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

Mar 2022

Project Reference Number

NIA2_NGET0004

Project Registration

Project Title

Centralised PAC

Project Reference Number

NIA2_NGET0004

Project Licensee(s)

National Grid Electricity Transmission

Project Start

August 2022

Project Duration

2 years and 2 months

Nominated Project Contact(s)

Thomas Charton (box.NG.ETInnovation@nationalgrid.com)

Project Budget

£1,325,796.00

Summary

The capability and versatility of protection hardware platforms has significantly increased over recent years opening opportunities for more centralisation and virtualisation of functions. This has been recognised and preparations for future standards, requirements are currently in preparation as part of CIGRE working groups and current innovation projects.

The proposed solution aims to take the next step in this development by delivering a demonstrator for a centralised substation platform. The solution will consist of Merging Units, process bus network and centralised PAC platform.

The project will include an assessment of current HW capability, SW architectures, development of specifications and requirements for scalable, open, cyber secure transmission substation solution, test methodology and a demonstrator for laboratory-based evaluation

Nominated Contact Email Address(es)

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Problem Being Solved

Electricity Transmission substations are equipped with a large number of devices delivering the required Protection, Automation and Control (PAC) functions for the transmission system. These may be hard wired and/or networked over Ethernet networks to various degrees depending on the level of digitalisation. Configurations, implementation of logic, and automation functions are inherently linked to vendor specific implementations within IEDs. Whilst the development of fully digital secondary systems has delivered benefits and efficiencies in terms of engineering, testing, physical footprint and system access requirements, issues with obsolescence, bespoke hardware and software platforms as well as other asset/lifecycle management challenges have not been addressed yet.

Some progress has been made with regards to centralised systems specifically at distribution level and with proprietary platforms, however there are still significant challenges to overcome to enable a scalable, open, resilient and cyber secure real time platform able to handle the requirements of a full transmission substation.

Method(s)

To address the above problem this project will carry out research into hardware and software architectures and technologies that will enable the virtualisation and centralisation of substation protection automation and control functions and enable all functions to be hosted on a common real time hardware platform. Based on the findings, the requirements for hardware and software components will be defined such that the system can meet the requirements of a transmission substation in terms of performance, scalability, security, dependability and cyber security requirements. The requirements will be documented and will provide the specification for a proof of concept prototype implementation of such a system. A detailed test plan will be developed to validate the performance of the system.

Apart from the above technical aspects the project will also investigate the economic aspect of this technology, i.e. better protection of investment into software through platform independence, investigation of open source solutions and the creation of an open source ecosystem providing opportunities to reduce and share development cost.

Data Quality Statement (DQS):

- The project will be delivered under the NIA framework in line with OFGEM, ENA and NGGT / NGET internal policy. Data produced as part of this project will be subject to quality assurance to ensure that the information produced with each deliverable is accurate to the best of our knowledge and sources of information are appropriately documented. All deliverables and project outputs will be stored on our internal sharepoint platform ensuring access control, backup and version management. Relevant project documentation and reports will also be made available on the ENA Smarter Networks Portal and dissemination material will be shared with the relevant stakeholders.

Measurement Quality Statement (MQS):

- The methodology used in this project will be subject to our supplier's own quality assurance regime. Quality assurance processes and the source of data, measurement processes and equipment as well as data processing will be clearly documented and verifiable. The measurements, designs and economic assessments will also be clearly documented in the relevant deliverables and final project report and will be made available for review.

In line with the ENA's ENIP document, the risk rating is scored 6 = low.

TRL Steps = 1 (2 TRL steps)

Cost = 3 (>£1M)

Suppliers = 1 (1 supplier)

Data Assumption = 1 (clearly defined assumptions and principles)

Scope

The scope of the project covers 3 phases. The first part of the project will focus on research and optioneering. Suitable technologies and innovative HW and SW architectures will be investigated with regards to their potential to be developed into a system that can deliver all PAC functions for a transmission substation. Capabilities and requirements with regards to performance, environmental and cyber security will be investigated. Standardisation, portability and interoperability will be some of the key principles used during development and evaluation of potential concepts. The key findings and options will be reported as part of the first phase of the project.

Based on the findings in phase 1, phase 2 of this project will deliver a review of available options and design optimisation in order to provide a requirements and design specification for a centralised PAC solution. The work will also cover lifecycle management for such solutions including the engineering process, design, delivery, maintenance and replacement. As part of the delivery, testing of such systems will be essential and in particular the interaction between software and hardware resources as the systems are scaled up for large substations. The methodology for testing will consider scalability as well as interoperability.

The final phase of the project will use the requirements specification and build a (small scale) proof of concept demonstrator that complies with these requirements and principles outlined in the project. The test plan developed in phase 2 will be used to evaluate the performance of the demonstrator. Based on the learning from the project an updated assessment of potential benefits to consumers and energy networks is also included in the work.

