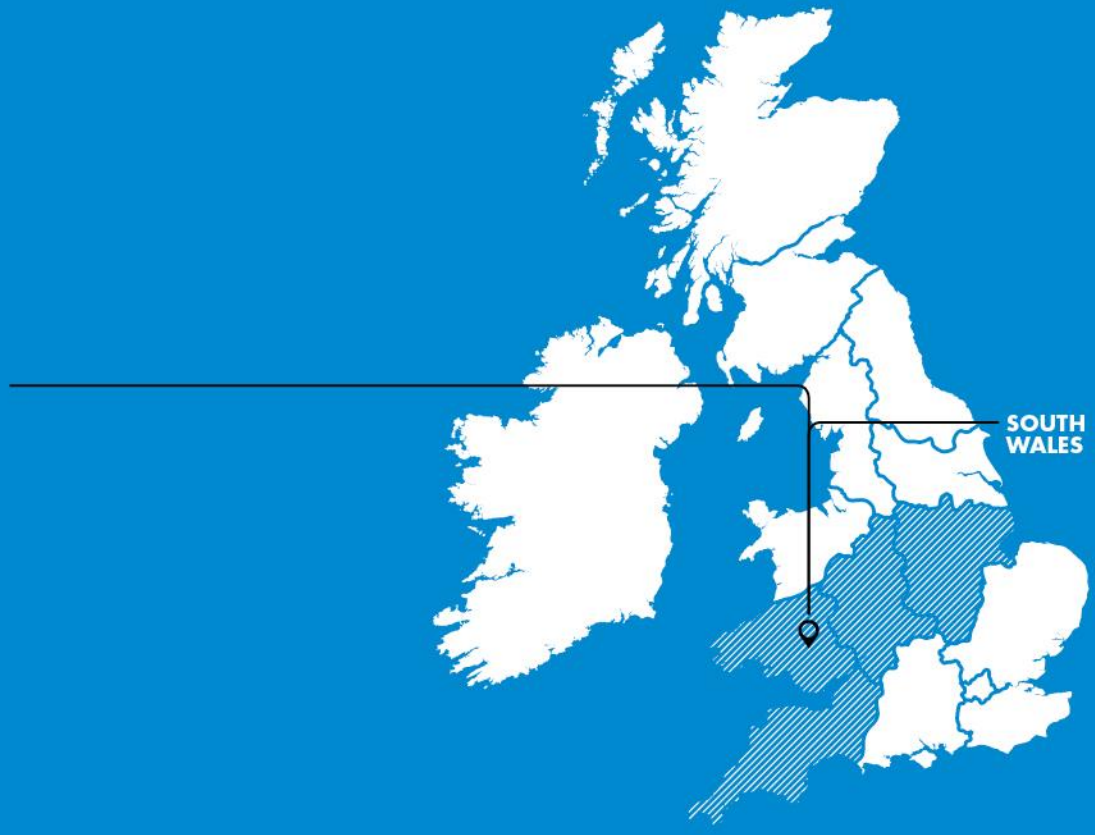
WESTERN POWER DISTRIBUTION

NETWORK TEMPLATES

LV NETWORK TEMPLATES FOR A LOW-CARBON FUTURE

Second Tier Reward

Panel Presentation



LCN Fund Low Carbon Networks

Llywodraeth Cymru Welsh Government

npower

University of Bath

imagination at work

passivenergy

Introductions

Roger Hey is Western Power Distribution's Future Networks Manager

Paul Jewell is Western Power Distribution's Policy Manager

Mark Dale is a Western Power Distribution Innovation Engineer

Richard Hampshire is CGI UK's lead for Future Utilities

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General | Q1

1. Please tell us, what are the exceptional outcomes from your project **(max 3)**? Please emphasise the truly exceptional outputs and/or transformational impact of project outputs on GB electricity networks? **(making clear comparison with what was expected at time of Project Direction)**

Link to the submission and key themes:

1. Proved that the approach was applicable to 82% of GB networks
   - Submission was a 50% applicability
   - 82% was achieved through collaboration with other DNOs, who shared their network data allowing other network types to be tested and validated
2. Identified that network design approach was conservative, enabling ~20% capacity to be released.
   - FSP identified potential benefits from deferral of network investment through the use of the templates to identify available 'headroom' without the need to invest in network monitoring
   - The opportunity to release ~20% of capacity allowed in network design for PV was an additional project finding
   - LV Network Templates established that design assumptions based on manufacturers' stated outputs were overly conservative, enabling additional network capacity to be released, enabling additional connections without the need for reinforcement.
3. This programme has already delivered reductions in electricity consumption of 398GWh / £58.2m per annum (equivalent to the electricity consumed by around 100k homes each year), based on 2017 supplied energy volume figures.
   - The opportunity to operate networks at lower voltages, and the associated energy savings, was an additional benefit identified through the project
   - The original submission assumed the annual energy saving would be £1.19m in 2022/23

