SP ENERGY NETWORKS

Flexible Networks for a Low Carbon Future

Methodology & Learning Report

Part of Work Package 2.3: Voltage Optimisation Methodology

September 2015

Contents

Executive Summary

Background

SP Energy Networks under a Tier 2 Low Carbon Network (LCN) Fund project, "Flexible Networks for a Low Carbon Future", investigated solutions to increase network capacity, required to connect and manage increasing levels of future demand and generation.

This reports presents the work carried out and outcomes of the voltage optimisation exercise. Voltage optimisation is considered to be one of the new tools available in the "Flexible Networks" toolbox to release network capacity in place of conventional network reinforcement.

Aims and Objectives

The key aims and objectives of the voltage optimisation activity were as follows:

- To create additional network capacity for the connection of embedded generation
- To improve the energy efficiency of our customers

Outcomes of the Voltage Optimisation

The primary network voltage at the Ruabon trial site was reduced and the effect on HV and LV network currents and voltages was observed using the extensive secondary substation monitoring system installed as part of the Flexible Networks project.

Learning Derived from the Methods

- Reduction of the network nominal voltage is the most cost effective method to accommodate increasing levels of embedded generation on the LV distribution network
- Reduction of the primary substation set point voltage is a more cost-effective and flexible method to reduce LV network voltages than changing the off-line tap settings of secondary transformers
- A reduction in voltage will generally result in a reduction in active power demand. This reduction will be larger over the short term than in the long term and the reduction achieved will depend on the types of load present, and therefore:
    - can vary between different parts of the distribution network
    - can vary between different seasons, and different times of day
    - can vary according to the ambient temperature
- Reactive power demand will generally be reduced by a larger factor than active power demand
- In the absence of local knowledge or experimental results, a reduction of 1% in active power demand in response to a 1% voltage reduction is a reasonable estimate
- The above reduction in power does reflect a direct energy saving for customers, where a 1% reduction in voltage can typically lead to a 1% reduction in energy consumption.
- A network voltage reduction does not generally seem to reduce the network current in the longer term. Therefore network copper losses (i.e. I2R losses in transformers, cables and overhead lines) are not reduced by reducing the network nominal volts.

Learning Derived from the Methods [continued]

- A number of customers whose supply voltage is in the lower range of the voltage limits band are likely to be affected whenever changes are made to nominal network operating parameters – and this needs to be understood and managed. But this does not outweigh the overall benefits to customers of a general voltage reduction.
- Any new network voltage control strategy should not simply be a new (lower) set point voltage. Additional flexibility (such as the ability to apply seasonal settings) may be necessary in the future. This will lead to a requirement for additional network monitoring (including future Smart Meters) as well as greater network active management and control, such as remotely settable voltage control relays at primary substations.
- The Grid Code requirement to provide voltage reduction as a means to achieve rapid load reduction should be reviewed, given that it is less effective than it used to be. An alternative could be for National Grid to procure instantaneous load reduction directly from DNOs (as part of a developing DSO model) as a network anciliary service.

Further Development

In order to fully adopt voltage optimisation into business as usual, the following developments have been identified:

Updating policy documents: The existing technical manuals and policy documents need to be updated to incorporate the application of voltage optimisation into network planning and operations codes of practice.

Updating voltage control relays: A large number of voltage control relays at primary and grid substations are still of the electro-mechanical type. Whilst robust and reliable, and with a long service life, the design of these types of relays pre-date the existence of SCADA systems and are not capable of remote control of target voltage. Modern electronic voltage control relays offer far greater functionality and flexibility, including the ability to remotely configure the relay settings. Significant volumes of electro-mechanical voltage control relays are currently being replaced by electronic relays anyway, based on traditional asset condition criteria. But, given the additional functionality of modern relays, there is a potential business case for accelerating and extending this asset replacement programme.

1 Introduction

This report presents the work carried out for the voltage optimisation exercise, which was carried out as one of the activities of the Flexible Networks project. It provides a summary of the outcomes and lesson learnt from this activity.

One of the objectives of the Flexible Networks project was to explore the ability of a DNO to reduce peak demand through better voltage management. In addition to the reduction in peak demand, voltage optimisation can also facilitate the greater uptake of embedded generation. The business & economic case for better management of network voltages was assessed through a network voltage reduction trial, which was undertaken at Ruabon. This trial site has extensive secondary substation monitoring installed, enabling more detailed observation of the impact of changes to network operational settings, such as primary voltage control relay set point voltage.

2 Background

The UK low voltage limits were partially harmonised with European voltage limits in 1990, when the 240V +/-6% & 230V +/-6% voltage limits were harmonised to 230V +10/-6%. In practice, no physical changes were generally made to actual voltage settings, as the old limits were largely captured within the range of the new. The European voltage limits are actually 230V +/-10%. Given that most UK domestic appliances have been manufactured to operate within the European voltage limits since 1990, it is probably time for the UK to consider the full adoption of the European voltage range of 230V +/- 10% and for DNOs to make appropriate changes to our voltage control policies and settings.

We consider that overall system headroom for generation could be increased through better optimisation of voltage set points and permissible voltage range. Whilst direct consideration of the adoption of European voltage limits is outside the scope of this work, it is hoped that our work will help to inform any changes considered appropriate should the European voltage limits be adopted in the UK in the future.

3 Details of the work carried out

This section presents details of the work carried out to implement the voltage optimisation trial.

3.1 Methodology for Selecting the Voltage Optimisation

Historically, it was assumed in the UK that a 3% reduction in voltage would reduce demand for electricity (at least in the short term) by 5%. Recent observations of the behaviour of load in response to changes in network voltage, and knowledge of the changing mixture of loads (for example, the growth in electronic equipment) have led this assumption to be questioned. The purpose of this trial was to carry out a voltage reduction exercise on a discrete section of HV network and observe the effect on network demand. Of the three Flexible Networks trial sites (St Andrews, Whitchurch, Ruabon), the Ruabon HV network was chosen for the voltage reduction trial as it was the trial area with the highest penetration of domestic PV installations and as such provide the double benefit of being able to observe both the peak load reduction and the generation headroom enhancement.

