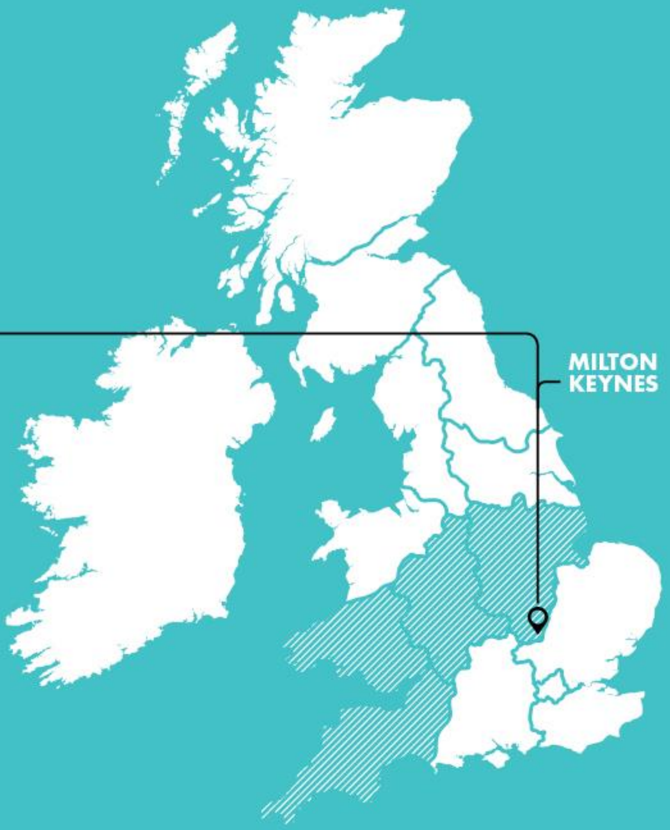
WESTERN POWER DISTRIBUTION

FALCON

DEVELOPING FUTURE POWER NETWORKS



SDRC 5/6 Dissemination Workshop

January 2015

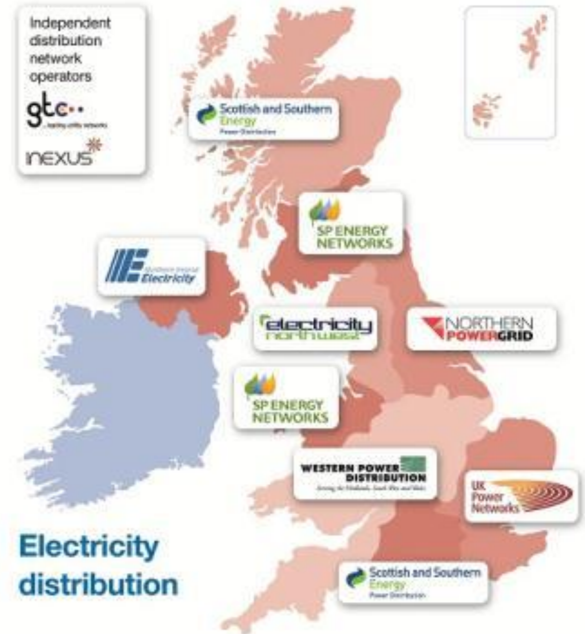
LCN Fund Low Carbon Networks · ALSTOM · Aston University · CGI · CISCO · Cranfield University

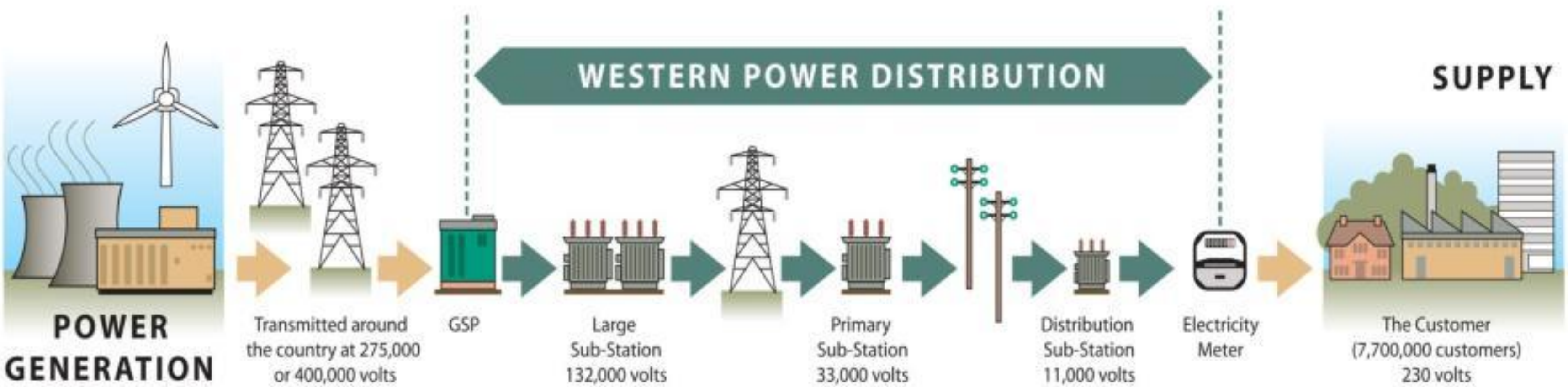
Who Are We

•We deliver electricity to over 7.8 million customers over a 55,500 sq kms service area

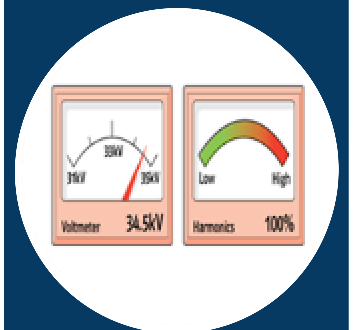
•Our network consists of over 220,000 kms of overhead lines and underground cables, and 185,000 substations maintained by over 6000 staff

•LV to 132kV Network ownership

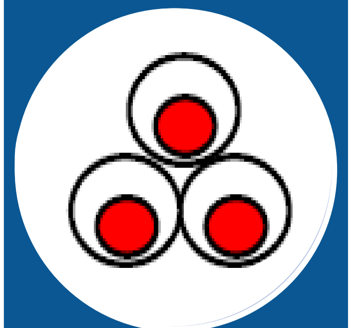




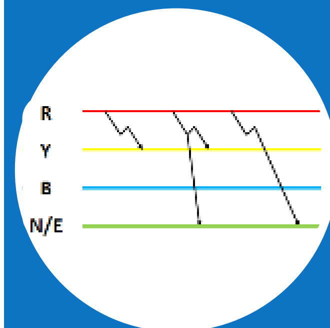
Distribution Network Challenges



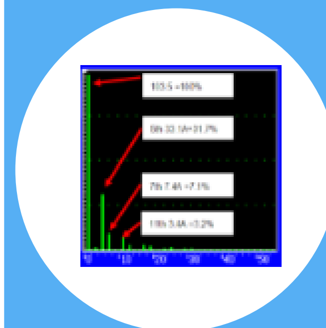
Voltage



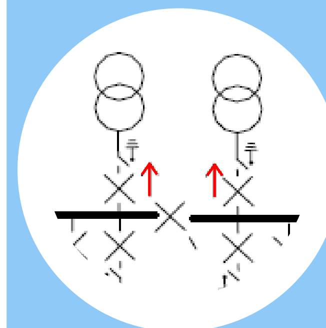
Thermal



Fault Level



Harmonic



Reverse Power Flow

Changing Load and Generation Mix

Innovation Strategy

Networks

Demonstrating alternative investment strategies to facilitate the UK's Low Carbon Transition

Customers

Testing innovative solutions to make it simple for customers to connect Low Carbon Technologies

