NIA ENWL005
Asset Risk Optimisation

Closedown Report

31 July 2017

CONTENTS

GLOSSARY

Term	Description
CBRM	Condition Based Risk Management
CNAIM	Common network asset indices methodology
DNO	Distribution network operator
HV	High voltage eg 6.6kV and 11kV
KPI	Key performance indicator
kV	Kilovolts
LV	Low voltage eg 230V and 400V
NAW	Network asset workbook
NPV	Net present value
RIG	Regulatory instructions and guidance
RIIO-ED1	Revenues = Innovation + Incentives + Outputs in Electricity Distribution period 1
SLC 51	Standard Licence Condition number 51 for RIIO-ED1

VERSION HISTORY

Version	Date	Author	Status	Comments
0.1	18 Nov 2016	R A Wells	First draft	For internal review
0.2	23 Nov 2016	R A Wells	Second draft	For business review
0.3	21 Dec 2016		Third draft	For business review
0.4	7 March 2017		Fourth draft	For business review
0.4A	8 March 2017		FInal	For business review

REVIEW

Name	Role	Date
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APPROVAL

Name	Role	Date
Steve Cox	Engineering & Technical Director	21/07/17

1 EXECUTIVE SUMMARY

This section does not appear on the Smarter Networks Portal.

1.1 Aims

This project was initiated to investigate the potential use of analytics and specifically optimisation within the context of the RIIO regulatory regimes that gas and electricity network operators within Great Britain (GB) are subject to. This would explore the potential to use the new model for asset risk measurement developed under the common network asset indices methodology (CNAIM) to optimise risk mitigation as a result of asset interventions at a reduced cost to customers.

1.2 Methodology

Within the water utility sector and widely adopted in the electricity sector in North America, optimisation techniques permit the analysis of work packages and programmes so that the implications of their implementation can be modelled, and their impacts compared in order to identify the optimum portfolio of investments for deployment. With the creation of the CNAIM and its introduction in RIIO-ED1, DNOs have for the first time the ability to model the implications of risk trading within an asset risk framework. The manner in which the water sector uses optimisation is different to that which could be used in the DNO sector and so the use of the techniques were explored in a DNO context.

A supplier of optimisation software (SEAMS) was engaged to investigate how the existing data used within the CNAIM could be adapted for optimisation, including the modification required of Electricity North West data sets, and the proprietary software and optimisation algorithms. SEAMS was provided with data which permitted the identification of an asset's position in the CNAIM 5x4 matrix structure and a dummy set of potential movements within the matrix together with the cost of moving the asset from one location to another within it. From this data the possible risk reductions and cost associated with an intervention within the matrix were mapped.

In order to achieve optimisation of the plan, all potential outcomes for the movement of every asset have to be mapped and the cost and risk reduction evaluated until the optimum position is determined.

In carrying out an optimisation it is also necessary to set certain parameters that the outcomes must meet, and constraints that need to be optimised within. The models were established to run these various scenarios and as a result of this, eight specific scenarios were studied to determine how the model would manage the restrictions and what result would be produced. The outputs of the models were compared in terms of whole life cost NPV calculations.

For this trial four asset groups were selected:

- 132 kV transformer
- LV underground link boxes (UGB)
- HV wood poles
- 11/6.6 kV distribution switchgear.

1.3 Outcomes

The outcomes of the modelling showed the following:

- Risk optimisation can be applied to the electricity asset base and create potential savings in cost of delivery against traditional intervention methods

- Inter-asset optimisation can result in some asset groups not being selected for any interventions in the period
- The model can cost potential out performance of agreed targets as well as identifying where programmes of work either fail to deliver targets or the cost of delivery is excessive, when compared with allowances or budgets.

1.4 Key learning

The following key learning points were achieved:

- Analytics, of which optimisation is a branch, can be successfully applied to the problem of delivering targets for less cost than originally envisaged
- Significant effort is required to ensure the data and its treatment is correctly modelled
- Linear optimisation techniques are most appropriate to this form of modelling
- Computing resources are a potential barrier to entry.

1.5 Conclusions

As a result of the project the following conclusions have been reached:

- Risk optimisation can be successfully applied to Electricity North West intervention programmes
- The savings which can be gained are potentially significant in the RIIO-ED1 period
- Linear optimisation is the appropriate form to be used
- The integration of the product to existing systems is a key dependency to the implementation of a business wide project.

