Notes on Completion: Please refer to the appropriate NIA Governance Document to assist in the completion of this form. The full completed submission should not exceed 6 pages in total.

NIA Project Registration and PEA Document

Date of Submission

Jun 2022

Project Reference Number

NIA_WPD_068

Project Registration

Project Title

Solving Intelligent LV – Evaluating Responsive Smart Management to Increase Total Headroom (SILVERSMITH)

Project Reference Number

NIA_WPD_068

Project Licensee(s)

National Grid Electricity Distribution

Project Start

June 2022

Project Duration

1 year and 0 months

Nominated Project Contact(s)

Laurence Hunter

Project Budget

£344,155.00

Summary

SILVERSMITH will investigate compliance issues that are expected to grow on our Low Voltage network as Low Carbon Technologies (LCT) and Distributed Generation (DG) connections increase. Phase 1 will conduct two network studies, the first using the Transform tool, the second using PowerFactory DIgSILENT. We will assess the demographic of future issues and produce an opportunity statement for devices to resolve them after evaluating novel technologies. Phase 2 then re-assess the network model using these technologies and produce a list of functional requirements and design methodology to selecting the best technology would be under different network conditions. To conclude, a comparison between each approach will be made to investigate what method of network analysis leads to the best investment decision making.

Problem Being Solved

Initial reviews of ED2 business plans and network models suggest that there will be a number of instances where Low Voltage (LV) networks are on a trajectory to experience both transformer thermal issues as well as non-compliant feeder voltages. Whilst we already have the ability to resolve these issues using conventional means, supply chain engagement indicates that some nascent LV voltage control technologies may offer an opportunity to resolve these issues in innovative ways. Past innovation projects have investigated some of these technologies and built some successful use-cases. UKPN's 'FUN-LV' investigated how power electronics can enable soft open points, Northern Powergrid's 'Customer-Led Network Revolution' investigated on-load tap changers and Electricity North West's 'QUEST' is investigating whole system voltage optimisation. What we are missing, is an understanding of how widespread these LV issues will be, and the extent to which different combinations will need to be resolved individually. There is not a clear methodology for DNOs to use when selecting the most suitable technology or solution. Furthermore, to better prepare for the scale of investment decision making required to achieve net-zero, we want to learn whether a finance based model aptly represents the network, or whether a load-flow based model leads to better investment decision making.

Method(s)

Phase 1: Network evaluation, and technology literature study

To consider a range of approaches, SILVERSMITH will feature analysis using two methods, delivered by separate consultants. Firstly,

EA Technology ltd's (EATL) Net Zero team will perform strategic investment analysis using Transform. This is an Excel based network model that uses 19 LV network archetypes to create representative models of each license area. The tool has been endorsed by Ofgem, and used by all UK DNOs for investment planning due to connected LCTs in ED1. Secondly, EATLs Power System Studies team are performing a power flow assessment. EATL's Power System Studies team will be completing the analysis to the same scope, but completing a power flow analysis of three representative networks (urban, dense urban, rural) using ConnectLV and DIgSILENT. The later can evaluate power flow phenomena such as harmonics and power factor correction.

This analysis will determine the scale of the issues that are developing on the LV network. These include transformer overloading, cable overloading, and non-compliant voltages. Crucially, we want to understand to what extent these issues coincide. Does a transformer overload typically coincide with a cable overload? In addition, what proportion of feeder cables experience a simultaneous voltage drop, and rise outside statutory limits? And most significantly, what proportion of substations experience all issues. Under different combinations of these issues, novel LV voltage control technologies may outperform conventional means, both at a functional level and price point. Using this network analysis, we want an opportunity statement that specifies 'if a device can offer X specific functionalities, at a set price point of Y or less, it will outperform conventional means as discussed before'. All proposed technologies will be compared against the current reinforcement method of dealing with compliance issues.