3.2 Voltage Optimisation Trial Site at Ruabon

The geographical layout of the Ruabon Network is shown in Figure 1. Detailed monitoring was installed at the Ruabon Secondary substation, along with Smart meters (recording voltage only) at the seven strategic locations shown on the map. This network contains approximately 320kW of PV generation.

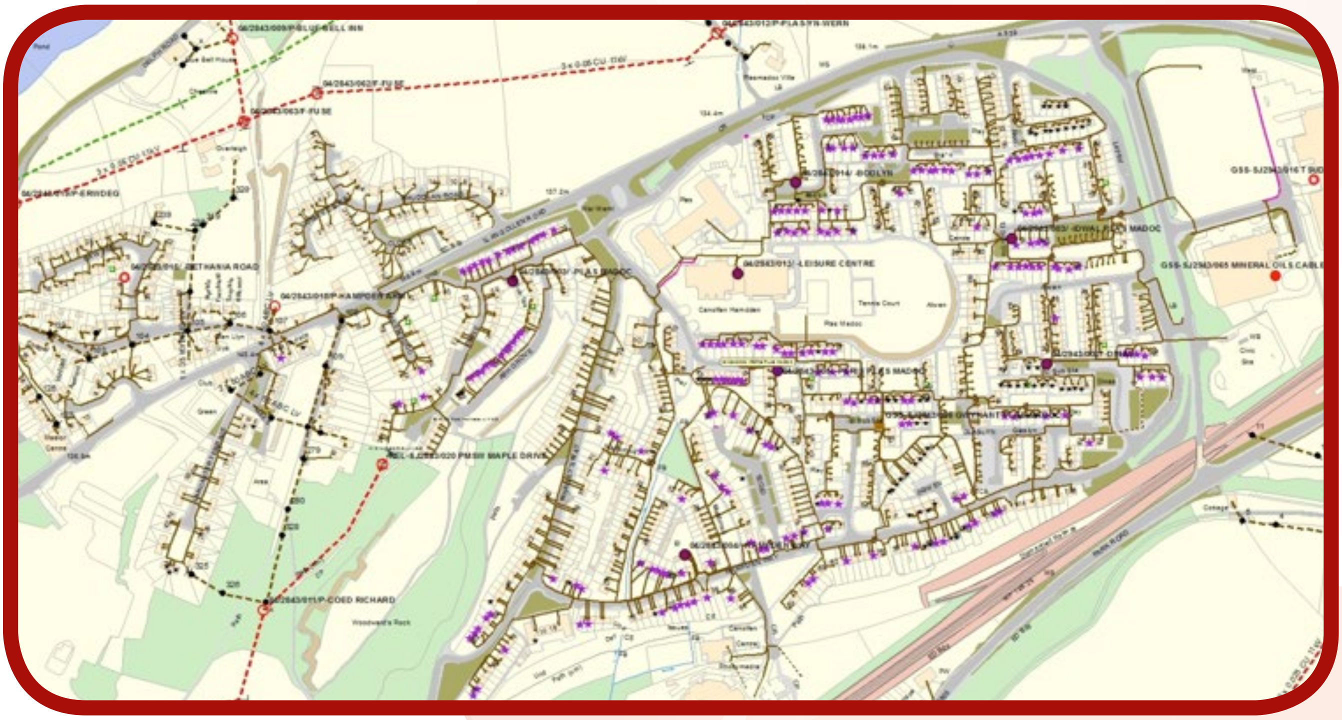

Figure 1: Geographical layout of the Ruabon Network

In January 2014, an experiment was undertaken at Ruabon primary substation to determine the effects of a reduction in the lower bound of the statutory +10% / –6% voltage limits. At Ruabon, a 3% voltage reduction was applied on the morning of 9th January, and was held until the afternoon of 30th January. The voltage reduction was removed temporarily in response to a customer complaint of low voltage, although upon investigation voltage at the customer's premises was found to be within statutory limits. However, some unusual voltage fluctuations were observed in the monitoring data, which was traced to an intermittent fault (failing joint) on the LV network. Once this was repaired, the voltage behaviour on the network returned to normal and the voltage reduction was re-applied on 21st May 2015, this time causing no issues for customers.

3.2 Voltage Optimisation Trial Site at Ruabon [continued]

Voltage, current and power measurements were retrieved from Ruabon primary substation and for monitored secondary substations in the area, which are located along three 11kV feeders fed from Ruabon primary. Measurements were retrieved for the period 1 December 2013 to 28 February 2014, to allow comparison of load before, during and after the period of the experiment. The days of application and removal of the voltage reduction were inspected in detail, and average weekday load current profiles were compared across three comparable periods in December, January and February.

3.3 Outcomes of the Voltage Optimisation Trial

The effect of PV generation can be seen clearly in Figure 2, where Feeder 1 (Hampton Way feeder) experiences power flows in the conventional direction (up to 60 Amps) in the evening (when no PV is exporting power) and reverse power flow (up to 40 Amps) during the day when PV generation reaches its maximum.

