WESTERN POWER DISTRIBUTION

INNOVATION

NEXT GENERATION NETWORKS

Balancing Act Conference

Thursday 11th May 2017

One Great George Street, Westminster

Agenda

09:30	**Registration & Refreshments**
10:00	**Welcome & Introductions** ***Nigel Turvey, Network Strategy and Innovation Manager***
10:10	**DNO-DSO Transition** ***Roger Hey, Future Networks Manager***
11:10	**Refreshments & Networking**
11:35	**Project ENTIRE** ***Matt Watson, Innovation and Low Carbon Networks Engineer***
12:35	**Lunch & Networking**
13:20	**Afternoon Breakout Sessions**
14:20	**Refreshments & Networking**
14:45	**Afternoon Breakout Sessions**

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DNO to DSO
The Role of Flexibility

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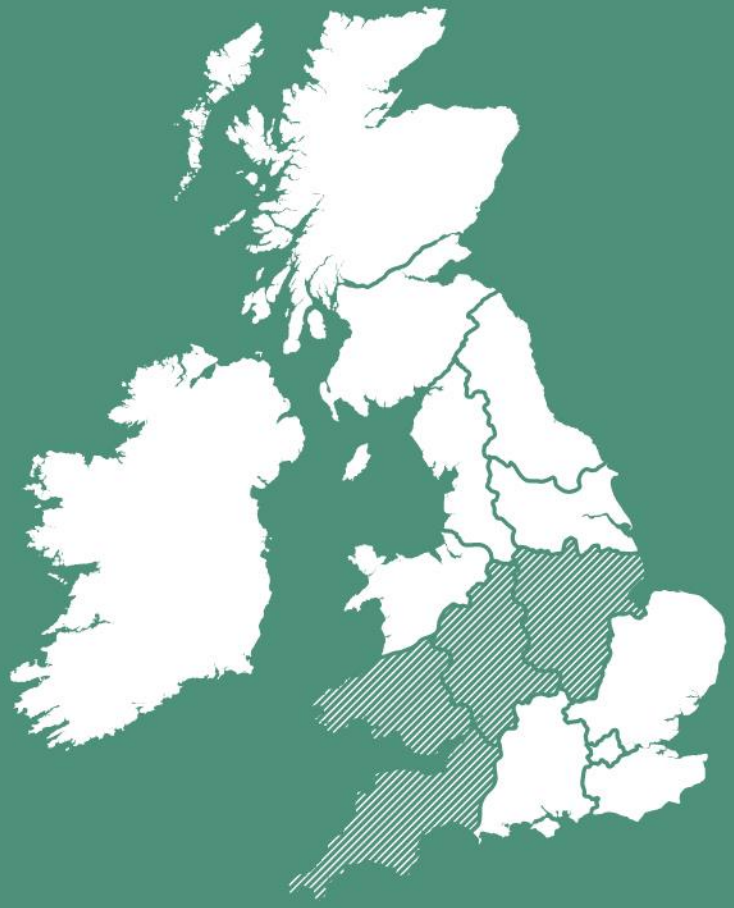


Roger Hey

Future Networks Manager

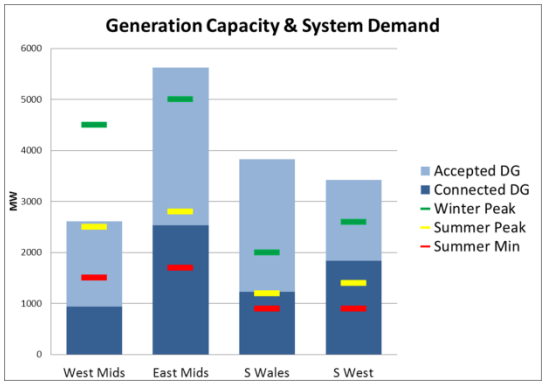
Distribution System Operator (DSO)

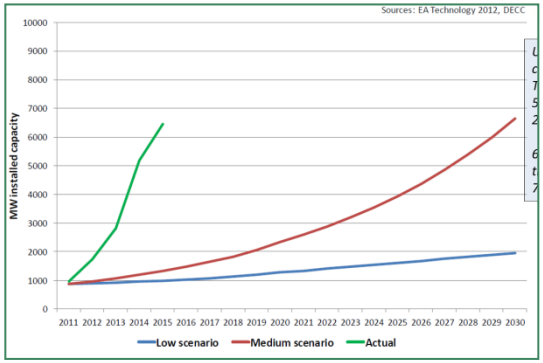
- A Distribution Network Operator (DNO) provides a network sized to support times of maximum demand and/or generation output. It is sufficiently large to enable the GB Market to consider it having infinite capacity.
- A Distribution System Operator (DSO) exploits ICT to deliver a network that makes optimal use of capacity:
  - smarter network solutions (eg. DAR; ALT, Meshing, ANM, Intertrips)
  - Non-network solutions (eg. DSR, DG, Storage, Reactive Power Services)
- DSO roles will include:
  - Modelling, managing, contracting and dispatching power and energy flows
  - Brokering ancillary services
  - Local and regional network balancing and congestion management
  - Relationship with the GB SO: Coordinate operations and provide services
  - Become a platform for energy suppliers, communities and other market participants to have visibility of network congestion in order to facilitate optimal DG and DSR solutions

Increased network visibility, advanced control systems and data analytics will allow the DSO to predict energy volumes and despatch flexibility services

DNO to DSO Drivers

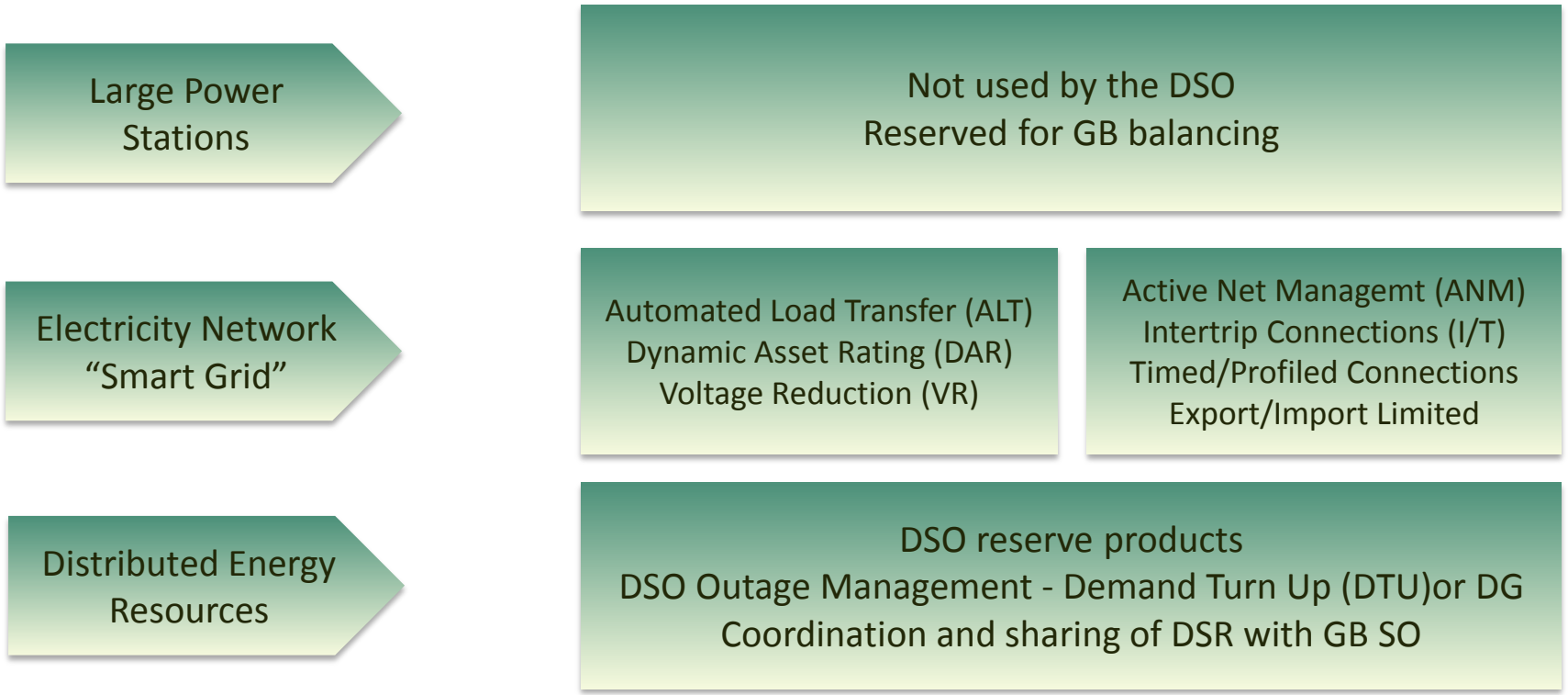
- International and UK binding Climate targets – delivered through renewable DG, Low Carbon Heat and Transport
- Rapid changes in distributed generation and other Distributed Energy Resources (DER)
  - much more DG (14GW Winter Peak; 20GW DG, 12% of Energy)
  - Behind the meter impact is unknown; volatile market/incentives
  - 8GW of Energy Storage applications
  - Growing ancillary services market - DSR at a national level
- Consideration of whole system optimisation
  - Centralised Generation, Gas, Heat and transport fuels
- ICT revolution and ubiquitous telecommunications
- Significant uncertainty over the pace of change
  - Electrification of Transport and Heating
  - Risk of stranded assets
  - Long lead times and planning restrictions to build conventional





DSO Flexibility Services

Electricity System Flexibility can come from three sources:



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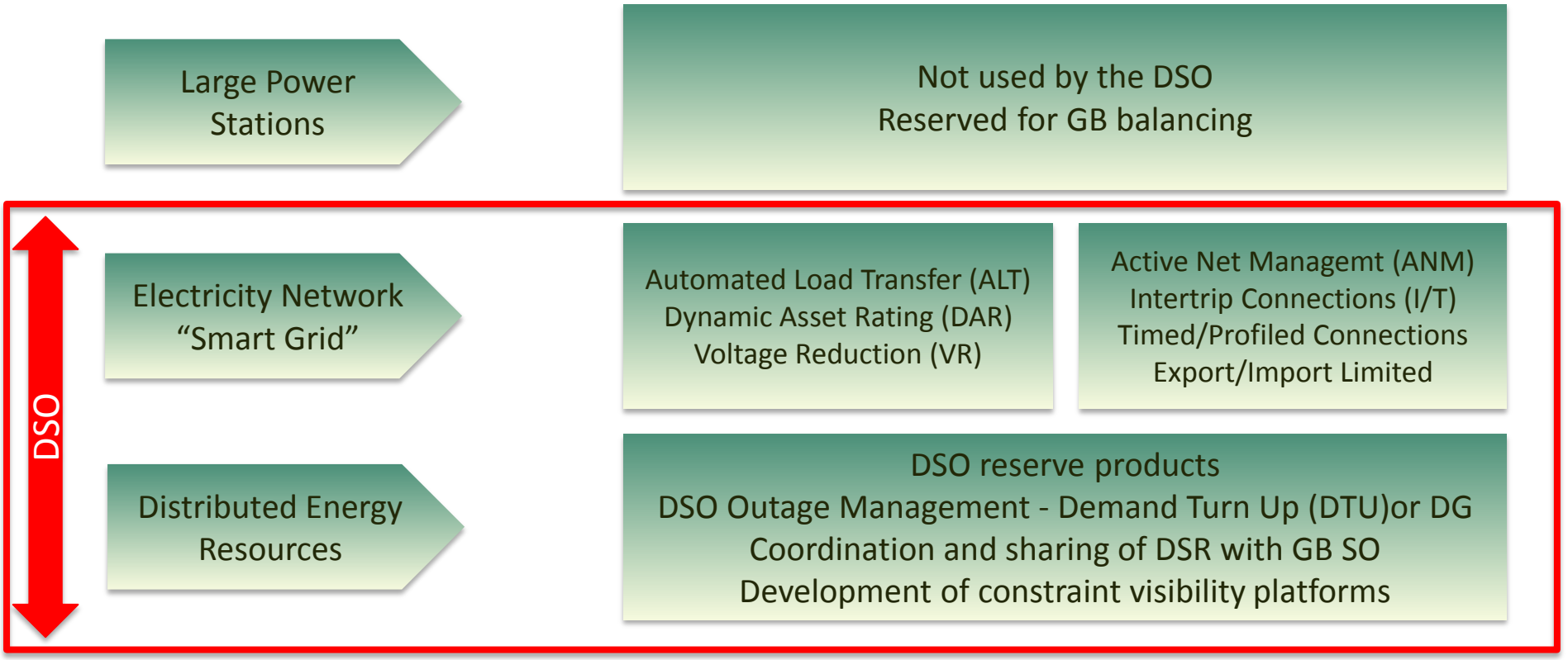


DSO Flexibility Services (Smart Grid)

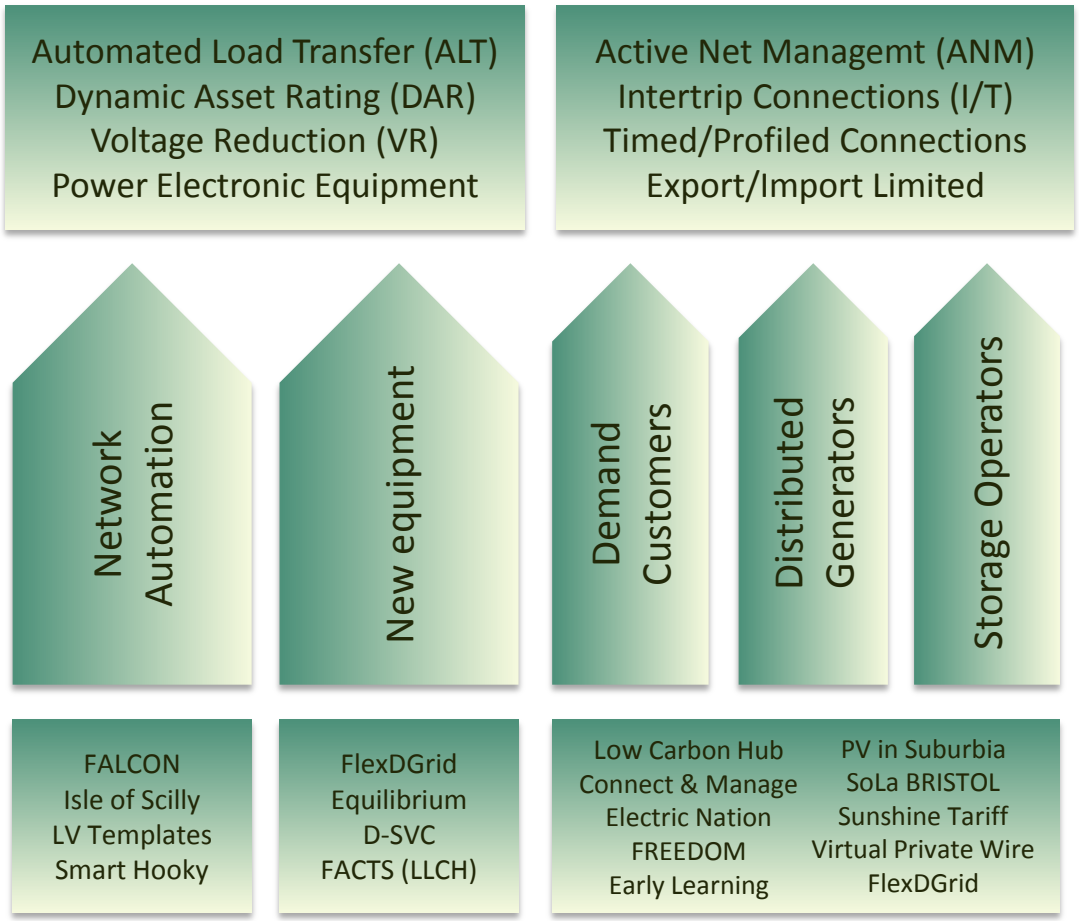
DSO Flexibility from the Electricity Network and Connections:

Electricity Network "Smart Grid"

- We are technology agnostic.
- Security and resilience are critical.
- High availability and fail-safe

- Alternative connections are customer led
- Rollout is prioritised by need.
- Plan to exploit Smart Meter data

- Our Future Networks Programme is delivering insight and will allow for a rapid rollout to BAU.



DSO Flexibility Services (DSR)

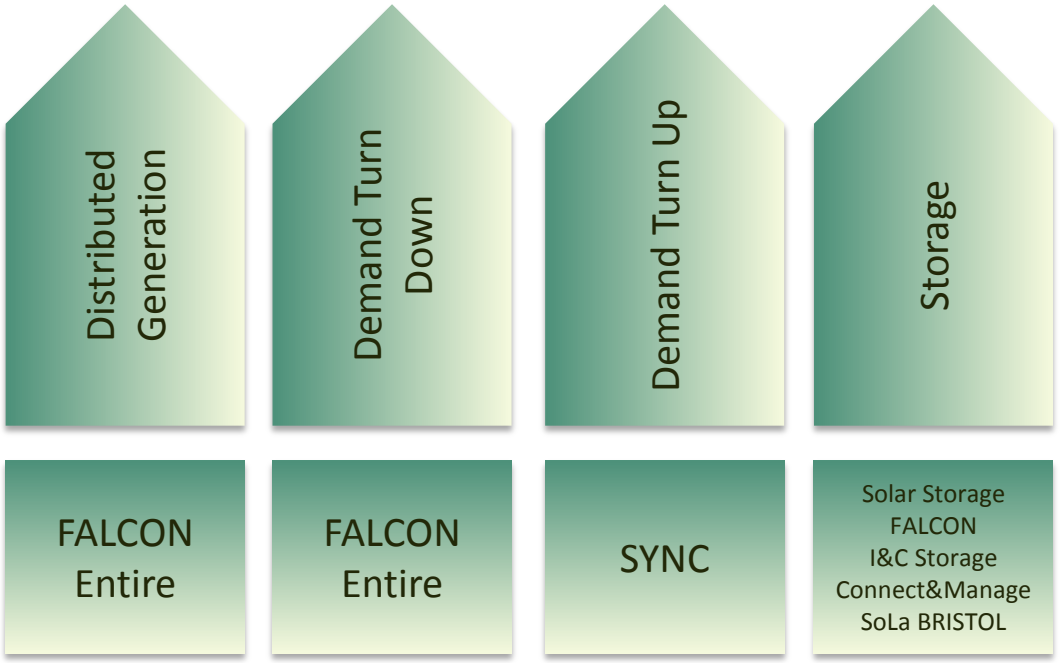
DSO Flexibility from Distributed Energy Resources:

Distributed Energy Resources

- We are technology agnostic.
- DSO flexibility products have different technical requirements to the GB SO.
- DSR is a market provided service.
- Products designed to secure supplies at the lowest possible *whole system* cost.
- Our Future Networks Programme is delivering insight and will allow for a rapid rollout to BAU.

Flexible Power
By Western Power Distribution

Reserve product – "Flexible Power"
Outage Management - Demand Turn Up (DTU)
Coordination and sharing of DSR with GB SO
Development of constraint visibility platforms



A DSO four-point plan

Expand the existing roll out and application of smart network solutions to the higher voltage networks, prioritising areas which are the most likely to benefit. From this we will optimise investment decisions, deliver greater network flexibility and maximise customer connection choice (flexible connections for demand, generation and storage).

Contract with customers and aggregators for non network solutions. Co-ordinate with other parts of the industry by helping to establish visibility platforms for suppliers, aggregators and customers. This will include the requirement to raise the awareness of DSR and to help customers to value stack where appropriate.

Co-ordinate with SO at the T/D interface. Share data and forecasts in multiple time horizons. Maintain overall system security. Consider whole system issues and propose solutions. Secure additional flexibility through prosumer awareness – actively support Power Responsive. No exclusivity in DSO flexibility contracts.

Protect the integrity and safety of lower voltage networks. We will maximise the use of smart meter data, apply additional network sensing where relevant and implement simple control schemes. We aim to develop wider flexibility for the use of import/export capping as an alternative to conventional solutions only reinforcing the networks when these solutions cannot deliver what is required.

