Northern Ireland Electricity Networks

DEMAND REDUCTION THROUGH VOLTAGE CONTROL

Innovation Project

September 2020

Contents

1. Background

Growing demand, penetration of distributed generation *(DG)* and low carbon technologies *(LCTs)* present significant challenges to the Northern Ireland distribution network. The projected demand increase due to the electrification of heat and transport will require innovative solutions to reduce congestion on the network without requiring costly traditional network reinforcement.

The previous approach has been to reinforce the network, but this is costly and often takes a considerable amount of time. A low cost and quickly deployed alternative to traditional reinforcement is needed. Methods of voltage and demand management have the ability to actively manage the network voltage, unlocking network capacity to connect further demand. One such solution is through the integration of Conservation Voltage Reduction *(CVR)* to the distribution network.

CVR takes advantage of the relationship between voltage and demand of some load types and offers a technique to reduce power flows by lowering voltages. Currently NIE Networks do not operate any CVR so there is a need to investigate the integration and the extent of the benefits to the network and customers of using this technology.

2. Project Summary

NIE Networks Demand Reduction through Voltage Control *(DRVC)* innovation project seeks to demonstrate how innovative CVR methods applied to existing networks has the potential to manage voltages and reduce demand, and hence unlock network capacity and defer traditional reinforcements, ultimately putting downward pressure on customer bills.

DRVC is the name given to the integration of the CVR method in NIE Networks' distribution network. The DRVC project consists of actively reducing the voltage for customers within predefined limits to reduce demand, generally achieved by controlling the voltage at the primary substation. The concept behind DRVC is that a reduction in voltage will reduce customers' demand and hence can reduce a network's maximum loading. DRVC not only has the capability to support the local network but may also provide support to the global network in the form of frequency support.

The proposed integration project offers solutions to overcome the uncertainty and provide NIE Networks with a means of control in this area.

3. Objectives

3.1 **Justification**

To integrate DRVC onto NIE Networks' distribution network, the following points need to be addressed via demonstrating:

- DRVC reduces customer demand and in turn network peak demand;
- Customer savings through a reduction in customer bills;
- The technology required to implement the DRVC methodology can be integrated into existing systems to provide a range of demand change capabilities and voltage management services that offer savings to customers without compromising quality of supply;
- DRVC improves the utilisation of assets;
- DRVC does not compromise system reliability;
- The DRVC technique has no or minimal impact on customers.

3.2 **Key Objectives**

The DRVC project will aim to accomplish a number of key objectives:

- Integration of DRVC in the NIE Networks' system including monitoring to provide visibility of voltages within NIE Networks' LV networks.
- Understanding of the relationship between voltage and demand to predict the demand reduction for consideration of system loading.
- Assess the potential to play in the DS3 System Services market by using voltage control in response to a frequency event and tap stagger to manage reactive power flow.
- Assess the impact to customers and quantify energy savings.
- Quantify the ratio of load types on the network.

4. Project Technique

11kV networks have limited voltage controllability. Voltage at this level is controlled from the primary substation using Automatic Voltage Control *(AVC)* relays that control the transformer On Load Tap Changers *(OLTCs)* to maintain the voltage at a particular target value. Along with appropriate network design, this target voltage is set to ensure that the LV network voltage is kept within the statutory limits as stated in the Electricity, Safety, Quality and Continuity Regulations *(ESQCRs)*, which specify an allowable LV voltage of 230V +10%, -6%.

The integration of the DRVC method consists of actively reducing the voltage for customers within predefined limits to reduce demand, achieved by controlling the voltage at the primary substation. The concept behind the DRVC technique is that a reduction in voltage will reduce customers' demand, and hence can reduce a network's maximum loading.

As well as investigating the potential to reduce network demand, the DRVC project will also investigate the potential for voltage management and frequency response using the following methods:

- Changing the voltage set point in response to a frequency event.
- Stagger the transfer taps at dual transformer primary substations to induce circulating currents and hence reactive power.