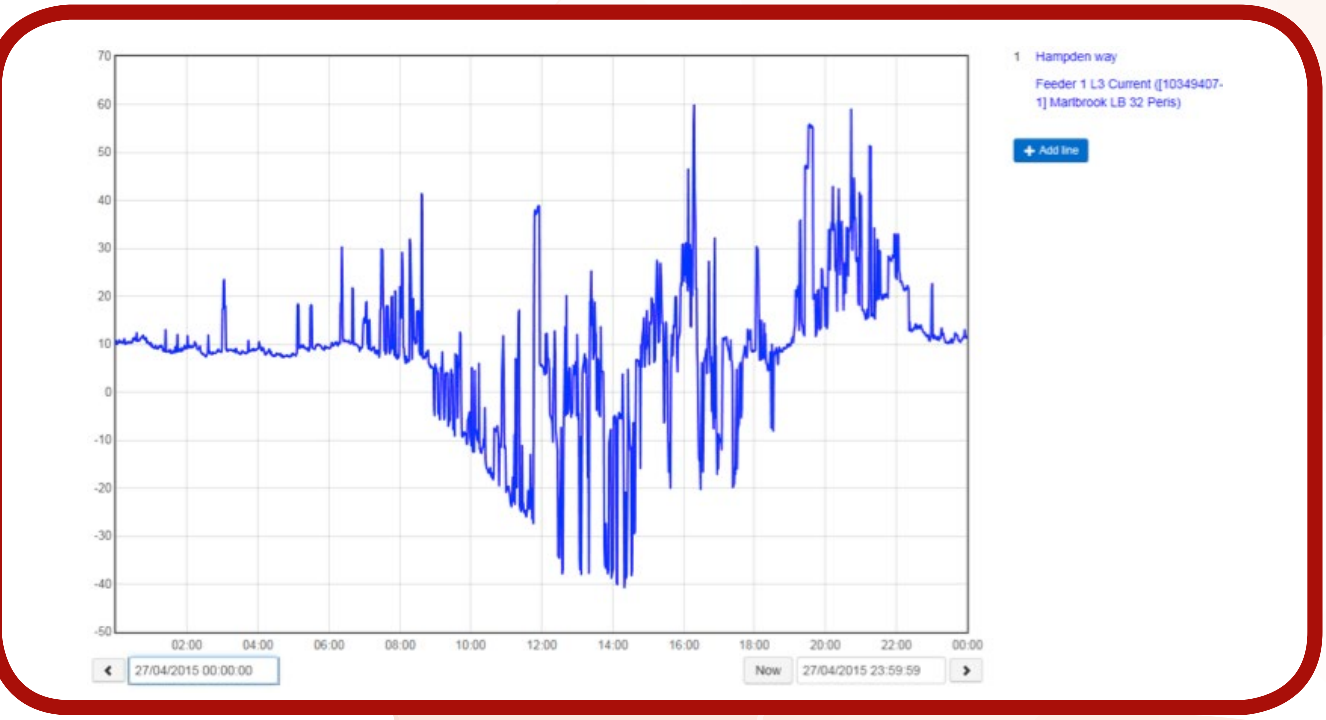

Figure 2: Bi-directional current flows on Hampton Way Feeder 1

3.3 Outcomes of the Voltage Optimisation Trial [continued]

The effect this has on voltages at the secondary substation busbars at Plas Madoc can be seen in Figure 3. The voltage at the LV busbar is typically around 250V, +/- 3 volts. Interestingly, the volts are highest during the evening, as a result of the voltage control (line drop compensation + negative reactance compounding) at the primary substation acting to boost the volts slightly, due to increasing overall load on the Primary substation.

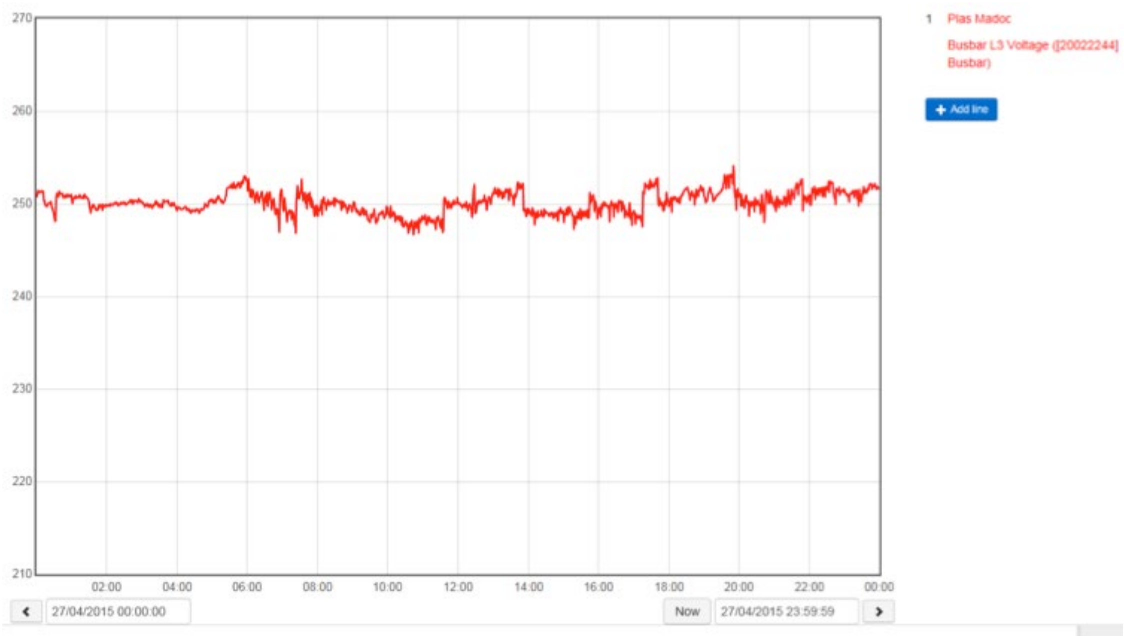

Figure 3: Daily voltage profile for Plas Madoc Secondary substation (LV Busbar)

3.3 Outcomes of the Voltage Optimisation Trial [continued]

A 3% voltage reduction was applied to the network on the morning of 21st May 2015. This was achieved by applying a "Stage 1" voltage reduction at Ruabon primary. The instant of voltage reduction can be seen in Figure 4, which shows the voltage at the LV busbar at Plas Madoc secondary substation. The voltage can be seen to reduce from about 250 volts to 242 volts.

