

LV NETWORK TEMPLATES FOR A LOW-CARBON FUTURE

Second Tier Reward
Application



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Executive Summary

Through the Second Tier Reward mechanism, Western Power Distribution welcomes the opportunity to provide a formal update on how the learning from the investment in LV Network Templates has progressed since the publication of the close down report in 2013.

LV Network Templates delivered what was, at the time, Europe's largest smart grid, covering 3000 homes. This ambitious and successful project was achieved thanks to £8m of LCN Funding. Western Power Distribution delivered this by working with the Welsh Assembly Government (WAG) to build upon their investment of £30m in existing and green-retrofitted properties, within the LV Network Templates test networks. This meant LV Network Templates could leverage the WAG's low carbon initiatives 'Arbed' sites, covering 3000 homes, which included 1000 photo voltaic installations, to provide a real-world testbed. Western Power Distribution also worked with npower so that their customers that were part of the Carbon Emission Reduction Target (CERT) and Community Energy Savings Programme (CESP), and had been provided with microgeneration in their homes, would be part of the LV Network Templates project.

LV Network Templates delivered significantly beyond expectations.

The additional DNO Template Validation activities demonstrated that the templates were applicable to 82% of all UK networks¹, a result significantly beyond the 50% of GB networks originally anticipated at the time of submission in 2010.

LV Network Templates established that there was a circa 20% increase in capacity headroom available for connection of Low Voltage domestic PV generation. This is because the rated output from panels used for planning purposes was too high due to a combination of using international output ratings not appropriate for UK solar levels and a diversity factor due to the panel orientation. These findings have been disseminated to Government and the Solar Industry and has been implemented into Western Power Distribution's network planning activity with consequent cost benefit to customers.

Additionally, LV Network Templates identified the benefits of voltage reduction. The learning has been embedded into business as usual through publication of the necessary policies and a rollout programme has been established. This programme has already delivered reductions in electricity consumption of 398GWh per annum (equivalent to the electricity consumed by around 100k homes each year), based on 2017 supplied energy volume figures. This reported energy reduction equates to a saving for customers of £58.2m per annum based on the average variable unit costs for standard electricity in 2017 for Western Power Distribution's areas.

These savings are expected to rise to 803GWhs per annum once the rollout programme has been completed across Western Power Distribution's areas that, on the same basis, equates to £116.6m saving per annum for WPD customers.

¹ [SDRC Application](#), Section 5

1. Project Description

The **primary objective** of the LV Network Template project was to establish a set of novel “templates” that would accurately estimate the daily and seasonal demand and voltage impacts on low voltage networks of different cluster types of load. If it could be demonstrated that it was possible to assign one of the resulting templates with sufficient statistical certainty to any given UK HV/LV substation, then the ability to accommodate new low carbon loads and generation to that substation could be assessed without the need to install costly and potentially customer disruptive 24hr demand and voltage monitoring at each substation and LV feeder end.

In developing such templates, four important **secondary objectives** were also derived due to the value and insight they would bring to the industry:

- The ability to identify the impacts on LV networks created by the progressive adoption of low carbon technologies through templates and the associated voltage profiles.²
- A greater understanding of the actual difference between stressed and non-stressed parts of the network due to either the connection, or not, of low carbon technologies (e.g. Heat Pumps, PV, Electric Vehicles)³ to that network.
- The statistical case for using readings from a limited number of PV feed-in-tariff meters to reflect the aggregate output of others.⁴
- Visibility of the degree of headroom and actual voltage levels measured across wide parts of the LV system (topology and customer mixes).⁵

Further **additional** activities were, through the emerging learning from LV Network Templates, identified and added to the scope and objectives of this project. This additional work has taken two forms: **DNO Template Validation** and the development of a business as usual **Classification Tool**.

- **DNO Template Validation:** In order to provide the industry with confidence that the learning from LV Network Templates is valid outside the South Wales area, further validation work was undertaken by analysing both fixed and variable data from all the other DNOs. This work considered the effectiveness of the classification process to confirm that this would be valid for other DNOs. It also compared estimates to actual values as recorded by the other DNOs’ monitoring equipment to check that the templates themselves were not limited to local use. This work was necessary for other DNOs to adopt the Network Templates and was carried out at no additional cost to the project. This value-adding activity was not initially planned for as the necessary monitoring by other DNOs was not in place at the time of the original submission. Nonetheless, this further validation was regarded as an unparalleled opportunity to further share and validate the templates’ suitability for application to “at least 50% of

² Stresses on the LV Network caused by Low Carbon Technologies Report

³ Stresses on the LV Network caused by Low Carbon Technologies Report

⁴ Report on the use of proxy PV FiT meters to reflect local area Generation

⁵ Stresses on the LV Network caused by Low Carbon Technologies Report & Discussion paper on adoption of EU low voltage tolerances (PWest)

the GB wider network⁶". Much of this validation using data from other DNOs was undertaken after the original LV Networks close down report was complete, so this submission contains the first formal record of the work and its findings.

