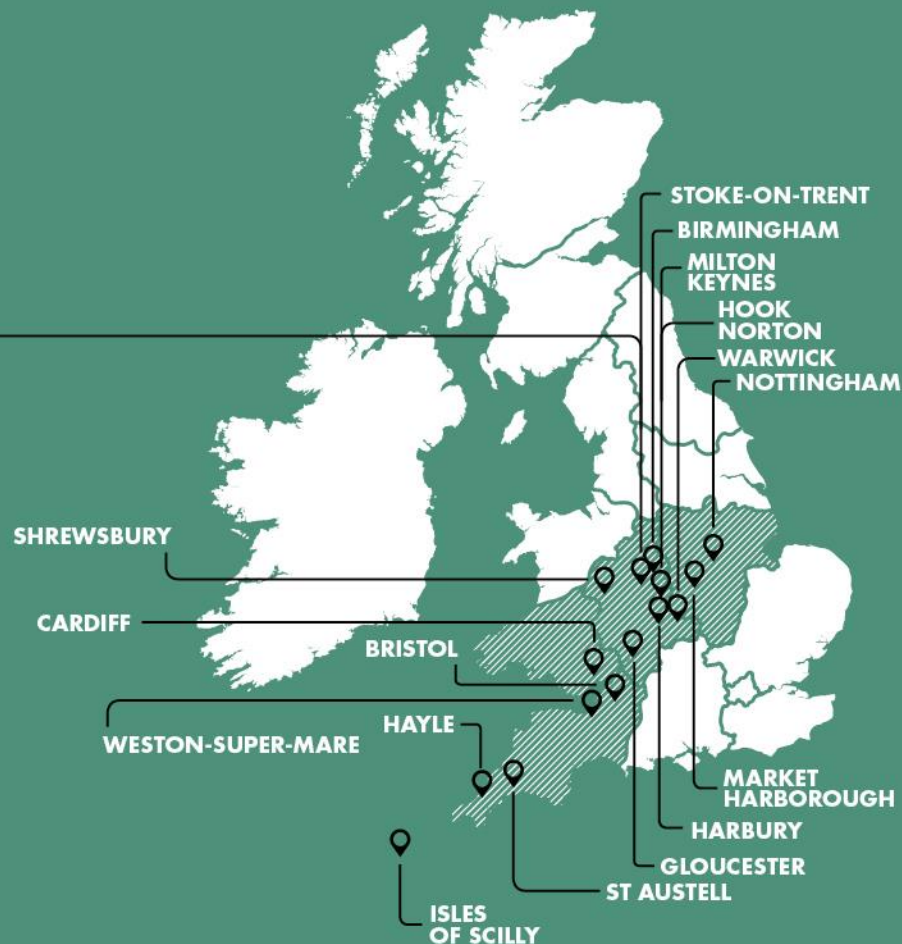


## NEXT GENERATION NETWORKS

WPD Innovation

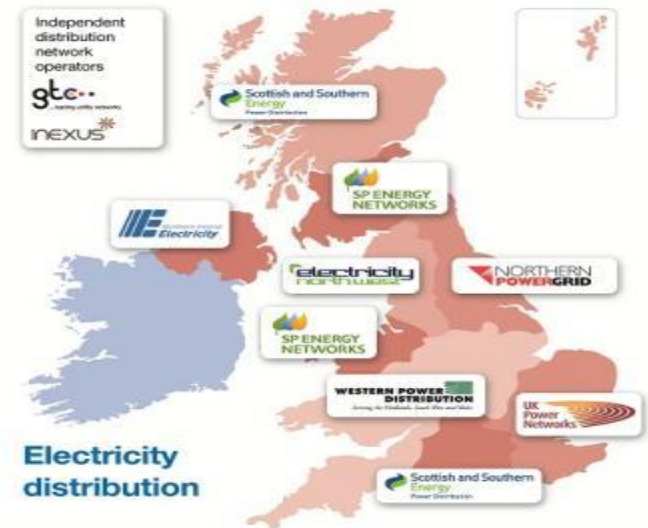
Paul Jewell

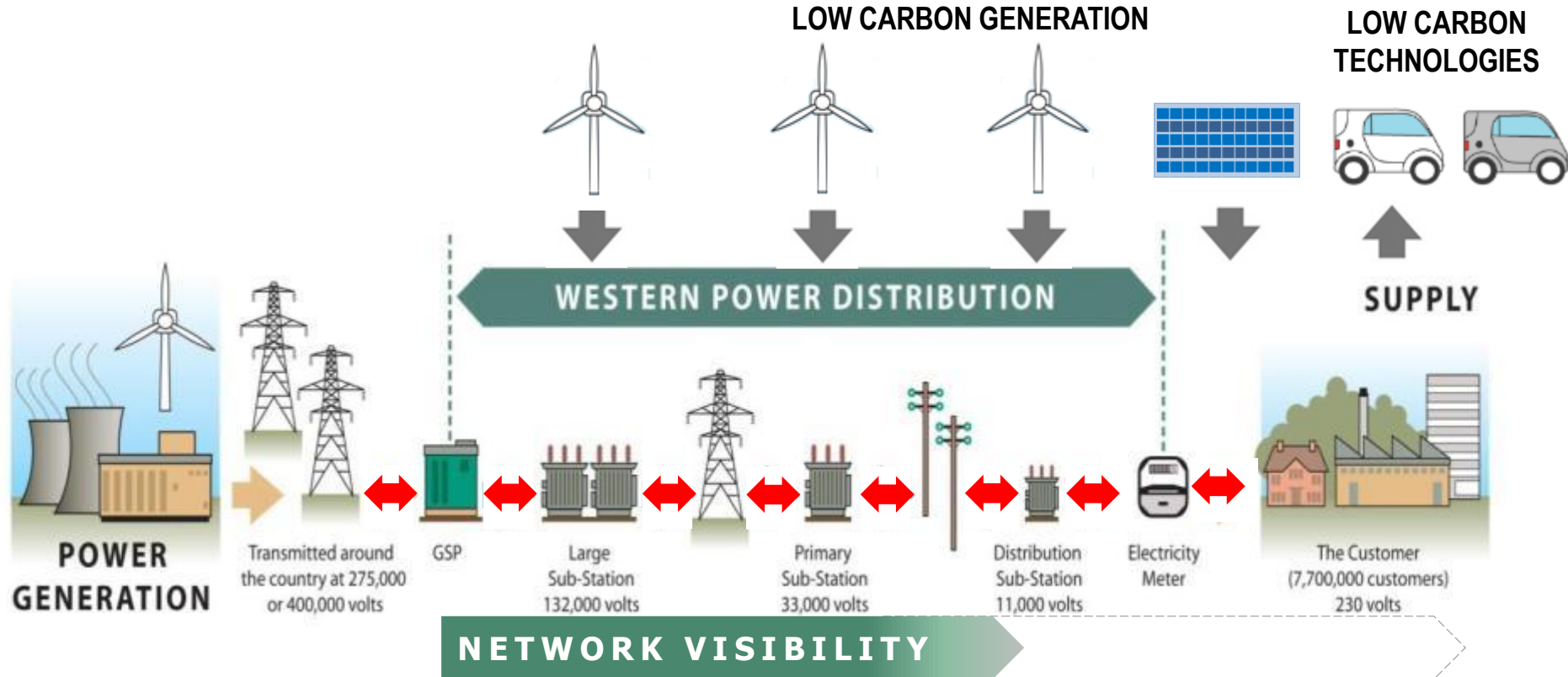
Policy Manager



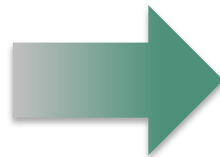
## Who are WPD ?

- Distribution Network Operator
- Midlands, South West and Wales
- 7.8 million customers
- 55,500 square kilometres
- 220,000km of lines & cable
- 185,000 substations
- Employ over 6,000 staff





- Limited capacity
- Passive design / operation
- Centralised Generation
- Limited Visibility
- One-way power flow
- Load centric design



- Reduced headroom
- Increased Intelligence / Active Management
- Distributed Generation
- Need for increased visibility
- Two-way power flows
- Utilisation centric design

# 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  
EQUILIRIUM

WESTERN POWER  
DISTRIBUTION  
CLEAN ENERGY  
BALANCING

WESTERN POWER  
DISTRIBUTION  
TELECOMS  
TEMPLATES

WESTERN POWER  
DISTRIBUTION  
energy  
technologies  
POWER & HEAT

WESTERN POWER  
DISTRIBUTION  
energy  
technologies  
ISENTROPIC

WESTERN POWER  
DISTRIBUTION  
Innovate UK  
LV PLUS

WESTERN POWER  
DISTRIBUTION  
Innovate UK  
WIRELESS  
HIGHWAYS

WESTERN POWER  
DISTRIBUTION  
ECHO

WESTERN POWER  
DISTRIBUTION  
COMMUNITY  
ENERGY ACTION

WESTERN POWER  
DISTRIBUTION  
LOSS  
MITIGATION

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

## Innovation into Business as Usual

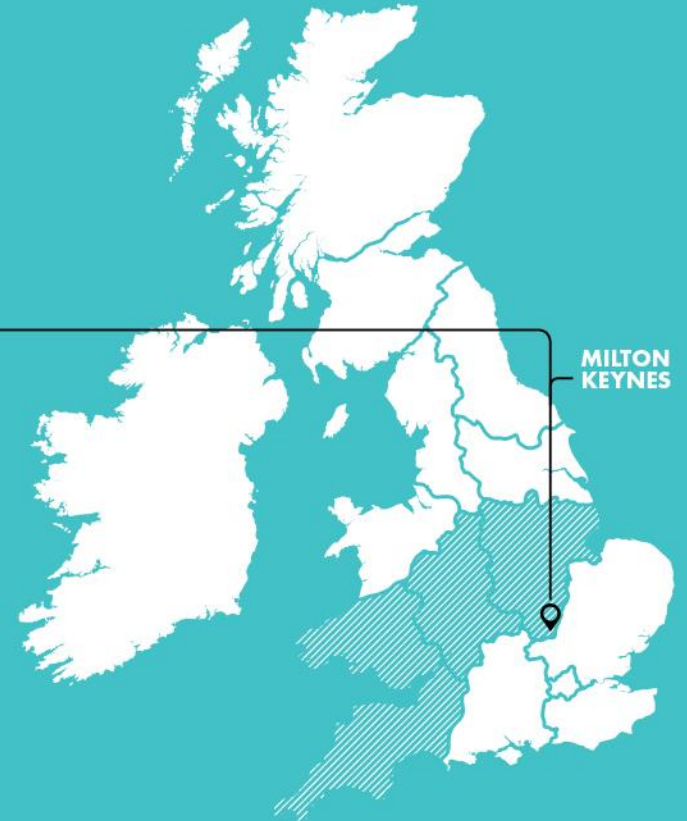
- Innovation Team and Policy/Standards Team are combined
  - Innovation is delivered by operational teams, who also feed in new ideas
  - Projects develop policies and procedures as the projects grow
  - Alternative Generator Connections – driven from an LCNF trial
-



## DEVELOPING FUTURE POWER NETWORKS

Project FALCON

**Roger Hey**  
Future Networks Manager



## Distribution Network Goals for Smarter Networks

- Addressing brief or occasional capacity issues
- Reducing interruptions and durations of outages
- Improving network security
- Avoiding or deferring capital investment costs
- Increasing existing asset utilisation
- Enhancing our knowledge of network assets
- Increasing our understanding of customer needs

**Leading to overall improvements for customers**

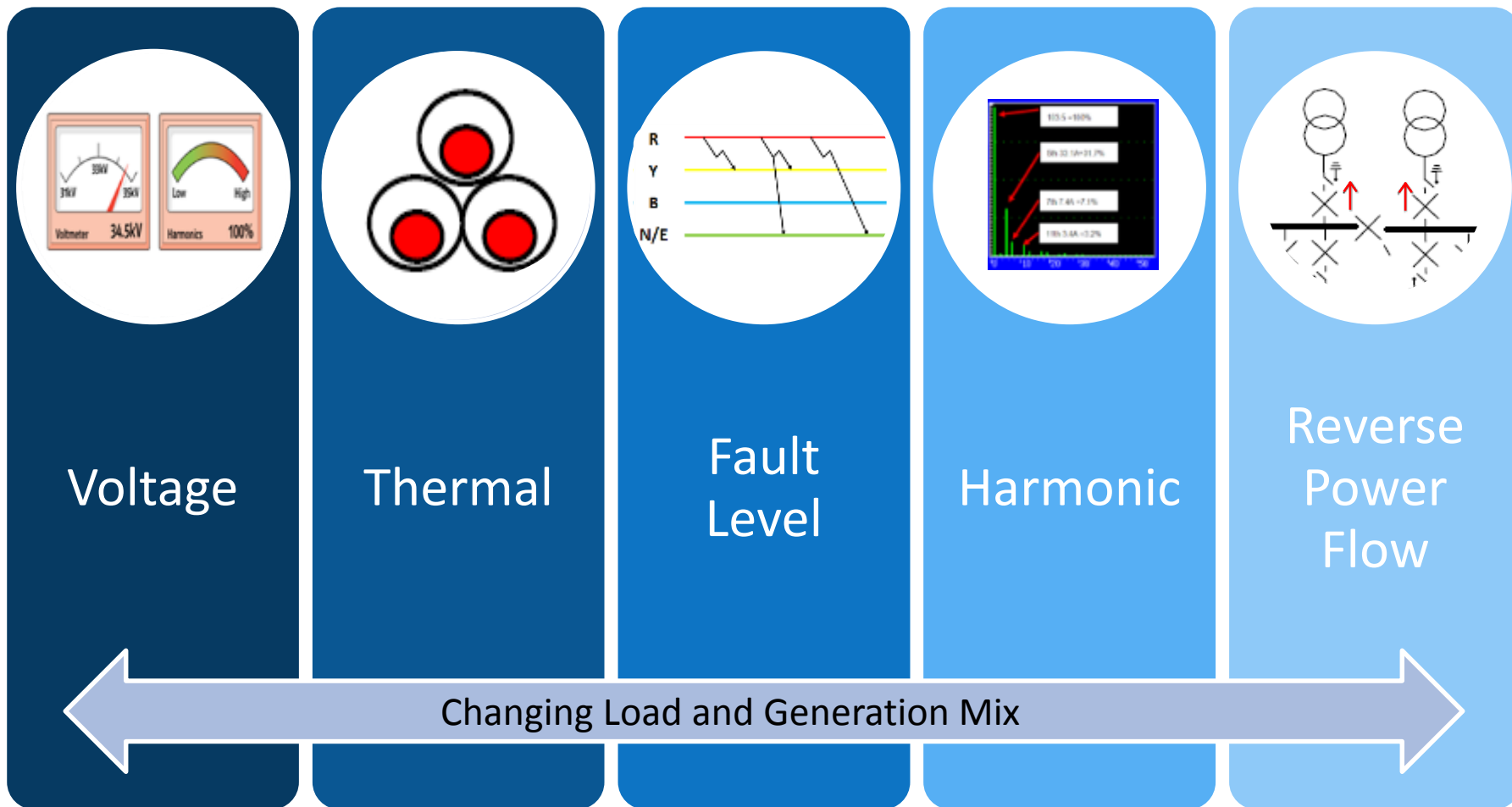
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## Distribution Network Challenges