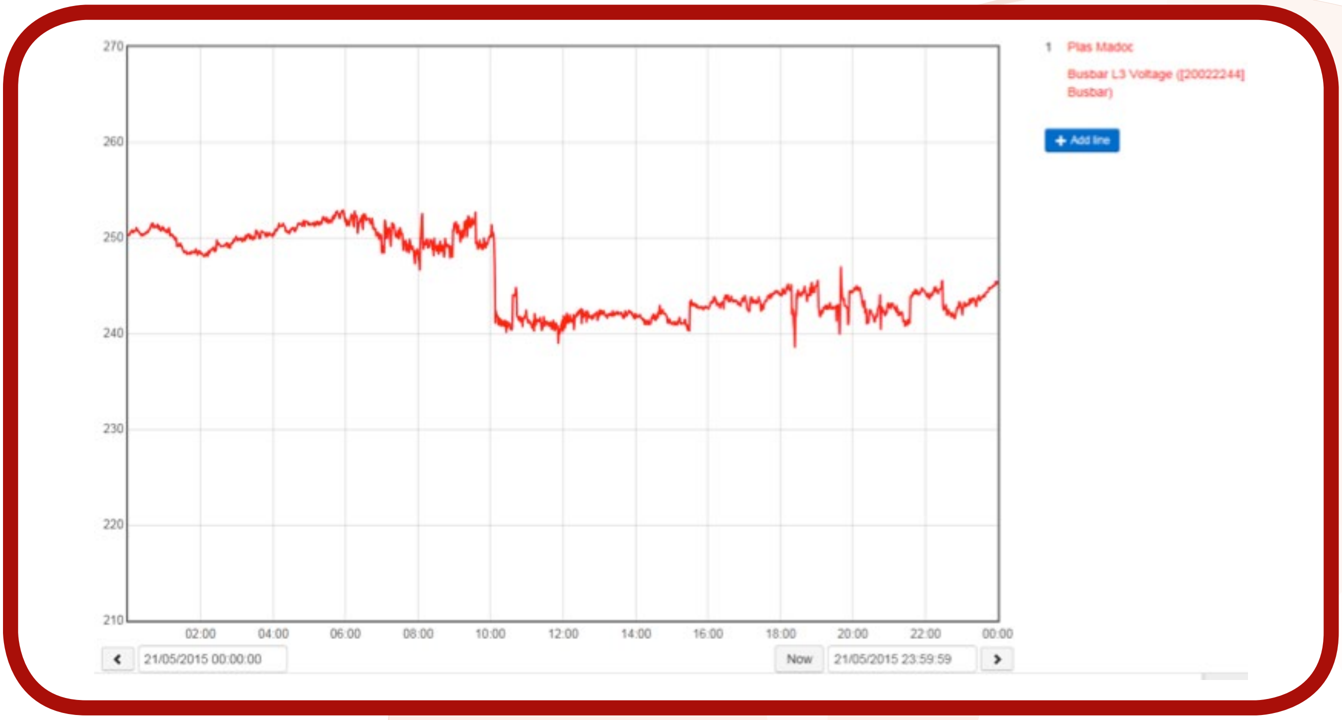

Figure 4: Voltage at Plas Madoc LV Busbar

3.3 Outcomes of the Voltage Optimisation Trial [continued]

The effect of this voltage reduction is shown (in Figures 5 and 6) for two of the seven remotely located customers with installed smart meter voltage monitoring.

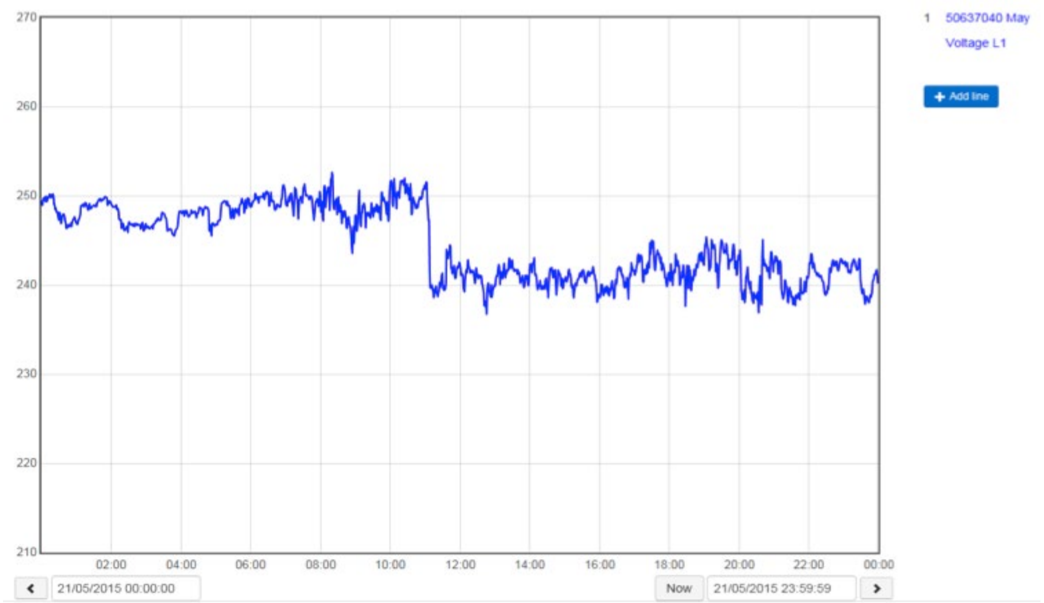

Figure 5: Supply voltage at remote customer (no PV on feeder)

