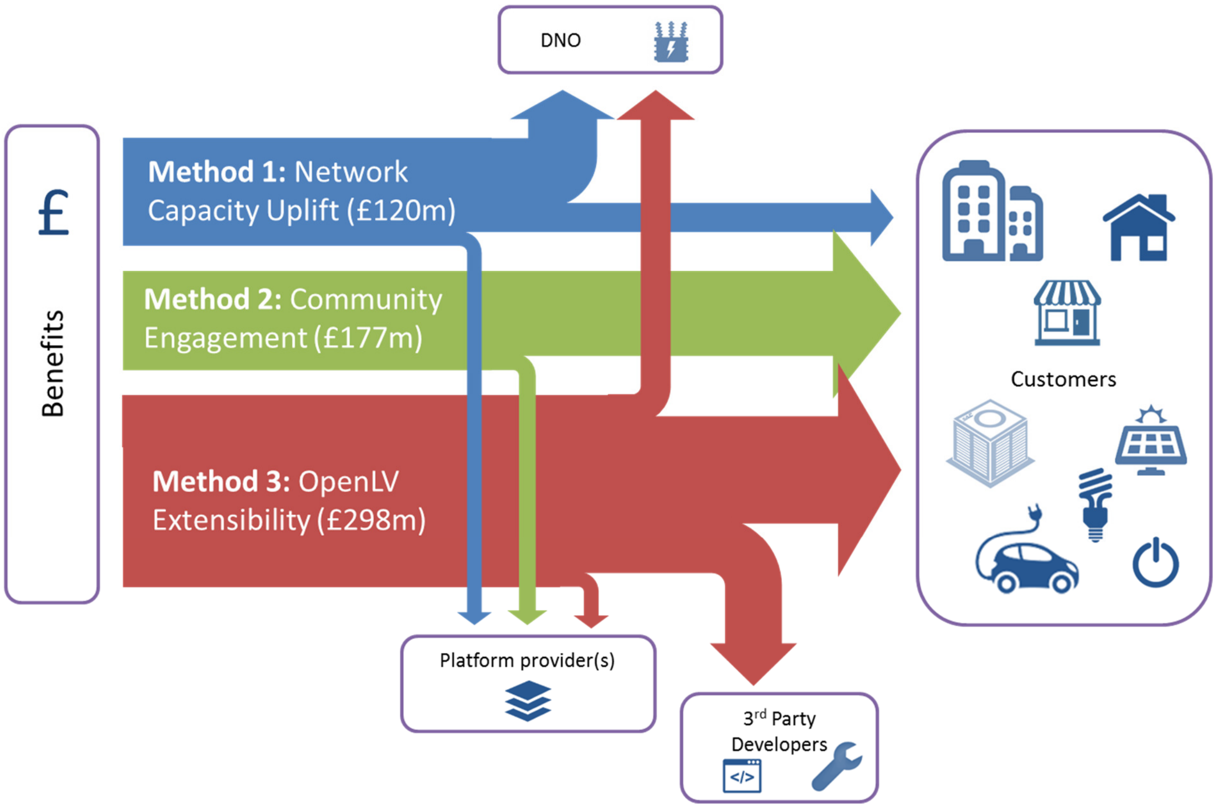

Figure 6: Delivering Financial Benefits to Customers

[3] https://es.catapult.org.uk/wp-content/uploads/2015/12/FPSA-Main-Report-130716-secured.pdf

Table 1 outlines how **OpenLV** will deliver benefits to customers:

- **Via the DNO** through lower reinforcement costs (reducing DUoS), improved connection in terms of speed & cost to connect and improved network performance (Method 1);
- **Directly to customers** through provision of data from the DNO to customers and community groups for their own purposes (Method 2); and
- **Through the platform and 3rd party developers** through cost savings made by DNOs by rolling out a single device that can support multiple Apps.

Once fully deployed, the roll-out of the Methods across GB could unlock **5827MW** of capacity to support the electrification of heat and transport (Table 1). Further information on capacity release is provided in Appendix A.

Table 1: Capacity Release across GB

Capacity Increase (MW)	2020	2030	2040	2050
Method 1 (Capacity uplift)	0	0	156	538
Method 2 (Community Engagement)	0	0	0	0
Method 3 (OpenLV Extensibility)	54	2,381	4,063	5,290
Total	54	2,381	4,218	5,827

At present, accommodating an increase in load due to the electrification of heat and transport would require the reinforcement of LV network(s) via the installation of new cables and transformers. The works involved in this reinforcement are expensive, time consuming and disruptive for customers due to jointing works, supply interruptions and civil street works. **The technologies proposed in Method 1 will release additional capacity from existing assets and enable the DNO to actively manage the existing assets rather than install new infrastructure.** This technology could be deployed in significantly shorter timescales at much lower cost with no disruption to customers. The deployment timescales for Method 1 would be in the order of weeks, in comparison to a number of months for traditional methods of reinforcement.

The GB rollout scale carbon benefits are provided in Table 2. Further information on the carbon benefits is provided in Appendix A.

Table 2: GB rollout scale carbon benefits

Benefit (t CO2)	2020	2030	2040	2050
Method 1 (Capacity uplift)	0	3,285	34,038	117,600
Method 2 (Community Engagement)	16	1,571	15,705	31,410
Method 3 (OpenLV Extensibility)	29,716	1,302,339	2,221,743	2,892,901
Total	**29,732**	**1,307,195**	**2,271,486**	**3,041,911**

4.2 Criterion: (b) Provides value for money to gas / electricity distribution / transmission Customers

Since the outset of the LCN Fund and now the NIC, WPD has been and is a key player in the UK innovation development for DNO's. WPD have successfully completed four LCN Fund Tier-2 projects: LV Network Templates; Sola Bristol; Lincolnshire Low Carbon Hub; and Falcon. And have two current on-going Tier 2 projects: FlexDgrid; and Equilibrium.

WPD has a proven track record in turning Innovation into Business as Usual. This is demonstrated by the following, which have already been rolled out across the business:

1. "Policy Relating to Revision of Overhead Line Ratings" – including the introduction of rating based on real-time weather data and a policy for applying it to other 132kV OHLs;
2. "Policy Relating to the Retro-Fitting of Monitoring Equipment in Live LV Cabinets" – A policy for how and when to fit monitoring equipment to LV cabinets, increasing the visibility of the LV network where new LCT are installed;
3. "Policy Relating to Automation Scheme Communication Design" – A policy outlining the communications solutions being deployed by WPD, supporting smart grids;
4. "Policy for Specification, Operation, Control and Maintenance of DStatcom" – A policy outlining how a Statcom is used in an existing distribution network;
5. "Policy for Alternative Connections including Timed, Soft intertrip and ANM" – A policy outlining how alternative connections are offered to DG customers;

These demonstrate how previous investments through innovation are leading to business change.

In addition, this project will **build on the learning provided from previous LCN Fund projects** to ensure value for money is provided to electricity distribution customers. This project will be led by EA Technology and supported by WPD.

This project will adopt and utilise the existing commercial agreements that have been provided by the My Electric Avenue project. This was the first LCN Fund Tier 2 project that was not led by a DNO.

EA Technology has demonstrated via My Electric Avenue competence in delivery of complex project of this nature and providing added value. EA Technology has taken the initiative to lead the development of national standards and establish key industry working groups (such as the EV-Network Group) to solve multi-stakeholder issues, for the benefit of UK plc.

The NIC funding request for the ***OpenLV*** project is £4.855m and the total benefits of rolling out all 3 Methods across GB is estimated to be £595 million. **This provides a GB net benefit to funding request ratio of 123:1.**

Table 3: GB Net Benefit to Funding Request Ratio Comparison

Project	GB Net Benefit (£m)	NIC Funding Request (£m)	Benefit: Funding Request Ratio
CELSIUS	583	4.744	123:1
FALCON	659	12.339	53:1
Network Equilibrium	1,500	11.48	131:1
Smart Street (eta)	692	8.438	82:1

The same level of learning could not be delivered at a lower cost because scaled trials are essential to advance the Technology Readiness Level (TRL) of the overall **OpenLV** Solution from testing in a laboratory environment (TRL4) to the system being demonstrated in an operational environment (TRL8).

The Project costs reflect our best estimate of the Project costs including contingency. Each Method has been developed at a scale which is essential to ensure it will deliver the required learning. This learning will be captured and disseminated in such a way that other DNOs can adopt these Methods quickly and effectively.

The Network Capacity Uplift Method is at an appropriate scale to enable the **OpenLV** solution to be tested at scale and attain credible results**. A lower level of funding would reduce the number of networks that could be targeted and reduce the amount of data collected and analysed as part of the trials.** Ultimately this would lead to less reliable information and may impede adoption as part of BaU. EA Technology has limited the number of devices that will be installed as part of the trials for Method 1 to ensure that costs are minimised whilst still achieving the required learning.

At the current time the potential market for the Community Engagement and **OpenLV** Extensibility Methods has not been established. However, a number of organisations have come forward to support these Methods as part of the RfI and bid development process (See Appendix F).

EA Technology has developed this bid with the support of WPD utilising an existing collaboration agreement. During this time, EA Technology has identified the requirement for several suppliers to support the delivery of this project. These support roles are listed in Appendix N.

During the preparation of the Full Submission Pro-forma, EA Technology has distributed Requests for Information (RfIs) to suppliers listed below. This demonstrates an open and competitive procurement process.

- Hardware provider to supply the hardware for the intelligent substation devices;
- Specialist support to assess the network security for the proposed systems architecture for the overall **OpenLV** solution;
- Specialist support services to support Method 2: Community Engagement; and
- Specialist support services to ensure project learning is captured and disseminated effectively.

The RfI responses have been used to identify potential companies that will be invited to tender for supplying equipment or providing services. In addition to this:

- EA Technology has followed the standard guidelines that WPD has to follow as a utility. WPD is governed by the EU Directives and in particular the Utilities Contract Regulations 2006 (UCR). Any procurement requirement over the current EU threshold value needs to be tendered in line with these regulations. This is standard for all NIC Fund projects;
- EA Technology has followed the negotiated procedure (in line with WPD procurement principles), which allows for negotiation to take place with potential suppliers during the tender process, and ensures that the best value for money is achieved at all times. EA Technology always aims to award a contract that provides the "Most Economically Advantageous Tender", to ensure performance of the product as well as the best price;
- EA Technology has also utilised the ENA database and web portal for publicising Requests for Information (RfIs) and Invitations to Tender (ITTs). These routes into the DNO marketplace are proven paths for SMEs, like EA Technology (50% of the current suppliers into the LCN Fund are SMEs); and

- EA Technology has also utilised social media (LinkedIn) to publicise the project and advertise the RfI process for the **OpenLV** project.

All the required services and equipment are available from multiple sources, making competitive selection the most appropriate route for this Project. If successful, following award, services will be procured through competitive tender for a value of approximately £1 million to ensure best value.

EA Technology has provided the number of person days and day rates for labour in the Full Submission Spreadsheet. The following key points show that a robust methodology has been employed to estimate costs:

- Costs (as provided in Appendix B) have been calculated using a bottom up and top down methodology;
- Estimates from multiple potential suppliers have been received for each RfI which has enabled EA Technology to validate cost estimates;
- The methodology employed to estimate overall projects has drawn on the significant experience of both WPD and EA Technology from other innovation projects; and
- Potential project suppliers have provided budgetary estimates of the equipment and associated services.

Table 4 provides a breakdown of the costs for each project phase. Further tables that help demonstrate how the **OpenLV** Project will meet this criterion are provided in Appendix O.

Table 4: Total costs for each project phase

Costs (£k)	Phase 1 Mobilise & Procure	Phase 2 Design & Build	Phase 3 Trial, Consolidate & Share	Sub-Total
Labour	£13.80	£181.20	£72.40	£267.30
Equipment	£0.00	£813.60	£40.00	£853.60
Contractors	£512.60	£2,437.40	£1,287.60	£4,237.60
IT	£0.00	£0.00	£2.50	£2.50
Travel & Expenses	£0.00	£21.30	£8.40	£29.70
Contingency	£55.90	£275.60	£120.00	£451.50
Decommission	£0.00	£0.00	£66.00	£66.00
Total (£k)	**£582.30**	**£3,729.10**	**£1,596.90**	**£5,908.30**

Table 5 outlines the cumulative benefits of **OpenLV** in discounted NPV terms.

Table 5: Cumulative benefits in discounted NPV terms

Benefits (£m)	2020	2030	2040	2050
Method 1 (Capacity uplift)	£0.00	£0.00	£37.56	£119.85
Method 2 (Community Engagement)	£0.02	£4.37	£59.39	£177.18
Method 3 (OpenLV Extensibility)	£4.91	£164.10	£250.37	£298.30
Total (£m)	**£4.93**	**£168.47**	**£347.32**	**£595.33**

4.3 Criterion: (d) Is innovative (i.e. not business as usual) and has an unproven business case where the innovation risk warrants a limited Development or Demonstration Project to demonstrate its effectiveness

No other LCN Fund or NIC project has demonstrated an open, flexible platform that could ultimately be deployed to every LV substation in the UK.

The technologies that will be deployed as part of the Solution are innovative. Method 1 is using a highly distributed, low cost architecture to enable decentralised control of the LV network. The project is targeting the use of a <£1k platform, which will be issuing commands to network actuators. Ensuring this operates safely, securely and in line with performance characteristics is non-trivial, and usually reserved for much more costly £10k+ Remote Terminal Units (RTUs) that are common in higher voltage Primary and Grid substations.

Real time thermal rating and meshing will be used as technical use cases for this Method. We have selected these use cases because the technical risk is well known and the resulting benefits are readily identified. Whilst both have been demonstrated on higher voltages, or in isolation on LV networks before, they have never been controlled by an architecture like LV-CAP. Hence the need for NIC funding to prove this as a technique.

Methods 2 and 3 represent completely new value streams to a wide array of solution providers/customers that do not have any precedent in the existing marketplace.

As a result, there is no available supporting data on which to build a case to adopt these methods for Business as Usual without significant commercial risk.

Given the significant potential benefits to all electricity customers, we do not believe it is appropriate that all of the necessary investment costs should be borne by a single licensee. The support of NIC is sought to enable the project to proceed, enabling all three Methods to be adopted as business as usual in every GB DNO.

4.4 Criterion: (e) Involvement of other partners and external funding

WPD's website www.westernpowerinnovation.co.uk sets out the work being delivered through the LCN Fund/NIC and provides contact details. Further to the information submitted in the ISP, EA Technology has distributed separate "Requests for Information" (RfIs) for specialist services. Each RfI was posted on the ENA Web Portal and on social media to seek expressions of interest.

The RfI responses have been received and used to shape the **OpenLV** Full Submission Pro-forma. Project suppliers will be selected through a competitive process, in line with WPD purchasing procedures and EU regulations.

WPD followed the now-established process for selecting ideas for ISP. This year, two potential projects were identified as worthy of consideration and evaluation from a list of over 30 submissions. WPD's evaluation process tests:

- The quality of the idea;
- How well developed the idea is;
- The quality of the documentation/research;
- The value the Solution may deliver;
- The appropriateness for NIC (particularly the scale of the project);
- How likely it is that the Solution would become a normal business solution (for example, ease of implementation and need for legal or regulatory changes);
- Project risk; and
- Timeliness.

In 2016, two projects were developed from concepts identified from third party organisations and both projects were successful at ISP stage: 1) **OpenLV** and 2) Proteus. **OpenLV** was selected after careful evaluation and challenge by WPD Senior Management.

Between the Initial Screening Process and completion of the Full Submission Pro-forma, EA Technology distributed a Request for Information (RfI) to service providers and equipment suppliers across the electricity industry. The RfI contained a specific section, which invited suppliers to outline any offers of contributing to the Project. On the basis of the RfI responses, EA Technology did not receive any offers of External Funding.

External funding will be sought to develop Apps for Methods 2 and 3. Therefore the value of the project is expected to rise over its duration.

As set out in Section 4.2, EA Technology will select Project suppliers in line with a competitive tender process for relevant services in line with WPD's procurement principles. The scope of each service is detailed in Appendix N.

4.5 Criterion: (f) Relevance and timing

The electricity sector faces unprecedented challenges to meet the targets set in the Low Carbon Plan. The targets set are complicated by the following:

- Ageing infrastructure and assets that were not designed to support the wide scale adoption of LCTs on the distribution network. Unless smarter network solutions are deployed to accommodate LCTs, existing networks will require large scale, expensive, disruptive and time consuming conventional reinforcement to increase capacity to meet increased customer demand;
- Uncertainty regarding the scale of the adoption of LCTs; and
- Uncertainty regarding where customers will adopt LCTs and what impacts clustering will have on the distribution network.

The above challenges mean that new technology solutions are required to release additional capacity that are applicable across the distribution network within GB. The **OpenLV** solution will enable DNOs and other organisations to gain visibility of the loading on the LV network. This will enable additional capacity to be released from existing assets and facilitate non-traditional business models therefore helping the electricity network meet the challenges it faces.

The Low Carbon Plan outlines that by 2030, up to around a half of the heat used in our buildings may come from low carbon technologies such as air or ground source heat pumps. Electric or hydrogen fuel cell cars are critical to helping reduce vehicle emissions to less than half today's levels.

Total registrations for electric vehicles in 2015 alone are higher than the previous 5-year period combined (https://www.goultralow.com/electric-car-registrations-record-high/) and rapid increases in the non-gasoline field as we move towards the zero new gasoline car sales targeted from 2040. Understanding and visibility of the LV network at this time of considerable change is paramount. Additionally, the network capacity uplift that will be provided by the successful implementation of Method 1 is both relevant and timely.

The Governments "Smart Power - National Infrastructure Report, March 2016" (https://www.gov.uk/government/publications/smart-power-a-national-infrastructure-commission-report) provides the following recommendation:

"Recommendation 5: Enabling the transition to more actively managed local networks should be a government priority. By Spring 2017 DECC and Ofgem should consult and set out how and under what timeframe this transition should best take place"

The Methods provided by OpenLV along with the open and extensible nature of the overall solution will enable practical, cost effective and flexible deployment of active management of local distribution networks and is therefore in line with government policy.

EA Technology has a track record of helping DNOs taking the technologies trialled as part of innovation projects and transitioning them to a BaU environment. Looking to the future, in this digital age, analysis of data at distribution substations will provide benefits to both the DNO and connected customers. Therefore, the **OpenLV** Solution is applicable to future business plans regardless of the uptake of LCTs.

The potential uses of the proposed distributed intelligent device are only limited by the imagination of those who are able to access and use the data. Expanding access to this data and providing an open platform for innovative applications increases and accelerates the likelihood of new novel non-traditional business ideas relating to the distribution of electricity.

WPD also has a track record of taking projects to TRL 8 and deploying them into BaU. The **OpenLV** project is envisaged to be the same. The Methods will reduce the need for network reinforcement; this will be reflected in the business plan in terms of reduced requirements for conventional asset investment and will contribute to the savings in WPD's Innovation Strategy. WPD's Innovation Strategy is already delivering new ways of working and improved efficiency (see approach in Figure 7).

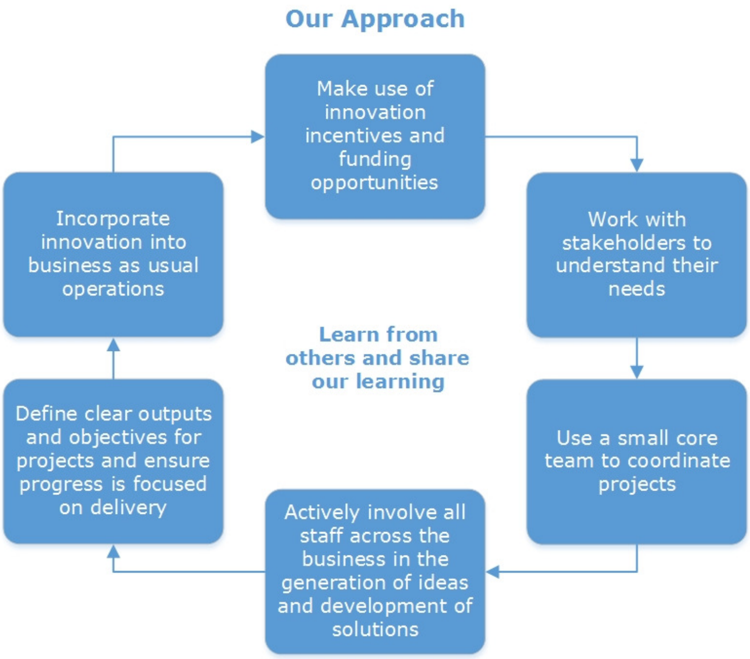

Figure 7: WPD Approach to Innovation

The RIIO-ED1 Period, 2015 – 2023, will bring many new challenges including the facilitation of new low carbon technologies. In the WPD business plan it states that:

- "We will submit proposals for the Network Innovation Competition leading to a total investment of £100m"; and
- "Innovation in smart solutions will help us accommodate LCT's without the need for high levels of conventional reinforcement".

The **OpenLV** project, run by EA Technology in full and supported by WPD is one of the NIC proposals for 2016, and if successful, will provide the detailed visibility of the LV network to enable targeted Low Carbon connections and to maximise the presumed additional capacity available from existing assets. In addition to this, the data visualisation platform will be available to 3rd parties, including community groups, academics, universities, schools and commercial organisations, to develop personalised applications that will enable them to maximise the benefits for their own needs.

For example, a community group that is considering an aggregated storage consortium can use the real data from their LV network to target the best times for charging / discharging their storage solution.

Likewise, a commercial enterprise looking to target an area for EV installations can use the platform to understand the local area constraints that may or may not be present. For example, providing LV transformer capacity and the associated demand profile.

As outlined in the WPD business plan, WPD will use information from more advanced monitoring of the network and data from smart meters to identify where LCT hotspots are emerging so that reinforcement work can be targeted to areas of the network where it is required.

Using EA Technology's Transform Model, WPD have developed a "Best view scenario" This work has derived the likely volume of LCT's and provided a more detailed view of the way LCT's will group together (cluster) on the network and the impact this will have on investment.

The **OpenLV** project can build on this and target the identified areas for more detailed monitoring, to fully understand how the uptake of LCTs in such an area is developing and its effect on the network. This combined with learning from the recently registered NIA project, "Car Connect", which is looking at the behavioural traits of EV car owners, should provide a really useful insight for the DNO industry, EV customers and commercial hardware providers.

If **OpenLV** proves to be cost effective at releasing additional capacity from existing assets and the open nature of the overall solution proves successful it can be reasonably expected to form part of the business plans of other GBs DNO when considering capacity constraints in their LV networks.

Section 5: Knowledge dissemination

This project conforms with the default IPR requirements as set out in the Network Innovation Competition Governance Document v2.

5.1 Learning generated

5.1.1 Demonstrating that significant new learning will be developed

This Project will deliver significant new learning, which is required before the open systems architecture trialled as part of this project can be safely and effectively rolled out by DNOs in their BaU processes. Appendix I provides the details of what EA Technology has learnt from other LCN Fund projects and how this has informed the development of **OpenLV**. The additional learning that **OpenLV** will deliver is provided below.

5.1.2 Outline of incremental learning

In terms of the overall **OpenLV** solution new knowledge will be generated in the following areas:

- How the Apps on the distributed devices can be managed and remotely deployed from the Application Deployment Server;
- How easy it is for 3rd party organisations to develop new Apps and what changes need to be made to guidelines provided to 3rd party organisations;
- How secure the overall ***OpenLV*** solution is and what changes need to be made for BaU rollout;
- Provide a Cost Benefit Analysis to identify the potential value of deployment of the solutions trialled within WPD's licence areas and across GB for all Methods based on the trial results;
- How the data from the LV network could be used by 3rd party organisations (Methods 2 and 3); and
- A final specification for the overall ***OpenLV*** Solution to enable rollout to BaU.