General | Q2

2. How has the project changed the culture of innovation in your organisation? Provide evidence of this change.

LV Network Templates informed the approach to and culture of innovation in the following ways:

- Innovation focused on delivering changes to 'Business as Usual' to benefit of customers
  - Organisational structure
    - Innovation team aligned with Policy team. Policy engineers involved in innovation projects from the outset
      - Ensures innovation project approach remains aware of BaU integration challenges, and
      - Policy engineers, who own changes to BaU, have an opportunity to influence the project outcomes
      - Facilitates early adoption of emerging learning into business as usual
        - Example: Implementation of changes to PV profiles into Windebut planning tool
- Extending time allowed for project design and construction phases
  - Enables greater consideration of customer impacts and approaches to minimise these
    - Example: Implementation of alternative approach to LV monitoring, avoid need to isolation of supply
- Importance of effective customer engagement
  - Example: use locally trusted 3rd party specialists

General | Q3

3. How has this Second Tier Reward incentive influenced your project management and operational practices? Provide evidence.

The Second Tier Reward incentive influenced our approach to the projects as follows:

- Whilst Second Tier Successful Delivery Reward mechanism ensured delivery of the project, the Second Tier Reward incentive ensured the project approach supported delivery into 'Business as Usual'
- This led to the following changes to delivery approach:
  - WPD linked Policy, Strategy and Innovation teams
  - Policy engineers involved in innovation projects from the outset
    - This was to ensure that the project approach remained aware of BaU integration challenges and
    - Policy engineers, who would own changes to BaU, had an opportunity to influence and understand the project outcomes

LV Network Templates example:

- Windebut PV profiles were updated in BaU before project end because of the involvement of policy engineers in the project from the outset.

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General | Q4ai

4. Please detail any datasets/other IP, generated as part of the project, that has been shared with other DNOs, academia? What efforts did you take to improve access and usability of any such data for interested users (over and above what was proposed in your original full submission and any subsequent project directions, if applicable)?

Organisation(s)	Data used	Purpose	Date
Bath University	Load data, network connectivity, customer profiles for primaries around Bath	The use of this data is only permitted for use by the licensee to Model the consumption of the city of Bath for the final year project of Joshua Olaleye.	14/05/2018
Centre for Sustainable Energy	LV Network Templates LV voltage and current data	The assessment of ways in which large datasets can be handled including data mining and large scale analytics. Analysis for temporal patterns	29/08/2013
EA Technology Open LV	Falcon and LVNT	The data is provided to inform the process of selecting substations to be used for different techniques within the Open LV project. The data will enable selection of substations with particular attributes and also analysis of the whole population of distribution substation types to ensure the substations selected form a broadly representative sample from which wider conclusions can be inferred	25/01/2017
Element Energy	LV Network Templates LV voltage and current data	Use in developing and modelling typical electricity network archetypes within the ETI multi-vector integration project.	21/09/2016
Energy Systems Catapult /Barringa / Bridgend Council	Various data including LVNT for substations in Bridgend	Various modelling activities to support the development of the Energy Path Operations tool.	21/07/2017

General | Q4aii

4. Please detail any datasets/other IP, generated as part of the project, that has been shared with other DNOs, academia? What efforts did you take to improve access and usability of any such data for interested users (over and above what was proposed in your original full submission and any subsequent project directions, if applicable)?

Organisation(s)	Data used	Purpose	Date
Energy Savings Trust, UCL	Various sets of load data and customer information	To support the development of the EDAM 2 tool for creating regionalised load estimates and forecasts for National Grid. Data will only be passed on to National Grid in the form of aggregated archetypes which will contain no Persona Data. Work will be in collaboration with University College London who will be subject to a separate data sharing agreement.	14/10/2014
Heriot Watt University	Solar Storage Data	To establish how battery storage can both support grid requirements and demonstrate the capability to shift renewable electricity usage away from solely generation hours, in order to assess the effectiveness of this technology to reduce exposure to network fluctuations and market volatility.	19/12/2017
Loughborough University	'Early Learning of LV network Impacts From Estate PV Cluster' (Crickhowell)	Research, development and validation of high-resolution models of electricity demand, distributed generation and their operation in low-voltage networks including the right to use in research projects funded by third parties.	01/04/2014
National Physical Laboratory	LV Network Templates LV voltage and current data	Supporting the NPL project "Verification of Carbon Savings for Smart Infrastructure".	18/12/2013
Oxford University – Stephen Haben	LV Network Templates LV voltage and current data	Evaluating load profiles for substations dominated by domestic load.	23/01/2017

General | Q4aiii

4. Please detail any datasets/other IP, generated as part of the project, that has been shared with other DNOs, academia? What efforts did you take to improve access and usability of any such data for interested users (over and above what was proposed in your original full submission and any subsequent project directions, if applicable)?