1.6 Closedown reporting

This project was compliant with the governance for Network Innovation Allowance (NIA) projects, and so this report has been structured to meet these governance requirements. The structure and headings in this report reflect these requirements.

A version of this report - including only the sections referenced - is available via the Energy Networks Association's Smarter Networks learning portal at www.smarternetworks.org. This version of the report provides additional information that we believe useful in understanding the project.

2 PROJECT FUNDAMENTALS

This section reproduces reference data as stated in the original project registration.

Title	Asset Risk Optimisation
Project reference	NIA_ENWL005
Funding licensee(s)	Electricity North West Limited
Project start date	July 2015
Project duration	2 years
Nominated project contact(s)	R A Wells Asset Management Modelling Manager

3 PROJECT BACKGROUND

This section reproduces the 'Problem' and 'Method' as stated in the original project registration.

3.1 The problem

DNOs have been developing the Condition Based Risk Management (CBRM) approach to asset management over the past ten years. This approach allows for a detailed assessment of the relative condition of assets within an asset type and more latterly, a consideration of their relative consequences of failure. CBRM models do not however integrate into an overall risk assessment framework; neither do they allow a DNO to plan for optimum investment to manage the asset risk.

With the development of the CNAIM for RIIO-ED1 under SLC51, a standard approach now exists for categorizing and quantifying risk across all asset types which opens up the possibility of inter-asset risk prioritisation. In addition, the development of new and innovative techniques for refurbishment and life-extension of assets is widening the range of intervention options available.

In effect, these two developments allow an almost infinite variety of potential investment portfolios to be assessed against each other in terms of their cost (both initial and lifetime) and monetized impact on asset risk. In principle, investment portfolios can now be optimized to deliver the best value asset risk reduction on the network, however the breadth of these options and the optimization algorithms required goes beyond conventional DNO modelling capability.

In order to enhance our knowledge of the issues around optimizing programmes of work we are proposing to investigate the interaction between:

- Investment in assets near end-of-life compared to earlier in their lifecycle
- The benefits of refurbishment options versus replacement
- The benefits of investments to reduce the consequences of failure compared to those aimed at reducing probabilities
- The relative benefits of different asset types
- The effect of including overall constraints to mimic real-world conditions (eg supply chain capacity).

3.2 Problem solving method

Electricity North West have identified a partner in SEAMS of Sheffield as an organization with recent experience carrying out optimization of asset investment programmes in the utility sector. SEAMS offer a software platform (WiLCO) which can indicate across different asset types the various impacts of investment decision by employing iterative modelling of scenarios.

We will partner with SEAMS to deliver an investment optimization model. This will initially be limited to just four asset groups and hence prove the concept of the use of these techniques.

The SEAMS software is tailored to the specific needs of the client, the modelling parameters are set so that the model produces scenarios around the base requirements. By adjusting the various parameters and constraints and running the model iteratively, it will provide a series of potential outcomes as a result of the parameters which it is asked to optimise. From the results of these iterative models we will gain knowledge of the inter-asset relationships as they relate to asset risk.

4 PROJECT SCOPE

This section reproduces the 'Scope' as stated in the original project registration.

Carry out a trial optimisation of the following asset investment programmes for the RIIO-ED1 period:

- Grid transformers
- Distribution HV switchgear
- HV pole (supports)
- Underground link boxes.

Using data generated from Electricity North West Limited data sources. The trial application will be hosted by SEAMS.

5 OBJECTIVES

This section reproduces the 'Objectives' as stated in the original project registration.

The project has the following objectives:

- Understand the data requirements to permit the optimisation of an existing programme of work
- Understand the techniques employed and how they may be customised to meet the industry's needs
- Vary parameters to understand the relative changes in overall delivery of the regulatory contract
- Understand the inputs required for a wider rollout of the technology to all asset groups modelled by CBRM
- Understand the IT technology implications of the models. Consider integration of the models to all corporate systems and the cost benefit
- Identify potential for optimising RIIO-ED2 submission to maximise benefits for customers while optimising investment.

6 SUCCESS CRITERIA

This section reproduces the 'Success Criteria' as stated in the original project registration.

