NIA Project Registration and PEA Document

Date of Submission

Jan 2026

Project Reference Number

NIA_SPEN_0126

Project Registration

Project Title

Modelling, Simulation and Analysis Innovation Centre (MOSAIC)

Project Reference Number

NIA_SPEN_0126

Project Licensee(s)

SP Energy Networks Transmission

Project Start

January 2026

Project Duration

1 year and 10 months

Nominated Project Contact(s)

Ahmed Salama

Project Budget

£5,760,000.00

Summary

MOSAIC is a strategic initiative by SPEN to address the growing complexity of the UK's power system as it transitions to net zero. With the rise of inverter-based resources, declining system inertia, and increasing operational challenges, traditional tools and approaches are no longer sufficient.

The Centre will bridge the gap between research and operations, ensuring that new tools and methods are validated, aligned with business needs, and integrated into day-to-day practice.

By enabling earlier detection of system instabilities, supporting efficient planning, and reducing modelling costs, MOSAIC will deliver significant operational and financial benefits. It will also play a key role in building a future-ready workforce and strengthening the UK's leadership in power system innovation.

Nominated Contact Email Address(es)

innovate@spenergynetworks.co.uk

Problem Being Solved

The UK's transition to a net zero energy system presents both unprecedented opportunities and complex challenges for electricity network operators. As the power system evolves to accommodate high penetrations of inverter-based resources (IBRs), distributed generation, and new demand patterns, the need for advanced modelling, analysis, and simulation (MAS) capabilities becomes critical.

SPEN, as a key player in the GB electricity sector, is establishing the Modelling, Simulation and Analysis Innovation Centre (MOSAIC) to address these challenges and unlock new value for the business and the wider industry. The main business needs are:

- Stability issues: The GB power system is increasingly experiencing instability events and complex dynamic phenomena that threaten supply quality, reliability, and resilience. These challenges are exacerbated by the declining presence of synchronous machines and the growing dominance of power electronics. SPEN's network, one of the most complex globally, is particularly exposed due to its low synchronous inertia and high base load. Stabilising this network beyond 2030 will require new tools, methods, and insights. Recent events have highlighted the urgent need to enhance modelling, analysis, and simulation capabilities to maintain power system stability. The April 2025 Iberian blackout and the August 2019 UK power cut both exposed vulnerabilities linked to power electronic-dominated networks. Instability observed in SPEN's Scottish network during the summers of 2023 and 2024 further underscores the need for a dedicated centre to address these emerging challenges.

- Innovation adoption gap: Despite significant investment in innovation, many projects struggle to transition into business-as-usual (BAU) operations. This is often due to a lack of alignment with operational needs, insufficient readiness, or the complexity of integrating new solutions into legacy systems. There is a clear need for a structured environment that can bridge this gap and accelerate the adoption of innovation.

- Skills Gap: The existing and incoming workforce lacks sufficient experience in the design, planning, and operation of power electronic-dominated networks. As the system becomes more complex, the skills gap poses a risk to operational excellence and innovation delivery. A dedicated training and development programme is essential to build a world-class workforce equipped for the future grid.

- Scotland as a flagship electricity network: SPEN is developing critical substations that will be dominated by IBRs. These assets must be de-risked and validated through rigorous simulation and testing before deployment. Without this, the risk of operational failure or underperformance could have significant financial and reliability consequences.

Method(s)

MOSAIC is structured around a clear and strategic roadmap that ensures innovation is not only developed but also aligned with industry needs and successfully embedded into operational practice. The roadmap is built on three core axes:

1) Needs Identification,

2) Innovation Outputs, and

3) Transfer to Business-As-Usual (BAU).

This approach directly addresses the well-documented barriers to innovation adoption and supports the delivery of impactful, scalable solutions.

The first axis of the roadmap focuses on identifying and prioritising the modelling, analysis, and simulation (MAS) needs of network licensees and the wider GB power industry. MOSAIC will act as a strategic partner, supporting early-stage engagement to define system challenges and innovation opportunities. The Centre will assist in drafting innovation proposals, connecting relevant stakeholders, and providing proof-of-concept validation to de-risk early ideas. This ensures that innovation efforts are grounded in real operational needs and aligned with regulatory and strategic priorities.

Once needs are defined, MOSAIC will lead or coordinate the development of tailored innovation projects. These projects may be executed in-house, leveraging the Centre's technical expertise, or delivered in collaboration with external partners where broader capabilities are required. The focus will be on producing actionable outputs—such as models, tools, methods, and insights—that are directly applicable to operational challenges and can be readily adapted for implementation.

The final axis of the roadmap addresses the critical challenge of translating innovation into BAU. MOSAIC will support this transition by curating and adapting innovation outputs to fit within existing business processes, systems, and regulatory frameworks. The Centre will also provide training, documentation, and stakeholder engagement to support change management and ensure successful integration. This structured approach will help overcome the "valley of death" in innovation, ensuring that promising solutions achieve real-world impact.