Method 1: **Network Capacity Uplift** will generate new knowledge in the following areas:

- Test and assess the potential of a new RTTR algorithm that has been developed by Manchester University, specifically for HV/LV transformers, to release additional capacity from existing network assets;
- Identify if and how much additional capacity can be released from existing network assets when RTTR of the transformer is combined with the capability to mesh the LV network. Whilst both approaches have been trialled in isolation the approaches have not been trialled in conjunction, therefore generating new learning;
- Assess how the LV network could be managed using distributed intelligent devices installed on the LV network with no requirement for a Control Engineer to confirm the actions taken by the intelligent devices;
- For the first time test how an open systems architecture that enables 3rd parties to develop innovative algorithms and applications can benefit the wider industry; and
- Generate learning that can be utilised to update the relevant standards for monitoring data, interfaces between systems, network security and communications.

Method 2: The **Community Engagement** will generate new knowledge as follows:

- Exploiting the market potential that the open nature of the proposed solution can provide to facilitate community energy schemes;
- Promote non-traditional business models and services at a social, community and local level;
- Remove some of the barriers faced by community groups from supplying the power they generate in their local area;

- Gain further insight into the potential benefits and risks to all consumers associated with: local supply, local balancing, distributed generation demand response and smart grids;
- Enhance the quality of data available to community engagement schemes and provide information on available network capacity to local communities;
- Enable new learning to be developed to aid understanding of how diversity and innovation can be promoted to foster the energy system revolution; and
- Provide the learning required to identify the wider Consumer benefits of community engagement including: social, economic and educational factors.

Method 3: **OpenLV Extensibility** will generate new knowledge in the following areas:

- Exploiting the market potential that the open nature of the proposed solution can provide to academics and companies (including non-energy companies);
- Gain further insight into the potential benefits of providing the wider industry with LV network data, for example, whether this promotes innovation; and
- Remove some of the barriers that hinder innovation and promote non-traditional business models and services by enabling third parties to develop and deploy innovative algorithms and/or applications on distributed intelligent devices.

5.1.3 Applicability of new learning to other DNOs

Each Method, deployed by itself, will provide valuable learning for other DNOs. When all three **OpenLV** Methods are combined with the 'open standards' principles of the overall Solution, considerable learning will be generated that will be applicable to all DNOs as the Solution will be able to be deployed in all LV substations.

5.2 Learning dissemination

Figure 8 shows the overarching strategy to achieve the learning objectives of **OpenLV**. Learning will be recorded in a log for ease of reference and will include analysis on whether there is an impact on DNO strategy or policies.

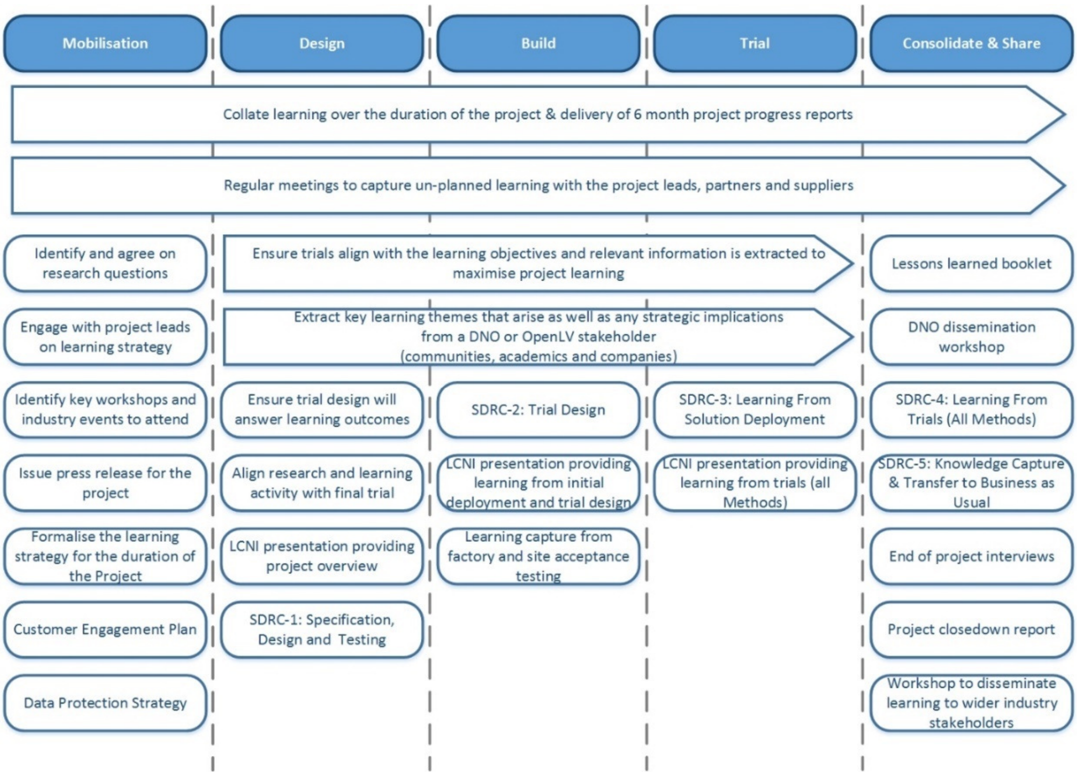

Figure 8: Learning Strategy for OpenLV

Knowledge capture is a fundamental element of the Project and requires a robust methodology and plan for delivery. In order to achieve this, EA Technology will use the proven approach for knowledge capture and dissemination developed and utilised on other WPD LCN Fund and NIC projects. Due to the nature of the project, new knowledge will be produced that relates to various stakeholders. A stakeholder map will be produced, which will then be mapped onto the overall project plan so that knowledge can be disseminated in a timely manner. Knowledge will generally be of two forms: planned and unplanned. The approaches for capturing these types of learning, along with the knowledge capture methodology, are detailed in Appendix P.

5.3 IPR

Table 6 outlines the details of the Background IP that will be brought to the **OpenLV** project and the Foreground IP that either will or could be generated on the project.

Table 6: IP Summary

#	Description	Detail of IP	IP Type	IP Created by	IP Assignment
IP001	Core LV-CAP™ system	Comprising the operating system image including Internal API, 3rd Party Developer API (v1.0) and the following containers: MQTT, Data Storage, Sensor Reads, Container Manager.	Background	EA Technology & Nortech	EA Technology[4]
IP002	LV-CAP™ Comms. Container (Method 1)	Comprising of the Nortech iHost comms. container	Background	Nortech	Nortech
IP003	iHost (Application Deployment Server Method 1)	Pre-Existing iHost platform	Background	Nortech	Nortech
IP004	Container Management from iHost (Method 1)	Development of iHost capability to manage & deploy container	Background	Nortech	Nortech
IP005	Cloud Based Hosted Platform (Method 2 and 3)	Existing Lucy Electric GridKey platform	Background	Lucy Electric GridKey	Lucy Electric GridKey
IP006	LV-CAP™ Comms. Container (Methods 2 and 3)	Comprising of the Lucy Electric GridKey communication container	Background	Lucy Electric GridKey	Lucy Electric GridKey
IP007	WeatherSense™ Transformer RTTR (DTR App)	EA Technology implementation of University of Manchester algorithm	Background	EA Technology & University of Manchester	TBC
IP008	LoadSense the LV Control App for Method 1 (Network Meshing App)	Application developed on the **OpenLV** project to enable automation of LV network meshing.	Foreground	Western Power Distribution (via EA Technology)	GB DNOs
IP009	3rd Party App Containers (Methods 2 and 3)	To be defined on the project	To Be Confirmed	Dependent upon funding mechanism	App developer / funder
IP010	LV-CAP™ API v2.0	A second iteration of the API to allow third party Apps to be created on the LV-CAP™ platform following learning from Methods 2 and 3	Foreground	Western Power Distribution (via EA Technology)	GB DNOs

[4] Pre-existing commercial agreement in place between EA Technology and Nortech for this purpose

Items IP001 to IP007 represent background IP that will be utilised as part of the overall **OpenLV** Solution and all IP will remain with the relevant organisation.

Item IP008 LoadSense will be developed by EA Technology using funding from the **OpenLV** project as part of Method 1. This App will be provided free-of-charge as part of future LV-CAP™ deployments and the resulting IP assigned to GB Network Licensees.

Under item IP009 a number of 3rd party Apps will be developed under Methods 2 and 3. The IP arrangements will depend upon a number of factors, for example, the funding mechanism and whether existing algorithms or products are developed into a software App. If the **OpenLV** project is successful, then the IP ownership will be identified on a case by case basis and agreed with the relevant parties before each individual App is developed. For the avoidance of doubt, if any Foreground IP is generated through NIA or NIC, this will be handled in accordance with the Default IPR requirements of the appropriate Governance Document.

Item IP010 will build on the existing API created by EA Technology as part of the funded development activity which preceded **OpenLV**. It is envisaged that this API will be refined following feedback from developers as they use this for Methods 2 and 3. This output will be publicly available, to maximise dissemination and enable new Apps to be developed for a broad range of stakeholders for the benefit of DNOs and their customers. This IP will be assigned to GB Network Licensees.

5.3.2. Roll-out model

As the **OpenLV** infrastructure needs to be deployed in a substation, we expect the end roll-out to be led by a DNO. It is anticipated that this could be used for either monitoring purposes (such as understanding the uptake of EVs on the network), or to directly improve network performance (i.e. to manage voltage, etc.). It is anticipated that the Apps deployed, will be highly location specific, and dependent on local substation needs.

Once the substation infrastructure in place, services can also be offered to the local community group(s) at minimal additional cost.

Third party developers would be able to create new Apps ahead of deployment, strengthening the business case for DNO or community group. It is anticipated that deployment of new Apps will require rigorous management, with strong verification and control to permit certain functions.

5.3.3. Benefits flow

OpenLV is seeking to open up benefits to a wide range of stakeholders, which are as follows:

End Customers include households, small / medium businesses, etc. The benefits envisaged are:

- Negotiating power: Visibility of aggregate demand and ability to use this to strike better deals with energy suppliers;
- Market access: A platform for the provision of services to DNOs/TSOs;
- Reduced DUoS payments: resulting from improvements made by the DNO; and
- Reduced connection costs: allows the LV customer to connect new forms of generation or demand in a more flexible way.

DNO benefits envisaged are:

- Direct cost reduction: the use of a standardised single platform rather than multiple overlaying solutions; economies of scale in procurement; and
- Improved flexibility: i.e. a platform rolled out for monitoring, can later be used to control the LV network, limiting the risk of stranded assets.

3rd party developer would include anyone (from sole trader to corporate entity, amateur to academic) capable of creating an App. The benefits envisaged are:

- Direct payment: 3rd party gets paid every time their App is commercially deployed on a substation platform; and
- Reduced barriers to entry: the developer does not have the responsibility or costs to provide the enabling platform or infrastructure - only the software App.

Platform provider(s) benefits envisaged are:

- Hardware deployment: payment for every unit rolled out in a substation. NB. this is expected to be marginal due to the low target costs (end platform cost of c£ [redacted] per unit); and
- App 'store' administration: payment by third party to manage Apps; potentially also from end users to tailor Apps for substations/community groups.

The beneficiaries from the platform beyond the end of the project are shown in Figure 9.

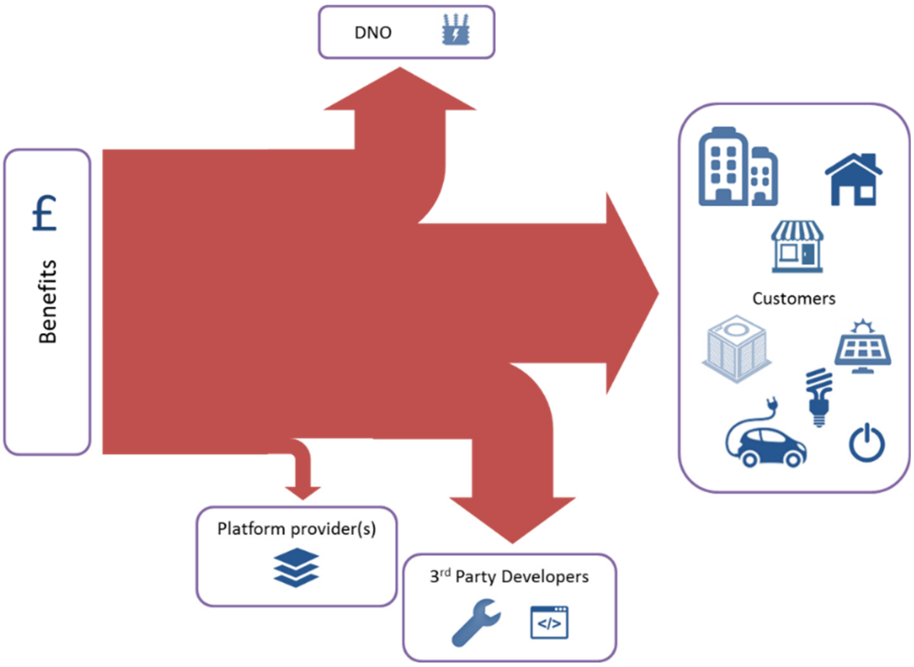

Figure 9: Benefits flow beyond the OpenLV project

5.3.4. Alignment of interests

As the platform provider of **OpenLV**, it is in EA Technology's interest for this project to succeed. This scenario will lead to widespread adoption of the platform by a wide range of innovative App developers, enabling the resulting benefits to flow to both the DNO and its customers.

EA Technology therefore has an aligned interest in making the platform as easily accessible as possible at low cost. In doing so, this will create a strong market pull that ensures long-term widespread adoption. Further information on the future potential of **OpenLV** can be found in Appendix L.

Section 6: Project Readiness

The requested level of protection against cost over-runs and unrealised direct benefits is 0%.

6.1 Evidence of why the Project can start in a timely manner

The following key focus areas provide the evidence that this Project is ready to start in January 2017:

1. Experience of Partnership Working;
2. Senior Management commitment from both WPD and EA Technology;
3. Availability of Novel Commercial Arrangements developed by the My Electric Avenue project and WPD's Governance Model;
4. Key suppliers for the provision of the overall Solution have been appointed;
5. Building on previous IFI, NIA and LCN Fund projects;
6. Streamlined procurement process and selection of project collaborators;
7. Experienced project delivery team;
8. Project logistics and the Project Plan; and
9. Initial engagement, at FSP stage, shows good market potential for Methods 2 & 3.

These elements are explained in more detail in the following sections. Sufficient time has been incorporated at the start of the project to enable the project team to be fully mobilised and to ensure that the commercial agreements for all parties can be detailed and agreed at the start of the project.

6.1.1 Experience of Partnership Working

The Novel Commercial Agreement created, tested and published by EA Technology as part of the My Electric Avenue Project has demonstrated that a third party organisation can effectively deliver innovation projects on DNO networks. This enables DNOs to realise the benefits of multiple innovation areas through the deployment of parallel projects; an approach that may be otherwise unfeasible depending on the size of the delivery team.

Through outsourcing the management and delivery of individual projects to third party suppliers, whilst retaining a high-level oversight and supporting role, DNOs can more effectively utilise available innovation funds. Learning from My Electric Avenue has shown that the expected management costs from the DNO associated with delivering My Electric Avenue was approximately 75% of the forecasts, demonstrating a greater benefit than initially anticipated. This learning has been utilised to forecast the costs associated with the **OpenLV** project providing an in-built level of cost saving.

Working in partnership, with a third party leading the project, has shown to be very successful providing a more efficient delivery mechanism. This approach that will be adopted on **OpenLV** will accelerate the deployment of both innovation and BaU projects on DNO networks.

6.1.2 Senior Management commitment from both WPD and EA Technology

Directors from both EA Technology and WPD are fully engaged with the **OpenLV** project, having been involved from project inception, and throughout the entirety of the bid process. The Boards of both organisations have been briefed on the Project, its scope and drivers.

6.1.3 Availability of Novel Commercial Arrangements developed by the My Electric Avenue project and WPD's Governance Model

EA Technology and WPD will build on the commercial learning from the My Electric Avenue project.

The Novel Commercial Agreement will be supported by a Management & Delivery document that will incorporate the principles of WPD's existing governance model. The governance model includes a Project Review Group comprising key stakeholders, including WPD's senior management. The Project Review Group will be responsible for ensuring that **OpenLV** achieves its stated Successful Delivery Reward Criteria (See Section 9). Our selected project collaborators will demonstrate their commitment to the project by appointing representatives to attend the Project Review Group.

6.1.4 Building on previous IFI, NIA and LCN Fund projects

Both EA Technology and WPD have experience of taking LCN Fund Tier-2 projects from inception to successful completion and final closedown. The valuable lessons learnt from working on other innovation projects will be fed into the **OpenLV** NIC project.

WPD is currently delivering two LCN Fund Tier 2 projects and EA Technology is currently working in collaboration with WPD and other DNOs on both LCN Fund Tier-2 and large NIA projects. The experience gained through the successful and valuable output from these projects will help to ensure that **OpenLV** starts in a timely way. A key learning point in the seamless transition from bid to delivery in both WPD and EA Technology's previous LCN Fund projects has been dovetailing the Bid Delivery team with the Project Delivery team. On this basis, the key personnel from both organisations that have developed the Full Submission Pro-forma will also be responsible for project delivery.

6.1.5 Streamlined procurement process and selecting Project collaborators

EA Technology will operate an open and competitive procurement process for the services and equipment required to deliver **OpenLV**.

During the **OpenLV** bid stage, separate Requests for Information (RfIs) have been used to identify and engage with service providers, equipment suppliers and other potential Project collaborators. This has given us the confidence to delay the selection of service providers, equipment suppliers and other potential Project collaborators until the funding decision has been announced. Key Supplier Roles are outlined in Appendix N.

6.1.6 Project logistics and the Project Plan

Using project management tools, aligned with the Project Management Institute and PRINCE2, a Project Plan (containing key milestones) has been created. This plan is contained in Appendix C and provides a firm footing for detailed design activities to take place in a timely manner.

OpenLV will be delivered using a similar structure to FALCON, FlexDGrid and Network Equilibrium with the following Work Packages: 1) Mobilise & Procure, 2) Design, 3) Build, 4) Trial and 5) Consolidate & Share (See Figure 8).

OpenLV will follow WPD's Innovation Project Governance Guidelines and work them into the Management & Delivery document for the project. This will support the delivery and management of the project in line with Ofgem requirements. The Management & Delivery document will:

- Create an agreed governance structure for the project;
- Outline common project controls for the project including the internal reporting and approval processes, and the gateway review and escalation processes;
- Support the consistency of delivery across projects throughout WPD's innovation programme and enable visibility of the project to the WPD Future Networks Manager in line with existing projects in the programme;
- Support reporting to the senior management team and Project Sponsor; and
- Assist with the coordination between projects where appropriate, facilitating continuous improvement and ensuring compliance.

In addition, to support delivery of the Project Governance Guidelines, EA Technology will adopt the suite of project templates that have been created on existing projects. These templates will enable the team to incorporate new governance requirements, improvements and project learning across project documentation quickly and easily and support the consistency of documentation across projects.

EA Technology has incorporated project mobilisation and design phase at the start of the project. On previous WPD projects this has been found to significantly de-risk the construction phase of the Project, allowing the site construction and equipment installation activities to begin as scheduled and with reduced uncertainty.

6.1.7 Experienced Project delivery team

EA Technology has the resources and experience to lead the delivery of **OpenLV**. Figure 10 outlines the organisational structure of the project team.

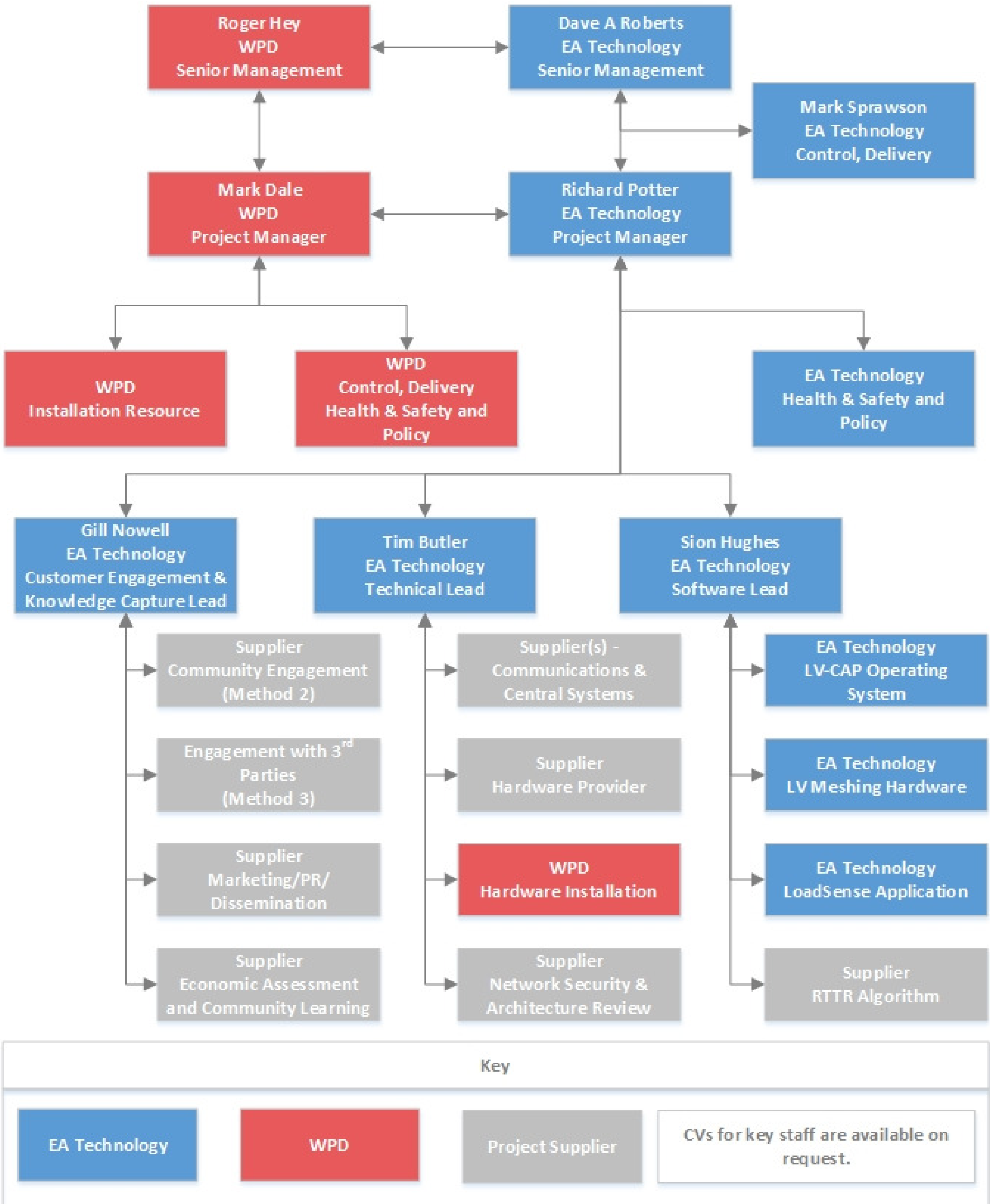

Figure 10: Organisational Diagram

The resources are of a sufficient size and quality to be reasonably expected to ensure **OpenLV's** delivery. An overview of the relevant experience of the key staff is outlined below:

- **Roger Hey (Senior Management - WPD):** Roger has worked in the energy industry for over 20 years. He initially trained as an operational engineer delivering networks construction and maintenance activities. Roger subsequently gained experience in Control Room and Telecommunications parts of a DNO business. More recently he spent several years managing the IT functions. In 2008 Roger was asked to bring together his varied experience and establish a Future Networks strategy and small team of specialist engineers. The department are responsible for the business's innovation strategy, delivery of demonstration projects and implementation of new solutions into core business activities. Key elements of the WPD Future Networks Programme are developing smarter local grids, leveraging value from smart meters and helping customers adopt lower carbon technologies such as electric cars, heat pumps and distributed generation.
- **Mark Dale (Project Manager - WPD):** Mark Dale is an Innovation and Low Carbon Network Engineer with Western Power Distribution, where he has spent all his working life. Mark was initially working in the metering department, very quickly progressed through the Planning department working on LV and HV system design. For 15 years Mark managed a Network Services Team dealing with all aspects of Construction, Maintenance and Replacement, from LV through to EHV. In June 2012 Mark joined the Future Networks Team as an Innovation and Low Carbon Network Engineer, Project Managing high value smart grid demonstration projects. He has successfully managed the Tier 2 Low Voltage Network Templates, and Sola Bristol projects.
- **Dave A Roberts (Senior Management – EA Technology):** Dave is the Director for the Smart Interventions business within EA Technology. He is responsible for this £5m business of c50 energy professionals, whose aims are to improve strategic choices for energy network customers through its consultancy services and embedded software platforms. Dave is a Chartered Electrical Engineer with the IET and has fifteen years in the UK electricity industry, joining EA Technology in 2009 from roles in ScottishPower. He has had an active history in network innovation, smartgrids and asset management, having led teams in both organisations. He was responsible for the UK's largest grid / electric vehicle trial (My Electric Avenue), and has since co-founded the EV-Network Group.
- **Mark Sprawson (Project Control – EA Technology):** Through a career that has included working both within a network operator and consultancy environment, Mark has contributed to a broad range of strategic studies associated with network development and policy using his core skills and understanding regarding electrical networks at all voltage levels. Recent experience includes leading projects within the Smart Grid Forum in the UK, developing the world's first techno-economic model to evaluate the impact that low carbon technologies will have on electricity distribution networks. Mark has experience of leading project teams and delivering innovative work for a range of clients including network operators, government, regulator, and generation developers. He is a Chartered Engineer and currently delivers a leadership role within EA Technology with particular responsibility for projects concerned with Network Innovation.
- **Richard Potter (Project Manager – EA Technology):** Richard is a Senior Consultant within EA Technology's Smart Interventions business; is a Chartered Engineer with the IET and has over 16 years' experience in delivering technology and research projects with a value of up to £29.9 million. Richard developed the Novel Commercial Arrangement for the My Electric Avenue project and recently completed a 6-month secondment within SSEPD as the Project Manager for the New Thames Valley Vision project. Over the past 4 years Richard has delivered SDRCs on a total of 5 LCN Fund projects working with: SSEPD, UKPN and NPg.