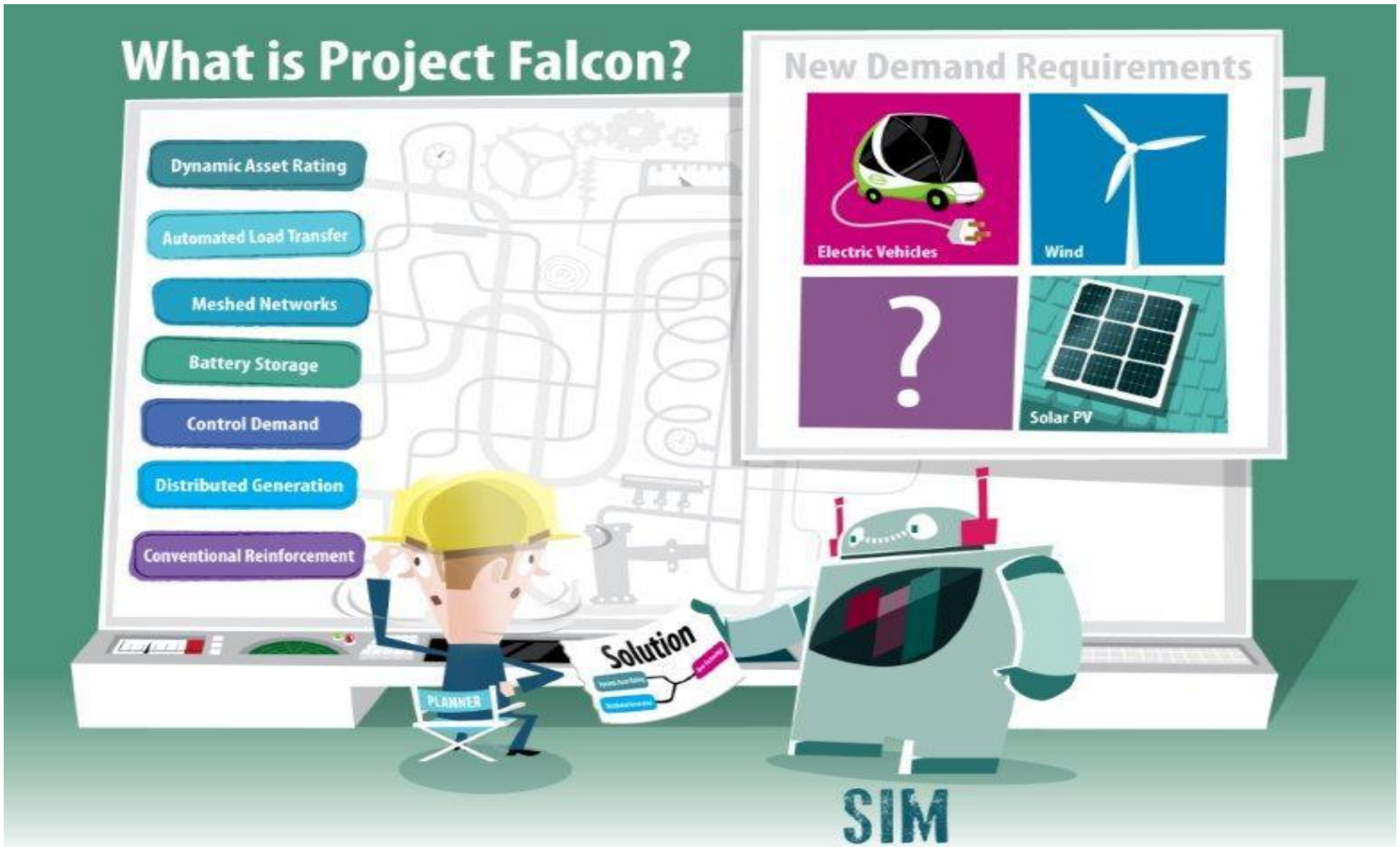
Performance

Developing new solutions to improve network and business performance

Stakeholder Engagement and Knowledge Management

- WESTERN POWER DISTRIBUTION NETWORK TEMPLATES
- WESTERN POWER DISTRIBUTION LOW CARBON HUB
- WESTERN POWER DISTRIBUTION SOLA BRISTOL
- WESTERN POWER DISTRIBUTION FALCON
- WESTERN POWER DISTRIBUTION FLEXDGRID
- WESTERN POWER DISTRIBUTION NETWORK EQUILIBRIUM
- WESTERN POWER DISTRIBUTION CLEAN ENERGY BALANCING
- WESTERN POWER DISTRIBUTION TELECOMS TEMPLATES
- WESTERN POWER DISTRIBUTION POWER & HEAT (energy technologies institute)
- WESTERN POWER DISTRIBUTION ISENTROPIC (energy technologies institute)
- WESTERN POWER DISTRIBUTION LV PLUS (Innovate UK)
- WESTERN POWER DISTRIBUTION WIRELESS HIGHWAYS (Innovate UK)
- WESTERN POWER DISTRIBUTION ECHO
- WESTERN POWER DISTRIBUTION COMMUNITY ENERGY ACTION
- WESTERN POWER DISTRIBUTION LOSS MITIGATION TEMPLATES
- WESTERN POWER DISTRIBUTION SOLAR STORAGE
- WESTERN POWER DISTRIBUTION STATISTICAL RATINGS
- WESTERN POWER DISTRIBUTION D-SVC INTEGRATION
- WESTERN POWER DISTRIBUTION ELECTRIC BOULEVARDS
- WESTERN POWER DISTRIBUTION CARBON TRACING
- WESTERN POWER DISTRIBUTION SUNSHINE TARIFF
- WESTERN POWER DISTRIBUTION AERIAL INSPECTION

Flexible Approaches to Low Carbon Optimised Networks



WESTERN POWER DISTRIBUTION
FALCON

Today

- Introductions
- Sharing some of our results up to the end of 2014
- Load estimation, energy modelling and scenarios
- Engineering Trials outputs
- Q&A

Project FALCON Commercial Trials

- Significant dissemination to date throughout 2014:
  - Dissemination Event June 2014
  - Interim Reporting online
  - Newsletter on first winter trials results
- Second set of winter trials mid way through now
- Further dissemination to take place during 2015
- All documentation available through:

www.westernpowerinnovation.co.uk

Load Estimation – October 2014 Update

Two documents published at the end of October

1) Update on the selected Scenarios and how these are implemented in the Falcon Energy Model.

   This followed on from a consultation with DNOs and other interested parties.

2) A comparison of Falcon Energy Model Estimates to monitored values.

Scenarios

To account for the large degree of uncertainty in predicting future loads, four scenarios are used. These have been chosen to be similar to those used for ED1 planning in Transform

Transform Scenarios	Summary	Heat Pump Uptake	EV Uptake	PV Uptake (LV/ small scale)	DSR	Wind, biomass and HV/EHV Photo Voltaic Generation Scenario	Energy Model Scenario Name
Transform Scenario 0	High Domestic Decarbonisation	High	High	High	Medium	High (Gone Green)	DECC3
Transform Scenario 1	Domestic decarbonisation to meet carbon budgets	High	Medium	Medium	Medium	High (Gone Green)	DECC1
Transform Scenario 2	Domestic decarbonisation to meet carbon budgets with less DSR	Medium	High	Medium	Low	High (Gone Green)	DECC2
Transform Scenario 3	Less domestic decarbonisation (purchase of credits)	Low	Low	Low	Medium	Low (Slow Progression)	DECC4
DNO's own		Medium	Low	Medium		High (Gone Green)	

Energy Model Levers

Low Carbon Technologies	
Abbreviation	Name
APP	Appliances (High rated energy efficient appliances)
LGH	Efficient Lighting
INS	Insulation and draught proofing
AHP	Air source heat pump
GHP	Ground source heat pump
CHP	micro CHP
SWH	Solar water heating
SPV	Photovoltaic Solar Panels
SMA	Smart Meters
VOP	Voltage Optimisation
EVS	Electric Vehicles

For each lever, we need to specify

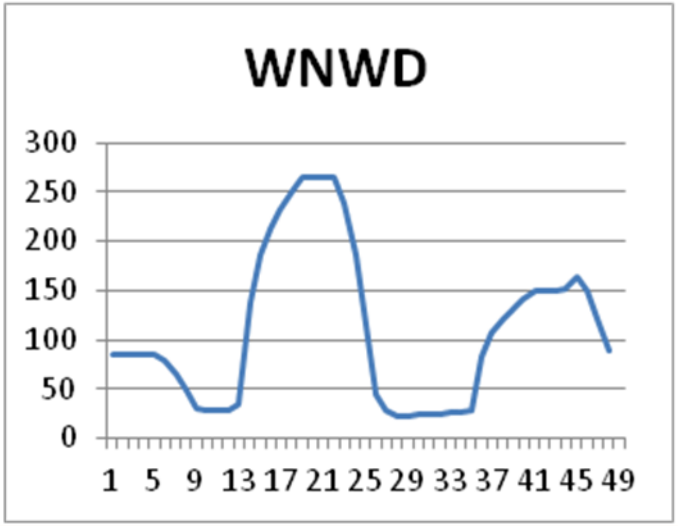
- How much is installed in year 2050.
- The shape of the uptake curve to 2050 – straight line, S-curve, other
- Relative likelihood of installation for the population of substations. (Clustering)

