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

Nov 2018

Project Reference Number

NIA_SPEN_0036

Project Registration

Project Title

A Holistic Intelligent Control System for flexible technologies

Project Reference Number

NIA_SPEN_0036

Project Licensee(s)

SP Energy Networks Distribution

Project Start

December 2018

Project Duration

4 years and 1 month

Nominated Project Contact(s)

James Yu

Project Budget

£1,200,000.00

Summary

This project will investigate the potential use of a Holistic Intelligent Control System for the power network.

Third Party Collaborators

Cardiff University

Arup

Nominated Contact Email Address(es)

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Problem Being Solved

There is a strong drive for DNOs to facilitate the ambitious UK government and Scottish Government target to ban all new petrol and diesel cars and vans by 2035 and 2040 respectively, and also relying on renewable energy resources for heat and transport. The way energy is consumed and generated are changing and customers are becoming an active player in the energy electricity system. Distribution networks are increasingly important to facilitate these changes in a most cost effective manner and provide the best value to customers. Providing active network operation and transition to a distribution system operator (DSO) arrangement are in the road maps of all the UK DNOs to accommodate the changes in electricity customers behaviour in line with the UK government Carbon Plan.

There has been growing integration of flexible and smart solutions in electricity distribution networks to enhance the utilisation of network assets. In addition the growing controllable nodes and visibility in the distribution networks are the enablers for transition to

DSO where network flexibility offers an adaptive system to customers' needs and facilitating the competition in energy market.

UK DNOs have been trialling different technologies that allow controlling network parameters such as voltages, power flow and network topologies in real-time e.g. Fun-LV, Active Response, LV Engine, Angle-DC and Equilibrium. Usually each flexible solution/technology requires its own controller which in principle aggregate the local and/or remote monitored data and uses an optimisation algorithm to determine the set points for the controllable devices. The control system architecture often consists of a Master and a number of slave controllers. Typically, the master controller uses regional input data, whereas slave controllers use data available locally.

There are similarities between these controller units in terms of their function, i.e. the control algorithms and the communication requirements. However, due to lack of a holistic smart control system, each flexible solution is currently independently designed, tested and taken through performance check for a period before it can be trusted for Business as Usual (BaU) adoption. This can result in the following technical and commercial issues:

- Incurring additional and unnecessary costs for a duplicate effort in designing the control systems for every solution

- Delaying the BaU adaption of the solution as the control system should go through a period of tests and refinement

- Incurring additional maintenance and training cost for operation staff as they have to deal with multiple systems provided by different vendors

- Sub-optimum network operation as each solution only limited to specific objectives, network area or voltage levels

Method(s)

A proposed solution can be a DNO (DSO) owned Flexible Holistic Intelligent Control System (HICS) that:

- Sets out the control signal hierarchy and overall network operation optimisation by considering the controllability and impact envelopes of controllable nodes and also the customers flexibility offer through aggregators

- Can be flexibly adapted to coordinate different optimisation objectives, of controllable devices, to enhance network performance, reliability and also provide commercial signals to other network flexibility providers (e.g. aggregators). Some of the high level network operation objectives can be network losses, wide area voltage optimisations, maximum network headroom capacity etc.

- Have the capability of machine learning or using artificial intelligence so it can be adaptive to network changes, robust against missing real time data loss through loss of network communications and be functionally independent safely.

- Provides a core control module which can flexibly and securely integrate the new technologies and interact with other DNO systems (data historian, Network Management System, Data integration platform etc.)

- Provides a level of interoperability, allowing communication and integration with various network monitoring equipment offering a vendor agnostic solution

- Is a DSO enabler and capable of providing market commercial signals and technical requirements associated with the DSO transition

- Identifies the corresponding international standards and forums, including but not limited to CIGRE B4, C4 studying committee, IEC and SQSS, to inform and influence the ongoing discussion and standardisation when applicable.

It is envisaged that the HICS consists of the main (master) controllers providing overall coordinated network optimisation and local (slave) control units providing fail-safe function and set point adjustments based on local data. This project aims to identify the system architecture, optimisation algorithms HCIS and also trial of HICS within the distribution network demonstrating its performance at different voltage levels.