The second half of this phase is the creation of a literature review by EATL's Net Zero team that documents all available LV voltage control technologies. It should introduce each type of device, explain how each technology operates, what functionality it offers, TRL, estimated price point and where it has been trialled. Either as part of an NIA project or academic setting. In addition, the report must explain the differences between low voltage management compared to other higher voltages. EATL are responsible for delivery, after a Request for Information has been published by National Grid. We will issue an open enquiry into the available technology, in which suppliers can share more information that would otherwise be out of the public domain. With the knowledge that they will gain access to the functional requirements which are produced in this work. The outputs of this work package are the following deliverables:

- 1: Network study results (June – December 2022)
- 2: Literature review of existing technologies (June – August 2022)

Phase 2: Functional requirements & methodology development

Providing phase one is successful, functional requirements will be matched to existing technologies and offered to the suppliers we engage with at the RFI. From this, we seek to document our recommendation and devise a methodology to identify where LV control technologies can benefit a DNO. Again, EATL's Net Zero team and EATL's Power System Studies team will complete this phase in parallel with a split between depth provided by EATL's Power System Studies team's power flow study, and breadth provided by EATL's Net Zero team's Transform study.

The outputs of this work package are the following deliverables:

- 1: Functional requirements (September – March 2023)
- 2: LV voltage control selection methodology (October – March 2023)

Extended technology investigation & final recommendations (completed throughout both phases)

This phase follows the new technologies that are being developed by new and existing suppliers to address LV voltage control throughout the entirety of the project. The technologies that are most likely to meet the functional requirements will be evaluated. Through supplier engagement, we aim to identify the extent to which they meet the functional requirements. In return for assisting with our project, we propose to provide suppliers with the results from our investigation that can help them direct their product's development in line with our requirements.

The output of this work package is the following deliverable:

- 1: Technology investigation report (June – December 2022)

Project close

After the analysis in phases 1 & 2, two approaches for network evaluation and design methodology will have been produced. Each will have prioritised varying aspects of the analysis, and as a result some variation between the design methodologies produced is expected. In addition, the specific functional requirements may indeed differ resulting in different technologies being recommended for further use. To conclude the project, National Grid will evaluate the overall approach of each consultant has taken and make recommendations for further work. In addition, the usual project closedown report will be produced by National Grid.

- 1 (National Grid) Methodology Comparison (December 2022 – April 2023)
- 2 (National Grid) Closedown report (December 2022 – May 2023)

Scope

Whilst DNOs have been trialling different LV voltage control technologies, there has not been a comparison of the relative strengths and weaknesses of each method. Nor has there been an application-based study to develop a methodology that identifies under what network conditions these new devices actually offer a benefit over conventional approaches. This project aims to do exactly that. To consider all approaches, we have decided run the analysis using two methods delivered by separate consultants. Firstly through a strategic investment methodology led by EA Technology ltd. and secondly a power flow assessment methodology led by EATL's Power System Studies team.

The project features two phases of research, accompanied by a period of technology investigation and supplier engagement. Phase 1 analyses the LV network with LCT connections added up to 2050 and evaluates the counterfactual method for dealing with compliance and constraint issues that arise. EA Technology ltd. (EATL) will complete all analysis in parallel with EATL's Power System Studies team to determine which method is best suited to this kind of analysis. EATL's Net Zero team will be completing the network study using the Transform tool, which is an Excel based network model endorsed by Ofgem that been used by all DNOs for strategic investment planning in ED1. EATL's Power System Studies team will be completing the analysis to the same scope, but completing a power flow analysis of three representative networks (urban, dense urban, rural) using ConnectLV and DIgSILENT. The later can evaluate power flow phenomena such as harmonics and power factor correction. To learn more about LV voltage control and the technologies entering the market, EATL will produce a detailed technology literature review. This will capture all relevant information required to complete the analysis in Phase 2, and explain how each technology works. Phase 2 utilises the information gathered in Phase 1 to make strategic decisions. Firstly, by pairing the future network requirements highlighted in the network study with the technologies assessed in the literature review to understand technologies functional requirements. Then, a general methodology and design toolbox for selecting which LV voltage control technologies best address certain future network issues. Finally, the extended technology investigation phase delivered by EATL, that follows the literature study, seeks to shadow the development of the most promising technologies and make a final recommendation of their applicability in a DNO. To conclude the project, National Grid would evaluate the methodologies used by each consultant to ascertain which offers a more comprehensive assessment of future network requirements and the creation of design methodologies. Followed by the standard NIA closedown report.