Other Assumptions

The energy model also includes other assumptions for:

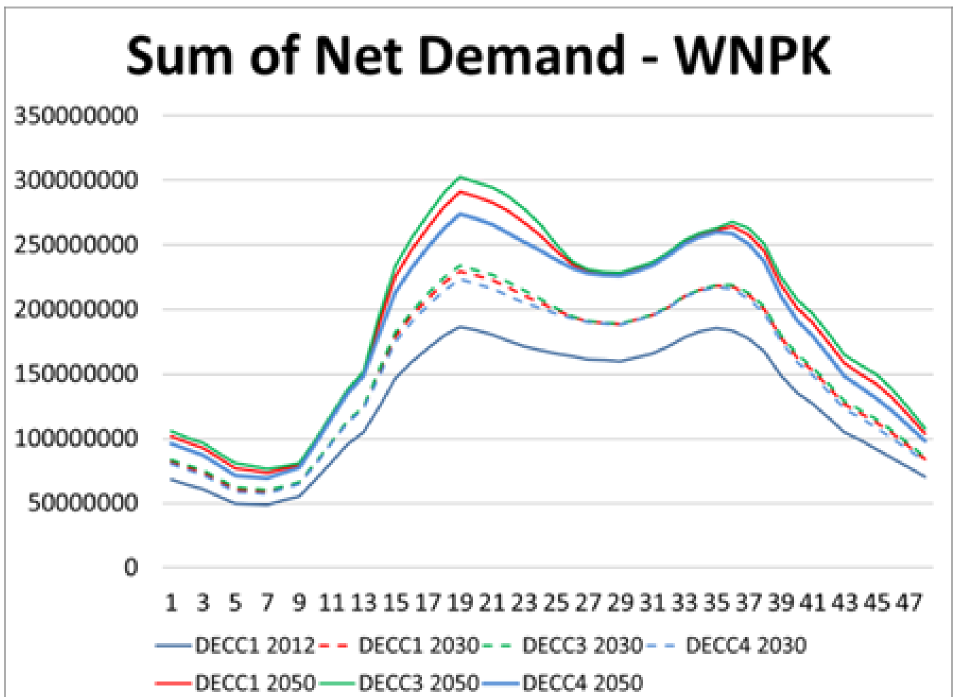
- The rate of increase in houses, non-domestic premises.
- Improvements in appliance efficiency via normal churn – rather than conscious decision to upgrade to more energy efficient appliances.
- The charging profiles for electric vehicles, split between charging at home, work etc.

This was an area where feedback on the consultation was most useful and the expected charging profile has been amended. Sensitivity analysis will be carried out to see the impact of EV charging assumptions.



Overall results

Levels of increase in peak load for winter peak average at 23% increase for 2030 and 57% increase for 2050. This is within the range predicted by other studies e.g. National Grid scenarios and UKERC Scenario work.



The load increases suggest moving from an evening peak to a morning peak, driven by EV charging profiles.

Validation of Load Estimates

Previous comparison of the Energy Model estimates has been updated with the data from monitored substations in Milton Keynes.

- Overall validation of the Energy Model
- Understanding of the factors which influence estimate accuracy

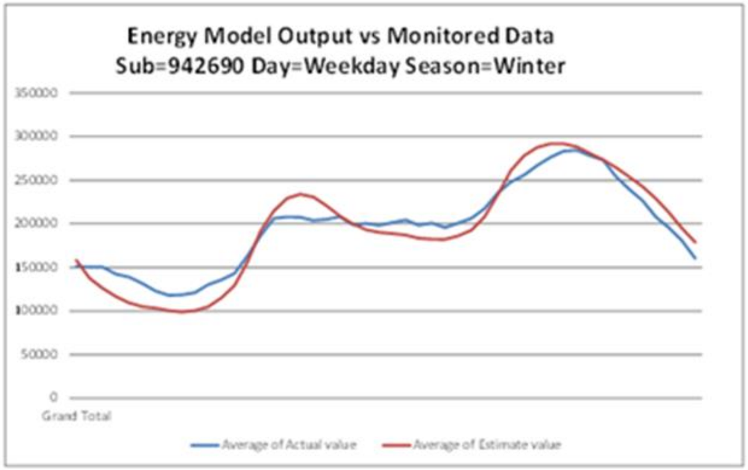
Overall Validation

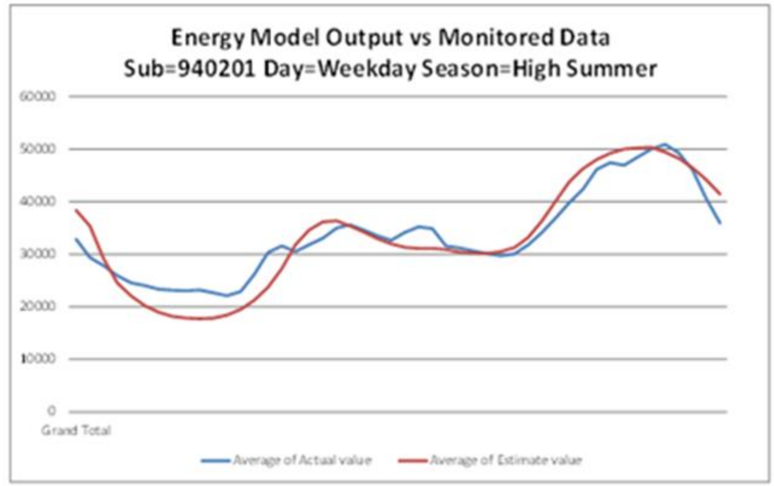
The energy model has an overall tendency to overestimate load, but this is minimal for the winter peak and is not likely to compromise the validity of FALCON's analysis.

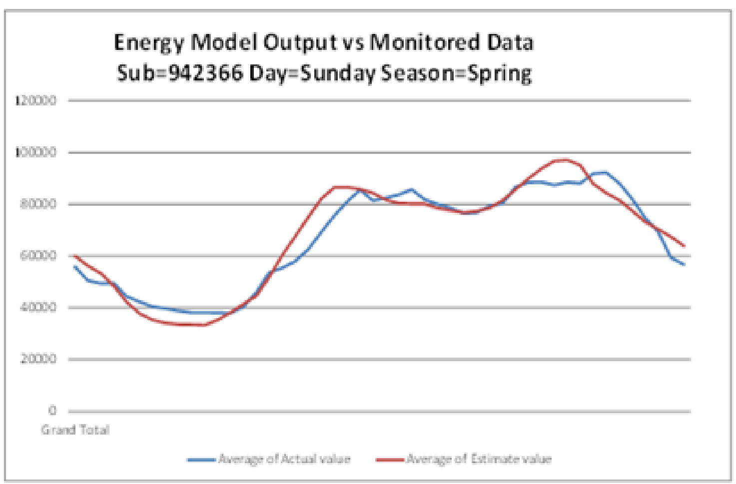
As with other estimation methods, especially good levels of agreement have been found for substations that are dominated by domestic load and have a larger number of customers.

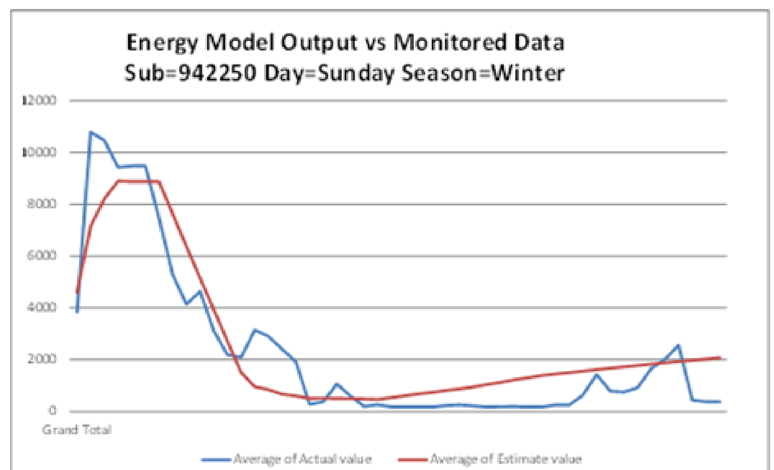
Quality metrics, such as correlation between the estimates and the actual values, suggest the Energy Model gives better estimates than LV Network Templates, which is likely to result from using given profiles for half hourly metered customers.