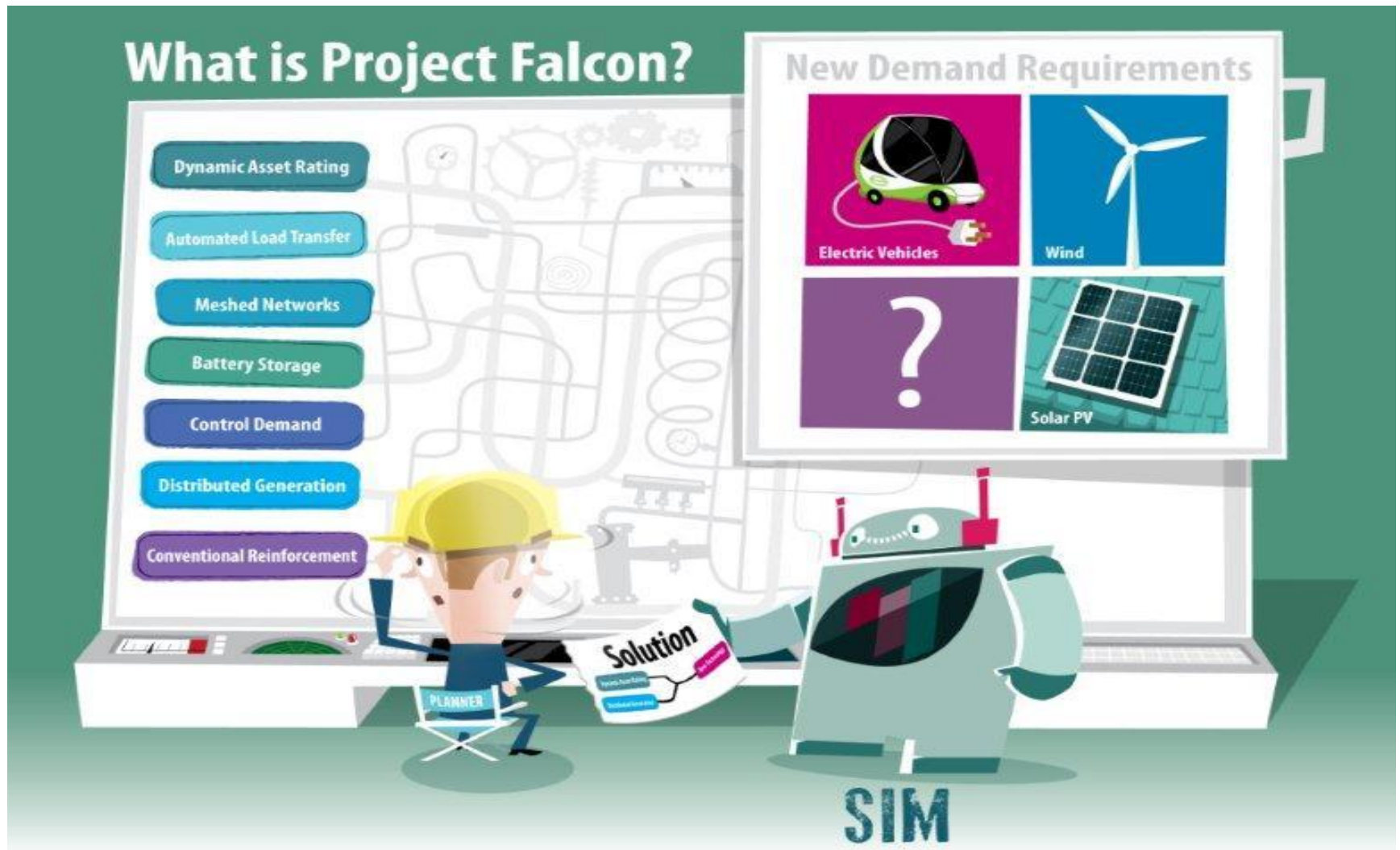
- Electrification of transport
  - Electrification of heating
  - Energy efficiency measures
  - Businesses moving or growing
  - Time of use supply tariffs
  - Increased numbers of distributed generation
  - Smarter home technologies
  - Domestic smart metering rollout
-



# Distribution Network Challenges



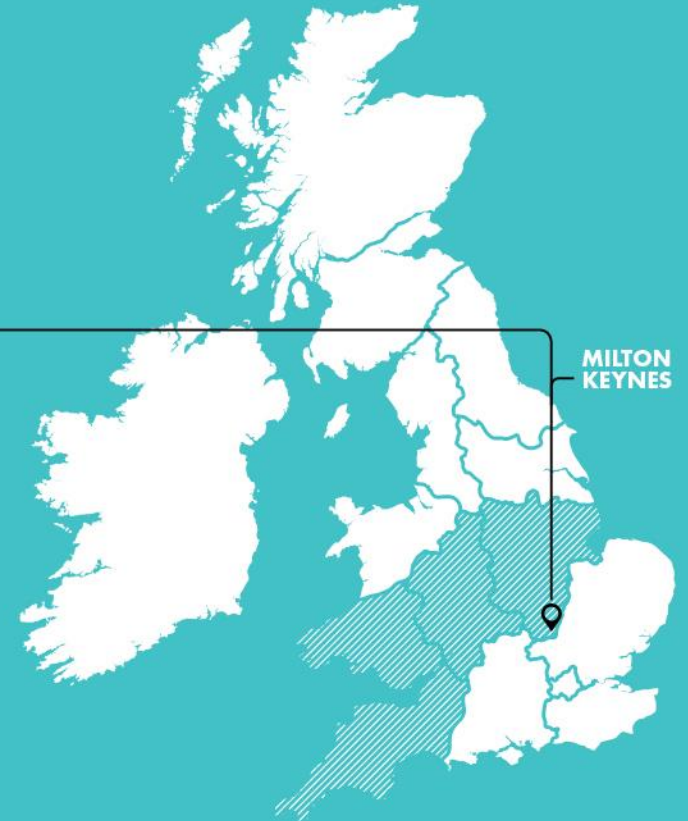
# Flexible Approaches to Low Carbon Optimised Networks