Scope

The project will be carried out in three stages, the main delivery phase is over a two and half year period. The start of each stage will be dependent on the success of the previous stage. Details of the stages are given below:

1. Stage One: System Design (duration 12-18 months)

This stage includes Identifying the system architecture design, optimisation algorithms functional specifications, communication requirements and user acceptance tests for a fit-for-purpose HICS.

Also proof of concept and functionalities within the controlled environment (i.e. through simulation and verification. Stage one will involve:

o Review and Identify the common control algorithm between various ongoing projects and also DSO requirements

o Develop IT security requirements, identify flexible communication protocols and requirements to interface with existing and future SPEN systems and compliance with IEC smart grid standards (IEC 61850, IEC 61970, IEC 61968, IEC 60870 etc).

o Identify the BaU system integration requirements, system ownership, roles and responsibilities and end user interfaces

o Detail the specific requirements for control at different voltages or different applications

o Develop the integration process of the controller with 3G/4G/other communications (such as Narrow Band or opt fibre.

o Simulate typical intact and N-1 distribution network scenarios, at different voltage levels, within the impact envelope of each controllable device.

o Fresh market research on technologies and capable suppliers to implement HICP

2. Stage two: Demonstration in SP Energy Networks with potential opportunities in other DNO networks (duration 12-18 months)

o Engaging with internal stakeholders of DNO (DSO) organisations

o Procurement of the hardware and software, liaising with internal stakeholders such as RTS, control and licensed programs

o System implementation and commissioning

o Performance demonstration using data from ongoing projects (such as ANGLE DC,LV Engine and DSR projects using Power Electronics) .

o Monitor the performance for 6 months, implement refinements and capture learning.

3. Stage three: Integration into BaU (duration 12 months)

o With potential to refine operational process, increase operational experience

o Develop policy documents, technical operational guidance and process for integration of further existing and upcoming controllable solutions

o Training and final handover to SPEN operation

o Reporting to national and international standards and forums, including but not limited to CIGRE B4, C4 studying committee, IEC and SQSS, to inform and influence the ongoing discussion and standardisation when applicable

The proposed approach would enable us to demonstrate process-level integration with UK systems and gain operational experience.

Objective(s)

The objectives of the project are to:

- Identify the features required for a Holistic Intelligent Control system owned by a DNO (DSO)
- Analysis the evolving characteristic of distribution network with uptake of renewable generation, energy storage and EV
- Define the existing and future control technical requirements to future proof the controller functional design

- Scoping and specifying the control interfaces depending on the engineering and/or commercial relationship
- Review and Identify the common control algorithm to standardise the process
- Assess the communication infrastructure requirements and its sensitivity in the control process
- Validate the design of a holistic system controller

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

The criteria will be used to determine whether the project has been successful:

- Provision of a Functional Specification of a Holistic Intelligent Control System (can be cross DNO areas or several GSP within one DNO area).
- Provision of initial system architecture design and simulation of the effective application of such a controller
- Provision of updated cost benefit analysis (including finance, CO2 emissions, QoS performance) compared with the existing controller.

Project Partners and External Funding

The project partners will be identified in the process of innovation project delivery

Potential for New Learning

This project has a high potential to deliver new learning with regards to:

- The method's viability to consistently improve the reliability and performance of the network operation;
- Provide a standardised controller functional specification;
- The function and impact of communication infrastructure to the controller.

The learning form the project will be shared via the ENA smarter networks portal and other industry portals, via reports and presentation.

Scale of Project

The project will be completed as a collaborative project.

Technology Readiness at Start

TRL6 Large Scale

Technology Readiness at End

TRL8 Active Commissioning

Geographical Area

The project will be completed as a collaborative project.

Revenue Allowed for the RIIO Settlement

No revenue has been allowed for this project in the RIIO-ED1 settlement.

Indicative Total NIA Project Expenditure

The total cost of the project can be estimated as:
Phase I: £260k

Phase II: £1.2m
Phase III: £200k

The licensees and the partners will continue the efforts to leverage funding and knowledge from existing innovation projects.