The effectiveness of DRVC is dependent on the mix of load types in the network in which the technique is used. For shunt impedance and constant current loads, their power reduces when the voltage is reduced; However for other loads, such as motors, that consume constant power, they do not exhibit the reduction in power as voltage is reduced. Therefore, load type will be considered through site selection and analysis of results.

How the voltage set point of the primary substation can be reduced to manage demand and the impact on demand will be analysed. This process will be automated using the measurements of the network and the appropriate commands will be sent to the AVC which controls the OLTCs of the transformers at the primary substation. The system shall ensure that voltages throughout the network are kept within statutory limits. This will require monitoring at locations on the network which represent the worst voltage conditions, potentially at the end of radial feeders at the point of the highest estimated voltage drop.

The project will include developing the methodology for the optimal substation target voltage calculation, as well as a methodology for analysing the system performance and calculating the demand reduction achieved via DRVC. It is expected that reducing the voltage will reduce demand, and the technique will aim to demonstrate that the relationship between the voltage and the demand can be quantified to achieve a forecasted reduction in peak demand.

Trialling periods shall be selected to allow for comparison of results between network operation with and without the DRVC. For instance, the system shall be operated with alternating combinations of days or weeks off and on. This allows monitoring of the impact on customers by reporting of any complaints received. Therefore it is deemed appropriate to avoid a constant pattern of trialling periods throughout the trial in order to ensure that genuine complaints reflecting the impact of trial techniques can be observed.

Success of the DRVC methods through the project will support the development of a DRVC system for BaU, capable of computing optimal voltage set-points for the AVC relays with an algorithm flexible enough for changes in network connections and ability to operate without regular intervention of a control engineer. The BaU system would be centrally managed by NIE Networks' control centre by integrating the system into NIE Networks' Network Management System *(NMS)*.

5. Method

The DRVC project aims to address the identified problems by focusing on lessons learnt from previous innovation projects and their transition into BaU. The project involves a number of key tasks, including both technical and customer based activities. These key tasks are detailed below.

5.1 Technology Assessment

An assessment of the available off the shelf equipment, including the DRVC system, monitors for LV circuits, AVC relay, control and communication system and frequency response control, will be conducted as part of the DRVC project. This will include analysis of potential systems; cost, operation, design life, protection and maintenance. Advantages and disadvantages for each device will assist a recommendation on the most suitable to this project and recommendations on site selection.

Research and gathering of lessons learned from previous or on-going projects using the method of CVR or similar methods to reducing voltage to reduce demand will be carried out. Some projects have presented solutions actively controlling the voltage whereas others have passively changed the voltage and analysed the results, any key findings will feed into the procurement specification and site selection.

A risk assessment for the DRVC system will also be completed at this stage, assessing the risk of voltage run off leading to damage to customer equipment or fatalities.

5.2 Site Selection

NIE Networks will complete preliminary site selection, identifying those with suitable loading and a variety of customer types. Preliminary circuits will be modelled to identify any voltage, power flow, fault level or protection issues as a result of integrating the DRVC system. Circuits which experience any of these issues will be discounted. Site selection shall also identify current or expected voltage constrained points, what impacts on the network the DRVC system may have and any practical limitations.

It is expected that urban areas will be identified as suitable locations for voltage reduction since they are likely to exhibit substation overloads without suffering from the same observed voltage issues most likely on long radial circuits in rural settings. However, the tap stagger functionality may be trialled in a more rural context.

The DRVC system will be trialled at 5 primary substations, however there is scope for this number to rise.

5.3 System Procurement

The procurement of the equipment will follow a tendering process with both technical and functional specifications developed for the DRVC system and any required software, data systems, communication systems and interfaces. The procurement specification will be developed in conjunction with the modelling outputs to determine the theoretical limitations of the equipment for a particular location.

A contingency plan will also be developed for returning to conventional operation and a failsafe mechanism will be established to prevent voltage run off. The specification will include staff training on the installation, operation and maintenance of the equipment.

