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NIA Project Registration and PEA Document

Date of Submission

Jun 2021

Project Reference Number

NIA_SHET_0033

Project Registration

Project Title

Protection Solutions to perform for Lower Levels of Fault Current on AC Networks (PSL-FC)

Project Reference Number

NIA_SHET_0033

Project Licensee(s)

Scottish and Southern Electricity Networks Transmission

Project Start

July 2021

Project Duration

4 years and 9 months

Nominated Project Contact(s)

Colin Mathieson

Project Budget

£717,000.00

Summary

This project aims to investigate how effective and reliable new Protection and Control equipment is on a future electricity network, which has even more renewable generation and power electronic equipment, via a combination of network simulation and open-loop device trials.

It is also the aspiration to determine new tests and validation processes for the Protection and Control equipment, in the future transmission system environment of low fault currents. Research would also be conducted into the shape and structure of new Protection and Control operating processes and protocols to help accommodate the transition of the network towards net-zero.

Third Party Collaborators

The National HVDC Centre

University of Strathclyde

Nominated Contact Email Address(es)

transmissioninnovation@sse.com

Problem Being Solved

Our present Protection and Control (P&C) equipment and protocols are based on the expectation of conventional fossil fuel generation contributing high levels of current during a fault. P&C systems are set to detect sudden abnormally high spikes in current and have fast operational times to isolate the fault from the system. With the increase in renewables and equipment controlled by power electronics, the associated abnormal fault current spikes are reducing in magnitude and their characteristics are changing. There is a growing concern that present P&C systems may not detect a future low-level current fault, nor operate to isolate the malfunctioning equipment as expected. New protection approaches that consider other factors associated with a fault are potentially available, but we have currently no method or framework by which their functionality and performance can be reviewed, tested and demonstrated.

Method(s)

This is a development project as the intention is to evaluate how a range of P&C products operate in a simulated future electricity system scenario. There are three clear steps that form the back bone of this innovation.

Step 1 – Validating the simulated future network

This will be achieved by placing the P&C products being investigated in parallel with the live network and monitoring how they respond to real-time system changes. To ensure that a range of real-time system events are captured the P&C products will be installed for a minimum of eighteen months. The real-time system changes will be run on the simulated future network to firstly ensure it reflects the real-time network and then to investigate how the P&C products respond between the real-time system and the simulated network.

Step 2 – Evaluating P&C operation on a future lower level fault current Alternating Current (AC) network

If the first step is successful, then further research will be conducted by emulating different future electrical system scenarios that will lower the fault current level and investigating how the range of P&C products responds.

If the P&C products struggle to detect lower levels of fault current, solution development work will have to be discussed with the P&C manufacturers and from a Transmission Network perspective more work will be required to determine other possible mitigation measures.

Step 3 – Developing low level fault current testing and validation protocols for AC networks

Alternatively, if the P&C products detect and operate to isolate the fault successfully, then work will commence to document the testing and validation of P&C products that are required to operate in lower level fault current AC networks. Also, the way the P&C products operate will be compared to today's traditional requirements, policies and procedures, for the purposes of identifying what changes need to be proposed. This will shape the next development stage and help to build a pathway to incorporating the P&C products that will operate in a lower level fault current network.

Measurement Quality Statement

This project requires real-system electrical network parameters, the data will be taken from existing measurement transformers already installed on the network. The measurement transformers that will be used are the same ones that connect to the existing traditional P&C equipment and which also supply data to the fiscal meters.

Data Quality Statement

In this project, real-time electrical system parameters taken via measurement transformers will feed directly into the P&C products under investigation.

The data inputs and outputs from the P&C products under investigation will be managed and available on request in line with standard SSEN Data Sharing Protocols.

The data outputs from the P&C products under investigation during the simulated system evaluation will also be managed and available on request in line with the SSEN Data Sharing Protocols.

Scope

The transition from traditional fossil fuels to renewable sources of energy is changing the transmission network characteristics as there is a reduction in very large spinning machines which can inject high levels of current onto the network during a fault. Renewable forms of energy are typically very small machines, there may be a hundred or so individual units to equal the power capacity of a single traditional fossil fuel unit. When a single fossil fuel unit responds to a fault it sends a very large, sudden, single bolt of current, however a renewable generator made of a number of individual units can respond with a prolonged, marginal current spike as the individual units' trip one after the other. The P&C systems are presently designed to monitor and react to a very large and sudden current event.

The scope of this project is to simulate a future electrical network where the fault current spike is marginal but prolonged and evaluate how present P&C products function and respond. Based upon the findings it will determine if a P&C solution can be further developed to address the future network issue.

The present mitigation measure for areas of the network that may be exposed to lower levels of fault current presently being investigated is a device called a Synchronous Condenser. A Synchronous Condenser can replicate a traditional fossil fuel power source and in the event of a fault it will respond with a very large, sudden, single bolt of current. A Synchronous Condenser also has associated challenges which need to be addressed before it could be used on the transmission system but it is estimated that such a device to install would be £15million.