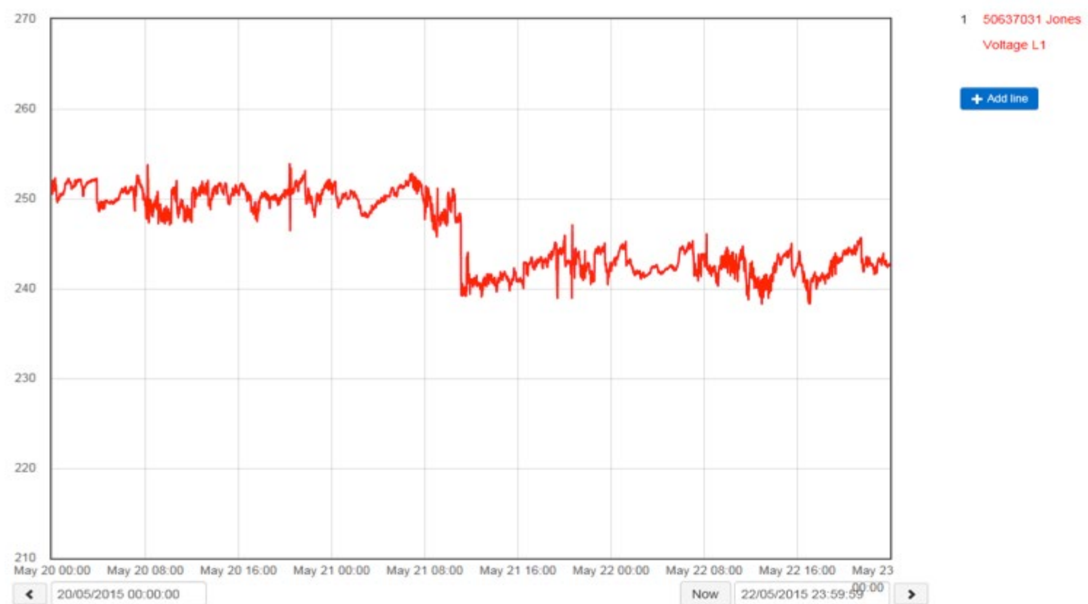

Figure 6: Supply voltage at remote customer (PV cluster on feeder)

Figure 5 represents a customer at the remote end of a feeder which does not have PV connected to it, whilst Figure 6 represents a customer at the remote end of another feeder which contains a significant cluster of PV installations.

4 Learning from the Project

This section presents the key learning points of the voltage optimisation activity. The main learning outcomes are:

- The creation of additional network capacity for the connection of embedded generation
- Improved energy efficiency of our customers
- No reduction in losses on the distribution network

4.1 Characterisation of PV Generation

It is difficult to resolve overvoltage issues caused by reverse power flows on the network using traditional network reinforcement measures (i.e. adding transformers and/or circuits). Reverse power flows are a consequence of the level of instantaneous local embedded generation being greater than the local load on the network. An alternative to conventional reinforcement is to reduce the nominal voltage set point on the network. However, this is at the expense of reducing the network capability for load. The key question, therefore, is what is the "optimum voltage" to release sufficient generation capacity headroom, without significantly compromising the load capacity of the network?

4.1.1 Key Metrics for the Characterisation of PV

Key metrics for characterisation of PV generation were found to be peak solar irradiance and minimum average weekday daytime demand. As part of this study, we developed the following methodology to improve the characterisation of PV generation and identification of available capacity headroom, based on monitoring data collected;

- Use of detailed irradiance data measured over the summer period to provide an accurate representation of actual PV output. A maximum PV generation of **90% of rated capacity** was derived based on our simple PV resource assessment model which correlates irradiance with PV generation output.
- A generic minimum demand profile was defined for domestic properties in the Ruabon LV network. This is based on the number of customers along an LV feeder and an average measured peak domestic summer demand (teatime peak around 6pm). Minimum daytime demand was found to typically occur during the morning, with morning demand generally lower during the week compared to weekends. Based on this analysis, **minimum demand at peak PV generation will be defined as 300W** (increased from 200W) in SPEN PV connection policy in future.

Experimental verification of the PV generation resource assessment model and generic minimum demand profile was achieved through comparison of measured load and voltage profiles with results from a power systems model of the Ruabon LV network developed in IPSA. Further model verification was carried out based on measurements of LV customer voltage along LV feeders.

4.2 The Impact of Voltage Reduction on PV Headroom

The characteristics of the LV busbar voltage profile for substations with a high and low PV uptake on a representative high solar irradiance day suggest that variations in loading of the LV network due to embedded PV generation i.e. reverse power flow, or demand do not influence LV busbar voltage significantly. The LV busbar voltage profile is however highly correlated with the upstream primary transformer HV busbar voltage profile. Therefore, careful consideration of the impact on downstream voltage should be made for the connection of HV generation on a feeder connected to an LV network with high levels of embedded PV generation.

In terms of wider LV network voltage management partly to enable further PV uptake and more generally to reduce existing voltages, there is a case for voltage reduction. This should be unlikely to lead to undervoltages during observed peak demand winter conditions. There is generally about 6% voltage legroom during typical high demand conditions based on LV customer voltage measurements towards the ends of LV feeders.

However, DNOs have an obligation under the Gride Code to keep some voltage legroom in order to comply with the National Grid "Stage 1" (3%) and "Stage 2" (6%) voltage reductions. These voltage reductions are called upon by National Grid when the transmission system is under stress, such as when there is a sudden loss of generation, resulting in a generation shortfall. Voltage reduction is used to reduce demand in an attempt to avoid load shedding whilst additional generation is brought on line. Such events are very rare and given the fact that voltage reduction is less effective at reducing demand than it used to be, perhaps it is time to re-consider this Grid Code requirement, perhaps replacing it with a direct obligation on DNOs to reduce demand. This would then give DNOs full control over their network voltages, enabling them to more optimally utilise the capability for either generation connections or load reduction, as appropriate. This is a practical example of how "Distribution System Operator" (DSO) ancilliary services might develop with National Grid in the future.

The bandwidth of the primary voltage relay should also be considered, trading thenumber of tap changer operations with tightness of voltage control when reviewing voltage distribution characteristics and potential benefits of voltage management techniques.

In conclusion, network voltage reduction can provide significant additional generation capacity headroom for the LV network. A 2% reduction in voltage enables a further 90% of PV generation by kW to be connected. Further details of our PV characterisation and the interactions with network voltage can be found in the TNEI report entitled "Improved Characterisation of PV Capacity at LV".

4.3 Customer Energy Efficiency and Network Losses

The effect of the 3% voltage reduction on power flows at Ruabon are presented below.

