WESTERN POWER DISTRIBUTION

INNOVATION

NEXT GENERATION NETWORKS

Voltage Reduction Analysis

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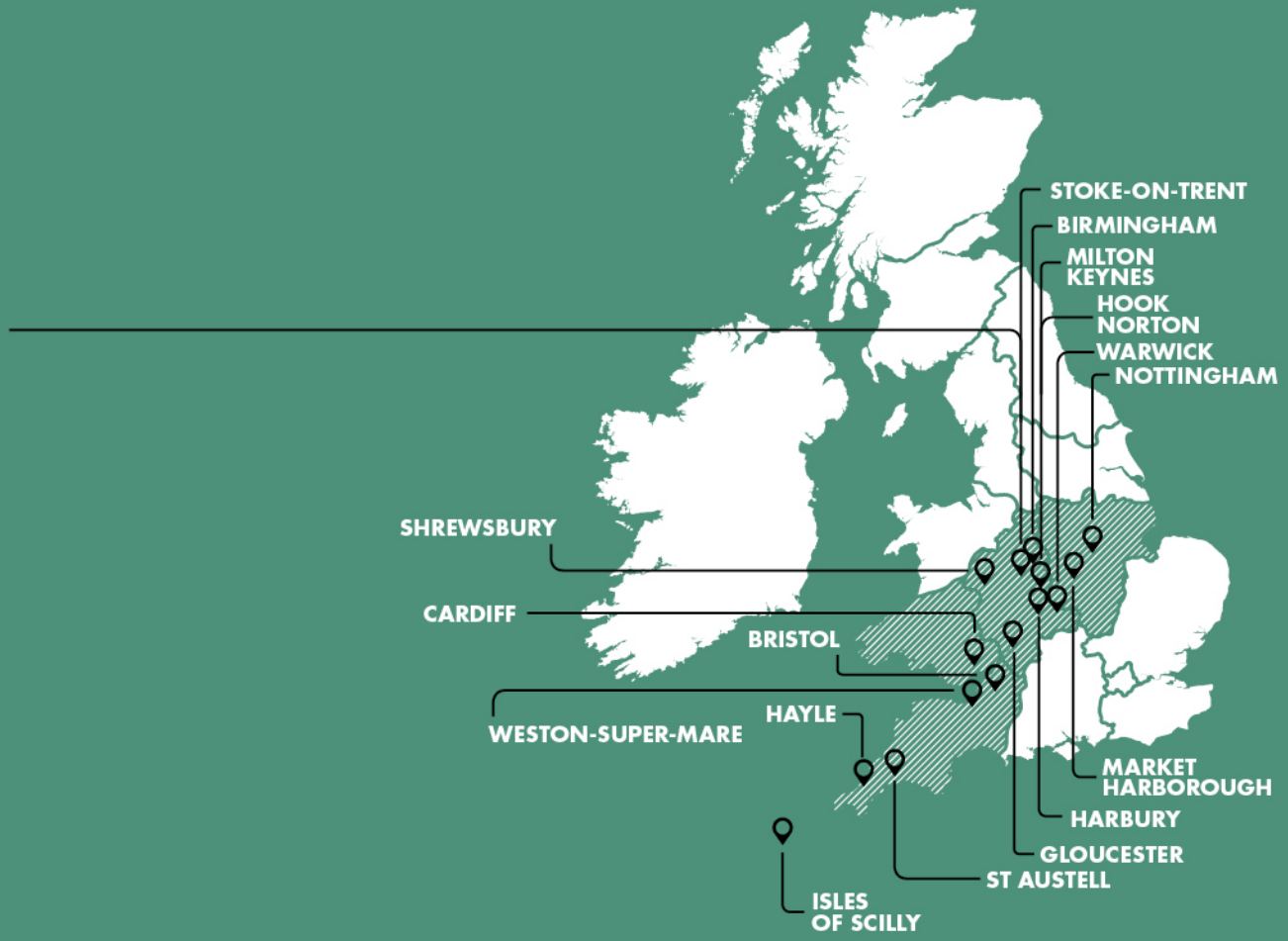


Outline

Overview of project and results (30 min)

- Summary of Low Voltage Network Templates Project
- Voltage Reduction Project
- Demand Analysis Results
- Voltage Analysis Results
- Future Applications

Questions (30 min)

- Please email all questions to: wpdinnovation@westernpower.co.uk

Low Voltage Network Templates
LVNT

LV Network Templates Overview

What we said we would do

- The main aim of the LVNT Project was to provide visibility of the LV Network by monitoring at both the substation and the associated feeder ends. In addition to this, data on installed Low Carbon Technologies, particularly PV installations, was incorporated to identify stresses caused, and voltage headroom available.

