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NIA ENWL011
Enhanced Voltage Control

Progress Report

31 July 2018

VERSION HISTORY

Version	Date	Author	Status	Comments
V1.0	10 May 2018	Geraldine Paterson Innovation Engineer	Final	

REVIEW

Name	Role	Date
Lucy Eyquem	Innovation PMO Manager	3 July 2018
Paul Turner	Innovation Manager	25 July 2018

APPROVAL

Name	Role	Date
Steve Cox	Engineering & Technical Director	31 July 2018

CONTENTS

GLOSSARY

Term	Description
AVC	Automatic voltage control
CLASS	Customer Load Active System Services
GB	Great Britain
MVA	MegaVoltAmpere
MW	MegaWatt
LDC	Load drop compensation

1 PROJECT FUNDAMENTALS

Title	Enhanced Voltage Control
Project reference	NIA_ENWL011
Funding licensee(s)	Electricity North West Limited
Project start date	November 2015
Project duration	3 years
Nominated project contact(s)	Geraldine Paterson (innovation@enwl.co.uk)

2 PROJECT SCOPE

This project will define the technical requirements to allow a GB rollout of the learning from the Second Tier Low Carbon Networks Fund project CLASS. The project will also provide new AVC settings for generator connections and investigate a technical solution to enable the offering of voltage managed connections for generators.

3 OBJECTIVES

The project has the following objectives:

- Devise appropriate technical solutions to meet the functional requirements for CLASS
- Trial technical solutions as necessary on the Electricity North West network
- Produce relevant documentation to allow future installations
- Devise new settings for generator connections
- Application of new settings at a number of primary substations on the Electricity North West network
- Develop a functional specification for a technical solution to enable the offering of voltage managed connections.

4 SUCCESS CRITERIA

- Successful trial of the business as usual technical solution for CLASS
- All relevant documents produced to allow purchase, installation and commissioning of the technical solution
- Settings devised for generator connections
- Successful trial of new settings for generator connections on a number of primary substations

- New voltage control policy incorporating the new settings
- New functional specification for a technical solution to enable the offering of voltage managed connections.

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

To optimise the operation of voltage control the project has been conducted in two stages:

- Offline simulation – using network models, appropriate simulation software, different scenarios, etc
- On load trial – where the operation of the voltage control is observed and evaluated.

The trial site is in Greater Manchester and has particular issues with achieving voltage control owing to the significant generation deployed downstream. The generation installed is 14MW of gas turbines and the transformers at the primary substation are rated at 10/14MVA. This generation runs all year round and either matches or exceeds the site demand for real power. Historically voltage control schemes have struggled with this because the net power flow measured at the transformer is at or about 0MW and the power factor constantly fluctuates due to reactive power flow. This site also has an open point which allows paralleling with an adjacent site.

During stage 1 an accurate model of the trial site was built and a number of simulations carried out to replicate different loading and generation conditions, taking into account:

- Variations in the load level
- Fixed load power factor
- Variations in the generation level
- Variations in the generation power factor.

The study gave an indication of the maximum and minimum voltage drop across feeders and the maximum voltage rise caused by generation and allowed the calculation of appropriate settings.

On site the relays will:

- Achieve smooth paralleling of the transformers
- Overcome the ‘voltage rise at the point of common coupling’ issue introduced by distributed generation
- Offset the voltage drop across the feeders
- Parallel adjacent substations successfully.

At the trial site Fundamentals SuperTAPP SG relays were commissioned and successfully allowed paralleling of the transformers which was an issue with older schemes. The relays minimised the circulating current between the two parallel transformers given the existing power factor swing conditions and the reverse power flow through the transformers.

Overcoming the voltage rise issue was achieved by measuring direct generation connections and estimating indirect generation connections to the substation busbars along with new

enhanced voltage control settings. Current transformers were installed on the generation feeders and these measurements fed into the SG relay. The relay was set up to use the additional current measurements taken from the feeders with generators and the generator bias (Gen Bias) function that the SuperTAPP SG relay is equipped with. The Gen Bias will drop down the busbar voltage, in proportion with the existing generation level, to overcome the voltage rise issue and maximise the voltage headroom.

Additionally voltages at all points remote to the substation will be maintained within statutory limits. To facilitate this, the load drop compensation (LDC) was used to offset the voltage drop across feeders. The LDC functionality will increase the voltage of the busbar in proportion to the true group load; this is a function of the current flowing through the transformers, direct generation connections and load estimation for indirect generation connections.

The settings for the trial site were calculated and tested using the simulation techniques. These settings were applied at site and have been monitored for the past 12 months. During this time measurements were taken both at the substation and remote points to ensure all voltages remain within statutory limits.

Unfortunately due to a tap changer fault that occurred during the trials T12 was unable to tap with T11 for full automatic voltage control operation meaning the performance cannot be fully evaluated and analysed. When the transformers are not on the same tap a circulating current voltage bias is introduced by the SuperTAPP SG relays to keep the two transformers from running away from each other. This means T11 only responds to its effective target by one or two taps before its target is restricted. However, it can be seen that, the voltage controller correctly prioritises minimising the circulating current (security of supply) rather than accommodating generation on the network.

The limited analysis has shown that the chosen settings are working very well including the interaction between the generator bias setting and the LDC. The voltage drop between the substation and the furthest point on the network (electrically) is 1.5% on average.

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

Following the registration of this project Electricity North West was encouraged by Ofgem and National Grid to progress the CLASS component of the enhanced voltage control to wide scale deployment as soon as possible. Rather than waiting on the results of this project a tender has been initiated using existing functionality developed as part of the Second Tier project, CLASS.

There have been some delays in installing the current transformers and applying the new settings. These delays were as a result of system constraints not allowing outages. There were also delays in producing the simulation models due to their complexity but they will not impact the overall delivery of the project.

An additional requirement was initially added to prove the ability to parallel adjacent substations. Site issues such as network or plant faults and planned replacement works have meant that this requirement was not fulfilled but it has not detracted from the learning of the project.

7 LESSONS LEARNED FOR FUTURE PROJECTS

This project has shown that the modelling and simulation stages can take more time then anticipated. The more accurate the model is, the more time the model needs to be constructed.

Online monitoring functionality has proved beneficial in determining the accuracy of the model and developing the settings. Monitoring equipment has been installed on the LV network at a remote point to collect voltage measurements and at the trial substation to monitor the performance of the SuperTAPP SG relays.

The substation monitoring provides 24/7 online monitoring facilities which allows oversight of the operation of the new equipment at all times. Additionally, the online monitoring equipment installed at the substation enables a view of historical trends of parameters such as busbar voltages, generator currents, load, etc. The historical trend can be used to develop more practical simulation scenarios and design the enhanced voltage control settings.

8 THE OUTCOME OF THE PROJECT

Not applicable.

9 DATA ACCESS

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

The voltages measured during this project can be made available to interested stakeholders on request.

10 FOREGROUND IPR

The process for calculating the settings for this project is currently being produced as part of a technical guide which will be made available with the project closedown report.

11 PLANNED IMPLEMENTATION

Not applicable.

12 OTHER COMMENTS

Not applicable.