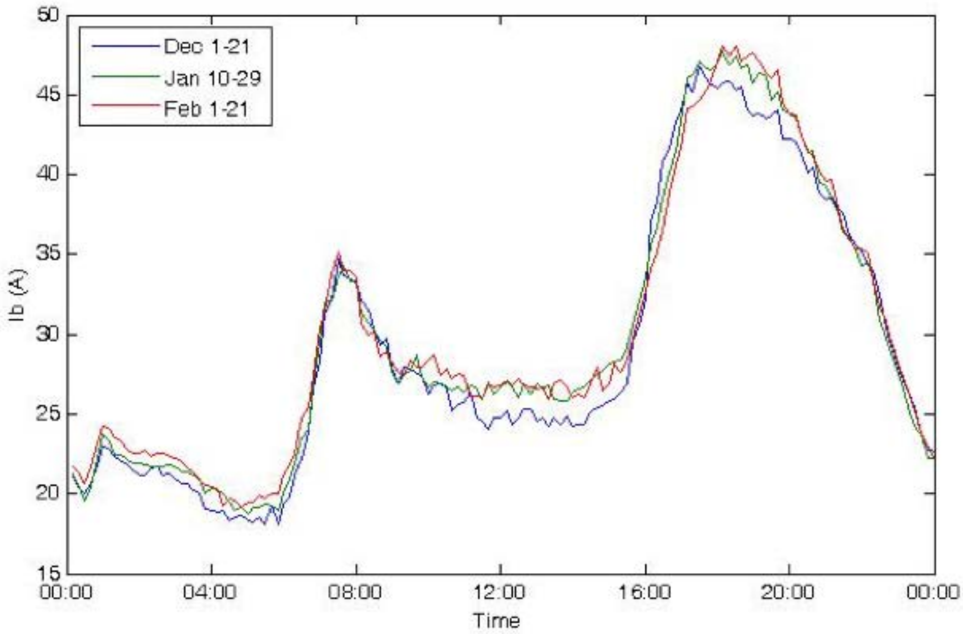

Figure 7: Average weekday B-phase current at Ruabon primary for three-week periods

Figure 7 shows the average weekday current profiles for three three-week periods in December, January and February. The period used to calculate the January profile corresponds to the period of voltage reduction. It can be seen that there is no clear difference between the January profile and the February profile. Similar plots were constructed for the three Whitchurch-area primary substations to investigate whether any variations could be detected which might reflect a deviation at Ruabon from a regional pattern (for example, if January were colder than February, then the similar pattern shown in Figure 7 might reflect an effective reduction in January load). Although some suggestions of this were found, there was little consistency between the three substations at Whitchurch.

