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

Dec 2018

Project Reference Number

NIA_NGTO030

Project Registration

Project Title

Overload Rotation to Increase Capacity of Transmission Boundaries

Project Reference Number

NIA_NGTO030

Project Licensee(s)

National Grid Electricity Transmission

Project Start

December 2018

Project Duration

2 years and 8 months

Nominated Project Contact(s)

Xiaolin Ding

Project Budget

£159,000.00

Summary

It is envisaged that the capacity of transmission boundaries can be increased by overloading the individual boundary circuits for a limited time period and then reducing their loading whilst overloading other circuits in the next time period. This is the concept of rotating overloads across different circuits exploiting the existing overload ratings of the assets. This rotation of overloading may provide an effective increase in boundary power flows under normal and fault conditions.
This is deemed appropriate because requirements for high power transfers are usually limited to 1 to 2 hours during system operation. On the other hand, in many European countries, overcurrent protection is set to 120% for, typically 20 minutes; this spare capacity can be used in the case of system.

Nominated Contact Email Address(es)

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Problem Being Solved

The cost of constraints drives investment in the transmission network. Increasing the boundary power flows alleviates these constraints and aims to reduce the cost of electricity for consumers. In order for National Grid to provide the reliability that is so valuable to customers and stakeholders, additional capacity is built into the design of the transmission network, to allow it to operate seamlessly under fault conditions. These overload or emergency ratings, allow the transmission owner and system operator to work together to provide power under scenarios when a fault occurs; keeping the system balanced and providing a continual supply to customers.
One way of reducing customer bills is to avoid capital investments in new boundary circuits by increasing the capacity of the existing transmission boundaries. This can be achieved by understanding and controlling the existing infrastructure in a better way.

Method(s)

It is envisaged that the capacity of transmission boundaries can be increased by overloading the individual boundary circuits for a limited time period and then reducing their loading whilst overloading other circuits in the next time period. This is the concept of

rotating overloads across different circuits exploiting the existing overload ratings of the assets. This rotation of overloading may provide an effective increase in boundary power flows under normal and fault conditions.

can be .

The proposed method can be applied in both normal and emergency system operation. It consists of three main components:

1. Dynamic thermal ratings of boundary circuits are used instead of nominal ratings.
2. Overload rotation is done on individual boundary circuits to provide higher circuit capacity during a longer time period.
3. Commercial aspects of generation rescheduling (for overload rotation) need to be investigated.

It is expected that dynamic thermal ratings will be higher than the nominal ratings.

Scope

This project will deliver the following work packages:

WP1: Overload Rotation Model and Software:

The Overload Rotation Model is a multi-stage mixed integer optimization model whose objective is to maximise power flows over boundary circuits in all time intervals by using the minimum amount of controllable actions. The model constraints are power flow equations, thermal and voltage limits. The control room ratings are used for all assets as nominal loading limits, whilst during emergencies boundary circuits are loaded up to dynamic thermal ratings that are produced in WP2. The overload rotation is realized by generation rescheduling, load curtailment and network switching.

WP1 Deliverables at the end of the study period:

- Mathematical model and Matlab software for the Overload Rotation Model.
- Full specification of the network data required for the Overload Rotation Model.
- Results of the initial model testing on the ‘standard’ IEEE reliability test network IEEE RTS-96.

WP2: Dynamic Thermal Ratings of Boundary Circuits:

WP2 investigates dynamic thermal ratings of boundary circuits. Dynamic thermal ratings are calculated using the IEC thermal balance model that takes into account external factors and loading conditions. Dynamic thermal ratings are input parameters in the Overload Rotation Model and are used as maximum loading limits of boundary circuits.

- WP2 Deliverables at the end of the study period Provide a range of dynamic thermal ratings of boundary circuits for different ‘typical’ external conditions that prevail in the relevant geographical region.

WP3: Testing of the Overload Rotation Model on National Grid Boundaries:

Relevant boundaries and parts of the National Grid transmission network surrounding them are studied. The network models with all relevant data are provided by National Grid. The overload rotation is tested on up to three boundaries, where two boundaries can be geographically close to each other. Each boundary is studied under critical loading and network conditions.