Objective(s)

- Understand the issues which are likely to be present on the Low Voltage (LV) network up to 2050. Business As Usual (BAU) activity does not investigate the LV network at this granularity.
- Document the current state-of-the-art LV voltage control options and evaluate which are likely to meet the functional requirements created in this work.
- Develop two design methodologies for selecting whether LV voltage control technologies can offer a benefit over conventional reinforcement strategies.
- Develop an understanding of which network assessment methodology is most suited for modelling issues and forecasting required investment on the LV network.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

N/A

Success Criteria

- A detailed literature review is produced that captures all of the state-of-the-art LV voltage control technologies available, how they work and which DNO has implemented them.
- Comprehensive network studies are carried out that identify the demographic of LV compliance issues. The outputs from each approach needs to explain clearly, where network compliance issues will be experienced.
- Each consultant produces a clear methodology, which is clear enough so DNOs can select the best LV voltage control devices based on what likely challenges are forecasted on their network.
- A detailed technology witnessing report is produced that explains whether the up-and-coming technologies can meet the functional requirements determined in the network study.
- A detailed methodology comparison report is produced that explains the strengths and weaknesses of each methodology employed by each consultant. This report clearly explains what method should be used in further analysis.

Project Partners and External Funding

- National Grid has experience in network modelling and analysis. In addition, experience in developing and trialling new technologies on the network.
- EA Technology Ltd. developed the Transform tool, which will be used for their analysis. They have considerable experience leading and delivering numerous NIA projects. In addition, experienced project managers have been assigned to the project who will oversee EATLs work in line with the project's objectives. EATL are contributing £8,916.00 towards the total cost of the project.

Potential for New Learning

From phase 1, parties are expected to learn about the growth of issues on the LV network and an estimate of the cost to resolve these through conventional means. Furthermore, through the literature review, parties will learn about the new LV voltage control technologies that are entering the market in the coming years. Phase 2 takes this further, and allows parties to understand where each technology may have a benefit over conventional means.

Aside from the network studies and investigation of technologies, parties will be able to learn from the project delivery process. By running two parallel approaches, parties can learn the differences between each approach and take our recommendation as to what is most appropriate for further use.

All finalised reports and deliverables will be made publically accessible on our website.

Scale of Project

The project is desktop only. Reports and network analysis studies will be produced with no technical demonstrations.

Technology Readiness at Start

TRL4 Bench Scale Research

Technology Readiness at End

TRL6 Large Scale

Geographical Area

This project will be run over all license areas of National Grid's network. Data from the Transform tool will be used to create representative views of each license area, and EATL's Power System Studies team will create representative networks in ConnectLV that can be used to model different parts of our network.

Revenue Allowed for the RIIO Settlement

N/A

Indicative Total NIA Project Expenditure

Total Project Cost £344,155.00 Agreed Partner Contributions (EA Technology ltd.) £8,105.00 Sub Total £336,050.00 National Grid DNO Contribution £33,605.00 Funding from NIA £302,445.00

Project Eligibility Assessment Part 1

There are slightly differing requirements for RIIO-1 and RIIO-2 NIA projects. This is noted in each case, with the requirement numbers listed for both where they differ (shown as RIIO-2 / RIIO-1).