## DEVELOPING FUTURE POWER NETWORKS

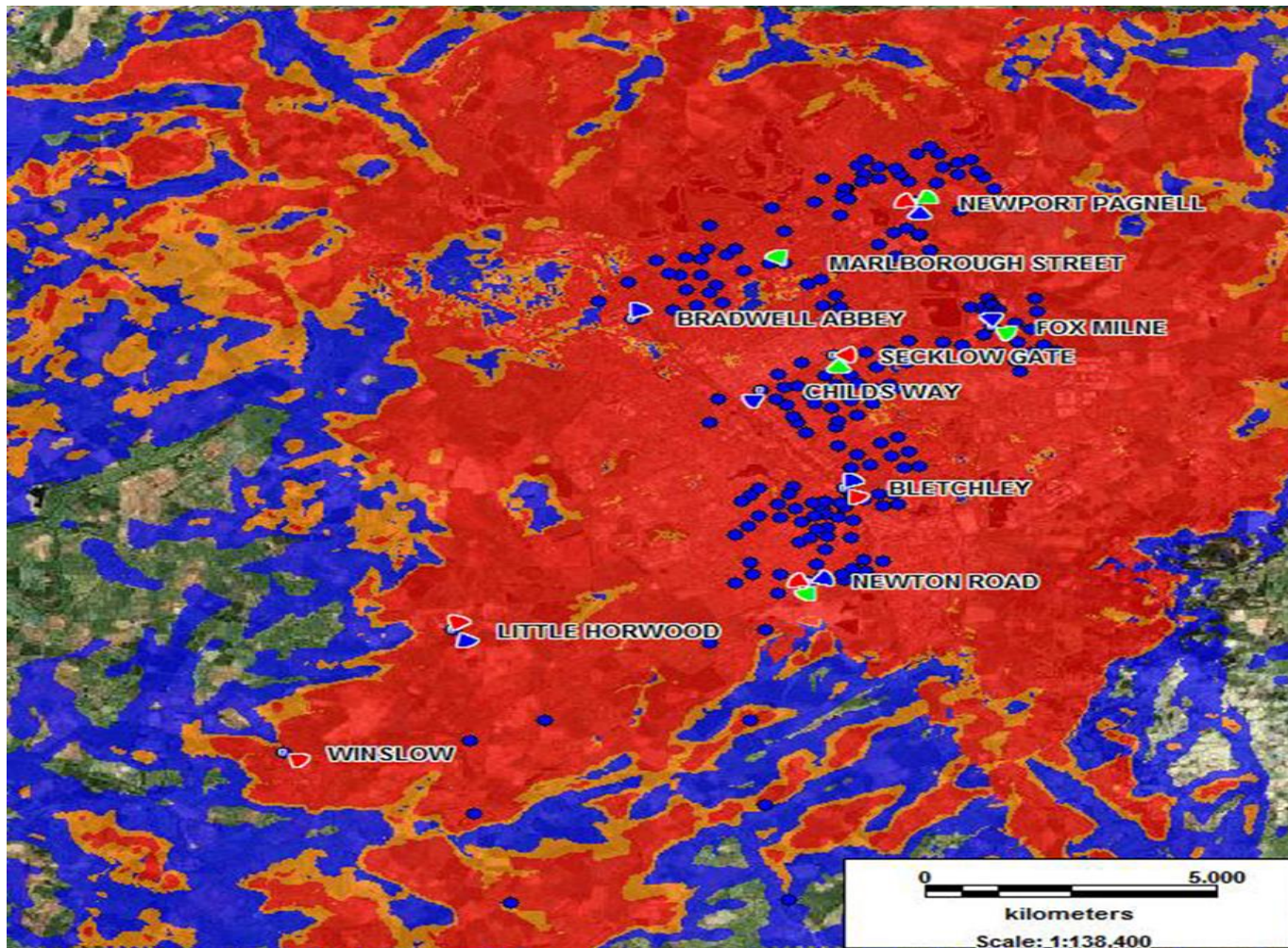
Telecoms Infrastructure

**Roger Hey**  
Future Networks Manager





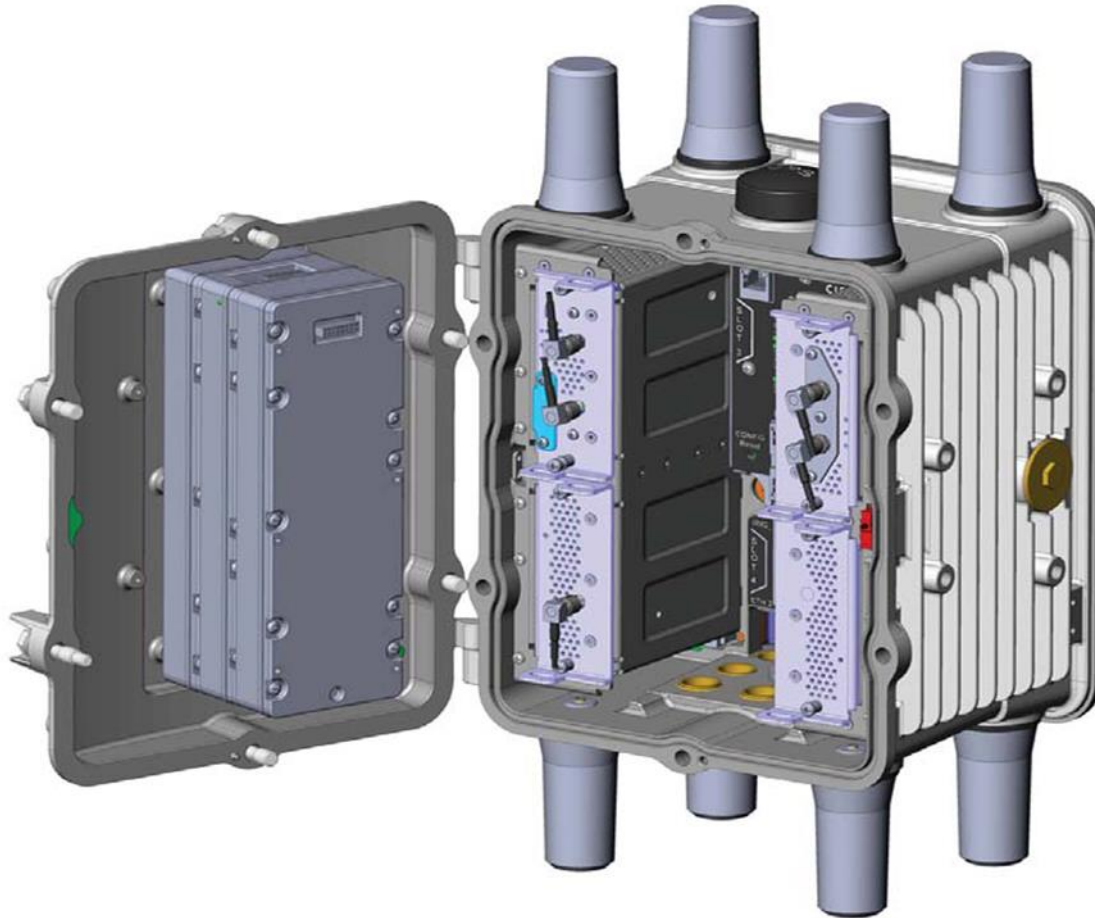
# Telecoms Infrastructure and Rollout



## Telecoms Infrastructure Design

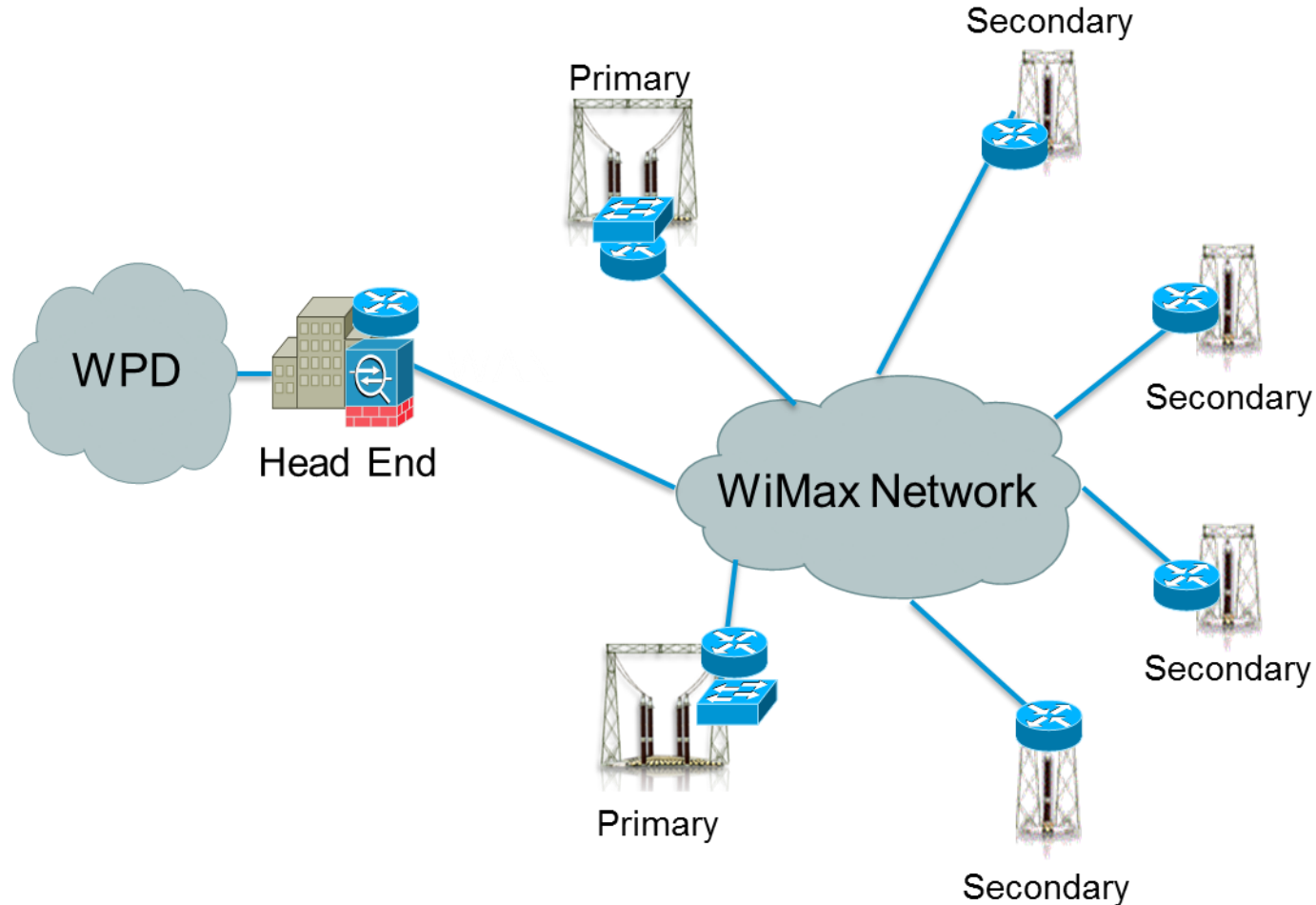
- Suitable capacity for ethernet backhaul requirements
  - Radio coverage at 1.4GHz for distribution access and 3.5GHz for WiMax backhaul to collector sites
  - Latency and design restrictions
  - Planning restrictions for telecoms infrastructure
  - Equipment selection maximising space availability
  - Primary substation build plan
  - Distribution substation build plan
  - Security
-

# Telecoms Infrastructure Design

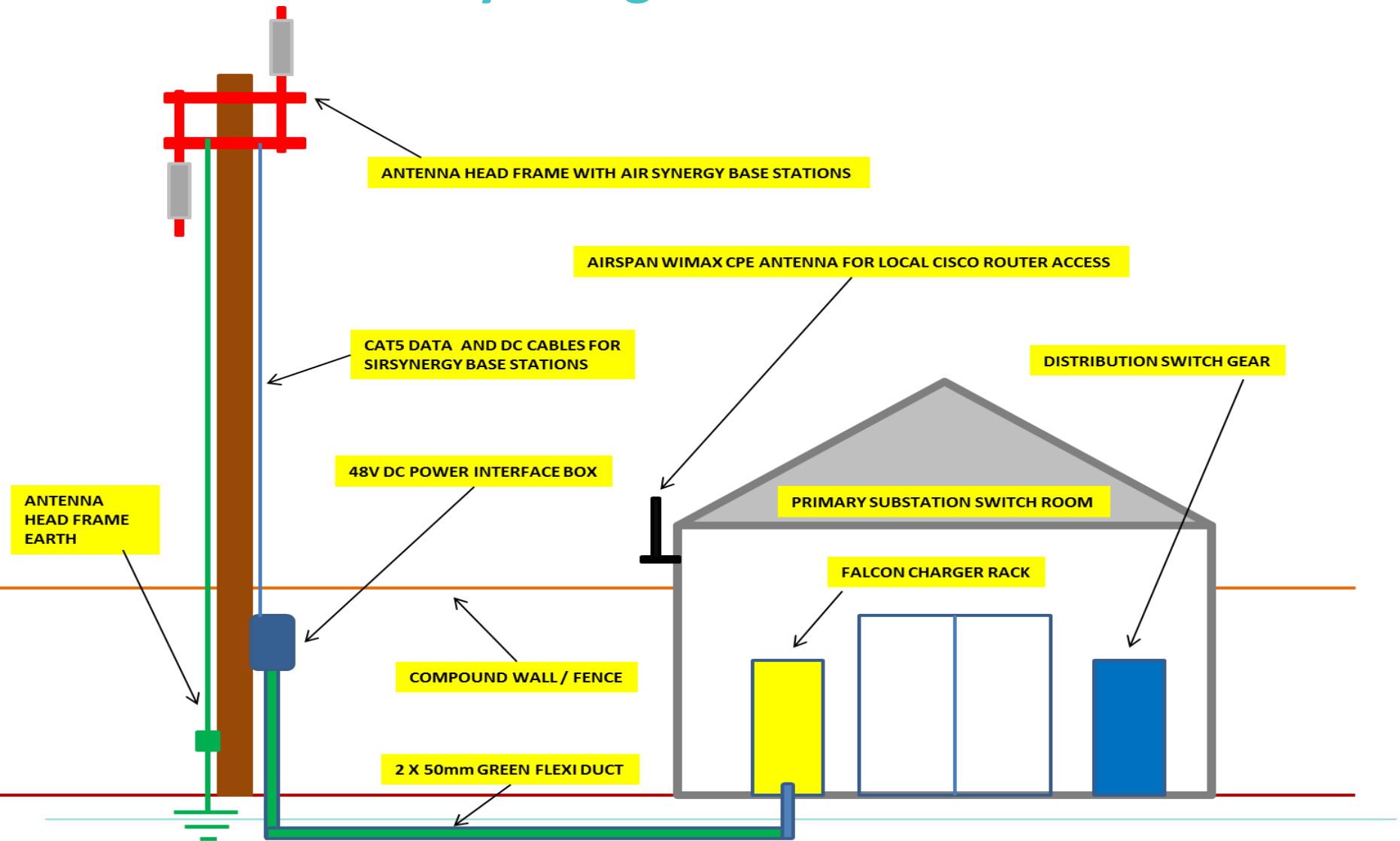




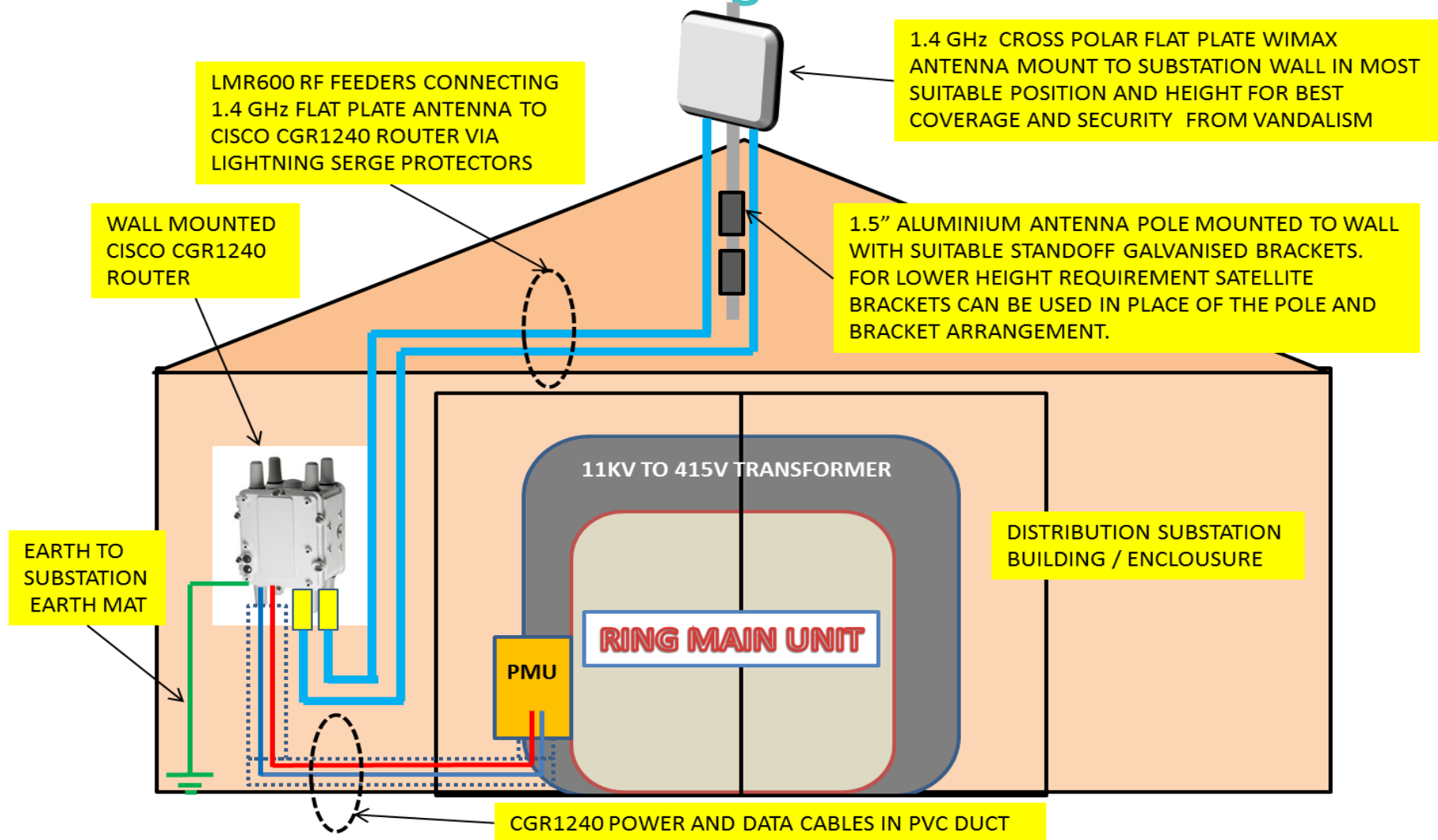
# Telecoms Infrastructure Design



# Telecoms Primary Design



# Telecoms Distribution Design



## Telecoms Learning

- Locational sensitivity
  - Seasons
  - Topology
  - Radio signal strength
  - Interference
  - WiMax Pros
  - Alternatives
-

Q&A?