- **Gill Nowell (Customer Engagement & Knowledge Capture Lead – EA Technology):** Gill is a Senior Consultant within EA Technology's Smart Interventions business. Gill has been with the company for over four years and has been project managing multi-million pound projects for 15 years, across both private and public sector organisations. In 2012, she bid managed a successful £4.5m application to Ofgem's Low Carbon Networks Fund for the Tier 2 My Electric Avenue (I2EV) project and managed all aspects of communication, as well as the dissemination of learning from the project. Gill is now managing customer research and all aspects of marketing to support customer recruitment of up to 700 trial participants, and dissemination of learning for Western Power Distribution's CarConnect project.
- **Tim Butler (Technical Lead – EA Technology):** Tim is a Senior Consultant within EA Technology's Smart Interventions business. A Chartered Engineer with the IET, Tim has experience in both highways and aerospace sectors prior to joining EA Technology and brings a capability of leading and working with multi-discipline teams to deliver large scale projects. Since joining EA Technology, Tim has been predominantly involved in projects for the Low Carbon Networks (LCN) Fund, managing the award winning My Electric Avenue Project on behalf of SSEPD.
- **Sion Hughes (Software Lead – EA Technology):** Sion has 8 years' experience working as a Software Engineer and is a Senior Development Engineer within EA Technology. Sion is the lead Engineer for the development of LV-CAP™ through InnovateUK.

6.1.8 Initial engagement with communities, academics and companies that shows good market potential for Methods 2 and 3

EA Technology is confident that there is very real and significant market potential for Methods 2 and 3. Through the RfI process significant interest has been shown in the **OpenLV** concept and letters of support are provided in Appendix F.

6.2 Evidence of the measures that EA Technology will employ to minimise possible cost overruns and shortfalls in Direct Benefits

The following key points outline the measures that EA Technology has employed to minimise cost overruns and shortfalls in direct benefits:

- The costs have been calculated using a bottom-up and top-down methodology;
- Costs for WPD commodity items have been used where possible to provide a greater level of certainty;
- In line with the development and Trial of the three Methods, the project has been broken down into separate and distinct work packages to provide a detailed overview of each area;
- Strong governance, that is already in place, will be used with project tolerances and KPIs monitored by EA Technology's senior management;
- Through a detailed design phase, uncertainty in the project will be reduced at an early stage; and
- Risk management processes will be implemented throughout the project: In keeping with standard innovation project risk management processes, every risk will be assigned an owner, based on the risk rating and the ability of the individual to manage the risk (see Appendix D).
- A Contingency, following the same principles used for My Electric Avenue, has been developed for the **OpenLV** Project. Further information is provided in Appendix E.

6.3 Verification of all the information included in the proposal

It is confirmed that:

- The Project proposal has been prepared by EA Technology in conjunction with WPD, with information provided from other potential project collaborators and equipment suppliers;
- The bid has been prepared by an experienced team of engineers, in partnership with dedicated Project Managers from EA Technology and WPD;
- The proposal has been through independent checking processes and peer review processes to ensure the accuracy of information;
- The technical sections of the Full Submission Pro-forma have been reviewed by experts, which were not directly involved in the bid formulation;
- Information from collaborators, service providers and equipment suppliers has been reviewed by EA Technology to ensure accuracy; and
- The Project submission has been reviewed and signed off by EA Technology's relevant Directors and WPD's Operations Director.

6.4 How the Project plan will still deliver learning in the event of fewer LCTs

In the event that the take up of low carbon technologies and renewable energy in the Trial area is lower than anticipated, the Project plan will still deliver learning from deploying the overall **OpenLV** Solution and each of the Methods:

- **Method 1 – Network Capacity Uplift:** This Method will demonstrate the deployment of data analytics at a substation level and increases in utilisation that could be achieved by meshing and adopting weather dependent ratings. Such learning is also relevant to flexible future network designs for improved customer service and potentially loss reduction. Secure communications and standard low cost network equipment may also reduce future costs of active network management and demand control;
- **Method 2 – Customer Engagement:** This Method will provide valuable insight into how DNOs can engage with local communities who want to become part of a smarter grid; therefore, supporting the uptake of LCTs. This learning provides significant benefits to both local communities and DNOs. Irrespective of LCT uptake it provides an opportunity to engage Customers as actors in low carbon networks; and
- **Method 3 – OpenLV Extensibility:** This Method will prove the value of the open nature of the overall **OpenLV** solution. This learning is valuable as it will enable the true value of the Solution to be assessed. This provides significant benefits irrespective of the level of LCT uptake.

In addition, at the start of the bid process it was envisaged that a single communications provider would be included within the project. Following the RfI process it is expected that the **OpenLV** Solution will be tested using two different communications providers providing data back to two separate systems. This will test and prove the open nature of the platform.

6.5 Process to identify circumstances to suspend the Project

The following processes are in place to identify circumstances where the most appropriate course of action will be to suspend the Project, pending permission from Ofgem, that it can be halted. This approach will give all the parties involved clarity and consistency from the outset.

6.5.1 Gateway Reviews

In order to ensure that the Project proceeds smoothly, gateway reviews have been incorporated at critical stages in its lifecycle, which are clearly indicated in the Project Plan. These include review points between the Work Packages set out in Figure 8 (overall learning section 5) and Figure 11 (key deliverables section 9).

The aim of each gateway review is to assess whether or not the Project can progress successfully to the next stage. They provide assurance that the Project is on track and being run in an efficient and cost-effective manner and give further assurance to stakeholders and Project team members alike that the Project can proceed.

The gateway review is a snap-shot at the point at which the review takes place. As such, recommendations are based on the documents provided and the review process is intended to be supportive and forward looking.

Senior Management from both EA Technology and WPD will assign a status in the form of a Delivery Confidence Assessment. This assessment will then provide the Project team recommended actions.

Actions fall in the following categories:

1. **Critical (Do Now):** to increase the likelihood of a successful outcome, it is of the greatest importance that the Project should take action immediately;
2. **Essential (Do By):** to increase the likelihood of a successful outcome, the Project should take action in the near future. Whenever possible, essential recommendations should be linked to Project milestones and/or a specified timeframe;
3. **Recommended:** the Project would benefit from the uptake of this recommendation. If possible recommended actions should be linked to Project and/or a specified timeframe;
4. **Halt the Project:** the Project has exceeded the tolerances set and agreed at Project initiation and the situation is deemed to be irrecoverable. The Project is to be halted and WPD senior management will contact Ofgem to discuss and agree the way forward.

6.5.2 Regular Project Review Group meetings

EA Technology and WPD Senior Management, together with the appointed WPD Project Manager, will:

1. Be briefed on Project progress;
2. Review the Project Plan, cost model and the Risk, Assumptions, Issues and Dependencies (RAID) log;
3. Approve key outputs and milestones since the previous meeting;
4. Assess delivery against the Successful Delivery Reward Criteria;
5. Discuss and recommend Project changes;
6. Document and review actions; and
7. Assign an overall Red/Amber/Green (RAG) status to the Project, where red means the Project has severe delays affecting output, amber means the Project has delays affecting output or additional cost are required to deliver outputs on time and green means the Project is on time and budget.

6.5.3 Proactive risk management

EA Technology maintains a number of specialised risk management strategies. The Project risk controls are a subset of the overall risk management. The risk management objectives are to:

- Ensure that risk management is clearly and consistently integrated into the project management activities and evidenced through the project documentation;
- Comply with WPD's risk management processes and any governance requirements as specified by Ofgem; and
- Anticipate and respond to changing Project requirements.

These objectives will be achieved by:

- Defining the roles, responsibilities and reporting lines within the team for risk management;
- Including risk management issues when writing reports and considering decisions;
- Maintaining a risk register;
- Communicating risks and ensuring suitable training and supervision is provided;
- Preparing mitigation action plans and contingency action plans; and
- Monitoring and updating risks and risk controls on a regular basis.

Section 7: Regulatory issues

7.1 Regulatory issues

7.1.1 Derogations

No derogations will be required for the Network Capacity Uplift, Community Engagement and **OpenLV** Extensibility Methods.

7.1.2 Licence consent

The Project does not require any additional Licence consents for the Network Capacity Uplift, Community Engagement and **OpenLV** Extensibility Methods.

7.1.3 Licence exemptions

The Project does not require any Licence exemptions for the Network Capacity Uplift, Community Engagement and **OpenLV** Extensibility Methods.

7.1.4 Changes to regulatory arrangements

The Project does not require any changes to regulatory arrangements for the Network Capacity Uplift, Community Engagement and **OpenLV** Extensibility Methods.

Section 8: Customer Impact

8.1 Customer Impacts

8.1.1 Project

The **OpenLV** Project, through the deployment of the overall Solution and use of all three Methods, will have positive Customer impacts:

- **Method 1 - Network Capacity Uplift:** Will deliver additional capacity from existing assets therefore avoiding or deferring significant LV network reinforcement and also the installation of new underground cables and transfer of services, which can have a significant 'behind the scenes' impact on customers;
- **Method 2 - Community Engagement:** Will provide communities with relevant LV network data will empower customers to understand how their energy use impacts the distribution network and the ability to deploy innovative algorithms and applications designed to benefit the community will provide significant benefits directly to customers. For example, many customer impacts are 'behind the scenes', which can lead to a disconnect between DNOs
- and customers. Increasing understanding and aligning aims so that customers also become actors in low carbon networks could be the part of a paradigm shift that de-risks the transition to a low carbon economy for both parties; and
- **Method 3 - OpenLV Extensibility:** Will provide academics and new and innovative service providers (including non-energy companies) with relevant LV network data and the ability to deploy innovative algorithms and applications designed that will ultimately provide significant benefits to customers.

The **OpenLV** project will not require any planned interruptions in supply to customers. Robust method statements for the installation of equipment already exist and will be updated specifically for the **OpenLV** project therefore minimising the risks of unplanned interruptions in supply to customers.

8.1.2 Method 1: Network Capacity Uplift

The network capacity uplift method does not require any interaction with Customers or on Customers premises. The Method includes the installation of the intelligent substation devices in LV substations.

The installation of the intelligent substation devices will have no impact on supply to Customers during the trials. The installation of the devices requires no planned or unplanned interruptions to supply and will follow the processes identified in existing method statement(s) that have been developed through previous LCN Fund projects.

8.1.3 Method 2: Community Engagement

It is not anticipated that the community engagement Method will have any impact on customers in terms of planned or unplanned interruptions to supply. No equipment will be installed in customers' premises as part of this Method.

As part of engaging with communities, members of the project team may be required to visit customers' premises to promote and discuss participation in the **OpenLV** project. The approach taken to engage with community groups will be outlined in the Customer Engagement Plan for the **OpenLV** project. The Customer Engagement Plan will be developed as part of Phase 1 of the project in line with the requirements for the document as outlined in the NIC Governance document.

8.1.4 Method 3: OpenLV Extensibility

It is not anticipated that the **OpenLV** extensibility Method will have any impact on customers in terms of planned or unplanned interruptions to supply. No equipment will be installed in customer's premises as part of this Method.

The approach for engaging with academics and companies (including non-energy companies) will be outlined in the Customer Engagement Plan that will be completed as part of the Phase 1 works for the **OpenLV** project.

8.2 Interaction or engagement with customers or customers' premises

No interaction or engagement will be required on customers' premises as part of Methods 1. The methodology for engaging with community groups (Method 2) and academics and companies (including non-energy companies) will be detailed in the Customer Engagement Plan.

8.3 Direct impact the project may have on customers

The Project will not have any direct impact on customers, in terms of new charging mechanisms, contractual arrangements or supply interruptions. However, there is the potential to provide benefits to groups of Customers who wish to engage with the project.

8.4 Planned interruptions

EA Technology does not anticipate any planned interruptions during construction or operation. Therefore, no protection from planned interruptions has been requested.

8.5 Unplanned interruptions

EA Technology does not anticipate any unplanned interruptions during construction or operation. Therefore, no protection from unplanned interruptions has been requested.

8.6 Alternative ways to implement the project to reduce or avoid need for customer interruptions

EA Technology has designed the project to avoid the requirement for customer interruptions.

8.7 Protection from incentive penalties

EA Technology does not expect any planned or unplanned interruptions during construction or operation. Therefore, no protection from incentive penalties has been requested.

Section 9: Successful Delivery Reward Criteria (SDRCs)

Figure 11 provides an overview of the key project milestones including: 1) Internal Project Reviews, 2) SDRC Reports and the Closedown Report.

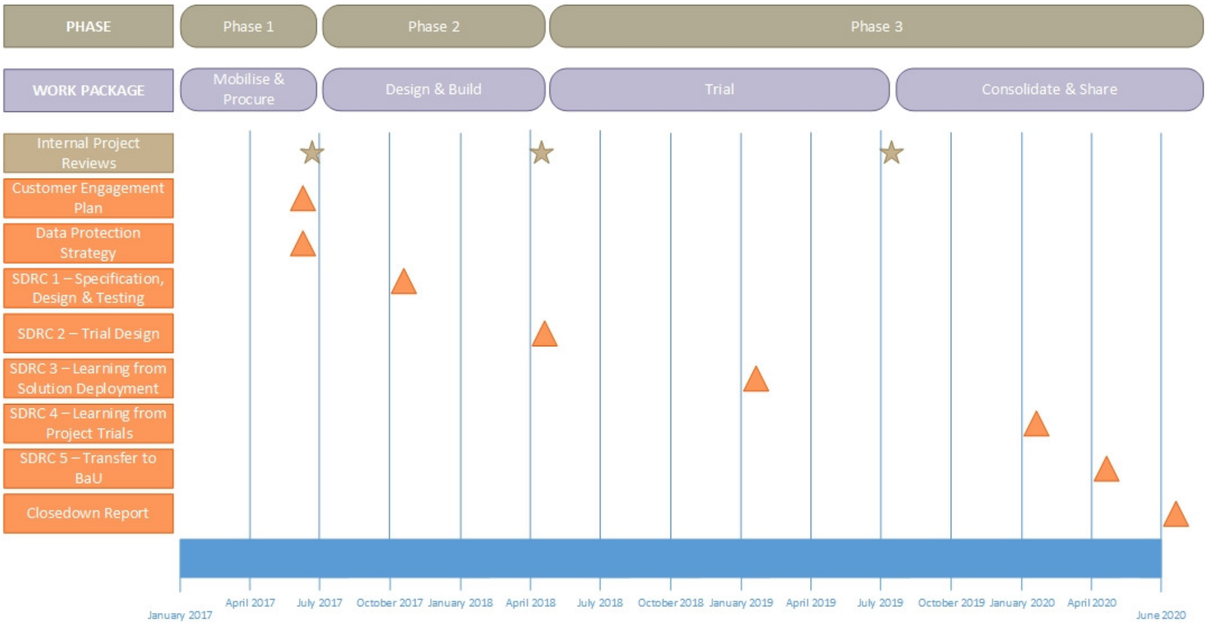

Figure 11: Key Project Milestones

9.1 Criterion 1 (SDRC-1)

Specific: Specification, Design and Factory Testing of the overall **OpenLV** solution.

Measurable: Technical Report – Outlining the detailed design of the overall **OpenLV** Solution. The report will contain chapters or appendices including the following information: (1) Detailed systems architecture; (2) Requirements specification for the **OpenLV** intelligent substation hardware; (3) An assessment of the development of the intelligent substation control software to identify whether any changes are required to the planned deployment for the **OpenLV** project; (4) Detail the approach for testing the overall solution ahead of wide scale deployment; (5) Factory and site acceptance test documentation; (6) Factory testing results.

Achievable: The systems architecture has been developed as part of the Full Submission Pro-forma this SDRC takes this information to the next level.

Relevant: The successful design and testing of the overall solution provides the basis for successful implementation of all methods and associated trials.

Time-bounded: The SDRC-1 report will be submitted to Ofgem on 27th October 2017.

SDRC-1 evidence

1. Sharing the specification for the **OpenLV** solution;
2. FAT and SAT documentation; and
3. FAT test results.

9.2 Criterion 2 (SDRC-2)

Specific: Identification of Target Networks (Method 1), Assessment of the Market Potential (Methods 2 & 3) and Detailed Trial Design for all Methods.

Measurable: Technical Report – To enable the successful implementation of all Methods. The report will contain chapters or appendices including the following information: (1) Assessment and identification of the target areas of the LV Network to maximise learning for Method 1; (2) An assessment of the market potential for Community Engagement (Method 2); (3) An assessment of the market potential for **OpenLV** Extensibility (Method 3); (4) Detailed trial design for all methods.

Achievable: The approach for identifying the target networks (Method 1) has been identified at Full Submission Pro-forma stage. Initial scoping of the Community Engagement and **OpenLV** Extensibility Methods has been completed at Full Submission Pro-forma stage. This SDRC builds on this existing information.

Relevant: The criterion enables the target geographic area(s) for Method 1 to be identified, assesses the potential for Methods 2 and 3 and provide detailed planning for the trials for all 3 Methods.

Time-bounded: The SDRC-2 report will be submitted to Ofgem on 30th May 2018.

SDRC-2 evidence

1. Sharing the technique(s) used to identify target LV networks.
2. 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;
3. 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); and
4. Detailed trial design for all methods.

9.3 Criterion 3 (SDRC-3)

Specific: Learning from Deployment of the Overall **OpenLV** Solution & Standard Guidelines for Application Development.

Measurable: Technical Report – Outlining the learning from the site testing completed on the **OpenLV** solution before wide scale deployment. The report will contain chapters or appendices including the following information: (1) An overview of the **OpenLV** Solution (technical specifications and how it works) (2) The installation documentation for the intelligent substation devices; (3) Confirmation that the third party system has been installed and configured to support wide scale deployment; (4) An overview of the training provided to installation and operational staff; (5) Site Acceptance tests for the central IT Architecture; (6) Results of site acceptance tests on the initial intelligent substation devices before wide scale roll-out; (7) Standard guidelines to enable 3rd party organisations to develop new Applications (8) App development kit (skeleton implementation of a software container to speed up App development).

Achievable: The SDRC builds on the systems architecture completed at Full Submission Pro-forma stage and the development work completed on LV-CAP™ as part of the InnovateUk project (See Appendix M).

Relevant: The central IT architecture underpins the successful trials for all 3 Methods. Installation of a small number of devices will test the overall **OpenLV** solution therefore de-risking wider rollout. The standard guidelines for Application development are required to exploit the full potential of Methods 2 and 3.

Time-bounded: The SDRC-3 report will be submitted to Ofgem on 1st February 2019.

SDRC-3 evidence

1. Sharing the installation documentation for the intelligent substation devices.
2. Sharing the training material provided to all installation and operational staff;
3. SAT results for the central IT architecture; and
4. Sharing the learning generated from the deployment of the central systems architecture and initial intelligent substation devices.
5. Quality Assurance processes / test processes to ensure Apps are sufficiently robust prior to being made available for deployment

9.4 Criterion 4 (SDRC-4)

Specific: Learning Generated from the **OpenLV** Project Trials for All Methods.

Measurable: Technical Report – Outlining the learning generated from the trials from Methods 1, 2 and 3. The SDRC will be split into three individual reports to showcase the learning generated from the project trials for all Methods.

Achievable: The Apps for all Methods will have been developed and deployed in order to maximise the learning from all three Methods.

Relevant: This criterion corresponds directly to the learning generated for all three Methods.

Time-bounded: The SDRC-4 report will be submitted to Ofgem on 31st January 2020.

SDRC-4 evidence

1. Sharing the level of capacity uplift achieved through Method 1;
2. Sharing which LV networks can benefit from **OpenLV** and why;
3. Establishing the level of capacity uplift that could be achieved in WPDs licence area and across GB (applicability of other DNOs);
4. Sharing how DNOs can engage with communities who want to become part of a smarter grid to exploit the open and flexible nature of **OpenLV**;
5. Sharing how community engagement supports the uptake of LCTs;
6. Outlining the routes communities can take to raise funding;
7. Sharing the network benefits provided by community engagement;
8. Sharing how DNOs can engage with academics, companies (including non-energy companies) to exploit the open and flexible nature of **OpenLV**.
9. Sharing the network benefits provided through Method 3; and
10. Sharing how the method facilitates non-traditional business models.

9.5 Criterion 5 (SDRC-5)

Specific: Knowledge Capture, Dissemination & Transferring the **OpenLV** Solution to Business as Usual.