This project is addressing the challenges associated with areas of the network that may be exposed to lower levels of fault current via P&C products, which are more commonly procured and installed for around £200k. If this project can evidence that P&C products have the potential to be developed, build a simulation that can test future P&C products in a lower level fault current environment and

identify the changes that need to be made to existing P&C policies and procedures, then this starts to open up an alternative solution to a Synchronous Condenser at a fraction of the cost.

It should be noted that the P&C product solution may only be suitable in certain network locations. If this project is successful, then further cost benefit analysis combined with technical limitation and network situations need to be further investigated to more clearly define the true cost of the benefit to the consumer.

Objective(s)

- Validating the simulated future network model
- Evaluating P&C operation on a future lower level fault current AC network
- Developing low level fault current testing and validation protocols for AC networks

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

We do not expect the project to have a direct impact on bills, as at this stage it is an investigation and analytical in nature. If the conclusions are positive to this project, it will support further validation works on the solution which is more cost effective.

The scenario of lower level fault currents on the AC networks is much more likely to occur initially on the Scottish Island communities. It may result in more frequent and larger scale disruption of electrical energy supply. Therefore, this project is investigating a solution which does not disadvantage island communities and has the potential to facilitate their electrical energy needs or opportunities in a similar way to those on the mainland.

Success Criteria

This project will be deemed successful if on validation of the simulated network model we are able to determine a supporting case to continue research into P&C products that function in a lower level fault current scenarios.

Project Partners and External Funding

The University of Strathclyde and the National HVDC Centre will be instrumental in building and validating the simulated network system model.

Potential for New Learning

This project will investigate if and how P&C products respond and function in a simulated lower level network fault current scenario. If the P&C products do not operate reliably then the evaluation and research work undertaken will help structure further discussions with the manufacturers with the aim of developing new P&C products which are suitable. If the testing shows promise, then work will be progressed to build a simulated model that can be used to prove future P&C products which are intended to operate on the network with low levels of fault current.

The learning and knowledge captured in the way the P&C products perform on the simulated low level network fault scenarios, will also be used to investigate how present P&C operational protocols and procedures need to be adapted and reshaped. Documenting and validating the P&C functionality will be the backbone to explaining why and how P&C schemes need to be designed for the future net zero electricity transmission system.

It is anticipated that beyond the standard dissemination events, papers and presentations will be given to CIGRE P&C conferences as well as other GB and European events.

Scale of Project

This project aims to investigate up to 3 different manufacturers P&C products, the manufactures chosen will be ones that supply P&C equipment to the GB market. Ensuring that a range of manufacturers P&C products are investigated will provide clarity on whether a solution to lower levels of fault current can be detected on a future simulated network, as the internal analytics and operating logic vary between manufacturer. Limiting the number of P&C products at this stage will provide supporting evidence to evaluate the first step in the outlined method – Validating the simulated future network, whilst limiting the associated risks.

If the simulated future network is validated, then progressing to the second stage in the outline method will continue - Evaluating P&C operation on a future lower level fault current AC network - as the P&C products will differ in operation and responses. This will positively determine the testing and validation processes required via the future simulated network, to define a response window that lower level fault current P&C products must function in.

The duration of the project needs to allow for an adequate real-time field data, at least eighteen months to cover two winter periods where bad weather is likely to trigger large AC network events and disturbances, which can be replicated on the simulation of the

network.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

SSEN network is at the edge of the transmission system, it also connects Island communities. It provides an ideal real-time field monitoring environment as weather events can have a large impact on the system.

The SSEN network is more likely to see and be at risk to lower level fault current situation occurring within the Island communities as the Islands are increasing their renewables capabilities and SSEN is developing future High Voltage Direct Current (HVDC) transmission system power feeds.

Revenue Allowed for the RIIO Settlement

Not applicable with regards to this project.

Indicative Total NIA Project Expenditure

This project expenditure is estimated to be £717k, 90% (£645.3k) will come from the NIA fund allocation, whilst the remaining 10% (£71.7k) will be funded by SHET.

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 transition from traditional fossil fuels to renewables sources of energy, is changing the transmission network characteristics as there is a reduction in very large spinning machines which can inject high levels of current onto the network during a fault. Renewable forms of energy are often very small machines, there may be a hundred or so individual units to equal the power capacity of a single traditional fossil fuel unit. When a single fossil fuel unit responds to a fault it sends a very large, sudden, single bolt of current, however a renewable generator made of a number of individual units can respond with a prolonged, marginal current spike as the individual units' trip one after the other. The P&C systems are presently designed to monitor and react to a very large and sudden current event.

The scope of this project is to simulate a future electrical network where the fault current spike is marginal but prolonged and evaluate how present P&C products function and respond. Based upon the findings it will determine if a P&C solution can be further developed to address the future network issue.

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

We do not expect the project to have a direct impact on bills, as at this stage it is an investigation and analytical in nature. If the conclusions are positive to this project, it will support further validation works on the solution which is more cost effective.