## DEVELOPING FUTURE POWER NETWORKS

Data & SIM

**Jenny Woodruff**  
Innovation & Low Carbon Networks Engineer



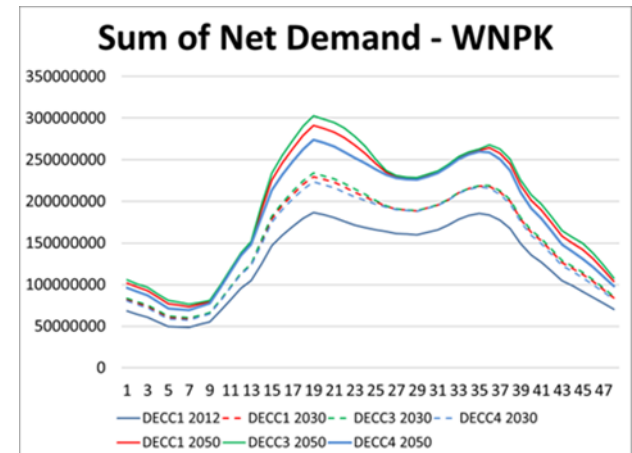
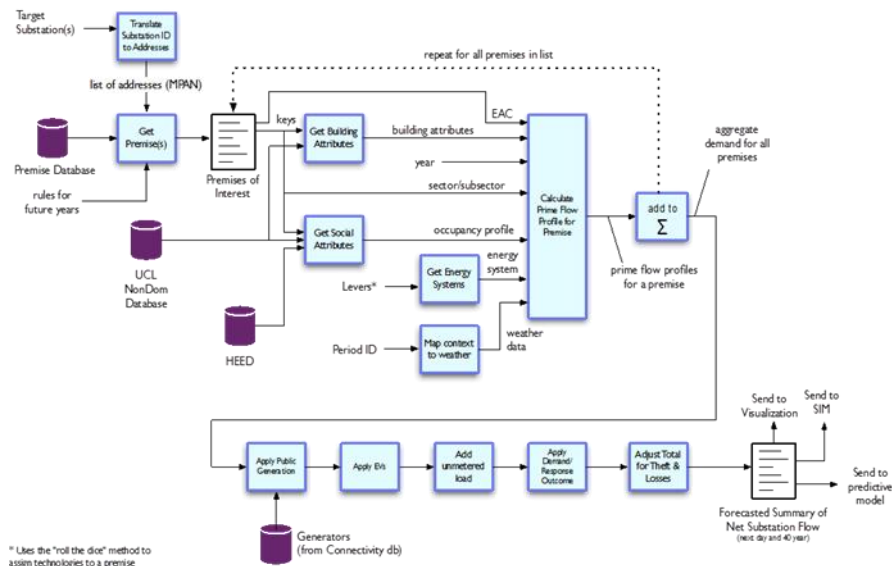


# FALCON Energy Model

Build up load profile by modelling building energy requirements for heating and water, profiling other end use types, lighting.

Scenarios models future adoption of heat pumps, EV, PV, efficient appliances etc.

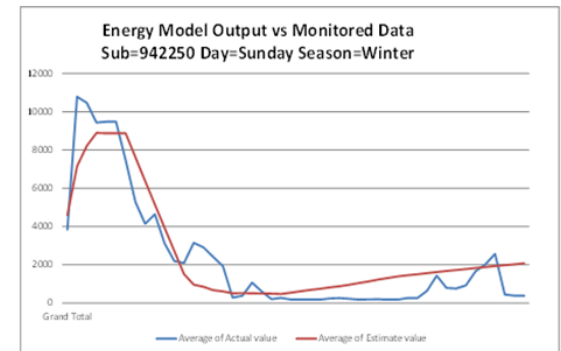
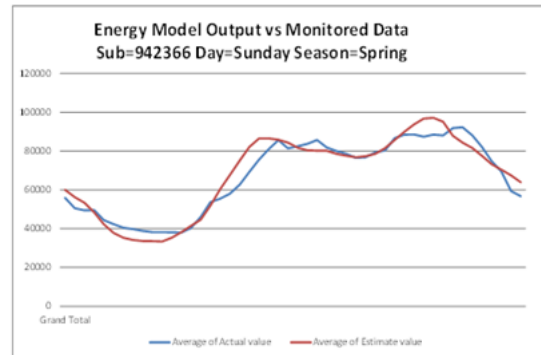
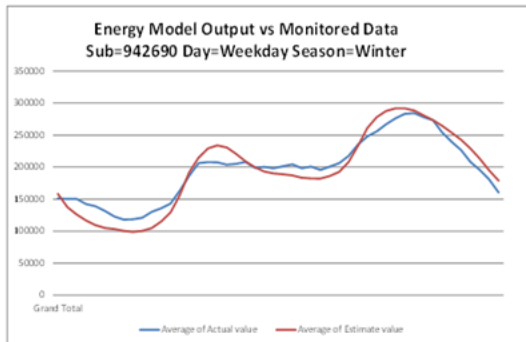
Falcon Energy Model Overview



## Challenges – Energy Model

- Very data intensive.
  - Time consuming to run.  
Off-line activity not providing data in real time.
  - Matching with external data sets.  
No building references, Address matching issues, Limited customer information, Data protection compliance.
  - Very large volumes of data coming back.  
1700 substations x 48 hh x 18 daytypes x 35 years  
X 4 scenarios with 4 sensitivity analysis versions too.
  - Experian data licence is expensive.
-

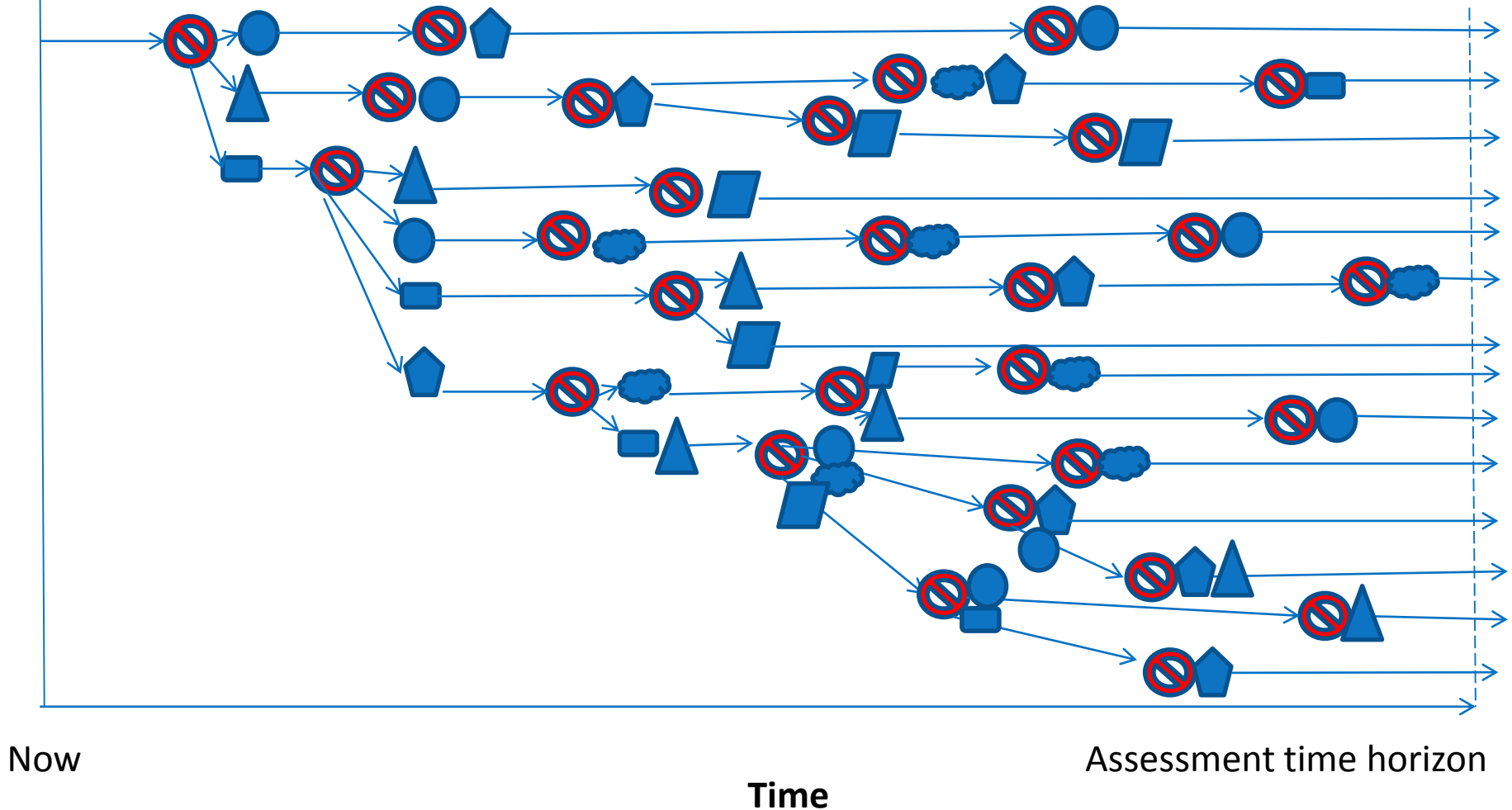
# FALCON Energy Model



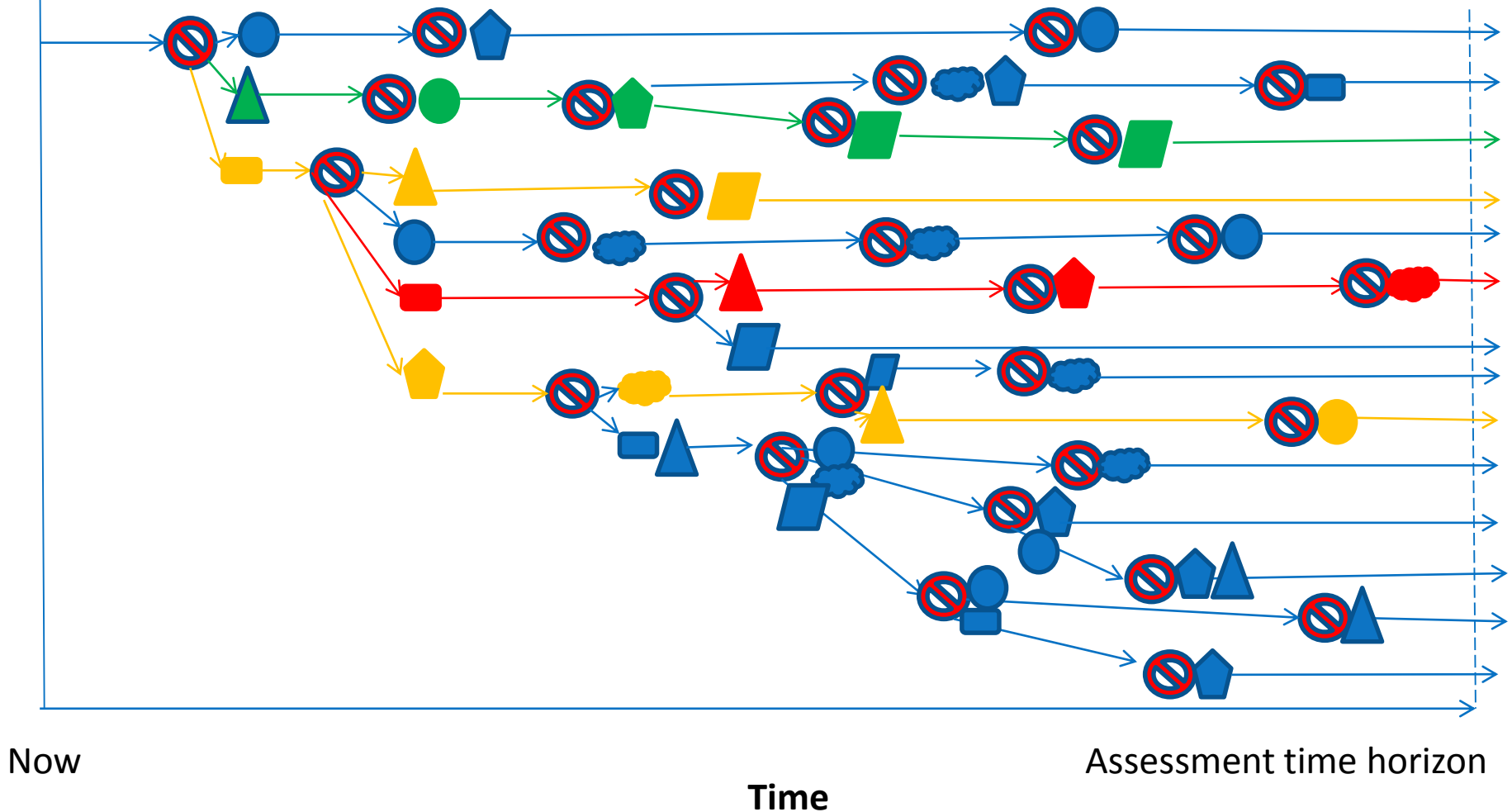
Can get very good results.

