NIA ENWL023
Intelligent Network Meshing Switch

Closedown Report

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VERSION HISTORY

Version	Date	Author	Status	Comments
V1.0	20/07/21	Ben Ingham	Issued for Comment	

REVIEW

Name	Role	Date
Lucy Eyquem	Innovation PMO Manager	22.07.21
Dan Randles	Head of Innovation	26.07.21

APPROVAL

Name	Role	Date
Steve Cox	Engineering & Technical Director	28.07.21

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GLOSSARY

Term	Description
GSM	Global System for Mobile Communications
INMS	Intelligent Network Meshing Switch
LV	Low Voltage
NMS	Network Management System
PLC	Power Line Carrier
UDB	Underground Distribution Box

1 EXECUTIVE SUMMARY

This project built on the learning from the use of the Lynx devices on the Smart Street project, and the experience of low voltage meshing in link boxes from other innovation projects, and sought to further improve the devices used so they could be applied more universally. Over the course of the project, which was extended by 12 months, a significant amount of learning was generated though the testing of the devices. This has allowed the further development of the device into a commercially available product which will be deployed on the ENWL network.

2 PROJECT FUNDAMENTALS

Title	Intelligent Network Meshing Switch
Project reference	NIA_ENWL023
Funding licensee(s)	Electricity North West Limited
Project start date	April 2019
Project duration	2 years
Nominated project contact(s)	Ben Ingham (Innovation@enwl.co.uk)

3 PROJECT BACKGROUND

Existing DNO networks are not designed to cope with the highly variable power flows that will be caused by the introduction of LCTs, such as vehicle charging and generation. Interconnection of LV networks is one of the means by which voltage, thermal and harmonic problems created by LCT loads and generation connected to LV networks can be significantly reduced.

The Smart Street and FUN-LV projects proved that dynamic meshing offers considerable benefit in managing these power flows and successfully trialled retro-fit devices installed in link boxes to remotely mesh the network when required.

The projects trialled different devices which are proven technology and suitable to be deployed on 80% of the low voltage network. However, some technical issues have been identified that require additional research to resolve to ensure the solution can be applied to 100% of sites. The issues currently restricting a GB wide BAU deployment in all areas of the network are:

- Condensation
- Communications
- Water ingress
- Heat dissipation

4 PROJECT SCOPE

This project looked to further develop and improve the link box meshing device to allow for deployment in all locations and environments. As part of the project the improved design was to be trialled in a number of scenarios to demonstrate the benefits of the enhancements made. These scenarios were selected to cover the full range of environmental issues and location types identified.

5 OBJECTIVES

A staged approach was proposed to produce a final device that is suitable for installation network wide. The three stages can be summarised as follows:

Stage 1
Improve the existing devices to make the device smaller with an improved water ingress IP rating. Investigate and select communication protocols that will provide maximum connection time to the installed device. Multiple protocols may be required to cover all location types.

Stage 2
Simulate the typical heat and humidity extremes observed in a link box with the device fitted. Investigate solutions and trial in a test environment. Develop a power supply and electronic design that will reduce overall heating and trial in a test environment.

Stage 3
Complete type testing and install a number of devices for live field testing. Evaluate live trial results.

6 SUCCESS CRITERIA

The following criteria will be used to determine if the project has been successful:

- Link box meshing devices show no signs of condensation during the trial period
- Link box meshing devices show no signs of water ingress during the trial period
- Link box meshing devices show high level of communication availability during the trial period

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

Supplementary document ‘Intelligent Network Mesh Switch Technical Report’, Kelvatek document number 19-1020-01 describes the design, testing and performance of the individual areas of the project in detail. The overall findings are summarised in this report

Stage 1 - Work for stage 1 concentrated on review of the LYNX device that was used on the Smart Street project. Following a detailed review of the LYNX set up the team elected to pursue a major conceptual redesign away from existing UDB switching technology in order to address the issues around heat dissipation/build up, and an improved water ingress IP protection rating. These changes are described in detail in the attached technical report, but they included separating and sealing the electronics and a redesign of the neutral connection to allow it to act as a heat sink as well.