Gerard Boyd, Commercial and Innovation Manager
SP Energy Networks

Nick Easton, Program Manager - Whole System
National Grid

Steve Atkins, Lead Commercial Contract Manager
Scottish & Southern Electricity Networks

Nigel Turvey, Network Strategy and Innovation Manager
Western Power Distribution

THANKS FOR LISTENING

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Western Power Distribution
Future Networks Manager

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INNOVATION

NEXT GENERATION NETWORKS

Project Entire

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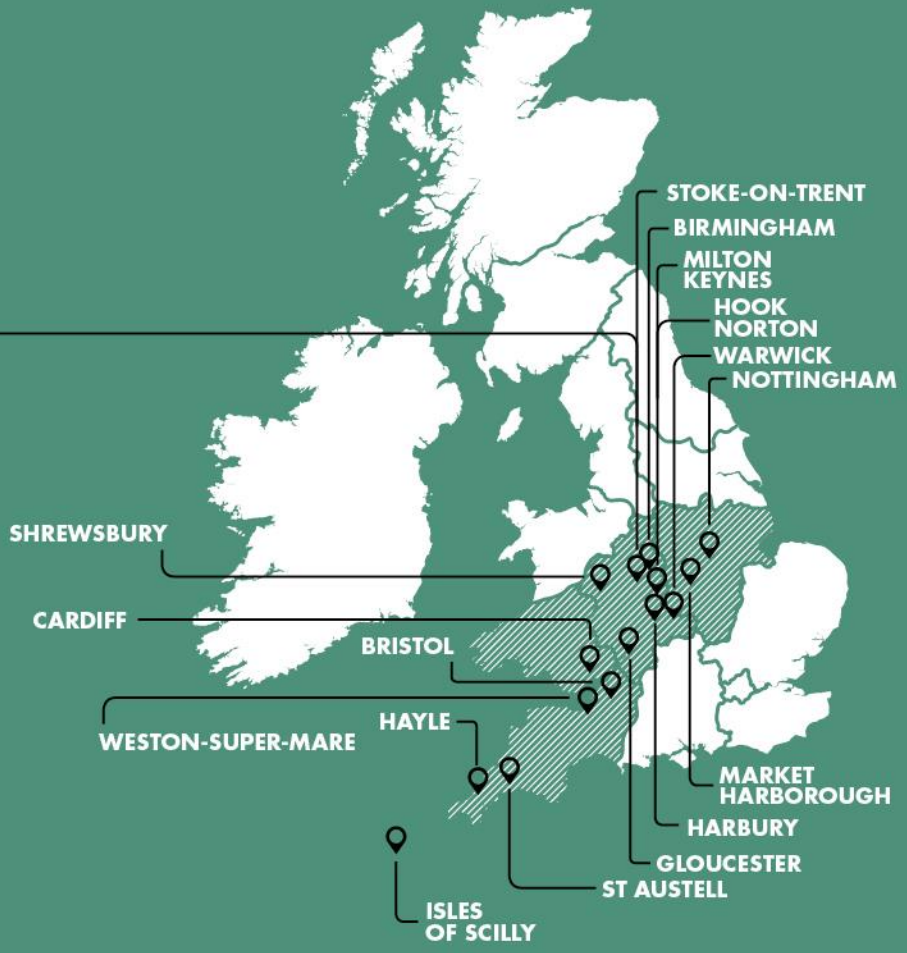

Matt Watson

Innovation & Low Carbon Networks Engineer

WESTERN POWER DISTRIBUTION
INNOVATION

WESTERN POWER DISTRIBUTION FLEXDGRID

WESTERN POWER DISTRIBUTION PLUGS AND SOCKETS

WESTERN POWER DISTRIBUTION SOLA BRISTOL

WESTERN POWER DISTRIBUTION LOW CARBON HUB

WESTERN POWER DISTRIBUTION OPEN LV NEW

WESTERN POWER DISTRIBUTION NETWORK EQUILIBRIUM

WESTERN POWER DISTRIBUTION SMART ENERGY ISLES

WESTERN POWER DISTRIBUTION NETWORK TEMPLATES

WESTERN POWER DISTRIBUTION FALCON

Future Networks Programme

Assets

- Telemetry
- Decision support
- Improved assets
- New assets
- Flexibility
- Automation
- Incident response

Customers

- New connections
- Upgrades
- Information
- Self Serve
- Products/Service
- Tariffs
- Communities

Operations

- Reliability
- Forecasting
- DSO
- DSR
- GBSO Interface
- Efficiency
- SHE and Security

Network and Customer Data

- Airborne Inspections
- AIRSTART[1]
- Telecoms Analysis
- Superconducting Cable
- SF6 Alternatives
- MVDC Test Lab
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- Smart Systems and Heat[2]

Note: 1 – Funded by Aerospace Technology Institution; Note 2 – Funded by the Energy Systems Catapult

Agenda

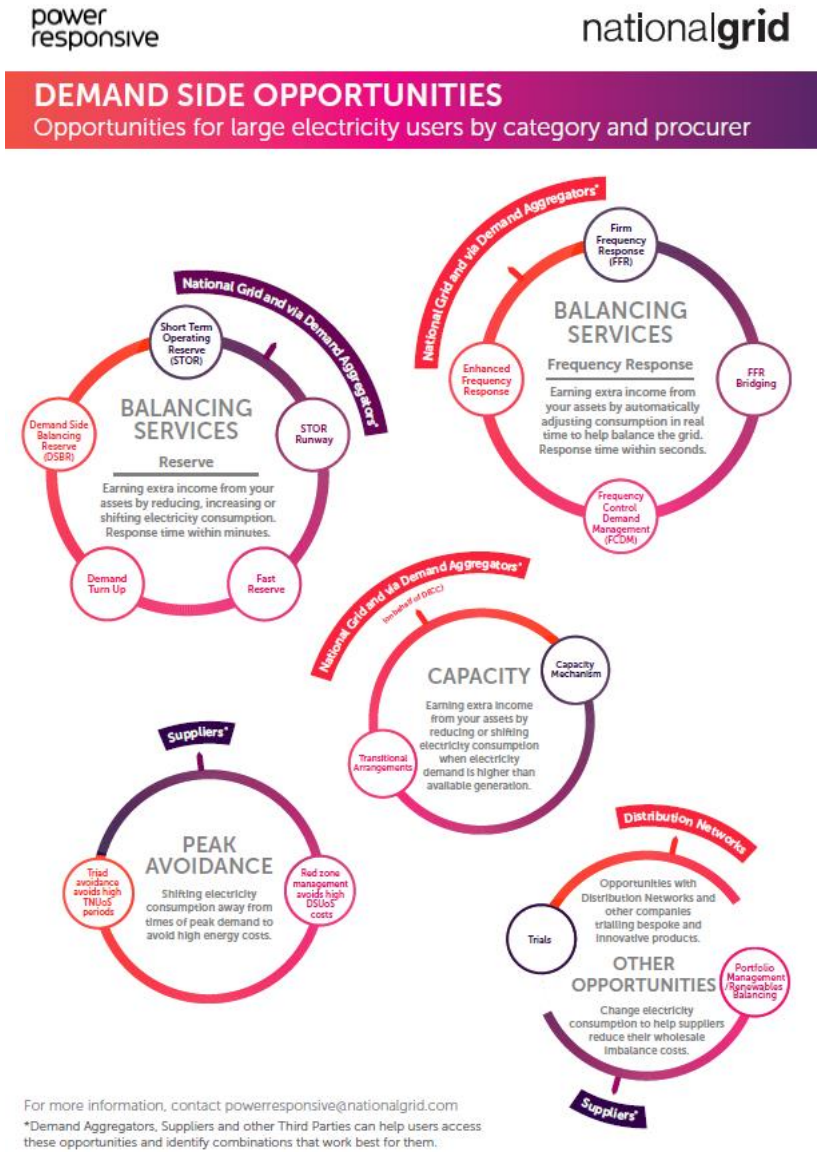
- What is DSR?
- Why would a DNO use DSR?
- Context for project Entire
- What we are doing
- Project timescales
- Customer proposition
- Questions

What is meant by Demand Side Response?

- *Demand side response is intelligent energy usage. By knowing when to increase, decrease or shift their electricity consumption, businesses and consumers will save on total energy costs and reduce their carbon footprint*. Power Responsive
- Utilises flexibility of the demand side to help balance network
- Demand that can change output following a signal
- “can” means both technically but also commercially

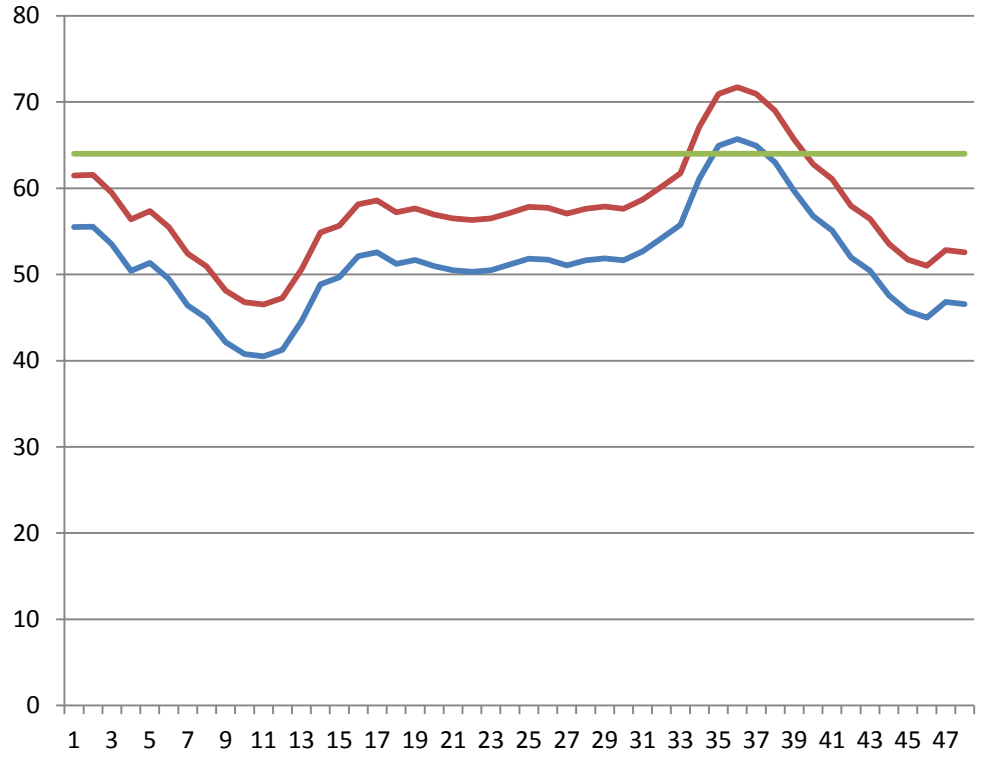
DSR sits in a wider market

- Lots of existing schemes and values for flexibility.
- Need to fit into wider market
- Commercial development of service just as important as the technical side.
- Very different from installing kit on the network



Why would a DNO want to use DSR?

- Avoid or defer reinforcement
- For both winter peak and summer minimum
- Will always compare against traditional reinforcement which has variable costs



Key characteristics

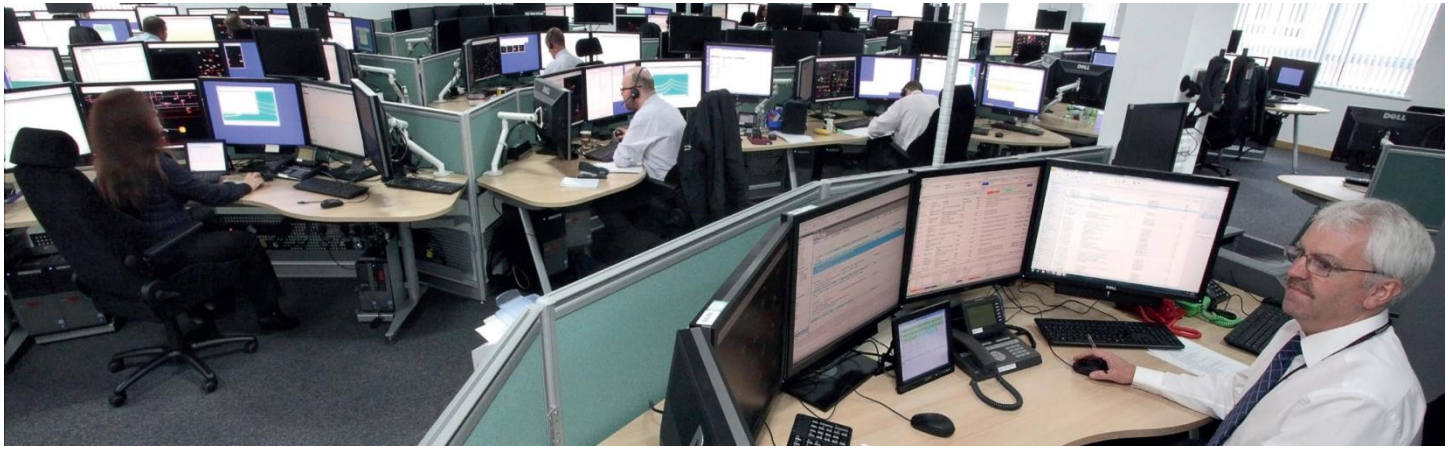
- Locational
- Higher voltages
- Limited capacity (pay as you go)
- Always compared with reinforcement
- Potentially time bound
- For n-1 conditions but called pre fault
- Needs to integrate with ANM
- Needs to be integrated with other DSR schemes

Project Entire

- A key DSR project following on from FALCON and SYNC
- Focus on commercial mechanisms and revenue stacking
- How to make DNO led DSR commercially viable
- Interaction between DNO and SO led DSR
- Understand scalability of DSR
- Fits into wider DSO and active networks innovation
- Looking for alternative solutions to 132kV reinforcement

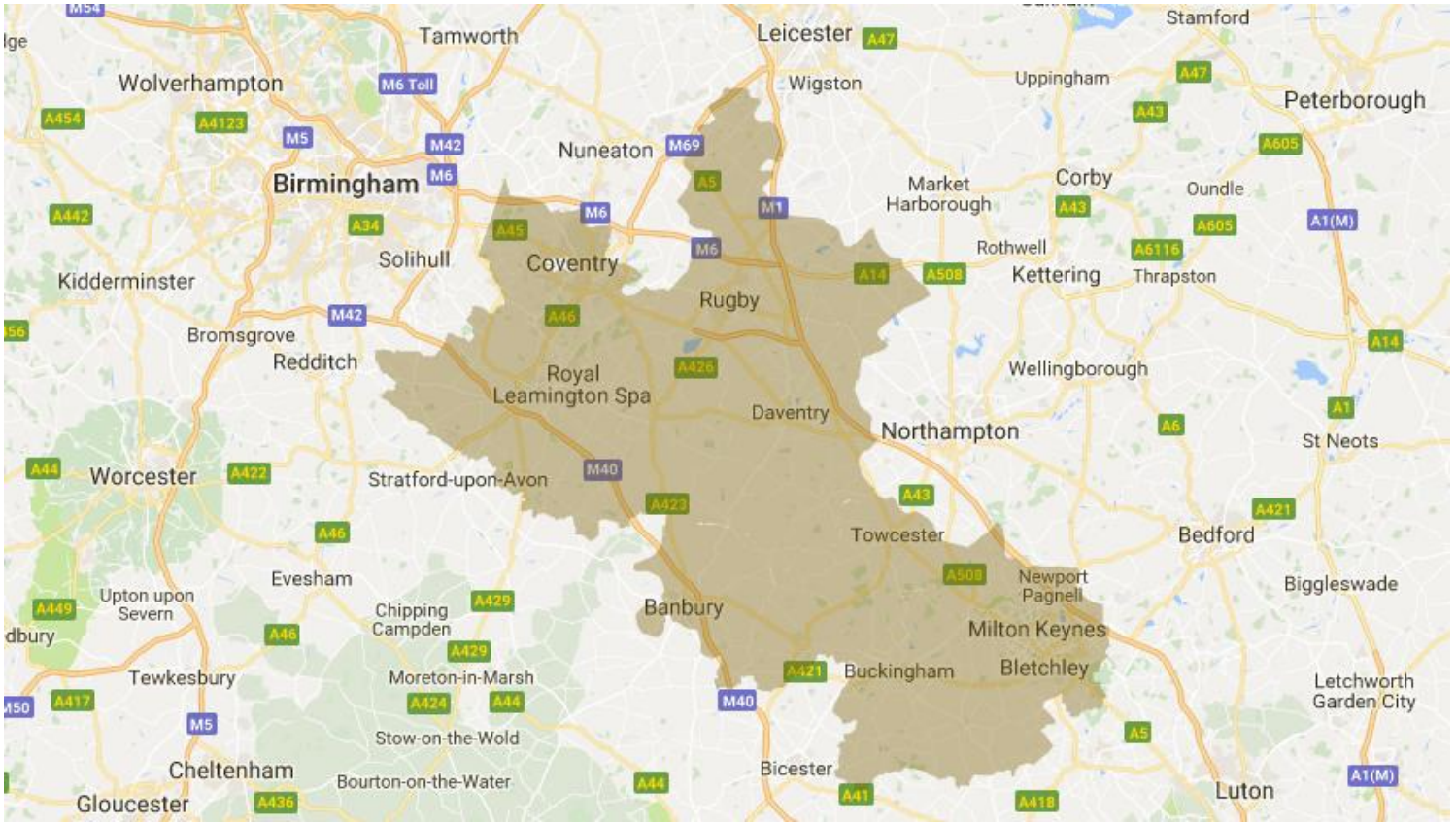
What we are doing?

- Facilitating 5 WPD CMZ services
- Developing managed service
- Create customer sales capability
- Developing technical systems and processes
- Wider engagement in target area



Where?