What we did

- Successful installation of 824 substation monitors giving detailed load profiles, and 3600 voltage monitors at feeder ends giving detailed voltage profiles.

Results from Templates

- Currently voltage sits at the top end of statutory limits, with very few excursions, especially for under voltage.
- If Target voltage was reduced from 11.4kV to 11.3kV (reduction of 0.88%), we could reduce energy consumption and therefore Customer bills by a calculated £9.4m each year, based on unit charges at the time (2013).

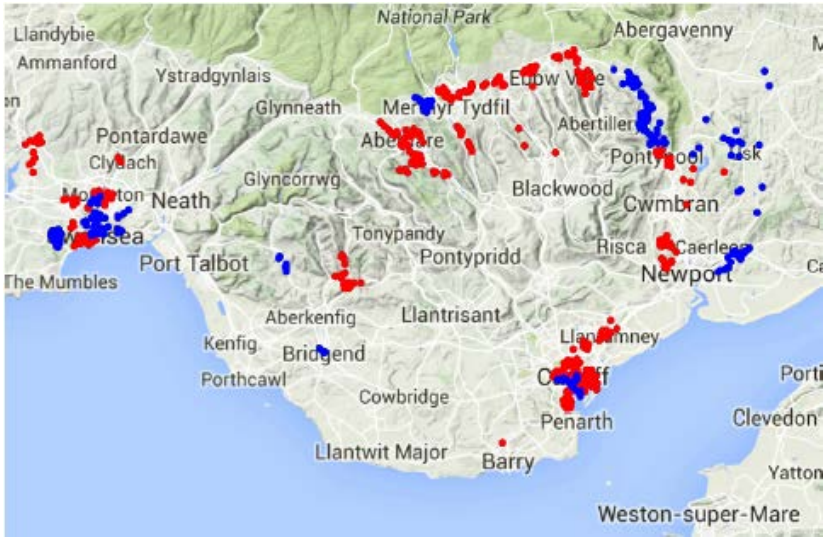
Changes following LVNT

- Policy **ST:TP50F** was written on 11kV Tap Change Control Settings in East Wales, Cardiff and Swansea Areas.
- The changes were made at Primary Sub-station level, reducing from 11.4 kV (+/- 200V) to 11.3 kV (+/-165V) and were made in a selection of substations in the South Wales area in the latter part of 2014.
- The aim of the VRA project was to determine whether the change in 11kV AVC settings in South Wales has had an effect on demand and voltage.

Voltage reduction analysis project

Data

- 10 minute average data from 2014-2015 was used from the LVNT monitoring network.
- Over 600 substations
  - 50m data points for demand
  - 50m data for voltage.
- Demand data was weather corrected and sense checked to remove outliers.
- Over 2000 feeder ends
  - 100m data points for voltage.