Example comparisons

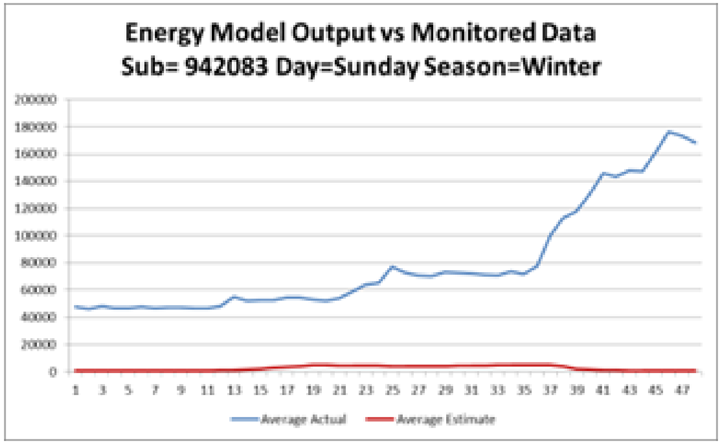


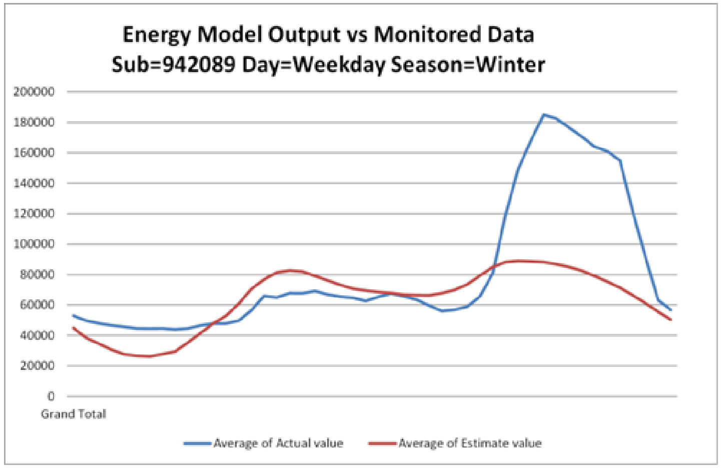






Estimate quality investigations





The substations where the estimates did not align well with the monitored data were investigated. In some cases this was due to new customers that had not been included in the original data, or hard to predict customers such as a sports stadium with high evening peaks.

Errors in connectivity or estimated annual consumption are likely to have the most impact on estimate quality.

No systematic issues were found.

Engineering Trials – December 2014 Update

One document published at the end of December

1) Initial FALCON Trials Learning.

Key contents:

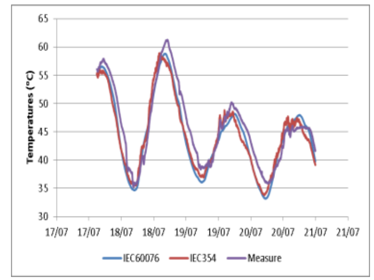
- Overview of Learning from Technique Trials Implementation
- Overview of Early Operational Learning
- Conclusions and Key Next Steps

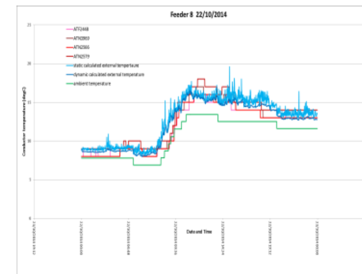
Engineering Trials – generalised conclusions from installation

1. Design and specification work stopped at a high level.
2. Limitations in factory acceptance testing caused delay and re-work in the installation/commissioning stages.
3. Measurement and data strategies are supremely important to the validation of trialled techniques.