Measurable: Technical Report – Assessing the Technology Readiness Level (TRL) of the overall **OpenLV** solution to enable the solution to be rolled out as part of BaU. The report will contain chapters or appendices including the following information: (1) The key learning generated from each of the Methods; (2) Replicability and scalability of the Methods, Trials and overall Solution; (3) An Cost Benefit Analysis of each of the Methods and the overall solution based on the data generated on the project; (4) A specification for the overall **OpenLV** Solution to enable the system to de taken into BaU; (5) Recommend changes to the overall Security of the Solution (if required); (6) Training needs analysis (who needs to know and what do they need to know) to enable the **OpenLV** solution to be rolled out as part of BaU.

Achievable: This SDRC will build on the overall learning generated by the project.

Relevant: This criterion corresponds to the delivery of all the **OpenLV** methods.

Time-bounded: The SDRC-5 report will be submitted to Ofgem on 30th April 2020.

SDRC-5 evidence

1. Summary of key project learning;
2. Knowledge and learning dissemination reports and presentations;
3. Network data being made available from each of the methods;
4. Six-monthly progress reports submitted to Ofgem throughout the project;
5. **OpenLV** project presentations delivered at six industry conferences during the course of the project from March 2017 to June 2020;
6. **OpenLV** project presentations delivered at each of the LCNI conferences during the course of the project;
7. Cost benefit analysis for each method;
8. A summary of the training needs analysis required to enable roll out as part of BaU;
9. Recommendations for changes to system Security ahead of wide scale deployment;
10. A summary of changes that need to be made to the overall **OpenLV** solution to enable roll out as part of BaU;
11. Delivery of the Loadsense App;
12. Economic analysis / extrapolation for the tested Community Applications Method 2; and
13. Enduring tools for community groups throughout GB to use beyond the end of the project.

Appendices

Appendix Title	Description
A1: Financial Benefits Table	Financial benefits table
A2: Capacity Benefits Table	Capacity benefits table
A3: Carbon Benefits Table	Carbon benefits table
A4: Explanatory Notes	Explanatory notes for appendices A1 to A3
B: Costs	Detailed cost spreadsheet showing the complete cost of the project and the spend per regulatory year
C: Project Plan	Detailed GANTT chart detailing the project activities and timelines
D: Risk Register	Document capturing the project risks and their severity
E: Contingency Plan	Document capturing the most severe project risks identified at the bid stage and provision of an appropriate contingency if the risk turns in to an issue
F: Letters of Support (Partners & Suppliers)	Letters of support provided by organisations that see value in this project being awarded and delivered to add knowledge and learning to the electricity network industry
G: Project Methods	Technical description of the three project Methods
H: Technology Overview	Details of the software platform and the LV-CAP™ devices
I: Learning from other projects	Overview of other LCN Fund projects that have common themes to **OpenLV** and the learning used to inform this project
J: Differentiators from previous LCNF Projects	Table identifying where each LCNF Tier-2 Project sits in terms of the problem each project aims to solve
K: Glossary of Terms	Explanations of terms used throughout the bid documentation
L: Future Potential of **OpenLV**	A high level view of what the long term potential for the **OpenLV** Solution could look like
M: Development of LV-CAP™ through InnovateUK	Overview of the InnovateUK project and development of LV-CAP™
N: Key Project Roles	Identification of the Key Project Roles on the **OpenLV** project and high level scope of works for each potential supplier
O: Value for Money	Provide the tables requested by Ofgem to demonstrate how the Project meets criterion (b) Provides value for money to electricity customers.
P: Learning Dissemination	Methodology for Knowledge Capture & Dissemination

Appendix A1: Financial Benefits

Financial benefit									
				Benefit (£m)					
Scale	Method	Method Cost (£m)	Base Case Cost (£m)	2020	2030	2040	2050	Notes	Cross-references
Post-trial solution	Method 1 (Capacity uplift)	[redacted]	[redacted]	0.000	0.000	0.000	0.000	OpenLV trial only - 60 units which will be decomissioned at the end of the project	Appendix A4
(individual deployment)	Method 2 (Community)	[redacted]	[redacted]	0.018	0.173	0.282	0.359	OpenLV trial only - 10 units delivering benefits directly to customers, which could therefore be left in situ at completion of trial	Appendix A4
	Method 3 (3rd party)	[redacted]	[redacted]	0.000	0.000	0.000	0.000	OpenLV trial only - 10 units which we assume will be decomissioned at the completion of the trial	Appendix A4
Licensee scale	Method 1 (Capacity uplift)	[redacted]	[redacted]	0.0	0.0	10.7	34.2	Four fourteenths of GB rollout	Appendix A4
If applicable, indicate the number of relevant sites on the Licencees' network.	Method 2 (Community)	[redacted]	[redacted]	0.0	1.2	17.0	50.6	Four fourteenths of GB rollout	Appendix A4
	Method 3 (3rd party)	[redacted]	[redacted]	1.4	46.9	71.5	85.2	Four fourteenths of GB rollout	Appendix A4
GB rollout scale	Method 1 (Capacity uplift)	[redacted]	[redacted]	0.000	0.000	37.562	119.853	Transform Model figures for costs of reinforcement with and without the Uplift solution being available	Appendix A4
If applicable, indicate the number of sites on the GB network.	Method 2 (Community)	[redacted]	[redacted]	0.018	4.365	59.392	177.175	Estimated uptake scenario with all benefits flowing directly to customers through reduced electricity bills	Appendix A4
	Method 3 (3rd party)	[redacted]	[redacted]	4.911	164.103	250.365	298.301	Benefit derived from assessing number of feeders requiring intervention, as indicated by the Transform Model, and assessing the number of LV-CAP platforms that could be deployed in lieu of a corresponding number of bespoke solutions	Appendix A4

Appendix A2: Capacity Benefits

Capacity benefit									
				Benefit (MW)					
Scale	Method	Method Cost (£m)	Base Case Cost (£m)	2020	2030	2040	2050	Notes	Cross-references
Post-trial solution	Method 1 (Capacity uplift)	[redacted]	[redacted]	0.0	0.0	0.0	0.0	OpenLV trial only - 60 units which will be decomissioned at the end of the project	Appendix A4
(individual deployment)	Method 2 (Community)	[redacted]	[redacted]	0.0	0.0	0.0	0.0	OpenLV trial only - 10 units delivering benefits directly to customers, which could therefore be left in situ at completion of trial. The aim is to provide financial savings to customers which may or may not result in a reduction in peak demand (i.e. capacity benefit) for the DNO	Appendix A4
	Method 3 (3rd party)	[redacted]	[redacted]	0.0	0.0	0.0	0.0	OpenLV trial only - 10 units which we assume will be decomissioned at the completion of the trial	Appendix A4
Licensee scale	Method 1 (Capacity uplift)	[redacted]	[redacted]	0.0	0.0	11.1	38.4	Four fourteenths of GB rollout	Appendix A4
If applicable, indicate the number of relevant sites on the Licencees' network.	Method 2 (Community)	[redacted]	[redacted]	0.0	0.0	0.0	0.0	Four fourteenths of GB rollout	Appendix A4
	Method 3 (3rd party)	[redacted]	[redacted]	3.9	170.1	290.2	377.8	Four fourteenths of GB rollout	Appendix A4
GB rollout scale	Method 1 (Capacity uplift)	[redacted]	[redacted]	0.0	0.0	155.6	537.6	Transform Model figures for the deployment numbers of the Uplift solution. The average capacity benefit relaised by this solution was calculated and multiplied by thde deployemtn numbers to give overall benefit	Appendix A4
If applicable, indicate the number of sites on the GB network.	Method 2 (Community)	[redacted]	[redacted]	0.0	0.0	0.0	0.0	The primary purpose of this Method is to provide custoerms with better informationa nd enable them to make decisions to save on their energy bills. This may release capacity to the network, but this cannot be guaranteed.	Appendix A4
	Method 3 (3rd party)	[redacted]	[redacted]	54.3	2381.4	4062.6	5289.9	Benefit derived from assessing number of feeders requiring intervention, as indicated by the Transform Model, and assuming that in each case a solution is deployed to give a very small benefit (on average). The figure taken for each intervention is 10% of the LV feeder capacity, in line with some academic work linked to previous innovation projects.	Appendix A4

Appendix A3: Carbon Benefits

Carbon benefit									
Scale	Method	Method Cost (£m)	Base Case Cost (£m)	Benefit (t CO2) 2020	2030	2040	2050	Notes	Cross-references
Post-trial solution	Method 1 (Capacity uplift)	[redacted]	[redacted]	441	441	441	441	OpenLV trial only - 60 units. Carbon benefit derived from avoided reinforcement using DTR solution - see appendix A3	Appendix A4
(individual deployment)	Method 2 (Community)	[redacted]	[redacted]	16	16	16	16	OpenLV trial only - 10 units. Carbon benefit derived from consumer energy savings - see appendix A3	Appendix A4
	Method 3 (3rd party)	[redacted]	[redacted]	74	74	74	74	OpenLV trial only - 10 units. Carbon benefit derived from avoided reinforcement using smart solutions - see appendix A3	Appendix A4
Licensee scale	Method 1 (Capacity uplift)	[redacted]	[redacted]	0	939	9725	33600	Four fourteenths of GB rollout	Appendix A4
If applicable, indicate the number of relevant sites on the Licencees' network.	Method 2 (Community)	[redacted]	[redacted]	4	449	4487	8974	Four fourteenths of GB rollout	Appendix A4
	Method 3 (3rd party)	[redacted]	[redacted]	8490	372097	634784	826543	Four fourteenths of GB rollout	Appendix A4
GB rollout scale	Method 1 (Capacity uplift)	[redacted]	[redacted]	0	3285	34038	117600	Transform uptake scenario for Uplift solution uptake. Carbon benefit derived from avoided reinforcement using Uplift solution - see appendix A3	Appendix A4
If applicable, indicate the number of sites on the GB network.	Method 2 (Community)	[redacted]	[redacted]	16	1571	15705	31410	Estimated uptake scenario. Carbon benefit derived from consumer energy savings - see appendix A3	Appendix A4
	Method 3 (3rd party)	[redacted]	[redacted]	29716	1302339	2221743	2892901	Transform uptake scenario excluding Method 1. Carbon benefit derived from avoided reinforcement using smart solutions - see appendix A3	Appendix A4

Appendix A4: Benefits Calculation

Calculation of financial benefit

The financial benefits have been determined through a range of means, depending on the particular Method being considered. It is important to note that in Methods 1 and 3, the benefits are calculated in terms of those received by the DNO, whereas in Method 2 the benefits flow directly to the customer. It should also be noted that in all cases, the Method cost at the trial level is the cost associated with performing the OpenLV trial, but the way the Method cost is calculated at a wider level varies and will be described below. Similarly, the Base cost at the trial level is zero, as the networks selected are not those necessarily in need of reinforcement, but the Base cost at a wider level is calculated through a range of means.

In all cases, the GB-wide Base and Method costs and benefits are scaled to give the licensee level costs and benefits by applying a factor of 4/14 to reflect the approximate size of the WPD asset and customer base as a proportion of Great Britain.

Method 1 - Network Capacity Uplift

As described in section 3.2, the Transform Model for Great Britain was used to establish the likely cost of reinforcing LV networks in the absence of the Uplift solution, and then again with the Uplift solution being present. The difference between these figures illustrates the benefit associated with the Uplift solution. The Transform Model uses NPV calculations in accordance with the Ofgem requirements and produces year-on-year results for investment and deployment. The parameters that were used for the Uplift solution are fairly conservative and are described in Figure 1, the 'solution template' that was fed into the Transform Model.

Method 2 - Community Engagement

As previously stated, all benefits in this Method flow directly to customers rather than being accrued by the DNO. The Base cost is zero as this is not an activity that would ordinarily be undertaken by the DNO, but making use of the LV-CAP™ platform and providing an app that permits customers to better understand their energy consumption can be done at marginal cost. The figures shown assume a ramp-up in use of such an approach from just 10 community groups in 2020 to 20,000 by 2050. The benefits assume a reduction in electricity bill as described in section 3.2.

Method 3 - OpenLV Extensibility

This Method demonstrates the extensible nature of the platform to provide a range of services and solutions via different apps. The precise nature of the apps to be deployed is, at this time, unknown. In order to quantify the benefit, it was assumed that an average number of circuits from the scenarios considered require reinforcement. The amount of these that are being accounted for under Method 1 was discounted from this number of feeders to avoid double counting.

An estimate was then derived by assuming that all the feeders were fed from similar substations, meaning that a minimum number of LV-CAP™ devices and Apps would be required, against the alternative cost of using bespoke hardware solutions to resolve the constraint. The difference between the cost of deploying hardware and the cost of utilising the LV-CAP platform and app-based solutions then demonstrates the benefit.

Solution Overview	Representative Solution:	**Uplift**			
	Variant Solution:	Uplift for LV transformers and cables			
	Description:	The use of measurement and ambient forecasting data to predict the rating (and hence current carrying capacity) of distribution transformers, combined with the ability to mesh downstream low voltage underground circuits at time of high load in a real-time manner.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			25%	Based on the work carried out under DS2030 (part of Smart Grid Forum Workstream 7), it was found that meshing at LV could provide a range of benefits depending on the specific geography and loading of the assets. This could be as much as 50%, so a conservative 25% has been applied.
	Thermal Transformer:			25%	Based on research being conducted at University of Manchester, it appears that transformers can be operated above nameplate rating under certain conditions without risk of premature ageing. The work is ongoing but early suggestions show an increase in rating of around 40% could be possible. A conservative assumption of 25% is taken here.
	Voltage Head:			0%	No expected benefit
	Voltage Leg:			0%	No expected benefit
	Power Quality:			0%	No expected benefit
	Fault Level:			-33%	Meshing increases fault level and, in line with standard practice within the Transform Model, this is taken to be a 33% reduction in the available fault level headroom.
Cost (£)	Capital:	[redacted]			Estimate based on the cost to install the controlling and monitoring equipment to allow the active management of the LV network, in line with information from suppliers of such equipment.
	Operational Expenditure:	[redacted]			Small ongoing opex to ensure communicatiosn channels are available for local control
	Cost Curve Type:	4			Assume a reduction in costs as solution volumes increase
	Life Expectancy of Solution:	10			A fairly conservative assumption of 10 years has been taken. Such devices have not been installed for long periods, so while asset life may well extend to 15 years, or beyond, this is an unknown and hence 10 years is applied here.
Merit Order	Totex (£):	[redacted]			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	2			Low disruption as the devices can be connected to the network with minimal impact
	Disruption Cost (£):	[redacted]			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	4			Devices could easily be moved from one circuit to another within their life expectancy
	Lead Time:	6			(months)
	Cross Network Benefits Factor:	0			No benefit expected
	Year solution becomes available:	2020			Following OpenLV project
	Year data (on soln) is available:	2019			Towards the close of the OpenLV project, sufficient information should be available to confirm the assumptions taken here
	Source of Data:	OpenLV			

Figure 1: Transform Model solution template for Uplift solution

Calculation of capacity released

Method 1 - Network Capacity Uplift

As per the Transform Model solution template above, it was assumed that the Uplift solution gives a capacity release of 25%. A weighted average of the ratings of feeders where the Transform Model was predicting the solution would be deployed was taken to derive a representative level of capacity released by each deployment. This was then multiplied by the number of deployments to determine the overall capacity released by this Method.

Method 2 - Community Engagement

As the purpose of this Method is to enable customers to better understand their energy consumption and potentially reduce their costs, the primary objective is not to release capacity on the network. It may well be that customers change their behaviour by either reducing their demand or re-shaping their demand profile as a result of having this greater visibility and potentially being incentivised by suppliers to do so. However, this is not necessarily the case and, as such, this Method does not claim any capacity release so as to provide a conservative estimate overall.

Method 3 - OpenLV Extensibility

As described earlier, this Method seeks to demonstrate the way in which the platform can be used to deploy a range of solutions to resolve different network constraints. As the precise nature of the interventions to be deployed is unknown, the exact capacity release must be estimated. The analysis of Method 1 was repeated to identify the weighted average of LV feeder capacities by the feeders that require the greatest number of interventions. Once the average feeder rating was determined, 10% of this rating was taken as being the amount that would be released. This, again, is a fairly conservative amount, based on some previous work that showed 10% could be released through the managed charging of electric vehicles. In reality, there may well be a range of solutions offering much more significant capacity release, so 10% offers a relatively conservative estimate.

Calculation of carbon benefit

The OpenLV platform enables environmental benefits to accrue in a number of ways, depending on the Method employed. It is therefore necessary to consider the benefits of each Method separately, with the aim of expressing all environmental benefits in common units – in this case tonnes of CO_2 equivalent.

Method 1 - Network Capacity Uplift

Using Transform Model simulation for this solution, the benefits analysis for Method 1 has already determined the number of circuits where this Method is likely to avoid cable reinforcement (16,000 – 241,000 by 2050). In addition, the Transform Model shows that the average length of the affected networks is 150m.

The Capacity To Customers (C_2C) project identified the embedded carbon in high-voltage cable reinforcement was between 49 tCO_2e/km and 75 tCO_2e/km[1]. The lower figure is for cables laid in pathways – and as such is generally applicable to low-voltage cables as well. A value of 49 tCO_2e/km was therefore chosen to assess the carbon benefit.

Taking the lower figure of 16,000 circuits produces a cumulative carbon benefit from Method 1 of 117,600 tCO_2 by 2050.

Note that this approach does not consider other savings (in terms of network losses, or embodied carbon in substation reinforcements) and so will tend to under estimate the total CO_2 savings. However, it is assumed that it is preferable to use published figures rather than attempt to estimate the complete CO_2 savings using unpublished assumptions.

Method 2 - Community Engagement

The key benefit under Method 2 rests with customers and the resulting savings in energy bills. Some of this saving accrues from lower energy prices and some of it is from lower energy usage. The latter is deemed to be the dominant carbon benefit and is used for the basis of this calculation.

We estimate that 50% of the resulting savings will come from energy savings, equating to an average of 175kWh/customer/year, with the solution supporting an average of 35.9 customers per substation and rolled out to an estimated 20,000 substations.

UK electricity has a current carbon intensity of 412g CO_2/kWh[2]. Note, however that this figure is expected to fall significantly to 150g CO_2/kWh by 2050[3]. To avoid exaggerating the benefits a median figure should be used; in this case, 250g CO_2/kWh has been chosen.

This results in a cumulative carbon benefit of 31,410 tCO_2 by 2050.

Method 3 - OpenLV Extensibility

The carbon benefit under Method 3 consists of two components: avoidance of reinforcement by conventional means (as per Method 1) and energy saving by customers (as per Method 2). Because this Method enables a much wider range of solutions to be delivered by 3rd parties, it is assumed that this Method will enable conventional reinforcement to be avoided for all suitable feeders by 2050 – i.e. 393,592 circuits according to Transform Model simulation runs, excluding those addressed through Method 1. It is likely that the 3rd party solutions through to 2050 will include an element of energy saving, as identified in Method 2. However to avoid any double-counting, these have been excluded from the customer energy savings for this method. This leads to a conservative estimate of carbon savings.

Method 3 therefore results in a cumulative carbon benefit of 2,892,901 tCO_2 by 2050.

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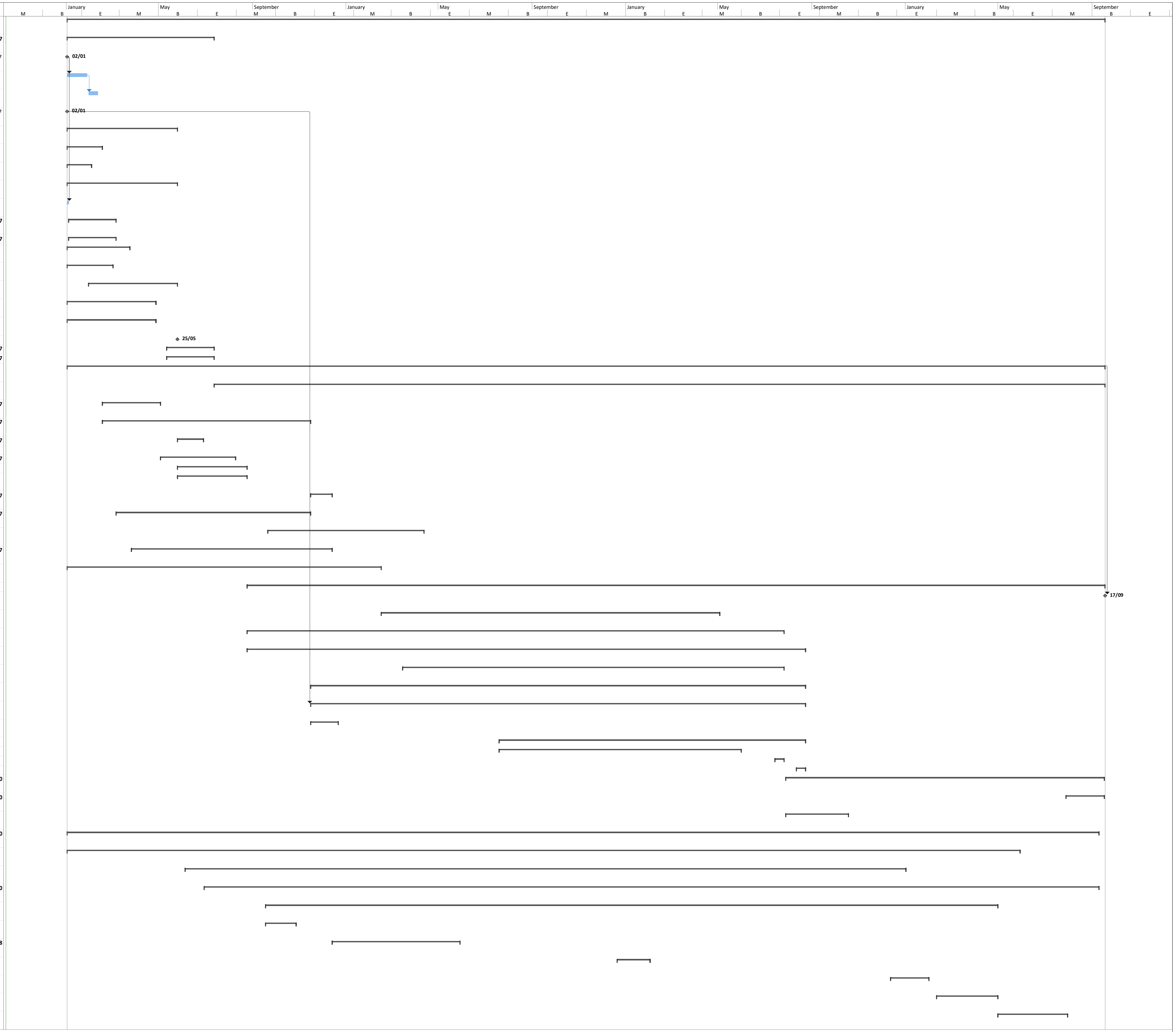
[1] http://www.enwl.co.uk/docs/default-source/c2c-key-documents/carbon-impact-assessment-trial-results.pdf?sfvrsn=4
[2] https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2016
[3] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48072/2290-pathways-to-2050-key-results.pdf

