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

NIA2_NGET0003

Project Registration

Project Title

Retrofitting Oil Source Heat Recovery to Transformers

Project Reference Number

NIA2_NGET0003

Project Licensee(s)

National Grid Electricity Transmission

Project Start

November 2021

Project Duration

2 years and 0 months

Nominated Project Contact(s)

Gordon Wilson (Box.NG.ETInnovation@nationalgrid.com)

Project Budget

£220,000.00

Summary

A partial heat exchanger system (oil side) will be installed on a de-energised transformer at the Deeside Centre for Innovation to demonstrate that such a system can be retrofitted to in-service transformers without compromising the transformer's cooling system and thereby affect its normal operation. The trial will determine how to install the system in such a way that both the transformer and the heat exchanger system may be accessed and maintained safely. A control system will be developed for testing purposes and integrated with existing controls.

The benefit of this project will be to demonstrate that waste heat generated from transformers can be used to support district heat networks close to transmission substations and reduce emissions of carbon dioxide that would otherwise be emitted in producing the necessary heat.

Preceding Projects

NGETEN02 - Offline Substation Environment for the Acceleration of Innovative Technologies (OSEAIT)

Third Party Collaborators

The University of Manchester

SSE Energy Solutions

Therma Mech Limited

Nominated Contact Email Address(es)

box.NG.ETInnovation@nationalgrid.com

Problem Being Solved

Waste heat from transformers can be used to provide energy to district heating networks where heat is transported from the source to local consumers as heating for the home or hot water. NGET has looked previously at methods for exploiting waste heat for transformers using air source heat pumps in transformer enclosures, but this was found not to be economic, and by designing heat recovery into a new transformer design. However, the application of a retrofitted design onto a transformer already installed at a substation raises concerns about the way in which a system could be integrated without having a negative impact on the transformer cooling, protection, or controls. The installation of such a system must not require extended outage time nor interfere with the ability to carry out routine inspections or maintenance on the transformer.

Method(s)

SSE Energy Solutions has developed a heat recovery design for an SGT at Deeside; the design has been verified by NGET engineers working on the OSEAIT NIC Project ("Deeside"). This design could be used as the basis for a full waste heat recovery system by considering the design and installation for any specific transformer. However, the system has not been tested to confirm the effect it would have on the existing cooling system of a transformer and there is a need to de-risk installing such a system on an operational transmission transformer. This project will therefore result in the installation of the oil-side of an oil-water waste heat exchanger system to demonstrate that there is no negative impact and may therefore deliver anticipated benefits of reduced CO2 emissions in district heat recovery systems. The learning from this project would form part of type registration for future installations of this design at operational substations

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 Low.

TRL Steps = 1 (2 TRL steps)

Cost = 1 (£220k)

Suppliers = 1 (1 supplier)

Data Assumption = 1 (data supplied by suppliers for analysis)

Scope

The scope of the project will be to procure, install and test the oil side of a waste heat exchanger system on a transformer that will be out of service for the duration of the project but that has previously been operational, it will also be returned to service as it is part of the infrastructure for the Deeside Centre for Innovation.

Development of the control system will be part of this project, it is necessary to demonstrate that the transformer will continue to be effectively and efficiently cooled and there is no risk to increased ageing as a result of fitting the waste heat exchanger. The control system will be linked to the transformer controls, but temperatures will be simulated within the control system during testing.

Heat exchangers are tried and tested technology and the transformer will not be energised so no heat will be exchanged and the water side of the system will not be installed.

The viability of this system in practice on an operational transformer and whether the low-grade heat from a transmission transformer is sufficient for use in a district heating scheme has already been considered before developing this project.

Objective(s)

The objectives of this project are to install and commission a power transformer oil heat extraction system and to successfully validate and test an oil heat extraction system against the trial criteria.