- East Midlands, along M1 and M40



Project timescales

- 4 year trial, started in June 2016

Task	Timescales
Project Design	June 2016 – February 2017
Build Phase	February 2017 – November 2017
Customer recruitment	April 2017– February 2019
Trial Phase	November 2017 – March 2020
Go-live for Triad	November 2017
Go-live for STOR	April 2018
Go-live for CMZ	June 2018
Review	Following each year of the trial
Report	April 2020- June 2020
Closedown	June 2020

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Customer proposition

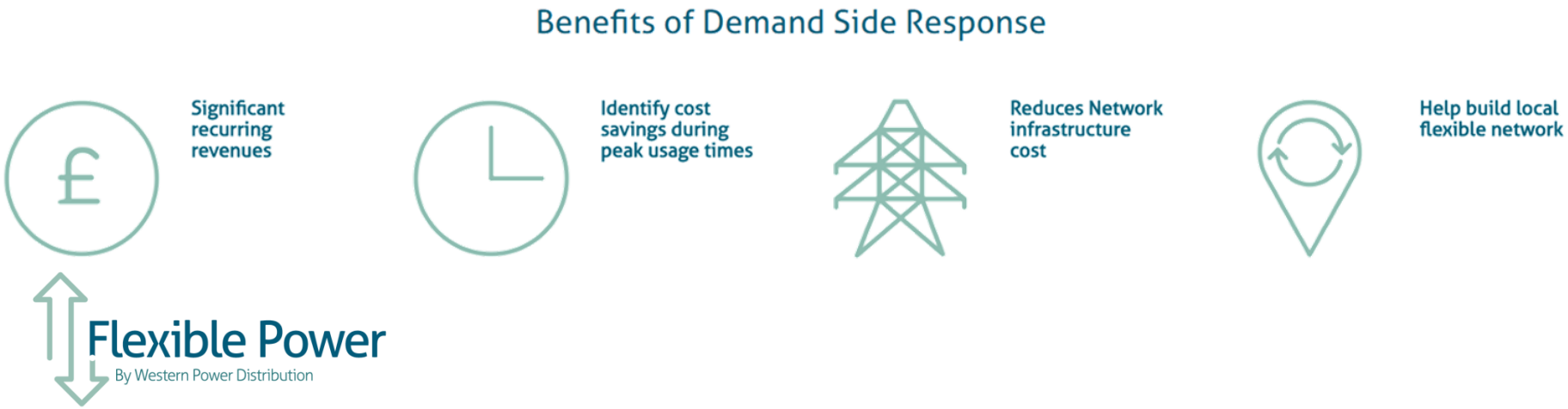
Customer Proposition

- Creation of Flexible Power branding
- Simplifying DSR programmes into single service
- Customer engagement and recruitment
- Increasing profile of DSR in target area
- Revenue stacking from multiple programmes

Flexible Power
By Western Power Distribution

Branding

- Clearly identifiable as a WPD initiative
- Retaining key aspects of WPD identity
- Unique web presence and contacts



Managed Service

- Advanced control capability from new centralised facility
- Continuous monitoring of assets with alerts and alarms
- Agreed operating procedures taking away local resource burdens.
- Customer has ultimate control of inhibiting dispatch
- Simplifying DSR for customers
- Asset optimisation
- Self service statements and reports through customer portal

Flexible Power
By Western Power Distribution

Services

Simple CMZ service:

- Week ahead notification of probable requirement
- Arming fee assures of profit
- Utilisation fee covers operating costs
- Designed to integrate with other services
- No deductions for service payments

Flexible Power
By Western Power Distribution

Services

National Grid services:

- Initially working with STOR flexible services
- De-rated capacity to maximise service quality and earnings
- Majority of generated revenue passed through to participants
- Simplified performance contracts
- No annual performance reconciliations
- Minimising negative impacts from group performance
- De-rated performance targets to 95%

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By Western Power Distribution

Services

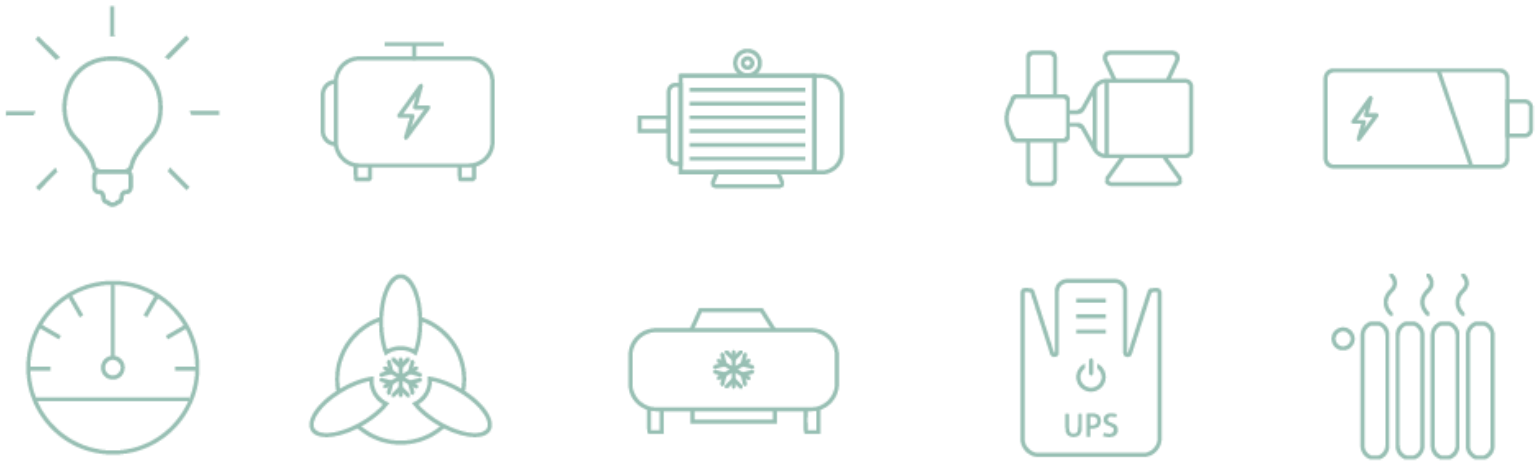
Triad Avoidance:

- TNUoS still valuable behind the meter
- Not pursuing export benefits
- Managed service, not warnings
- Continuing successful record of avoidance from low response durations
- Compatible with CMZ

Flexible Power
By Western Power Distribution

Who are we targeting?

- Half hourly metered customer in the target area
- Ability to reduce demand or increase generation within 15 minutes of a signal and hold for at least 2 hours
- Simple or managed service
- Direct customers or through aggregators



Flexible Power
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What's the process?

- Simple and easy to access

Consultation with customer

Audit customer energy usage

Recommend revenue sources

Install equipment

Bid the customer in

Send recurring payments to the customer

- Ongoing admin via client app

Flexible Power
By Western Power Distribution

How to get involved

- www.flexiblepower.co.uk

- Wpdflexiblepower@westernpower.co.uk

Flexible Power
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Energy Storage

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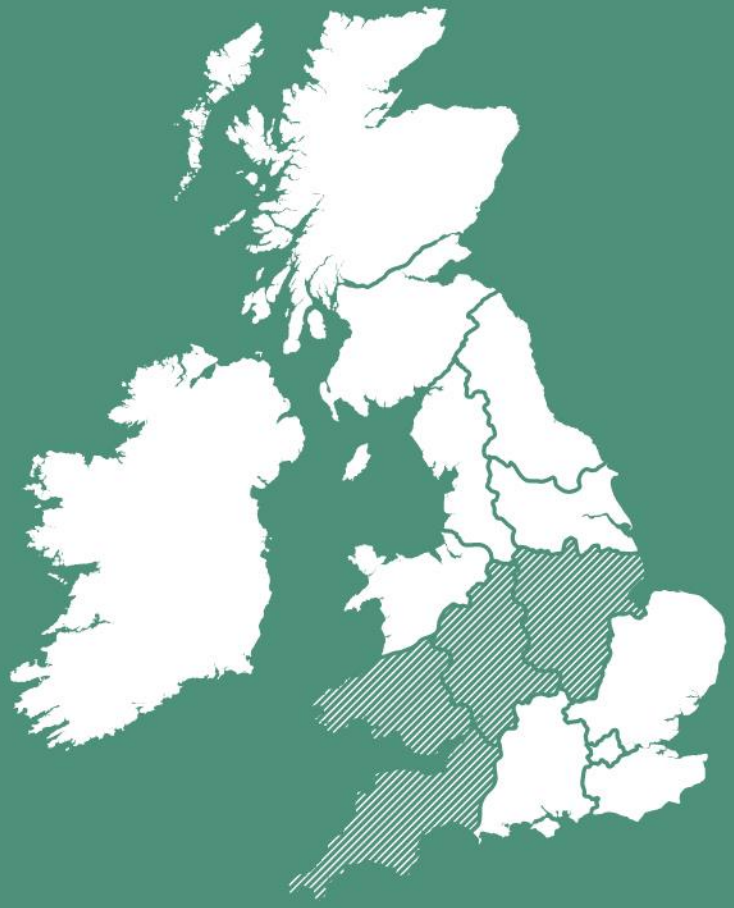

Faithful Chanda

Innovation & Low Carbon Networks Engineer

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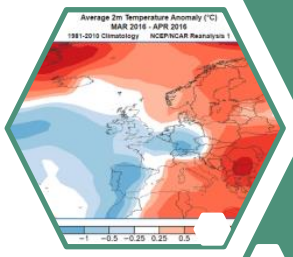
Context

Network Issues



Climate change is happening

Constrained and overloaded grid

Reduction in centralised generation

Rapidly increasing sale of EVs

EVs are part of electrical energy systems

New loads and load profiles on the grid

Increase in distributed generation

Smart systems require control

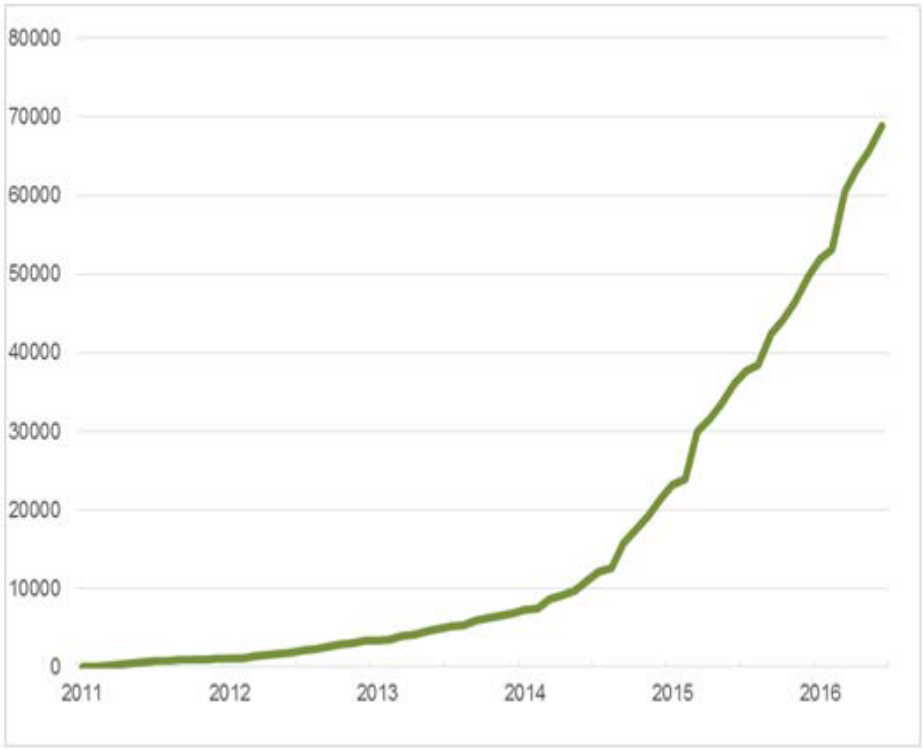
A strong future for distributed storage

Why are we interested in Storage?

Keeping the lights on	• Assists in power system stability – frequency and voltage • Deploy multiple purposes
Facilitating the Low Carbon transition	• Enables the connection of intermittent renewable generation • Provides fast response
Keeping electricity bill as low as possible	• Enables the deferment of network reinforcement to manage peak loads

A typical demand increase in EVs

- From the start of data collection (Q2, 2012) the cumulative Electric Vehicle (EV) data shows a sustained and dramatic growth of the EV car and van market
- In Q2, 2012, there were 3,000 registered EV's on the road
- By Q2, 2014, this had rose to over 10,000
- After this time there was exponential growth
- The latest results Q3, 2016, shows 90,000 registered EV's



The future strategy for managing the grid

In order to cope with the increase in demand for electric vehicles, the grid can do one of three things:

- Introduce more capacity to the grid through generation and expand the networks capacity
- Introduce more flexible generation in order to deal with spikes seen from chargers
- Introduce local storage to greatly reduce the demand spike by using storage to deal with the ramp up of power

Option 3 is the most cost effective for the network as options 1 & 2 both require the local, and eventually, the national network to be upgraded in order to handle the capacity increase / capacity potential.

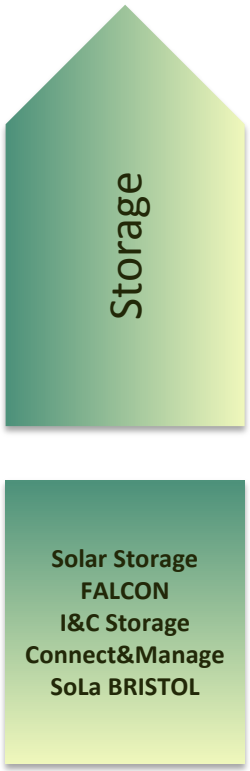
Government's response

- £30m for UK electric, hybrid, hydrogen and biomethane buses (*Electric Vehicle charging Newsletter August , 2016).*
- West Midlands Travel, £3m to fund 10 hybrid and 19 fully electric buses, and install electric charging facilities.
- Birmingham City Council and Transport for London, jointly £2.8m for 42 state-of-the-art hydrogen fuel cell buses.

- Merseytravel, £4.9m for a total of 72 biomethane, hybrid or electric buses and associated infrastructure.
- Nottingham City Transport, £4.4m for 53 biomethane buses and infrastructure.

Our response – WPD Innovation Projects

DSO Flexibility from Energy Storage



- Solar Storage
  - ✓ Co-location with Solar DG.
  - ✓ Testing revenue stacking conflicts and optimisation
- FALCON
  - ✓ Assessment of DSO owned storage
  - ✓ Technical and Commercial insight
- I&C Storage
  - ✓ Co-location with larger demand customers
  - ✓ Connection design options and DSR services
- SoLa BRISTOL
  - ✓ In-home storage plus PV. DC networks. Community microgrid optimisation.
- Connect and Manage
  - ✓ Integration of domestic storage (connection options)
  - ✓ DSR revenue stacking and smart grid integration

Transition from DNO to DSO

Passive DNO

Ensuring backup

- Asset owners
- Incremental / targeted at issues

Active DNO

Managing a dynamic network

- ✓ Behaviour change
- ✓ Commercial change
- ✓ Capabilities

- Facilitate distributed energy resources
- Whole system consideration

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  - ✓ Non-network solutions (eg. DSR, DG, Storage, Reactive Power Services)
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  - ✓ Become a platform for energy suppliers, communities and other market participants to have visibility of network congestion in order to facilitate optimal DG and DSR solutions

Increased network visibility, advanced control systems and data analytics will allow the DSO to predict energy volumes and despatch flexibility services

Industrial & Commercial Storage Project

In our own depots/sites

Trial	Objective	Approach	Outputs
Test different configurations	Deliver more options for customer connections	Industrial & Commercial storage	Engineering recommendations on connections
Deliver more options for customer connections	Derive and design new technical policies	Work with experts - Tesla	Dissemination

Trial sites


Spilsby
EAST MIDLANDS
Cardiff
WEST MIDLANDS
SOUTH WALES
Boston
Taunton
SOUTH WEST

Roof top PV mounted installations

Different Sizes of PV

- Already installed in the depots/sites
- Cardiff – 8kW
- Taunton – Two arrays of 50kW & 6kW
- Boston - 21kW
- Spilsby - 30kW

Contract & Procurement

- Project Partner: Tesla
- 4 systems of 50kW/210kWh each
- 4 * 1 Inverter
- 4 * 1 Powerpack
- 4 * Site Master Controller
- Battery Management System
- DC and Communication Cable Harnesses
- Delivery to sites in the UK in Q2 2017
- 10-year system warranty

TESLA **POWERPACK INVERTER**

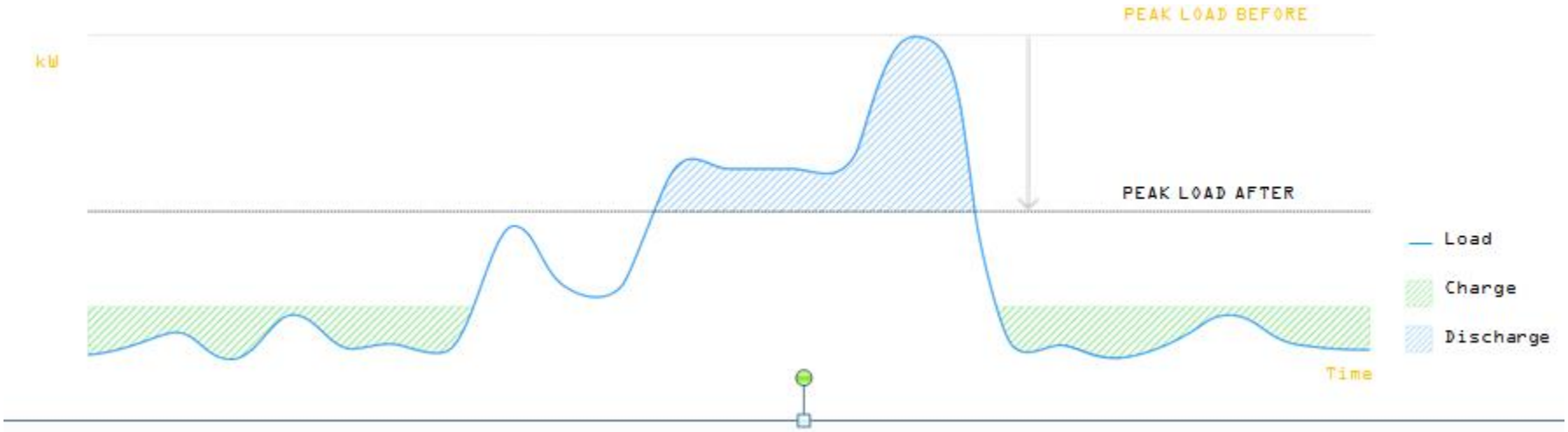
Project 1

Application: Peak Shaving

- Spilsby – Vale Road
- Planned size: 50kW/210kWh
- Requirements:
  - ✓ Load profile available
  - ✓ Peaky load profile
  - ✓ Site Meter
  - ✓ Free switchgear – suitable for 80A connection
  - ✓ approx. 3.6 m x 3.3 m outdoor

Project 1

Peak Shaving



Project 2

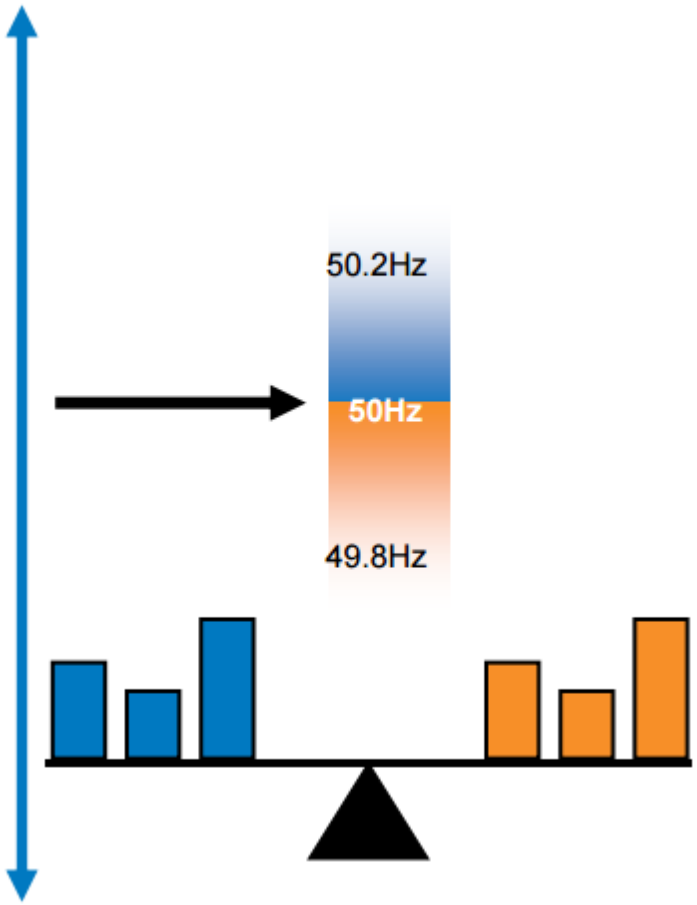
Application: Active control by WPD

- Boston – Endeavour Park
- Planned size: 50kW/210kWh
- Requirements:
  - ✓ Site Meter
  - ✓ Interface between WPD control and Tesla Powerpack Controller
  - ✓ Free switchgear – suitable for 80A connection
  - ✓ approx. 3.6m x 3.3m outdoor

Project 3

Application: UK “standard” battery storage approach

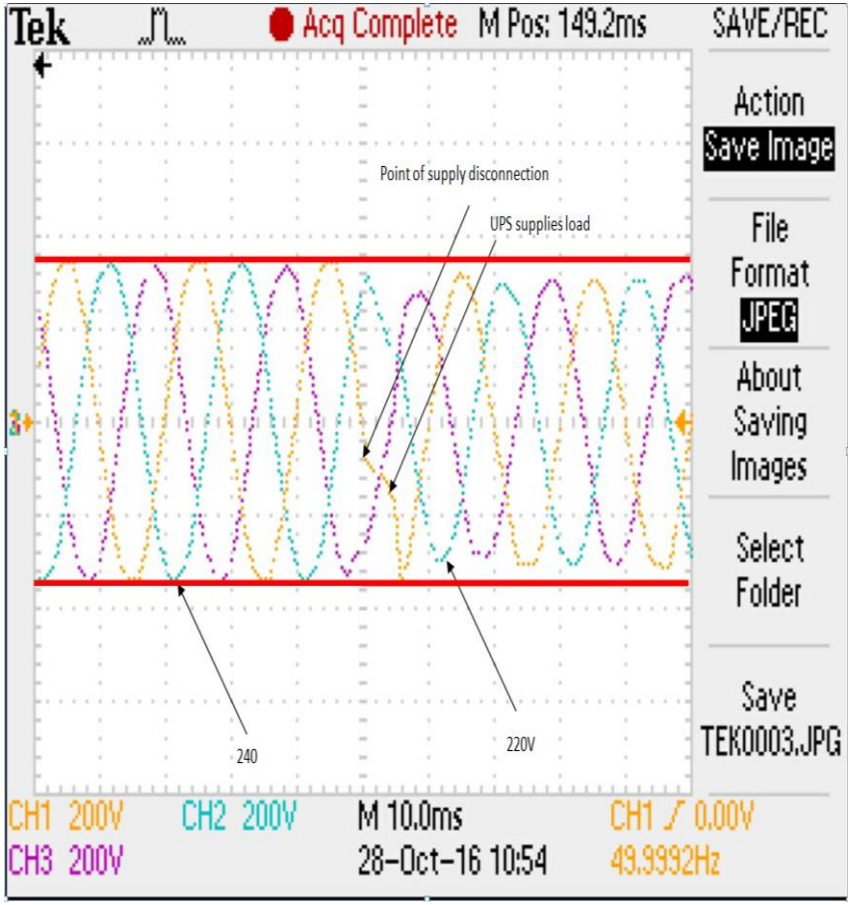
- Cardiff - Lamby Way
- Combination of: FFR, DUOS and TRIAD avoidance
- Planned size: 50kW/210kWh
- Requirements:
  - ✓ Load profile available
  - ✓ Site Meter
  - ✓ Free switchgear – suitable for 80A connection
  - ✓ approx. 3.6 m x 3.3 m outdoor
  - ✓ Question: Real market access or simulated?

