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

Oct 2021

Project Reference Number

NIA_SPEN_0062

Project Registration

Project Title

DynaLoad – Dynamic loading of transformer insulation

Project Reference Number

NIA_SPEN_0062

Project Licensee(s)

SP Energy Networks Distribution

Project Start

August 2021

Project Duration

4 years and 5 months

Nominated Project Contact(s)

David Walker

Project Budget

£200,000.00

Summary

Dynaload will characterise the long-term mechanical endurance of transformer insulation under heavy dynamic loading conditions through testing and modelling.

Third Party Collaborators

SINTEF

Nominated Contact Email Address(es)

innovate@spenergynetworks.co.uk

Problem Being Solved

Due to the energy system transition, consumers will become even more dependent on a reliable electricity system for their essential services including heating and transport. Power transformers are key components in the electricity transmission system. Transformer failures are disruptive incidents that require expensive replacement work and may result in fires, explosions and significant collateral damage. Such failures are costly for society causing potentially harmful outages and reduced security of energy supply. This project looks to characterise the long-term mechanical endurance of transformer insulation under heavy dynamic loading conditions to better protect against transformer failures.

Method(s)

- Fundamental material research on improved mechanical endurance of winding insulation
- Modelling of the thermo-mechanical impact of rapid dynamic loading on transformer windings

- Sensor-based condition monitoring of transformers in service
- Fine tune business case

Present final report

Scope

- Characterise the plastic deformation of winding insulation materials due to rapid thermal and mechanical stress cycles
- Develop and validate a model that predicts the clamping pressure response due to rapid load and temperature cycling
- Perform online monitoring of (clamping) pressure, and temperature in an in-service transformer
- Communication and dissemination with stakeholders and working groups

Objective(s)

To characterise the long-term mechanical endurance of transformer insulation under heavy dynamic loading conditions.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

N/A

Success Criteria

- Develop and validate a model that predicts the clamping pressure response due to rapid load and temperature cycling
- Identify the impact of a new thermal-hydraulic model of transformer winding insulation

Project Partners and External Funding

- SINTEF Energy AF (Delivery partner)
- Norges Teknisk-Naturvitenskapelige Universitet (NTNU) (Delivery Partner)
- Kungliga Tekniska Högskolan (KTH) (Delivery Partner)
- SP Transmission PLC - £140k
- Electricité de France (EDF) - £140k
- Statnett SF - £140k
- Weidmann electrical Technology AG - £105k
- Statkraft Energi AS - £85k
- Kolektor Etra - £30k
- Elvia AS - £190k

Potential for New Learning

The project will allow for the development of new standards based on verifiable knowledge of combined ageing and mechanical degradation of the insulation materials; necessary for transformer design, estimation of life expectancy, and for calculating costs from increased intermittent operation.

Scale of Project

This project is research based and is being undertaken by SINTEF energi AF and supported by a number of European network partners.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL5 Pilot Scale

Geographical Area

N/A

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

£200,000 including internal costs

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:

As the energy system transition progresses a reliable electricity system will become even more essential as our society becomes ever more reliant on electricity for essential services including heating and transport. Transformer failures resulting in outages will have even greater consequences than currently. The learnings from this project have the potential to improve transformer reliability and availability through informing improved requirements specifications and maintenance procedures.

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

The project has potential to benefit customers in vulnerable situations by reducing the potential for power outages which may be particularly challenging for vulnerable customers depending on the nature of their vulnerability.

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)

This is a researched based project so an estimate cannot be made.

Please provide a calculation of the expected benefits the Solution

This is a researched based project so an estimate cannot be made.

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

We believe that the research learnings could be applied to other UK & Ireland TSOs.

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

This is a researched based project so an estimate cannot be made.

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

- [x] 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 allow for the development of new standards based on verifiable knowledge of combined ageing and mechanical degradation of the insulation materials; necessary for transformer design, estimation of life expectancy, and for calculating costs from increased intermittent operation.

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?

- [x] 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.

Checks on ENA Smarter Networks Portal revealed no other projects for this specific problem.

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

DynaLoad will experimentally study the long-term development of the mechanical properties of conventional (cellulose) and novel (e.g. aramid) high temperature insulation materials under rapid (<1 h cycles) dynamic loading, a highly relevant topic that has not been properly tested or modelled before. These longterm rapid dynamic loading tests will, combined with general ageing experiments on plastic deformation, give information about insulation material degradation under dynamic loading that is beyond what is required in today's standards (IEC 60641).

Relevant Foreground IPR

DynaLoad will develop a dynamic thermo-hydraulic +
mechanical model of a transformer winding.

The following Background has been brought into the Project:
KTH Royal Institute of Technology
Commercial finite element software : In-house developed user-defined material subroutines
(known as UMAT in Abaqus and LS-Dyna or Usermat in Ansys).
Access to the software for use in the project by other Parties does not include access to the source code or object code.
EDF
As for Finite Element modelling (No access to the source code of EDF in-house tools Code
CARMEL 3D, Code Saturne and SYRTHES and Electromagnetic Transient modelling (EMTP models)
.
Kolektor Etra
Information on transformer design data and transformer insulation system. Details on pressure sensor installation and optical fiber connection. Information on windings layout, clamping system and used materials.

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 the SP Transmission RIIO-2 business as usual funding that is appropriate to fund 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

The project has both technical and commercial risks. The success of the project an associated financial benefits of the project cannot be determined at this stage therefore it can only be undertaken with the support of NIA.

This project has been approved by a senior member of staff

☑ Yes