Scope

The programme of work of the centre are divided according to the centre functions; identification of system needs), Innovation Projects

(TRL 1-6) and Transfer to Business as usual (TRL6-9). More info can be seen below:

Establishing the Centre

- EC.1 Designing a MAS Centre for the Power Industry

- EC.2 Business Model Development of MASIC

- EC.3 Designing the Computational Hardware and Interfaces

- EC.4 Procuring the Computational Hardware and Interfaces

- EC.5 Implementing the Computational Hardware and Interfaces

- EC.6 Software Development for BAU and Associated Infrastructure Design

- EC.7 Software Development for BAU and Associated Infrastructure Implementation

- EC.8 Funding Preparation for the Next Phase

Identification of System Needs

- SN.1 Critical Survey of Simulation Tools for Net Zero

- SN.2 Critical Survey of Analysis Tools for Net Zero Power Networks

- SN.3 Surveying the GB Innovation and Research Landscape

Innovation Project (TRL 1–6)

- IP.1 Durable and Interoperable Models (OPEN GB)

- IP.2 Model Reduction and Aggregation of Very Large Systems

- IP.3 Automatic Simulation of Very Large Systems

- IP.4 Probabilistic assessment tool for Large Systems

- IP.5 Resilience of multisector energy systems

Transfer to Business as Usual (TRL 6–9)

- TB.1 Surveying and Consolidating the Output of NIA MAS-Related Projects

- TB.2 GB Common Impedance Analysis Tool

- TB.3 GB SSO Identification Tools

- TB.4 Methodology to Locate Stability Devices in the GB Power Network

- TB.5 Study of the Operation of the Scottish Network Post-EGLs

- TB.6 Training on Tools and Techniques to Transition to BAU

- TB.7 Benchmarking of Generic Models

- TB.8 Study of the SPT System Based on the Developed Tools

Centre Administration

- CA.1 Board Meetings

- CA.2 Dissemination Events

Objective(s)

- Advance MAS capabilities by developing and applying cutting-edge tools, models, and methods tailored to the needs of the GB power system

- Bridge the gap between academic research and BAU operations, ensuring that innovation is aligned with real-world challenges and integrated into operational practice

- Provide analytical insights to support evidence-based decision-making in investment, planning, and operations

- Consolidate and leverage existing research, transforming fragmented studies into a coherent, scalable knowledge base

- Collaborate with international stakeholders, including power system operators, research institutions, and innovation bodies, to share knowledge and accelerate progress

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 and programme of work, within budget and agreed timelines.

Project Partners and External Funding

- SPEN

- National HVDC Centre

- University of Strathclyde / PNDC

- University of Manchester / Grid Stability

- SuperGrid Institute

- Universitat Politècnica de Catalunya (UPC) / Eroots

- University of Cardiff

Potential for New Learning

The project will generate substantial new learning across modelling, analysis, and simulation (MAS) for converter-dominated power systems. Key areas of new learning include:

- Next-generation modelling techniques tailored for low-inertia, IBR-dominated networks, including EMT-based and hybrid RMS–EMT co-simulation frameworks.

- Methodologies for large-scale system simulation, covering model reduction, aggregation of very large EMT network models, and automated large-system simulation workflows.

- Validated, interoperable model libraries for GB networks, building on the IP.1 "Open GB" work package.

- Processes for transitioning innovation tools into BAU, including structured validation, documentation, training, and governance approaches.
Insights from consolidation of past innovation outputs, curated within a centralised knowledge base (TB.1).

- Improved assessment of constraint risk, blackout risk and system stability margins through probabilistic assessment and real-time co-simulation.

Learning will be disseminated through ENA's Smarter Networks Portal, technical reports, industry workshops, and collaboration with NESO, NGET, SSEN-T, PNDC, National HVDC Centre, and academic partners.

Scale of Project

MOSAIC represents a national-scale initiative whose activities cannot be delivered through smaller isolated studies. The required capabilities, high-performance computing, real-time co-simulation, novel model development, and multi-year innovation, necessitate a

centralised, multi‑million‑pound investment.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL7 Inactive Commissioning

Geographical Area

As SPEN will be the leading party, a lot of the network models and studies will be based on SPEN's transmission network. However, any developed solutions and methodologies will be agnostic and applicable to any GB TO.

Revenue Allowed for the RIIO Settlement

0

Indicative Total NIA Project Expenditure

£5.76m including SPEN's contribution of 10% of total project value

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 project directly supports the energy system transition by advancing modelling capabilities for emerging technologies within the GB electricity network. It contains:

1. A novel mathematical framework for representing new grid-connected devices improving the capability of designers

2. A co-simulation methodology that enhances the accuracy of system modelling by integrating power flow and electromagnetic transient (EMT) simulations, increasing the speed and accuracy of studies

3. Generation of new technical knowledge applicable to system planning and operation;

4. Development of specialist skills and expertise among project participants as new knowledge generated from this process will be shared with the industry

5. Attract and train new talent to the industry working on Network challenges

While the primary focus is on system transition, the improved modelling and simulation capabilities may indirectly benefit consumers in vulnerable situations by enhancing system reliability and reducing the risk of disruptive events.