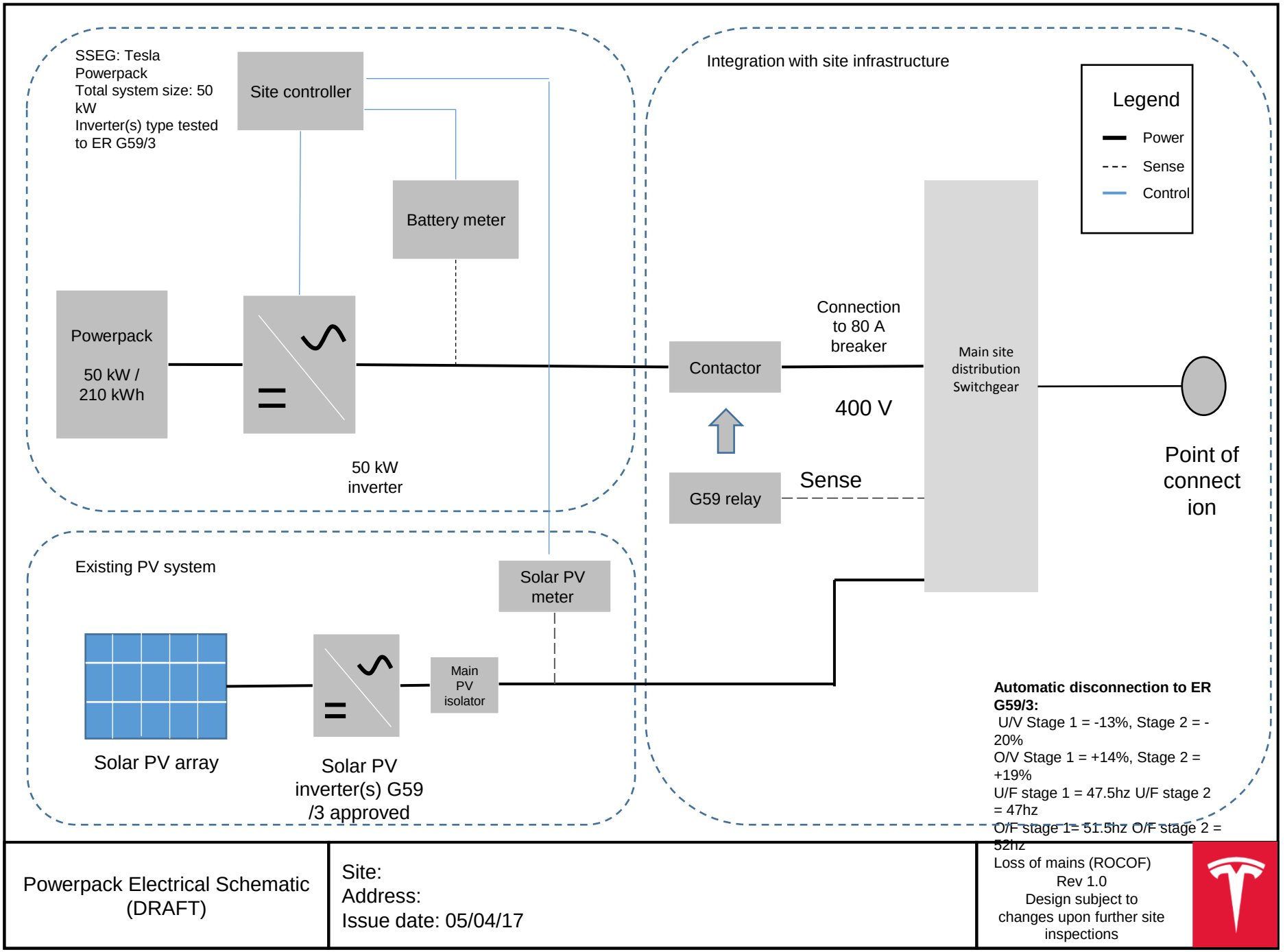


Project 4

Application: Test Bed (Backup, PV interaction, etc.)

- Taunton – Priorswood Industrial Estate
- Planned size: 50kW/210kWh
- Requirements:
  - ✓ Site that allows for back up tests (connection into a sub-section of a site that facilitates on/off switching)
  - ✓ PV inverters facilitate frequency dependent power control
  - ✓ Site Meter
  - ✓ Switchgear allowing for back-up relay & 80A connection
  - ✓ approx. 3.6 m x 3.3 m outdoor



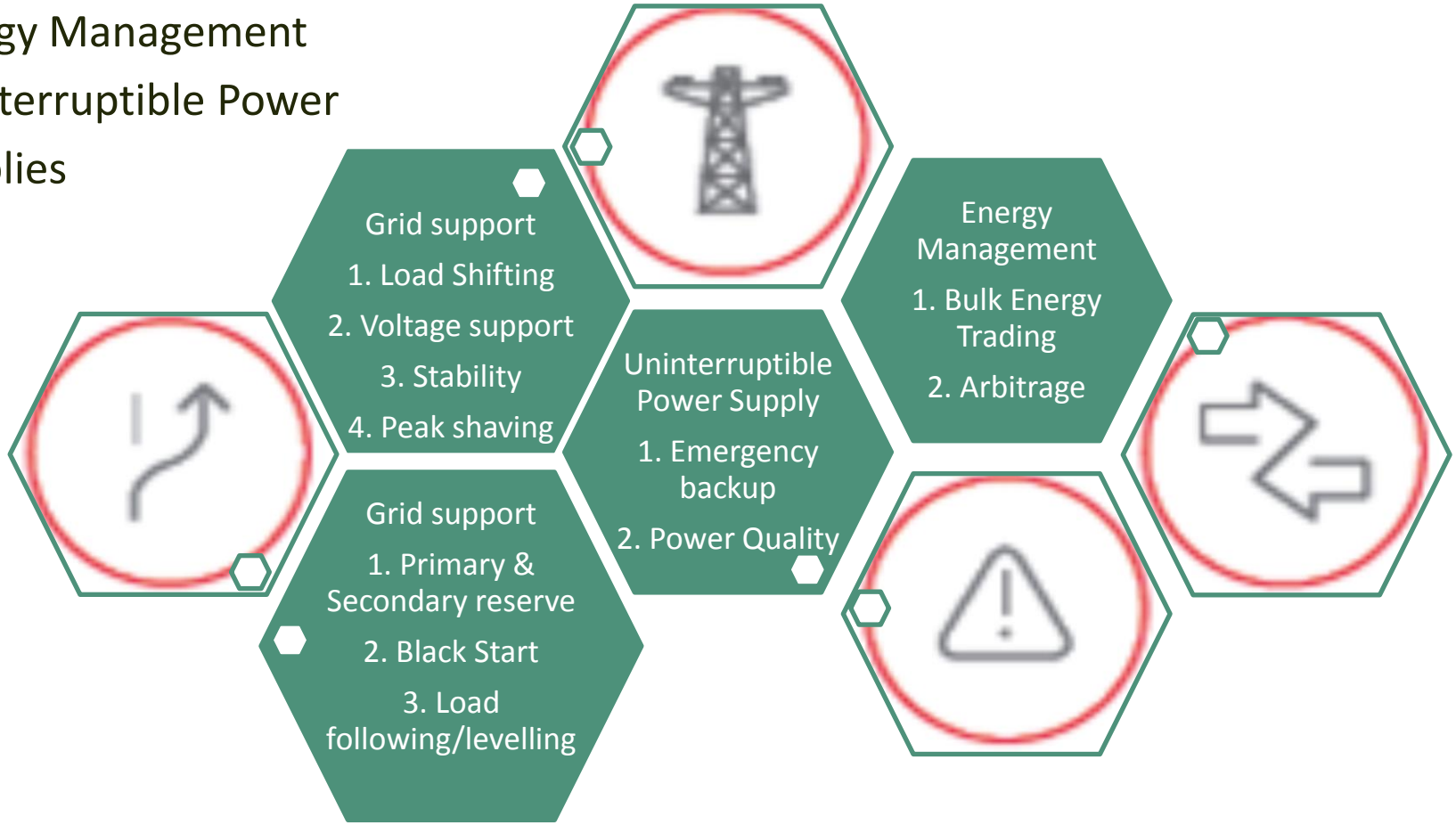

SSEG: Tesla Powerpack
Total system size: 50 kW
Inverter(s) type tested to ER G59/3
Site controller
Battery meter
Powerpack
50 kW / 210 kWh
50 kW inverter
Integration with site infrastructure
Legend
Power
Sense
Control
Connection to 80 A breaker
Contactor
400 V
Main site distribution Switchgear
Point of connection
G59 relay
Sense
Existing PV system
Solar PV meter
Main PV isolator
Solar PV array
Solar PV inverter(s) G59 /3 approved
Automatic disconnection to ER G59/3:
U/V Stage 1 = -13%, Stage 2 = -20%
O/V Stage 1 = +14%, Stage 2 = +19%
U/F stage 1 = 47.5hz U/F stage 2 = 47hz
O/F stage 1= 51.5hz O/F stage 2 = 52hz
Loss of mains (ROCOF)
Rev 1.0
Design subject to changes upon further site inspections
Powerpack Electrical Schematic (DRAFT)
Site:
Address:
Issue date: 05/04/17

Progress so far

- Tendering – Completed
- Procurement – In progress
- Design - Started
- Site surveys – Ongoing
- G59 ENA Connection Application - Offered
- Construction – Not started
- Installation & commissioning – Not started
- Tests and experiments – under development
- Dissemination – WPD events/LCNI
- Project finishes December 2018
- Closedown Report

In general we can use the Tesla Powerpacks for….

- Grid Support
- Energy Management
- Uninterruptible Power Supplies



What we may learn from the project

I & C Storage Project will explore……

Avoid Costly Upgrades

CO_2 Reduction

Renewable Connectivity

Cost Reduction

Smart Grid Integration – Potential Income

UPS Functionality

Going forward

Through innovation and other avenues

1. We will seek and develop flexibility services through our projects
2. We will continue to collaborate with government and the regulator on addressing regulatory challenges
3. We will work with the System Operator to improve our interface
4. We will always seek to lowest cost solution for our customers using market solutions wherever feasible

WESTERN POWER DISTRIBUTION

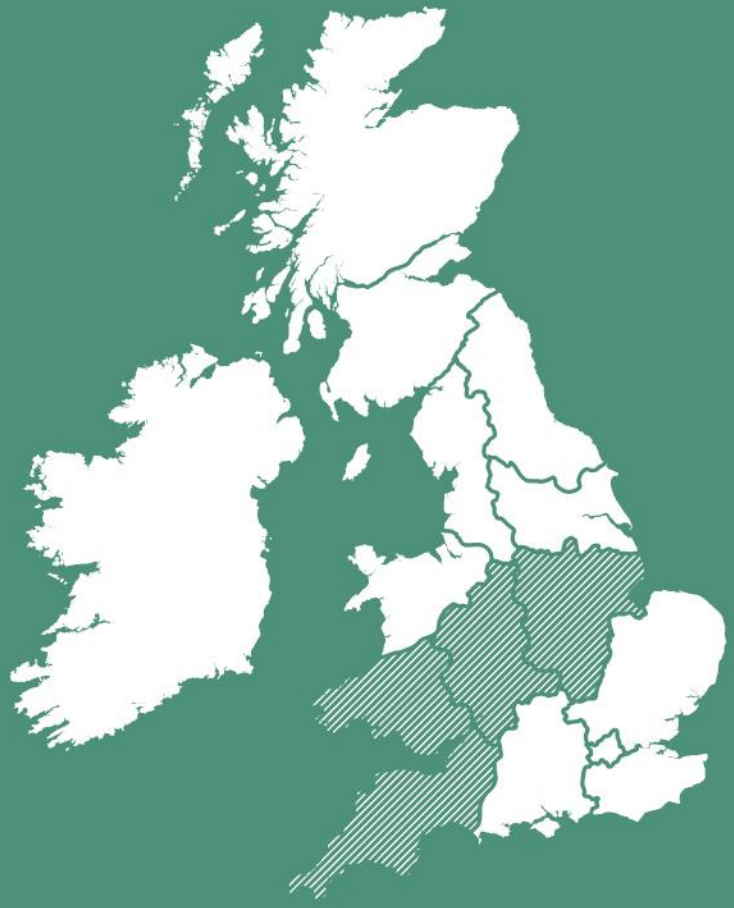
INNOVATION

NEXT GENERATION NETWORKS

Energy Storage

Balancing Act Conference

Thursday 11th May 2017



Mark Dale

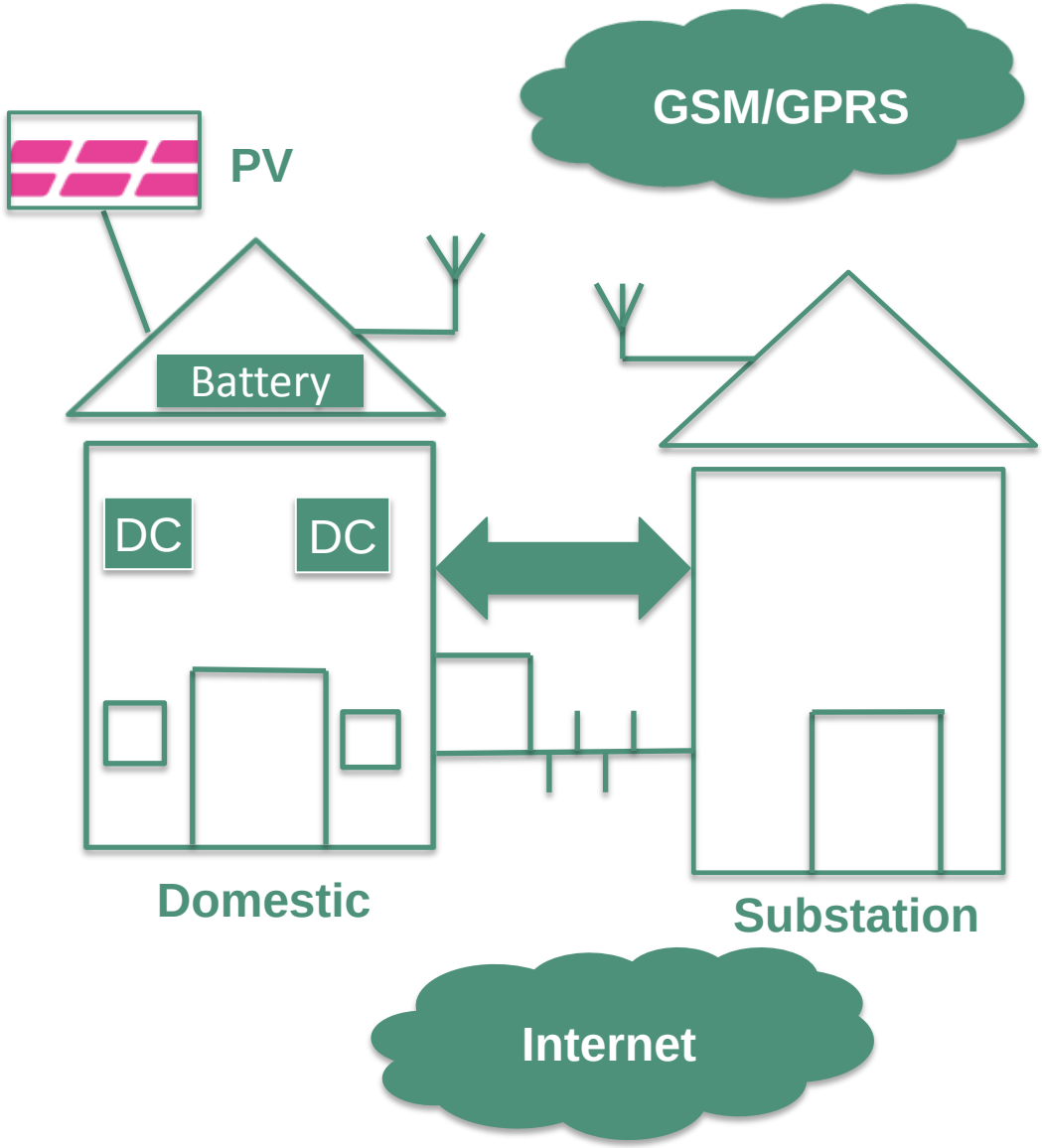
Innovation & Low Carbon Networks Engineer

Solar Bristol Partners

- **Bristol City Council**
  - Deploying technology at their sites, engaging with schools and offices
- **Knowle West Media Centre**
  - Leading the domestic properties engagement
- **Siemens**
  - Designing and developing technology for the project
- **University of Bath**
  - Academic partner, Knowledge dissemination, tariffs and design

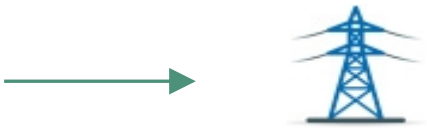
Domestic Arrangement

- 26 Domestic Local Authority homes with Battery storage linked to PV Panels. 24v DC lighting throughout.
- PV Panels on roof can charge the battery using excess PV generated electricity.
- Battery runs the 24v DC lighting in the home
- Battery can export if required at high demand periods to support the electricity network.

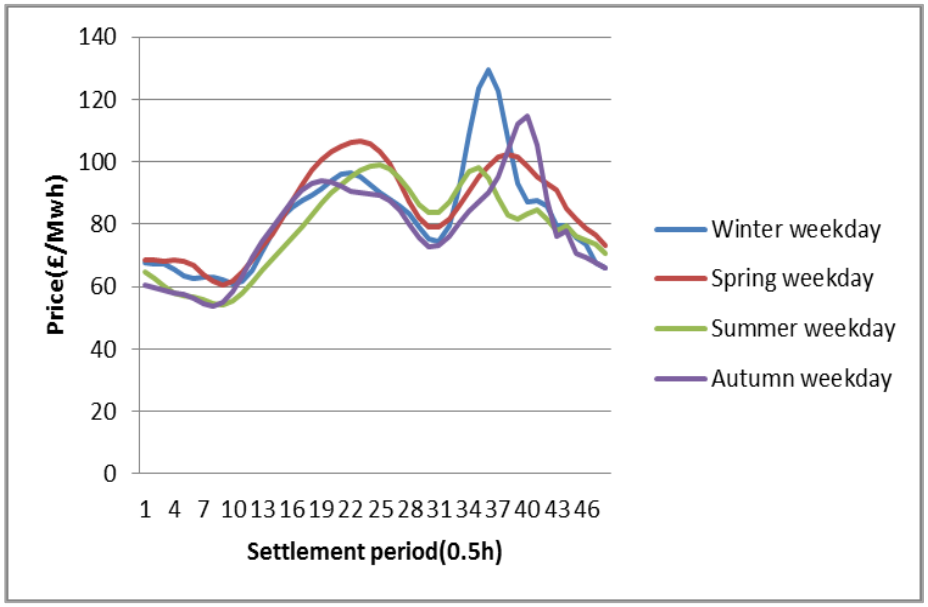


Smart Tariffs Design (Battery Storage)

Energy Price



Distribution/ transmission charges, environment cost , etc.