Upon completion of the trial, the system will be decommissioned and removed.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

District heating schemes allow centralised heat sources to be connected to many heat customers. The key advantages of district heating schemes over gas-fired boilers are that they can deliver heat more efficiently, more cheaply and with lower carbon emissions. Although there are relatively few systems like this in the UK, in future it will be a key source of sustainable heating in urban areas. The reduced cost of heating through district heating schemes is not targeted at any particular consumers other than those in urban environments where the high capital cost of the installation may be justified. Any reduction in energy costs will have benefits for all consumers, while in absolute terms this may benefit higher income earners with greater energy costs, it will have a larger proportional benefit for lower income households where heating is a higher proportion of their income and whose houses may be less energy efficient.

The benefit for this project is based upon reduced carbon dioxide emissions, which will benefit all consumers.

Success Criteria

The project will be considered successful if the following trial criteria are achieved:

- The new pipework associated with the facilitation of a heat recovery system is fitted and the heat exchangers installed safely with no risk of mixing oil and water or increasing the risk of oil leaks from the transformer. Oil leaks will be evaluated over an extended period of at least 1 year to cover all seasons.
- The transformer cooling is not affected in any way that is deleterious to the transformer life
- The control system controls can be safely integrated into the existing controls to collect operational data
- A successful test of the fail-safe condition of the cooling of the transformer in the event of issues in the heat exchanger system
- The installation does not prevent access to the transformer for maintenance purposes.
- Maintenance of the new system can be achieved without interfering with the transformer or infringing safety distances to the transformer -i.e. the transformer would not need to be out of service

Project Partners and External Funding

The project has been developed in partnership with SSE Energy Solutions which is providing royalty free licence to use materials related to the design to enable the project to proceed at reasonable cost.

The project will be delivered at Deeside Centre for Innovation, built as part of the NIC project “OSEAIT”.

Potential for New Learning

The new learning will stem from the integration of a heat recovery system retrofitted to a transmission system. There are likely to be challenges related to installation of the equipment, integration into the control system and operation of the control system that will feed into future designs.

NGET and SSE Energy Solutions have a mutual interest in publishing the outcomes of the innovation project and will do so jointly on completion of the project through appropriate channels, joint announcements on the proposed project has already stimulated national interest. As the project is being delivered at Deeside, the OSEAIT Technical Advisory Board will be invited to see the installation once it has been constructed.

Scale of Project

The project will be delivered on a single transformer at the Deeside Centre for Innovation. Heat recovery has already been trialled on transformers but the approaches to date have involved transformers designed with heat recovery as part of the design not where the system has been retrofitted to an older transformer where heat is currently lost to the surrounding environment. The trial will demonstrate that heat recovery is feasible on a transmission transformer design similar to hundreds of others installed across transmission networks. When transformer designs vary, it may not be possible to develop a heat recovery system for all these transformers by case-by-case design review to ensure that waste heat may be recovered in this manner.

If the project is successful future projects in support of district heating schemes would see installation of these systems on multiple transformers at relevant substations. Presently, as many as 10% of NGET’s substations have been identified as potential sites where heat recovery could be installed based on the potential for local heat networks in the area.

A full heat exchanger system was deemed unnecessary to deliver the expected level of outcomes, it would be more expensive and with little additional benefit. During testing, the temperature changes will be simulated in the control system software to ensure the correct responses result. Raising the temperature of the oil in the transformer would have required significant additional cost and would have generated carbon dioxide emissions with little additional benefit.

Technology Readiness at Start

TRL6 Large Scale

Technology Readiness at End

TRL8 Active Commissioning

Geographical Area

The project will be delivered at the Deeside Centre for Innovation in North Wales.

Revenue Allowed for the RIIO Settlement

Not applicable

Indicative Total NIA Project Expenditure

£198,000

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 aim of the project is to demonstrate and test a system that in future may be used to recover heat that is normally rejected to the atmosphere via the transformer cooling system and instead use it to source a high efficiency heat pump. This heat pump will in turn feed district or communal heating networks. Implementing such a solution aligns carbon reduction objectives as it will reduce reliance on existing methods for generating heat in homes, which is typically through gas boilers.