- **Classification Tool:** Alongside the development of the templates, a classification tool was developed as part of Western Power Distribution's additional contribution to the project. The classification tool makes use of the templates to allocate a template to a non-monitored substation. This tool, alongside traditional planning tools, will enable the templates to be embedded into business as usual when required.

The South of Wales was selected to be the trial area for this project (refer to diagram below) as this was considered best able to fulfil LV Network Templates' objectives. The project area identified LV networks that represented the wider GB network due to the variations in network topology, as well as the number and type of low carbon technologies/generation connected to the network. Additionally, the project trial area was chosen because it would be able to take advantage of the Welsh Assembly Government's (WAG) ARBED strategic energy performance investment programme. The ARBED investment by WAG provided, what was at the time, a rare opportunity to study the impact of clusters of low carbon technology installations by acquiring fixed data on 4036⁷ retrofitted homes with low carbon technologies and energy efficiency solutions (e.g. 912 PVs, 616 Solar Water Heaters, 62 Air Source Heat Pumps).

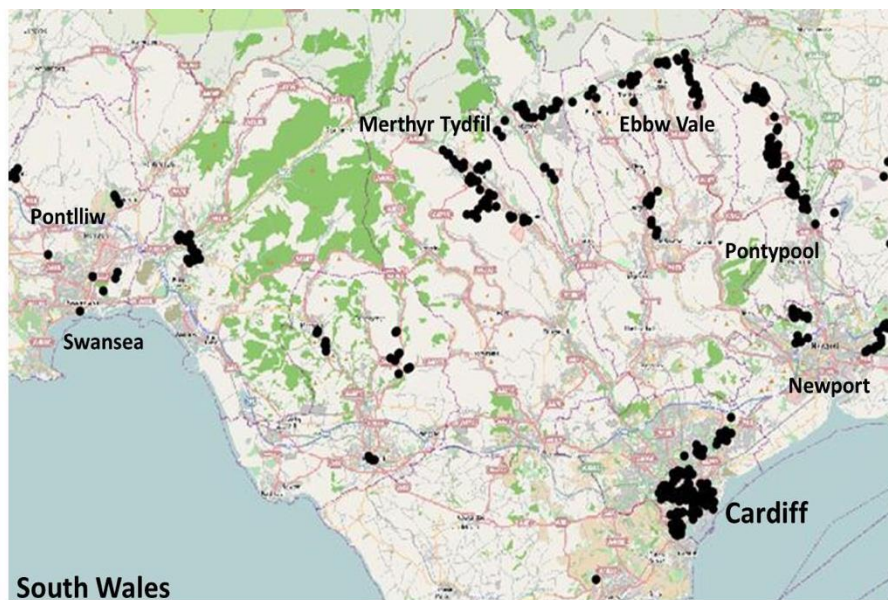


Figure 2: Map of locations of monitored substations within the South Wales Study Area

As a result, the scope of the trial area included both stressed and non-stressed parts of the network, from rural to urban locations and residential to commercial customers. The South Wales trial area therefore provided the ideal test bed for development of the templates as it

⁶ Statement made in the Original Submission "Low Carbon Networks Fund Full Submission Pro-forma"

⁷ Note, that at the time of the analysis undertaken 4036 homes were retrofitted with low carbon technologies and energy efficiency solutions.

reflects the extensive spectrum of challenges that all DNOs will face with similar network topologies, customer mixes and stresses to the system from low carbon technologies. As a result of these factors, the resulting templates and project findings would also be credible, representative and suitable for other DNOs' networks to adopt.

Behind the templates development is both fixed and a full years' worth of half hourly monitored data. The monitored data was collected from over 824 substations, 3600 feeder-ends and 525 domestic PV installations. It should be noted that the fixed ARBED data was associated with 115 substations of which ca. 100 were within the trial area of the project.

1.1. Criterion A: Exceptional Performance of the Project

LV Network Templates delivered significantly beyond expectations. The additional DNO Template Validation activities demonstrated that the templates were applicable to 82% of all GB networks⁸, a result that was significantly beyond the 50% of GB networks originally anticipated at the time of submission in 2010.

Additionally, LV Networks Templates identified the benefits of voltage reduction. The learning has been embedded into business as usual through publication of the necessary policies and a rollout programme has been established. This programme has already delivered reductions in electricity consumption of 398GWh per annum (equivalent to the electricity consumed by around 100k homes each year), based on 2017 supplied energy volume figures. This reported energy reduction equates to a saving for customers of £58.2m per annum based on the average variable unit costs for standard electricity in 2017 for Western Power Distribution's areas.

1.2. Criterion B: Additional Investment of DNO's Own Money

Western Power Distribution made an additional contribution of £294.5k to support delivery of LV Network Templates. The additional contribution primarily funded a dedicated, reliable communication network and the leasing of the necessary spectrum.