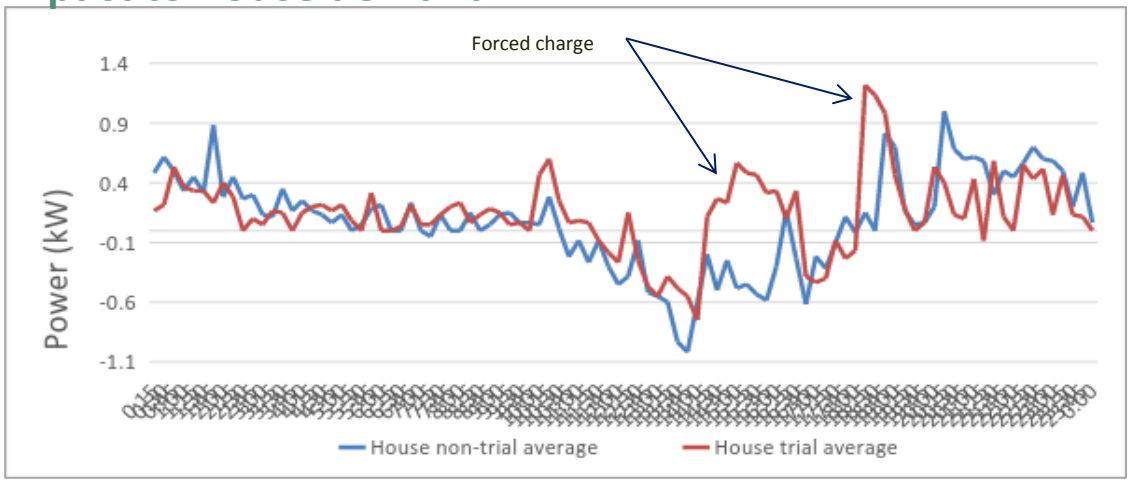


Electricity Bill

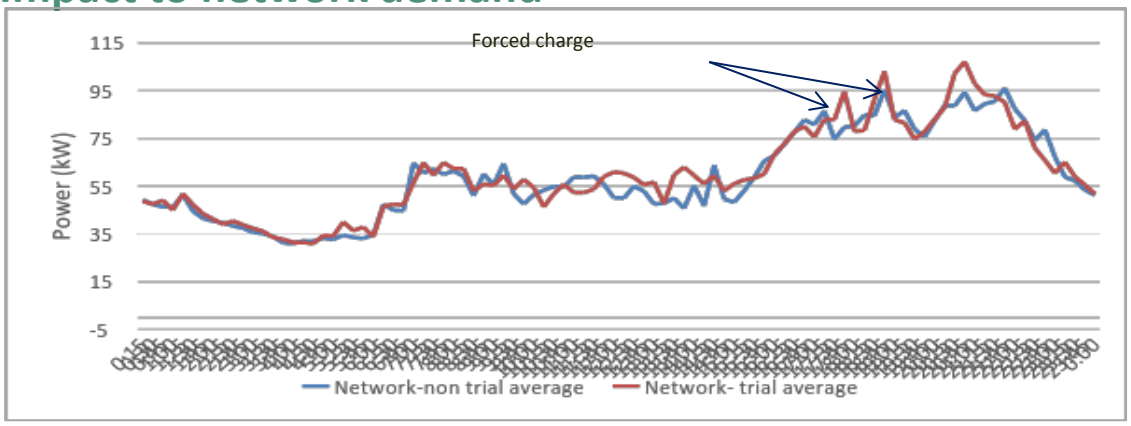
Half hourly domestic tariff to reflect the cost of electricity generation over a 24hr period will enable customers to maximise the benefits of energy storage.

Impact to Demand from Forced Battery Charging and Discharging

Impact to house demand

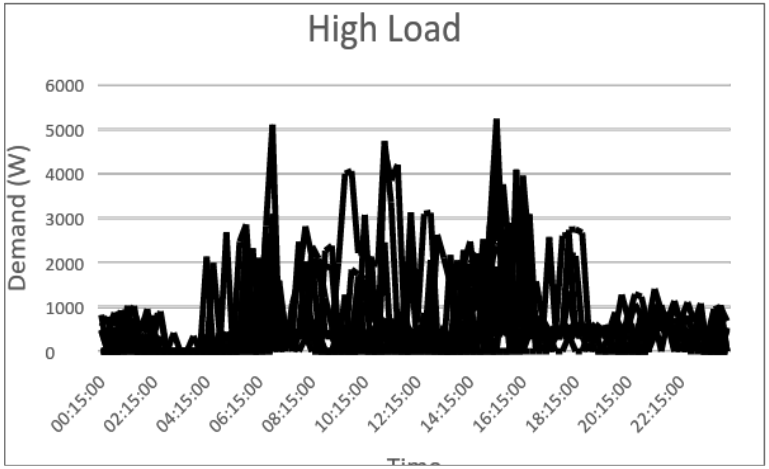


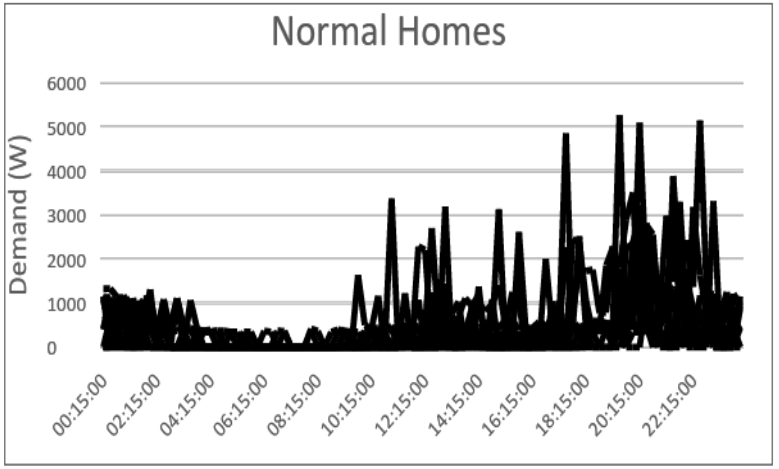
Impact to network demand



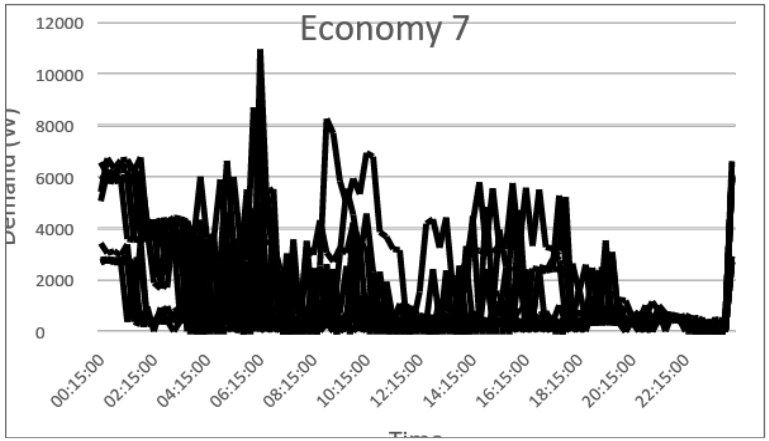
- Batteries were forced to charge between 2.30pm – 4.30pm & 6.15pm – 7pm
- Forced discharge was between 5pm – 6.15pm
- This can be seen in the house demand profile quite clearly
- Impact on the network is not so clearly defined, due to the sample size (4.3% of customers had batteries) and the varied nature of the overall substation demand profile
- In order to see a significant impact on network demand, it is estimated that you would need 60% - 70% of customers on a substation to have this solution.

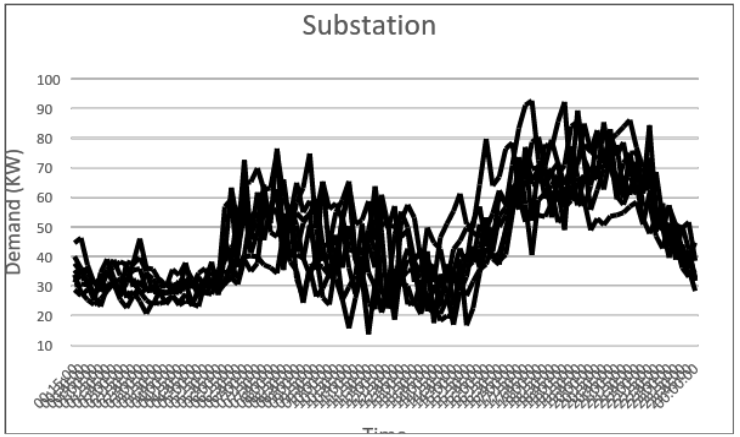
Load Profiles Over time



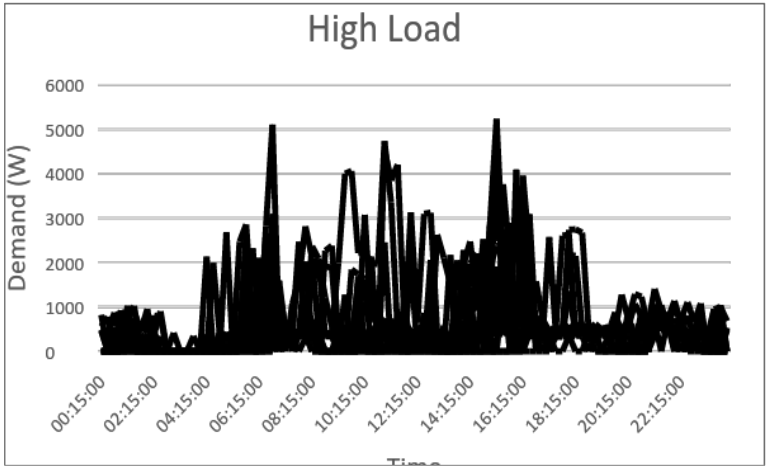


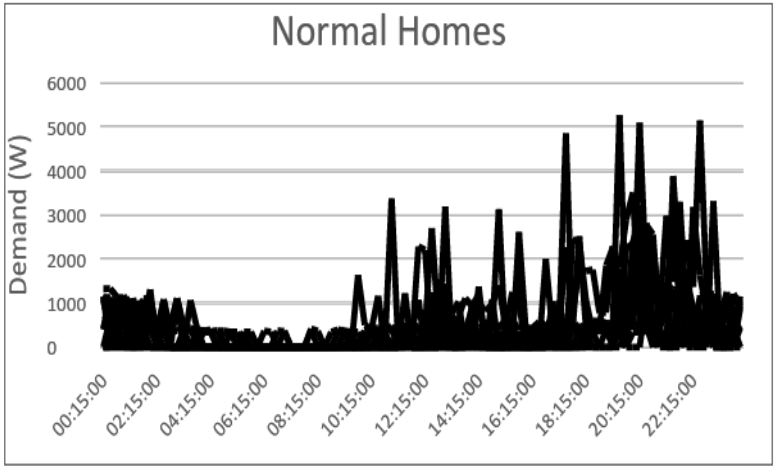
Charging/discharging settings need to be tuned to customers load profiles.





Load Profiles Over time





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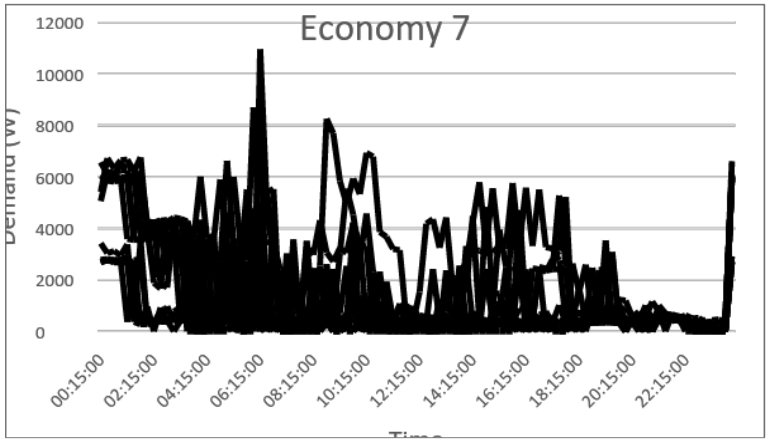
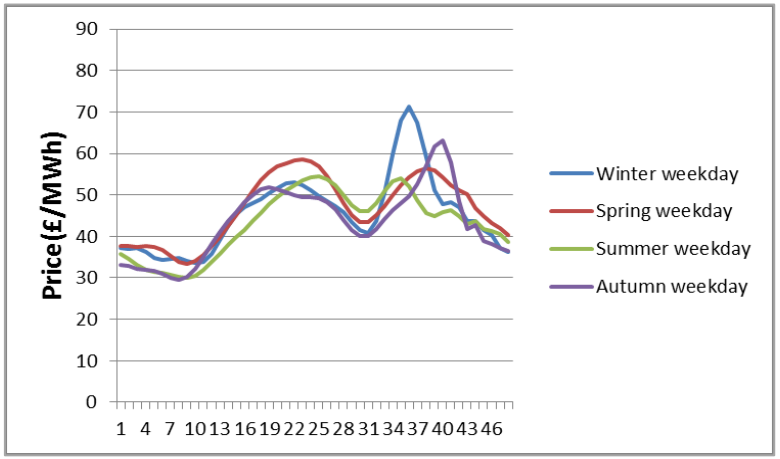




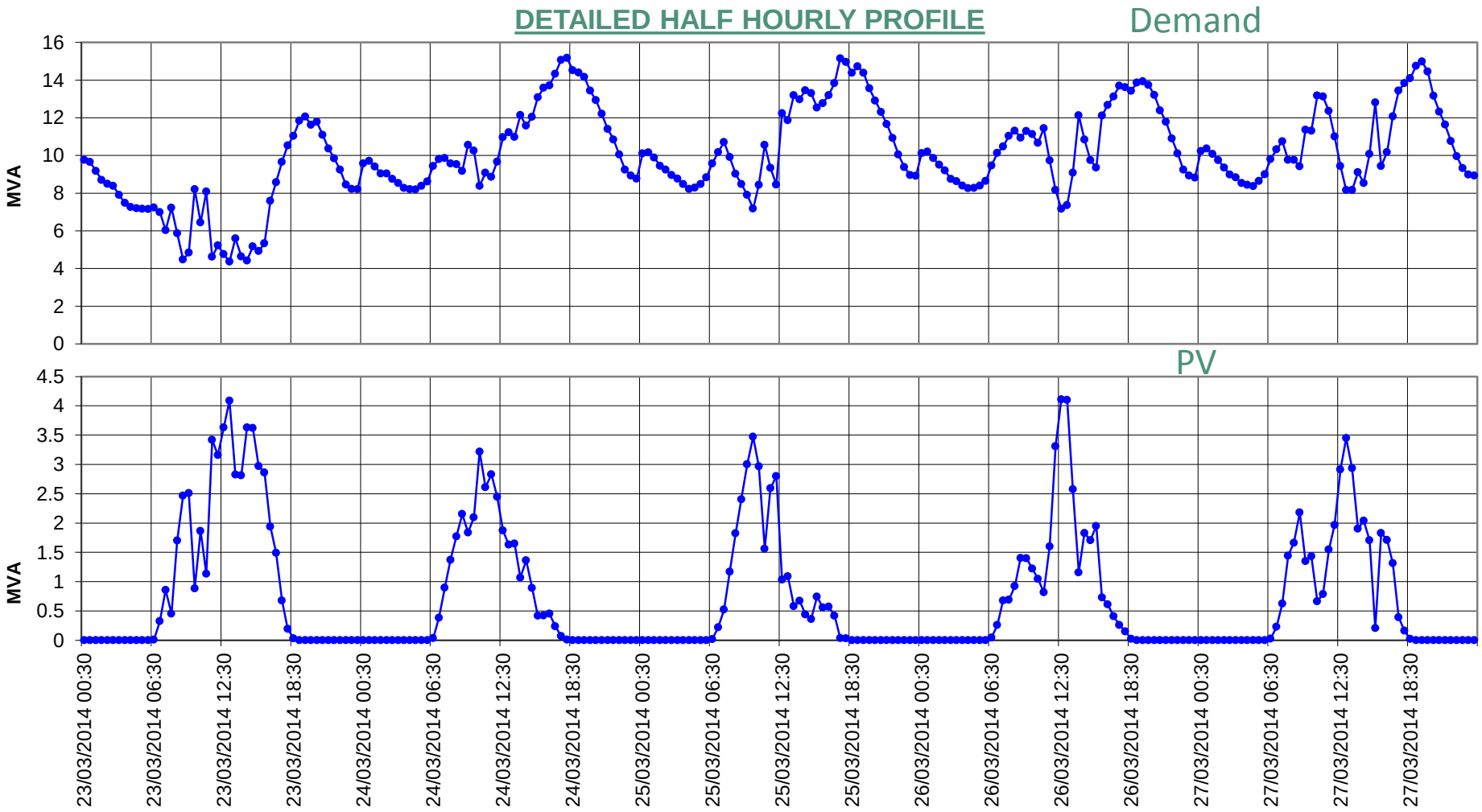
Solar Storage Description

- Techno-economic trial of a real battery energy storage system on a large solar generator's side of the meter, in Somerset.
- Quantify benefits for both the DNO and Customer with real data.
- WPD South West & 2 other project partners:

- What will be the benefits of generator connected storage?
- Explore routes to market – challenges and rewards.
- Making the case for energy storage in new connection offers.
- Registered under NIA in April 2015

Site Installation

Technical Challenges – Daily Profiles



Business Challenges

- High demand for renewables connections in the South West.
- Renewable generation does not match peak local demand.
- Renewable generation has high ramp rates and is very `spikey'.
- Network capacity built for worst case scenarios and operated within conservative limits.
- Power quality management is not currently provided by renewables operators (other than specifying a power factor).

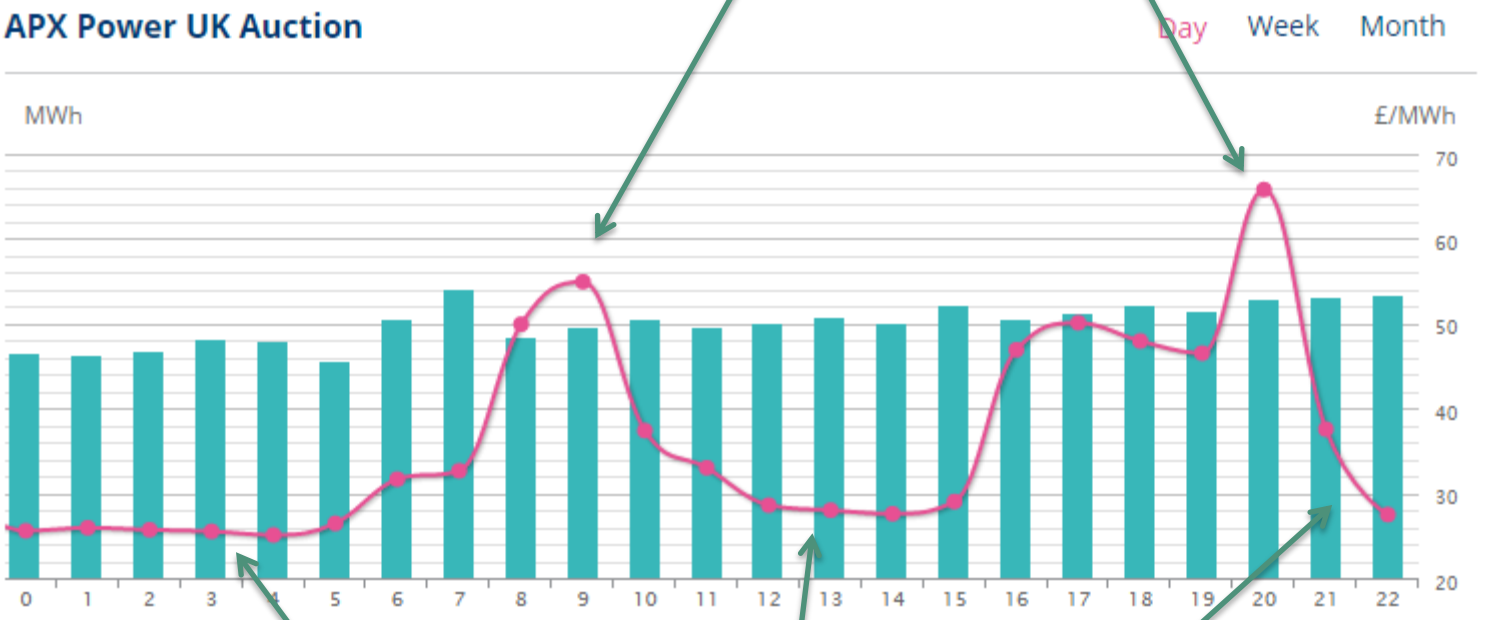
Storage has been calculated to offer £60k/MVA/year of benefits to distribution networks alone - how can these benefits be made commercially realisable by DNOs?