Analysis of outliers suggests odd results caused by data issues – likely to impact all estimation methods.

## Scenario Investment Model



# Optimisation

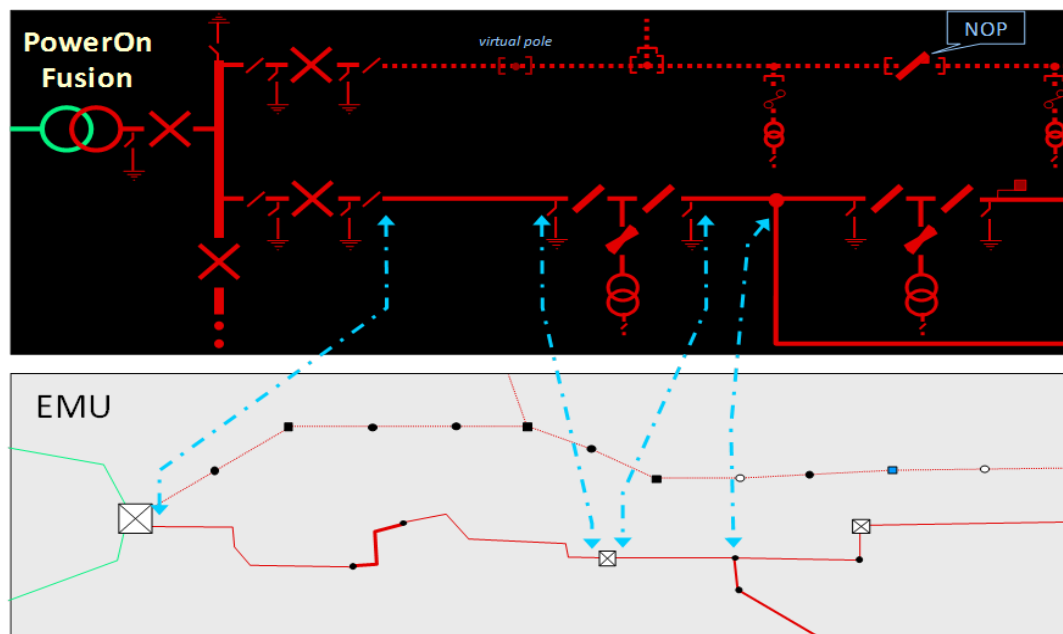


## Integrated Network Model

- Network data to support power flow analysis
- + extra to support application of techniques.
- Merge datasets - Control room, Asset Management and GIS.

Mismatches investigated

Extend to other voltages and align with Common Information Model (IEC standard.)





Q&A?

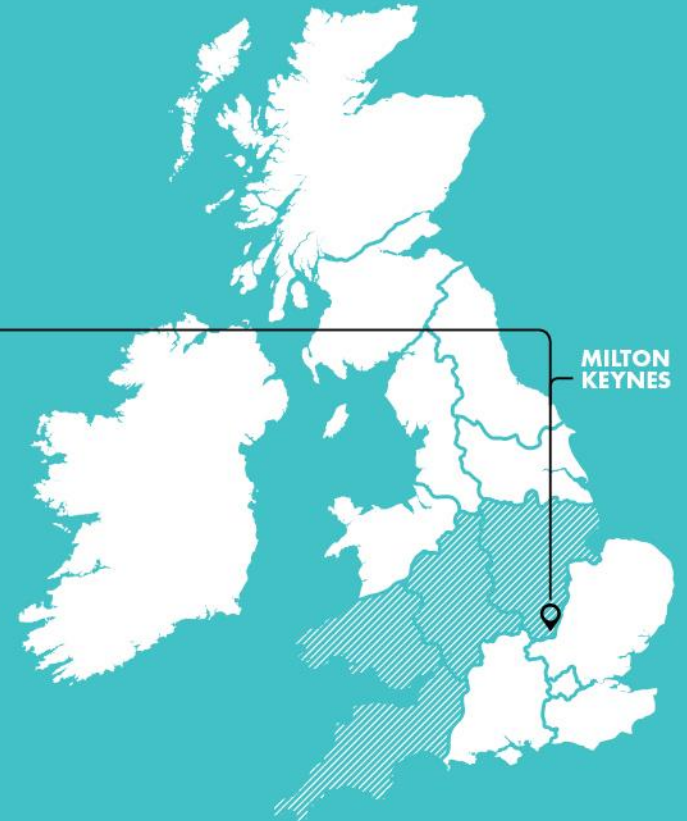
# Refreshments – 20mins

## DEVELOPING FUTURE POWER NETWORKS

Energy Storage for Distribution Networks

Chris Harrap

Engineering Trials Implementation Lead



## Equipment Deployed

100 kWh  
Base Unit



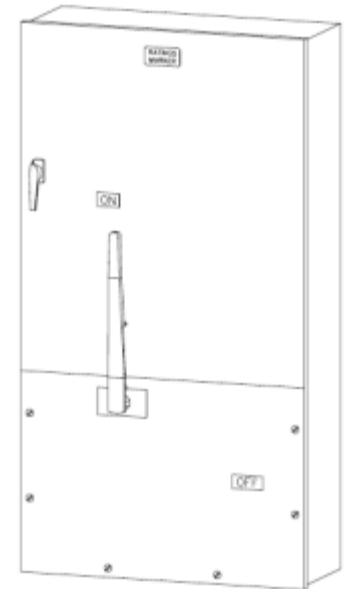
50(100) kW  
Inverter



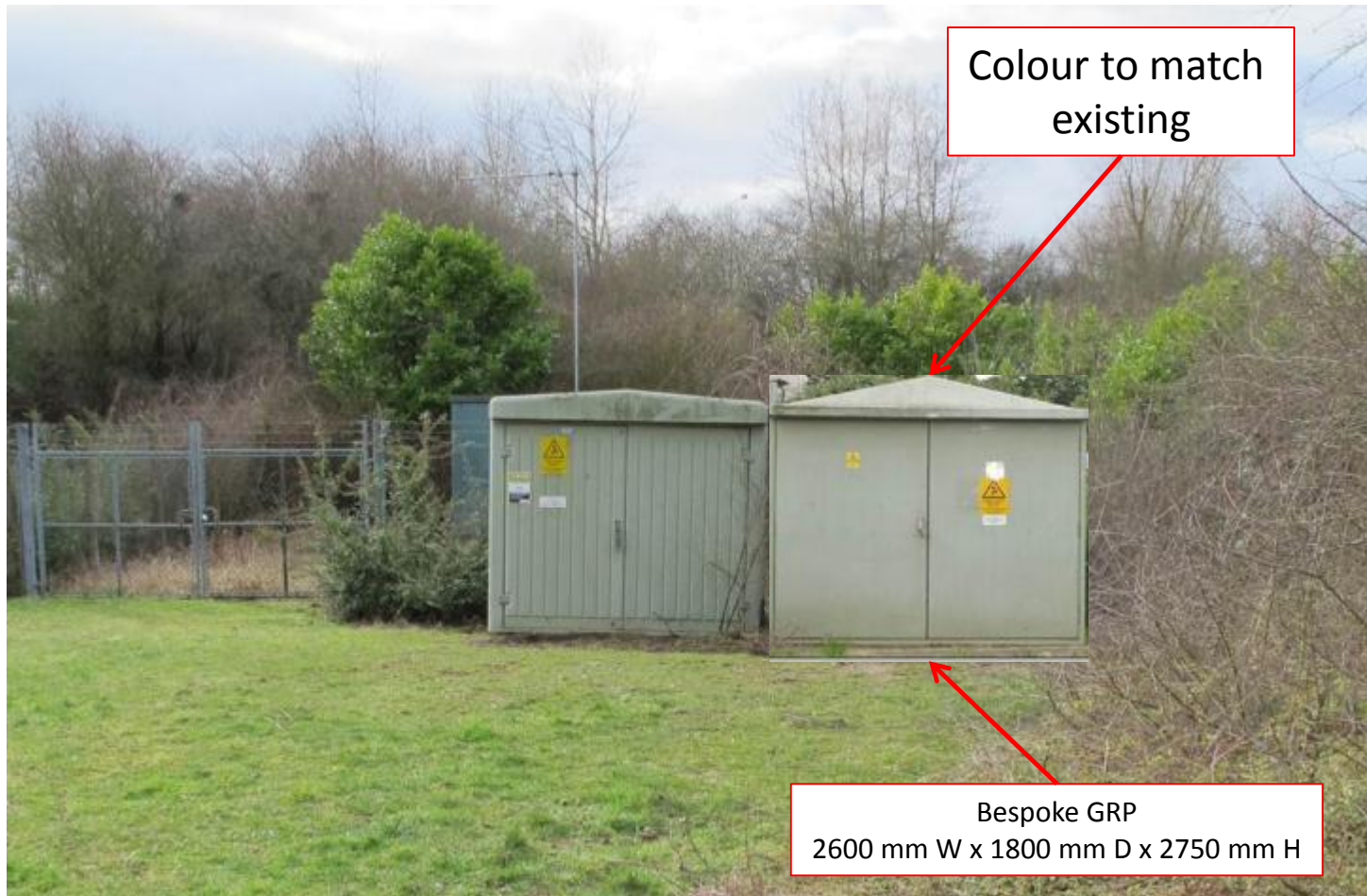
Site Controller



DC Switchgear



## Existing Distribution Sites





## Installed Layout





## Installed Layout



## Installed Layout



# Physical Installation Challenges

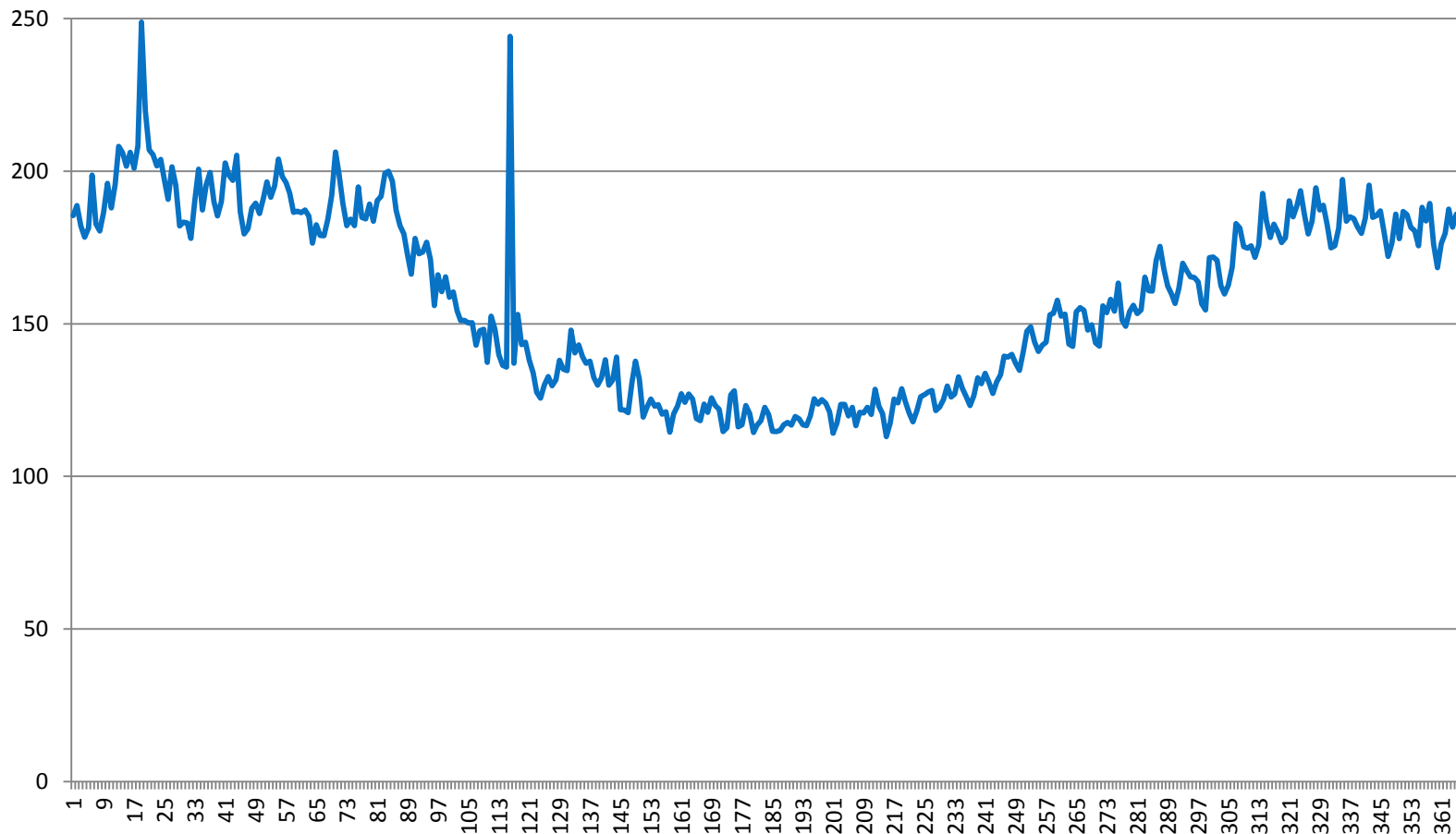


- Large Form Factor
- Difficult to manoeuvre
- DC wiring knowledge gaps
- Fan Noise
- Switching Frequency Noise
- Environmental Conditions
- Heat Dissipation
- Electrical Protection (G59)
- Modes of Failure
- Harmonic Content