1.3. Criterion C: Exceptional Efforts

Western Power Distribution has made significant efforts to embed the lessons for LV Network Templates into business as usual across the UK sector. This has included the engagement with DNO peers to deliver the Template Validation and ensure it is relevant to their networks.

Western Power Distribution led the formation of and chaired the Energy Network Association's Statutory Voltage Limits Group and is continuing to lead on the need to amend the ESQCR legislation, which is where the UK's statutory voltage limits are specified.

⁸ [SDRC Application](#), Section 5

Tier 2 Project Name	Licensee	Project summary (2 Sentences)	Tier 2 funding £k (nominal prices)	Licensee compulsory contribution £k (nominal prices)	Other contributions £k (nominal prices)	Link to Close-Down Report
LV Network Templates	Western Power Distribution (South Wales)	A focussed project assessing the impact of low carbon, demand-side technologies as they are connected to the low voltage network. The aim was to create generic network models to assist DNOs in efficiently planning, developing and operating these networks as they transition to facilitate a low carbon future. The project leverages existing Welsh Assembly Government and RWE npower initiatives.	8048 ⁹	896	294.5	https://www.westernpower.co.uk/docs/Innovation/Closed-projects/Network-Templates/LVT-Closedown-Final-2.aspx

Table 1: Summary of Tier 2 LV Network Templates

⁹ Figure taken from Ofgem's Project Direction

2. Criterion A: Exceptional Performance of the Project

LV Network Templates delivered several major findings that have proved to be of national importance in relation to adopting solar PV generation onto low voltage networks. These include:

- measured outputs strongly suggested that capacities quoted by installers tended to simply multiply manufacturers quoted outputs for individual panels (these being based on an international figure for solar radiation that is not appropriate for the UK) and did not take into account other output reductions due to orientation and losses.
- significantly lower aggregated outputs resulting in less impact on network voltages, thus providing significantly more capacity headroom, enabling additional PV installations without the need for network reinforcement.
- This information was shared widely, including being shared with the DECC Solar PV Strategy Task Force (Grid sub group meeting Victoria St 4/11/2013) and the BRE National Solar Centre.

2.1. Aspects of the Carbon Plan and/or Clean Growth Strategy that have been facilitated

LV Network Templates delivered a set of standard templates that enable network planners to accurately estimate the load and voltage at any given substation without the need for the installation of costly monitoring. This approach facilitates the adoption of low carbon technologies by enabling planners to more accurately estimate the capacity and voltage headroom available and be able to more confidently conclude whether the installation of a low carbon technology will lead to voltage or thermal limits being breached.

By providing network planners with the tools to rapidly assess the impacts of low carbon technologies on any given network, Western Power Distribution and other DNOs are able to facilitate the Clean Growth Strategy. Decisions on the need for network reinforcement can be taken rapidly, helping remove delays and economic barriers to the deployment of low carbon technologies, such as EV charging posts, where there is sufficient capacity headroom or potential to absorb the increased demand through the use of flexible connections. The use of these Templates also enables networks with constraints to be proactively identified and informed investment decisions to be taken. In doing so, this addresses potential barriers to the adoption of EVs by customers and facilitates the ambition in the Clean Growth Strategy for Britain “to have one of the best electric vehicle (EV) charging networks in the world”¹⁰. Some of the learning from LV Network Templates also helped inform the development of Electric Nation (one of Western Power Distribution’s current NIA projects) looking at the potential to defer or avoid the need for network reinforcement and reduce the impact on customers’ bills through automating management of EV charging. Electric

¹⁰ [The Clean Growth Strategy](#), Accelerating the shift to Low Carbon Transport, P87

Nation is cited as a case study in The Smart Systems and Flexibility Plan¹¹ and Western Power Distribution's current OpenLV NIC project is making use of the templates.

The key findings of LV Network Templates and the templates it delivered will help DNOs make more informed, cost-effective investment and operational decisions for the management of the low voltage distribution network as the UK transitions to a low carbon economy. For customers, this enables quicker decisions about connection applications and can aid identification of suitable locations with capacity headroom.

The area of learning from LV Network Templates that makes the greatest contribution to the UK achieving the Carbon Plan and subsequently the Clean Growth Strategy is the identification of the scale of benefits for consumers arising from the UK adopting the wider +/-10% EU voltage tolerances. Western Power Distribution has taken a lead in promoting this finding in discussion with Government, Ofgem, NGC, and through national forums.

LV Network Templates demonstrated that voltage tolerances were within current limits, with greater numbers of networks above the nominal level than below, thus affording the ability to reduce target voltages at the HV level. This action delivers demand and CO₂ reduction, savings on customers' bills, and provides additional voltage headroom for LV Distributed Generation.