	A	B	C	D	E	F	G	H	I	J	K	L
1	**NIC Funding Request**											
2			2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	**Total**			
3	**Cost**	*From Project Cost Summary sheet*										
4		Labour	18.03	122.01	53.62	66.25	7.40	-	267.31			
5		Equipment	70.02	745.54	35.17	2.91	-	-	853.64			
6		Contractors	516.75	2,110.10	852.97	682.26	75.60	-	4,237.68			
7		IT	-	0.29	1.76	0.44	-	-	2.49			
8		IPR Costs	-	-	-	-	-	-	-			
9		Travel & Expenses	2.00	13.56	5.96	7.37	0.82	-	29.71			
10	Payments to users & Contigency		451.46	-	-	-	-	-	451.46			
11		Decommissioning	-	-	-	66.00	-	-	66.00			
12		Other	-	-	-	-	-	-	-			
13		**Total**	1,058.26	2,991.50	949.48	825.23	83.82	-	5,908.29			
14												
15	**External funding**	*Any funding that will be received from Project Partners and/or External Funders - from Project Cost Summary sheet*										
16		Labour	-	-	-	-	-	-	-			
17		Equipment	-	-	-	-	-	-	-			
18		Contractors	67.36	203.01	91.13	89.79	11.32	-	462.61			
19		IT	-	-	-	-	-	-	-			
20		IPR Costs	-	-	-	-	-	-	-			
21		Travel & Expenses	-	-	-	-	-	-	-			
22	Payments to users & Contigency		-	-	-	-	-	-	-			
23		Decommissioning	-	-	-	-	-	-	-			
24		Other	-	-	-	-	-	-	-			
25		**Total**	67.36	203.01	91.13	89.79	11.32	-	462.61			
26												
27	**Licensee extra contribution**	*Any funding from the Licensee which is in excess of the Licensee Compulsory Contribution - from Project Cost Summary sheet*										
28		Labour	-	-	-	-	-	-	-			
29		Equipment	-	-	-	-	-	-	-			
30		Contractors	-	-	-	-	-	-	-			
31		IT	-	-	-	-	-	-	-			
32		IPR Costs	-	-	-	-	-	-	-			
33		Travel & Expenses	-	-	-	-	-	-	-			
34	Payments to users & Contigency		-	-	-	-	-	-	-			
35		Decommissioning	-	-	-	-	-	-	-			
36		Other	-	-	-	-	-	-	-			
37		**Total**	-	-	-	-	-	-	-			
38												
39	**Initial Net Funding Required**		*calculated from the tables above*									
40		Labour	18.03	122.01	53.62	66.25	7.40	-	267.31			
41		Equipment	70.02	745.54	35.17	2.91	-	-	853.64			
42		Contractors	449.39	1,907.09	761.84	592.47	64.28	-	3,775.07			
43		IT	-	0.29	1.76	0.44	-	-	2.49			
44		IPR Costs	-	-	-	-	-	-	-			
45		Travel & Expenses	2.00	13.56	5.96	7.37	0.82	-	29.71			
46	Payments to users & Contigency		451.46	-	-	-	-	-	451.46			
47		Decommissioning	-	-	-	66.00	-	-	66.00	Check Total = to Initial Net Funding request		
48		Other	-	-	-	-	-	-	-	in Project Cost Summary		
49		**Total**	990.90	2,788.49	858.35	735.44	72.50	-	5,445.68	**OK**		
50												
51	**Direct Benefits**	*from Direct Benefits sheet*										
52		Total	-	-	-	-	-	-	-			
53												
54												
55												
56	**Licensee Compulsory Contribution / Direct Benefits**		*from Project Cost Summary sheet*									
57		Labour	1.80	12.20	5.36	6.63	0.74	-	26.73			
58		Equipment	7.00	74.55	3.52	0.29	-	-	85.36			
59		Contractors	44.94	190.71	76.18	59.25	6.43	-	377.51			
60		IT	-	0.03	0.18	0.04	-	-	0.25			
61		IPR Costs	-	-	-	-	-	-	-			
62		Travel & Expenses	0.20	1.36	0.60	0.74	0.08	-	2.97			
63	Payments to users & Contigency		45.15	-	-	-	-	-	45.15			
64		Decommissioning	-	-	-	6.60	-	-	6.60	of Total Initial Net Funding Required		
65		Other	-	-	-	-	-	-	-	**OK**		
66		**Total**	99.09	278.85	85.84	73.54	7.25	-	544.57	Check that **Total** is = or > than		
67										Total Direct Benefits		
68										**OK**		
69	**Outstanding Funding required**		*calculated from the tables above*									
70		Labour	16.23	109.81	48.26	59.63	6.66	-	240.58			
71		Equipment	63.02	670.99	31.65	2.62	-	-	768.28			
72		Contractors	404.45	1,716.38	685.66	533.22	57.85	-	3,397.56			
73		IT	-	0.26	1.58	0.40	-	-	2.24			
74		IPR Costs	-	-	-	-	-	-	-			
75		Travel & Expenses	1.80	12.20	5.36	6.63	0.74	-	26.74			
76	Payments to users & Contigency		406.31	-	-	-	-	-	406.31			
77		Decommissioning	-	-	-	59.40	-	-	59.40	Check that Total is =to		
78		Other	-	-	-	-	-	-	-	Total Outstanding Funding required		
79		**Total**	891.81	2,509.64	772.52	661.90	65.25	-	4,901.11	**OK**		
80												
81	balance	4,854.58	0.00	1,453.13	712.15	61.08	(0.30)	0.00	4,854.58			
82	interest		0.00	31.54	10.83	3.87	0.30	(0.00)	46.53			
83									4,901.11	-	click this button to calculate the NIC funding request	
84												
85		Bank of England interest rate		0.5%		**NIC FUNDING REQUEST £**			**4,854.58**			
86		interest rate used in calculation		1.0%								
87		RPI adjustment	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/2024	2024/2025	
88		Index	267.5	275.8	284.3	293.1	302.2	311.6	321.2	331.2	341.5	
89		Annual inflation	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	

ID	Task Mode	Task Name	Duration	Start	Finish
1		**OpenLV Project**	951 days?	Mon 02/01/17	Thu 17/09/20
2		**Phase 1 - Mobilise & Procure**	138 days	Mon 02/01/17	Wed 12/07/17
3		Project Direction Issued by Ofgem	0 days	Mon 02/01/17	Mon 02/01/17
4		Western Power Distribution/EA Technology agree commercial arrangement pre-funding available	20 days	Mon 02/01/17	Fri 27/01/17
5		Mobilise Project Team	10 days	Mon 30/01/17	Fri 10/02/17
6		Funding Available for project	0 days	Mon 02/01/17	Mon 02/01/17
7		**Commercial Agreements & Project Initiation**	104 days	Mon 02/01/17	Thu 25/05/17
8		**Principal Contract**	34 days	Mon 02/01/17	Thu 16/02/17
12		**Management & Delivery Document**	24 days	Mon 02/01/17	Thu 02/02/17
17		**Partner & Supplier Contracts & Task Orders**	104 days	Mon 02/01/17	Thu 25/05/17
18		Development of partner / supplier contractual template	2 days	Mon 02/01/17	Tue 03/01/17
19		**Agreement 1 - Central IT Intrastructure & Backhaul Communications (M1)**	44 days	Wed 04/01/17	Mon 06/03/17
23		**Agreement 2 - Central IT Intrastructure & Backhaul Communications (M2 & I**	44 days	Wed 04/01/17	Mon 06/03/17
27		**Agreement 3 - Hardware Provider**	60 days	Mon 02/01/17	Fri 24/03/17
32		**Agreement 4 - RTTR Application Support**	44 days	Mon 02/01/17	Thu 02/03/17
36		**Agreement 5 - Network Security**	84 days	Mon 30/01/17	Thu 25/05/17
43		**Agreement 6 - Community Engagement Specialist**	84 days	Mon 02/01/17	Thu 27/04/17
50		**Agreement 7 - Marketing/PR/Dissemination**	84 days	Mon 02/01/17	Thu 27/04/17
57		Contractual Negotiations Complete	0 days	Thu 25/05/17	Thu 25/05/17
58		**Customer Engagement Plan**	44 days	Fri 12/05/17	Wed 12/07/17
64		**Data Protection Strategy**	44 days	Fri 12/05/17	Wed 12/07/17
71		**Phase 2 - Design & Build**	951 days	Mon 02/01/17	Thu 17/09/20
72		**Marketing**	813 days	Thu 13/07/17	Thu 17/09/20
78		**Assess LV-Cap™ OS (from InnovateUk)**	54 days	Fri 17/02/17	Wed 03/05/17
81		**LV Network Assesment**	194 days	Fri 17/02/17	Wed 15/11/17
90		**Develop (FAT) & (SAT) test documentation for the OpenLV Solution**	24 days	Fri 26/05/17	Wed 28/06/17
93		**Development of Loadsense Application**	70 days	Thu 04/05/17	Wed 09/08/17
97		**Assess Market Potential for Method 2 - Customer Engagement**	65 days	Fri 26/05/17	Thu 24/08/17
101		**Assess Market potential for Method 3 - OpenLV Extensibility**	65 days	Fri 26/05/17	Thu 24/08/17
105		**Detailed Trial Design**	20 days	Thu 16/11/17	Wed 13/12/17
107		**Central Systems Architecture (incl FAT & SAT)**	182 days	Tue 07/03/17	Wed 15/11/17
114		**Network Security Evaluation**	140 days	Thu 21/09/17	Thu 12/04/18
120		**Supply Intelligent Substation & Switch devices**	188 days	Mon 27/03/17	Wed 13/12/17
127		**Agree Installation Procedures & Install Intelligent Substation devices & Switches (Method 1)**	288 days	Mon 02/01/17	Thu 15/02/18
136		**Phase 3 - Trial, Consolidate & Share**	782 days?	Thu 24/08/17	Thu 17/09/20
137		Phase 1 Complete	0 days	Thu 17/09/20	Thu 17/09/20
138		**Method 1: Network Capacity Uplift**	310 days	Fri 16/02/18	Fri 03/05/19
143		**Method 2: Customer Engagement**	489 days	Thu 24/08/17	Fri 26/07/19
153		**Method 3: OpenLV Extensibility**	509 days	Thu 24/08/17	Fri 23/08/19
163		**Maintenance**	350 days?	Fri 16/03/18	Fri 26/07/19
165		**Monitoring of trials**	450 days	Thu 16/11/17	Fri 23/08/19
166		**Procure & setup data storage and analysis PC**	450 days	Thu 16/11/17	Fri 23/08/19
167		**Data management**	26 days	Thu 16/11/17	Thu 21/12/17
174		**Data Analysis**	280 days	Fri 20/07/18	Fri 23/08/19
175		**Method 1**	220 days	Fri 20/07/18	Fri 31/05/19
179		**Method 2**	10 days	Mon 15/07/19	Fri 26/07/19
181		**Method 3**	10 days	Mon 12/08/19	Fri 23/08/19
183		**Decommissioning**	292 days	Mon 29/07/19	Wed 16/09/20
184		**Data management**	36 days	Wed 29/07/20	Wed 16/09/20
187		**Equipment**	60 days	Mon 29/07/19	Fri 18/10/19
191		**Management & SDRC**	945 days?	Mon 02/01/17	Wed 09/09/20
192		**Project Management**	872 days?	Mon 02/01/17	Fri 29/05/20
196		**Six Month Project Progress Reports (PPR)**	655 days	Mon 05/06/17	Thu 02/01/20
227		**Project Closedown Report**	816 days	Fri 30/06/17	Wed 09/09/20
249		**SDRC Deliverables**	666 days	Mon 18/09/17	Thu 30/04/20
250		**SDRC-1: Specification, Design and Factory Testing of the overall OpenLV solutic**	30 days	Mon 18/09/17	Fri 27/10/17
255		**SDRC-2: Identify Networks, Trial Design & Assess Market (M2 and M3)**	113 days	Thu 14/12/17	Wed 30/05/18
260		**SDRC-3: Learning from Deployment and Standard Guidelines for Application Development**	25 days	Fri 21/12/18	Fri 01/02/19
265		**SDRC-4: Project Trial Learning for All Methods**	30 days	Fri 13/12/19	Fri 31/01/20
270		**SDRC-5: Knowledge Capture, Dissemination & Transferring the OpenLV Solution to Business as Usual**	58 days	Tue 11/02/20	Thu 30/04/20
275		**SDR Application Report**	65 days	Fri 01/05/20	Thu 30/07/20



Project: Appendix C - OpenLV Pro
Date: Fri 14/10/16

Task | Split | Milestone | Summary | Project Summary | External Tasks | External Milestone | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | Deadline | Progress | Manual Progress

Appendix D - RISK REGISTER

Risk Ref. No.	Risk Status	Risk Frequency	Owner	High Level Definition "There is a risk that..."	Impact	Probability	Proximity	Rating	Raised by	Raised on	Risk Start Date	Target Date	Last Updated	Review Date	Cause "...because of..."	Effect "...leading to..."	Mitigation Action Plan	Signs that the risk is about to occur or become an Issue
Next No.	Dropdown list	1=Timebound/One-off 2=Ongoing/Recurring 3=Not started	Responsible for mgmnt	Details of the Risk	Score 1-5 (see guide)	Score 1-5 (see guide)	Score 1-5 (see guide)	Auto Calculated	Who raised the Risk?	when was it raised?	When does this risk become relevant (eg: installation risks will not occur until the after the procurement process)	Target Date for Resolution	Last date the risk was updated	Date risk rating should be reviewed	What will Trigger the Risk?	What will happen if it occurs?	How will this Risk be avoided?	
R001	Raised	3	RP	There is a risk that the development of LV-CAP from the InnovateUK project is delayed.	4	2	2	16	RP	18/05/2016	01/01/2017	31/01/2017	18/05/2016	01/01/2017	Dependency on InnovateUk	The OpenLV solution will not be able to be implemented in the project plan leading to a formal change request to Ofgem.	Regular contact with the InnovateUk project team, agreement of timescales for OpenLV implementation and building in tolerance to enable some slippage in dates if the risk is realised.	Lack of communication or buy in from the InnovateUk project team.
R002	Raised	3	RP	There is a risk that the development of LV-CAP from the InnovateUK project does not provide the OpenLV project with the functionality that is required.	4	2	2	16	RP	18/05/2016	01/01/2017	31/01/2017	18/05/2016	01/01/2017	Dependency on InnovateUk	Re-work by the InnovateUk project team and delay in the OpenLV implementation programme or ultimately a formal change request to Ofgem.	Written agreement of the OpenLV requirements that are agreed by the InnovateUk project teram, agreement of timescales for OpenLV implementation and building in tolerance to enable some slippage in dates if the risk is realised.	Lack of communication or buy in from the InnovateUk project team. Reluctance to sign written agreement.
R003	Raised	3	RP	There is a risk that the development of the WeatherSense application form the InnovateUk project is delayed.	4	2	2	16	RP	18/05/2016	01/01/2017	31/01/2017	18/05/2016	01/01/2017	Dependency on InnovateUk	Trials of the transformer RTTR for network capacity uplift are delayed (Method 1).	Regular contact with the InnovateUk project team, agreement of timescales for OpenLV implementation and building in tolerance to enable some slippage in dates if the risk is realised.	Lack of communication or buy in from the InnovateUk project team.
R004	Raised	3	RP	There is a risk that the development of WeatherSense from the InnovateUK project does not provide the OpenLV project with the functionality that is required.	4	2	2	16	RP	18/05/2016	01/01/2017	31/01/2017	18/05/2016	01/01/2017	Dependency on InnovateUk	Re-work by the InnovateUk project team and delay in the trials for Method 1 or ultimately a formal change request to Ofgem.	Written agreement of the OpenLV requirements that are agreed by the InnovateUk project teram, agreement of timescales for OpenLV implementation and building in tolerance to enable some slippage in dates if the risk is realised.	Lack of communication or buy in from the InnovateUk project team. Reluctance to sign written agreement.
R005	Raised	3	RP	There is a risk that the integration of LV-CAP with generic hardware and the use of Alvin switching devices is more complex than expected and delays the OpenLV programme.	4	3	2	24	RP	18/05/2016	01/01/2017	31/01/2017	18/05/2016	01/01/2017	Lack of planning and understanding between EA Technology departments/staff.	The OpenLV solution will not be able to be implemented in the project plan leading to a formal change request to Ofgem.	Written and signed agreement of the OpenLV solution requirment by all departments within EA Technology.	Lack of communication or buy in from the relevant development teams. Reluctance to sign written agreement.
R006	Raised	3	RP	There is a risk that the development of the Nortech communications container and associated management of the software/devices does not function as expected.	4	2	2	16	RP	18/05/2016	01/01/2017	31/01/2017	18/05/2016	01/01/2017	Selection of hardware and associated software and or protocols that do not operate as expected.	A significant number of site visits are required to complete software updates.	Robust testing of the communications and IT infrastructure before widescale roll out.	Reluctance from Nortech to share information and/or delays in factory acceoptance testing or dis-agreement on tests for accepotnace testing.
R007	Raised	3	RP	There is a risk that the communications between the distributed devices and the third party platform is not robust and trial data is lost.	4	2	2	16	RP	18/05/2016	01/01/2017	31/01/2017	18/05/2016	01/01/2017	Selection of hardware and associated software and or protocols that do not operate as expected.	A significant number of site visits are required to retrieve data.	Robust testing of the communications and IT infrastructure before widescale roll out and specification of sufficient memory in the ghardware to store relevant data.	Failure of FAT and/or SAT.
R008	Raised	3	RP	There is a risk that the last mile communications between the distributed LV-CAP devices and the switches on the LV network is not robust and the devices cannot be switched as expected.	4	3	2	24	RP	18/05/2016	01/01/2017	31/01/2017	18/05/2016	01/01/2017	Selection of hardware and associated software and or protocols that do not operate as expected.	Trials for Method 1 may be delayed and trials may be halted due to dsafety concerns for operational staff.	Due diligence when seecting the method of communications and the associated software/hardware devices.	Lack of buy in and confidence from members of the EA Technology development team.
R009	Raised	3	RP	There is a risk that the automated switching and meshing of the network leads to safety issues for operational staff.	5	2	1	10	RP	18/05/2016	01/06/2017	30/03/2017	18/05/2016	01/06/2017	Poor design of the OpenLV solution and/or inadequate documentation and training for operational staff. Kit needs to be installed.	Ultimately assets being energised when they are not expected to be creating a H&S risk.	The design of the OpenLV Solution will be independently reviewed by WPD operational staff to ensure it is fit for purpose.	Lack of agreement or sign off of the OpenLV Solution.
R010	Raised	3	RP	There is a risk that, if the network was meshed in a network fault scenario, that damage could be caused to network assets.	1	2	1	2	RP	18/05/2016	01/06/2017	30/03/2017	18/05/2016	01/06/2017	Poor design of the Open LV solution and instigation of project trials. Kit needs to be installed.	Damage to networks assets.	Accounted for in the design of the overall OpenLV solution (circuit breakers at the relevant substation(s)) providing protection in a fault scenario.	Lack of inclusion of relevant protection in the design of the OpenLV Solution.
R011	Raised	1	RP	There is a risk that the FSP is not written in the right way to show it meets all the Ofgem requirments.	3	2	4	24	RP	18/05/2016	18/05/2016	08/08/2016	13/07/2016	03/08/2016	Lack of understanding of the Ofgem requirments and/or inadequate review.	The OpenLV bid is not successful.	Review team have the skills/experience/knowledge requeired to assess the written bid against the Ofgem criteria (governance document). Review process agreed in advance. Open sharing of docuemntation and progress between WPD and EA Technology.	Issues flagged by either WPD or EA Technology bid team.
R012	Raised	1	RP	There is a risk that the CBA for Method 1 does not score the project highly enough to gain the agreement of Ofgem (CBA is not possible for Methods 2 and 3)	3	2	4	24	RP	18/05/2016	18/05/2016	08/08/2016	13/07/2016	03/08/2016	The potential benefits of network capacity uplift are limited in size and/or scale.	The OpenLV bid is not successful.	Work to be undertaken by experienced staff early enough to re-run and re-assess if required.	Issues flagged by either WPD or EA Technology bid team.
R013	Raised	1	RP	There is a risk that the FSP is not developed in time for the 8th August deadline (bid and financials).	3	1	4	12	RP	18/05/2016	18/05/2016	08/08/2016	13/07/2016	10/08/2016	Lack of resource and/or effective planning.	The deadline for submission is not met leading to the project not being awarded.	Regular reviews of progress and allocation of resources required by EA Technology.	Issues flagged by either WPD or EA Technology bid team.
R014	Raised	1	RP	Relevant partners/suppliers cannot be engaged to enable delivery of the OpenLV project.	5	1	4	20	RP	18/05/2016	18/05/2016	08/08/2016	13/07/2016	03/08/2016	Lack of or late information regarding partner/supplier roles provided to the wider industry.	It won't be possible todeliver the planned scope of works.	Relevant information circulated in a timely manner through Achilles, NIC Collaboration Portal and LinkedIn.	Lack of progress shown by the EA Technology bid team.
R015	Raised	1	RP	There is a risk that the competitive tender process does not, in the view of Ofgem, provide value for money.	4	1	4	16	RP	18/05/2016	18/05/2016	08/08/2016	13/07/2016	03/08/2016	Ofgen review of costs as part of the bid process.	The project may not be awarded.	EA Technology to follow standard WPD procurement processes.	Review of finances shows that the costs are higher than expected.
R016	Raised	3	RP	There is a risk that funding cannot be secured for the development of 'Community Apps'.	5	3	2	30	Ofgem	04/10/2016	24/08/2017	31/10/2017	14/10/2016	24/08/2017	Community groups are unable to source funding for the development of suitable applications.	The project will be unable to demonstrate the benefit to communities.	WPD will fund the development of a single application, potential for use in multiple locations if alternative funding sources cannot be identified.	Early attempts by communities and the CES do not identify any appropriate sources of funding.

Appendix E – Contingency Plans

A contingency plan has been developed for the significant risks on the Risk Register. All risks will be continually monitored and were appropriate, pre-emptive actions will be implemented to prevent the risk escalating to an issue. Where prevention is not possible, mitigating actions will be deployed to reduce the impact as far as practicable.

R003: There is a risk that the integration of LV-CAP™ with generic hardware and the use of Alvin™ switching devices is more complex than expected, and delays the OpenLV program.
Mitigation • The provision of a working LV-CAP™ software platform, successfully integrated with the Alvin™ hardware will be agreed via internal contracts. • Use off-the-shelf components where possible, to minimise development required in parallel with OpenLV project. **Contingency** • Re-evaluate technology requirements. • Reduce the number of technology installations.
R006: There is a risk that the last mile communications between distributed LV-CAP™ devices and the switches on the LV network is not robust and the devices cannot be switched as expected.
Mitigation • Undertake due diligence when selecting trial locations and implementing communication techniques (e.g. mobile phone signal confirmation) **Contingency** • Implement cabled communications between devices as a last resort.
R009: There is a risk that the Loadsense application will take longer to develop to a suitable, stable state.
Mitigation • Begin work on the Loadsense application (Network Control App) as soon as practicable after contracts are agreed. • Ensure involvement from all relevant individuals within Western Power Distribution and EA Technology at early stages. **Contingency** • Implement a basic control application that initiates network meshing based on fixed criteria.
R023: There is a risk that the contracts cannot be agreed between all stakeholders.
Mitigation • Ensure all concerns raised by the expert panel are addressed appropriately, either by formal responses or through incorporation into the bid submission documentation. • EA Technology to be involved in any contractual negotiations between WPD and Ofgem to ensure it can sign onto any risks posed by that contract. **Contingency** • If contractual agreement cannot be reached between Ofgem / Western Power Distribution or Western Power Distribution / EA Technology then no contingency plan is possible • If contractual agreement cannot be achieved between EA Technology and the Project suppliers then an invitation to tender will be re-issued and involvement from other companies will be sought.

nortech

Specialist Monitoring Products and Systems

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Mr. Richard Potter
Senior Consultant
EA Technology
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Chester
CH1 6ES

3rd August 2016

OpenLV – Proposed Project – Nortech Involvement

Dear Richard,

Nortech Management Ltd. is a long established provider of specialist monitoring products to utilities, generators and system integrators. We already work with multiple UK DNOs to deliver system information from multiple monitoring locations to the DNO control rooms via our iHost platform. This platform has been used to support the development of the LV-CAP™ platform.