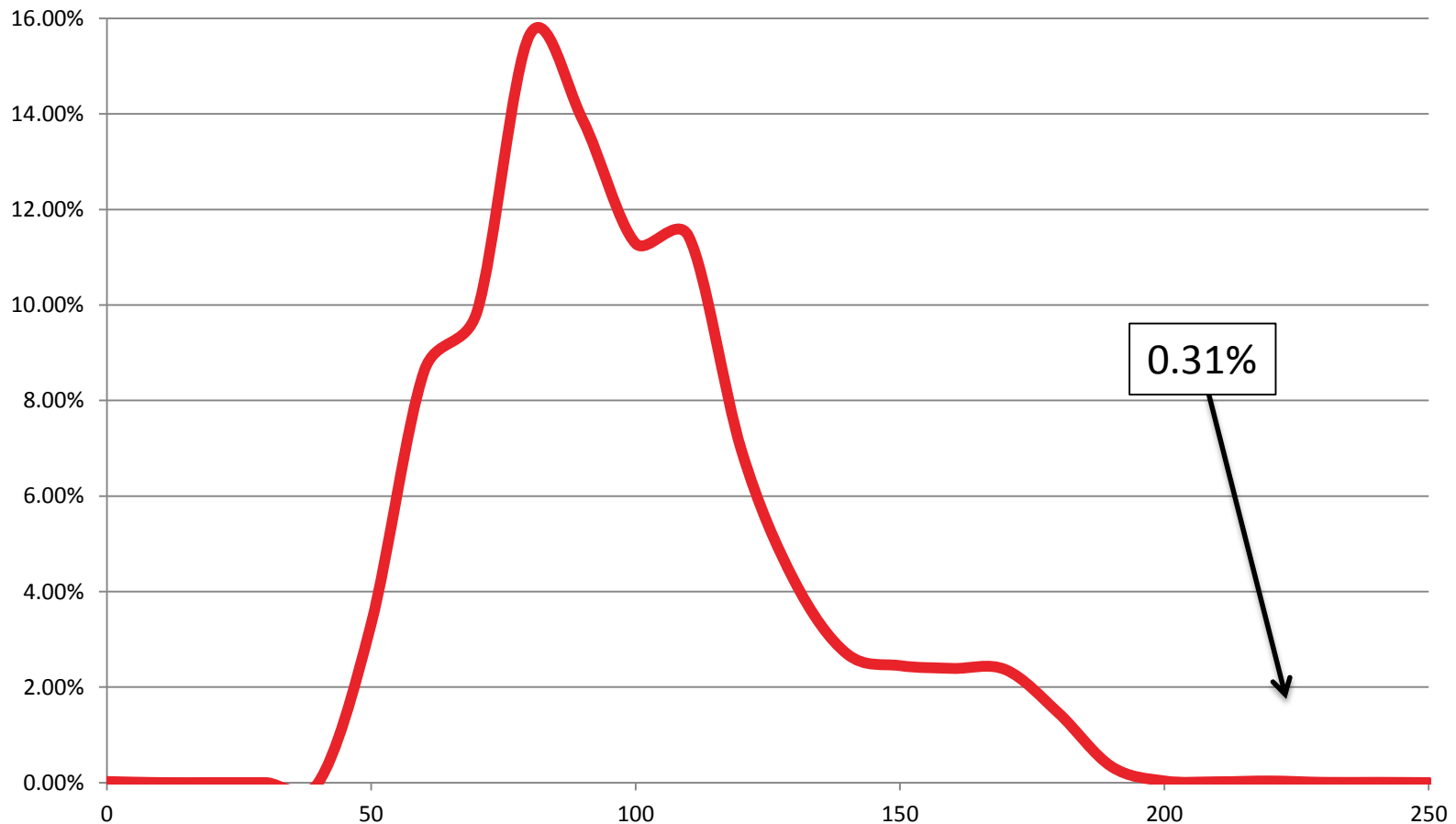
# DNO Usage Profile

## 250A Circuit

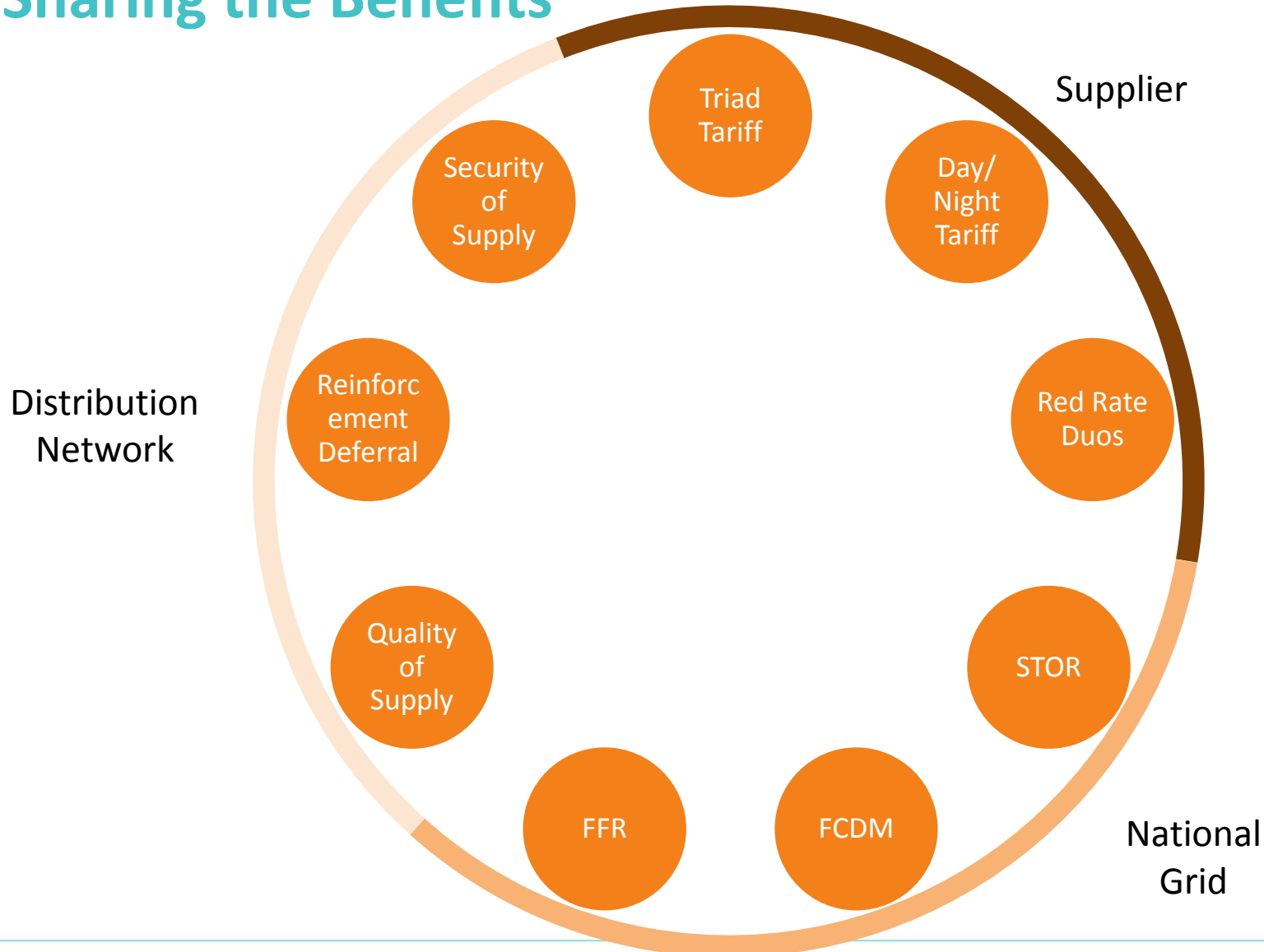


# DNO Usage Profile

**250A Circuit**



# Sharing the Benefits

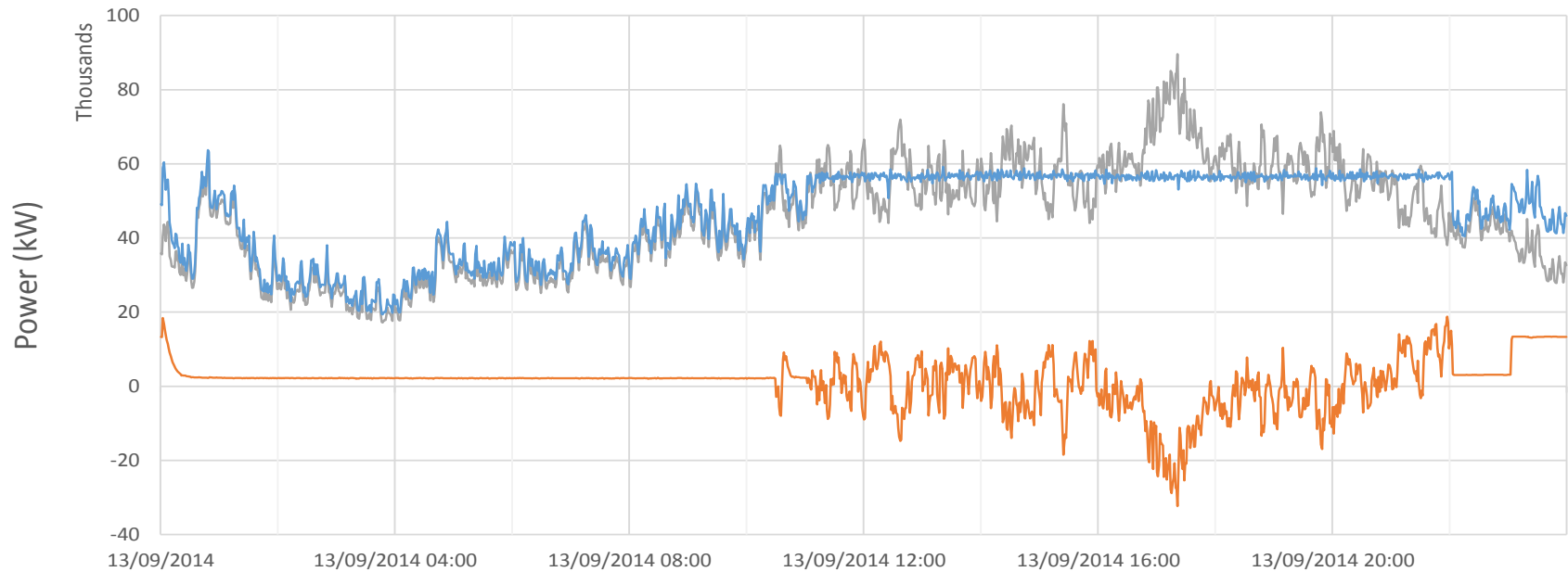


# Peak Shaving (24 hours)

Site Name Year Month Day Period

Sum of Total mean busbar active power - inc energy storage Sum of Energy storage unit active power Sum of Sub active power excluding energy storage

## AMBRIDGE GROVE



Values

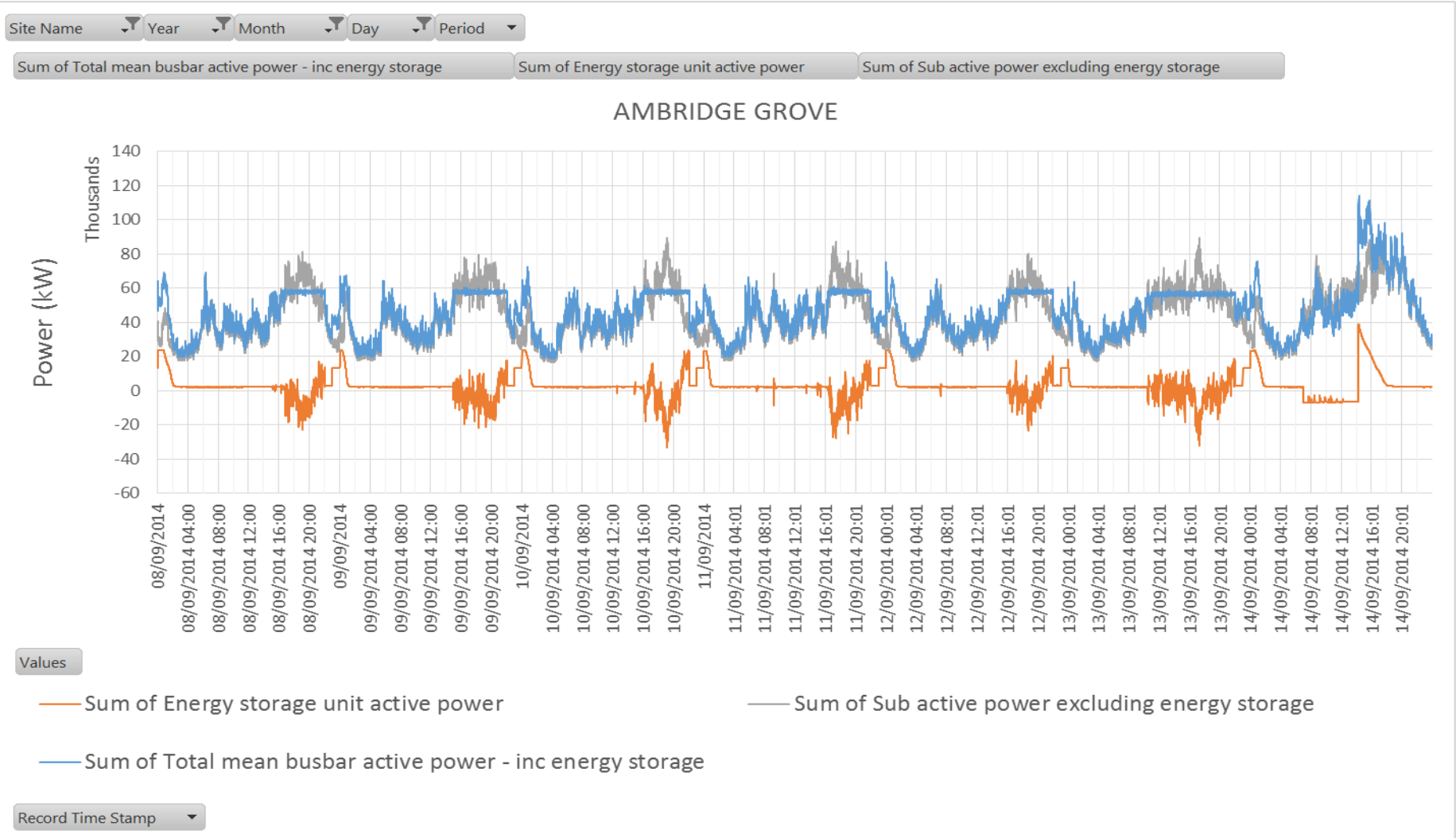
— Sum of Energy storage unit active power