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)

Not applicable

Please provide a calculation of the expected benefits the Solution

The benefit will be achieved through reduction of carbon dioxide emissions resulting from capturing waste heat rather than generating the heat using gas or electricity to feed into a district heat network. The benefit calculations are based on the avoided emissions of installing the system compared with another source with an estimated carbon intensity of 67 gCO2e/kWh over an expected life of a heat exchanger system of 25 years.

It has been estimated for an exemplar installation for a district heat network making use of waste heat from transformers that the avoided cost of emissions has a benefit of £14.8k per annum. Making conservative assumptions about the number of installations and when they might be commissioned over the next 25 years, the total net NPV is £1m.

An assessment of the cost of installing waste heat recovery on transmission transformers compared with not installing it and sourcing the heat elsewhere has not been carried out by NGET and is assumed to be comparative.

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

Across England & Wales 24 sites have been identified as being potentially suitable for using waste heat recovery to support district heat networks. An assessment has not been made for sites covered by other transmission networks.

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

The cost of installing a waste heat recovery system on transformers would vary on a case by case basis and would be part of a larger project to provide heat through a district heat network. It would have to be balanced against the cost of the commercial opportunity.

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

This is a feasibility project to demonstrate that waste heat recovery may be retrofitted to a pre-existing transformer without compromising its normal operation. A successful project will demonstrate that this may be achieved, and licensees may use the learning to develop their own opportunities to do the same. Design assurance and due diligence would still be required for any projects where this would be utilised.

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.

There is no awareness of retrofitted waste heat recovery systems retrofitted to in service transmission transformers. NGET has undertaken heat recovery systems using alternative technologies and on transformers designed specifically to feed heat recovery systems but this would be the first time that a system was installed as a modification to the existing cooling system.

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

Waste heat recovery systems of different types have been used to capture waste heat from transformers previously. NGET has trialled air source heat exchangers in transformer noise enclosures to provide heating and hot water for substation buildings and there are three transmission transformers equipment with oil/water cooling exchangers in North London that were designed with this capability. There have been similar developments on distribution transformers. However, there is an opportunity to retrofit a system onto an older transformer at the Deeside facility and demonstrate that this can be done without affecting future performance of the identical design transformer and therefore de-risk future deployments.

Relevant Foreground IPR

The heat exchanger design is owned by SSE Energy Solutions and will remain its property. The design is being made available to NGET for the duration of the trial. The design is specific to the transformer being used for the trial and appropriate for the Deeside location. Any future design of heat exchanger to be retrofitted on another design in a different location would need a revision of the design for that situation and would derive limited benefit from using the design used for this trial.

The foreground IPR will be a report detailing the testing carried out in the trial, the results and any learning that may be relevant to future installations for commissioning, maintenance and decommissioning to achieve the same or better outcomes

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 project will deliver societal benefits through a reduction of carbon dioxide emissions if the project is successful and rollout proves commercially viable as part of the development of district heat networks. While there is a mechanism to evaluate the commercial benefit of avoided carbon dioxide emissions, it is not certain that NGET will accrue commercial benefits from a successful project and there is a risk that no benefit will be achieved as NGET is not planning at this point to develop district heat networks and cannot directly influence the accrual of benefits through their development.

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 technical risk stems from the potential interference with the transformer's cooling system resulting from the retrofitting of a heat exchanger system, this could have long term negative impacts on the natural ageing of the transformer arising from typical loads. This would not be tolerated on an in-service transformer; it could impact on normal operation and may result in early replacement. If the project shows that this risk is possible then it is likely that no further implementation of heat recovery systems on in-service transformers will take place. As this is a possibility NIA, rather than BaU is the appropriate funding mechanism for this project

Although the project is anticipated to generate sufficient benefit to justify the expenditure over 10 years, the success of the project will only become truly apparent over a longer period of time. Clearly over a 25-year period, used for the cost benefit analysis of the project there is significant uncertainty over what may influence to the extent to which the technology rollout would be.

This project has been approved by a senior member of staff

☑ Yes