The potential of the LV-CAP™ platform to deliver wide reaching benefits to the electricity industry and customer is significant and our partnership with EA Technology in the development of the platform demonstrates our commitment to this.

The platform also has the potential to deliver benefits to customers through providing greater transparency of how the network operates as well as to academia and other commercial companies. Improved information and research relating to the energy industry, and a reduction in the cost of deployed equipment will ultimately deliver further value back to customers.

It also provides Nortech the ability to deliver value to the OpenLV Project, and demonstrate the ability of the trial platform to integrate, via the iHost system, into DNO control system if this were deemed to be required.

If the OpenLV Project is successful in securing funding, Nortech will provide support to the project relating to the deployment of the trial equipment and provision of the associated communications infrastructure for monitoring and control of the LV-CAP™ devices.

As a consequence of the above, Nortech supports the goals of the OpenLV Project and if the funding request is approved, we look forward to working with Western Power Distribution and EA Technology.

Yours sincerely

Julian Brown
Managing Director

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EA Technology Limited,
Capenhurst,
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CH1 6ES

For the attention of Richard Potter

30 July 2016

Dear Richard,

Open LV – Proposed Lucy Electric involvement in Open LV

Lucy Electric is a long established supplier of electrical switchgear and automation equipment to Distribution Companies in the UK and worldwide. Employing over 1200 staff in the UK, Middle East and Far East, these systems include both pole and ground mounted MV and HV switches as well as a family of Remote Terminal Units (known as Gemini) and SCADA network management systems. More recently, in December 2015, Lucy Electric acquired the Selex ES Ltd interests in the GridKey low voltage monitoring system, the assets and IP for GridKey are now held in Lucy Electric GridKey Ltd. GridKey has been provided as part of a number of LCNF Tier 1 and Tier 2 projects and more recently Lucy Electric GridKey Ltd are project partners on several NIA projects.

GridKey is designed to produce actionable information which brings direct value to the Distribution Network Operators by reducing operating costs, improving service to the consumer and assisting in the planning process for asset maintenance and replacement. GridKey consists of monitoring equipment that is installed in the substation and a cloud based secure data centre which collects all the data generated and can run advanced analytics and the actionable information is generated through a combination of locally generated alarms and reports generated by the data centre. Discussions with the DNOs and others have highlighted three needs –

- to be able to get information from the GridKey system to the operations and planning staff who need that information in a timely manner
- the ability to be able to combine information from various sources to produce enhanced actionable information
- that other Government agencies, commercial organisations and consumers can benefit from access to the data generated by GridKey and other systems.

Lucy Electric GridKey supports the aims of the Open LV project as it provides a potential cost-effective solution to these three needs. Creating a GridKey container into which data from the monitoring system can be transferred would allow information to be passed into the DNO systems using the iHost communications container. Creating a GridKey communications container would allow both GridKey and other systems data to be sent to the GridKey data centre hosted in the cloud for additional analytics and also to provide a portal outside of the DNO firewalls which would allow third party access to the data from GridKey and any other systems connected.

System integration is a core skill of Lucy Electric ranging from simply integrating products to complete SCADA control systems supply consisting of sensing, IT and radio communications, processing, switchgear and operator displays.

EA Technology and Lucy Electric GridKey have entered into technical and commercial discussions for the supply of a number of items and services and have agreed a letter of intent to cover the following:

- Development of a GridKey data container
- Development of a GridKey Data Centre communications container for use on Methods 2 (Community Engagement) and Method 3 (OpenLV Extensibility)
- Provision of the GridKey cloud based data centre services to retrieve data for Methods 2 and 3
- Provide support to extract and display relevant LV network data to support Methods 2 and 3
- Systems integration and engineering support
- Input to help transition into Business as Usual

Lucy Electric looks forward to working with Western Power Distribution and EA Technology on this important programme.

Yours sincerely

Paul Beck
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Mr Richard Potter
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Reply to Suzanne Wilson
Bristol City Council
Bristol Futures, PO Box 3176, Bristol,
BS3 9FS

Telephone 0117 35 74714
07469 400 781

E-mail Suzanne.wilson@bristol.gov.uk

Date 27 July 2016

Dear Richard

I am writing to express my support for the OpenLV Project that EA Technology is submitting to Ofgem in partnership with Western Power Distribution.

Bristol City Council has championed increase renewables and reduction in energy demand for over a decade, the first UK council to introduce wind turbines, challenging targets to be carbon neutral by 2050, a community solar energy fund, support for electric vehicals throughout the city, setting up our own municipal energy company – Bristol Energy, and working with Western Power Distribution to discover how we can address fuel poverty, meet carbon reduction targets and reduce demand on the grid through our hugely successful SoLa Bristol Project.

We work in partnership with a strong network of organisations committed to addressing climate change, over 900 public and private organisations are part of Bristol Green Capital partnership and Bristol was named European Green Capital 2015. The network is particularly strong around energy with Bristol Energy Network working across the city to support community energy groups share good practice, ideas and support one another. Bristol and Bath also has the strongest IT cluster outside of London, Bristol hosts the Engine Shed, part of the global number one university business incubator - Setsquared, Bristol Robotics Laboratory part of the four UK driverless cars trials, and Bristol Is Open a world-leading smart city infrastructure to allow experiental networking and testing of IOT in the living laboratory of the City. Bristol is an Open Data Institute (ODI) node and has over 700 members across the south west region who are interested in the publication and use of open data. Bristol City Council works closely with this group to encourage the use of open data, and in particular has produced apps to address congestion issues – such as encouraging use of public transport

We are particularly interested in how the opportunity of increasing data around energy can move us toward reduction in carbon, increase renewables and addressing fuel poverty A Smart Energy Collaboration group, convened by the Centre for Sustainable Energy, including Bristol City Council and Western Power Distribution met throughout 2015 and produced a report[1]setting out a series of actions to move us toward that goal. Bristol City Council is taking forward a number of those actions through its European funded project Replicate in East Bristol where it will pilot, amongst other things, home automation, smart appliances and an energy demand management platform. The 100+ homes involved in this pilot will be a key group who can engage with the benefits of shifting their energy demand at peak times to maximise savings through a time of use tariff, and reduce carbon emissions by reducing need for additional energy generation. Our Bristol Energy company also has plans to trial a time of use tarif.

As one of the UK's leading smart cities[2] we are supportive of this exciting initiative and have every confidence in this proposed bid and the ability of energy and data experts in the City to capitalise on the opportunity of valuable data about energy use at substation level, as part of a wider move to make cities sustainable and grow our smart, green, connected economy.

Yours sincerely

Suzanne Wilson
City Innovation Manager
Bristol City Council

[1] https://www.cse.org.uk/downloads/reports-and-publications/policy/community-energy/insulation-and-heating/planning/renewables/towards-a-smart-energy-city-maping-path-for-bristol.pdf "Bristol smart energy city collaboration. Towards a Smart Energy City: mapping a path for Bristol" CSE, December 2015

[2] http://www.huawei.com/en/news/2016/5/UKs-leading-smart-cities "London and Bristol crowned UK's leading smart cities" Huawei 2016

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25 July 2016

Dear Richard,

Re: OpenLV Project

Thank you for your recent communication regarding the OpenLV project, which sounds very interesting..

The Sustainability Team have been working with our academic colleagues in Engineering for two years now on techniques and technologies aimed at making best use of a more constrained grid, including participation in an InnovateUK project called IODiCUS. We have been working on different methodologies for varying demand in response to national and local grid fluctuations.

We have a variety of sites and buildings connected at LV. We currently know nothing about how we contribute to grid congestion locally. It would be very interesting to see how, as a user with a varied LV portfolio, our demand could be modified dynamically to make better use of existing network infrastructure. We understand how important this will be in future as local grids accommodate electric heating, more intermittent renewables, electrical storage and charging points for electric vehicles.

We would also look forward to promoting the opportunity of working with students who may wish to study, manipulate and use this data as part of projects to develop apps.

Yours sincerely,

Dr John Brenton
Sustainability Manager (Analysis)

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3 August 2016

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Statement of Support

Dear Mr Potter,

On behalf of the Energy Research Lab at the University of Reading, I am writing to express my strong support for the OpenLV project, led by EA Technology, to be submitted to the Electricity Network Innovation Competition. The OpenLV project will provide an accessible platform for innovation in LV networks that will benefit network operators, energy companies and ultimately energy consumers.

The Energy Research Lab is a constituent part of the Technologies for Sustainable Built Environments (TSBE) Centre within the School of the Built Environment at the University of Reading, and falls under the Energy and Environmental Engineering research theme. The school has a strong orientation towards interdisciplinary 'real-world' problems, and is ranked 3rd in the UK for the impact of its research in architecture, built environment and planning, including intelligent energy systems.

The Energy Research Lab has been actively involved in research on solutions for managing Low Voltage (LV) distribution networks that are rapidly evolving with the uptake of Low Carbon Technologies (LCTs) and changes in demand behaviour. As academic partners on the New Thames Valley Vision, an LCNI project with SSEPD, the Energy Research Lab have conducted extensive modelling of LV networks and has developed control algorithms for distributed energy storage. We recognise the value of actively managing the operation of LV networks for distribution network operators and their customers. Furthermore, previous and current research carried out by our PhD students has specifically looked at applying distributed intelligence to manage the power balance and support networks through energy storage and demand management.

Much of our research relies on the visibility of LV networks, through access to monitoring data and other operational information, to ensure that our control algorithms are able to maximise improvement to the network operation and benefit to the users of the network. The OpenLV platform can provide this visibility. Specifically, the work within *Method 3: OpenLV Extensibility* could be the key component to enable innovation and deployment of intelligent distributed solutions by providing pathways for both academics and companies to create novel control schemes for network assets. Managed competition will yield greater innovation and better solutions. Furthermore, the OpenLV platform can be used to provide further visibility on the operation of LV distribution networks more widely, including to energy consumers and policy makers.

In summary, I believe that the OpenLV project will provide real value to a wide range of stakeholders and contains key elements not present in existing or previous projects, such as the provision of an open platform for innovation. Specifically, I believe that the OpenLV project will provide unique and exciting research opportunities at the University of Reading that will lead real impact. I wish the bid every success and look forward to engaging with the OpenLV platform once the project commences.

Yours sincerely,

____

Dr Ben Potter

Oxford Mathematics

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01 August 2016

Mr. Richard Potter
Senior Consultant
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Dear Mr. Potter

I am writing to state my complete support for the OpenLV project, a partnership between EA Technology and Western Power Distribution (WPD), for the Electricity Network Innovation Competition.

I have been working with Scottish and Southern Electricity Power Distribution (SSEPD) for over two years as part of the New Thames Valley Vision project, a low-carbon network fund (LCNF) project. This work has involved close collaboration with EA Technology, the members of which present a clear and strategic outlook, unifying academic visions with practicalities.

EA Technology has the management and structure in place to ensure successful collaborations with a wide range of partners - with the focus on real-life applicability. As a company, EA Technology are forward facing and keen to implement changes which are flexible to match evolving electricity demands, and that capitalise upon technology available.

This ethos is demonstrated by their OpenLV project, which targets a range of areas that aim to engage with communities and academic institutions. The future of electricity consumption is changing, and a stronger connection between customers and industry is imperative. Engaging with communities and academic institutions not only builds understanding of domestic electricity behaviour, but it builds customer understanding of the network and is conducive for building trust. Nonetheless, this engagement must be done in a non-obtrusive, non-time-consuming manner. Therefore, the proposal of developing new Apps is an excellent approach.

In conclusion, I support the efforts of EA Technology as they seek funding to support the OpenLV project. This project will enable them to continue finding visionary ways to ensure electricity customers encur minimum costs whilst their electricity behaviour continues to make dramatic changes.

Yours sincerely

Dr. Tamsin E. Lee
https://www.maths.ox.ac.uk/people/tamsin.lee

Appendix G – Technical Description of the Methods

Method 1: LV Network Capacity Uplift

What happens currently? Today, LV networks are largely managed passively and limited 'intelligent' technologies are installed in distribution substations. As a result, DNOs have limited real time or historic demand data for LV distribution substations.

Triggers for network reinforcement are based on high Maximum Demand Indicators (MDIs), the number of faults, customer complaints or blown fuses. Reinforcement of the LV network is based on asset replacement or re-arrangement. To date there has not been a need for a different approach as network load has remained relatively static. With the uptake of LCTs this is changing, therefore new approaches are needed.

How will this Method release additional capacity? This Method will use two techniques in concert, ultimately to send control signals to actuators on the network:

> ***Thermal Rating of the Transformer:*** Existing equipment ratings are based on assumptions about the cyclic nature of the connected load. These are conservative and often mean that the "nameplate" rating of a transformer may be significantly below what it can actually deliver. Real Time Thermal Rating (RTTR), also known as Dynamic Thermal Rating (DTR), of the local HV/LV transformer has been shown to release additional capacity. In this Method RTTR of the local LV transformer will be provided by a 'DTR App' developed by Manchester University prior to this project.
>
> ***Meshing the network:*** Meshing of the LV network is not a new concept, with previous deployments in the likes of FUN-LV and Smart Street. These projects have shown that meshed operation of the LV network could increase its capability to support higher penetrations of LCTs.

How will this Method be Trialled? Following an assessment of WPD's networks, 60x LV-CAP™ devices will be installed at candidate distribution substations. This selection will be on the basis of similarity to the LV Network Templates, developed previously by WPD in order to ensure maximum applicable learning to the wider GB electricity network. The Method 1 Trials will ideally be deployed on eight of the ten network types, excluding 'Industrial Flats' and 'Lighting'.

Templates	**Descriptions**
1	**High I&C 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 I&C Dominance (~90%)**
7	**Modest Domestic Dominance (~60%) (Rural)**
8	Industrial Flat
9	**Domestic Economy 7 Dominance (~65%)**
10	Lighting

A 'Network Control App' will assess the load on the LV network and automatically provide additional network capacity via the 'Dynamic Thermal Ratings' and 'Network Meshing' Apps.

Network load data will be collated along with the instructions provided by the 'Network Control App' and this information will be sent back to the 'Application Deployment Server'. The project team will then analyse this data to determine the level of capacity uplift that can be provided.

What outputs will be delivered by trials of this Method? Technical report(s) including:

- A detailed description of how LV networks can be assessed to identify which network locations would benefit from the installation of the LV-CAP™ 'Intelligent Substation Devices' (Section 9, SDRC-2);
- An assessment of how much additional capacity can be delivered by this Method. This will include Dynamic Thermal Rating in isolation, Network Meshing in isolation and both techniques combined (Section 9, SDRC-4); and
- An assessment of the costs and benefits of deploying the **OpenLV** platform against the traditional methods of reinforcing the LV network (Section 9, SDRC -5).

What are the benefits of this Method? The Method will provide a low cost flexible alternative to traditional reinforcement whilst maintaining the long term reliability and efficiency of the LV network. It is expected that it will provide approximately 25% additional capacity through Dynamic Thermal Rating of the HV/LV transformer and approximately 25% additional capacity through Network Meshing. The benefits from this Method would flow to customers via the DNO, such as: reduced DUoS resulting from lower LV network reinforcement costs; or lower connection costs for new developments.

Method 2: Community Engagement

What happens currently? Today, little or no data can be made available from the LV Network to organisations or individuals wanting to participate in Community Energy Schemes. In addition, while smart meters provide individuals feedback on the consequences of their behaviours with respect to energy usage in the home, there is no feedback mechanism for groups of customers acting in concert as part of a community energy scheme. WPD are in dialogue with a number of community groups who desire this functionality, but currently there is no economic way that it can be provided by the DNO.

How will this Method test community engagement? **OpenLV** will utilise two external specialists to ensure engagement both in and beyond the project. The first of these will act as the Community Engagement Specialist and will be responsible for engaging with the community to promote the availability of the substation intelligence platform and associated LV network data. This company 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.

Relevant learning from engagement via previous projects including Sola Bristol, LV Templates and FALCON will be utilised where applicable to maximise learning from this Method.

Up to 10 LV-CAP™ devices will be deployed at specific HV/LV substations to meet the community's needs. Access to relevant data will be provided to communities via the Internet.

The funding required to develop the specific Apps will be raised outside of the project budget, for example, public funding or the private sector.

Following the trial, the second specialist will be responsible for Economic Assessment and Extrapolation of Community Learning to review performance of the community case studies and support broader adoption by:

- Analysing 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.
- Testing the learning tools with communities outside of the project trial to ensure they are fit for purpose.

What outputs will be delivered by this Method? The Community Engagement Method will support the development of new Apps and determine the appetite at present amongst communities for the availability of information about their local network. Importantly it will, through economic analysis, evaluate the effectiveness and replicability of the approaches and will produce materials and tools to support other communities in adopting these approaches across Great Britain. The learning generated from developing these Apps and engaging with communities will be collated and reported (Section 9, SDRC-4 and SDRC-5).

What are the benefits of this Method? The **OpenLV** project will provide feedback to ensure that community-led low carbon projects are successful by providing community engagement to get the right level of buy-in and showcase how the provision of LV network data can provide benefits for communities and DNOs by recognising behaviour patterns that lower network costs while simultaneously enabling the uptake of LCTs.

The benefits from this Method will flow directly to customers or community groups.

What benefits have been seen from previous community energy schemes? The Community Energy Strategy Report, published by DECC, includes the following examples[1]:

- *Amberley Primary School in Newcastle* was able to generate 25% of the school's electricity requirements through installing solar panels and a wind turbine in a project funded by the Big Lottery Fund. Previously the school had been spending around £8,000 per year on electricity;
- *Ashton Hayes Going Carbon Neutral in Cheshire* managed to reduce energy consumption by 23% in three years providing savings to households of up to £300 per year, through encouraging behaviour change and energy efficiency measures; and
- Energy assessments undertaken on 119 households under the *Warming Barton project in Oxford*, funded by DECC's Pioneer Places Green Deal pilot scheme, recommended 579 energy efficiency measures, which offer potential savings of £450 per household.

Method 3: OpenLV Extensibility

This Method will provide OpenLV as a secure platform to third parties for them to develop and release their own Apps offering new services to DNOs and customers alike.

What happens currently? Today, there are limited solutions deployed on the LV network. However, as volumes of LCT increase, we expect the numbers of solutions to increase

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[1] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/275163/20140126Community_Energy_Strategy.pdf

dramatically. Using today's technology, these would be deployed across multiple proprietary (vendor specific) systems, which would be both inefficient and expensive. This Method will enable DNOs to source innovative algorithms and/or applications from multiple vendors, at relatively low cost, and deploy them on a single device located at the HV/LV substation(s).

*How will this Method enable **OpenLV** Extensibility?* 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.

The 'third party developer API' will be shared allowing interested organisations to develop their Apps on the common platform. Up to 10 LV-CAP™ devices will be available for use on the LV network for this purpose and access to relevant data will be provided via the 'Cloud Based Hosted Platform'. Sending relevant data back to this platform, instead of the 'Application Deployment Sever' for Method 1, showcases the open nature of the Solution.

The funding required to develop the specific Applications will be raised outside of the project budget, for example, via the private sector or academic funding.

What outputs will be delivered by the application of this Method? This Method will result in a number of new Apps being developed with a range of companies or research organisations. Through these, it will demonstrate the effectiveness of the LV-CAP™ platform to add value through means other than meeting DNO requirements. The learning generated from developing these Apps will be collated in a report outlining how the **OpenLV** platform and associated LV network data can be used by 3rd Parties (Section 9, SDRC-4).

What are the benefits of this Method? There are now many examples of open-data competitions run by data-owning companies (in this case WPD) where benefits are shared with the producers of value-realising analytics or through Apps but the innovation risk and cost is often borne by the producer not the data-owner.

It is difficult to predict the potential economic benefits of opening up LV data as proposed. The full range of applications to which it would be available are extensive. Nevertheless, the economic and social value of opening up data for access and use by third parties to serve their needs or market initiatives is well established (See: http://theodi.org/the-value-of-open-data). Typically, the innovation is nearly always funded from outside the data 'owner' while often producing common benefits and/or direct value for them.

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.

How do these Methods work together?

OpenLV's platform Operating System (LV-CAP™) is the enabler for all three Methods. Ultimately each Method could be deployed in isolation, however it is envisaged that deployment will be initially DNO led for DNO purposes (either LV monitoring or control). Once deployed, the DNO would have the opportunity to offer the data / platform up to third parties, who in turn can offer further value-add services on the same platform.

The control algorithms defined in Method 1 are challenging in a highly decentralised world. In order to manage the risk associated with this task, EA Technology is keen to prove this, using its own equipment. Once deployed, the broad methodology will be shared. The inclusion of engagement with communities (Method 2) and the supply chain including non-energy companies (Method 3), adds significant value to the project – showing a life beyond innovation funding.

Appendix H – Technology Overview

The OpenLV Solution uses the following core components:

- **Intelligent Substation Devices**: These devices will be physically located in the substation and are designed to monitor the LV network and host multiple Apps that can be developed by any software developer;
- **Application Deployment Server**: Provides management of the distributed substation devices and enables new Apps to be deployed remotely with no need for on-site visits. This Server will also enable relevant data to be extracted for the project trials for Method 1; and
- **Cloud Based Hosted Platform**: Enables data to be extracted, utilised and presented for community groups and 3rd Party Developers for Methods 2 and 3.

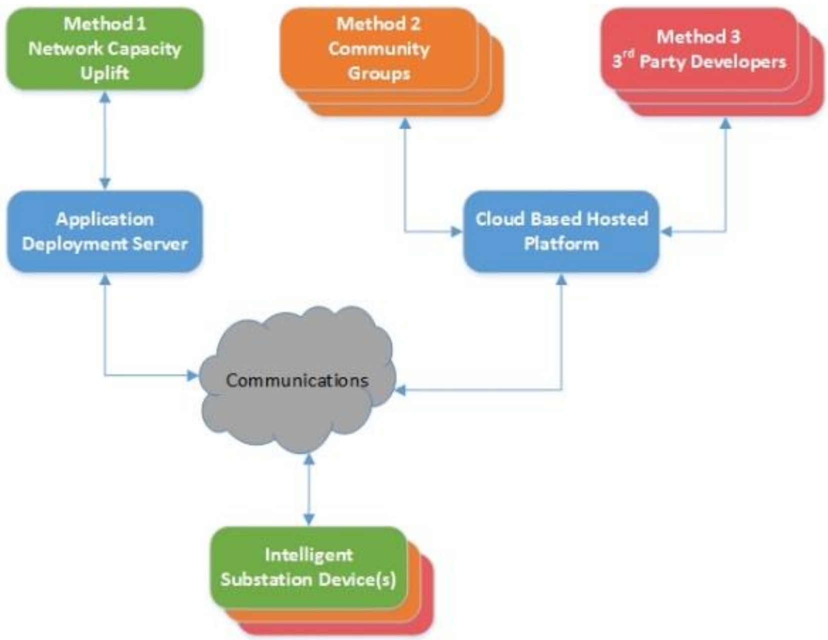


Figure 1: Overview of OpenLV Core Components

Each of the three Methods have been selected to trial specific features to demonstrate the practical implementation of the Solution.

The **'Intelligent Substation Device'** consists of several core components:

- **Inputs**: Taken from the LV network (e.g. current and voltage) and provided to the relevant Apps;
- **Hardware**: An off-the-shelf ruggedised PC, designed to be installed and run in harsh environments;
- **Operating System**: LV-CAP™ is a new Operating System (OS) that has been developed in the InnovateUK project to enables the individual Apps to run on the Hardware, ensuring the relevant data is shared between Apps;
- **Communications Container**: Provides relevant information back to the Application Deployment Server and Cloud Based Hosted platform; and
- **Application Containers**: Separates the resources available on the Hardware to enable different Apps, from multiple different vendors, to run on the same single device.