4.3 Customer Energy Efficiency and Network Losses [continued]

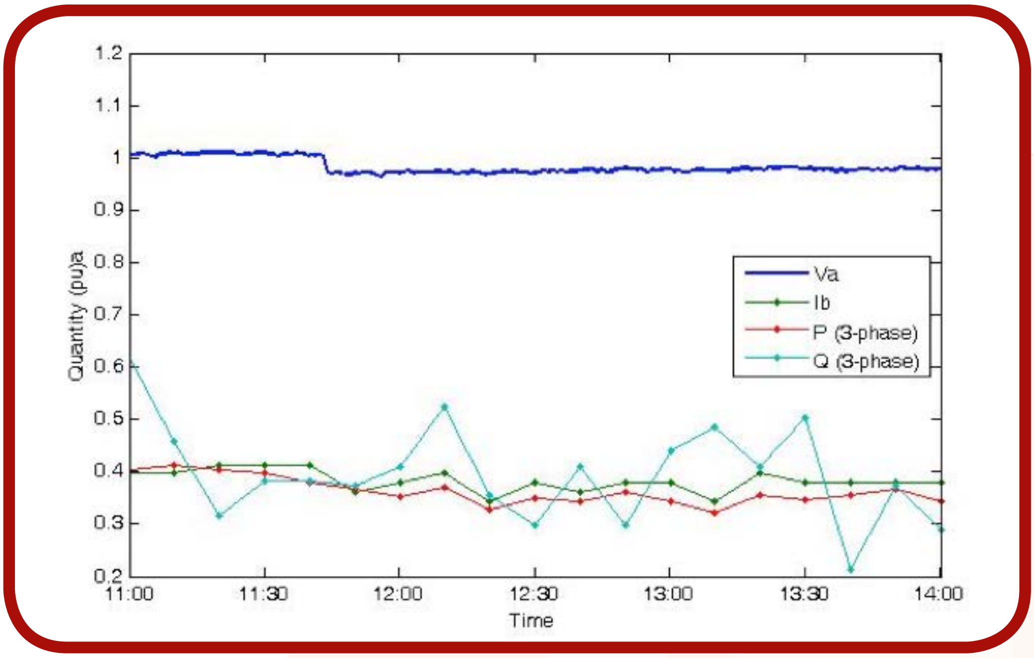

Figure 8: Ruabon load at application of voltage reduction

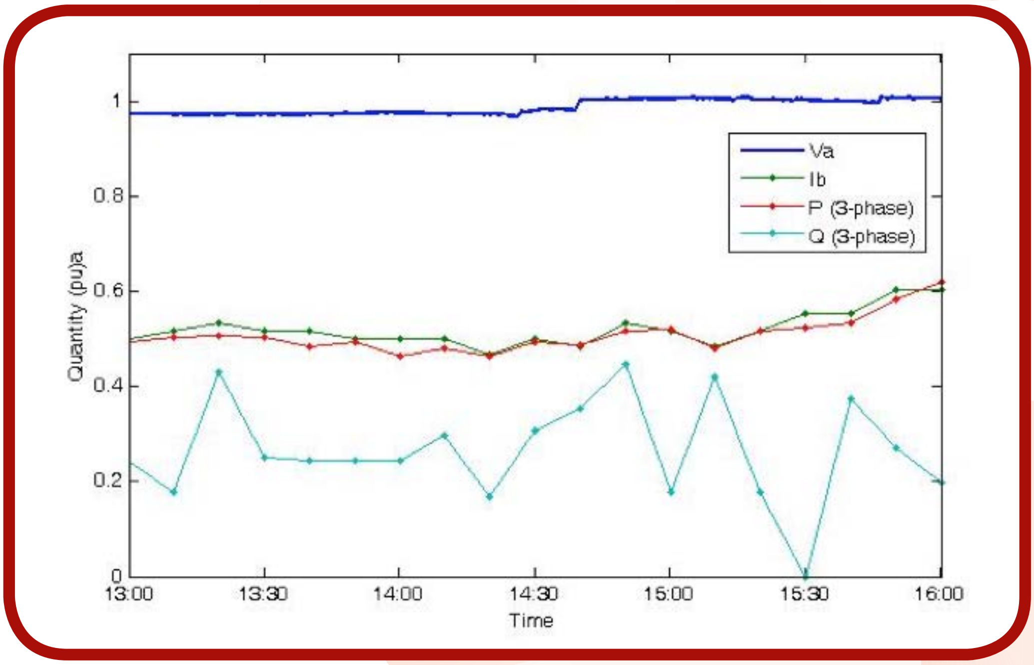

Figure 9: Ruabon load at removal of voltage reduction

Figure 8 and 9 show the real and reactive power flow in the transformer at Ruabon primary substation at, respectively, application and removal of the voltage reduction. The recorded voltage is also shown to provide a reference to the point of application or removal of the voltage reduction. Instantaneous current, and 10-minute average active and reactive power are normalised to their highest value over the three-month period considered (it should be noted that Ruabon power factor was always above 0.98, and generally above 0.995 for this period).

4.3 Customer Energy Efficiency and Network Losses [continued]

From the two graphs, it does appear that there is a change in active power and current at the point of the voltage step. Upon voltage reduction, the 10-minute average active power measurement is in a generally falling trend of about 3% every 10 minutes, which appears unaltered by the voltage reduction. The instantaneous current measurement however shows a sharp drop of about 12.5% between measurements, around two thirds of which is recovered over the following twenty minutes. It is possible that the response of the active power is being masked to a degree by the averaging process.

At the end of the experiment, the voltage increase occurs in two steps: the increase in active power at the first is approximately 6%, and 5% at the second. Current follows a similar pattern, with a slightly larger initial increase as a result of the increase in reactive power which occurs at the same time.

These results suggest that there may be some change in load associated with the change in voltage at Ruabon. It is however difficult to quantify the magnitude of the reduction on the basis of the measurements available.

The usual difficulty was encountered, in that, because the load change is so small and because the load is continually changing anyway as a consequence of constant changes in electricity demand from each individual customer, it is difficult to establish an accurate and precise link between voltage reduction and a sustained load reduction.

So, based on this work and the work of others, the following conclusions are drawn:

- A reduction in voltage will generally result in a reduction in active power demand. This reduction will be larger over the short term than in the long term and the reduction achieved will depend on the types of load present, and therefore:
  - can vary between different parts of the distribution network
  - can vary between different seasons, and different times of day
  - can vary according to the ambient temperature
- Reactive power demand will generally be reduced by a larger factor than active power demand
- In the absence of local knowledge or experimental results, a reduction of 1% in active power demand in response to a 1% voltage reduction is a reasonable estimate
- A network voltage reduction does not seem, on average, to reduce the network current. Therefore network copper losses (i.e. i2R losses in transformers, cables and overhead lines) are not reduced by voltage reduction.
- The above reduction in power does reflect a direct energy saving for customers, where a 1% reduction in voltage can typically lead to a 1% reduction in energy consumption.

5 Updated Business Case and Customer Benefits

5.1 Business Case Update

A financial evaluation has been carried out to determine the benefit that can be gained by deploying voltage optimisation. For this evaluation, the unit costs were obtained from indicative quotations from SPEN's approved suppliers and provided from SPEN's Unit Cost Manual document. The full business case is given in "Flexible Networks Project Cost Benefit Analysis – Voltage Optimisation", but the key elements are given below, in terms of base case, carbon savings, social and environmental benefit and financial benefits.

5.1.1 Reinforcement Base Cost at LV

In order to allow for the potential amount of capacity released by this project to be provided by conventional reinforcement, 358kVA of capacity would need to be provided. Using the pro-rata base cost of £150/kVA for additional LV capacity, the base cost of network reinforcement is;

PV Generation Capacity created 358kVA @ £150/kVA = £53,700

5.1.2 Carbon Saving:

For this trial it is estimated a saving of 200,000kWh can be realised through the reduced energy consumed by the customers

Cost of Carbon = Energy x Conversion Factor x Value of Carbon

Using the equation above;

Energy = 200,000kWh
Conversion Factor = 0.45211 kgCO2e/kWh (average over RIIO ED1 8 year period to 2023)
Value of Carbon = £14.03/tCO2e (average over RIIO ED1 8 year period to 2023)
The Cost of Carbon/year = 200,000kWh x 0.45211 ÷ 1000 x 14.03 = £1,269
Carbon Saving over 10 years = a saving of £12,686

Benefit rating: 4 (significant)

5.1.3 Social and Environmental Benefit

The element of the project provides for energy saving for customer loads which use less power with a lower voltage input and thereby operate at a reduced power (the overall power saving is nullified for thermostatically controlled equipment or non-linear loads). It also provides for additional SSEG to be connected which would otherwise create an overvoltage situation.

Customer energy savings = 50,000kWh (load) + 150,000kWh (generation) = ~200,000kWh x £0.137/kWh = £27,400pa (or £274,000 over 10years)

The above only accounts for the reduced load energy savings and the renewable generation energy saving and does not include the customer investment for the SSEG (probably solar PV). The investment for renewable SSEG (e.g. solar PV) is typically offset via the Feed in Tariff. Additional SSEG capability (Feed in Tariff for 80 typical domestic installations) = 150,000kWh, @14p/kWh = £21,000 (or £210,000 over 10years)

Benefit rating: 4 (significant)

5 Updated Business Case and Customer Benefits [continued]

5.1.4 Financial Benefit:

The project identified the voltage range which maintained the voltage within the DNO's statutory obligations.