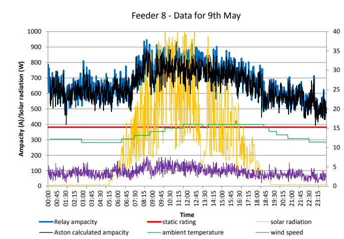
Early Engineering Trials – DAR

1. Much of the work to date has been about validating thermal models/parameters in use for OHL, cables and transformers





2. Comparison of dynamic and static asset ratings are being undertaken



3. The use of forecast ambient conditions is now being actively pursued to investigate viability of forecast ampacity

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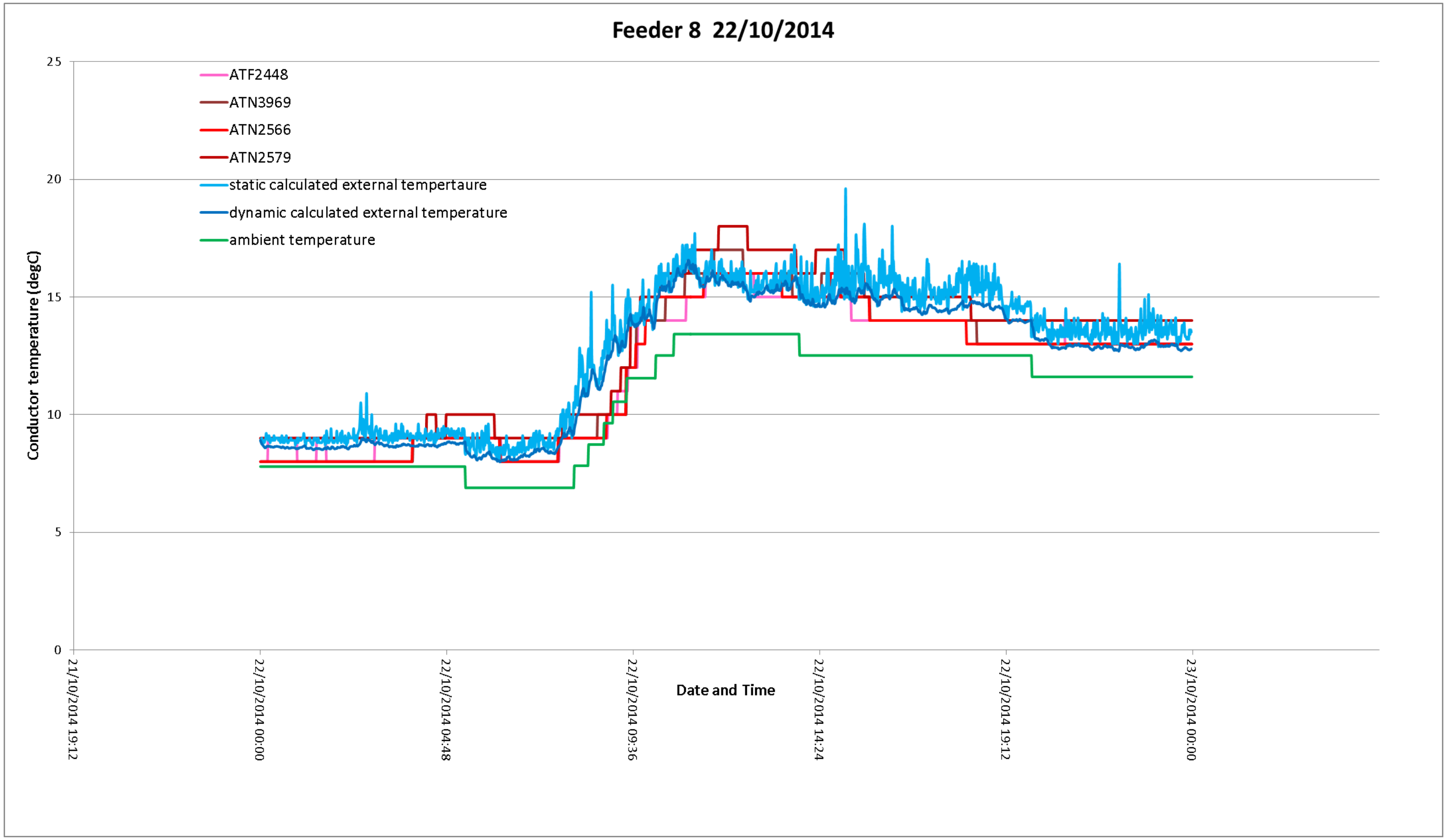
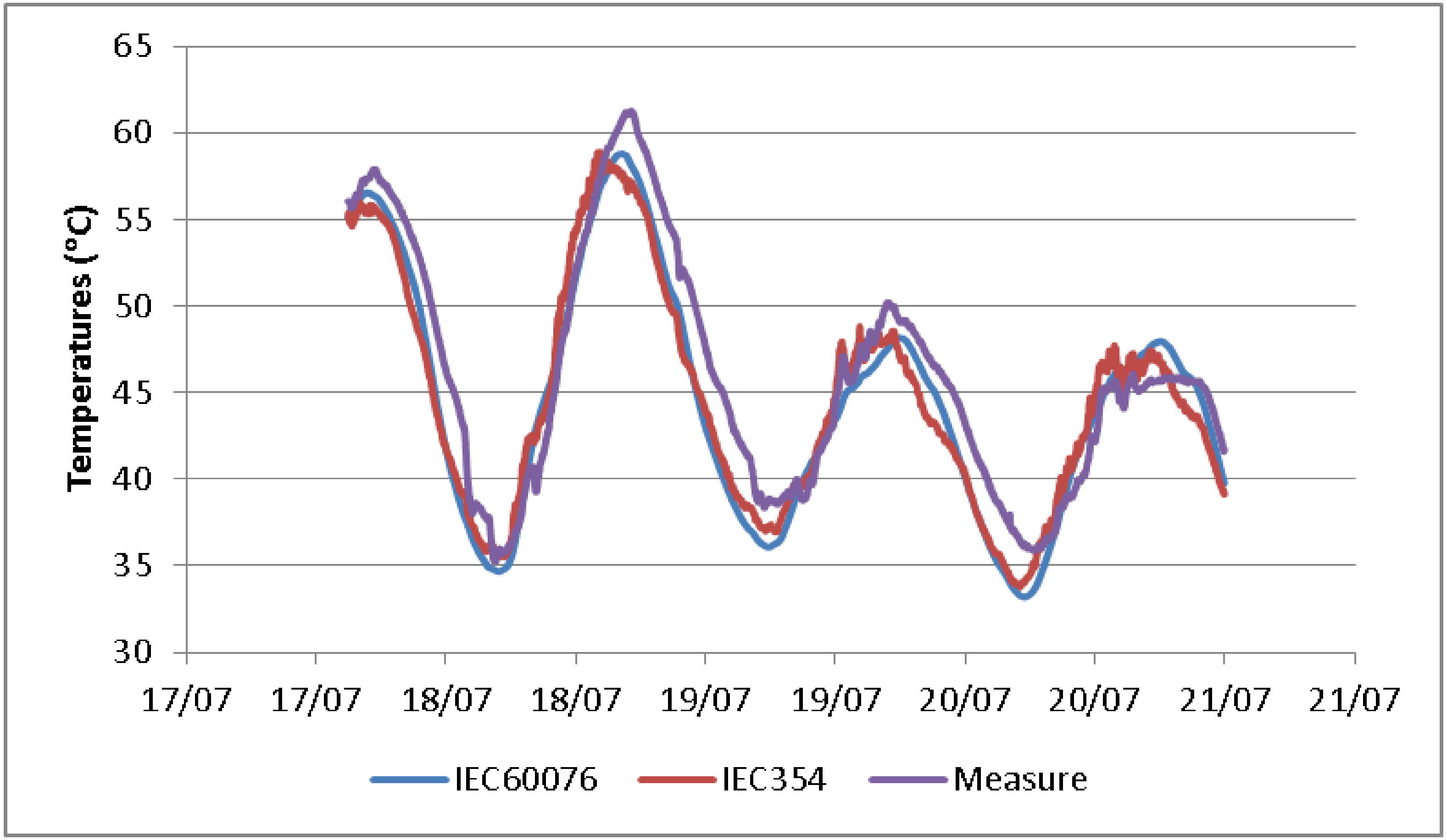
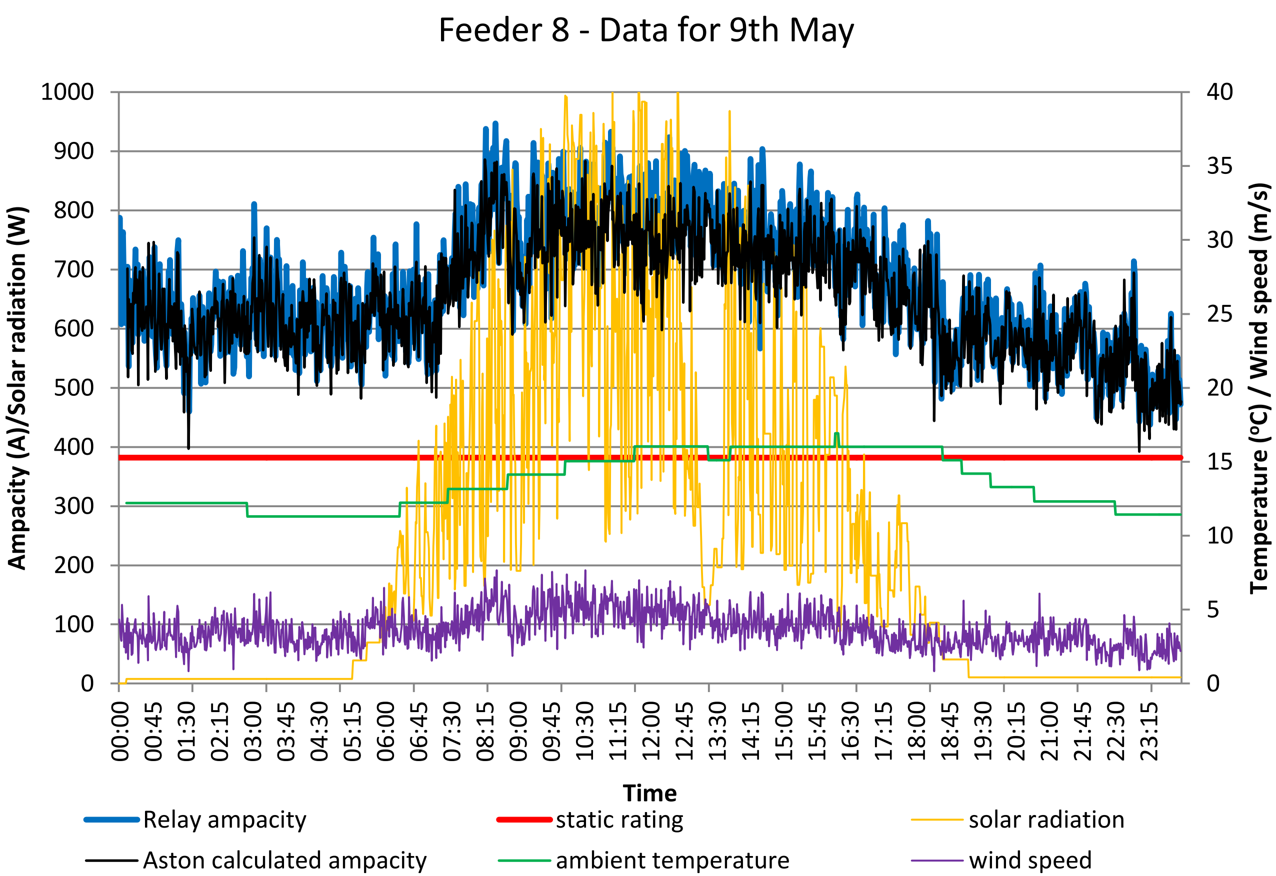
Engineering Trials – Correlation of OHL thermal model to measure conductor temperature



Engineering Trials – Correlation of Transformer top oil temperature model to measured values



Engineering Trials – Correlation of OHL dynamic rating with static rating



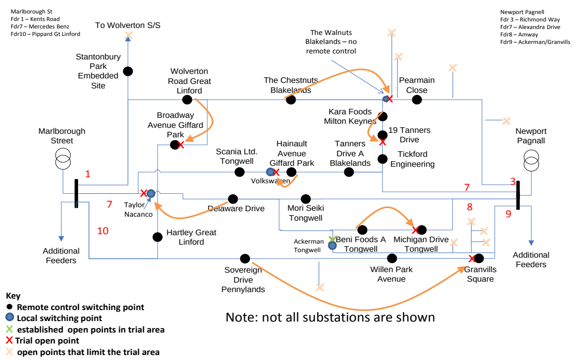
Early Engineering Trials – ALT

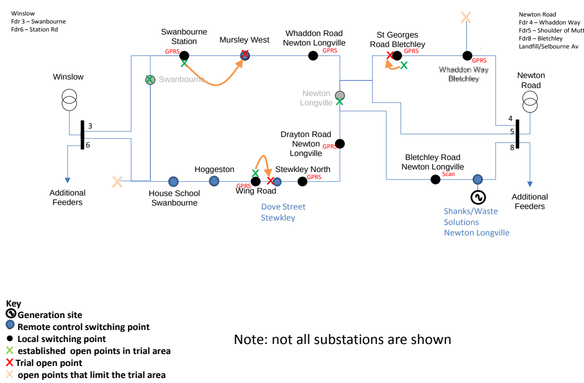
1. Initial trials have looked to validate approach and provide early pointers.

