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

Mar 2019

Project Reference Number

NIA_NGN_242

Project Registration

Project Title

Constraint Based Optimisation Solution: Network Reinforcement

Project Reference Number

NIA_NGN_242

Project Licensee(s)

Northern Gas Networks

Project Start

March 2019

Project Duration

0 years and 10 months

Nominated Project Contact(s)

Mike Charlton

Project Budget

£329,733.00

Summary

The objective is to develop and test a bespoke methodology, building on NGNs global model approach, and solution to optimise the network reinforcement investments required to minimise the use of open cute mains replacement.

Nominated Contact Email Address(es)

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Problem Being Solved

The primary methods for gas mains replacement are live/dead insertion and open trench replacement. Insertion is preferred by NGN as it is safer, lower cost and has a lower impact on customers and the environment.

While insertion offers cost, customer and environmental impact benefits it will result in a reduction of live gas main diameters. This will result in a reduction in gas distribution capacity, which if not mitigated may cause the minimum safe gas pressure to be breached for a number of customers. Critical reductions in gas distribution capacity resulting in a breach of the minimum safe gas pressure is referred to as constraints.

To be able to safely replace Tier 1 iron mains with extensive use of insertion, REPEX project planning must identify when and where these constraints will occur in relation to the phasing of gas mains replacement and be able to mitigate them. Current and past practice at NGN was to identify constraints associated with each mains replacement project and mitigate them within each project. This would be achieved by including an element of open cut replacement within the mains replacement project, allowing some larger diameter PE pipe to be laid to reinforce the network.

Method(s)

Going forward NGN would like to reduce the number of open cut replacements by making strategic reinforcement investments that will mitigate excessively low pressure for multiple replacement projects. These reinforcement investments will include some open cut replacement to allow larger diameter mains to be laid but also increasing the downstream pressure at district governors.

Planning the optimal programme of network reinforcement investments for a given mains replacement programme will require a

software solution combining hydraulic flow modelling capability with constraint-based optimisation. Constraints must include financial, physical and operational constraints for example, minimum pressure and maximum shrinkage. No current software solution available on the market meets these criteria without requiring significant manual intervention making them impractical for analysing multiple replacement scenarios and business as usual use.

This project will develop a methodology and enabling tool to enable NGN to effectively plan the strategic network reinforcement investments required to deliver effectively the REPEX programme with maximum mains replacement by insertion. The methodology will build on the existing, partially manual, solution (Global Model) currently being used by Northern Gas Networks to develop and optimal programme of network reinforcements. The methodology and enabling tool developed through this NIA project will improve on the performance and usability of the Global model. The project will also deliver a technical and commercial feasibility study assessing how the tool could be developed and deployed as a business as usual solution.

Technically the solution will require two key functionalities:

A) Ability to model the hydraulic flow in the gas network to identify when and where low-pressure constraints are breached during the REPEX programme from now until 2032 without the requirement for manual intervention each time a constraint is identified.

B) Intelligently select the optimal network reinforcement investments by using mathematical optimisation, based on a set of objective functions and constraints, to mitigate excessively low pressure and enable maximum mains replacement by insertion. Reinforcement options includes new pipes, open-cut replacement with larger diameter pipes and increasing District Governor outlet pressures.

To improve upon current NGN capability (Global Model) the methodology and enabling tool will:

A) fully automate and significantly speed up the end to end process,

B) solve for all network constraints simultaneously (rather than one-by-one) and (B) leverage state of the art mathematical constraint-based optimisation and the scalability of cloud computing to evaluate much larger numbers and combinations of options than possible with a human decision maker.

Hydraulic modelling approach
Our approach will use a simple flow equation suitable for steady state analysis of natural gas flow in a distribution pipe. Plan to use Lacey/Pole or low pressure Spizglass formula (a Synergi Gas option) for pressures below 75 mbar. Focus will be to simplify hydraulic computation to its bare-bones to allow optimisation process to run efficiently but maintaining credible pressure predictions.

Optimisation approach
This optimisation capability will be built using Constraint-Oriented Reasoning™ (COR). COR is a 5th generation programming language that enables the user to quickly create high-value analytical solutions in complex problem domains. Unlike conventional modelling, COR automatically generates mathematical representations of all system constraints and their interactions. This avoids the need for specialised developers and allows users with asset and risk management to build models and apply their expertise directly. COR can be used to simultaneously model operational, physical and financial constraints, making it ideal for this application. COR will be required to model multiple constraints including but not limited to, minimum and maximum safe gas pressure, construction lead time and shrinkage/leakageCOR will make use of CPLEX to find the optimal (lowest cost) network reinforcement investments for a given mains replacement programme.

Scope

To meet the planning challenge outlined about the proposed solution will:

• Model the NGN low pressure distribution network at an individual pipe level.
• Model the mains replacement projects, their costs and phasing.
• Model the cumulative impact of the mains replacement projects on gas pressure to identify when and where “constraints” would develop.
• Intelligently (using constraint-based optimisation) select the most cost-effective Capex investments to augment network capacity to mitigate the ‘constraints’.

Allow the user to define the effective lead-time and planning constrains for reinforcement investments (for example 12 months before dependant replacement project).

Take into consideration other types of constraint (other than low pressure) such as shrinkage/leakage and high pressure.

Further, to ensure it is usable the solution will:
• Have a rapid set-up and solve time to effectively support a dynamic and iterative planning process, for example re-solving for multiple C55 investment scenarios. We expect the solve time for a single scenario to be between 4 and 6 hours. If required multiple scenarios can be run in parallel with no additional time impact (assuming solution is hosted in the MS Azure cloud).

