

NIA ENWL004

Combined Online Transformer Monitoring

Closedown Report

31 July 2023



VERSION HISTORY

Version	Date	Author	Status	Comments
V1	21/07/23	A Howard	Draft	

REVIEW

Name	Role	Date
Ben Ingham	Innovation Technical Manager	28/07/23
Geraldine Paterson	Innovation Manager	28/07/23

APPROVAL

Name	Role	Date
Victoria Turnham	Head of Innovation	30/07/23

CONTENTS

GLOSSARY	3
1 EXECUTIVE SUMMARY	4
1.1 Aims	4
1.2 Methodology	4
1.3 Outcomes	4
1.4 Key learning	4
1.5 Conclusions	5
1.6 Closedown reporting	5
1 PROJECT FUNDAMENTALS	6
2 PROJECT BACKGROUND	6
3 PROJECT SCOPE	6
4 OBJECTIVES	7
5 SUCCESS CRITERIA	7
6 PERFORMANCE COMPARED TO THE ORIGINAL PROJECT AIMS, OBJECTIVES AND SUCCESS CRITERIA	7
7 THE OUTCOME OF THE PROJECT	8
8 REQUIRED MODIFICATIONS TO THE PLANNED APPROACH DURING THE COURSE OF THE PROJECT	8
9 LESSONS LEARNED FOR FUTURE PROJECTS	8
10 PLANNED IMPLEMENTATION	9
11 DATA ACCESS	9
12 FOREGROUND IPR	9
13 FACILITATE REPLICATION	9
14 OTHER COMMENTS	9

GLOSSARY

Term	Description
DGA	Dissolved gas analysis
DNO	Distribution network operator
ENWL	Electricity North West
IFI	Innovation Funding Incentive
IPR	Intellectual property rights
LCN Fund	Low Carbon Networks Fund
NIA	Network Innovation Allowance
PAS	Photo-Acoustic Spectroscopy
PD	Partial discharge
RIIO-ED1	First electricity distribution price control to reflect the new RIIO model (Revenue = Incentives + Innovation + Outputs)
RIIO-ED2	Price Review 2023 - 2028

1 EXECUTIVE SUMMARY

1.1 Aims

This project builds on previous innovation which identified that regenerating transformer oil towards the expected end of the asset's design life would extend its life by approximately 10 years.

This project used equipment and data already available coupled with further monitoring to further confirm the expected life extension.

The project also looked to develop a data visualisation tool to allow the data to be viewed and assessed in a consistent simple manner.

As the volume of data increases further data validation and corresponding calibration of life extension can be made.

1.2 Methodology

Our project partner, Camlin, have developed significant experience in online oil sampling methodologies and equipment, data collection and analysis using various techniques, and in systems to visualise and report information from this analysis.

Starting with the equipment and data from the initial First Tier project, this project developed a dashboard/ decision tool for use by Electricity North West (ENWL), then with the increasing volume of sampling data validated the previous end of life results.

Online sampling results were supported by lab analysed oil samples.

1.3 Outcomes

The project developed a dashboard/decision tool which includes a reporting function that generates and emails monthly and annual reports to key stakeholders within ENWL.

This tool has also been made available and used as part of the project NIA ENWL014 Optimising Oil Regeneration which investigated when, during an asset's life, is the optimal time for oil regeneration.

Online monitoring to carry out Dissolved Gas Analysis (DGA) was installed. The multiple data points were collected, grouped and combined into a series a key indicator and ultimately down to a single index.

Analysis of the data confirmed that by carrying out oil regeneration towards the end of a transformer's design life it can be extended by approximately ten years.

1.4 Key learning

The project confirmed that carrying out oil regeneration can provide an improvement in transformer condition and thereby extend its life.

The analysis of the data showed that whilst the ageing process continues, the speed of ageing is reduced following oil regeneration.

Transformer loading, hence heating effect within the transformer, remains a key factor in how quickly a transformer ages and what its asset life will be. Whilst the effect of future loading can make it difficult to convert monitored ageing rate into a prediction of remaining asset life in months/years, this and previous innovation projects have demonstrated that this could be approximately 10 years.

1.5 Conclusions

A dashboard/decision tool was developed which provides regular health reports, via email, on all monitored assets to key stakeholders within ENWL. The dashboard was refined and enhanced based on learning from our transformer related innovation projects and feedback from the ENWL stakeholders.

The health reports are based on analysis of the data collected from the online monitoring installed prior to carrying out oil regeneration. These health reports can be used by our asset managers to inform future replacement programmes.

The project confirmed that carrying out oil regeneration can provide an improvement in transformer condition and thereby extend its life.

1.6 Closedown reporting

This project was compliant with Network Innovation Allowance (NIA) governance and this report has been structured in accordance with those requirements.

This report and the associated documents are available via the Energy Networks Association's Smarter Networks learning portal at www.smarternetworks.org or via the Electricity North West [website](#).

1 PROJECT FUNDAMENTALS

Title	Combined Online Transformer Monitoring
Project reference	NIA_ENWL004
Funding licensee(s)	Electricity North West Limited
Project start date	September 2014
Project duration	8 years
Nominated project contact(s)	innovation@enwl.co.uk

2 PROJECT BACKGROUND

As part of operating an efficient network Distribution Network Operators need to maximise the use of existing assets. This forms a key part of our Innovation strategy for RIIO ED1.

Electricity North West has proposed that approximately 50% of the 132kV and 33kV transformers that traditionally would have been due for renewal in the RIIO-ED1 period will now be refurbished and the oil regenerated to improve the Health Indices.