2. General revision of open points from current position suggests reduction in losses (3% to 13% for u/g, 7% to 20% for o/h).

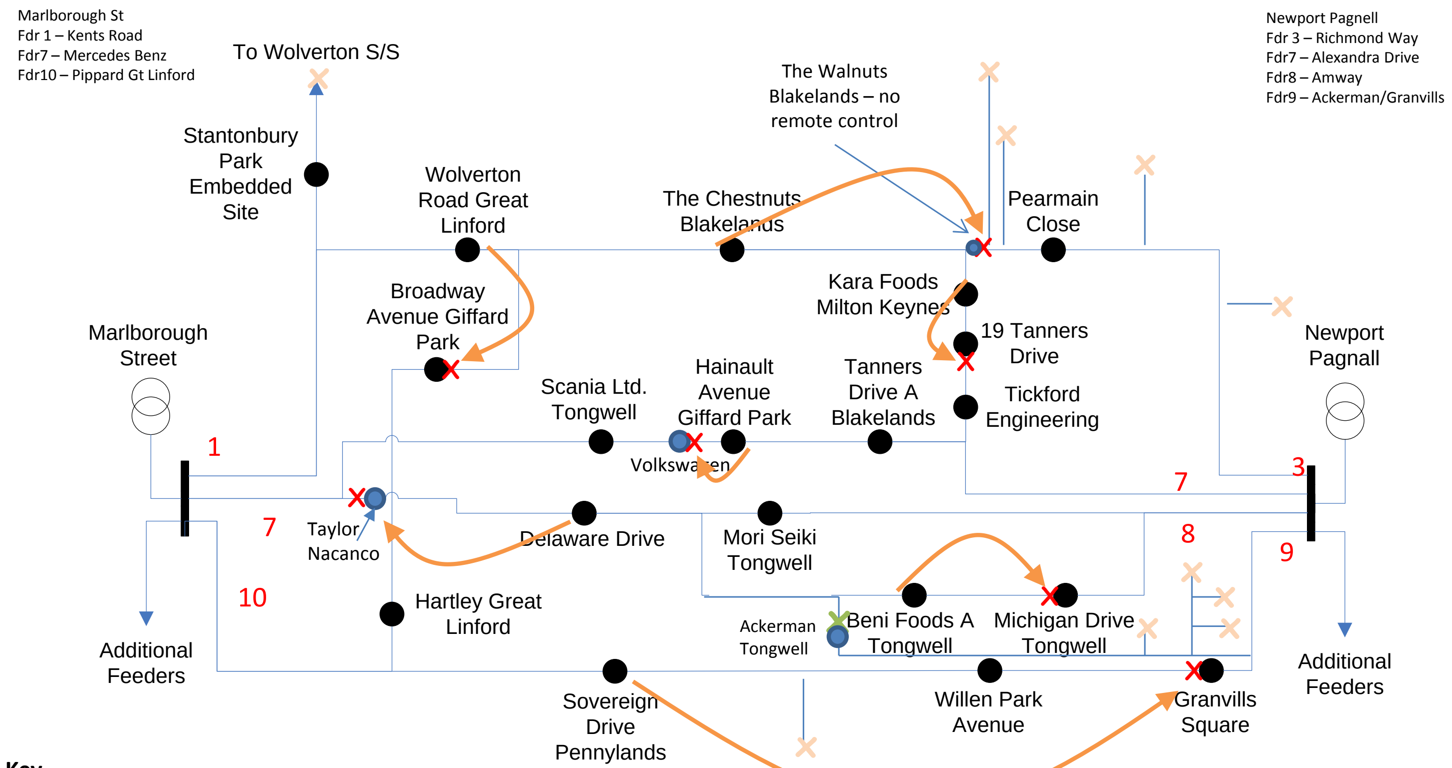
3. No significant improvement in voltage occurred.

4. Improvement in branch utilisation (creation of headroom) was inconsistent and will be investigated further.





Engineering Trials – Early u/g network ALT trial

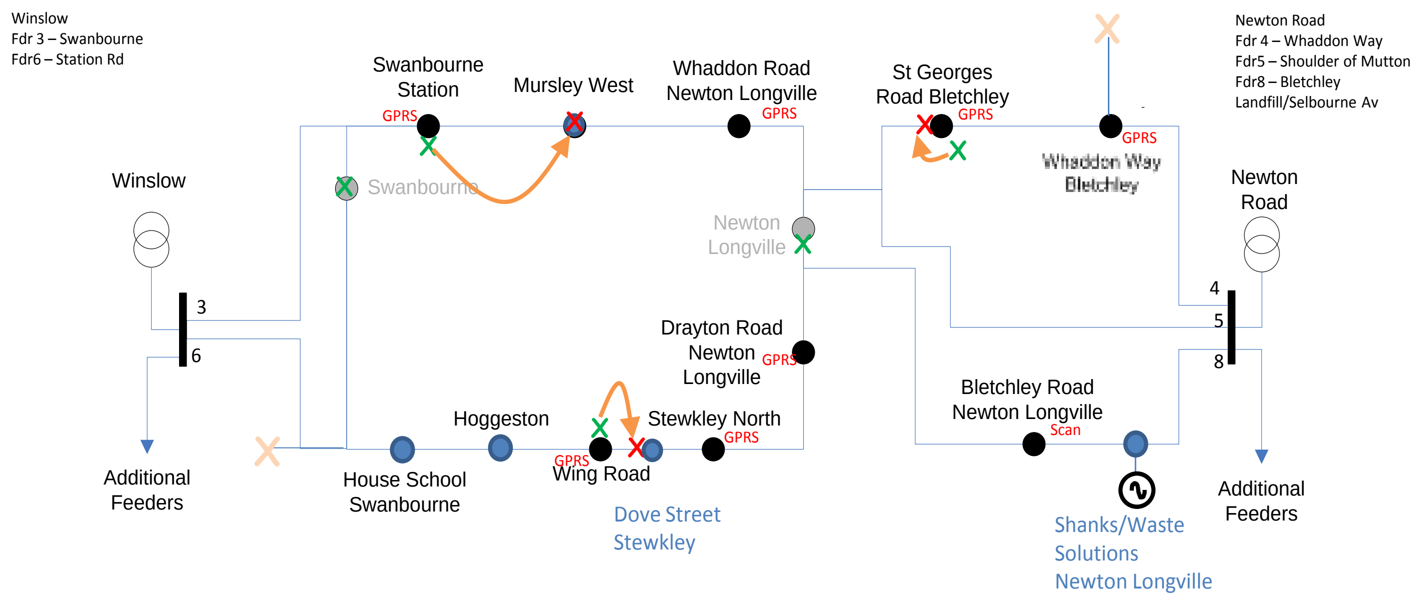


Key
- **Remote control switching point**
- **Local switching point**
- **established open points in trial area**
- **Trial open point**
- **open points that limit the trial area**

Note: not all substations are shown

Underground ALT Trial 17-24 Jun 2014

Engineering Trials – Early overhead network ALT trial



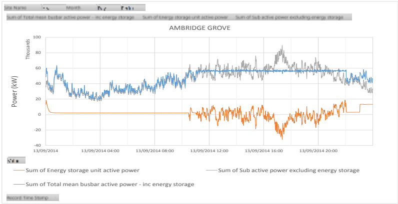
Key
- **Generation site**
- **Remote control switching point**
- **Local switching point**
- **established open points in trial area**
- **Trial open point**
- **open points that limit the trial area**

Note: not all substations are shown

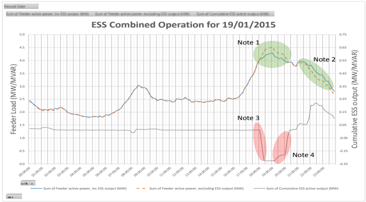
Overhead ALT Trial 07-14 Oct 2014

Early Engineering Trials – Energy Storage

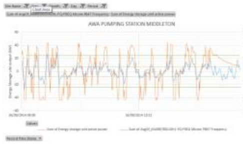
1. Operational experience extends back to Jan '14 for one of the five units.