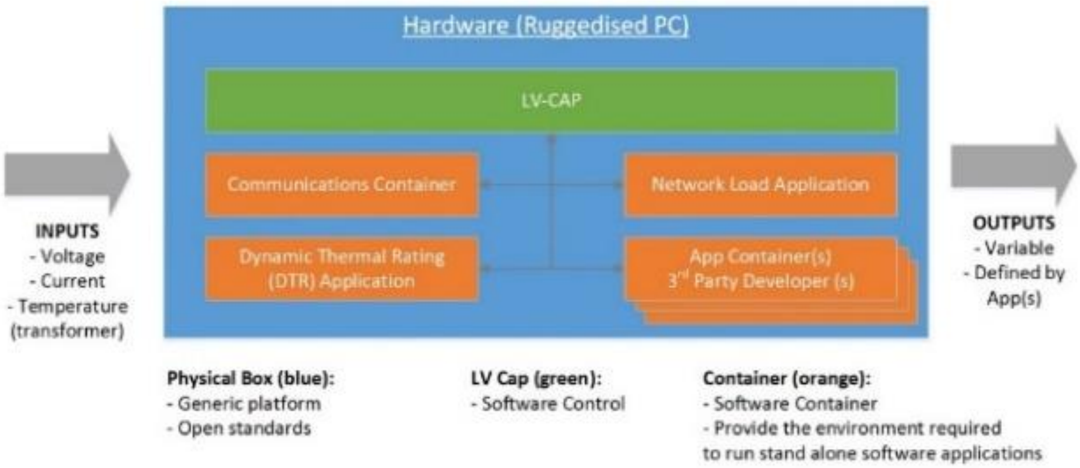


Figure 2: Overview of the OpenLV substations platform

Details – Trial Hardware

Intelligent Substation Device (ISD)

This refers to the hardware to be installed within the trial substations. It comprises an embedded computer taking inputs from a number of sensors and communication links, enabling the software deployed upon it to function effectively.

The device will be deployed with a Linux based operating system upon which the LV-CAP™ software and associated Apps will be utilised. This will be used for all 80 LV-CAP™ installations.

Sensors

The LV-CAP™ system will have a number of sensors connected to it to provide the inputs necessary for effective operation:

- Voltage Transformer (VT): Measures the voltage on the network at the LV busbars
- Current Transformer (CT): Measures the current passing within the cables:
  - Incoming to the transformer for the 11kV network; and
  - The LV feeder connecting to the controllable switch and the adjacent substation
- Transformer temp. sensor: Measures the surface temperature of the transformer casing

This will be available for all 80 LV-CAP™ installations, and could be used across all three Methods.

Controllable Switch

A controlled switch will be installed within the substations at either end of five trial networks (ten switches in total). One device will, in the absence of any instruction, remain 'open' leaving the connecting feeder fed from the substation connected at the other end of the cable. On receipt of an instruction from the ISD, the switch will close (if safe to do so), meshing the networks together, sharing the total load of both feeders between the two connected distribution substations. These will only be deployed for the Stage 2 testing under Method 1.

Details - Software

LV-CAP™

LV-CAP™ is a hardware agnostic operating system that in and of itself does not provide any direct functionality but instead makes available the environment in which various 'apps', each designed to provide specific a network benefits (or benefits) can be deployed. The LV-CAP™ software platform manages the available processing capability, memory (RAM), sensors (CTs, temperature probes etc.), data stored on an internal hard drive or SD Card and internal system communications, granting the installed applications access to each as required. Consequently, the realisable network benefits for LV-CAP™ are constrained only by the data available to the platform and the imagination of the industry in developing applications to benefit the network.

Weathersense™

Weathersense™ is an application under development as a collaborative endeavour between the University of Manchester and EA Technology. The University of Manchester is currently undertaking tests, modelling and simulation work to determine the necessary algorithms to enable calculation of the Real-Time Thermal Rating (RTTR) of a monitored transformer. EA Technology will then embed these algorithms into the app to enable capacity uplift of the transformers. This application will calculate the RTTR to determine the transformer's available headroom in near real time whilst also being able to forecast the available headroom in the future, based on historical load data.

This will only be used for Method 1.

Loadsense

Loadsense is an application designed to respond to outputs from Weathersense™ relating to real time and predicted network loading (described in the bid as the 'Network Control App'). These outputs may trigger an immediate (relatively) response or be a prediction alert, effectively stating that "unless network load is less than predicted, the transformer is going to exceed its RTTR rating in x-hours." Loadsense would schedule a LV network meshing to occur prior to that time slot, if the networks to be connected also have sufficient capacity (as determined by LV-CAP™ on that network).

This will only be used for Method 1.

Switch control application

A switch control application will communicate with the specific controllable switch installed at the normally open point in response to the output from the Loadsense™ application.

This will only be used for Method 1.

3rd party applications

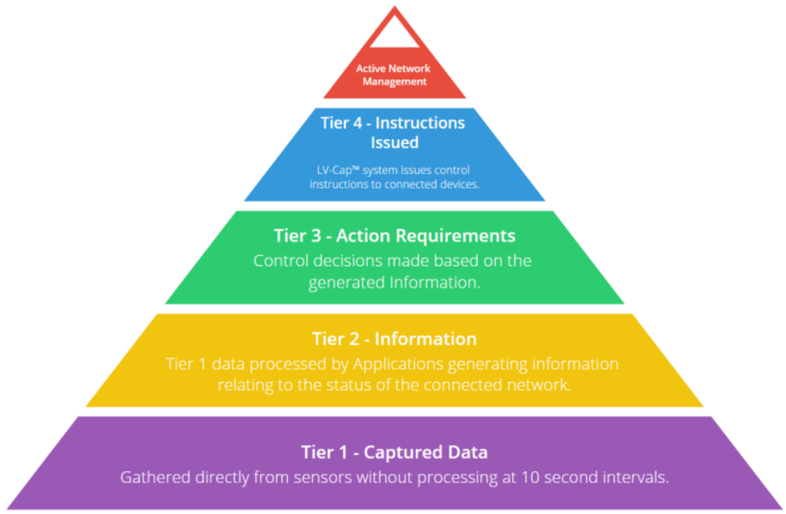
The OpenLV project will be establishing contact (via a community engagement specialist) with community groups within WPD's licence areas with a view encouraging involvement via alternative funding streams. A number of groups have been in touch with WPD previously requesting information relating to the operation of their local LV network and substation. OpenLV has the potential to provide them with data and information using specific applications written for that purpose, running on the LV-CAP™ platform.

These will be developed for Methods 2 and 3.

System monitoring

Data

The trial system, as outlined in the architecture diagram above, will gather data relating to the LV network, (voltage, load and temperature of the transformer) and will then process this data, creating further data and associated information. The hierarchical nature of this process is detailed below.



Tier 1 – Raw data: This comprises unprocessed data, captured directly by the VTs, CTs and Transformer temperature sensor.

Tier 2 – Processed data: This comprises processed data, calculated from the Tier 1 data. For example, RTTR calculations determining the transformer rating at the time, and forecast into the future, calculated using the readings captured from the CTs and temperature sensors are Tier 2 data.

Tier 3 – Actions: Where a calculated Tier 2 value requires the system to perform an action, (e.g. close the switch in the normally open point to mesh two adjacent LV networks), 'action' messages are issued within the LV-CAP™ system in response.

Tier 4 – Response: Where an action is required, 'confirmation of receipt' and 'confirmation or failure to comply' messages must be provided from the target device. Ideally, in the event that the instruction cannot be actioned, (e.g. a fault on the adjacent network prevents closure of the normally open point), a reason behind the failure to comply will be provided.

Applications developed for community groups and customers (Method 2) are expected to bridge the Tier 2 and Tier 3 stages, processing data and determining what to send to interested parties and when to send it.

Applications developed by companies and universities would also fit within Tiers 2 and 3, utilising captured data to generate new information or trigger actions by equipment elsewhere on the network.

Data capture frequency

It is required that the LV-CAP™ system capture / generate the above tiers in accordance with the below:

- Tier 1 data from the sensors must be captured at 10 second intervals;
- Tier 2 information must be processed at 10 minute intervals;
- Tier 3 actions must be determined in response to appropriate values being generated as Tier 2 data;
- Tier 4 instructions must be issued in response to action determinations.

Trial network requirements

The OpenLV Project will select networks for participation in the trials ensuring that:

1. The targeted learning is achieved and maximised;
2. Whilst minimising necessary expenditure on equipment and network alterations; and
3. Reducing required site visit expenditure after Site Acceptance Tests (SATs) are completed.

To achieve this, the networks ultimately chosen for participation in the trials will be selected on the basis of the below criteria.

Sensors and associated data sampling components will be capable of capturing data about the connected networks at a higher load and temporal resolution than is required for the LV-CAP™ Apps currently available. This will provide greater capacity for additional analysis and for Apps that will be developed in collaboration with Communities and Third Parties.

Ground mounted substation: In order to simplify and minimise potential issues with the trial equipment, only ground mounted substations shall be utilised for the trials. This will reduce the environmental protections necessary for the trial equipment, prevent adverse weather conditions significantly affecting equipment deployment and maintenance and allow a single 'design' of hardware to be used.

Adjacent networks: It will be necessary to establish a 'trial site' between two substations that are connected by a single LV feeder with a normally open point somewhere between them, suitable for modification with a controllable switch device. Requirements specific to the controllable switch selected for the Project will also be considered, for example, cable lengths between devices and the effectiveness of Power Line Carrier Communications technology.

Proximity: Wherever possible, small groupings of trial sites will be selected in reasonably close proximity to each other to minimise travel requirements between sites.

Modelling suitability: Modelling will be undertaken, based on the outputs of the previous WPD project 'Network Templates' to identify the most suitable network types for implementing the trials.

Appendix I – Learning from Other Projects

Purpose

The purpose of this Appendix is to outline the learning that will be utilised within **OpenLV** from previous LCN Fund and NIC projects.

Learning from Previous Projects

Table 1 shows the how learning from previous projects will be utilised within **OpenLV**.

Table 1: Learning from previous projects

Project Name	DNO	Tier	End Date	Commercial	Customer Engagement	LV Substation Installation	Trial Selection	Network Meshing	Real Time Thermal Rating
My Electric Avenue	SSEPD	2	Complete	X	X	X	X		
FALCON	WPD	2	Complete	X				X	X
FUN-LV	UKPN	2	Dec-16					X	
LV Network Templates	WPD	2	Complete	X		X	X		
Distributed Intelligence	WPD	1	Complete			X			X
Sola Bristol	WPD	2	Complete	X	X				
CLNR	NPg	2	Complete						X
CELSIUS	ENWL	NIC	Mar-20						X
Flexible Plug & Play	UKPN	2	Complete						X
Smart Street	ENWL	2	Dec-17					X	
Network Equilibrium	WPD	2	Jun-19	X					

The following sub-sections of this Appendix outline the learning that will be utilised from the projects outlined in Table 1 under each of the identified subject areas.

Commercial

EA Technology was responsible for the delivery of the My Electric Avenue project with SSEPD acting as the supporting DNO. My Electric Avenue was the first project to have an SME leading the delivery of a Tier 2 LCN Fund project. **OpenLV** will be delivered in the same way with EA Technology acting as the lead deliverer and WPD acting as the supporting DNO. The commercial learning gained from the My Electric Avenue project will be utilised when agreeing the principal contract between EA Technology and WPD and the sub-contracts between EA Technology and project suppliers. These commercial documents were updated when the My Electric Avenue project closed down in 2015.

Relevant commercial learning will be utilised when setting up the project from WPD's previous LCN Fund and NIC projects including: FALCON, LV Network Templates, Sola Bristol and Network Equilibrium.

Customer Engagement

As part of the My Electric Avenue project EA Technology successfully engaged with a large number of customers to sign up over 200 people to the Electric Vehicle trials that were completed as part of the project. The learning gained as part of this process will be utilised in Methods 2 and 3 of the **OpenLV** project.

Relevant learning from WPD's innovation projects will also be brought into the **OpenLV** project through liaison with the WPD Project Manager for **OpenLV**.

LV Substation Installation

EA Technology deployed 10 substation monitoring devices in LV substations as part of the My Electric Avenue project. WPD deployed 951 LV substation monitoring devices as part of the LV Network Templates project. Relevant learning from the installation of these devices will be utilised for the installation works that will be completed a part of the **OpenLV** project, for example, Risk and Method Statements (RAMS) and installation procedures.

Trial Selection

In order to identify trial locations for 10 Clustered EV trials, as part of the My Electric Avenue project, EA Technology assessed a total of 370 potential locations in SSEPD's and Northern Powergrid's license areas. In order to complete this work remote access to SSEPD's GIS system was provided. A similar approach will be adopted to identify the trial locations for all Methods as part of the **OpenLV** project, with WPD providing EA Technology remote access to their GIS system. EA Technology will utilise the learning gained on My Electric Avenue to ensure the most relevant networks will be selected whilst also ensuring the technology can be successfully deployed.

WPD collected LV network data as part of the LV Network Templates project. WPD will make this data available to EA Technology in order to select the most relevant networks to maximise the learning from the **OpenLV** project.

Network Meshing

EA Technology has implemented technology to mesh the LV network as part of the UKPN FUN-LV project. In total 1,200 LinkSwitch devices have been installed in the LPN licence area. The installation procedures identified for the meshing technology will be used as a basis to inform safe and efficient installation of the meshing technology as part of the **OpenLV** project. In addition, learning gained from the deployment of the communications medium and associated protocols will be utilised on **OpenLV** to provide secure and reliable communications to maximise learning from the project trials.

WPD has outlined the benefits that can be delivered by meshing the HV network as part of the FALCON project. **OpenLV** will utilise relevant learning from deployment on the HV network to de-risk the deployment of the LinkSwitch devices on the LV network.

It is noted that the Smart Street project included trials to mesh the LV network. There are significant differences between Smart Street and OpenLV that are outlined in the "Differentiators from previous LCNF Projects" Appendix.

Real Time Thermal Rating

EA Technology has experience of either implementing or supporting DNO's to implement Real Time Thermal Ratings (RTTR) on the LV network, specifically as part of the Distributed intelligence and Customer Led Network Revolution (CLNR) projects. In Addition, WPD has implemented RTTR on both HV and LV networks as part of the FALCON and Distributed Intelligence projects. Relevant experience from deploying RTTR algorithms and assessing their impact on the network will be utilised to assess the network benefits that will be provided by **OpenLV**.

CELSIUS was awarded in January 2016 and will run until March 2020. At this point in time it is not clear what or if any learning from this project will be utilised as part of OpenLV. However, EA Technology and WPD will actively engage with ENWL to identify whether relevant learning generated as part of the CELSIUS could be used to inform **OpenLV**.

Management & Knowledge Capture

EA Technology has experience of running and delivering LCN Fund Tier-2 projects, for example My Electric Avenue. Learning regarding successful management and knowledge capture will be brought to this NIC project.

Appendix J – Differentiators from Previous Projects

Purpose

The purpose of this Appendix is to outline the key differentiators between OpenLV and previous LCN Fund and NIC projects.

OpenLV Key Differentiators

The key differentiators for OpenLV are listed below. No other research and innovation projects within this space (LCN Fund and NIC) have delivered:

- A solution that will show how 'distributed intelligence' can be deployed and used to provide automated and active management of the LV network;
- An overall solution that combines: 1) Real Time Thermal Rating and 2) automated meshing of the LV network to release additional capacity from existing assets (See Table 1); and
- An 'open' intelligent substation device that enables other parties to develop and deploy innovative algorithms and applications on a single device.

Table 1 shows the Tier 2 LCN Fund projects that have included dynamic ratings and/or meshing of the network to provide additional capacity. The only other project that has combined dynamic ratings and network meshing is Flexible Approaches for Low Carbon Optimised Networks (FALCON). The trials as part of the FALCON project targeted primary substations on the 11kV network. The solution delivered for the OpenLV project will utilise relevant learning from the FALCON project and utilise it to ensure the OpenLV solution will be successfully deployed on the LV network.

Table 1: Tier 2 Dynamic Ratings & Network Meshing Project Summary

DNO	Project Title	RTTR/Dynamic Ratings Applied in Project	Network Meshing Applied in Project
NPg	(CLNR) Customer-Led Network Revolution	X	
ENWL	(C2C) Capacity to Customers		X
SPEN	Flexible Networks for a Low Carbon Future	X	
UKPN	(FPP) Flexible Plug and Play	X	
WPD	(LCH) Low Carbon Hub	X	
WPD	(FALCON) Flexible Approaches for Low Carbon Optimised Networks	X	X
UKPN	(FUN-LV) Flexible Urban Network – LV		X
ENWL	(eta) Smart Street		X
SSE	(LEAN) Low Energy Automated Networks		X
ENWL	Celsius	X	
	OpenLV	X	X

Table 2 Shows the Tier 2 and Tier 1 LCN Fund projects that have included dynamic ratings of either transformers and/or cables it also outlines whether the trials completed on the projects targeted the HV or the LV network.

This shows that all the projects listed have targeted the HV network with the exception of the Customer-Led Network Revolution (CLNR) and Celsius projects.

The key differentiators between the CLNR and Celsius projects and OpenLV, in terms of RTTR, are that the OpenLV project will test a new RTTR algorithm that has already been developed specifically for HV/LV transformers. This RTTR algorithm will be deployed in conjunction with LV network meshing to release additional capacity. As shown in Table 1 neither the CLNR nor the Celsius projects include meshing of the LV network. It should be noted that the RTTR algorithm has already been developed and no funding has been requested to develop RTTR algorithms as part of the OpenLV project.

Table 2: Tier 1 & Tier 2 RTTR Project Summary

Project Title	DNO	Tier	RTTR/Dynamic Ratings Applied in Project			
			High Voltage	Low Voltage	Transformer	Cable
(CLNR) Customer-Led Network Revolution	NPg	2	X	X	X	X
Flexible Networks for a Low Carbon Future	SPEN	2	X			X
(FPP) Flexible Plug and Play	UKPN	2	X		X	X
(LCH) Low Carbon Hub	WPD	2	X			X
(FALCON) Flexible Approaches for Low Carbon Optimised Networks	WPD	2	X		X	X
Celsius	ENWL	2		X	X	X
Implementation of Real-Time Thermal Ratings	SPEN	1	X			X
Temperature Monitoring Wind Farm Cable Circuits	SPEN	1	X			X
Distributed Intelligence	WPD	1		X		X
OpenLV				X	X	

Table 3 shows the Tier 2 LCN Fund projects that have included meshing of either the HV or LV network. This shows that all the projects listed have targeted the HV network with the exception of the Flexible Urban Network – LV (FUN-LV) and (eta) Smart Street projects.

Table 3: Tier 2 Network Meshing Project Summary

Project Title	DNO	Tier	High Voltage	Low Voltage
(C2C) Capacity to Customers	ENWL	2	X	
(FALCON) Flexible Approaches for Low Carbon Optimised Networks	WPD	2	X	
(FUN-LV) Flexible Urban Network – LV	UKPN	2		X
(eta) Smart Street	ENWL	2		X
(LEAN) Low Energy Automated Networks	SSE	2	X	
OpenLV				X

The key differentiators between the FUN-LV and (eta) Smart Street projects and OpenLV are as follows:

1) OpenLV will utilise RTTR and meshing of the LV network to release additional capacity from existing assets;
2) OpenLV will use distributed intelligent devices that will provide automated management of the LV network; and
3) OpenLV uses an 'open' systems architecture that will allow 3rd parties to develop innovative algorithms and applications and deploy them on a single intelligent substation device.

A large number of LCN Fund projects (see below list) have included network monitoring and associated collection of data. However, none of these projects have delivered a solution that has designed to be 'open' and support the deployment of innovative algorithms and applications, on the LV network, that have been developed by 3rd parties. Projects that include collection of network monitoring data are as follows:

- LV Network Templates;
- Low Carbon London;
- Flexible Networks for a Low Carbon Future;
- Flexible Plug and Play;
- Flexible Approaches for Low Carbon Optimised Networks;
- Innovation Squared: Electric Vehicles (My Electric Avenue);
- New Thames Valley Vision;
- Flexible Urban Network – LV;
- Solent Achieving Value from Efficiency;
- Network Equilibrium; and
- Celsius.

A number of Tier 2 and Tier 1 LCN Fund projects have included engaging with communities (see below list). Again, none of these projects have delivered a solution that has been designed to be 'open' and support the deployment of innovative algorithms and applications, on the LV network, that have been developed by 3rd parties. It is expected that the 'open' functionality, provided by OpenLV will remove significant barriers and facilitate new business models that will benefit both customers and DNOs. Projects that include community engagement are as follows:

- Accelerating Renewable Connections (ARC);
- Vulnerable Customers and Energy Efficiency (VCEE); and
- Solent Achieving Value from Efficiency (SAVE).

In addition, it is noted that the NIC SPEN Future Intelligent Transmission Network SubStation (FITNESS) project is trialling a new digital substation architecture that significantly reduces the number and duration of circuit outages required throughout the life cycle of the substation. It is noted that this project includes support for interoperability of multi-vendor equipment in a substation. This focusses on implementation hardware from multiple vendors in a single substation and is therefore, conceptually considerably different to the proposed OpenLV Solution.

Appendix K – Glossary of Terms

Distribution Substation:	The distribution substation steps the electricity supply down from 11kV to 230 / 400V and distributes it along connected feeders.
HV Feeder:	The incoming supply to the distribution substation.
In-Line Tap Changer:	A tap changer is a component of a transformer. It controls the transformer's output voltage by adjusting its winding ratio.
Loadsense:	Loadsense is an application designed to respond to respond to outputs from Weathersense™ relating to real time and predicted network loading. These outputs may trigger an immediate (relatively) response or be a prediction alert, effectively stating that "unless network load is less than predicted, the Transformer is going to exceed its RTTR rating in x-hours." Loadsense would schedule a LV network meshing to occur prior to that time slot, if the networks to be connected also have sufficient capacity (as determined by LV-CAP™ on that network).
Low Carbon Technology:	A type of technology implemented for the production of power with substantially lower amounts of carbon dioxide than is emitted from conventional fossil fuel power generation, typically utilising natural energy sources such as wind, solar, hydro etc.
LV-CAP™:	LV-CAP™ is a hardware agnostic operating system that in and of itself does not provide any direct functionality but instead makes available the environment in which various 'Apps', each designed to provide specific a network benefits (or benefits) can be deployed.
LV Feeder:	The outgoing supply from the distribution substation.
Nameplate Rating:	The Data on the Nameplate of transformers consists of kilo-Watts rating, Voltage Rating, Frequency, Number of Phases, Temperature, Type of Cooling, % Impedance and Reactance, Name of Manufacture, Year of Manufacture etc.
Network Meshing:	Joining adjacent normally separated networks by closing a Normally Open Point.
Normally Open Point (NOP):	A Normally Open Point (NOP) is generally located between two feeders, connected to different distribution substations. It allows the Distribution Network Operator (DNO) to reconfigure the network through closing the point to join the two networks together.
Real Time Thermal Rating:	RTTR devices calculate the thermal ratings of power equipment based on the actual weather conditions and the electrical current and temperature of the equipment.
Substation:	A point on the network where voltage transformation occurs.
Technology Readiness Level (TRL):	Method of assessing and defining maturity of technology.
Transformer:	Device that changes the voltage of an a.c. current, without changing the frequency.
Weathersense™:	Weathersense™ is an application under development as a collaborative endeavour between the University of Manchester and EA Technology. It will provide the Real-Time Thermal Rating (RTTR) of a monitored transformer to release additional capacity.