Following the registration of the NIA project, NIA_NGN_242 Constraint Based Optimisation Solution: Network Reinforcement. The project has experienced timeline setbacks, resulting in the original delivery date being no longer attainable. To ensure the original project aims and objectives are met, it is necessary to extend the project timeline until the 15/11/2019.

Objective(s)

The objective is to develop and test a bespoke methodology, building on NGNs global model approach, and solution to optimise the network reinforcement investments required to minimise the use of open cute mains replacement.

The project will deliver the following core objectives:
• Quantified benefit case for optimised and automated network reinforcement planning process
• Business case and plan to implement improved process as business as usual
• Optimised network reinforcement programme (to 2032) using improved methodology

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

Project:
• Demonstrate and quantify significant benefits of the optimised and automated process (over the as-is process) in the following areas:
• Producing a better (lower cost and lower customer risk) network reinforcement programme of works to 2032.
• A more agile and faster end to end planning process
• A more transparent and demonstrable evidence-based process
• A more auditable and controlled process.
• Assess the technical and commercial feasibility of a BAU solution.
• Provide a robust and meaningful optimised network reinforcement programme (to 2032) using improved the methodology.
• Identify additional opportunities and indirect benefits of the approach and solution developed.

Technical:
• Model cumulative impact of whole mains replacement programme to 2032 on gas pressure in the whole LP distribution network within agreed level of accuracy.
• Intelligently (using constraint-based optimisation) select the optimal series of strategic network reinforcement investments to ensure minimum LP constraints are not breached.
• Enable users to run scenarios on alternative mains replacement programmes in a user friendly and timely manner (4-6 hours per scenario).
• Identify critical governors associated with each mains replacement programme.
• Quantify level of shrinkage/leakage throughout mains replacement programme and link with leakage reduction/incentives.
• Provide results in accessible and user-friendly format (solution use to run scenarios and produce results will be highly technical and only suitable for ‘expert users’).

Project Partners and External Funding

Business Modelling Associates UK LTD

Potential for New Learning

This project will develop new learning on how hydraulic and optimisation modelling can be combined to improve GDN decision making specifically in the context of reducing the proportion of open cut mains replacement.

The learning from this project will be disseminated through publication of a full technical report and subsequent knowledge dissemination events.

Scale of Project

This project will involve modelling and planning for network reinforcement investment for Northern Gas Networks whole Tier 1 iron mains population from now to 2032.

Technology Readiness at Start

TRL4 Bench Scale Research

Technology Readiness at End

TRL7 Inactive Commissioning

Geographical Area

NGN geographic region

Revenue Allowed for the RIIO Settlement

N/A

Indicative Total NIA Project Expenditure

External costs – £247,300
Internal costs – £82,433
Sanctioning costs - £329,733

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)

The benefits analysis will include benefits in the following areas:

Develop and demonstrate a better solution than currently possible (lower cost, less customer risk) by allowing the constraint-based optimisation algorithm to consider larger number of options than possible with a human decision maker.

An initial estimate of the potential cost benefit from this solution would be enabling and providing greater confidence around the reduction of open cut mains replacement from 7 percent to 2 per cent of total replacement activity.

Note these savings are based on clients who were largely depending on excel based modelling. Given the relative maturity of the existing NGN solution we would limit the expected benefit to 6-8% reduction in cost.

Also enabled will be a transparent and demonstrable evidence-based plan (scenario analysis to test assumptions) and an auditable and controlled process

Please provide a calculation of the expected benefits the Solution

We envisage that the NIA project will provide us with an improved "Global Model" answer. Improving on the current results by an estimated 6-8% per annum. At the end of this project, this percentage is going to be validated.

We estimate this to be £70,000 per annum based on assumed increase in insertion over open cut.

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

The results of this will be network specific which will need to be qualified. An estimated view would be £70k over 8 networks at £560k per annum.

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

The project will define what potential options are available for deployment across GDN's. This a key deliverable of the project outputs.

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

All networks undertake modelling and analysis of network capacity. The solution developed through this project will be relevant and available to other Network Licenses

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

The challenge addressed from this project is the ability to undertake automated capacity analysis of the network. The direct outcome of the computer driven analysis will enable analysis and sequencing of the strategic network reinforcement investments required to deliver effectively the REPEX programme with maximum mains replacement by insertion.

☑ 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.

We have conducted market research and internal trials, including development of a POC solution. We are confident an equivalent solution is not available on the market or in currently owned software solutions.

No similar projects are being carried out by other Network Licensees.

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

Other methods and approaches have been used to drive efficiency in the mains replacement programme. As these have been delivered successfully we look to further ways to deliver efficiencies. This innovation in digital technology is challenging, however we believe it now offers the best opportunity to find additional efficiencies in the mains replacement programme that up to now remains unproven.

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

We recognize the need to build upon and improve our current modelling and analysis capabilities. However, this project study is mid level TRL and the outcomes are uncertain. Clarity is needed to evaluate future potential hence the reason we are investing in this project through the NIA mechanism. This project is highly innovative and involves higher technical risk than would be acceptable through our business as usual funding. It represents a novel use of software decision support technology not previously used in the industry or globally.

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

Within NGN we currently use manually driven modelling and analysis of network capacity, this technique has not changed in a number of years and whist proving effective, there are areas where improvement may be possible from a commercial, operational, reliability and wider asset management functionality requiring assessment to enable change from current practice.

This project has been approved by a senior member of staff

☑ Yes