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 project has the potential to produce benefits as follows:

Benefit to ongoing projects: This project generate knowledge, standard approach and methodologies which will inform the existing projects to provide efficiency in delivery, reduce risk of overspent in implementation and procurement of hardware and software components. The most relevant exiting projects are Angle-DC, LV Engine, Fusion and North Wales Active Network Management (ANM). In addition, staff times required for working on implementation of internal IT equipment can be saved as the exiting projects can potentially use the same equipment (e.g. Servers) within corporate network. It is anticipated that up to £425.0k benefit can potentially materialises across all the projects.

Roll-out Benefits: The larger benefits of this project will be through more efficient approach to roll-out of smart technologies. If the ongoing projects are successful, they will be potentially rolled out in large scale in the networks. HICS can provide a proven platform for facilitating the roll out of technologies, reduce the overall risk of non-deployment of the solutions by providing a lower implementation cost and better business case. For a relatively small incremental costs for hardware, more virtual control servers can be added which allows further savings to be released on a per scheme basis. It is conservatively estimated that the overall benefit in facilitating roll-out of the solution will be around £5.0m by 2030.

Benefits of wide area network optimisation: Network losses and network congestion management can be optimised in a wide area of the network by using a holistic system controller rather than conventional approach that a controller focusing only on a specific objective function.

Please provide a calculation of the expected benefits the Solution

Benefit to ongoing projects

The base line is considered as a percentage of equipment cost (those within SPEN Corporate network) and staff time in some of the ongoing projects. The breakdown of the benefit would be as follows for each project.

The project will also have direct positive impact on the ongoing NIA projects across the sector.

Roll-out Benefits

It has been assumed that through HICS, the implementation cost of different solutions would be lower and that may result in a conservative 5% additional roll-out benefits. In the original submissions to Ofgem it has been estimated that Angle-DC, LV Engine and Fusion will provide £50m benefits to customers by 2030. By de-risking the delay in deployment of this solution, using the same IT equipment and reducing the implementation cost, we assume to see 5% additional benefit of £2.5m by 2030. This figure can be conservatively doubled if we consider other technologies/solutions providing controalbility will be also added to the network by 2030, hence, a benefit of £5.0m can be expected.

Benefits of wide area network optimisation

The baseline is that each power electronic devices in the network will deploy their own controller and without coordination at the system level. Compared with this baseline, the proposed approach can have the potential to generate the following benefits:

1. Optimised voltage profile at the HV and LV network, hence reduce the system losses in the order of 20% based on simulation studies carried out; which is equivalent to losses in Anglesey and North Wales are anticipated to be reduced by approximately 13,030 MWh annually in the planned area;

2. This tangible benefits can be converted to £18m by 2050;

The calculation is prudent and based on the simulation of winter peak and summer min scenarios for 33kV and below networks within SPEN's franchised area.

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

The project is intended to be rolled out across the license areas of participating DNOs. The DNOs would need to procure their own HICS hardware and scheme central controller algorithms. The project standardised model and common application platform could then be replicated on the host server running the virtual machines at a minimal development cost.

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

Below is the estimated reduced cost per license area for 3 schemes plus DSO. For each system in a TRL 9 level, we estimates the cost of controller hardware and software will be significantly dropped to c. £600k, representing 60%-70% of current estimation.

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):

- [x] 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).
- [x] A specific novel arrangement or application of existing licensee equipment (including control and/or communications systems and/or software)
- [x] 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

Currently, active network management has no standard or ENA Engineering Recommendation (ER). There is a need to develop a common approach to controllable network devices at all voltage levels, which will allow for efficiency savings through a best practice holistic approach. For example, purchasing one server with multiple virtual servers running each control scheme , instead of multiple bespoke servers, each running one scheme . With a holistic control ER or standard, DNOs could procure hardware and software at less risk with a better state of knowledge on how to integrate them at the lowest cost.

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

☑ 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.

The document is shared with key stakeholder in the public ENA portal

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

The project is innovative in that it proposes a coordinated, interoperabable power electronic controller, base on the recent technology advancement and increasing demand in the network applications. The pace of such a development was the main reason for lack of trial before

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

Network Licensees have strong interests, hence taking the leading role to facilitate the work under NIA. But the TRL is not at the business as usual yet.

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

TRL, the potential benefits to customers will warrant for NIA funding

This project has been approved by a senior member of staff

☑ Yes