The project success criteria are:

- Development and enhancement of knowledge about the inter-dependencies of KPIs and constraints associated with inter-asset modelling and hence permit optimisation of programmes of work
- That the project permits the asset intervention programme to be varied in a manner which permits delivery of all KPIs in a more efficient manner
- That the model can be accessed to allow various criteria to be run and optimised by Electricity North West
- That the project outputs are scalable and other asset types can be added to the model, based on existing asset data sets.

7 PERFORMANCE COMPARED TO THE ORIGINAL PROJECT AIMS, OBJECTIVES AND SUCCESS CRITERIA

This section appears in the 'Performance Compared to the Original Project Aims, Objectives and Success Criteria' section on the Smarter Networks portal.

The project was delivered to plan against the original aims, objectives and criteria. An additional piece of work was added to the end of the project to improve the robustness of the learning made.

A trial optimisation involving the following four asset categories has been carried out:

- 132kV transformer
- Distribution switchgear
- HV wood poles
- LV underground boxes.

Using the risk movements of an asset, as defined in the CNAIM 5 x 4 Matrix (Probability of Failure and Consequence of Failure) interventions can be identified which will result in movements from one cell to another. Using the Secondary Deliverable Impact (SDI) requirements as stated in the RIIO-ED1 RIGs Annex A, as a result of a replacement or refurbishment intervention the cost of the intervention and the impact on recorded asset risk can be estimated. This is provided to the model with the volumes of assets in each cell. The target risk reduction required is provided and an optimisation takes place. The output of the model provides volumes of assets to have an intervention with a cost for that work. The model is unable to provide a detailed list of assets by asset registry number to be intervened on.

The model was further developed so it could recommend specific assets to which an intervention should be applied across all 21 assets for which an asset risk is reported in the RIIO-ED1 Network Asset Workbook (NAW); and consider the degree of integration this methodology could have within existing company systems.

A set of four prototype models were delivered in October 2015 which permitted the principles of the methodology to be demonstrated. These models showed there is potential for the optimisation processes to be applied to any asset group which has an asset health score and hence risk. An opportunity for additional learning in order to better match the original objectives of the project was identified and implemented.

8 THE OUTCOME OF THE PROJECT

This section appears in 'The Outcomes of the Project' section on the Smarter Networks Portal.

The project was designed to understand how risk (as defined by the CNAIM) and the associated risk reduction as defined in the Network Asset Workbook for RIIO-ED1 could be better managed and the same results delivered for a saving to customers. The project was designed to increase DNO learning of the potential for the use of analytics and specifically optimisation tools which have been used in other utility sectors, especially water and wastewater.

Using the 5x4 matrix established in the CNAIM, asset movement across the matrix for each asset group were defined. It should be noted that some movements were considered to be inappropriate as they could not or would not be supported under cost benefit analysis. As each cell of the matrix has an assigned value the movement of an asset from cell to cell creates a benefit. The sum of these benefits creates the measure of risk reduction. The introduction of the CNAIM therefore gives a value to every intervention and therefore the concept of risk trading can be established.

The outputs of the CNAIM are used to create a target risk reduction of each asset type as established in the Company Network Asset Workbook (NAW) reported to Ofgem via the Secondary Deliverables Reporting Pack. In this process the potential value of asset risk where no investment would take place is compared to the value of asset risk where the proposed asset investment has been delivered in accordance with the Well Justified business plan of the RIIO ED1 review. The difference between the two values art a specified point in time is the risk reduction target, a secondary deliverable with an associated incentive, set in the RIIO ED 1 licence.

A software package was developed to understand the relative costs, movements and benefits of an intervention as well as the relative positions of the assets within the matrix. The software was configured so that values such as required risk reduction, budgets, and resources together with capping and collaring of these variables could be influenced. The software could then calculate the programme of work to be delivered to achieve the required parameters. All scenarios were run against the RIIO ED1 final determination of the Well Justified Business Plan for the RIIO ED1 period, which sets the Company allowances for the period.

As a result of this optimisation it was shown that:

- Optimisation can result in certain assets classes or types requiring zero intervention during a regulatory period. This zero intervention may not actually be desirable however.
- The software has a tendency to ignore resource constrains resulting in the output of the model suggesting unusual or impossible delivery requirement – This can be managed by applying collars to the system.
- Risk reductions targets can be met at lower costs than might otherwise have been and hence reduce cost bases against this measure.