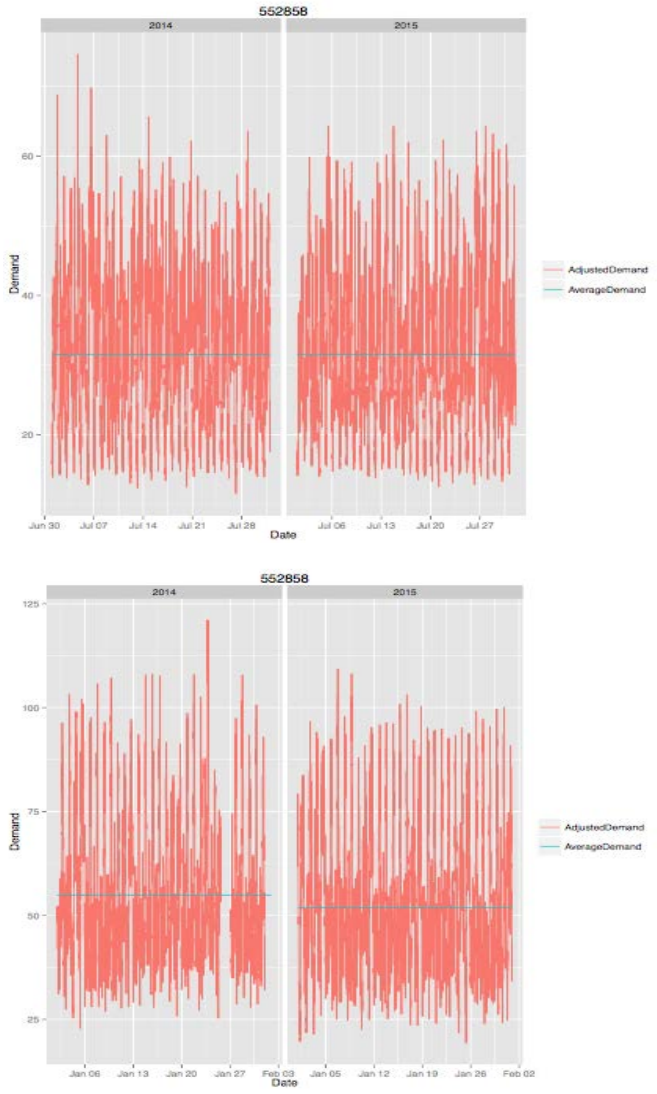


Substations with voltage change
Substations without voltage change

Demand Analysis

Statistical analysis

- Paired analysis.
- Compare differences between the average monthly demands for each individual substation.
  - before and after change in settings.
- Sub-analyses were performed for selections of substations based on their characteristics.



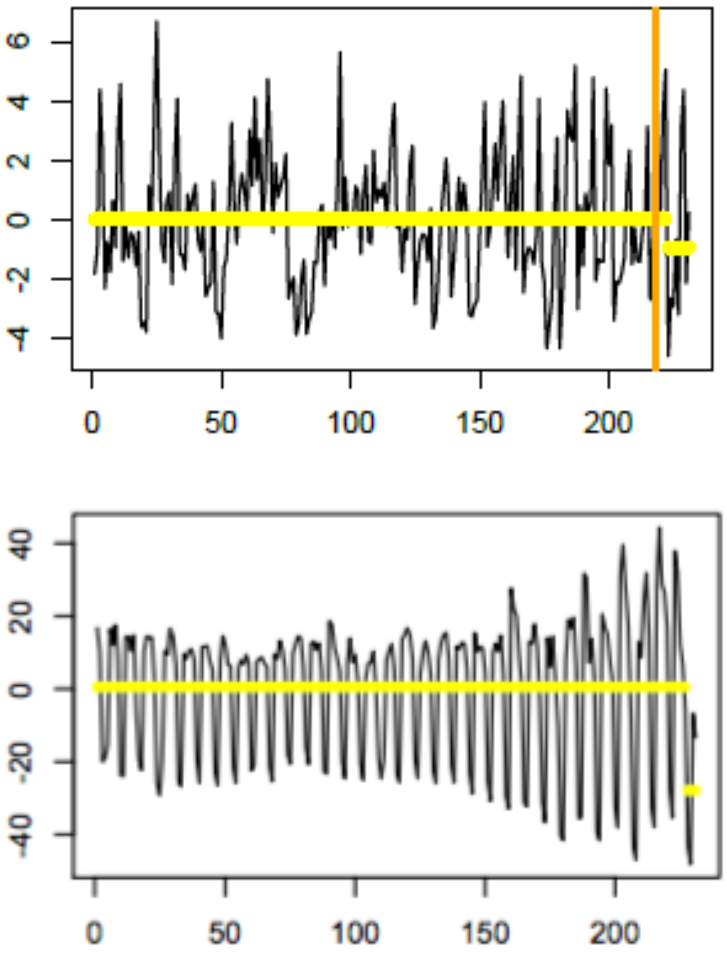
Average Demand Results

- Reductions in average demand (equivalent to consumption) were statistically significant for all months, expect May and July.
- Reductions were greater in the winter months.
- Substations without a change did not show a clear pattern of reductions.
- Results were the same for both daily and monthly analyses.