Objective(s)

The objective of this project is to develop the technologies required for centralised protection, automation and control systems in transmission substations. This includes research into software and hardware platforms and architectures interacting with a digital substation process bus network. The project aims at delivering a state of the art of current capabilities in this area and developments in the near future concerning virtualisation of functions and real time hardware platforms suitable for centralised PAC. New and

emerging technologies will also be investigated. The solutions need to allow virtualisation of substation functions and allow portability between platforms to enable separate management of software and hardware lifecycles.

Based on the findings a requirements specification and functional design specification will be produced. The project will also aim to develop the engineering, design, delivery, maintenance and replacement methodology in order to cover the full life cycle of centralised PAC systems. Specifically testing and commissioning requirements and plans will be developed. Based on these outputs the project will develop, build and test a reduced scale proof of concept system that can demonstrate the required functionality and performance.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

Financial distributional impact: The project is expected to support energy networks to deliver and manage substation protection automation and control systems more efficiently and at lower cost through centralisation, virtualisation and digitalisation. If these savings are achieved, the financial distributional impact of this project aligns with the simplest case discussed in OFGEM's Assessing the impact of economic regulation report. The report confirms that the savings as a percentage of household income are more significant for lower income deciles and therefore the achieved benefits will be particularly valuable to vulnerable consumers. The pricing structure for energy transmission will not be impacted, e.g. benefits delivered as part of this project can be passed on to all consumers including households using a prepayment meter.

Technical and wellbeing impact: The consumer impact of any of the methods or solutions developed in this project is not dependent on any of the following factors:

- Dwelling and location (potentially including tenure)
- Readiness for digital technology
- Personal and social factors (for example, households with disabilities and medical conditions, or which speak English as a foreign language)

Energy technology and usage profiles: The results of this work can be applied regardless of energy technology and will not differentiate between consumer usage profiles.

Success Criteria

The success of this project can be measured based on the extent to which the objectives have been achieved, i.e. the successful delivery of reports, designs, specifications and a demonstrator including hardware and software for a centralised protection, automation and control platform as follows:

D1: A report on the state of the art and future developments for centralisation and virtualisation of substation PAC functions. This includes innovative designs, architectures and software.

D2.1: Requirements specification for centralised PAC systems

D2.2: Functional design and system specification

D2.3: Asset management and lifecycle management report

D2.4: Test plan and strategy

D3.1: Centralised PAC system based on specifications developed in this project including a test platform with process bus interfaces for laboratory testing and validation. This also includes all design documentation.

D3.2: Report on achieved test results and performance evaluation.

D3.3: Report on current and future economic viability, rollout options and interoperability.

D3.4: Summary of findings and new learning as well as dissemination of project outcomes.

Project Partners and External Funding

Not applicable

Potential for New Learning

This project has the potential to deliver significant new learning in the field of virtualisation and centralisation of transmission substation functions. Containerisation and docker technology has been available for some time and the use of virtual machines is now common as part of the delivery of substation control and automation platforms, however the integration of protection functions has so far been challenging due to the requirement to achieve deterministic and reliable performance and consume and process significant amounts of data from the substation process bus. Currently no commercial solution for transmission substations is available that meets the requirements and objectives of network licensees with regards to performance and cyber security whilst offering asset management benefit due to open platforms, potentially open source based software and independence between hardware and software suppliers. This project will develop new learning with regards to the requirements on hardware, hypervisors and software that will make up a viable centralised PAC system. The project will also document the performance that can be achieved with the chosen reference system, inform future policy and business cases and will be the foundation for future research and development in this area. The learning will be disseminated through the publication of the final project report and depending on opportunity through publication and presentation of research papers at conferences and through the ENA and CIGRE.

Scale of Project

The scale of the project includes a desktop study and desktop-based research and development work. A small-scale demonstrator has also been included in this work which will require some software development work. The current maturity of this technology is at a stage where some initial work has been done regarding a review of the concept in general but no practical information and test results are available which is why the project has included the construction of a small scale demonstrator to prove the concept and provide much needed real life test results and performance evaluation as proposed in the laboratory based trials in this project. None of this could be delivered by a desktop-only study. The potential benefits of rolling out centralised PAC systems are significant and far outweigh the R&D investment even when considering that some further work may be required to bring the technology to full maturity. More details are included in the benefit assessment below.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

The project will be partly desktop based and partly consist of laboratory trials. The work will be carried out at the relevant supplier's premises and the demonstrator will be transferred to NGET's test laboratory for further development and evaluation.