As a result of these findings, and subsequent to the publication of the LV Network Templates Close Down Report, Western Power Distribution has been implementing the planned reduction in the voltage levels across all our licence areas. This was initially rolled out in South Wales, which is now 85% complete, before the programme was extended to the other three licence areas.

This is now a WPD modification (MOD1151 Voltage Reduction) and forms part of our regulatory reporting. The most recent figures are presented in Table 2.

DNO	Total Sites	Complete Sites	Outstanding Sites	Percent complete
South Wales	359	306	53	85%
South West	566	218	348	39%
East Midlands	774	149	625	19%
West Midlands	465	303	162	65%

DNO	GWh supplied 2017	Saving	Total Potential GWh Saved	Actual GWh saved
South Wales	11,424	1.13%	129	110
South West	14,041	1.13%	159	61
East Midlands	21,017	1.13%	237	46
West Midlands	24,598	1.13%	278	181

Table 2: MOD1151 Voltage Reduction progress report, Ofgem Regulatory Reporting Pack

¹¹ [Upgrading Our Energy System: Smart Systems and Flexibility Plan](#), July 2017, P13 / [The Clean Growth Strategy](#), Delivering Smarter, More Efficient Energy, P99

At the time of the Close Down Report, it was estimated that for the South Wales region this would save approximately 15.7MW¹² in maximum demand, 41,000¹³ tonnes of CO₂ and save customers £9,421,000¹⁴ per annum off their bills. This financial return alone exceeds the total LCNF funding for LV Network Templates of £8m.

At the time of the close down report it was projected that, if rolled out nationally, in conjunction with the adoption of EU network voltage tolerances (+/- 10%) the savings could be 618MW, £315m per annum and 1.98 million tonnes of CO₂¹⁵. The voltage at supply terminals is defined within UK legislation¹⁶. WPD is leading discussions about how, and when, this potential legislative barrier can be addressed.

LV Network Templates, through the additional DNO Template Validation activities undertaken by analysing both fixed and variable data from an additional 200+ substations across all the other DNOs, demonstrated that the templates were applicable to 82% of all UK networks¹⁷. This result is significantly more than the 50% of GB networks originally anticipated at the time of submission in 2010.

2.2. Releasing network capacity

LV Network Templates concluded that selective voltage reduction in South Wales would reduce peak demands by 15.7MW, equating to a 41,000 tonne carbon saving and £9.4m per annum on customers' bills.

If secondary legislation can be amended to harmonise the statutory limits with those of the EU (+/-10%) and the benefits are extrapolated nationally, that would translate to 618MW reduction in peak demand (equivalent to a 2.5% capacity margin increase, although it was acknowledged this will tend to increase with the closure of generating capacity), equating to 1.98 million tonnes of carbon and £315m per annum off customers' bills.

LV Network Templates finished in July 2013. Western Power Distribution followed up on the potential benefits accruing from voltage reduction with the Voltage Reduction Analysis project, which ran between September 2015 and June 2016. This project demonstrated that the reduction in voltage led to a measurable reduction in demand that, if scaled to the whole of the South Wales area, would equate to a yearly decrease of 131.9GWh, worth approximately £14.9m per annum on customers' bills. This would also save ca. 70,000 tonnes of CO₂ per year¹⁸. In addition, the reduction in maximum demand would release capacity on thermally constrained LV networks, enabling reinforcement to be deferred and creating headroom to enable low carbon technologies to be connected to those networks.

2.3. Delivering Financial Benefits

The projected financial benefits arising from the opportunity to reduce system voltage, identified through the use of the templates developed and validated by LV Network

¹² [LV Network Templates for a Low-Carbon Future | Close Down Report](#) P117

¹³ [LV Network Templates for a Low-Carbon Future | Close Down Report](#) P118

¹⁴ [LV Network Templates for a Low-Carbon Future | Close Down Report](#) P117

¹⁵ [LV Network Templates for a Low-Carbon Future | Close Down Report](#) P118-120

¹⁶ [The Electricity Safety, Quality and Continuity Regulations 2002, 27\(3\)\(b\)](#)

¹⁷ [SDRC Application](#), Section 5

¹⁸ [Voltage Reduction Analysis Close Down Report](#), Executive Summary

Templates, were projected to be £9.4m per annum when implemented across South Wales. Through the follow on project, Voltage Reduction Analysis, this figure became £14.9m per annum.

The learning from LV Network Templates delivered the confidence that Western Power Distribution required to implement the voltage reduction programme across all our licence areas. The current MOD1151 Voltage Reduction figures, reported as part of the annual Regulatory Reporting Pack to Ofgem, record a realised annual electricity consumption reduction of 398GWhs per annum, which is expected to rise to 803GWhs per annum once the rollout programme has been completed.

Applying the average variable unit costs for standard electricity in 2017 for UK licenced distribution areas¹⁹ for Western Power Distribution's areas, the reported energy reduction equates to a realised customer saving of £58.2m per annum, rising to £116.6m per annum once the rollout programme has completed.