Organisation(s)	Data used	Purpose	Date
Reading University	LV Network Templates LV voltage and current data	[Work for SSE regarding their New Thames Valley Vision LNCF project]	03/10/2013
Ricardo – Proteus LV	LV Network Templates LV voltage and current data	[E.g. the assessment of ways in which large datasets can be handled including data mining and large scale analytics.] Review the data to examine the number of instances when voltages, currents and temperatures approach equipment or Statutory limits. This information will be used to inform the business case for a NIC project investigating ways of reducing network constraints.	22/06/2016
University of Southampton - JUICE	LV Network Templates LV voltage and current data	As input to a model of a PV farm with battery storage that the student is developing. This is part of the PhD project, undertaken within the scope of the Joint UK India Clean Energy Centre (JUICE), titled 'Interplay between Environmental Objectives for Renewable Energy Co-Located Storage Systems.'	16/10/2017
UKPN via LIG (David Hawkins)	LV Network Templates LV voltage and current data	Validation of Photovoltaic connection assessment tool (LCNF project UKPNT1004)	07/02/2014
UPL (Utility Partnership Limited)	LV Network Templates LV voltage and current data	Data required to support the 3-year collaborative European Commission Project known as 'Mas2tering' – Multi Agent Systems and Secured Coupling of Telecom and Energy Grids for Next Generation The data is to be used for modelling the Low Voltage electricity network to determine the impact of Low Carbon Technologies and potential developments to improve network operation such as demand side management and increasing the flexibility of networks through greater interconnectivity and automation.	27/01/2015

General | Q4b

4. Please detail any datasets/other IP, generated as part of the project, that has been shared with other DNOs, academia? What efforts did you take to improve access and usability of any such data for interested users (over and above what was proposed in your original full submission and any subsequent project directions, if applicable)?

- The Classification Tool developed as part of LV Network Templates has been made available to all DNOs

Project Specific | Qi

i. Please explain your specific additional efforts in increasing the applicability of the network templates to 82% of the GB distribution networks as against the anticipated 50%?

- LV Network Templates was conducted on a specific set of networks in South Wales
  - These were anticipated to provide validated templates that would be applicable to 50% of GB networks
- Other DNOs were requested to, and did, provide fixed data on a sample of their monitored sub stations
  - The provided data was fed into the classification tool and the results checked against actuals for accuracy
  - This established that the network templates created through the investment in LV Network Templates could be applied to the wider range of network types, covering 82% of GB networks
  - The Final Classification Tool was made available to all DNOs

Project Specific | Qiia

ii. The effect of voltage reduction on demand has been known for a long time. How has this project brought a significant change/addition to this existing knowledge?

- Whilst the physics associated with voltage reduction is understood, the accepted industry practice has been to operate demand led networks at the upper end of the voltage ranges
  - mixed demand and generation networks need a lower set point within the statutory voltage limits
- LV Network Templates provided an opportunity to challenge the accepted practice and study the impact of operating networks at voltages more centrally within the statutory voltage limits
  - The project provided both short term and long term data sets on the performance of a range of networks operating at reduced voltages
- LV Network Templates provided the confidence to operate networks at more central voltages as 'Business as Usual' practice, with the additional benefit of creating capacity that enables the connection of additional low carbon technologies, supporting the Carbon Plan.
- The ENA Engineering Technical Report 140 on "Statutory Voltage Limits at customers' terminals in the UK and options for future application of wider limits at low voltage" can be found here:
  - http://www.energynetworks.org/assets/files/ENA-17-01%20Statutory%20Voltage%20Limits%20consultation%20pack.zip

Project Specific | Qiib

ii. The effect of voltage reduction on demand has been known for a long time. How has this project brought a significant change/addition to this existing knowledge?

- LV Network Templates established:
  - A statistically significant reduction in demand was associated with sub-stations that had changes in 11kV AVC settings
  - No significant change was found in substations without the changes in settings
  - The reduction was estimated to be 1.16% in average demand
    - This was established to be robust to changes in the temporal resolution used for the analysis
  - Using the methodology established in the LVNT project ,a 1.16% reduction would equate to an estimated reduction of 132GWh over a year, worth £14.9 million p.a. if all substations in South Wales were changed.
  - There was also a significant drop in average reactive power demand of approximately the same magnitude
  - A statistically significant drop of 1.13% in Maximum Demand was also found

Project Specific | Qiii

iii. Please provide detail on the usage of network templates by DNOs (provide supporting evidence). How widespread is their use and what is the enduring value of these going into the future?