Month	% difference	P-value
January	1.40	0.00
February	0.97	0.00
April	1.53	0.01
May	0.13	0.39
June	1.48	0.00
July	0.70	0.08
August	1.13	0.01
September	0.91	0.04
October	3.77	0.00
November	1.58	0.00
December	1.70	0.00

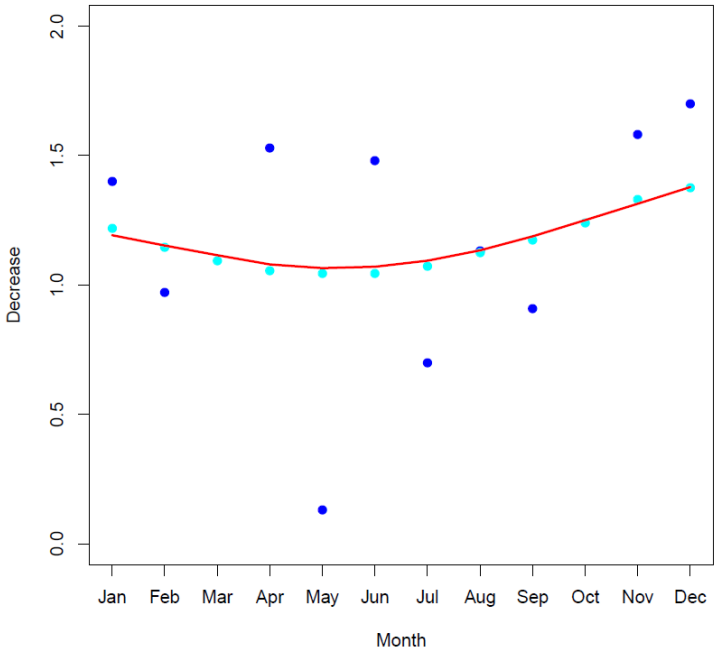
Change point analysis

- Can we detect underlying changes in demand without knowledge of when settings may have changed?
- Statistical change-point models.
- Change-points found
  - within a week of the specified dates: ~60%
  - Using data from at least 2 months before and after changes: ~75%.
- ~10% false positives.



Average Demand Results

- Statistically significant reduction in average demand
- Change backed up by change point models
- An average reduction of 1.16%
- Worth approx. £14.9 million per annum across South Wales



Maximum Demand Results

- Reductions in Maximum demand were statistically significant for all months, expect May and July.
- Reductions were greater in the winter months.

	Mean of substation maxima 2014 (kW)	Mean of substation maxima 2015 (kW)	Mean of difference (kW)	p-value	Percentage drop
Dec, Jan, Feb	161.00	159.20	1.83	0.00	1.13
Apr, May	100.30	99.86	0.43	0.13	0.43
Jun, Jul, Aug	98.04	97.37	0.67	0.03	0.68
Sep, Oct, Nov	119.20	117.50	1.65	0.00	1.38

Reactive Power Demand Results

Month	Mean 2014 (kVAr)	Mean 2015 (kVAr)	Mean Difference (kVAr)	Percentage difference	p-value
January	14.96	13.67	1.29	8.62	0.00
February	13.80	12.63	1.16	8.44	0.00
April	10.05	9.48	0.56	5.60	0.04
May	10.66	9.77	0.89	8.35	0.00
June	12.61	11.45	1.16	9.20	0.00
July	13.52	12.36	1.16	8.59	0.00
August	11.70	10.89	0.81	6.95	0.00
September	12.35	11.18	1.17	9.48	0.00
October	13.26	12.39	0.86	6.52	0.00
November	12.83	12.06	0.77	6.02	0.00
December	12.73	12.23	0.49	3.89	0.00

Voltage Analysis

Substations

- Paired analysis
  - Substation
  - Feeder end
- Clear pattern in reductions with voltage change.
- Significant reductions seen for substations that had the change in voltage settings.
- Seen at both substation and feeder ends.