These targeted transformers will be operating beyond their original design life and under a first Tier funded project Electricity North West installed online Dissolved Gas Analysis and Partial Discharge condition monitoring on six transformers to monitor their condition and assess their actual condition compared to academic research.

This approach also aims to extend the life span of the transformers at or near their original design life thus deferring their replacement and/or also avoiding de-rating based on age.

There is now a need for data visualisation of the results as well as further research into validating and calibrating the data from the installed on-line condition monitoring research into exploring the optimum life of a transformer.

The project will use the online DGA and PD monitoring equipment already installed under First Tier funding to further monitor the condition of the six 132kV transformers. This data will allow further academic research to develop an understanding of the effects of life extension on failure modes and maintenance requirements of assets. The actual data will calibrate the theoretical research data to prove that oil regeneration life extension is a safe, reliable and cost-effective asset management technique.

The combination of these techniques would represent a holistic interpretation of transformer condition in near real-time and investigate the optimum life of a transformer which would be able to be utilised in future asset management strategies.

3 PROJECT SCOPE

Previous research carried out under an Innovation Funding Incentive (IFI) project defined an oil regeneration window for transformers at or near the end of their design life which would

extend it by approximately ten years. The First Tier Low Carbon Networks Fund (LCN Fund) project deployed online monitoring equipment at six sites where the oil regeneration technique will be used.

This Network Innovation Allowance (NIA) version of the First Tier project will validate the data from the monitoring equipment and use it to calibrate the previous IFI research. These results will then be fed into data visualisation software that has been developed to allow consistent comparison.

Electricity North West will work closely with an academic resource to validate the data and calibrate the life extension results once sufficient online data has been recorded for a significant time period to allow the results to be reliable and consistent.

4 OBJECTIVES

This project is split into two distinct phases:

Phase 1: the development of a dashboard/decision tool to be used by Electricity North West. This phase was completed by April 2016.

Phase 2: the data validation of existing research into transformer life extension by oil regeneration. This phase was due to be completed by September 2017 but has been extended to allow for further chemical ageing and degradation processes to occur and to be validated against the research results.

5 SUCCESS CRITERIA

- Completion of a dashboard and decision tool utilising the online results
- Validation and calibration of the actual end of life oil regeneration results against predicted values derived from academic research.

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

The project leveraged equipment and learning from the initial First Tier project to monitor transformers following oil regeneration.

Online monitoring to carry out DGA, and moisture content analysis, based on Photo-Acoustic Spectroscopy (PAS) was installed. The online monitoring was supported by lab analysed oil samples taken from site.

The data from the online monitors was collected and analysed by our project partner, Camlin and validated using the lab analysed oil samples. The analysis allowed us to ensure that the condition benefit gained from the oil regeneration remained and to confirm the prediction of ten year life extension made in the IFI project.

The multiple data points collected were grouped and combined into a series a key indicator and ultimately down to a single index. The indices were then colour coded into 5 classifications based on CIGRE Technical Brochure TB 227.

To enable better understanding of the results Camlim developed a dashboard/ decision tool including a reporting function that generates and emails monthly and annual reports to key stakeholders within ENWL.

This project was originally planned to last three years. However, we decided to extend the monitoring period to further improve the analysis and to enable our NIA project “Optimising Oil Regeneration for Transformers” to provide additional transformer monitoring following oil regeneration giving more opportunities to enhance systems and learning.

ENWL therefore believe the project has met its aims, objectives, and success criteria.

7 THE OUTCOME OF THE PROJECT

Analysis of the data collected during the project has confirmed that by carrying out oil regeneration towards the end of a transformer’s design life it can be extended by approximately ten years.

The project has developed the processes to collect and analyse transformer oil and then provide the outputs in a dashboard/decision/reporting tool which can be used by all relevant internal stakeholders to inform future investment decisions.

The dashboard/decision/reporting tool has been made available and was used as part of our NIA project “Optimising Oil Regeneration for Transformers” which investigated when, during an asset’s life, is the optimal time for oil regeneration.

Building on the lessons learned from the project, ENWL have made improvements to our oil sampling and oil regeneration processes.

All of the transformers which have undergone oil regeneration are still in service and we are continuing to monitor these assets to confirm the life extension.

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

The project was originally planned to last three years. However, we decided to extend the monitoring period to further improve the analysis and to enable our NIA project “Optimising Oil Regeneration for Transformers” to provide additional transformer monitoring following oil regeneration giving more opportunities to enhance systems and learning.

9 LESSONS LEARNED FOR FUTURE PROJECTS

With projects that generate significant learning that can continually be feedback to further enhance the learning, there is the potential to continually extend the project. With this project ENWL are satisfied that the project has improved the systems developed and more robustly justified the extension of transformer asset lives.

When a project runs for a longer period, project members and the experience they bring will change. The risks to the outcomes of the project need to be carefully managed.

10 PLANNED IMPLEMENTATION

In our RIIO-ED2 business plan, ENWL have committed to the continued use of oil regeneration and enhanced monitoring to benefit from the life extension it provides and optimise our investment plans.

We will continue to identify additional enhancements in monitoring techniques and analysis continue and implement then where cost effective to do so.

11 DATA ACCESS

The data gathered as part of this project is applicable to specific ENWL assets and is of limited value to external stakeholders. The data could be made available on request in line with our [innovation data sharing policy](#) which can be found on our website.

12 FOREGROUND IPR

There is no foreground IPR associated with this project.

13 FACILITATE REPLICATION

All learning from this project is published on ENWL's website and will be shared on the Smarter Networks Portal to ensure that other network operators can build on the project work or consider it for their business practices. We have held network operator dissemination sessions on oil regeneration as part of the previous innovation projects and the output of this project provides more detail on when this should be carried out.

14 OTHER COMMENTS

None.