— Sum of Sub active power excluding energy storage

— Sum of Total mean busbar active power - inc energy storage

Record Time Stamp

# Peak Shaving (week)





# Frequency Regulation (9 hours)

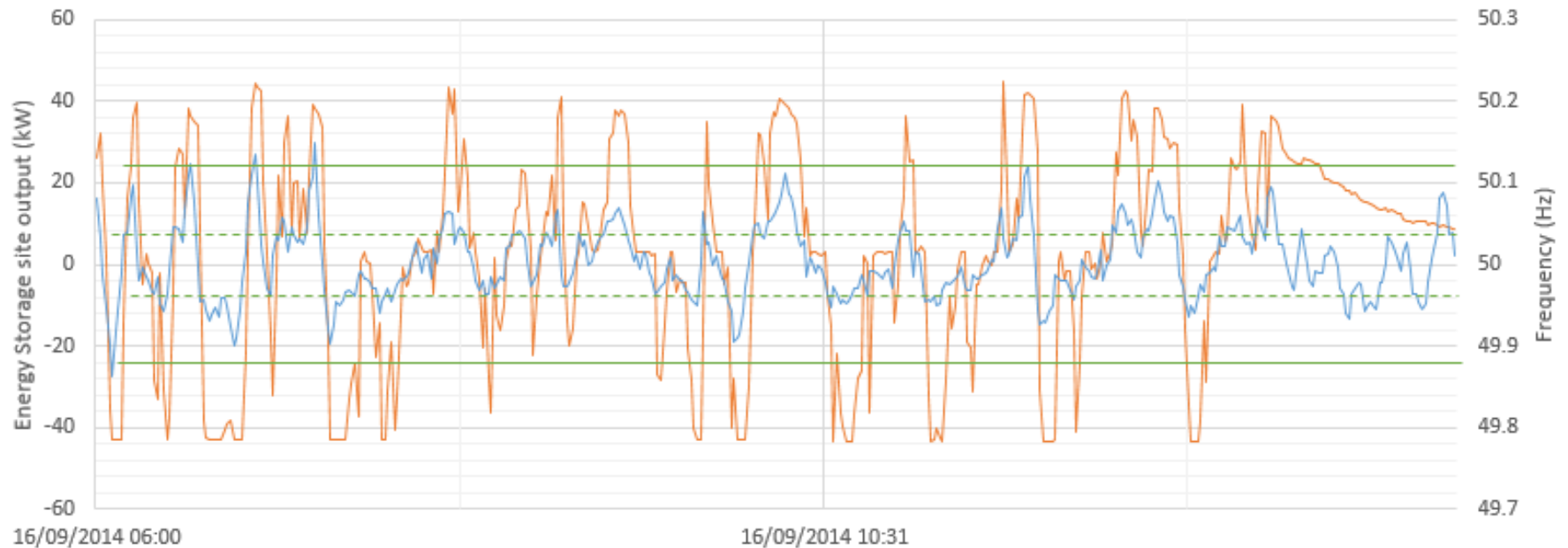
Site Name Year Month Day Period

Chart Area

Sum of AvgOf\_MARBOROUGH1-FQ:FREQ Micom P847 Frequency

Sum of Energy storage unit active power

## AWA PUMPING STATION MIDDLETON



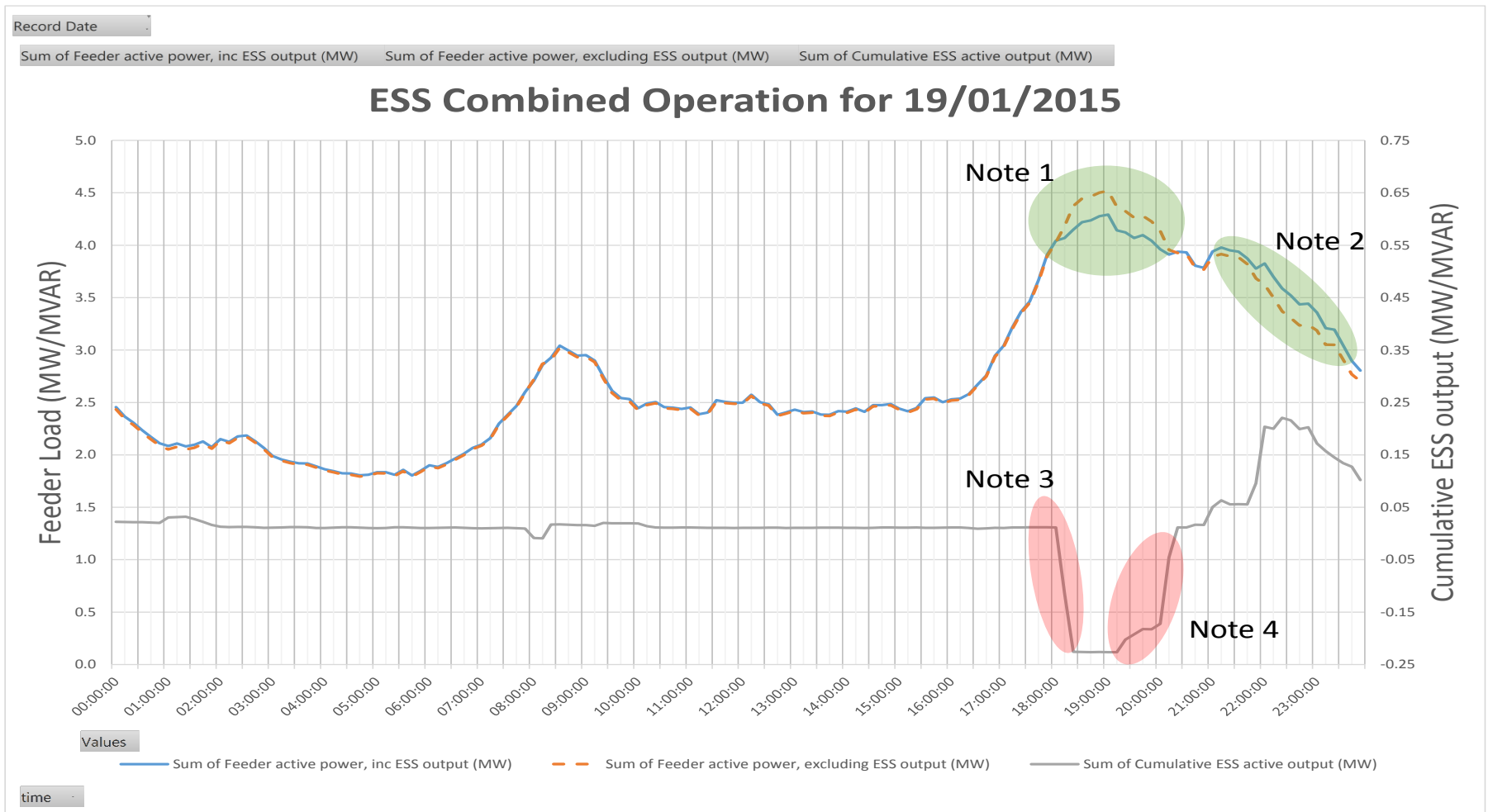
Values

— Sum of Energy storage unit active power

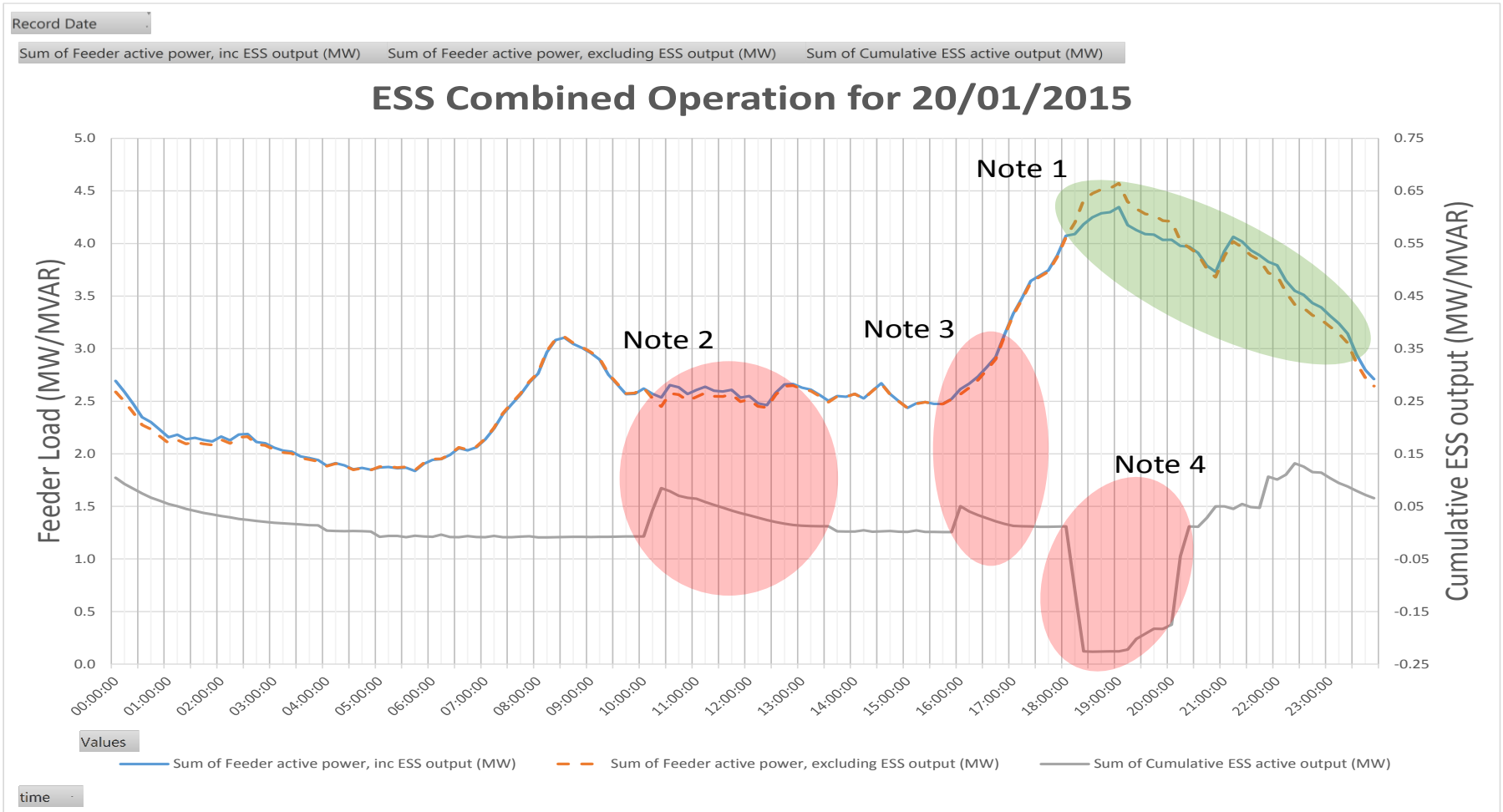
— Sum of AvgOf\_MARBOROUGH1-FQ:FREQ Micom P847 Frequency

Record Time Stamp

# Combined Operation Results



# Combined Operation Results



## Project Learning

- Optimum charge and discharge windows
  - Available triggers for charging regime
  - Best placement of storage on the system
  - Lifespan of battery versus running operation
  - Integration of ESSs with existing control environments
  - Improvements for equipment specifications
  - Input to UK-wide Good Practice Guide on storage
  - WPD Policy design for installation of battery storage facilities
-

## Project Benefits

- Reduction in I<sup>2</sup>R system losses
  - Voltage support
  - Reinforcement deferral
  - Reduced risks of stranded assets as deployment of battery storage gives options to delay reinforcement investment until demand trends are established
  - Power quality improvements
  - Facilitation of more Low Carbon Technologies
  - Key learning on the use of electrical energy storage systems for the GB utility industry
-

Q&A?