Revenue Allowed for the RIIO Settlement

Not Applicable

Indicative Total NIA Project Expenditure

Total NIA expenditure: £1,193,216.00

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:

The energy system transition will require more efficient, agile, and flexible delivery of substation functions. Ensuring network stability in a network with high penetration of Inverter Based Resources (IBR) may also require wide area monitoring, protection automation and control as well as more responsiveness and awareness of current system status. Centralised PAC systems will be able to support any type of future substation function including interfaces to wide area schemes and will facilitate a more efficient and flexible delivery of network connectivity and capacity.

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

Not applicable

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)

Not applicable

Please provide a calculation of the expected benefits the Solution

Due to the low TRL level of this technology the benefit assessment is based on a number of assumptions, i.e.;

The solution will be market ready for deployment within the next 5 years, i.e. from 2026.

In the worst case a benefit of 10% over the current baseline solution is expected. This is widely accepted as a conservative estimate since substation digitalisation alone has been shown to deliver benefits up to 30% in some applications and fully centralised PAC is expected to exceed the digitalisation benefits.

Based on these assumptions the NPV of this solution for currently planned work between 2026 and 2031 is approximately £7M. This includes one off costs for tools, training and type tests and registration.

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

Centralised protection automation and control platforms can be installed on all transmission substations. The benefit assessment is based on brownfield or greenfield new builds but the project will also investigate the business case for extensions, refurbishments and replacements.

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

The rollout of these systems will be on new substation builds where a saving over the current baseline solution can be proven. No rollout to existing infrastructure is envisaged at this stage. Applying the technology to refurbishment and replacement projects may be investigated in the future.

One-off costs for type testing, standardisation and design assurance are included in the CBA above.

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 this project as documented in the project deliverables will benefit all network licensees. The results of the desktop study into virtualisation and centralisation as well as the experience gained on the test system together with the specification will provide valuable insights for all stakeholders and accelerate the availability of these systems.

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

Not applicable

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.

A review of ongoing and previous projects has not shown any duplication with regards to this work. Some aspects of this work are also included in the Constellation project and liaison with the project team has confirmed that whilst some virtualisation technologies are in scope a fully virtualised and centralised PAC system is not part of the scope of this project. This project will build on previous work with EPRI as part of the Common Substation Platform project which was completed earlier in 2021.

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

Not applicable

Additional Governance And Document Upload

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

The TRL level of fully virtualised, open, centralised substation PAC systems is currently in the “research and feasibility study” phase and a lot of unknown factors regarding the hardware and software requirements still exist. The allocation of hardware resources to containers and functions in a way that delivers deterministic operation and the required reliability over the asset’s life is still a topic for research and such systems are not currently commercially available.

Relevant Foreground IPR

The foreground IPR created in this project will be embedded in the project deliverables, i.e. the reports, design documentation, requirements specifications, test results and demonstrator configuration. The supplier will bring their own background IPR to the project with regards to substation functional requirements, real time hardware and software platforms, data processing, networking, cyber security and substation secondary equipment design. The foreground IPR embedded in the project reports can be used without access to any background IPR.

Data Access Details

Data for this project and all other projects funded under the Network Innovation Allowance (NIA), Network Innovation Competition (NIC) or the new Strategic Innovation Fund (SIF) can be found or requested in a number of ways:

- A request for information via the Smarter Networks Portal at https://smarter.energynetworks.org, to contact select a project and click ‘Contact Lead Network’. National Grid already publishes much of the data arising from our innovation projects here so you may wish to check this website before making an application.
- Via our Innovation website at https://www.nationalgrid.com/uk/electricity-transmission/innovation
- Via our managed mailbox box.NG.ETInnovation@nationalgrid.com

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

The current TRL level of virtualised, centralised protection automation and control systems for transmission substations is relatively low and still in the research and feasibility study phase. There is also significant uncertainty regarding the technical feasibility, requirements, performance, lifecycle and economic viability as well as mechanisms to roll out this technology as part of a refurbishment rather than for new builds only. The low TRL level and risk associated with this project indicate that NIA funding in the correct mechanism rather than BaU delivery.

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

Commercial risks:

Whilst the concept of centralised transmission substation protection, automation and control is well established, the actual requirements in terms of hardware and software are not known and hence the commercial assessment of such solutions relies on assumptions regarding the feasibility and effort to build test, commission and maintain such systems. There is also interest from new players to engage in this market however beyond a research interest it is uncertain how the market will evolve in future.

Technical risks:

Technical feasibility requires further work before the required hardware architecture and resource requirements are confirmed that will facilitate the reliable operation of centralised PAC systems. Whilst confidence is high that the required technical outputs can be delivered the effort to do so is uncertain and might make such systems economically unviable. There is also a technical risk regarding deterministic performance over a long life cycle, typically 15 – 20 years for the hardware.

Operational risks:

N/A

Regulatory risks:

N/A

This project has been approved by a senior member of staff

☑ Yes