Capabilities of existing generation and load customers, as well as network switching are used to assess potential overloading of boundary circuits. Where these capabilities are deemed insufficient, connection of new generation, demand and energy storage customers is further investigated.

WP3 Deliverable at the end of the study period:

- Capabilities of existing and new customers to deliver boundary circuit overloading.

WP4: Commercial Aspects of Overload Rotation:

This WP investigates commercial aspects of the overload rotation from both the societal and utility perspective. The societal benefit is the monetary value from deferred/avoided network investments. A utility will benefit from connection revenues contributed by the new

customers who are willing to participate in the ‘new’ ancillary service. A methodology to allocate (a part of) these benefits to existing and new customers’ needs to be developed, as well as incentive/reward regime.

WP4 Deliverable at the end of the study period:

- A review of potential methodologies to apportion monetary benefits between utility and customers participating in the overload rotation; as overload rotation may require the participation of multiple parties.

Objective(s)

The objectives of this project is to determine the feasibility of overload rotation and quantify the benefits it can provide.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

This project will be deemed successful if the technoeconomic feasibility of overload rotation is established.

Project Partners and External Funding

No partners for the feasibility study.

Potential for New Learning

This feasibility study offers the potential to understand how existing capacity in the network may be better used. This type of technology could be used by any licensee that owns assets that have a dynamic rating.

Scale of Project

This initial feasibility study was chosen to investigate the potential benefits from this concept, prior to any larger investigations being carried out. A desktop study was deemed suitable as this is capable of capturing a clear narrative around how overload rotation could work and will provide a preliminary assessment of the benefits; which will be required to fund further work in this area.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL3 Proof of Concept

Geographical Area

Desktop studies

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

£159,000

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:

n/a

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)

If overload rotation is adopted as a system operation, this could provide significant increases in boundary power flows. This may delay or prevent large investment in the network, which could save consumers £10s to £100s of millions

Please provide a calculation of the expected benefits the Solution

As this is a research project, a cost benefit analysis is not yet applicable.

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

This method could be applied to the whole transmission network and could ultimately be coordinated by the system operator This could also be theoretically used at distribution levels if appropriate systems were put in place.

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

As this concept is at a very early stage of development estimates are difficult to make, but this system would likely cost £5-£10 million to implement across the transmission network.

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

1. The innovation will be used in everyday real-time transmission system operation to transfer increased power flows over boundary circuits without affecting system integrity/security/stability and individual asset health.
2. Limited capacity of transmission boundaries.

Or, please describe what specific challenge identified in the Network Licensee's innovation strategy that is being addressed by the project (RIIO-1 only)

This project fits within the (chose from below) value area of the Electricity Innovation Strategy:

Service Delivery - Developing new service-based propositions and business models

☑ Has the Potential to Develop Learning That Can be Applied by all Relevant Network Licensees

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.

Dynamic ratings and emergency ratings of individual electrical route have been investigated extensively and significant development work has gone into this area. This project is investigating the use of existing dynamic capacity in the network and co-ordinating the use of these dynamic ratings to provide a net increase in boundary power flows; This is distinctly different to researching how to dynamically rate an individual asset or route.

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

NGET have done a fair amount of research related to dynamic ratings of individual overhead lines (OHL). The objective was to find maximum OHL loadability based on line loading and environmental parameters. The natural extension of this research is to apply dynamic ratings in a network area in which overload problems exist during system outages. This idea led to a novel concept, called “Overload Rotation”, which is proposed in this project. This technology has the potential to provide value to the consumer, subject to a positive business case.

Relevant Foreground IPR

n/a

Data Access Details

n/a

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

There is an uncertainty about the business case for the overload rotation concept and the technical risks are also unknown.

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 inherent risk of the project is detailed above and the learning from the project will be directly relevant to all Network Licensees. For this reason, NGETbelieve this project is appropriately funded through NIA.

This project has been approved by a senior member of staff

☑ Yes