A number of communications protocols were investigated in depth, including a new concept for GSM antenna installation, use of roaming SIM cards to be able to connect to the highest power GSM provider rather than a fixed GSM service provider, as well as Power Line Carrier (PLC) technology.

If no or limited GSM coverage is available, PLC becomes a reduced functionality (lower bandwidth) alternative. This was tested on ENW's network, and the reduced bandwidth is evident, but is sufficient to enable basic switching control operation and voltage and current monitoring features.

GSM, as a higher bandwidth technology is preferred, and testing was carried out on antenna integration into the new ventilated UDB access cover. Results from the field show that this approach will work in a majority of installations.

Stage 2 – Prior experience in Smart Street showed that good thermal management could prove critical in this application. Getting heat out of the underground cavity was key to the design from the outset, and improved heat management techniques concentrated on ventilation and maximising the use of that ventilation. Advanced computer simulation was used to test candidate concepts, followed by prototype testing on the Kelvatek LV test network in Lisburn, Northern Ireland.

The final design used a newly installed ventilated pavement level cover, with associated frame that needs to be installed into the road level. This cover supports heat exchange with the outside environment, and prevents excessive temperature rise in the UDB cavity itself. The design was optimised using the simulation data along with new heatsink designs to provide a decrease in the rise-over-ambient temperature in the region of 25 %. Work was undertaken to re-distribute power across the entire system to further assist with thermal management.

Stage 3 – Comprehensive testing was carried out on the new design – Physical design tests check the fit to the UDB and how that design assisted in thermal management, testing of the ventilated access cover and the overall system architecture. Additional information can be found in the technical report 19-1020-01.

8 THE OUTCOME OF THE PROJECT

The outcome from this project has produced a completely new paradigm in UDB switching and Intelligent Network Meshing, and will facilitate in the delivery of LV network automation projects and roll outs involving aspects of network meshing and automation. It is expected that this will be taken up by a number, if not all, of the UK DNO's.

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

The major areas of investigation in the project did not change, as they were well established at project specification stage from prior experience gained during the successful Smart Street demonstration project, and the challenges that would be faced in this project were relatively well understood from the outset.

10 PROJECT COSTS

Item	Category	Estimated costs (£k)	Final costs £k (rounded)	Variance
1	Project Management	480,450	64,106	416,344
2	Research and Development	1,389,550	1,389,550	0
	Total	**1,870,000**	**1,453,656**	**416,344**

As the project progressed and confidence in the approach being taken by the project partner was gained the amount of supervision on the development phase was reduced. In addition the level of testing, and the variety of environmental conditions that could be applied at the partners test centre meant that it was possible to reduce the amount of field testing leading to further efficiencies on the project management side.

11 LESSONS LEARNED FOR FUTURE PROJECTS

The LV Underground Distribution Box is a harsh and challenging environment. As the technology for this area of the LV network automation is in a relative infancy compared to say the 20+ year experience with LV fuse way automation, there are still approaches to be investigated in the future. As the technology matures and the lifetime of devices and associated control electronics are better understood and very reliable, then consideration should be given to complete sealed and buried LV automation, monitoring and switching equipment. Without years of reliability data, currently this approach is considered risky as it would require excavation if repair or maintenance were ever needed.

12 PLANNED IMPLEMENTATION

Implementation of the project outcomes will see many new INMS units being installed on Electricity North West's network from 2022 onwards, and Kelvatek will actively discuss with other DNO's the application of this technology to their networks and projects that actively manage the interconnection of LV networks.

13 DATA ACCESS

Electricity North West's innovation data sharing policy can be found on our website.

14 FOREGROUND IPR

The default IPR position has been applied to this project, and there has been no relevant foreground IPR registered as part of this project.

15 FACILITATE REPLICATION

The INMS switch device with new thermal management design and associated replacement UDB cover and pavement level frame, with integrated antenna, is fully developed. Further work on the implementation of communications architecture for use with various NMS systems may be required for each individual application of the technology.

16 OTHER COMMENTS