The scenario of lower level fault currents on the AC networks is much more likely to occur initially on the Scottish Island communities. It may result in more frequent and larger scale disruption of electrical energy supply. Therefore, this project is investigating a solution which does not disadvantage island communities and has the potential to facilitate their electrical energy needs or opportunities in a similar way to those on the mainland.

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

The scope of this project is to simulate a future electrical network where the fault current spike is marginal but prolonged and evaluate how present P&C products function and respond. Based upon the findings it will determine if a P&C solution can be further developed to address the future network issue.

The present mitigation measure for areas of the network that may be exposed to lower levels of fault current presently being investigated is a device called a Synchronous Condenser. A Synchronous Condenser can replicate a traditional fossil fuel power source and in the event of a fault it will respond with a very large, sudden, single bolt of current. A Synchronous Condenser also has associated challenges which need to be addressed before it could be used on the transmission system but it is estimated that such a device to install would be £15million.

This project is addressing the challenges associated with areas of the network that may be exposed to lower levels of fault current via

P&C products, which are more commonly procured and installed for around £200k. If this project can evidence that P&C products have the potential to be developed, build a simulation that can test future P&C products in a lower level fault current environment and identify the changes that need to be made to existing P&C policies and procedures then this starts to open up an alternative solution to a Synchronous Condenser at a fraction of the cost.

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

It should be noted that the P&C product solution may only be suitable in certain GB network locations. If this project is successful, then cost benefit analysis combined with technical limitation and network situations need to be further investigated to more clearly define the true cost of the benefit to the consumer.

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

It should be noted that the P&C product solution may only be suitable in certain GB network locations, if this project is successful then cost benefit analysis combined with technical limitation and network situations need to be further investigated to more clearly define the true cost of the benefit to the consumer.

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

Both National Grid Electricity Transmission and Scottish Power Transmission have identical future renewable and power electronic energy system transitions challenges which will require economic and cost effective solutions to protect their networks and customers.

National Grid Electricity System Operator has a vested interest in 'keeping the lights on' in a future greener energy system as it will be a challenge without finding a solution to maintaining the electrical supply on a network that has low levels of fault current as a result of a fault.

This project if successful helps to address both these future network challenges.

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.

Recent research work looking into the shape and dynamics of the future 'greener' transmission network has identified that lower levels of fault current may result in the present P&C systems being at risk of not detecting and responding to the situation. As this is an emerging opinion this proposed NIA project is the first to specifically address the challenge.

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

Our present P&C equipment and protocols are based on the expectation of conventional fossil fuel generation contributing high levels of current during a fault. P&C systems are set to detect sudden abnormally high spikes in current and have fast operational times to isolate the fault from the system. With the increase in renewables and equipment controlled by power electronics, the associated abnormal fault current spikes are reducing in magnitude and their characteristics are changing. There is a growing concern that present P&C systems may not detect a future low-level current fault, nor operate to isolate the malfunctioning equipment as expected. New protection approaches that consider other factors associated with a fault are potentially available, but we have currently no method or framework by which their functionality and performance can be reviewed, tested and demonstrated.

The functionality and operation of P&C products is unproven on an AC network that experiences lower levels of fault current. It is highly likely that new procedures to accompany the P&C products will have to be drafted to facilitate wider industry discussions. Further validation and trials may be required.

Relevant Foreground IPR

The anticipated Foreground IPR will be associated with the element of simulated network model developed from the funding support of this project. If the model is validated successfully then additional Foreground IPR will be generated in setting up low level fault current scenarios on an AC network with the aim of establishing a model and methods that can be used to test and evaluate how different P&C products perform.

The P&C products will for all intents and purposes be a 'black box', how they are designed, and function will be background IPR owned solely by the manufacturer. Please note that the development of P&C products is not within the remit of this NIA Project, if the P&C product was not suitable it would be up to the manufacturer to invest in subsequent development.

Data Access Details

Data Quality Statement

In this project, real-time electrical system parameters are taken via measurement transformers and feed directly into the P&C products under investigation.

The data inputs and outputs from the P&C products under investigation will be managed and available on request in line with standard SSEN Data Sharing Protocols.

The data outputs from the P&C products under investigation during the simulated system evaluation will also be managed and available on request in line with the SSEN Data Sharing Protocols.

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

The low level fault current situation has not arisen yet on the GB network, but present investigation work into the shape of the future

network as we move towards net zero is highlighting it as a problem without a future solution. To conducted further research into this phenomenon, a simulated model which can accurately represent low level fault current scenarios needs to be built as a means of testing P&C products ability to function. This type of investigative work and development is out-with normal business as usual activities.

This project will also identify how the P&C products work in a network environment that witness low level fault current. It is anticipated that knowledge gained here will be required to build a case to modify existing P&C protocols, prior to further live system trialling events.

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 both technical and operational risks associated with the present P&C products that are available as they may not be able to detect an event in a future net zero network that produces a lower level fault current.

This project has been approved by a senior member of staff

Yes