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NIA ENWL015
Tap Changer 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	27/07/23
Geraldine Paterson	Innovation Manager	27/07/23

APPROVAL

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

CONTENTS

GLOSSARY

Term	Description
TEM	Thermo-Electro-Mechanical (indices)
VA	Vibro-Acoustic (indices)

1 EXECUTIVE SUMMARY

1.1 Aims

This project builds on previous innovation work at ENWL investigating tap changer monitoring that had identified further investigation was required to develop a robust technique for future use.

This project therefore aimed to develop a retrofittable tap changer monitoring system, install the system across 40 ENWL sites, collect and analyse the data from those sites and identify "trigger points" that would initiate ENWL actions, e.g., equipment investigation, pre fault repair.

1.2 Methodology

Working with our project partner, Camlin Power, a system was developed by December 2016 and installed across 40 sites by August 2018. Data from these sites continued to be collected and analysed till the end of the project.

The data collected included traditional electrical and innovative mechanical (vibration) information. These inputs where collated into two key indices Standard Thermo-Electro-Mechanical [TEM] and New Vibro-Acoustic [VA] indices.

The data was compared across transformer pairs at the same site and similar tap changer equipment across multiple sites.

A portfolio of period reports where created (daily to quarterly) where performance of the tap changers would be reported. Reports covered both individual units, and the project fleet. Anomaly reports where also created, these were created when the analysis identified an anomalous state suitable for further investigation.

Identified variances were then investigated by ENWL staff. Any equipment faults were retrospectively analysed to see if this could have been predicted. The learning from these investigations further informed the analysis algorithms.

1.3 Outcomes

The project met all objectives and success criteria. It provided a robust monitoring system across several sites and has been shown to be able to predict a number a developing issues within the tap changer portfolio it was monitoring

1.4 Key learning

The project has identified further areas for continued development including:

- Refining predictions by continuing data collection of exiting installations.
- Installing additional sensor technologies to broaden the input data for analysis.
- Simplification of monitoring equipment and embedding with other technologies (oil sampling) to reduce costs for a broader roll out of a monitoring system across ENWL.

1.5 Conclusions

The project has proved that is technically possible to produce a robust system of tap changer monitoring that can predict potential tap changer issues developing and allow pre-emptive measures to be taken.

ENWL are reviewing the outputs from the project and considering whether the simplified solution is at a sufficient technology readiness level to transition to business-as-usual deployment.

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	Optimising Oil Regeneration
Project reference	NIA_ENWL0015
Funding licensee(s)	Electricity North West Limited
Project start date	February 2016
Project duration	6 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 Electricity North West's Innovation strategy for RIIO ED1.

The industry has identified that there is a lack of any accurate online monitoring of tap changer condition to identify when intervention is required for repair, maintenance or replacement.

The development of a leading indicator of asset condition aims to minimise the number of tap changer failures that the industry has seen over recent years by identifying early warning indicators allowing proactive intervention.

The project will develop, bring to pre-production, and ultimately trial, a tap changer condition monitoring system. Other Tap changer monitoring techniques will also be explored.

The project will carry out field trials to identify the optimum point at which Tap changer monitoring is required in the life cycle of a transformer. To ensure a representative sample of the transformer population is analysed, a varying number of tap changer types with different manufacturing periods, designs and operating environments will be selected. Tap changers of the same type/model will have monitoring installed at varying ages of their lifecycle to allow comparison.

There is a need to identify and develop intervention and investigation trigger points through data visualisation which will feed into the future asset management strategies.

3 PROJECT SCOPE

Following previous research into tap changer monitoring carried out under an Innovation Funding Incentive project, it has been determined that the technique utilised was not sufficiently robust and that further monitoring is required. Therefore, we will work closely with Camlin Power to develop and produce a retrofittable tap changer monitoring system to accurately monitor the tap changer performance and consequently determine the intervention/trigger points.

For this project it was proposed to install the system on 10 x 132kV tap changers and 30 x 33kV tap changers and monitor and analyse the tap changer performance over a 24-month period to allow seasonal changes to be considered.

The project will allow Electricity North West to develop its understanding of the effects of tap changer failure modes and maintenance requirements and to identify the optimum window for monitoring in the life cycle of tap changers.

4 OBJECTIVES

This project is split into four distinct phases:

- Phase 1 is to develop a retrofittable tap changer monitoring system. This phase was completed in December 2016.
- Phase 2 is the onsite installation of 40 monitoring systems. This phase was completed by August 2018.
- Phase 3 is the continuous data analysis and visualisation of the tap changer condition. This phase to be completed by August 2021
- Phase 4 is the implementation of identified trigger points into company policy and procedures. This phase to be completed by February 2022

5 SUCCESS CRITERIA

- Production and trial of a condition monitor for tap changers.

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

The project has mostly delivered its original project aims, objectives and success criteria Trigger points to drive maintenance or replacement have been identified but are not yet fully embedded into policy and we are developing the business as usual specification for the monitoring system.

The project was extended by one year to allow further data to be collected. This additional data improved the quality of the analysis undertaken and allowed for any additional events to occur within the monitored population to confirm the project outputs against real world events

By the end of the project the volume of data collected has filled the storage and analysis system built for the project. Data collection and analysis has now ceased.

7 THE OUTCOME OF THE PROJECT

The project has developed a retrofittable tap changer monitoring system and deployed it on 40 tap changers. The data from the system was collected and analysed.

Analysis has shown that issues with tap changers have been / could have been predicted. The analysis also provided trigger points for ENWL to consider embedding into policy, and provided confidence to the outcomes of existing policy.

The device techniques deployed include both electrical and mechanical (vibration) monitoring which when coupled together can identify several trends and incidents occurring within the tap changer.

The analytics developed for the project have been refined and adapted as the project learning has increased, and as specific tap changer events have occurred.

Towards the end of the project several of the monitored tap changer's AVC schemes were adapted for inclusion in the CLASS service. The analysis of data collected on these tap changers showed no variance in condition between CLASS and non-CLASS units.

The project has also identified a road map towards a business as usual system. The project learning showed that the type, quality and number of data points and the associated monitoring devices can be modified without impacting system accuracy. This will allow a simpler roll out of the technology across the ENWL fleet of transformers.

ENWL are considering the next steps to full adoption of this methodology

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

No modifications to the planned approach were made during the project, except the opportunity was taken to extend and continue active data collection and analysis, which is continuing to inform future developments.

9 LESSONS LEARNED FOR FUTURE PROJECTS

As a general lesson relating to projects collecting new data for analysis there needs to be a recognition that as you increase the volume of data collected and analysed the amount of learning increases. This is because the analysis techniques can be refined and improved resulting in further additional learning. The optimum point for this learning curve can only be estimated at project initiation and some flexibility is required based on the rate of progress being made.

On this project ENWL and our partners believe the additional analysis performed has been beneficial.

Whilst not project specific, the tracking of transformer tap position on certain unit types had occasional issues. This was due to the quality and compatibility of the mechanical contact arrangement within the historic tap changers with the electronic control equipment being fitted as part of modern tap change control systems.

10 PLANNED IMPLEMENTATION

The monitoring system developed for this project was suitable for development of the analysis algorithms but is overcomplicated for a business as usual solution.

The learning showed that the accuracy and frequency of data from the on-site devices used in the project is not required for a business as usual system, and hence savings could be made in future systems.

ENWL is considering if the technology used in this project, and the suggested enhancements is at a suitable maturity, and will be cost effective to adopt across a larger proportion of the tap changer fleet.

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.

14 OTHER COMMENTS

None.