## DEVELOPING FUTURE POWER NETWORKS

Demand Response

Gary Swandells  
Commercial Trials Lead



MILTON  
KEYNES

## Project FALCON – Commercial trials preparation

- New resources and processes to engage with customers.
  - Interact with customers directly and / or via aggregators
  - Author and approve new ‘performance based’ contracts
  - Financial approval of viable business proposition
  - Control room dispatch arrangements
  - Performance assessment software
  - Back office systems for settlement processes
  - Identify & detail market conflicts and propose any potential solutions
-

## Project FALCON trials preparation

- ✓ New resources and processes to engage with customers.
  - ✓ Interact with customers directly and / or via aggregators
  - ✓ Author and approve new 'performance based' contracts
  - ✓ Financial approval of viable business proposition
  - ✓ Control room dispatch arrangements
  - ✓ Performance assessment software
  - ✓ Back office systems for settlement processes
  - ✓ Identify & detail market conflicts and propose any potential solutions
  - ✓ *Knowledge Management*
-

## Project FALCON

### Commercial trials season 1 completed Feb 2014

FALCON met all recruitment objectives for **Distributed Generation** trials

- Direct and third party contracts
- Participation of six aggregators, three of which successfully recruited trialist
- In excess of 10MW of capacity from 11 participants
- Small, medium & large capacity generators
- Stand by and CHP
- Diesel & Gas engines

## Project FALCON

### Commercial trials season 1 - exceptions

Despite several prospects there were *no* Load Reduction participants either directly or via aggregators.

This was not unexpected as it broadly reflected across the majority of DSR programmes and trials.

---

## Project FALCON

### Commercial trials season 1 statistical results

- 30 minutes notice of an event
- Maximum duration 2 hours / Minimum 1 hour
- 18 Events called between 27<sup>th</sup> November & 28<sup>th</sup> February
- Approximately ¼ GWh of generation for purposes of trial
- Relatively small number of incidents of delivery failure
- DNO DSR programme conflicts with National Grid Balancing Service



# Project FALCON

## Commercial trials season 1 results

| site | 04-Nov | 11-Nov | 18-Nov | 25-Nov | 02-Dec | 09-Dec | 16-Dec | 23-Dec | 30-Dec | 06-Jan | 13-Jan | 20-Jan | 27-Jan | 03-Feb | 10-Feb | 17-Feb | 24-Feb |
|------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
|      | 1      | 2      | 3      | 4      | 5      | 6      | 7      | 8      | 9      | 10     | 11     | 12     | 13     | 14     | 15     | 16     | 17     |
| 1    | n      | n      | n      | n      | y      | y      | n      | n      | n      | y      | y      | y      | y      | y      | y      | y      | y      |
| 2    | n      | n      | y      | n      | n      | n      | n      | n      | n      | n      | n      | n      | n      | n      | n      | y      | y      |
| 3    | n      | n      | y      | n      | y      | y      | n      | n      | n      | y      | y      | y      | y      | y      | y      | y      | y      |
| 4    | n      | n      | n      | n      | n      | n      | n      | n      | n      | n      | n      | n      | n      | n      | n      | n      | n      |
| 5    | n      | n      | n      | y      | y      | y      | n      | n      | n      | y      | y      | y      | y      | y      | y      | y      | y      |
| 6    | na     | na     | na     | na     | na     | na     | n      | y      | y      | y      | y      | y      | y      | y      | y      | y      | y      |
| 7    | y      | y      | y      | y      | y      | y      | y      | y      | y      | y      | y      | y      | y      | y      | y      | y      | y      |
| 8    | y      | y      | y      | y      | y      | y      | y      | y      | y      | y      | y      | y      | y      | y      | y      | y      | y      |
| 9    | y      | y      | y      | y      | y      | y      | y      | y      | y      | y      | y      | y      | y      | n      | n      | y      | y      |
| 10   | y      | y      | y      | y      | n      | n      | n      | n      | n      | n      | n      | n      | y      | y      | y      | y      | y      |
| 11   | y      | y      | y      | y      | y      | y      | y      | y      | y      | y      | y      | y      | y      | y      | y      | y      | y      |

- 181 potential availability windows
- 61 declaration unavailable
- 66.3% reliability factor

## Project FALCON - Season 2

### Parameters

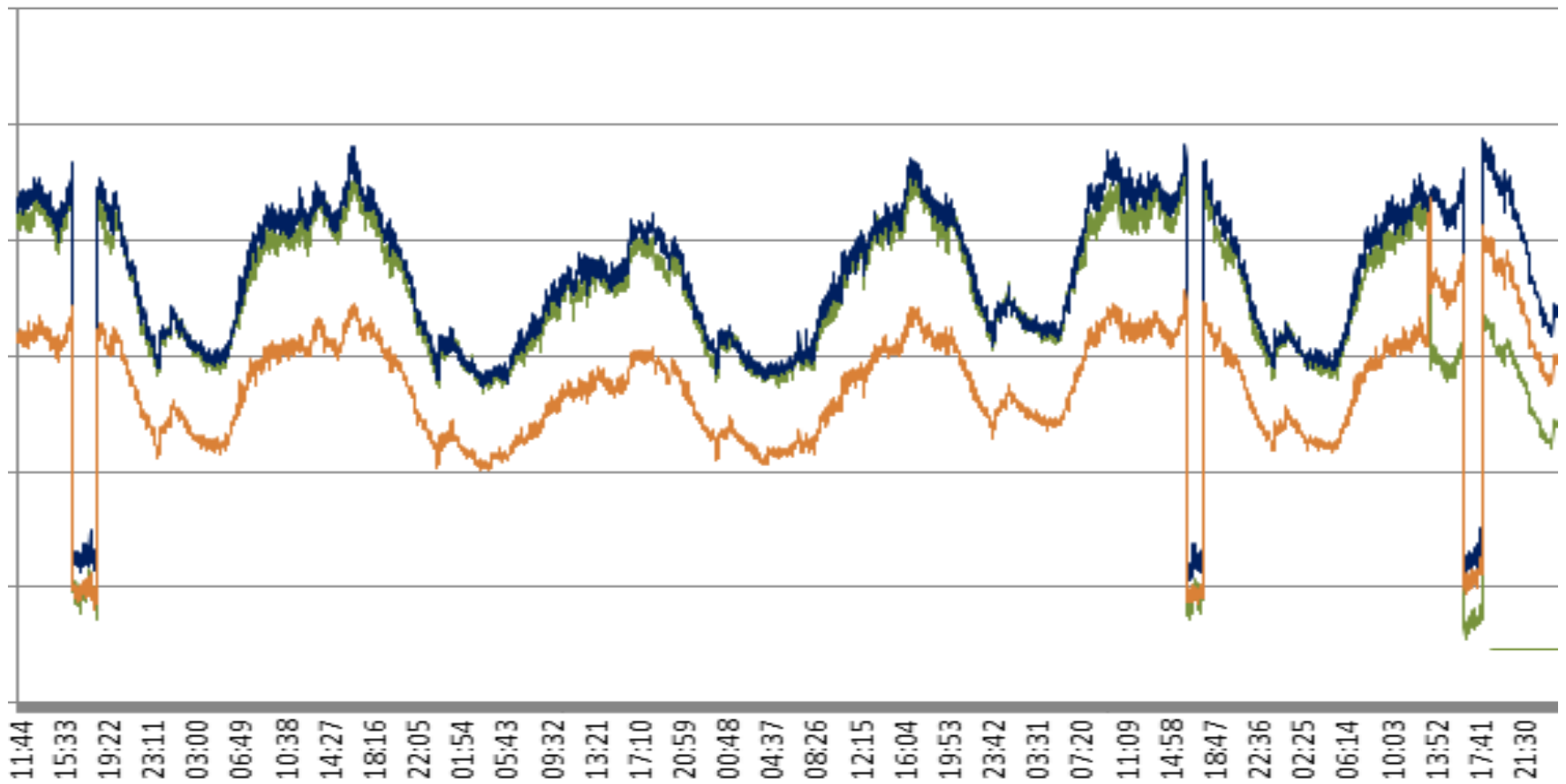
- Week ahead notification of operating schedule
  - Capped consumption target based on previous year's peaks
  - New back office systems
  - Increased incentive for load reduction
  - Additional aggregator involvement
  - Data from new Smart Meter solution
-

## Season 2 Results

- Trials completed on time & budget
  - We have trialled load reduction alongside generation
- Reliability improved
  - Week ahead declarations improved site reliability
  - Forecasting 7-12 days ahead provided predictable results probably adequate for DNO peak avoidance use.
- Processes proven
  - Capped consumption resulted in predictable response behaviour.
  - Smart metering was effective with no lost files and excellent data integrity
- Systems proven
  - Back office version 2 far easier to operate and quicker due to batch processing
  - Statements process was concluded almost 3 weeks ahead of schedule.

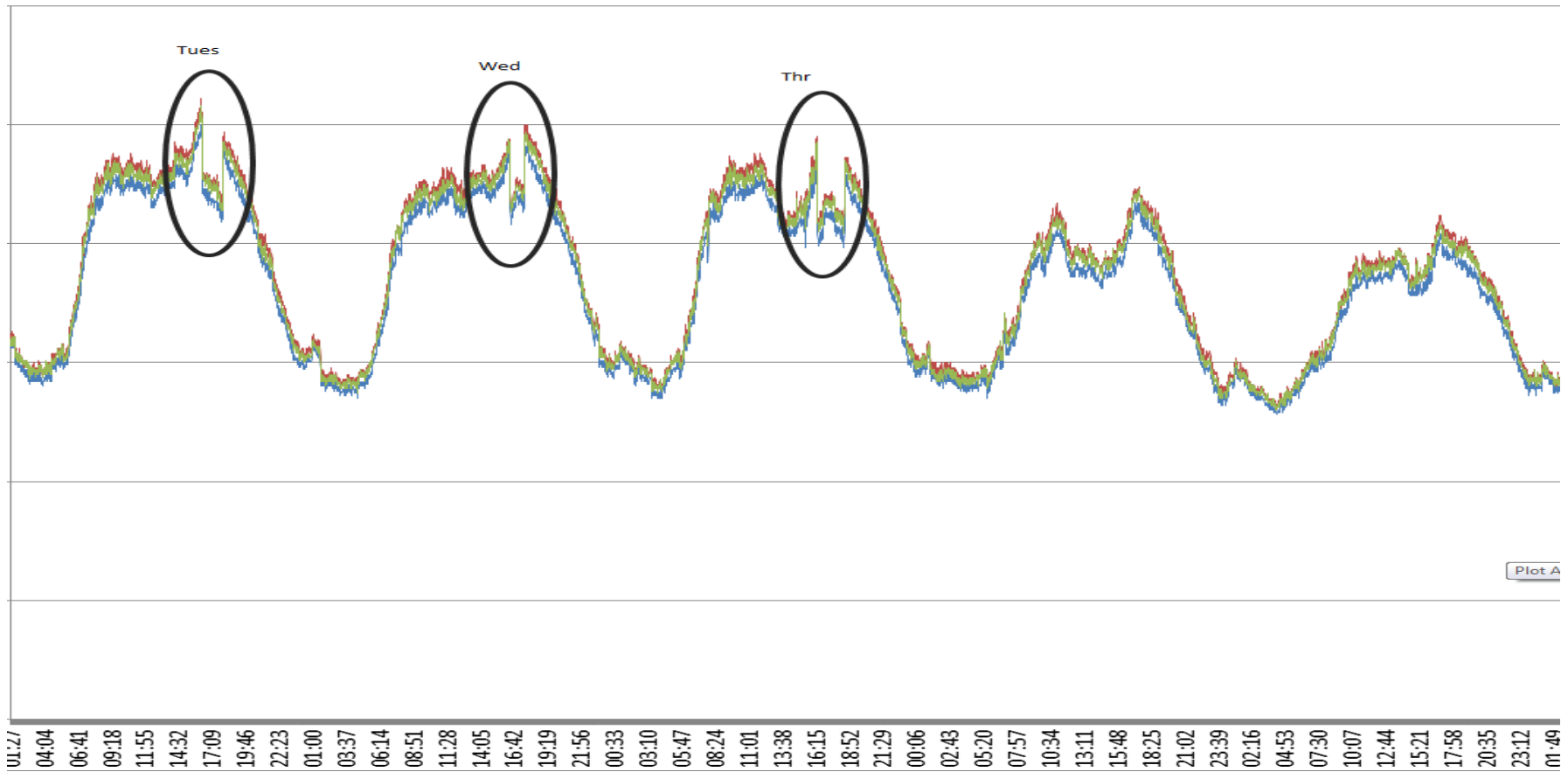
## Project FALCON - Season 2

### 11kV Transformer Impact



## Project FALCON - Season 2

### 33kV Transformer Impact



## Post Trial - FALCON

- Proposing NIA scope for I&C Load **Increase** in the South West
  - Stimulate predictable and reliable load increase to manage volts, VAR and reverse power flows
  - Develop financially viable system for generators to pay demand increases.
  - Establish attractive opportunities for location of Energy Storage
- Dedicated NIA trial for I&C DSR in the Midlands
  - Detailed analysis of networks to locate all potential generators that could provide DSR
  - Determining impact of existing generators on network planning
  - Reviewing connections policies and processes to support DSR
  - Optimising WPD's own generator fleet to maximise asset investments



Q&A?



[www.westernpowerinnovation.co.uk](http://www.westernpowerinnovation.co.uk)

[wpdinnovation@westernpower.co.uk](mailto:wpdinnovation@westernpower.co.uk)