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

Constraint Cost Avoidance: The MOSAIC initiative is projected to deliver significant reductions in constraint costs by enabling earlier identification and mitigation of system instabilities that currently lead to the curtailment of renewable generation. The current CBA conservatively estimates annual savings of £1.2 million, based on the assumption that 1.5 GW of generation would be constrained for 8 hours per year, using a historically low balancing cost of £100/MWh. However, this estimate has been approached from multiple angles, all of which suggest that the actual value at stake is considerably higher. For instance, the sub-synchronous oscillation events in the Scottish network during Summer 2023, which persisted intermittently over a four-week period, highlighted the operational and financial risks posed by poorly damped inverter-based resources 1. Furthermore, NESO's analysis of non-thermal constraint costs indicates that constraint-related expenditures are rising and expected to continue to rise sharply. These insights reinforce the strategic importance of MOSAIC in reducing constraint costs not only through direct operational improvements but also by de-risking future

system configurations and supporting more efficient network planning.

Blackout Risk Reduction: MOSAIC is expected to play a critical role in reducing the risk of large-scale blackouts by enhancing the GB system's ability to model, simulate, and mitigate complex dynamic phenomena associated with inverter-based resources.

The CBA estimates an annual benefit of £0.78 million from blackout risk avoidance for Scotland, based on a conservative scenario. This estimate is grounded in the methodology used by SSE, which values the economic impact of a major blackout at 0.7% of GDP. While such events are rare, their consequences are severe, as demonstrated by the April 2025 Iberian Peninsula blackout, which affected Spain, Portugal, and parts of France due to voltage instability and cascading failures. Similarly, the Texas power outages in 2021 resulted in widespread disruption, with estimated economic losses exceeding $100 billion (1.44% of GDP), highlighting the vulnerability of modern grids to extreme events.

MASIC's EMT simulations and real-time co-simulation capabilities will enable more accurate black start planning, better system resilience assessments, and faster response strategies—substantially reducing the likelihood and impact of such catastrophic events. These capabilities are essential as the GB system becomes increasingly reliant on power electronic converters and low-inertia configurations.

The Cost-Benefit Analysis for MASIC demonstrates a compelling financial case for investment. Over a 25-year study period, a Net Present Value (NPV) of approximately £8.8 million is observed for Scotland alone, reflecting strong long-term value even under conservative assumptions. When the benefits are scaled to the GB system level, accounting for broader network exposure and constraint volumes, the total NPV exceeds £106 million, highlighting the national strategic relevance of MOSAIC.

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

As part of the project, SPEN are constantly engaging with NESO, NGET and SSEN-T to ensure that the developed solutions and methodologies are applicable to all GB transmission licencees

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

To be determined in the conclusion of the project once the solutions and methodologies have been established

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 project will generate new learning applicable to electricity transmission and distribution licensees, particularly in the areas of:

- Advanced modelling techniques for emerging technologies;
- Co-simulation approaches for system-level analysis;
- Integration of open-source tools into operational modelling workflows.

Learning will be disseminated via the ENA Smarter Networks Portal, technical reports, and industry forums, ensuring accessibility and applicability across licensees.

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.

Extensive internal and external engagement has been undertaken to ensure the project does not duplicate existing innovation efforts. Coordination with modelling teams across transmission licensees and consultation with the ENA have confirmed the project's uniqueness.

A steering board comprising NESO, SSEN, National Grid, and other stakeholders will oversee delivery to maintain transparency and alignment with industry needs.

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 its holistic approach to modelling and simulation, which is not currently part of BAU activities. It addresses:

- Technical challenges in integrating new devices into system models;
- Operational risks associated with system oscillations and restoration;
- Commercial uncertainty regarding the scalability and adoption of the proposed methods.

The project cannot be funded through standard operational budgets due to its speculative nature and associated risks. NIA support is essential to de-risk the development and validate the approach.

Relevant Foreground IPR

The project is expected to generate the following types of Relevant Foreground IPR:

·   New EMT and hybrid simulation models for large‑scale GB power systems.

- Model reduction and aggregation algorithms for converter-dominated systems (IP.2).

- Automated system simulation tools (IP.3).

- Probabilistic assessment tools for stability and operability (IP.4).

The project applies the default IPR position, ensuring outputs are accessible to GB transmission licencees.

Data Access Details

Access to this data must be requested by contacting Innovation@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

The project involves early stage research with unknown outcomes and presents a risk that would not be borne by the business which necessitates innovation funding.

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 presents too much technical and commercial risk due to the uncertainty of the outcomes, and therefore it can only be undertaken with NIA funding

This project has been approved by a senior member of staff

☑ Yes