2.4. Rollout across the DNO's system and across GB

This submission focuses solely on the additional benefits accruing from what Western Power Distribution considers to be exceptional and the efforts that we are undertaking to realise the benefits for our customers. Other DNOs are also looking at system voltage reduction.

2.4.1. Current implementation of learning within Western Power Distribution

Within Western Power Distribution's own licenced distribution networks we have established voltage reduction programmes within the current statutory limits. Initially this was in the South Wales area (ST:TP50F) in 2014. The success of this initiative has led to WPD extending the programme (ST:TP50G) across our other three areas in 2017. This is completed wherever possible in line with the scheduled maintenance programmes.

Western Power Distribution committed to pursuing voltage reduction in our RIIO-ED1 price control submission. LV Network Templates, which completed in 2013 delivered the confidence to commit to this programme and its deliverability.

The energy saved through this initiative is part of Western Power Distribution's Regulatory Reporting Pack submitted to Ofgem on an annual basis.

As at March 2018 voltage reduction had been completed on 976 networks against the target for that time period of 743. The programme is 45% complete.

This translates to an energy saving of 398GWh²⁰ per annum (equivalent to the electricity consumed by around 100k homes each year), based on 2017 supplied energy volume figures, delivered through the voltage reductions already implemented. The potential saving, once the voltage reduction programme has been implemented across all Western Power Distribution's licence areas, is 803GWh²¹ per annum (equivalent to the electricity

¹⁹ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/624442/table_224.xls

²⁰ MOD1151 Voltage Reduction Report. See Table 2 in this paper.

²¹ For the avoidance of doubt, the 45% of voltage reductions implemented applies to ~50% of electricity supplied through our networks.

consumed by around 200k homes per annum). These figures are recorded in our submissions to Ofgem in the Regulatory Reporting Pack.

2.4.2. Take up across GB

Electricity North West, Northern Powergrid and UK Power Networks are all exploring the potential benefits from voltage reduction on their networks.

2.4.3. Alternative approaches

Western Power Distribution believes that this approach of voltage reduction is complimentary to other innovation approaches to release capacity and therefore should be used in addition to other approaches, not as an alternative.

2.4.4. Dissemination

Recognising the significance of voltage reduction, Western Power Distribution led the formation of the Energy Network Association's Statutory Voltage Limits Group. This group developed and published the ENA Engineering Technical Report 140: Statutory Voltage Limits and customers' terminals in the UK and options for future application of wider limits at low voltage". The report resulted in an industry consultation on moving the UK voltage limits from +10%/-6% to +/-10%. Paul Jewell from Western Power Distribution chaired this working group and is continuing to lead on addressing the points raised from the consultation²² of September 2017 and the need to amend the ESQCR legislation, which is where the UK's voltage limits are specified.

This commitment to share learning and embed it in not just Western Power Distribution's but into the industry's working practices demonstrates our commitment to ensuring the benefits of innovative techniques such as voltage reduction are realised for customers.

2.5. Value for money to Customers

2.5.1. Efficient Use of Funding

LV Network Templates received £8m of funding through Tier 2 of the Low Carbon Network Fund in its first year, 2010. It was one of the smaller innovation projects to receive funding that year.

The approach to minimising the network costs to consumers through LV Network Templates was to identify trial networks that already had densities of low carbon technologies embedded within them. This approach ensured that the project did not have to fund the low carbon technologies or their installation whilst acquiring statistically robust quantitative data on the performance of networks that were already suffering the expected stresses from the progressive adoption of low carbon technologies. In this way, representative results, in which the whole DNO sector could have confidence, were produced.

This was achieved by working with the Welsh Assembly Government (WAG) to build upon their investment of £30m by utilising existing and green-retrofitted properties within the LV Network Templates test networks. This meant LV Network Templates could leverage the

²² [ENA Statutory Voltage Limits Working Group Consultation](#), Sept 2017

WAG's low carbon initiatives 'Arbed' sites, covering 3000 homes, which included 1000 photo voltaic installations. Western Power Distribution also worked with npower so that their customers that were part of the Carbon Emission Reduction Target (CERT) and Community Energy Savings Programme (CESP), and therefore had been provided with microgeneration in their homes, would be part of LV the Network Templates project.

The LCN Funding covered the network operational technologies but leveraged the Welsh Assembly's and npower's investments in low carbon technologies; these were costs that were typically borne by smart grid innovation projects at the time. Through this approach Western Power Distribution was able to deliver a project at a scale that was appropriate to produce meaningful learning, whilst delivering value for money for consumers.

LV Network Templates delivered what was, at the time, Europe's largest smart grid, covering 3000 homes.

LV Network Templates addressed an emerging issue; the of lack of visibility of low voltage networks, and the implications that could have for customers' ability to choose to adopt, and benefit from, low carbon technologies in their homes and businesses connected to those LV networks.