Requirement 1

Facilitate the energy system transition and/or benefit consumers in vulnerable situations (Please complete sections 3.1.1 and 3.1.2 for RIIO-2 projects only)

Please answer **at least one** of the following:

How the Project has the potential to facilitate the energy system transition:

N/A

How the Project has potential to benefit consumer in vulnerable situations:

N/A

Requirement 2 / 2b

Has the potential to deliver net benefits to consumers

Project must have the potential to deliver a Solution that delivers a net benefit to consumers of the Gas Transporter and/or Electricity Transmission or Electricity Distribution licensee, as the context requires. This could include delivering a Solution at a lower cost than the most efficient Method currently in use on the GB Gas Transportation System, the Gas Transporter's and/or Electricity Transmission or Electricity Distribution licensee's network, or wider benefits, such as social or environmental.

Please provide an estimate of the saving if the Problem is solved (RIIO-1 projects only)

The conventional means to address these issues may involve building a new substation or upgrading existing infrastructure, which can incur significant capital expenditure. Our Connections charging statements provides the cost for a range of jobs and services. For example, a typical ground-mounted 1 MVA distribution substation can cost between £34k and £57k and the baseline cost of laying a cable in an urban environment can be up to £5.7k for the first 10m with an additional cost of up to £256/m. Therefore, if there are a large number of instances where simultaneous thermal and voltage compliance issues are present, that previously may require an upgraded transformer and new higher capacity cabling, a more cost-efficient way to fix this could be the use of LV voltage control. One of the technologies we will assess is the 'IONATE Smart Hybrid Transformer'. With a unit cost of £20k, and the ability to independently manage HV and LV voltages, cable replacement may be avoided in some severe cases by replacing only the transformer with a smart device. By eliminating replacement cables, the smart transformer could actually offer a financial net benefit if over 60m of cable is not required to be replaced. However, until we establish a more comprehensive understanding of the future network conditions through our network study, the scale of the benefit is unknown.

Please provide a calculation of the expected benefits the Solution

The financial benefits the project offers is outlined in 3.2.1. An in-depth cost-benefit analysis will be performed as part of the design methodology and more detailed costs and savings will become part of the project's learning.

Please provide an estimate of how replicable the Method is across GB

All network analysis will be carried out with network archetypes that can easily be replicable for all UK DNO's at no expense.

Please provide an outline of the costs of rolling out the Method across GB.

N/A

Requirement 3 / 1

Involve Research, Development or Demonstration

A RIIO-1 NIA Project must have the potential to have a Direct Impact on a Network Licensee's network or the operations of the System Operator and involve the Research, Development, or Demonstration of at least one of the following (please tick which applies):

☑ A specific piece of new (i.e. unproven in GB, or where a method has been trialled outside GB the Network Licensee must justify repeating it as part of a project) equipment (including control and communications system software).

☑ A specific novel arrangement or application of existing licensee equipment (including control and/or communications systems and/or software)

☐ A specific novel operational practice directly related to the operation of the Network Licensees system

☐ A specific novel commercial arrangement

RIIO-2 Projects

☐ A specific piece of new equipment (including monitoring, control and communications systems and software)

☐ A specific piece of new technology (including analysis and modelling systems or software), in relation to which the Method is unproven

☐ A new methodology (including the identification of specific new procedures or techniques used to identify, select, process, and analyse information)

☐ A specific novel arrangement or application of existing gas transportation, electricity transmission or electricity distribution equipment, technology or methodology

☐ A specific novel operational practice directly related to the operation of the GB Gas Transportation System, electricity transmission or electricity distribution

☐ A specific novel commercial arrangement

Specific Requirements 4 / 2a

Please explain how the learning that will be generated could be used by the relevant Network Licensees

This project has the potential to save DNOs money in several strategic ways. The most significant is a result of the project being capability led rather than technology-led. For example, by clearly assessing the forerunning LV voltage control technologies, and evaluating them against the network functional requirements, we eliminate the potential for money to be spent trialling technologies that would not offer any strategic benefit. Overall, the project seeks to direct investment to where it is most impactful at an early stage.

An in-depth cost-benefit analysis will be performed as part of the design methodology and more detailed costs and savings will become part of the project's learning.