Month	Substations without a Voltage change	Substations with a Voltage change
	% decrease	% decrease
January	0.11	0.52
February	0.23	0.46
April	0.07	0.42
May	0.14	0.62
June	0.09	0.52
July	-0.17	0.62
August	-0.15	0.55
September	-0.07	0.52
October	-0.14	0.31
November	0.06	0.24
December	0.24	-0.08

Feeder ends

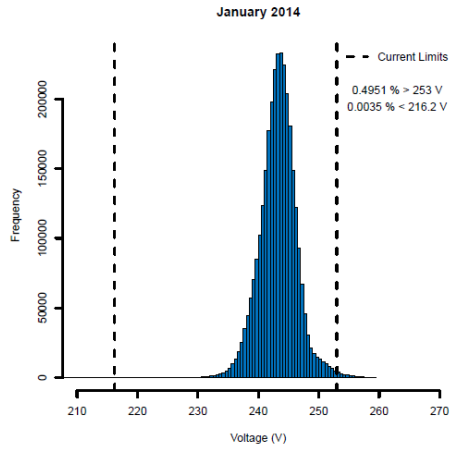
- Paired analysis
  - Substation
  - Feeder end
- Clear pattern in reductions with voltage change.
- Significant reductions seen for substations that had the change in voltage settings.
- Seen at both substation and feeder ends.

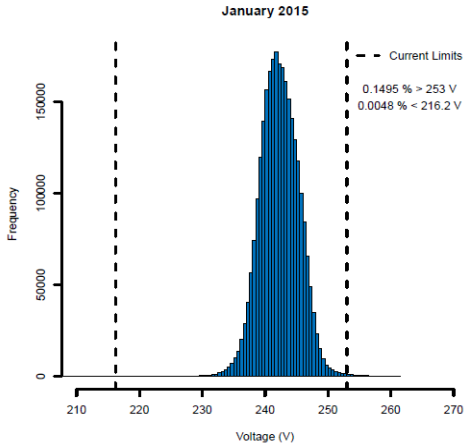
Month	Substations without a Voltage change	Substations with a Voltage change
	% decrease	% decrease
January	0.14	0.56
February	0.28	0.44
April	0.08	0.33
May	0.08	0.35
June	0.16	0.31
July	-0.12	0.34
August	-0.06	0.34
September	0.04	0.38
October	-0.04	0.19
November	0.18	0.14
December	0.24	-0.10

Voltage distributions - Substations

- Overall there were very few excursions
  - Very small proportion of under excursions

- Examples: January 2014 and 2015
  - Over excursions
    - January 2014: 0.4951%
    - January 2015: 0.0004%
  - Under excursions
    - January 2014: 0.1495%
    - January 2015: 0.0048%

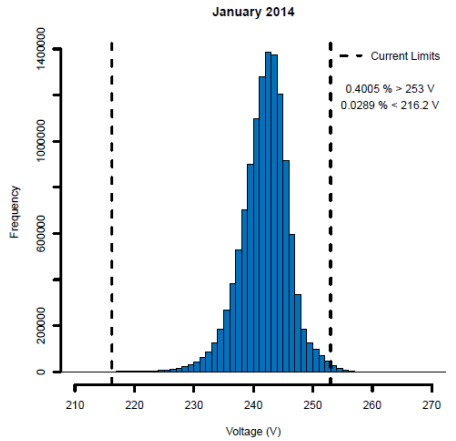


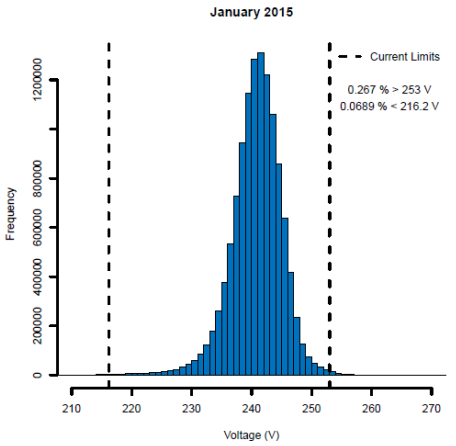


Voltage distributions – Feeder ends

- Overall there were very few excursions
  - Very small proportion of under excursions.

- Examples: January 2014 and 2015
  - Over excursions
    - January 2014: 0.4005%
    - January 2015: 0.0289%.
  - Under excursions
    - January 2014: 0.2670%
    - January 2015: 0.0669%.