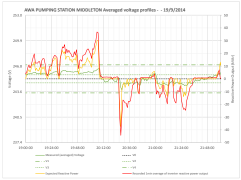
2. Demonstrable capability to peak shave at local substation.



3. Combined discharge reduces primary substation load.

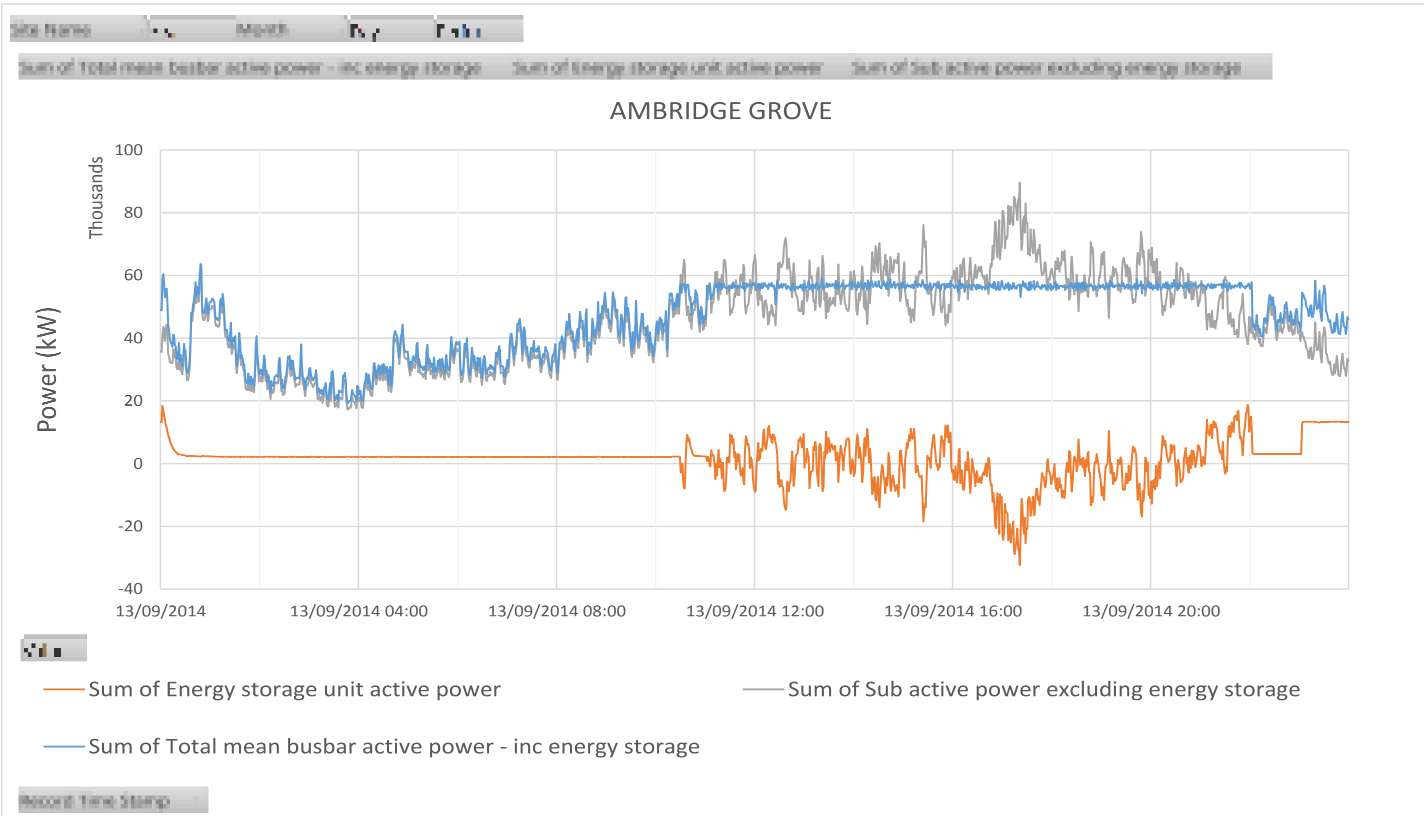


4. Frequency response demonstrated – though not in an "NGC format".

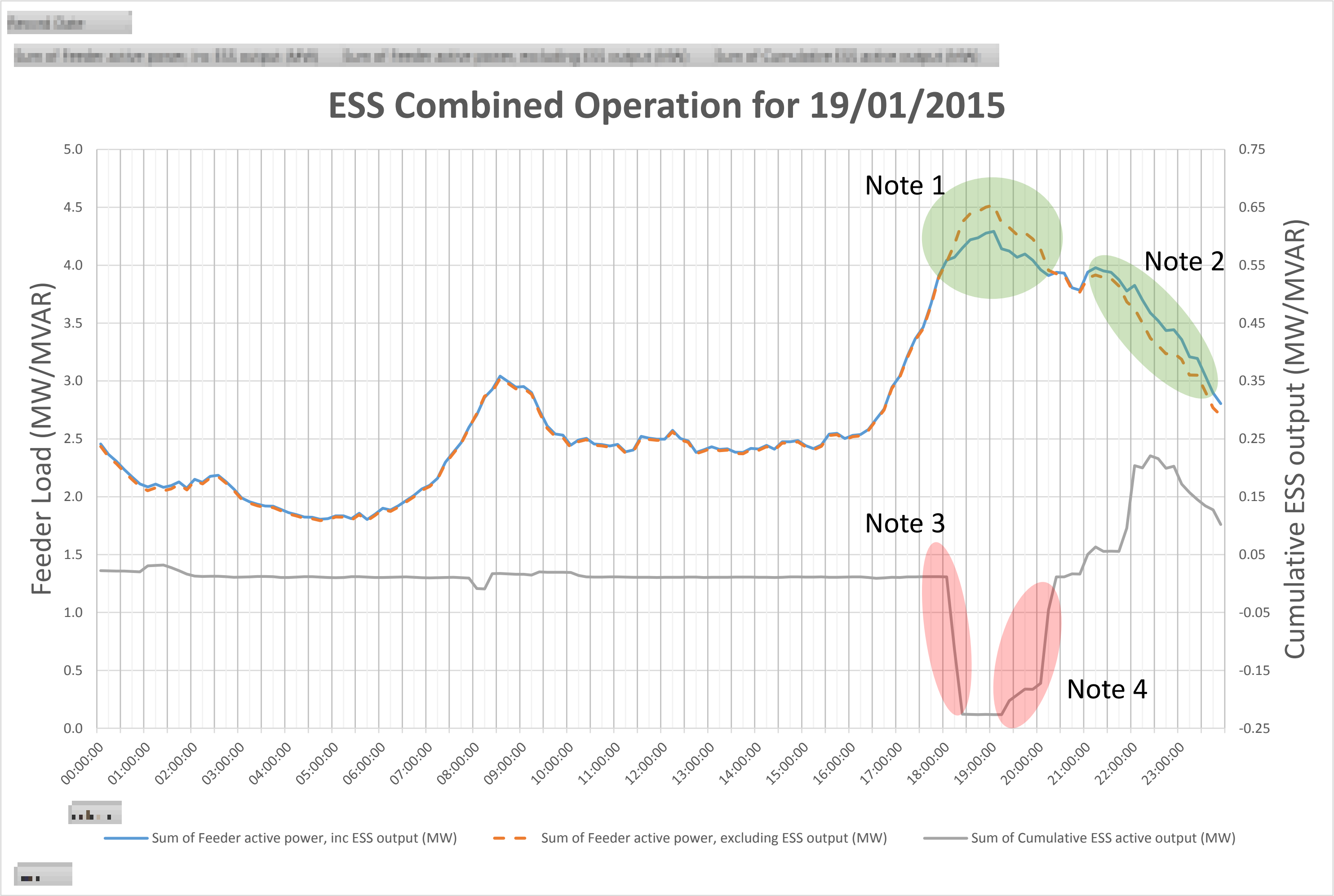


5. Voltage influence appears limited at present – demonstrated variation in reactive output with measured voltage.

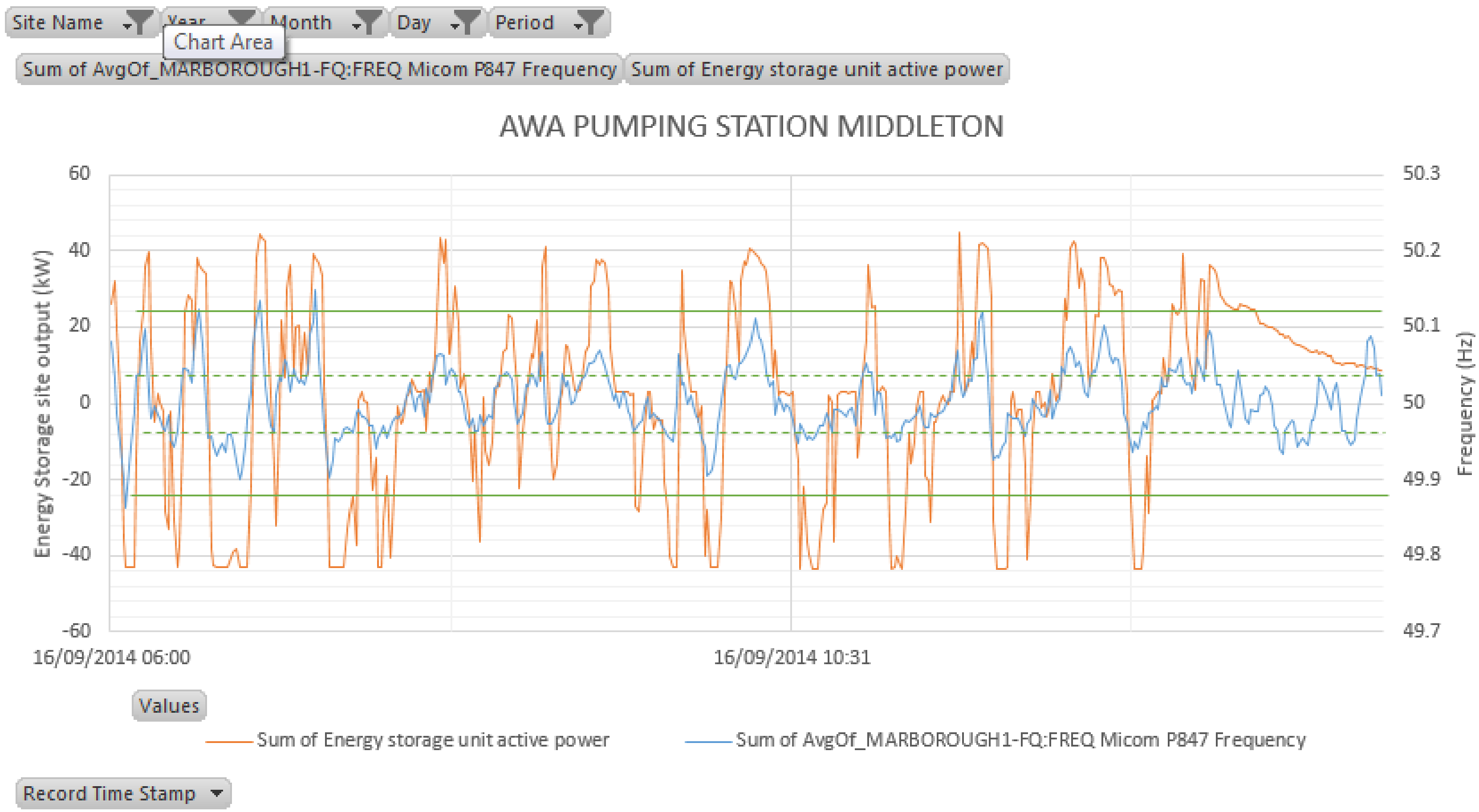
Engineering Trials – ESS peak shaving



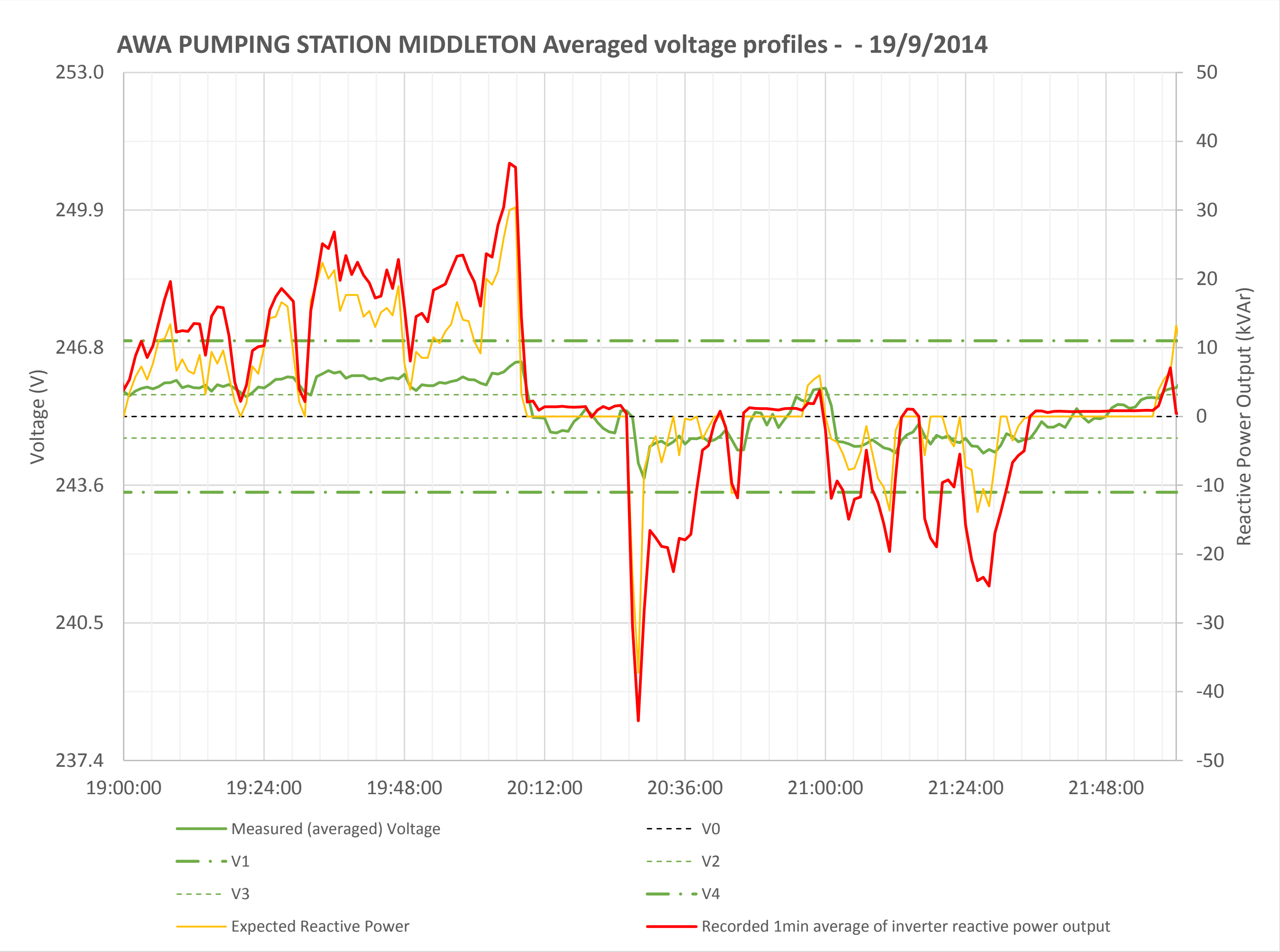
Engineering Trials – ESS impact of combined discharge



Engineering Trials – ESS frequency response



Engineering Trials – ESS reactive output



Engineering Trials – high level conclusions from early operation

1. Working with equipment of Potential Technology Readiness Levels of 7 requires recognition of risk and float in plans.
2. Early indications for DAR are around being too “dynamic” to be of immediate use, with values above and below static ratings.
3. Potentially much of the indicated ALT improvements could be captured through one-off adjustments to NOPs.
4. Energy storage, clearly demonstrable capability to:
   - peak shave, and respond to system frequency
   - to a lesser extent influence voltage
   - further assessment required on availability and efficiency

Key early learning for the SIM from initial trials

1. A range of parameter amendments have been proposed for DAR cable and transformer models based on model improvements achieved in the engineering trials.

2. Information requirements for DAR may be quite challenging, for example, duct versus direct laid cables.

3. For ALT the trials have indicated how a greater degree of optimisation of normal open points could be implemented in further revisions of the SIM.

4. For ESS SIM modelling should be based on the successfully proven peak shaving operation and that placement of ESS sites should be done boldly in the SIM environment.

Q&A

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