Solar Storage Usage cases

Usage Case	Beneficiary
1) Sell electricity for a higher price per kWh	Owner
2) Local demand peak lopping.	DNO / load customer
3) Peak lop network demand.	DNO
4) Raise minimum demand to limit voltage rise.	DNO
5) Voltage control via reactive power.	DNO
6) Peak lop generation to build bigger solar parks.	Owner
7) Smoothing / Power Quality.	DNO
8) Change peak lopping level (glass ceiling).	DNO
9) Multiple storage system control	DNO

Use Case 1: Arbitrage

Discharge and sell electricity when prices are high

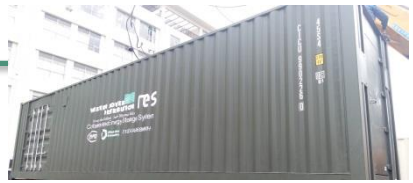


Charge battery when prices are low

Use Case 2: Local Demand Peak Lopping

Other customers

New Demand Customer with ANM connection agreement and



Battery

ANM controlled network

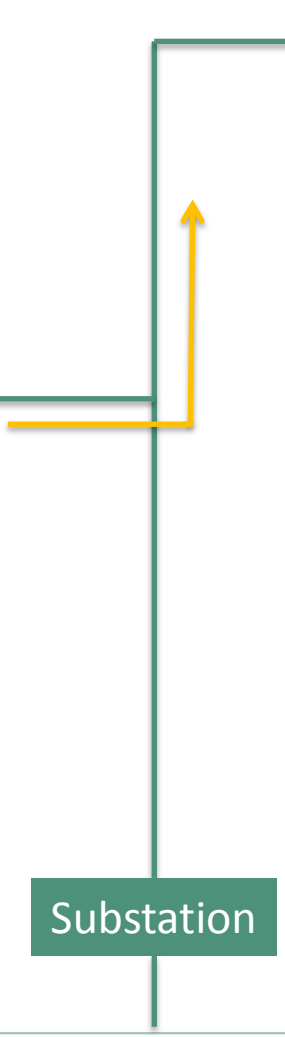
High load upstream could trip out ANM demand customer

Primary Substation

ANM Demand customer contracts with Battery to generate when soft inter-trip signal received or on timed schedule based on forecasts) Limits upstream current and avoids being tripped off.

Use Case 3: Peak Lop Network Demand

Battery



Battery supplies power to avoid reinforcement on asset e.g. primary transformer.

Also to prolong summer maintenance window when operating under n-1 conditions.

Use Case 4: Raise minimum demand to limit voltage rise

Battery

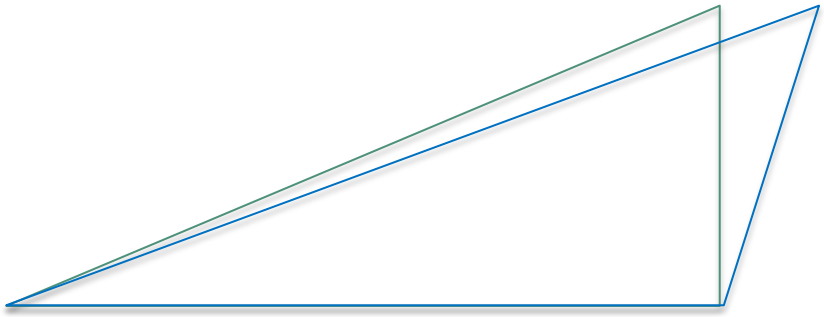
Voltage rise on networks with embedded DG can be an issue at times of minimum demand. The battery can be charged to help keep voltages under limits.

Rest of network

Substation

Use Case 5: Voltage control by reactive power

Battery

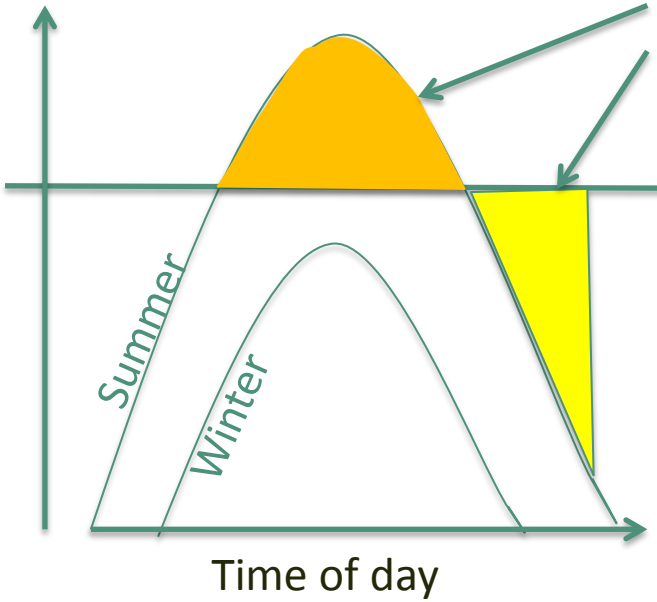


Battery inverters can alter the degree of reactive power that is delivered, and hence alter the voltage.

Use Case 6: Peak lop generation

Battery

Maximum generation exceeds connection export limit



In summer months, generation exceeding the export capacity can be stored for export later in the day

Export limit

In winter months export limit may not be exceeded , storage can be used for other services.

Use Case 7: Smoothing – Power Quality

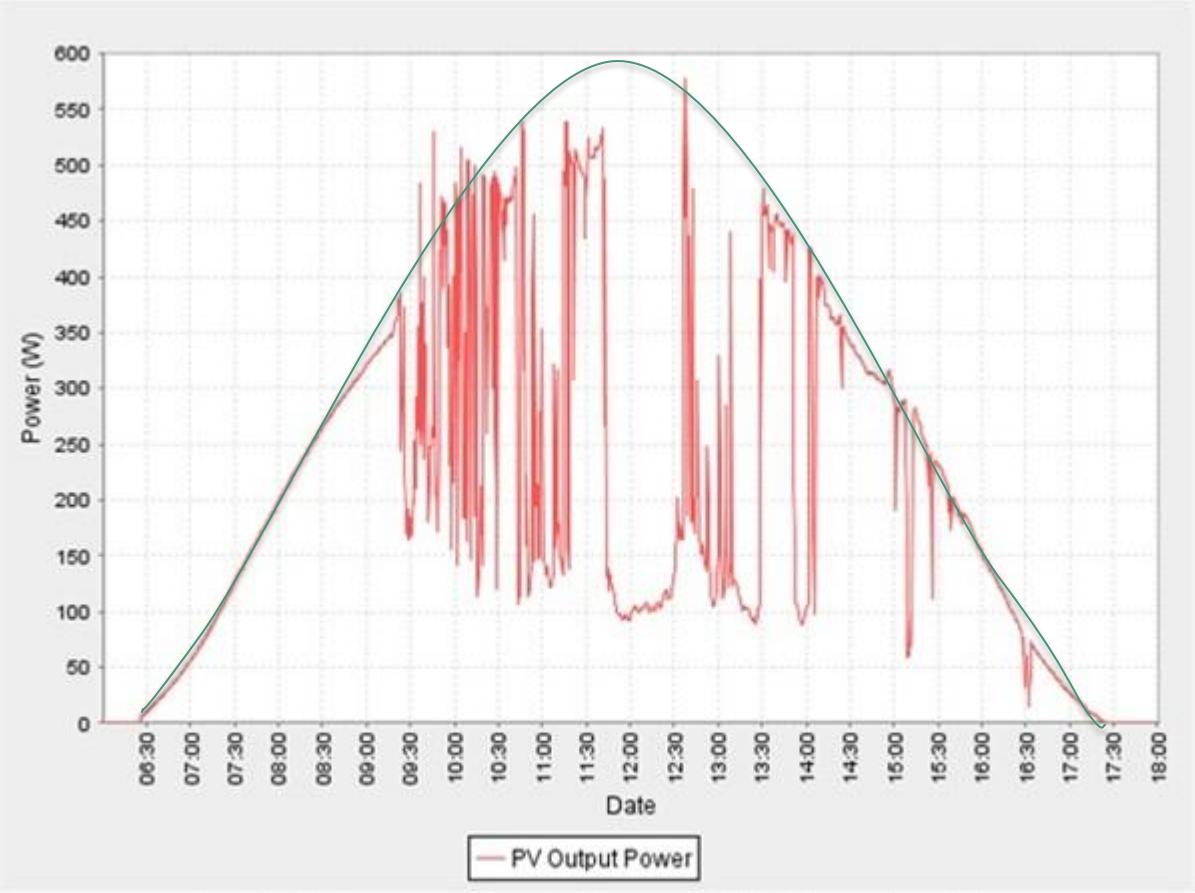
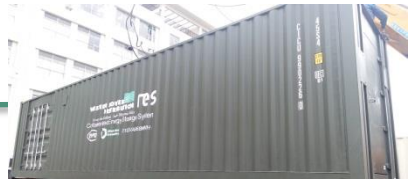


Fig 1: Intermittent Solar PV Production

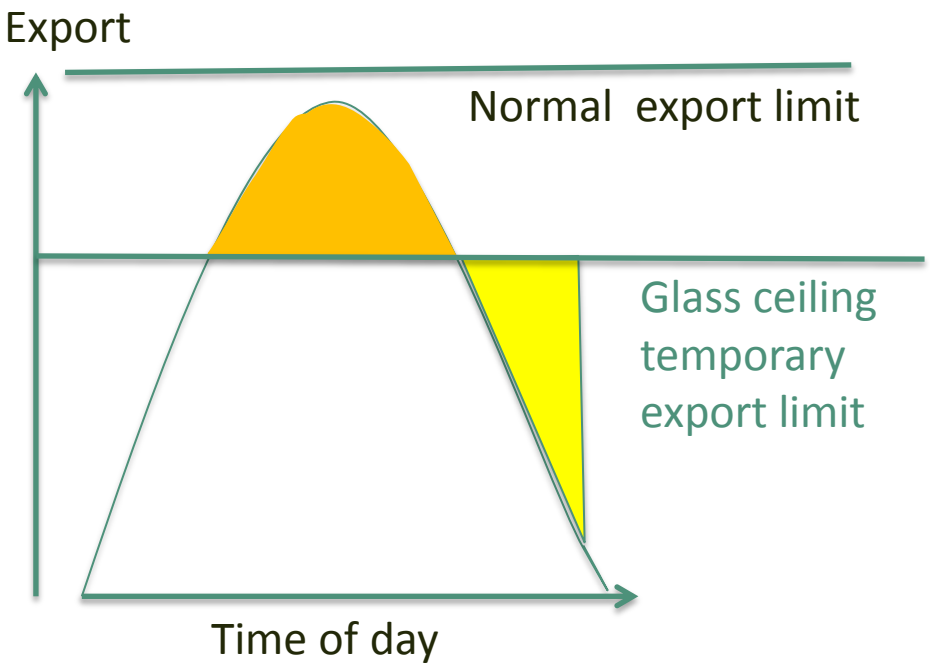
Using storage to compensate for reduction of PV due to clouds can create a smoother export profile, improving forecast reliability and avoiding step changes.

An issue to consider is whether improving the predictability of the PV output is at the cost of having greater unpredictability of storage assets, which may also have rapid step changes in their output if providing frequency response services.

Use Case 8: Glass ceiling



Maximum generation exceeds temporary export limit



At the request of a DNO operate to a lower export limit than normal.

This could allow for more sophisticated real time control by the DNO to ensure system stability. The height of the glass ceiling could have a set level or be communicated by the DNO.

Use Case 9: Multiple Storage system control

Looking forward to a smarter grid, multiple storage systems could be co-ordinated with each other and other smart grid elements.

Multiple storage control system

Load customer with DSR

Load customer

Load customer

Co-ordination should avoid operations that negate each other. E.g. if BESS1 increases charging to support voltage this is undermined if BESS2 starts generating. Similarly if BESS1 starts exporting to reduce the demand on the network this is undermined if BESS2 starts charging.

Combining Use Cases

Multiple use cases can be performed in a day.

Use cases can be carried out sequentially but it may be that the same action supports more than one use case.

e.g. battery charging may provide the store of energy required for arbitrage while at the same time providing a voltage reduction service for the DNO.

Early Learning/Issues

- String Imbalance – There is an ongoing issue where the 4 battery strings drift apart and cause the BMS to override the programmed schedule in order to prevent the battery breaching the 90%/10% operational limits.
- There needs to be a contractual clause linked to % imbalance between strings that covers this event.
- As with previous battery storage projects, SOC accuracy needs to be considered as over time this can drift. Regular re calibration may be required.
- Faulty CT gave spurious errors. Now rectified, but further work proposed to improve CT and algorithm accuracy

Current DNO Limitations

- DNOs are required to maintain the network
- They are not allowed to trade energy
- Battery vs conventional reinforcement
- When done for a connection we are obliged to offer the least cost scheme
- Current governance limits the situations when we would be able to use storage

Conclusions

- Several key questions remain open about the integration of energy storage with renewable generation on the network.
- Effective commercial arrangements and overcoming legislative barriers are key, as well as improving technical and economic performance.
- Solar Storage aims to answer these questions by under taking a real world trial, usage cases, producing real data, informing the commercial position.
- At present we do not see WPD as owner operators of large scale storage. We expect an increasingly open market from which to procure Network and/or flexibility services, but believe DNOs should be the storage / flexibility service provider of last resort where the market can’t meet requirements.

Project Timeline

Activity	Timeframe
Installation & Site Acceptance Testing	Completed October 2016
Battery operation – Use case demonstration	October 2016 – Jan 2018
Third party review of testing by National Solar Centre	May/Jun 2017
Evaluate potential for auction	Aug/Sep 2017
If required, Battery removal	Jan/Feb 2018
Analysis of data	April 2017 – Feb 2018
Dissemination of results	March 2018

Q&A

THANKS FOR LISTENING

WESTERN POWER DISTRIBUTION

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WESTERN POWER DISTRIBUTION

INNOVATION

NEXT GENERATION NETWORKS

Alternative Connections

Balancing Act Conference

11th May 2017

Steven Gough

Innovation & Low Carbon Networks Engineer

WESTERN POWER DISTRIBUTION
INNOVATION

WESTERN POWER DISTRIBUTION FLEXDGRID

WESTERN POWER DISTRIBUTION PLUGS AND SOCKETS

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WESTERN POWER DISTRIBUTION LOW CARBON HUB

WESTERN POWER DISTRIBUTION OPEN LV NEW

WESTERN POWER DISTRIBUTION NETWORK EQUILIBRIUM

WESTERN POWER DISTRIBUTION SMART ENERGY ISLES

WESTERN POWER DISTRIBUTION NETWORK TEMPLATES

WESTERN POWER DISTRIBUTION FALCON

Future Networks Programme

Assets

- Telemetry
- Decision support
- Improved assets
- New assets
- Flexibility
- Automation
- Incident response

Customers

- New connections
- Upgrades
- Information
- Self Serve
- Products/Service
- Tariffs
- Communities

Operations

- Reliability
- Forecasting
- DSO
- DSR
- GBSO Interface
- Efficiency
- SHE and Security

Network and Customer Data

- **Airborne Inspections**
- **AIRSTART[1]**
- **Telecoms Analysis**
- **Superconducting Cable**
- **SF6 Alternatives**
- **MVDC Test Lab**
- **Smart Energy Laboratory**
- **Statistical Ratings**
- **Primary Network Power Quality Analysis**
- **Hybrid Heat Pump Demonstration**
- **Hydrogen Heat & Fleet**
- **Carbon Tracing**
- **HV Voltage Control**
- **Solar Storage**
- **LV Connect and Manage**
- **Sunshine Tariff**
- **CarConnect**
- **Industrial & Commercial Storage**
- **DSO/SO Shared Services**
- **Project SYNC**
- **Project ENTIRE**
- **Smart Meter data for Network Operations**
- **Distribution Operability Framework**
- **Times Series Data Quality**
- **Voltage Reduction Analysis**
- **LV Connectivity**
- **Smart Systems and Heat[2]**

Note: 1 – Funded by Aerospace Technology Institution; Note 2 – Funded by the Energy Systems Catapult

Presentation Overview

Steven Gough:

- Alternative connections background
- New developments

James Bennett:

- Fault Level derived Soft-Intertrip

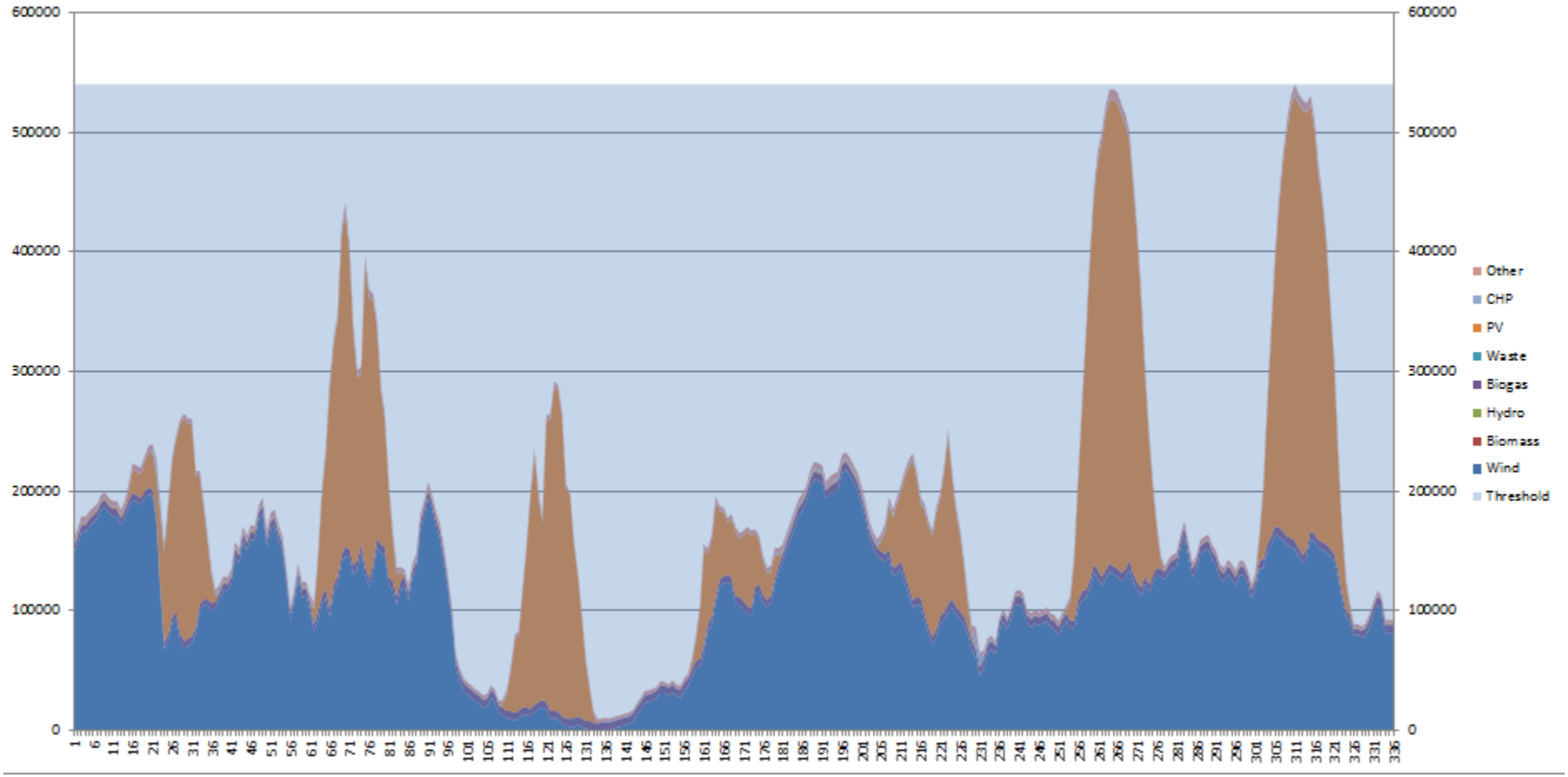
Sam Jupe:

- LV Connect and Manage

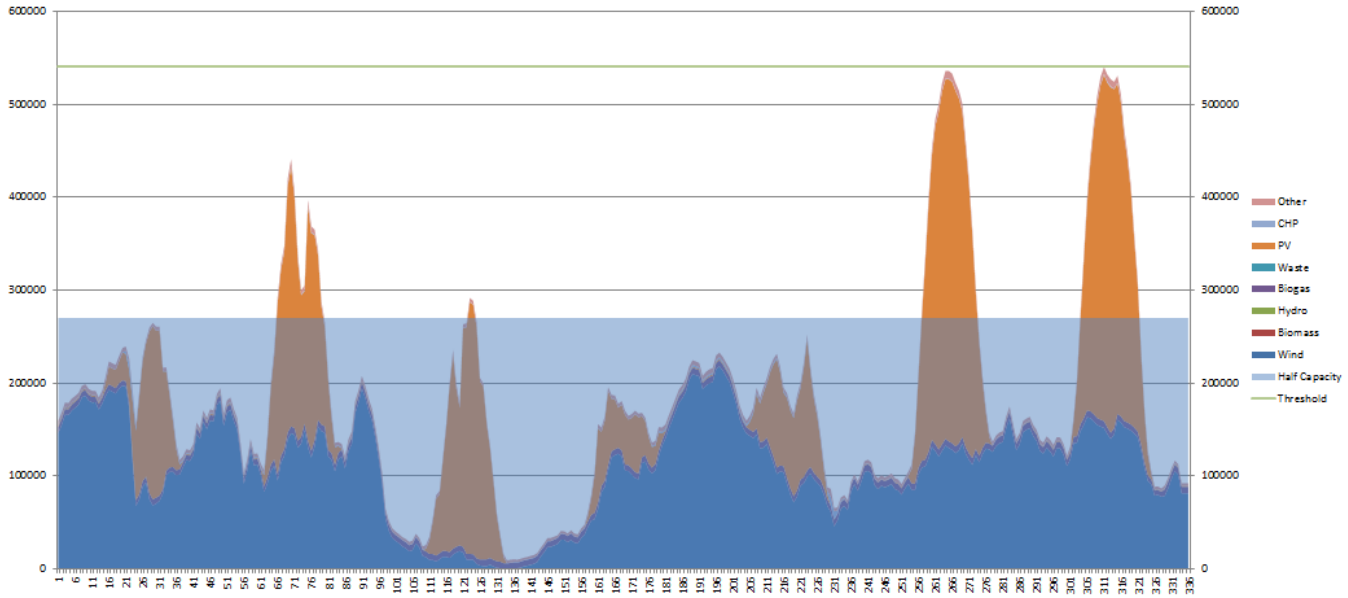
Alternative Connections

- Developed as parts of the network became ‘full’
- ‘Full’ = Limitations from Thermal, Voltage, Protection or Fault Level
- Customers must be willing to accept some level of curtailment in return for a saving in reinforcement costs and timescales
- Level of curtailment can be fixed or dynamic
- WPD currently has four options of increasing technicality

Alternative Connections



Alternative Connections



- 50% capacity available 85% of the time

Alternative Connections – Export Limiting

- Measures Apparent Power at Exit Point
- Uses information to restrict the generation and/or balance the customer demand in order to prevent agreed ASC being exceeded
- Suitable for all capacities & voltage levels
- Reduces generators contribution to thermal or voltage infringements (Fault Level Restrictions may still apply)

Alternative Connections - Timed

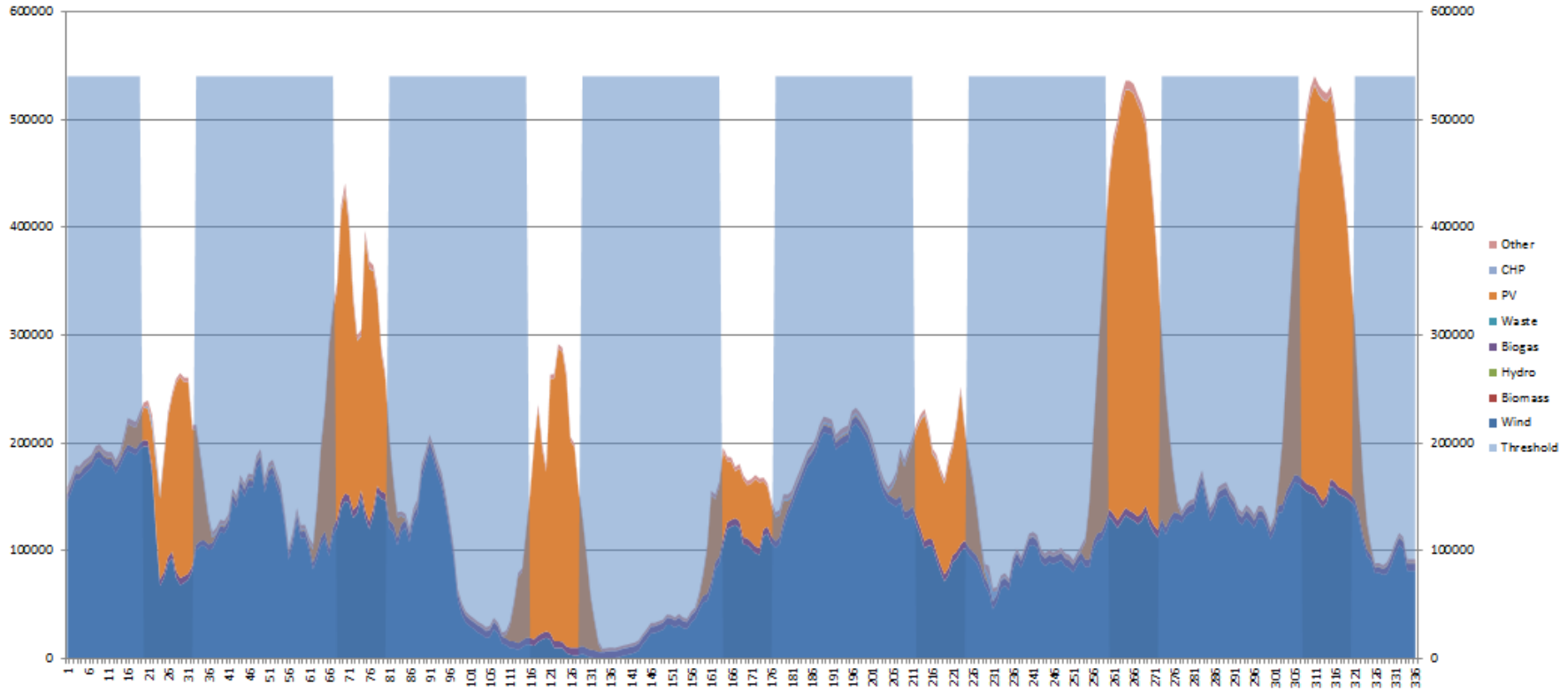
- Achievable where we have predictable load and generation patterns
- Connections will be given an operating schedule which will define times and levels of capacity available
- Typical constraint times:

  October to March – No constraint

  April and September – Constrained 30% output 10am to 4pm (no constraint outside of these hours

  May to Aug - Constrained 0% output 10am to 4pm (no constraint outside of these hours
- Method of curtailment provided by WPD or customer
- Suitable for sub 1MVA generation installs at 11kV

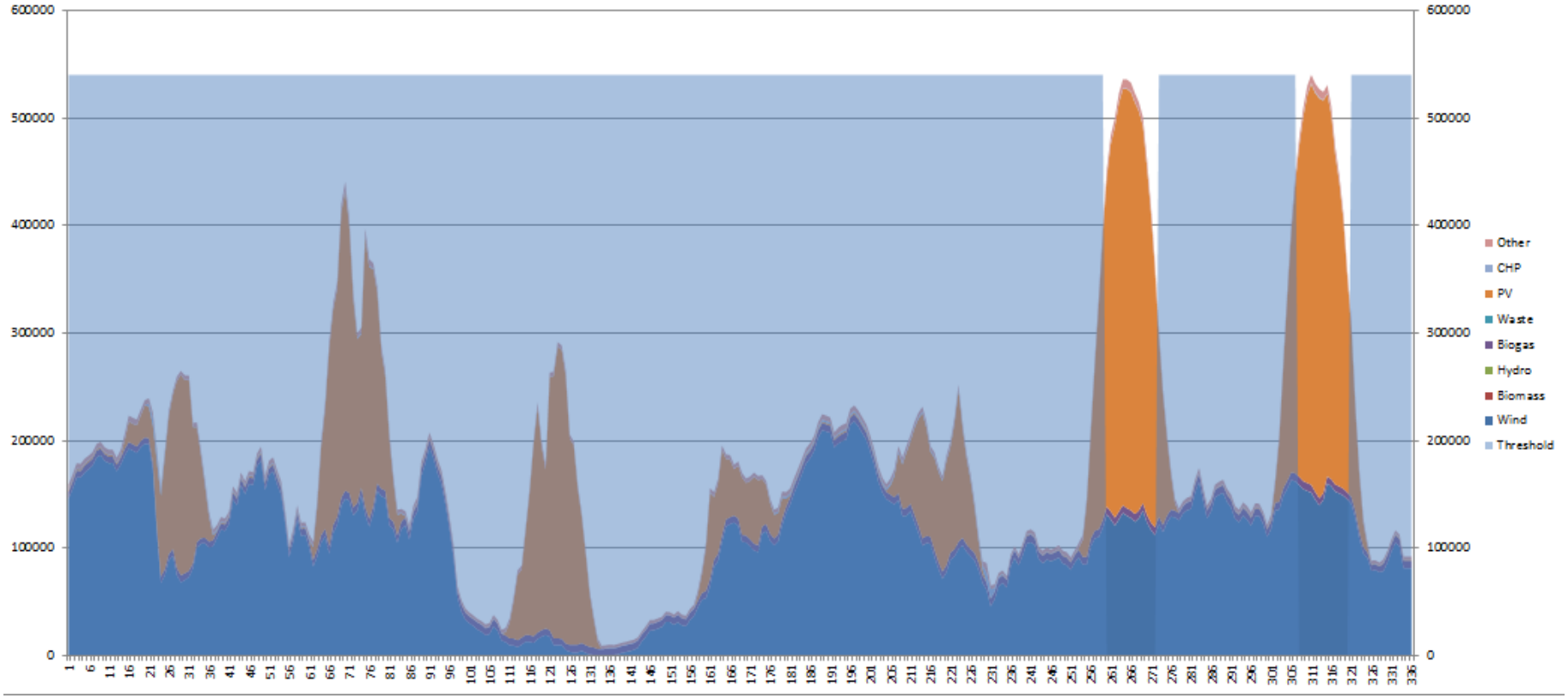
Alternative Connections - Timed



Alternative Connections – Soft-Intertrip

- Network Constrained by a single upstream asset requiring reinforcement
- Through monitoring these conditions using the network management system, further capacity can be released when these limits or assets are within normal operating parameters
- On-site WPD RTU issues two stages of constraint – 30% total output and 0% total output
- Suitable for all generator applications connecting at HV or with an export level of 250kW and above
- Limited participants per area
- Can monitor Transformer Reverse Power, (N-1) Constraints, Voltage Constraints, Thermal Constraints

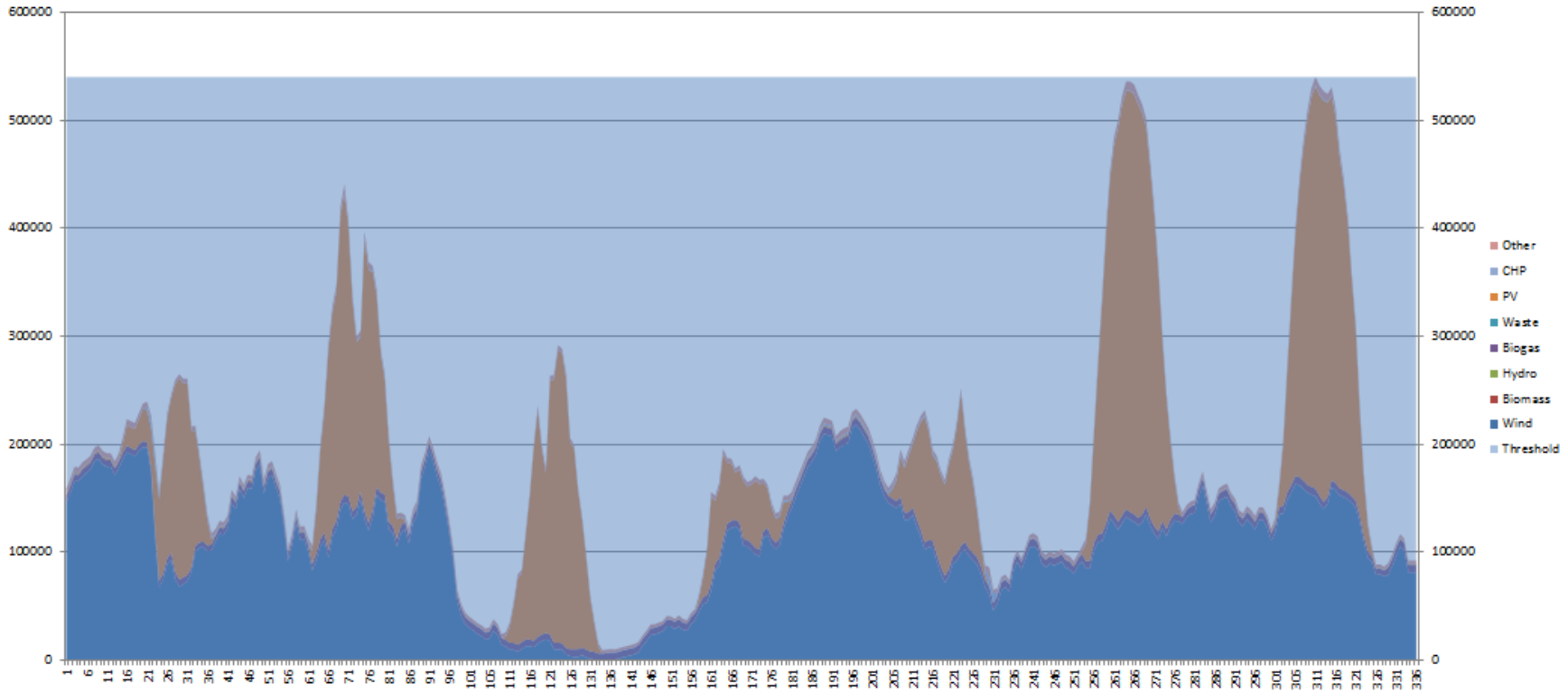
Alternative Connections – Soft-Intertrip



Alternative Connections – ANM

- ‘Active Network Management’
- Multiple complex constraints affecting a number of customers
- Distributed control systems continually monitor all limits on the network then allocate the maximum capacity to customers in that area
- New ANM ‘Zone’ being rolled out every six months with a view to making the whole network available for customers to apply for an ANM connection by 2021

Alternative Connections – ANM



ANM Background in WPD

- WPD's Innovation Strategy (part of ED1 business plan) outlines the zones:
- The development of ANM was prompted by increasing areas of the WPD network triggering very high reinforcement costs or long timescales for new connections
- The plan is to role ANM out to the entire network

GSP Group	Active BSP Group	Quoting form	Building during
Bicker fen	Skegness	Active	Active
Grendon	Corby	Active	Active
	Northampton	Apr-16	Apr-17
Bridgwater	Bridgwater	Active	Active
	Street		Active
West Burton	Horncastle	Active	Active
Indian Queens	Truro	Active	Nov-16
Swansea North	Swansea	Nov-16	Nov-17
Pembroke	Pembroke	Nov-16	Nov-17
Cellarhead	Meaford	Apr-17	Apr-18
Rassau	Abergavenny	Nov-17	Nov-18
Feckenham	Feckenham	Apr-18	Apr-19
Berkswell	Warwick	Apr-19	Apr-20
Bishops Wood	Hereford	Nov-19	Nov-20
Pyle	Pyle	Apr-20	Apr-21
Remaining GSPs		Jan-21	Nov-21

ANM suppliers

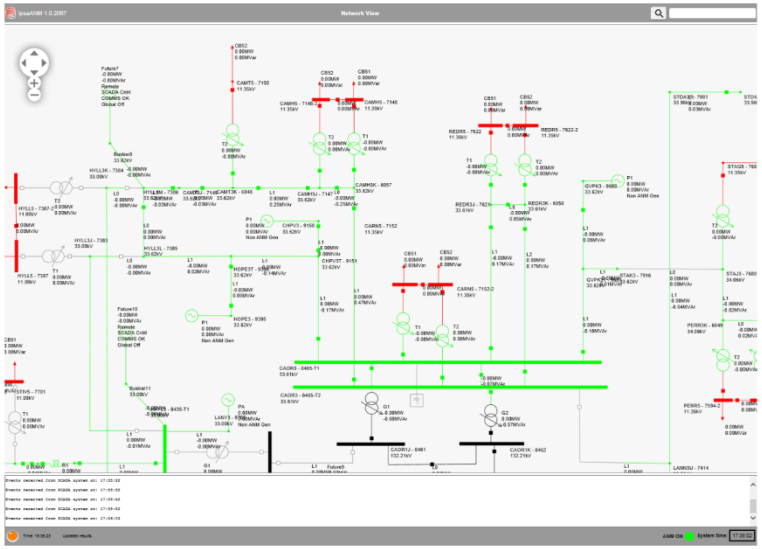
We have a framework agreement with three suppliers:

- Smarter Grid Solutions – for simple topologies
- CG Automation – for more complex topologies
- GE – for more complex topologies

The framework contract will be reviewed after 3 years where it may be extended for 2 years or a new framework tender will be issued.

How Alverdiscott/Indian Queens is different to the other zones

- All other ANM zones are provided by SGS except Alverdiscott/Indian Queens.
- This zone is provided by CG Automation, the provider of the of the Generator Constraint Panel.
- The system is has ‘Load Flow in the Loop’ making it more versatile the complex network in Alverdiscott/Indian Queens.
- This means there is closer integration with PowerOn.