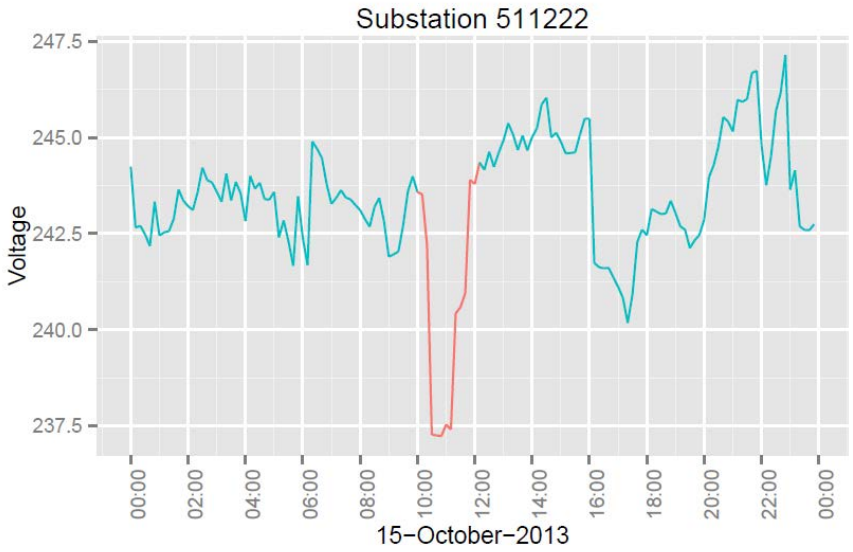


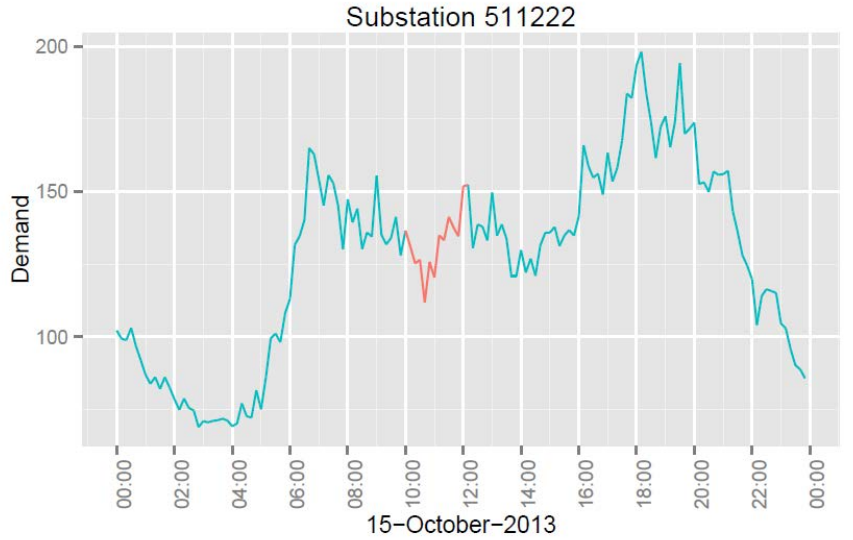


Operation Juniper

Voltage

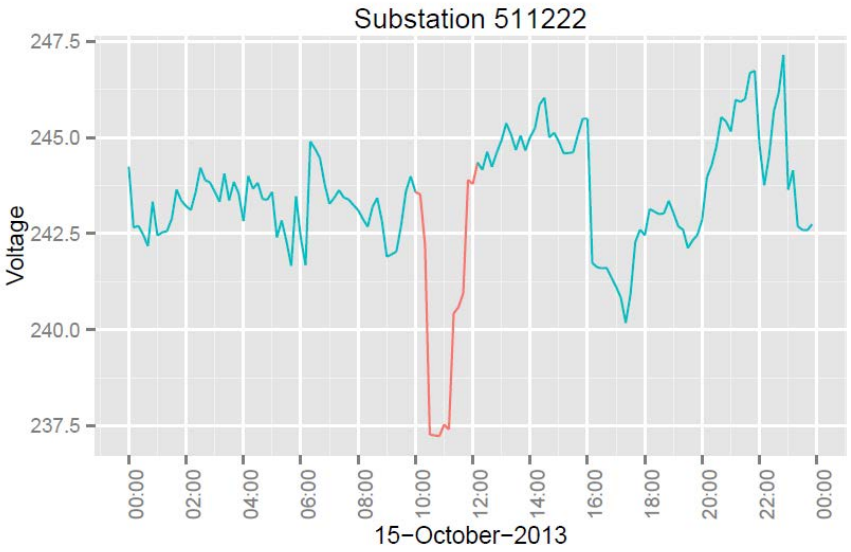
- On Oct 15th 2013 a 3% voltage reduction was implemented across South Wales as part of a National Grid trial.
- Trial periods: 10.00-12 noon & 14.00- 1600.
- Significant decreases in voltage compared with two hours before and after
  - -0.8V (-0.9, -0.7), p<0.001.
- Similar findings for substations and feeder ends.