2.5.2. Minimising the Cost of Resource

Western Power Distribution sought to apply best practice to drive best value by minimising the costs of project resources.

The selection of project partners was based on their willingness to contribute to the delivery of the project. This included discounts on standard rates cards for services or operating at cost.

Our approach to selecting and training the installers that would work on the programme was based on delivering the programme cost effectively.

Rather than simply going with the installation of expensive sub-station RTUs, the programme team were creative and chose to install industrial and commercial smart meters in substations to acquire the required data.

In order to improve quality and reduce installation time, Western Power Distribution set up a production line at one of our workshops to mass produce sensor boxes.

2.6. Relevance and timing of project

At the time that LV Network Templates was being developed for Low Carbon Network Funding in 2010, it was becoming increasingly clear, through the UK Low Carbon Transition Plan²³, that electricity networks designed for centralised, high-carbon generation would become increasingly challenged by the progressive adoption of low carbon technologies, the creation of a decentralised supply side, growth in demand and even passive energy

²³ [The UK Low Carbon Transition Plan](#), July 2009

efficiency measures. Each of these changes to the way networks are being used would create different and varied impacts on electricity networks²⁴.

Western Power Distribution recognised that the low voltage networks that distribute electricity to people's homes and small businesses would be the ones that would be most affected by the changing nature of their use, not least because low voltage networks lack the diversity that exists for higher voltage networks. The envisaged challenges at the low voltage level were compounded at the time by the lack of sensors and the associated lack of visibility of these networks. There was, therefore, a lack of data to inform the potential capacity headroom and demand profiles seen by those assets. This meant that the implications for the design and operation of low voltage networks due to the adoption of low carbon technologies were unclear and a matter of growing concern in the DNO sector. This was especially true about how this might impact the DNOs' ability to achieve the European power quality standard EN50160 and meet their regulatory obligations.

Through the targeted deployment of sensors onto networks that were identified as having significant densities of low carbon technologies as well as comparison with some 'normal' networks to provide a control group, Western Power Distribution was able to gain visibility of power flows and voltages for the first time.

This provided Western Power Distribution with the ability to compare the operation of the networks with higher concentrations of low carbon technologies with the operation of networks that were not under low carbon stress. This enabled us to understand the implications of low carbon technology adoption into our low voltage networks and assess the implications for the design and operation of networks that were capable of supporting the Carbon Plan and the Clean Growth Strategy.

Based on the quantitative evidence generated by LV Network Templates, the University of Bath (a project partner) was able to produce a suite of reusable network templates that enable DNOs to inform decisions about investment in smart techniques or network reinforcement, as appropriate, to ensure that customers continue to benefit from the quality and reliability of supply they enjoy today whilst addressing potential barriers to the adoption of low carbon technologies. The templates allow this to be done without the need for installation of what were, at the time, expensive sensors; or identify networks where actual visibility would be likely to deliver a return on that investment.

The learning from LV Network Templates has been adopted into Western Power Distribution's Business as Usual working practices. These include our policy of ST SPKD2 Live Installation of LV Monitoring, which means that consumers benefit from the avoidance of an outage to install monitoring equipment; and policies ST:TP50F 11kV Tap Change Control Settings in East Wales, Cardiff and Swansea Areas and ST:ST50G Reduction of 11kV Tap Change Control Settings.

The understanding of the value of deploying sensors appropriately has led to a demand for sensor technology, which in turn has led to the establishment of a supply chain for sensors,

²⁴http://www.energynetworks.org/assets/files/electricity/futures/smart_meters/Smart_Metering_Benefits_Summary_ENASE_DGImperial_100409.pdf

enabling competitive procurement of this technology, delivering cost benefits that ultimately flow through to the customer. This has led to LV monitoring equipment costs having dropped by around 95% from the costs at the start of the programme to the prices being seen in the current procurement round²⁵.

Whilst LV Network Templates delivered on its core objectives in understanding the impacts of low carbon technology adoption on low voltage networks, Western Power Distribution was able to go above and beyond the core scope by undertaking further validation work to understand the benefit across a wider set of networks. This was achieved through the analysis of data from an additional +200 substations provided by other DNOs. This demonstrated that the templates were applicable to 82% of all GB networks. This result is significantly more than the 50% of GB networks originally anticipated at the time of scoping LV Network Templates. This additional analysis provided a means of engaging with Western Power Distribution's peers and ensuring that the learning from LV Network Templates was both relevant and understood by other DNOs.

Through the application of the LV Network Templates, the potential benefit from voltage reduction became clear. Western Power Distribution has gone significantly beyond the dissemination approach we set out in the full submission for Low Voltage Network Templates. We led the formation of the Energy Network Association's "Statutory Voltage Limits Group that developed and published the ENA Engineering Technical Report 140: Statutory Voltage Limits and customers' terminals in the UK and options for future application of wider limits at low voltage". The report resulted in an industry consultation on moving the UK voltage limits from +10%/-6% to +/-10%. Paul Jewell from Western Power Distribution chaired this working group and is continuing to lead on addressing the points raised from the consultation²⁶ in September 2017 and advocating the need to amend the ESQCR legislation, which is where the UK's voltage limits are specified.

