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

Apr 2025

Project Reference Number

NIA_SPEN_0112

Project Registration

Project Title

Short Circuit Calculation in IBR Dominated Networks

Project Reference Number

NIA_SPEN_0112

Project Licensee(s)

SP Energy Networks Transmission

Project Start

June 2025

Project Duration

0 years and 9 months

Nominated Project Contact(s)

Agusti Egea-Alvarez

Project Budget

£100,000.00

Summary

This project aims to address the limitations of current fault current calculation methods in power networks with high integration of inverter-based resources (IBR). Existing standards like IEC60909 and its adaptations do not adequately model IBR devices, leading to significant errors in fault current calculations. These inaccuracies can result in financial losses, equipment damage, and operational risks. To mitigate these issues, SPEN is partnering with eRoots, a company that has developed a new, patented method for accurate fault current calculation in IBR-dominated networks which has demonstrated substantial error reduction compared to traditional methods. The project will not only enhance the accuracy of fault current calculations but also foster informed discussions within the industry, potentially leading to updates in existing standards and improved network reliability.

Nominated Contact Email Address(es)

innovate@spenergynetworks.co.uk

Problem Being Solved

Fault current is a fundamental metric for planning, designing, and operating power networks. Recently, the increasing integration of inverter-based resources (IBR), such as wind generation or HVDC links, has posed challenges to standard fault current calculations. Several methods exist for calculating fault current, including the ANSI and complete superposition methods. However, the IEC standard has been successfully used in Europe for the past 30 years. The IEC60609 standard has been adapted in different European countries to reflect the needs of their local grid owners and operators. For example, in Germany, the IEC standard was adapted resulting in the VDE0102, and in Great Britain, resulting in the Engineering Recommendation (ER) G74.

Recent modifications to the standard have included IBR devices, but they still present limitations. These modifications have not

reformulated the short circuit calculation methodology, and therefore not overcoming the fundamental limitations on how IBR devices should be modelled. The calculation of fault current significantly influences various aspects of network planning, design, and the associated costs of facilities. It is essential for determining the ratings of circuit breakers, fuses, and other protective devices, as well as for the overall design of network components. Incorrect fault current calculations can lead to over or under spending, affecting return on investments and potentially damaging equipment and the reputation of SPEN and the GB power industry. In the context of operation, particularly with IBR, incorrect fault current calculations might lead to united weak grid conditions or sub-synchronous oscillations.

Method(s)

WP1: Modelling and SPEN Network Characterisation

This WP will adapt an IP-free model of the SPEN network to be used in the new modelling tool. At the same time, the team will perform tests to check the compliance of the converter control algorithms and GB grid code adaptation. The following tasks have been identified for this work package:

- T1.1: Steady-state model mapping
- T1.2: Converter control evaluation
- T1.3: Grid code limits study

WP2: Simulation and Comparison

This task will perform simulations of a three-phase balanced fault using the proposed tool and PowerFactory, the current tool used in SPEN. A three-phase balanced fault is chosen as it is the worst-case scenario and is usually used to size the equipment. A comparison between the methods used for SPEN and the new tool will be provided. The following tasks have been identified for this work package:

- T2.1: Algorithm adaptation
- T2.2: Balanced short-circuit calculation
- T2.3: PowerFactory results extraction
- T2.4: Results comparison

WP3: Reporting and Paper Publication

Three documents will be prepared by the team: a report for SPEN with recommendations, a conference paper for industry professionals, and a white paper for broader industry discussion. The following tasks have been identified for this work package:

- T3.1: SPEN Report writing
- T3.2: Technical paper writing
- T3.3: White paper writing

WP4: Optional Comparative Study for unbalanced faults:

An optional work package includes the comparative study and reporting considering unbalanced faults. This study could be very useful to identify future grid code requirements and scenarios that might be relevant in IBR dominated networks but are usually not considered in the planning and design stages. This study will be performed depending on the results obtain in WP2 and further engagement during the project.

Scope

This project aims not to replace the current short circuit calculation used in SPEN but to raise awareness of the errors associated with standard techniques and assess their impact on operations, planning, and design considering a SPEN study case. Furthermore, the project seeks to foster an informed opinion within SPEN to lead the dialogue towards changing the standard ER G74 used in the GB network.