- Other projects within WPD
  - Open LV sub station selection
  - Electric Nation NAT development
  - Project FALCON used Templates to validate load estimations by EST
  - All WPD sub stations now mapped to the 10 Templates
- UKPN – Validation of PV LCNF UKPNT1004
- Data shared with SPEN
- Classification Tool made available to all DNOs
- All DNO's provided data to enable the development of the classification tool
- Other DNOs cite LV Network Templates in their losses strategies:
  - SPEN: https://www.spenergynetworks.co.uk/userfiles/file/SPEN_Revised_Losses_Strategy_Final_Issue_1.pdf (5.2.2, 5.2.5 P19)
  - ENWL: https://www.enwl.co.uk/globalassets/about-us/regulatory-information/documents/public-information/losses-strategy---april-2015.pdf (5.6, P30)

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Project Specific | Qiv

iv. Please explain further your exceptional effort in promoting the findings from this project (as distinct from what was proposed in your final submission)?

- National Grid workshops visibility embedded LV PV & national voltage reduction 3rd Oct 2013
- National Grid presentation PV Forecasting Methods 6th Oct 2013
- DECC UK Solar PV Strategy Task Force arranged by ENA 4th Nov 2013
- ENA DG Technical Forum 24th Oct 2013
- Leadership of the ENA Voltage Reduction group
- Papers submitted:
  - Quantification of Low Voltage Network Reinforcement Costs: A Statistical Approach May 2013
  - Understanding LV Network Voltage Distribution – UK Smart Grid Demonstration Experience, 2015
  - Development of Low Voltage Network Templates:
    - Part 1 – Substation Clustering and classification, 2015
    - Part 2 – Peak load estimation by clusterwise regression, 2015
  - Load Profiling on Time and Spectral Domain: From Big Data to Smart Data, 2015
  - Bath University: Big Data Analytics for Flexible Energy Sharing (article), June 2018

Project Specific | Qv

v. Please comment on the stated customer savings of ~£60m per annum (that can rise to ~£116m per annum by the end of ED1 period) attributable to this project.

a. Are these net benefits (i.e. net of any other related costs that will be needed elsewhere on your network)?

b. Have you considered any of the system costs associated with voltage reduction at LV if it is rolled out widely?

c. Can you identify and quantify these in case of rollout across WPD and more widely across GB?

a. The stated customer savings of ~£60m pa rising to ~£116m pa be end ED1 are net benefits

- This has been achieved through the implementation approach of undertaking the works as part of scheduled maintenance cycles. The work involves changing settings on control panels that are checked/set as a part of the normal protection maintenance task. Costs associated with achieving these savings are therefore marginal.

b. System costs are considered in the ENA consultation and associated Engineering Technical Report 140 (July 2017) on "Statutory Voltage Limits at customers' terminals in the UK and options for future application of wider limits at low voltage", which can be found here:

- http://www.energynetworks.org/assets/files/ENA-17-01%20Statutory%20Voltage%20Limits%20consultation%20pack.zip

c. Costs associated to roll-out:

- The ENA report states: "Most DNOs would complete the task to reconfigure as a part of other planned protection system works and would take up to three years to complete."
- The ENA group and its DNO reps expected that this could be accommodated within other tasks and costs were not significant.

Project Specific | Qvi

vi. Why was reliable communications infrastructure not included as part of original project plan, if critical to successful delivery of project?

- This was the first LCNF project that involved mass data collection and transfer.
- The project planning assumption was that the proven approaches to communication for data collection at higher voltages could be applied to low voltage networks
- LV Network Templates established that LV data collection had additional communications requirements
  - the collection of data from a whole set of distribution substations is very different from a comms network feeding distribution substations.
  - At primary level WPD has 1600 sites
  - At distribution level we have 200,000, so the scale of the challenge is fundamentally different
  - Comms requirements before this time were for automation that could be moved to the “next sub along” if the signal was poor
  - This is not an option when 100% coverage was required
- LV Network Templates helped to establish the understanding of and identify the communication requirements for LV networks and how these differed from the experience at higher voltages.
  - This provided important learning that has informed all future projects

Summary

- LV Network Templates delivered what was, at the time, Europe's largest smart grid, covering 3000 homes.
  - This was possible through the choice of the trial area, which was benefiting from £30m of Welsh Assembly low carbon funding, effectively enhancing the £8m award from the Low Carbon Network Fund
- Established that the approach was applicable to 82% of GB networks
- Identified that design approach was conservative, enabling ~20% PV design capacity could be released
- 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
- Western Power Distribution led the formation of, and chaired, the Energy Network Association's Statutory Voltage Limits Group

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Thank You

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