Or, please describe what specific challenge identified in the Network Licensee's innovation strategy that is being addressed by the project (RIIO-1 only)

N/A

Is the default IPR position being applied?

☑ Yes

Project Eligibility Assessment Part 2

Not lead to unnecessary duplication

A Project must not lead to unnecessary duplication of any other Project, including but not limited to IFI, LCNF, NIA, NIC or SIF projects already registered, being carried out or completed.

Please demonstrate below that no unnecessary duplication will occur as a result of the Project.

The methodology for SILVERSMITH has been reviewed against other projects registered on the Smarter Networks Portal and circulated with other DNOs and TNOs ahead of registration to ensure no unnecessary duplications will occur.

If applicable, justify why you are undertaking a Project similar to those being carried out by any other Network Licensees.

- Electricity North West's 'Street Smart' trialled several innovative ways to manage voltage issues on the LV network, which will be used in our literature review and help us to make decisions in the design methodology. We will develop the exciting work ENWL produced into a clear methodology that DNOs can use to use the right technologies.

- Electricity North West's 'QUEST' will create an overarching control system to co-ordinate voltage management techniques and investigate their benefits. Whilst it does cover voltage control techniques, it does not study the low voltage network in the same depth as SILVERSMITH, nor does it investigate the specific solutions available at LV.

- Electricity North West 'Low Voltage Network Solutions studied the characteristics, behaviour and future needs of their low voltage distribution network. It created 25 real LV networks and some examples of LCT profiles to understand the effect that they will have on the network. The project looked at the maximum number of connections possible before compliance issues prevented further requests. SILVERSMITH will build on this learning by investigating the novel technologies that may extend the number of connections possible via unconventional means.

- Electricity North West's 'Low Voltage Integrated Automation (LoVIA)' investigated how an integrated solution and novel application of automated voltage control using on-load tap changers can be used to provide coordinated voltage control. SILVERSMITH expands on this learning by considering a larger range of technologies that can provide value to the LV network. In addition, it will create a methodology for selecting the best strategy based on the specific issues that are present on a given network.

Additional Governance And Document Upload

Please identify why the project is innovative and has not been tried before

There has not been a vendor-independent review into voltage control on the Low Voltage networks. At this early pre-adoption stage, we believe it is important to fully understand the scale of benefit available, rather than progress straight to a large-scale demonstration or trial of a particular technology. This involves a bottom-up capability assessment to evaluate what functional requirements are needed to address future LV network issues, capture the demographic of the issues that are present and evaluate the most cost-effective solutions. This approach to LV voltage control development has not been completed before.

The key innovative element of SILVERSMITH is the creation of a design methodology that we and other DNOs can utilise when making investment decisions surrounding LV voltage control or the need for reinforcement. The methodology will explain the most significant issues and explain the network conditions and constraints that cause them. For example, a coinciding volt rise, cable utilisation issue, and transformer overloading issue. If this could be addressed with a smart device that reduces the need for the immediate reinforcement of cables and decreased operational costs from tap-changing, this would be of key interest to DNOs.

Finally, by comparing two separate methods for evaluating network reinforcement on the LV network we can learn what approach works best. The transform tool has been used extensively by DNOs, so having a chance to sense check it with a more rigorous power flow assessment we are able to understand if it is appropriate to continue using the tool going forwards.

Relevant Foreground IPR

The Relevant Foreground IPR is:

- All deliverable reports and documents

The Relevant Background IPR required to produce this is:

- National Grid's network modelling data
- The Transform tool

Data Access Details

Additional data will not be collected for the project.

Please identify why the Network Licensees will not fund the project as apart of it's business and usual activities

We would not be able to fund this type of investigative work as a BAU activity. The methodology is not proven and too high-risk for BAU.

Please identify why the project can only be undertaken with the support of the NIA, including reference to the specific risks(e.g. commercial, technical, operational or regulatory) associated with the project

We would not undertake this project without NIA funding as the technology readiness level (TRL) would be too low and risk involved would be too high.

This project has been approved by a senior member of staff

☑ Yes