Table 1 below (Modelled Scenarios table) illustrates those scenarios used to optimise the four asset types and the relative costs of delivering the risk reduction in terms of whole life costs. This takes as its basis the overall aggregate asset risk position for these asset types as calculated under CNAIM and comparison with the associated previously planned level of investment. These scenarios are deliberately high level as they represent the forms of question asked within the Asset Investment decision process. The optimisation process must be able to cope with this degree of scenario definition.

Table 1: Modelled scenarios

Table 1	**Modelled scenarios**	
Scenario Reference	Scenario Description	CAPEX Investment (Whole Life Cost in £M NPV)
1	Maintain current asset risk at least total investment cost.	14.2
1a	Maintain current asset risk at least total investment cost (undiscounted).	15.0
2	5% reduction in total asset risk by 2019, with a further 10% reduction by 2023.	34.6

Table 1	Modelled scenarios	
3	5% asset risk reduction in each asset class risk by 2019, 10% by 2023.	39.8
4	Maintain asset risk at RIIO ED1 start levels, with constraints as defined: • minimum £500k p/a spend on link boxes, • max £1m total spend on HV poles, • No zero spend on any asset class in any year.	28.7
5a	Achieve the best asset risk score possible with 10% reduction in spend The spend is that required and modelled in Scenario 1 above.	12.8
5b	Best asset risk score possible with 20% reduction in investment spend The spend is that required and modelled in Scenario 1 above.	11.4
6	Maintain asset risk in the RIIO ED1 period (no more than 5% asset risk increase for any asset class).	26.5
7	Maintain asset risk in the RIIO ED1 period (replace at least one transformer every year, replace no more than 6000 HV switches across analysis period).	14.3
8	Best asset risk score for the RIIO ED1 period (annual budget cap of average annual expenditure from the spend is that required and modelled in Scenario 1 above..	14.8

From the data produced by the prototype modelling it was shown that the company risk target for the four asset groups could be achieved with an £800k saving over the final determination, well justified business plan for scenario 1.

From a detailed analysis of the scenario results against the RIIO ED1 final determination the following has been concluded:

- Scenario 1 could deliver a risk reduction, as defined in the NAW, at a reduced cost
- Scenarios 2,3,4 demonstrates the scale of increasing costs required for additional risk reduction
- Scenario 5 demonstrates that a significant reduction in investment would prevent delivery of the base case risk level
- Scenarios 6, 7 and 8 demonstrated that the modelling techniques could be used to optimise complex constraints and still achieve cost savings against existing business plans.

The project has demonstrated that risk optimisation tools can be applied to the manner in which the Electricity sector is regulated and therefore a wider application of the techniques can be made using the methodology developed by the project. A prototype software model has been established hosted by SEAMS our supplier which Electricity North West can access and run test scenarios.

9 REQUIRED MODIFICATIONS TO THE PLANNED APPROACH DURING THE COURSE OF THE PROJECT

This section appears in the ‘Required Modifications to the Planned Approach During the Course of the Project’ section on the Smarter Networks portal.

There were no modifications to the planned approach of developing the software or providing data to it. As a result of discussions during the project however, it was identified that there was a need to fully understand the implications to the business of the deployment of the software into the Company. This was because of the knowledge the supplier had in deploying this form of analytics to other utility businesses. As a result of this, a “discovery stage” was included in the project to determine if the deployment of the software would require structural changes to the business; software and delivery systems.

As a result of the discovery stage it was concluded that the existing systems and structure of the business was adequate for the implementation of a project rollout as are or existing business systems, which could be integrated to an optimisation system. This has been demonstrated by a number of potential suppliers.

10 VARIANCE IN COSTS AND BENEFITS

This section does not appear on the Smarter Networks Portal.

10.1 Cost variance

The development of the risk optimisation tool was registered at £100,000. Actual costs were £106,000.

The reasons for the variations are:

Software tool

- Development of the optimisation methodology format – SEAMS financially contributed to this work, resulting in a saving to the project
- Data mastery work was carried out internally rather than contracted out at a further saving.

Discovery work

- The additional discovery work identified during the project, resulted in additional supplier expenses which when combined with the savings made elsewhere resulted in the net £6,000 increase to the registered project budget.

10.2 Benefit variance

The additional expenditure delivered the following benefits:

- Confirmation that structural changes were not required to the business to implement the system
- Confirmation that current IT systems were adequate to support the system
- The level of project support required to implement an optimisation system limited to the CNAIM risk optimisation principles
- The potential for future development into an enterprise wide system covering assets not specifically part of the CNAIM
- The potential for and benefits of the conversion of delivery systems to an enterprise wide delivery system specifically tailored to analytics.