Objective(s)

- Model part of SPEN's network using eRoot's new fault current calculation tool
- Compare error percentage difference between new fault current calculation tool and PowerFactory standard fault calculation method
- Provide some recommendations on how fault current should be calculated in the future including modifications of the ER G74
- Produce a technical paper detailing project findings

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

This project has been assessed as having a neutral impact on customers in vulnerable situations.

This is because it is a transmission project.

Success Criteria

- The delivery of the above objectives, within budget and within agreed timelines as is reasonable depending on the knowledge at this stage of the development phase.
- Production of the final technical reports containing all the learnings and recommendations

Project Partners and External Funding

eRoots is the new fault current calculation developer and will be collaborating with SPEN on this project.

Potential for New Learning

This project aims to raise awareness amongst the TOs of the errors associated with standard techniques and assess their impact on operations, planning, and design considering a SPEN study case. Furthermore, the project seeks to foster an informed opinion within SPEN to lead the dialogue towards changing the standard ER G74 used in the GB network with the support of the TOs and NESO.

Scale of Project

A small part of SPT network will be used as a case study for comparing the errors produced using the new modelling tool, compared to using PowerFactory.

Technology Readiness at Start

TRL6 Large Scale

Technology Readiness at End

TRL7 Inactive Commissioning

Geographical Area

The development and trial of the modelling tool will take place in eRoot's office.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

£90k (90% of £100k)

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:

If there is an error between the standard fault calculation and the one suggested in this document. It might provide benefits in the design of the substations reducing the footprint and therefore the cost, as well as, improving the network operation.

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)

N/A

Please provide a calculation of the expected benefits the Solution

The purpose of this research project is to identify the inefficiencies in the current methods of calculating fault current under the ER G74 standard and demonstrate if the standard could be updated to support TOs produce more accurate calculations. The new modelling method has been patented and results show that in a case where the penetration of IBR is 19.5%, an error exists between their method and the IEC60609. That error increases to 52.6% when the penetration of converters reaches 75%, which is like the case of the SPEN network. Similar results have been verified with the Texas power network. If that error were to be negated through a change of standard, which this project aims to drive, then overinvestment into electrical protection equipment could be reduced by up to 40% in SPEN and other TOs who use the IEC60609 methodology and have similar network topology.

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

The findings of this project will be applicable to all TOs.

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

It is not expected that in this stage of the project the methodology will be deployed at GB level. This project will only provide a framework to assess if further change of the present fault current calculation is required.

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

In WP3 technical reports detailing the findings of the project will be made available to all the GB TOs upon request.

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.

We have reviewed the ENA portal and have not identified any other past or ongoing projects that would give rise to unnecessary duplication of research effort.

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

There are no commercial software solutions that can represent inverter-based resources (IBR) during a fault correctly. The IEC60609 standard has been adapted in different European countries to reflect the needs of their local grid owners and operators. For example, in Germany, the IEC standard was adapted resulting in the VDE0102, and in Great Britain, resulting in the Engineering Recommendation (ER) G74. The same standards have been implemented in PowerFactory, currently used at SPEN. Recent modifications to the standard have included IBR devices, but they still present limitations. These modifications have been added rather than reformulating the short circuit calculation methodology, not overcoming the fundamental limitations on how IBR devices should be modelled. The project wants to assess the new methodology provided by eRoots that has shows 100% accuracy with EMT simulations compared to the IEC standard that provided 75% error. The proposed tool and methodology have not been developed before with the input of the GB electricity network.

Relevant Foreground IPR

No foreground IPR is expected as the project is a study case using a already developed technology

Data Access Details

Access to this data must be requested by contacting SPInnovation@spenergynetworks.com. Please provide the following information in your request:

- Affiliation, position and contact details of requesting party
- Relevant project and type of data required
- Reasons for requesting this data and evidence that this data will be used in the interest of the UK network electricity customers
- How data will be shared internally and externally by the requesting party Any data request deemed unsuitable for sharing will be highlighted to the appropriate requesting party.

After receiving the request we will provide the estimated date for completing the data provision based on other requests and our team workload at that time. All requested data remains the property of SP Energy Networks.

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

There is no allowance within our RIIO-T2 settlement for carrying out this innovation project.

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

This project would present too much commercial and technical risk for conventional TO plans. Therefore, this activity could only be undertaken with the support of NIA.

This project has been approved by a senior member of staff

☑ Yes