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## NIA Project Registration and PEA Document

### Date of Submission

Nov 2019

### Project Reference Number

NIA\_SPEN\_0047

## Project Registration

### Project Title

A Transition to LVDC - Phase 2

### Project Reference Number

NIA\_SPEN\_0047

### Project Licensee(s)

SP Energy Networks Distribution

### Project Start

November 2019

### Project Duration

2 years and 5 months

### Nominated Project Contact(s)

Michael Eves

### Project Budget

£500,000.00

## Summary

Building upon the learning in 'A transition to LVDC', LVDC Phase 2 will conduct laboratory tests on the LV cables & network apparatus most prevalent on SPENs network to gain an understanding of how SPENs LVAC cables & network apparatus behave and perform when energised with LVDC. The outcome of the tests will then inform which areas of the network would be suitable for conversion to LVDC through case-based cost benefit analysis, as well as building a case for new LV schemes to be LVDC by design from their initiation.

### Nominated Contact Email Address(es)

innovate@spenergynetworks.co.uk

## Problem Being Solved

The decarbonisation of transport and heat, whilst a hugely important step towards reducing the effects of climate change, will put a huge strain on the electricity network. Particularly for Low Voltage networks where without intervention, circuits will become heavily overloaded with the expected EV uptake in the coming years.

Coupled with this issue is that many Low Carbon Technologies such as EV chargers have a DC output meaning they are incurring a AC to DC loss as result. LVDC seeks to address both of these issues by converting areas of the LVAC network to LVDC to allowing for huge increase in power transfer capacity in the cables and reducing/negating conversion losses at LCTs.

LVDC Phase 1 demonstrated that there is a cost, time and environmental benefit may be realised through conversion to LVDC as opposed to conventional network reinforcement.

Therefore, LVDC phase 2 will continue the research in this area to enable LVDC to become BaU through testing AC assets under DC conditions to verify their capability for conversion.

## Method(s)

## Package 1: Cable Laboratory Testing

- Laboratory testing of both 3-core and 4-core cable at increasing DC voltage levels and loads.
- The impact of DC on cable rate of ageing will be determined using partial discharge and cable temperature monitoring.
- The impact of cable failure will be tested to understand the HSE & O&M requirements for converted DC circuits. The energy released from DC fault is normally higher than in AC due to the high transient discharge currents and steady state fault currents without zero crossings. The test will provide understanding the impact of such phenomena which will give design engineers and district staff the confidence that circuits can be operated at DC without additional unmanageable risk.

## Package 2: Test Outcome Analysis and Network Reinforcement CBAs

- Case studies for network reinforcement with detailed CBAs to demonstrate the financial benefit that would be realised using a DC reinforcement/design approach as opposed to a traditional LVAC reinforcement method.
- Recommendations for network applications which would benefit the most from the deployment of LVDC distribution.

## Scope

LVDC Phase 2 will have two major work packages that will be delivered in order to complete the project objectives.

### LVDC Phase 2 – Work Package 1:

The most populous mains and service cables on our LV network:

- 3 core XLPE CNE Waveform mains cables
- 4 core PILC SNE mains cables
- Single core XLPE CNE Hybrid service cables
- 2 core PILC SNE service cables,

as well as prevalent linkboxes and joints will be subject to tests at voltage of:

- $\pm 707$  Vdc &  $\pm 500$  Vdc Bipolar.

The tests will include:

-Establishing cable initial health through a combination of:

- o Time Domain Reflectometry
- o Conductor and Insulation resistance
- o Cable capacitance
- o  $\tan \delta$

- Partial Discharge

- DC Loading Operation Cycles for the above voltages

- Accelerated aging of cables through:

- o Voltage loading &
- o Thermal loading

-DC Fault behaviour & analysis

LVDC Phase 2- Work Package 2:

The outcomes of these tests will inform what cables are attractive for conversion to LVDC and thus lead onto Package 2 where case study CBAs will identify areas where LVDC can provide cost savings over traditional network reinforcement. Coupled with rural areas where longer LVDC feeders provide a better alternative to LVAC.

These outcomes will aid in the transition to LVDC being BaU by providing a road map to standards and governance for LVDC and a much deeper understanding of what LVDC can provide.

### Objective(s)

- To compile a testing specification which covers the predominant AC assets within the LV network;
- Conduct a tender exercise for a testing facility to complete the testing specification created;
- To complete the testing specification and compile a report on the findings from the laboratory testing;
- To create a series of case studies and a cost-benefit analysis which will conclude where converting existing assets to LVDC would be technically and economically viable.

### Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

### Success Criteria

- Completion of the tendering exercise for laboratory testing
- Completion of testing programme (by supplier)
- Reporting on the possible use cases of LVDC using existing assets
- Detailed Cost-Benefit Analysis of viable use cases as a result of the report produced from the testing specification

### Project Partners and External Funding

N/A

### Potential for New Learning

- Capability of existing AC assets to operate on DC
- Required network configurations and associated costing with conversion
- Market capability for working with LV DC
- Appropriate convertor technology which would support LV DC conversion

### Scale of Project

Scale of the project is reasonable with prime costs to cover the scope of the testing framework.

### Technology Readiness at Start

TRL2 Invention and Research

### Technology Readiness at End

TRL4 Bench Scale Research

### Geographical Area

The testing facility will be determined within the project through a competitive tender and the use cases will be within the SPEN licence areas (use cases finalised during the reporting)

### Revenue Allowed for the RIIO Settlement

N/A - Research project, Cost-Benefit Analysis to be completed as part of the project scope.

### Indicative Total NIA Project Expenditure

£350000

## 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)

LVDC Conversion as opposed to traditional LVAC reinforcement can provide potential project cost savings of approx. 50% per case. Of the SPEN circuits which are forecast to be reinforced by the end of ED2, assuming a LVDC conversion rate of 5%, potential savings of approx. £11.25m can be realised over the next decade.

Network loss reduction as a result of negating the AC to DC conversion at LCTs such as PVs, Battery Storage and EV chargers has the potential to save SPEN customers £2.75m per annum upon roll out.

#### Please provide a calculation of the expected benefits the Solution

N/A - Research

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

To be determined within project scope.

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

To be determined within project scope.

### 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

The learning from the project will apply to DNOs for LV DC conversion possibilities (viability of LVDC converted assets, associated technology, market capability and network configurations)

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

Deliver Value to Customer - Managing an ageing network & A Smarter Flexible Network - Preparing networks for LCTs, Network Flexibility & Communications

- Has the Potential to Develop Learning That Can be Applied by all Relevant Network Licensees

#### 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.

No other project identified within the UK that looks at existing asset conversion, which was a part of the Phase 1 scope (see literature review) & ENA portal review

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

n/a

### Additional Governance And Document Upload

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

Using existing AC assets under DC load conditions has not been explored previously. The area of LVDC as a whole is a new concept and this aspect of the field is newer still, there are many applications of LVDC networks using new assets. This project seeks to maximise the value of existing assets while removing the constrained assets therefore supporting LCT uptake.

#### Relevant Foreground IPR

n/a

## Data Access Details

n/a

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

The business case determined thus far is unproven and rests on the viability of the AC assets working under DC conditions.

### **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**

There are specific commercial risks of supporting rollout that requires this prerequisite research, and the key technical risk that the aged assets may fail during the testing period. Furthermore, there is a need to prove the operational requirements of network conversion.

### **This project has been approved by a senior member of staff**

Yes