Appendix L – The future of LV-CAP™

"LV-CAP™ everywhere…"

It is well established that the traditional electricity distribution network is facing an unprecedented challenge[1]. Exposed directly to changes in customer behaviour, the low-voltage distribution network is at the frontier of this challenge.

At over 400,000km in length[2], the UK low-voltage network is larger than the combined high-voltage and transmission networks. Yet this huge asset base remains largely passive; lacking in communication or monitoring, it is invisible to control systems and almost entirely manually operated. Many attempts[3] have been made to bring monitoring, communication and control technology to low voltage networks, but these have not yet achieved widespread adoption. EA Technology believes that, in order to achieve widespread adoption, it is essential that the platform provides tangible benefits not only to the network operator, but also to the end customer.

LV-CAP™ takes a different approach, in that: 1) it is designed from the outset to be low cost, 2) it is designed from the outset to benefit network operators, customers and other service providers, 3) it is a software platform, to be implemented on suitable hardware by any vendor or integrator; and 4) it is a flexible platform that can adapt and evolve as requirements change.

As joint owners of the core IP within the platform, EA Technology and Nortech intend to establish LV-CAP™ as the preferred platform for low-voltage network monitoring, communication and (ultimately) control. Initially, the focus will be on the United Kingdom, using demonstration deployments such as OpenLV to establish the business case, technical suitability and security of the platform.

The business plan for LV-CAP™ depends initially on licensing revenue for the LV-CAP™ software (either to OEMs or manufacturers of retro-fit solutions), together with associated service revenue for the secure deployment and management of containers (in partnership with Nortech).

It is expected that a number of valuable containers and associated services will be developed for the platform. EA Technology intends to develop a number of these solutions itself and commercialise them through sales of licensing and services. However, we will also be encouraging third parties to do the same, and so the LV-CAP™ 3rd Party Developer API is expected to remain freely accessible and be complemented with developer kits and community assistance to encourage adoption.

Ultimately, there may well be a very wide variety of LV-CAP™ solutions on the market, in which case there will be a further business opportunity around curating and managing the intelligence deployed onto the network e.g. through commission for containers sold through an 'App Store', or for more a formally managed environment. In such an event, some sort of partnership with an established service provider is likely, in order to give LV-CAP™ access to the global market that is envisaged.

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[1] https://es.catapult.org.uk/what-we-do/fpsa/
[2] http://www.eurelectric.org/media/113155/dso_report-web_final-2013-030-0764-01-e.pdf
[3] http://www.smarternetworks.org/ProjectList.aspx?TechnologyID=1

Appendix M: Development of LV-CAP™ through InnovateUK

The development of the LV-CAP™ platform is joint-funded by InnovateUK under the project name "Common Application Platform for Low Voltage Network Management". This funding was the result of a successful bid in the Energy Catalyst – Mid Stage – Round 1 competition.

The Energy Catalyst fund aims to support businesses and researchers, who can deliver innovative solutions that contribute to all elements of the energy trilemma: reducing emissions, improving security of supply and reducing cost. The Mid-stage awards are for projects that take innovative ideas forward through the technology development stage by conducting industrial research and development including, for example, laboratory studies, component or system development and testing, verification and evaluation in simulated environments.

The project involved the formation of a £500,000 SME-led collaboration between EA Technology, Nortech and the University of Manchester to develop a novel, common, low cost, robust monitoring and management system for the Low Voltage (LV) network. It aims to optimise and reduce costs of asset replacement, reduce emissions and improve security of supply. Based on an open and flexible software architecture, it enables the incorporation of a range of third party algorithms that share sensor data and can use each other's outputs as inputs. This not only enables complex decisions to be made locally, but also ensures relevant data can be sent to a central aggregation server to provide much-needed insight into the operation of the low-voltage system with the aim of reducing the cost of connecting low carbon technologies.

In order to demonstrate these capabilities and meet the required outputs of the project, the University of Manchester are engaging in research into the thermal behaviour of transformers to validate and improve existing Dynamic Thermal Ratings (DTR) algorithms. This work will enable the demonstration of how the LV-CAP™ platform can enable greater network headroom (and hence reduced costs) though the use of local algorithms. The original concept for the common application platform is illustrated in Figure 1.

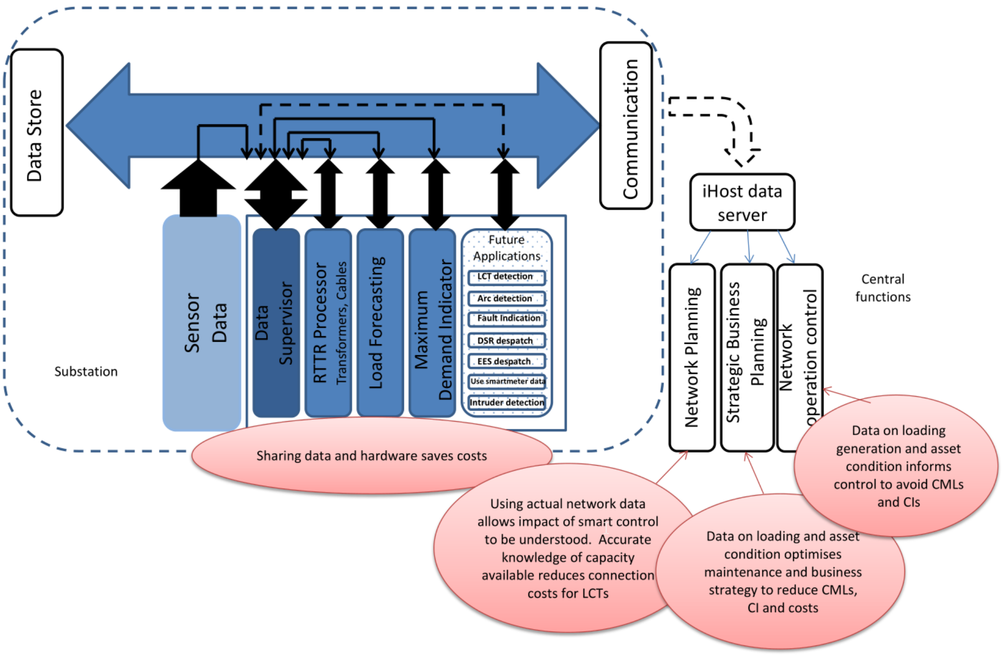

Figure 1 Original concept for a common application platform

One of the key developments in the project has been to define and implement the above concept using industry-standard components to deliver a robust, scalable and secure architecture that can be widely deployed on the LV network. The resulting LV-CAP™ architecture uses containerised algorithms hosted by a standard Docker instance on an industry-standard Linux host. Inter-algorithm communication is achieved using the MQTT messaging standard. This arrangement is shown in Figure 2.

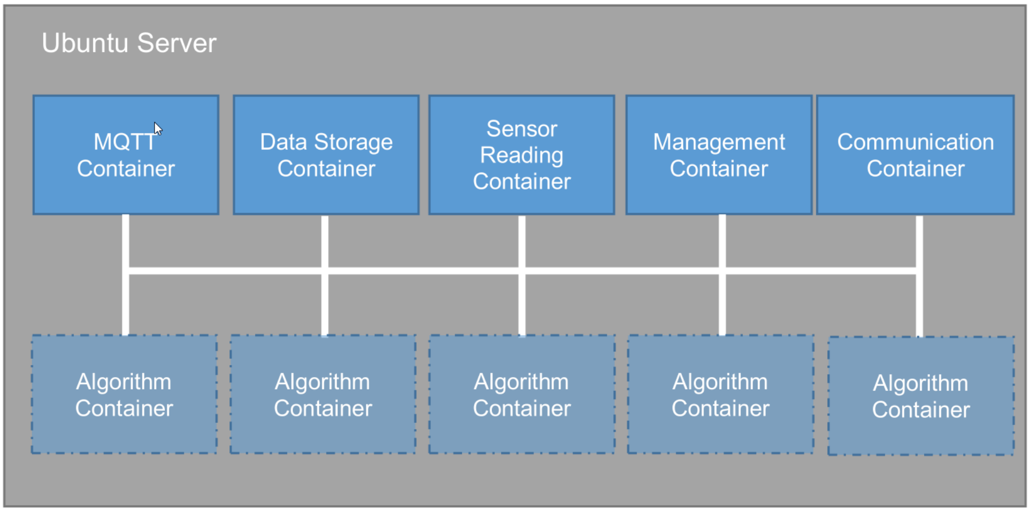

Figure 2 LV-CAP™ container architecture

The LV-CAP™ architecture overcomes any dependency problems from third party developers, and enables the secure maintenance and management of containers. The messaging system provides for robust process isolation and the local storage function enables persistent data to be maintained – two key issues for any form of containerised system. Furthermore, a 3rd party API specification is available that enables LV-CAP™ compliant containers to be developed by anyone. It should be noted that container deployment remains the sole preserve of the upstream container manager, enabling complete control of what functionality is delivered to which instance.

The InnovateUK project is developing and testing the LV-CAP™ platform in a laboratory environment, using the hardware arrangement shown in Figure 3.

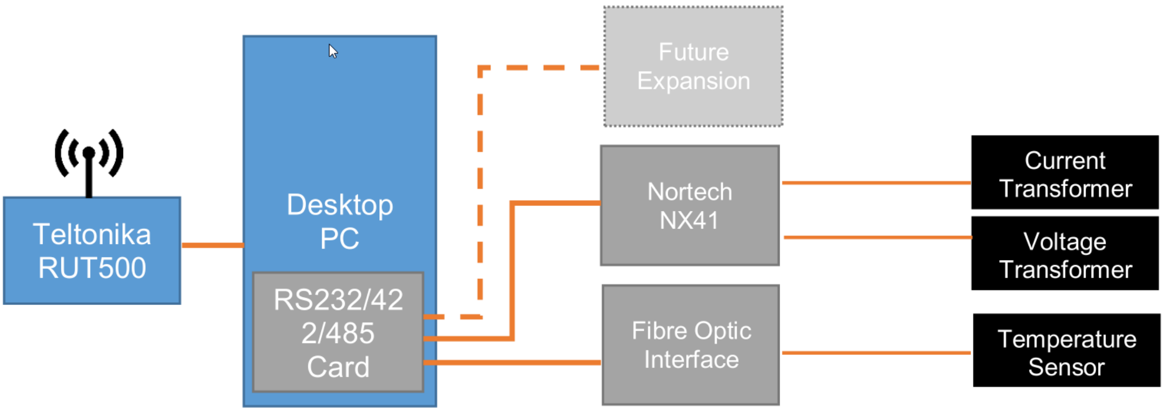

Figure 3 InnovateUK project software development and testing environment

The OpenLV project will build on this work, taking the platform out of the laboratory and into a real-world controlled trial.

Appendix N – Key Project Roles

Purpose

The purpose of this Appendix is to outline the key supplier roles that are required for the successful delivery of OpenLV. The Key project roles are listed below:

Host / Supporting DNO	Western Power Distribution (WPD)
Project Lead	EA Technology
Communications & IT Architecture	EA Technology, Nortech and Lucy Electric Gridkey
Systems Integration Support	Lucy Electric Gridkey
Community Engagement Specialist	To be awarded by competitive tender
Hardware Provision	To be awarded by competitive tender
Network / System Security	To be awarded by competitive tender
Marketing, PR and Dissemination	To be awarded by competitive tender
Hardware Installation	Western Power Distribution (WPD)
Software Environment Imp. & Support	EA Technology
Software Provision	EA Technology & University of Manchester
Economic Assessment and Extrapolation of Community Learning	To be awarded by competitive tender

Communications & IT Architecture for Method 1

Nortech will provide the communications equipment and associated software (communications container on the intelligent substation device) for Method 1. The Central IT Architecture provided by Nortech (Application Deployment Server) will enable deployment of new Apps on the intelligent substation devices. This comms system can also be used for Methods 2 & 3, particularly if DNOs also wish to access data via iHost or their SCADA systems.

Communications & IT Architecture for Methods 2 and 3

Lucy Electric Gridkey will provide the communications equipment and associated software (communications container on the intelligent substation device) for Methods 2 and 3. The Central IT Architecture provided by Lucy Electric Gridkey (Cloud Based Hosted Server) will enable relevant data from the intelligent substation devices to be shared with 3rd party organisations for Methods 2 and 3.

Systems Integration Support

The Systems Integration company will provide technical support and guidance throughout the project lifecycle. This will include a review of the OpenLV systems architecture, the requirements specification for the intelligent substation devices, assessing the approach for wide scale deployment and providing input to how the OpenLV Solution could be transferred to BaU.

Community Engagement Specialist

The community engagement specialist will engage with communities to enable up to 10 intelligent substation devices to be deployed. These devices will enable communities to exploit the LV monitoring data provided by the OpenLV intelligent substation devices and/or develop innovative algorithms and applications that could be deployed on the OpenLV intelligent substation devices.

Hardware Provision

The hardware provider will be responsible for providing the devices for deployment with LV-CAP™, provide technical support for hardware issues and issue replacement units in the event of hardware failure.

Network / System Security

The Network / System Security company will be responsible for undertaking a Design Review and Implementation Check of the overall OpenLV solution, including the communication links proposed for system operation and provide advice and support in ensuring reasonable system security.

Marketing, PR and Dissemination

The Marketing, PR and Dissemination company will be responsible for developing the Project's marketing strategy, including creation of Project Branding, establishment, hosting and management of the Project Website. The company will also manage PR and Dissemination for the Project, in coordination with EA Technology's and WPD's marketing representatives.

Economic Assessment and Extrapolation of Community Learning

The party selected to provide Economic Analysis and Extrapolation of Community Learning will be responsible for assessing the longer term potential and economic impact of the use of OpenLV devices by community groups. They will evaluate the effectiveness of the community deployments within the project and develop materials to be shared with other communities beyond the project, to share learning and provide guidance on how these other communities across Great Britain can benefit from the learning gained within the project.

Appendix O – Value for Money

Purpose

The purpose of this Appendix is to provide the tables requested by Ofgem to demonstrate how the project meets criterion (b) Provides value for money to electricity customers. All Tables have been calculated using 2016/2017 prices.

Value for money

Table 1 provides the staffing costs for each project Phase, for Western Power Distribution, this includes the Labour (days, costs, and effective day rates) and the number of staff (FTEs by Phase).

Table 1: Western Power Distribution Labour Days, Costs, Day Rates & FTE Equivalent

	Labour (Days)	Labour (Cost)	Labour (Effective Day Rate)	FTE Equivalent
Phase 1	21	[redacted]	[redacted]	0.16
Phase 2	280	[redacted]	[redacted]	0.33
Phase 3	112	[redacted]	[redacted]	0.16
Total	414	[redacted]	[redacted]	0.22

Given the nature of this project, EA Technology has put forward a very senior team of staff to ensure delivery. It is further noted that EA Technology's in-kind contribution reflects a significant reduction in fees for this project from its 'standard' rates.

Table 2 provides the staffing costs for each project Phase, for EA Technology, this includes the Labour (days, costs, and effective day rates) and the number of staff (FTEs by Phase). Given the nature of this project, EA Technology has put forward a very senior team of staff to ensure delivery. It is further noted that EA Technology's in-kind contribution reflects a significant reduction in fees for this project from its 'standard' rates.

Table 2: EA Technology Labour Days, Costs, Day Rates & FTE Equivalent

	Contractor (EA Technology) (Days)	Contractor (EA Technology) (Cost)	Contractor (EA Technology) (Effective Day Rate)	FTE Equivalent
Phase 1	493	[redacted]	[redacted]	3.71
Phase 2	1,309	[redacted]	[redacted]	1.52
Phase 3	686	[redacted]	[redacted]	0.98
Total	2,488	[redacted]	[redacted]	2.07

As outlined in the FSP if the OpenLV bid is successful services will be procured through competitive tender for a value of approximately £1million to ensure best value. Therefore, at this stage, it is not possible to provide equivalent tables for each of the Project Supplier roles required to deliver the OpenLV project.

Appendix P – Learning Dissemination

Purpose

The purpose of this Appendix is to outline the methodology to successfully capture the learning generated by the OpenLV project.

Learning dissemination

Knowledge capture is a fundamental element of the Project and requires a robust methodology and plan for delivery. In order to achieve this, EA Technology will use the proven approach for knowledge capture and dissemination developed and utilised on other WPD LCN Fund and NIC projects. Due to the nature of the project, new knowledge will be produced that relates to various stakeholders. A stakeholder map will be produced, which will then be mapped onto the overall project plan so that knowledge can be disseminated in a timely manner. Knowledge will generally be of two forms: planned and unplanned. The approaches for capturing these types of learning are detailed below.

Plans for learning dissemination to other DNOs

Planned learning:

- The learning outcomes for the overall project and each project area will be clearly identified by the relevant project team member and documented during Phase 2 (Design & Build).
- The learning outcomes will be integrated into the plan for each project area to ensure knowledge capture is seen as an integral part of each team member's role.
- The knowledge gained throughout the project will be shared through reports published on WPD's innovation website (www.westernpowerinnovation.co.uk) and the ENA Smarter Networks Portal (www.smarternetworks.org).
- Access to data supporting the learning will available to third parties to access and analyse independently in order to stimulate the generation of additional learning.

Unplanned learning:

- It is very difficult to anticipate the nature of these lessons learnt and, as such, issuing a standard template would be counterproductive. Instead, the learning lead for the Project will conduct regular meetings with Work Package (and Project) leads to identify all lessons learnt. The advantage of having a project team together is that the discussion brings out a far richer context which, when captured in a coherent manner, can be very valuable. Interviews will be integrated into the Project Plan and take place at regular intervals. This will make it a part of normal Project activity, thus highlighting the importance of knowledge capture.
- This means that it will be a relatively quick process to capture knowledge and lessons learnt with the majority of the work in post-processing and collating the information.
- These commentaries will be organised into a coherent structure, as described in the following section, and any recurring issues will be investigated where necessary. At agreed stages in the project, learning will be collated and shared amongst the Project participants to enable implementation of any relevant lessons learnt.
- This will capture issues that occur on an on-going basis but would otherwise be forgotten.

Knowledge capture methodology

To enable the rapid collation of detailed learning, planned or unplanned, we have designed a simple hierarchy structure to manage the knowledge gained. This structure will allow integration of all levels of knowledge and learning, no matter how high or low level they may be. Much of the detail will form wide learning topics. This list will never be exhaustive and certainly, as the project develops, will expand at all levels.

Learning will be categorised across seven learning categories: Customer Engagement; Project Management; Construction Process; Technology & Equipment; IT & Telecommunications; People & Culture; Industry Process & Regulation; Stakeholder Analysis.

Each Project area has ten learning (parent) topics and will provide the content of the final Project Closedown report:

1. The overall **OpenLV** Solution;
2. LV network capacity uplift (RTTR and/or Meshing);
3. Engagement with local communities;
4. Engagement with academics and companies (including non-energy companies);
5. Exploiting the open nature of the overall **OpenLV** Solution;
6. Guidelines for the development of innovative algorithms and/or applications;
7. Commercial guidance for the development of innovative algorithms and/or applications on open platforms (e.g. raising funding for development and dealing with IPR issues);
8. Scalability and replicability of the overall **OpenLV** solution;
9. Autonomous control of the LV network utilising distributed intelligent devices;
10. Safety considerations when deploying autonomous devices on the LV network; and changes required enabling transition to BaU.

The knowledge management structure is shown in Figure 1.

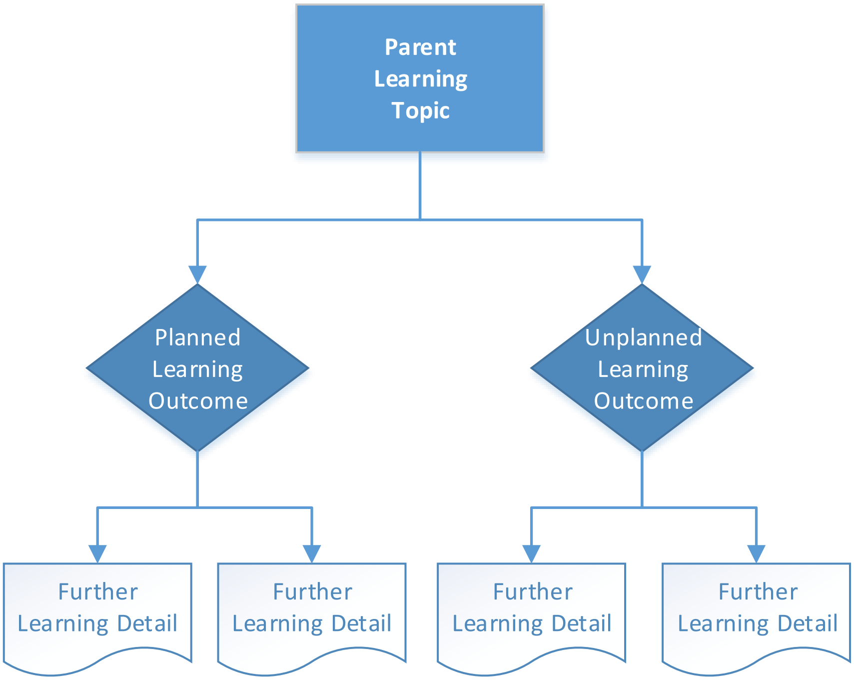

Figure 1: Knowledge Management Structure

Terminology explanation:

Learning Topic – Parent:

- A high level learning topic, made up of several learning outcomes which will be a combination of planned and unplanned learning outcomes.
- Example: How to implement **OpenLV** at a system level.

Learning Outcome – Planned:

- Belonging to a Learning Topic (Parent) each planned learning outcome is one of those we set out to learn either during the development of the bid, or one we have identified during the design phase; there will be several of these per learning topic.
- Example: There is significant interest from 3rd party organisations and Apps are developed that utilise LV network in a very beneficial but unexpected way.

Learning Outcome – Unplanned:

- Belonging to a Learning Topic (Parent), each captured learning outcome is one of those we will capture or collect as the project progresses. There will be several of these per learning topic.
- Example: The LV-CAP™ (OS) can be rolled out on a ruggedised PC with a much cheaper processor i.e. an ARM processer rather than an Intel processor significantly reducing the BaU costs of implementing the overall Solution.

Each of the individual learning outcomes, either planned or unplanned, will potentially contain more than one learning document. The learning document captures the detail behind that outcome, the catalyst for the learning, the owner and a method of dissemination, where applicable. It also captures any correlation to other areas of learning across the Project.

The purpose of the hierarchal structure and supporting documentation is to capture a historical footprint of each area of learning for the business to retain as a library. It will also form much of the content towards the final Project Closedown report.

Whilst the learning will be captured by the EA Technology Project Manager as much as possible, it will be the responsibility of each Work Package lead to own their areas of knowledge and commit to regular review periods to ensure the detail remains in date and valid.

As the Project progresses, it is expected that much of the detail will either grow or alter, as is the case for innovative projects.

As part of capturing learning, regular interviews with Work Package leads (or teams, if appropriate) will be integrated into the Project Plan. This ensures that learning objectives remain a priority throughout the Project. The regular interviews will focus around what issues the project teams faced and how they dealt with them, as well as what aspects have gone well and what factors contributed to this. This type of experience will be very valuable to other parties interested in rolling out similar projects (e.g. DNOs, service providers and equipment suppliers). Combining this with periodic written reports (throughout the project), collating experiences and evidence across different sub-projects, will make it easier for other parties to learn from EA Technology's experience.