An evaluation of the technical proposals against the technical requirements together with the commercial evaluation will identify the most appropriate and cost-effective solution. Once the preferred suitable supplier is selected, procurement of the relevant DRVC equipment, monitoring and control equipment including IT and communication equipment and software can be completed.

5.4 Installation

Prior to delivery and installation, Factory Acceptance Tests *(FATs)* of DRVC equipment will be conducted in an environment that replicates the network conditions in which the equipment will be installed.

Communications will be established for the DRVC system as required, including all monitoring equipment for enhanced visualisation of network parameters for analysis. All systems will be commissioned and Site Acceptance Tests *(SATs)* will be carried out. Tests will confirm that the system performance meets the requirements and the technical specifications.

5.5 Trial

NIE Networks will develop a testing schedule for the trial to ensure all possible outcomes are tested, in line with current standards. Live trials of the DRVC system will be run to test operation and performance. The learning outcomes will be used to create the specifications, settings and configuration parameters required to optimise the operation of the distribution networks to be implemented as BaU.

The trialling periods will be selected to allow for comparison of results between network operation with and without the DRVC system. This will also allow monitoring of the impact on customers by reporting of any complaints received, which will form part of the customer experience analysis.

5.6 Analysis of Results

The results for this trial will be monitored continuously by NIE Networks for the duration of the trial which is expected to begin in June 2021 and last for at least one year. This is an indicative start date and could change depending on procurement timelines.

Data for all relevant parameters will be gathered from the DRVC monitoring equipment and analysed to demonstrate that:

- DRVC reduces customer demand and in turn network peak demand and customer bills;
- he technology required to implement the DRVC methodology can be integrated into existing systems to provide a range of demand change capabilities and voltage management services that offer savings to customers without compromising quality of supply;
- The proposed DRVC improved the utilisation of assets;
- System reliability is maintained;
- The technique has no or minimal impact on customers.

When the trial is complete, a detailed assessment on the ability of DRVC for CAPEX deferral and to offer system services will be conducted. The assessment shall also take account of the impact on quality of supply, losses, the effect on existing plant and ratio of load types on the network which will feed into the cost benefit analysis *(CBA)*. The CBA will be completed for a single installation of DRVC and for the roll out to business as usual.

5.7 Customer Experience

Reducing the voltage will directly impact customer loads and although impacts are expected to be small it is possible that these effects are noticed by customers. In order to demonstrate the impact that this technique has on the affected customers it is necessary to know their prior assessment of the quality of their supply. An initial customer survey will be conducted with all customers potentially affected and results documented.

Understanding the impact of deploying DRVC on quality of supply is important to determine the effect on customer experience. Following on from the initial customer survey, a survey is required of all customers affected during and on completion of the trial, monitoring voltages and complaints. The level and type of customer engagement will be decided after the site selection phase.

5.8 Transition to Business as Usual

Provided the trial is successful and the CBA is in favour of DRVC, NIE Networks will roll out into BaU. This will include updating policies and specifications and training and support of staff.

A close down report at the end of the trial will encompass all project work, analysis of results, impact on losses and quality of supply, customer feedback, CBAs and recommendations for BaU deployment; circuit selections criteria, effect on asset life etc.

NIE Networks will facilitate the dissemination of project learning with up to 3 dissemination events. NIE Networks will host these events and will include a presentation of the project conclusions and engage with stakeholders in discussion, answering any questions.

The transition to BaU comprises of three key tasks:

- Making a fully justified business case in order to demonstrate the benefits of the DRVC project and the knowledge that stemmed from the integration project.
- Preparing the necessary documentation that would cover planning and operation policies and the specifications of the DRVC system.

- Determine the ownership of the DRVC system within NIE Networks and provide NIE Networks' staff with appropriate and sufficient training and support.

6. Project Timeline

Q2 2020	Q2 2021	Q1 2023
START DATE	TRIAL START	EXPECTED COMPLETION