This commitment to share learning and embed it in not just Western Power Distribution's but the industry's working practices demonstrates our commitment to ensuring the benefits of innovative techniques such as voltage reduction are realised for customers across Britain.

2.7. Methodology robustness and project readiness

Low Voltage Network Templates was funded in the first year of the Low Carbon Network Fund and so the management of an unfamiliar innovation programme involving multiple stakeholders beyond the usual DNO stakeholder communities presented new challenges.

In order to build confidence in the deliverability and budget for LV network templates, in preparation for the LV Network Templates submission, Western Power Distribution trialled the installation of a current transformer within an 11kV LV substation in Pontypool. This gave us confidence that the proposed project approach was appropriate, that the budget was adequate and that the project readiness meant that it was deliverable in a timely manner.

²⁵ Note: This is subject to on-going procurement and therefore commercially confidential.

²⁶ [ENA Statutory Voltage Limits Working Group Consultation](#), Sept 2017

Western Power Distribution, recognising the importance of customer experience, went to great lengths in the selection, training and mobilisation of installers. Selection criteria included not just technical competency, but also their strength of the communication skills. Selected installers were also required to undergo a training programme developed for LV Network Templates (necessary due to the installation of the monitoring equipment being novel). Installers were also required to undertake a practical assessment of their competency. Those that were successful were issued with an authorisation for the installation of the monitoring equipment.²⁷

The programme controls put in place around working with the Welsh Assembly Government (WAG) to recruit LV Network participants from the 3000 homes involved in the ARBED low carbon initiatives, including the 1000 photo-voltaic solar generation installations, enabled us to identify that customer engagement needed to be stepped up if LV Network Templates was going to achieve the level of statistical robustness required. A significantly more intensive engagement strategy was adopted, offering incentives and door to door engagement to achieve the levels of participation required if LV Network Templates was to deliver statistically robust results.

Being an early innovation project, LV Network Templates delivered significant learning around customer engagement. This insight, along with learning from other projects, has informed Western Power Distribution's approaches to customer engagement. We believe that this is evidenced by Western Power Distribution consistently being ranked to the top of Ofgem's Stakeholder Engagement and Customer Vulnerability Incentive²⁸.

Follow on Projects

LV Network Templates informed a number of follow on innovation projects, these include:

- SoLa BRISTOL.
- Electric Nation
- Connect and Manage
- FREEDOM
- Voltage Reduction Analysis
- LV Sensors (in collaboration with UK Power Networks)
- OpenLV

2.8. Other Benefits

LV Network Templates established that, as a result of voltage reduction there is an associated drop in losses. This analysis of the losses was undertaken at the request of the Energy Network Association's Statutory Voltage Limits Group.

²⁷ [LV Network Templates for a Low Carbon Future | Close Down Report](#), P35

²⁸ https://www.ofgem.gov.uk/system/files/docs/2017/11/decision_on_riio-ed1_stakeholder_engagement_and_consumer_vulnerability_incentive_2016-17_-_dnos.pdf

3. Criterion B: Additional Investment of DNO's Own Money

Western Power Distribution made an additional investment of £294.5k to ensure the project could successfully deliver vital industry learning. Further details have been included below.

3.1. Details and significance of DNOs additional contribution

Western Power Distribution procured spectrum and antennae for use in delivering LV Network Templates.

This equated to an additional contribution of £294.5k, the majority of which was for the use of spectrum during the period of the project.

The decision to deliver this as additional funding was based on the spectrum having the potential to be used for other applications beyond LV Network Templates itself.

3.2. Issues that justified the additional contribution

For a programme with the geographic scale of LV Templates it was judged to be important to have a reliable and resilient communications network for the acquisition of the project data.

3.3. Demonstrable benefits to customers

Throughout this submission Western Power Distribution has sought to demonstrate the benefits that LV Network Templates delivered to customers are applicable beyond the trial areas and can deliver benefits to customers across the UK when some of the project methods are deployed nationally.

The communication networks, established through the additional funding from Western Power Distribution, delivered the resilient communications required for trial data to be acquired reliably and in a timely manner. The comms network was integral to the success of the project.

4. Criterion C: Exceptional Efforts

The project team undertook exceptional effort to generate valuable learning from all aspects of the project, which was significantly more than expected at the FSP stage. This learning has been systematically captured and disseminated for the good of all DNO customers as described over the next three sections.

4.1. Demonstrate where the project has delivered more learning than was expected

LV Network Templates has delivered outcomes of quality and value significantly in excess of those envisaged in the submission, and achieved this within timescale and budget.