By carrying out this work Electricity North West have ensured unnecessary expenditure is avoided in any future implementation phase.

11 LESSONS LEARNED FOR FUTURE PROJECTS

This section appears in the 'Lessons Learnt for Future Projects' section on the Smarter Networks portal.

11.1 Exploitation

The technique of risk optimisation using risk trading within the context of the CNAIM is possible under the current regulatory system in GB. In order to deploy the technique however there is need to:

- More accurately map potential movements within the matrix of the Common Network Asset Indices Methodology and confirm costs of those movements
- Implement rule sets to ensure that were multiple assets are replaced by a single asset this is appropriately understood and mapped
- Develop techniques for the optimiser to manage the removal of overhead lines to an underground solutions
- Develop enduring interfaces between the optimisation software existing company systems.

11.2 Trialling

The adoption of risk optimisation as described will bring benefits to the customer and the company. As a result, Electricity North West are not proposing to carry out any further trialling but are moving to a wide scale implementation of an optimisation software package.

11.3 Issues discovered

There were no issues in the development of the prototype software or provision of data to drive the optimisation.

The following issues were identified which will impact future implementation:

- Server capacity – Operating the software requires significant server processing capacity. The currently hosted software uses cloud functionality when carrying out optimisation.

11.4 Future implementation

A project funded from within the business to specify and implement a productionised optimisation tool for use in the business has been started. Electricity North West will carry out a call for competition from organisations who can demonstrate they have the ability to develop, integrate and support an optimisation tool. It is anticipated that development will take place in 2017 with implementation in 2017/2018.

11.5 Effectiveness of research and development

The project has allowed Electricity North West to understand the potential role of optimisation in improving efficiency to deliver risk mitigation targets. It has further promoted the possibility of applying the technique to other workstreams. Electricity North West believes that over time the application of the techniques will assist in driving efficient delivery in all areas of the business. The optimisation techniques identified are also likely to be applicable for RIIO-ED2 planning.

The research stage of the project, funded by our supplier, looked at the most appropriate form of optimisation to apply to the problem by assessing linear and non linear optimisation techniques. It was concluded and agreed that the most appropriate form of optimisation for the problem would be linear. This was tested by running both forms and comparing the results. Linear was selected as the most appropriate because:

- The outputs between both types of optimisation were similar
- The non linear optimisation takes significant addition computing time and recourses for little additional benefit
- Linear optimisation is more appropriate to simple problems.

12 PLANNED IMPLEMENTATION

This section appears in the 'Planned Implementation' section on the Smarter Networks Portal.

Electricity North West will look to implement an enterprise wide optimisation system to cover the 25 asset classes within the scope of CNAIM. The supplier will be selected through a call for competition in a competitive tender. As part of the project rollout Electricity North West will develop, with the supplier a road map of future developments in the area of analytics which will be applied more widely to the software estate and our business processes.

As a result of the delivery of the project into the business, the results of the optimiser will be used to adjust work programmes so as to meet the risk reduction targets as specified by the NAW. This will be achieved by ensuring that the optimise details the most effective assets to target at the minimised cost and hence effectively details the order of buy within the programme. This is anticipated to result in a significant efficiency in asset replacement and refurbishment works.

The Electricity North West team that delivered this project is the same team that are delivering the CNAIM in conjunction with Ofgem and the other DNOs. Learning obtained through the life of the project has been shared through the various forums in which the CNAIM is being developed.

12 FACILITATE REPLICATION

This section appears in the 'Other Comments' section on the Smarter Networks Portal.

The objective of this project was to investigate the potential use of analytics and specifically optimisation in the area of Asset interventions within the GB area of operation.

As a result of this work SEAMS have contacted all the DNOs in the UK and some non UK companies to discuss the outputs of the work.

Electricity North West have also undertaken discussions with other GB DNOs on a one-to-one basis, specifically, Northern PowerGrid; Scottish Power and Western Power Distribution on the results of the outputs of the project. Electricity North West are currently arranging to discuss the learning with National Grid Gas and are happy to provide details to other interested parties as to the outcome of the research.

13 APPENDICES

This section does not appear on the Smarter Networks portal.

None.