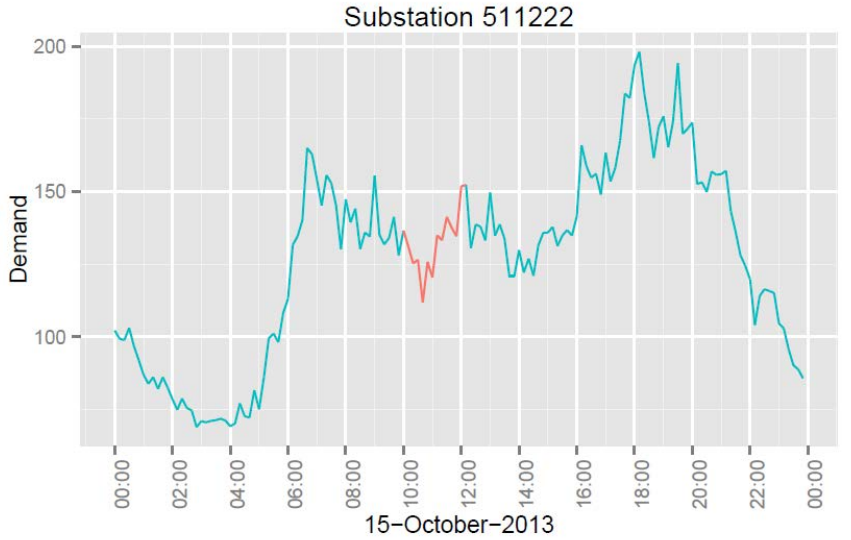




Demand

- Project Juniper found that on average a 3% reduction in voltage only resulted in a 1.5% reduction in demand.
- Demand during the trial period was estimated based on a model for underlying demand.
- Estimated values without reduction compared to measured values.
- Estimated reduction was 0.6% ($p<0.017$).





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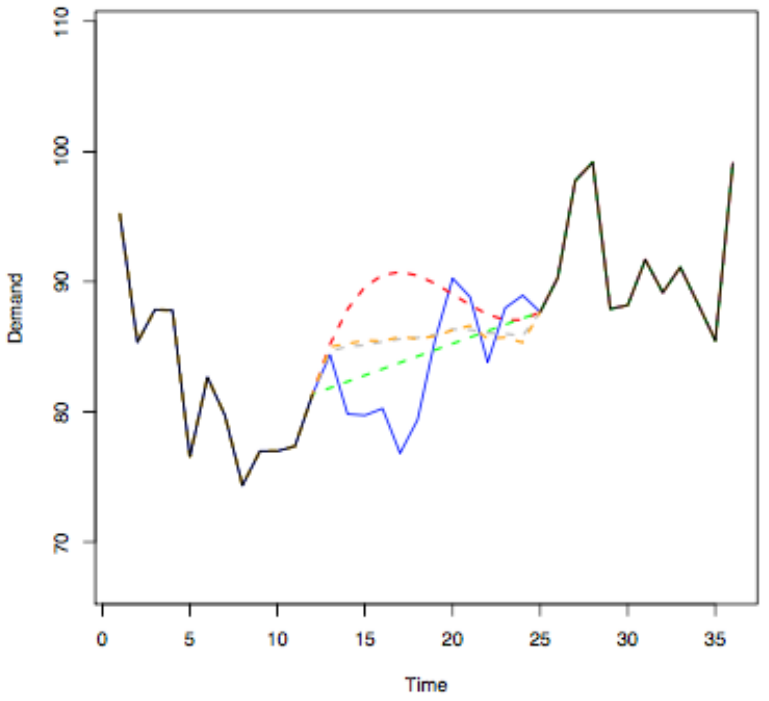

Future application

Future application

- WPD are now looking to implement a similar 100V drop on the AVC schemes across the 4 license areas
- This should be applied over the next maintenance period (3 years)
- This should improve quality of supply and reduce consumption and maximum demand

THANKS FOR LISTENING

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