- The Templates concept has been proven to have applicability to some 82% UK networks, which is significantly higher than the level of 50% anticipated at full submission. The other DNOs have actively engaged with the project, resulting in a widespread validation exercise and development of a Classification Tool, neither of which was included in the submission.
- The project identified a circa 20% increase in available capacity headroom based on the design approaches that existed at the time. This capacity can be released for connection of LV PV. This 20% capacity release arises from a combination of the existing design rules using international PV output ratings not appropriate for UK solar levels and from inefficient panel orientation. This has been disseminated to Government and the Solar Industry and has been implemented into Western Power Distribution's network planning activity with consequent cost benefit to customers.
- The voltage monitoring part of the project identified the potential benefits from reducing the voltages on networks. WPD has established a business as usual rollout programme to deliver these considerable benefits for consumers.

4.2. Additional learning as a result of exceptional effort of the DNO

There are 2 areas that Western Power Distribution delivered through exceptional efforts. These were:

- The applicability of LV Network Templates to 82% of networks (significantly greater than the level envisaged at submission in 2010) was only achieved through effort that was significantly greater to that envisaged at the outset of the project. The DNO Template Validation exercise involved convincing other DNOs to give access to both their fixed and variable data. This work was necessary for other DNOs to adopt the Network Templates and was carried out at no additional cost to the project. This further validation presented an unparalleled opportunity to further share and validate the templates' suitability for application. Much of this validation using data from other DNOs was undertaken after the original LV Networks close down report was complete, so this submission contains the first formal record of the work and its findings.
- The second area where Western Power Distribution has gone above and beyond is the dissemination of the benefits of voltage reduction. Voltage reduction can make a significant contribution to releasing capacity on constrained networks, to reducing electricity consumption, and consequentially reducing both CO₂ emissions and bills.

Western Power Distribution led the formation of the Energy Network Association's Statutory Voltage Limits Group, which developed and published the ENA Engineering Technical Report 140: Statutory Voltage Limits and customers' terminals in the UK and options for future application of wider limits at low voltage". The report resulted in an industry consultation on moving the UK voltage limits from +10%/-6% to +/-10%. Paul Jewell from Western Power Distribution chaired this working group and is continuing to lead on addressing the points raised from the consultation²⁹ of September 2017 and the need to amend the ESQCR legislation, which is where the UK's voltage limits are specified.

4.3. Exceptional capture and dissemination of learning in a way that maximises value for all customers

- In the case of undertaking the DNO Template Validation exercise, it presented an unparalleled opportunity to engage and collaborate with Western Power Distribution's peers in the DNO sector. The exercise provided a platform through which awareness of the learning from LV Network Templates could be raised and understanding the challenges of its wider applicability across the UK established and addressed.

Through the validation exercise, the applicability of the Network Templates approach to 82% of UK networks has been proven and other DNOs have had an opportunity to assess how they can use the learning.

- Western Power Distribution is committed to transferring successful innovations into business as usual. We have published three policies based on the learning from LV Network Templates. Two of these facilitate the rollout of voltage reductions and the other covers the live installation of the sensors, minimising disruption to customers' supplies. MOD 1151 Voltage Reduction Progress Report is part of our annual Regulatory Reporting Pack, providing visibility of the progress we are making in realising the benefits of LV Network Templates for our customers and raising awareness of the opportunity with other DNOs.

Western Power Distribution is also working to embed voltage reduction in the industry working practices. We led the formation of the Energy Network Association's Statutory Voltage Limits Group, which developed and published the ENA Engineering Technical Report 140: Statutory Voltage Limits and customers' terminals in the UK and options for future application of wider limits at low voltage". The report resulted in an industry consultation on moving the UK voltage limits from +10%/-6% to +/-10%. Paul Jewell from Western Power Distribution chaired this working group and is continuing to lead on addressing the points raised from the consultation of September 2017 and the need to amend the ESQCR legislation, which is where the UK's voltage limits are specified.

This rollout of the voltage reduction programme has already delivered reported reductions in electricity consumption of 398GWh per annum (equivalent to the electricity consumed by around 100k homes each year), based on 2017 supplied energy volume figures. This reported energy reduction equates a saving for customers of

²⁹ [ENA Statutory Voltage Limits Working Group Consultation](#), Sept 2017

£58.2m per annum based on the average variable unit costs for standard electricity in 2017 for Western Power Distribution's areas.

- LV Network Templates established that there was a circa 20% increase in capacity headroom available for connection of LV PV. This is because the output from panels was over-rated due to a combination of using international output ratings not appropriate for UK solar levels and through sub-optimal panel orientation. This has been disseminated to Government and the Solar Industry and has been implemented into Western Power Distribution's network planning activity with consequent cost benefit to customers.

This information was shared widely, including being shared with the DECC Solar PV Strategy Task Force (Grid sub group meeting Victoria St 4/11/2013) and the BRE National Solar Centre.