Base Cost: £53,700
Method Cost: £31,000
Non-Network Derived Benefits:
Carbon + Social; £12,686+ £27,400 = £40,086
Method Cost – Non Network Derived Benefits;
£31,000 - £40,086 = -£9,086
Financial Benefit = Base Cost – Method Cost
Financial Benefit = £53,700 – (-£9,086)
Financial Benefit = £62,786

Benefit rating: 3 (medium)

5.2 Customer Benefits

Customers can gain benefit from DNO's deploying voltage optimisation as follows:

- Facilitating the connection of higher volumes of embedded generation on the LV distribution network and at lower cost
- Improving the energy efficiency of customers
- Since reducing network voltage can facilitate the connection of more domestic-scale embedded generation, this can in turn lead to a reduction in network power flows and therefore potentially reduce network losses, as long as the local generation is in scale with the local demand.

6 Lessons Learnt for Future Innovation Projects

This section provides an overview on key challenges encountered and lesson learnt in the course of the voltage optimisation exercise.

6.1 Power Flows

Distribution networks are currently designed for uni-directional power flow, receiving power from the National Grid Supply Points and distributing and transforming that power from the higher voltage levels down to the lower levels for load customers. Under these circumstances, it is sensible to maintain the network busbar voltages as high as possible in order to maximise the thermal capability of circuits for the supply of load, with circuits reaching their thermal limit before the lower voltage limit is exceeded. However, this arrangement severely limits the ability of LV networks to absorb generation. Generally, reverse power flow at the secondary substation will indicate the potential for voltage exceedances at the feeder ends, if the generation is installed at the remote end of the feeder. So, in order to connect more generation it is necessary to reduce network voltages. The question is by how much? We currently believe that a 2% voltage reduction is possible, but in reality we will not know for sure until we try it on a wider area of network. So, rather than go from a trial and then straight to application into business as usual, we recommend introducing a "pilot" project as an intermediate progressive step.

6.2 Load Variations

Network load is simply the aggregate of individual customer demand. It is very difficult to precisely predict the consumption of individual customers, especially domestic customers, whose demand can vary between a few hundred watts (i.e. overnight) to over 15kW ((i.e. when the shower and the kettle is on simultaneously). Therefore, network designers rely on diversity and averaging effects of groups of customers in order to estimate substation demand. The larger the group, the greater the averaging effect and so it is easier to predict the network load behaviour for larger network groups. Our work, along with others, has highlighted the significant variation in demand patterns that can occur at the more granular levels of the network – i.e. at the secondary substation and LV feeder level. Whilst some of the variations have plausible explanations (i.e. the differences between domestic, commercial and industrial demand patterns), each of these load groups have significant variations within them as well. And in practice many groups are made up of a mixture of domestic, commercial and industrial loads. Therefore, whilst general rules of thumb will continue to be applied in the absence of better information, it may be possible to exploit these differences in the future, based on information obtained through detailed network monitoring.

6.3 Data Analysis

Some of the information is difficult to extract directly from the load data, because of the presence of random variables, or "noise". The use of statistical methods is often necessary to filter out the "noise" in order to reveal underlying trends.

7 Project Replication

A pre-requisite for voltage optimisation is an improved understanding of the actual behaviour and performance of the existing "fit and forget" network. This requires more detailed network monitoring, modelling and analysis. However, this activity has to be fit for purpose, with a positive cost-benefit. We have found the most cost-effective approach is to :

i) Make better use of existing primary substation data

ii) Phase in the use of "Smart MDI's" to replace conventional MDIs. Smart MDIs could provide voltage information as well as current information

iii) Make use of voltage measurements at the customer terminals (via Smart meters in the future)

The use of highly detailed network monitoring (i.e. monitoring each phase of each secondary substation feeder) is only justified in specific situations, such as clustering of low carbon technologies, and is likely to be installed as a temporary installation.

8 Planned implementation

We currently believe that a 2% voltage reduction is possible, but in reality we will not know for sure until we try it on a wider area of network. So, rather than go from a trial and then straight to application into business as usual, we plan to introduce a "pilot" project as an intermediate stage. The philosophy is based on the principle that we will reduce the potential for over-voltage issues by reducing the network nominal voltage. If this introduces isolated under-voltage issues, we will consider the merits of various mitigation measures (such as restoring the original voltage set point in low voltage problem areas or applying seasonal voltage settings) and network interventions (such as 11kV in-line voltage regulators or STATCOMs) to resolve low voltage issues.

8.1 Voltage Optimisation in the SPEN ED1 Business Plan

SPEN has now made progress on developing these requirements. In the following a summary of these developments are given.

SPEN has a programme of asset replacement during ED1 to replace significant numbers of voltage control relays, including a significant population of electro-mechanical relays. The original programme was accelerated and expanded in anticipation of the need for voltage optimisation during ED1 and was included as part of SPEN's "Smart Grid" strategy.

However, altering the network voltage set point is a major change to the network operating condition, with the potential to have a significant impact on customers. So, the decision to change the voltage set point will not be taken until we are completely satisfied that we have considered all the information available to us. Whilst we are satisfied with our own findings, we are also aware that other DNOs are doing similar work in similar areas. So, we will wait until all this information is available before making any final commitments.

9 Further Reading

This methodology and learning report is supported by a series of more detailed reports, as identified below:

1. "Improved Characterisation of PV Capacity at LV", TNEI, September 2015
2. Technical Note on Modelling of Load, University of Strathclyde, June 2014
3. Ruabon Voltage Test, University of Strathclyde, May 2015
4. Flexible Networks Project Cost Benefit Analysis – Voltage Optimisation, SPEN, September 2015
5. Recommendations for Policy, TNEI, September 2015

10 Contact Details

Further information on the project is available from the project team members, whose contact details are given below:

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