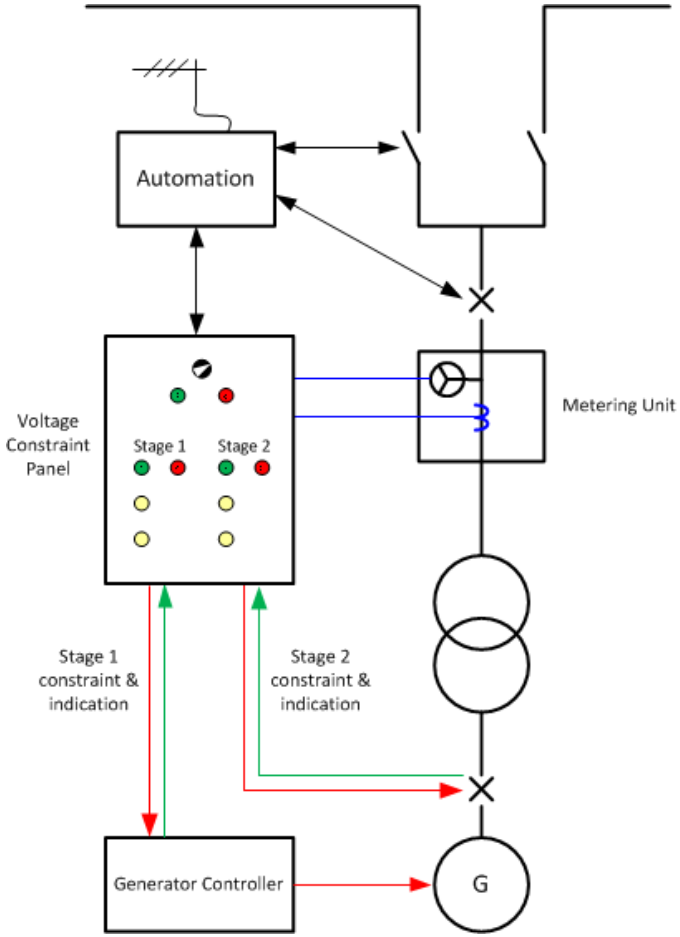


Significance of ‘Load Flow in the Loop’

- ‘Load flow in the loop’ means a Load Flow Engine is included within the system. In this case it is Ipsa.
- The system takes data from the PowerOn over an ICCP link, runs a load flow, from the results from the load flow curtails the generators
- Load flows are run every 10 seconds
- It allows for unplanned abnormal running to be accommodated
- However needs a large amount of data to be kept up to date
- The modal needs to be kept up to date

New Developments

- Through the development of the generator constraint panel and the ANM system in Alverdiscott/Indian Queens the interface has been modified for controllable demand connections.
- This was extended to be able to control import and export on a single site, ideal for full control of batteries.
- We are due to trial some controlled demand connections using similar infrastructure in the coming months
- Working with various NIA projects to incorporate commercial elements to ANM



WESTERN POWER DISTRIBUTION

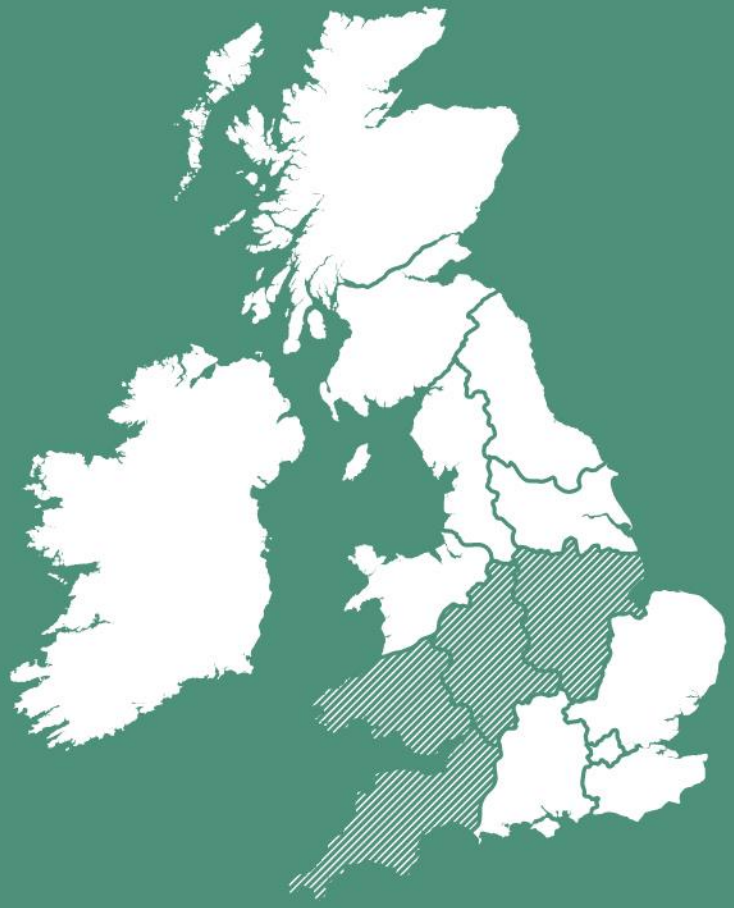
INNOVATION

NEXT GENERATION NETWORKS

Alternative Connections – Fault Level

Balancing Act Conference

11th May 2017

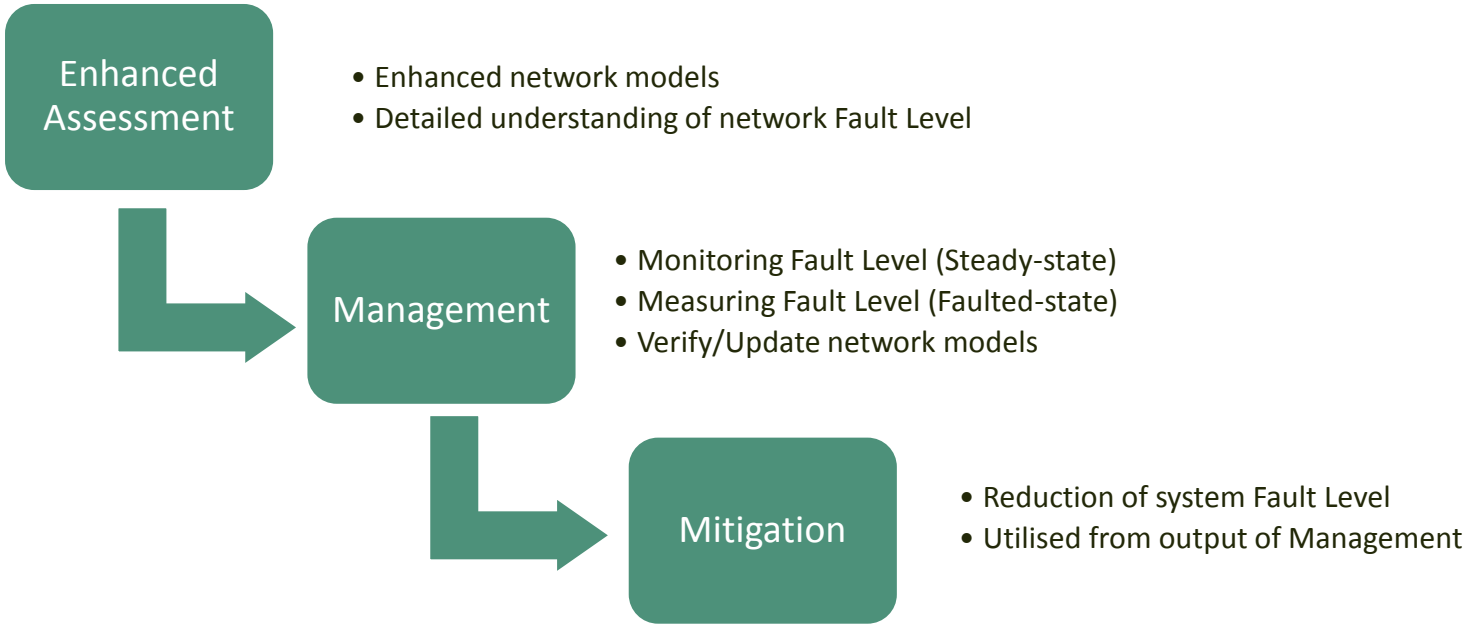


James Bennett

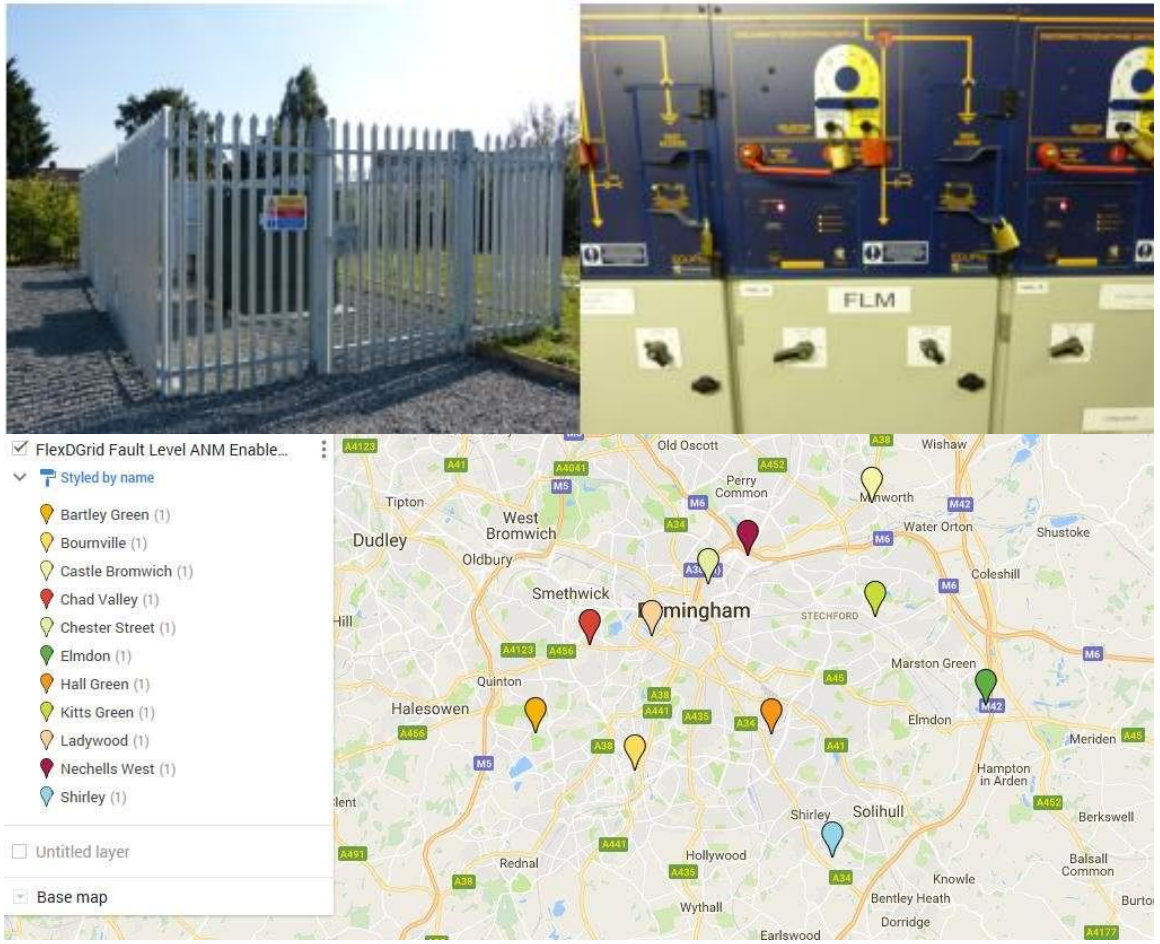
Innovation & Low Carbon Networks Engineer

Alternative Connections – FlexDGrid Fault Level

What is FlexDGrid? – Tier 2 Innovation Project recently completed March 2017



Alternative Connections – FlexDGrid Fault Level



Alternative Connections – FlexDGrid Fault Level

Key Aims

- Use the Fault Level Monitoring data to provide ‘Quicker & Cheaper’ connections for customers currently restricted by Fault Level constraints
- Ensure any solution is easy to roll-out to both customers and the business. Both commercially and operationally
- Trial with a customer

Alternative Connections – Comparisons to Existing

Limitations

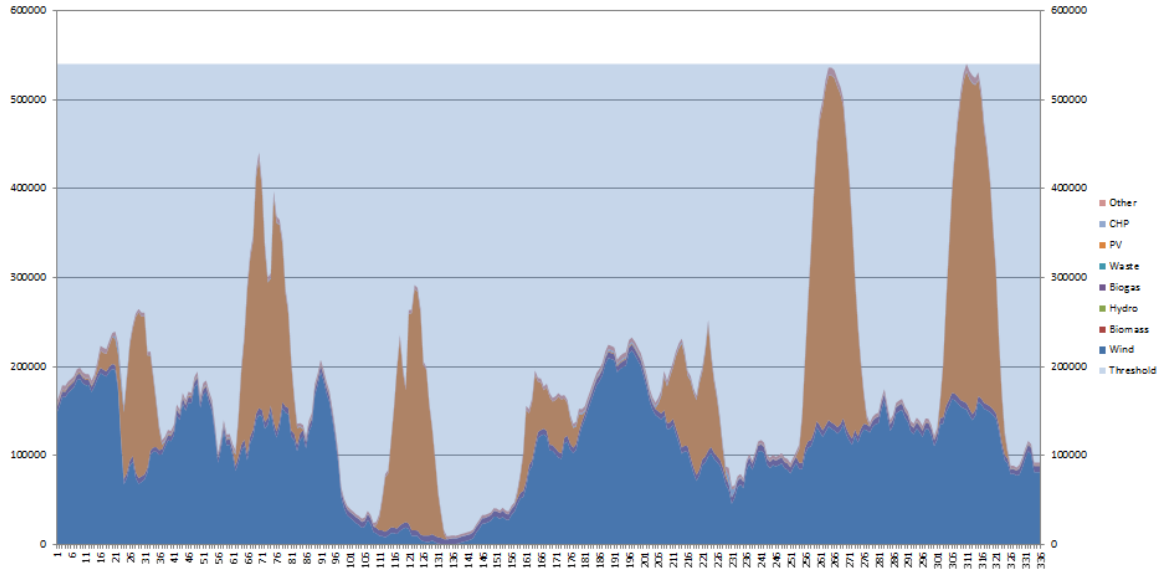
- Constraints not seasonal or have any patterns
- Export can not be limited – Must be totally disconnected
- Measurements not ‘Real-Time’ in the true sense
- No fall back protection operation

Strengths

- Periods of potential curtailment known in advance

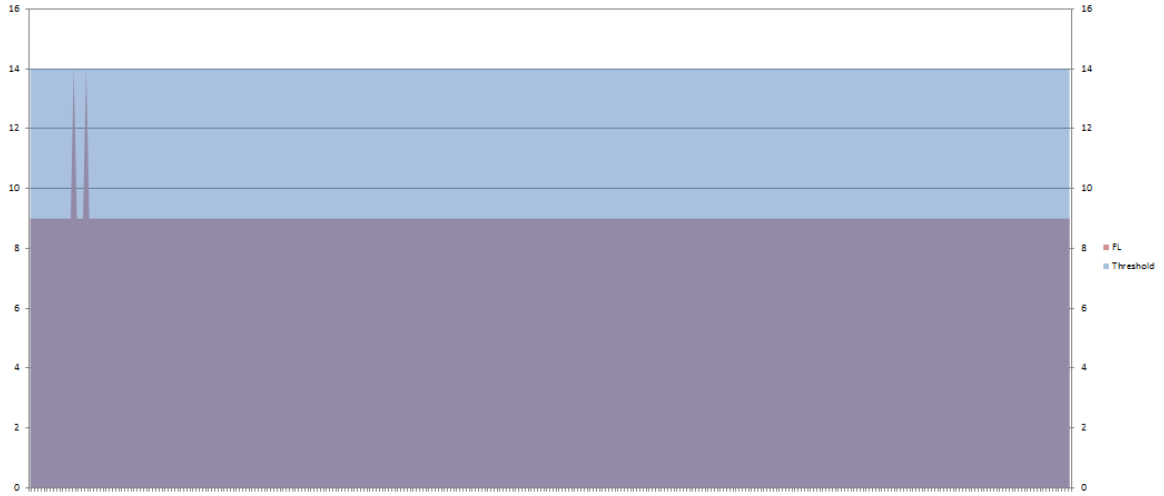
Balancing Act - Alternative Connections

kW



Time Steps

kA



Fault Level – Potential Solution

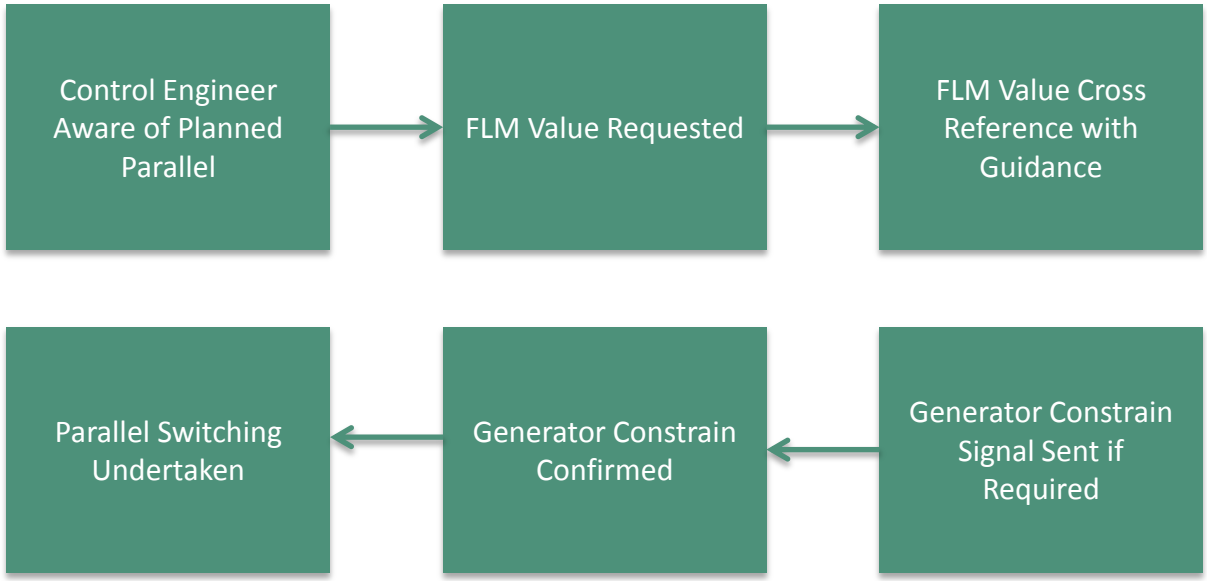
ANM

- Ideal scenario
- Lack of true ‘Real-Time’ data makes conventional implementation not possible
- Costs associated with full ANM integration ruled it out as part of the project
- However, Fault Level Soft-Intertrip principals will need integrating in to ANM to cater for the possibility of both Fault Level and thermal constraints

Fault Level – Proposed Solution

Soft-Intertrip

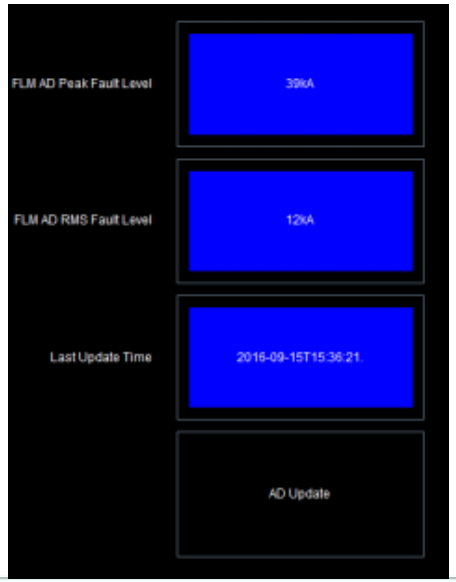
- Simpler & Cheaper installation
- Existing Soft-Intertrip coding can be altered internally to include an operator in the loop for the final decision

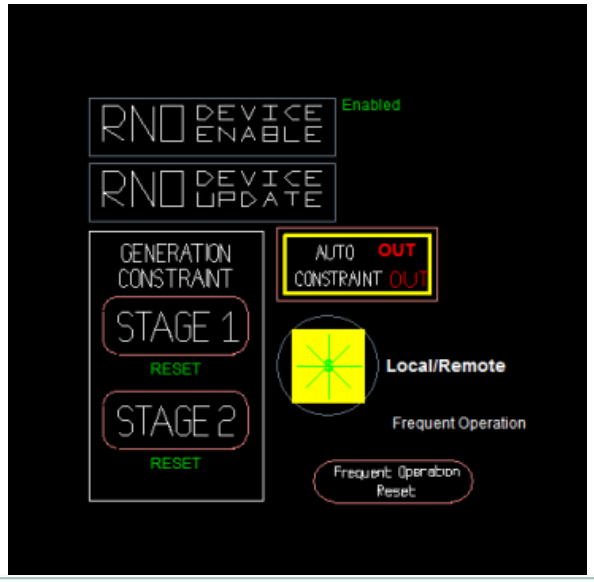


Fault Level Soft Intertrip - Development

Systems Integration

- Routed FLM data in to the WPD corporate network
- Created FLM PoF interface
- Developed ‘On-Demand’ Intellirupter control
- Re-configured Generator Constraint Panel





Fault Level Soft Intertrip - Development

Trial Customer

- Nechells West
- Existing on –site Fault Current Limiter at the end of its useful working life. Two large CHP & One 800kVA Gas Generator
- Interested to understand the impact on their business
- Installed solution up to the generator to prove and provide visual indication

Fault Level Soft Intertrip -

Trial Customer

- Off-Line calculations to establish thresholds

FLM Value (kA)	Mitigating Actions
≥12.705	No Acceptable Mitigating Actions Available
12.190 to 12.704	800kVA Gas Generator Disconnected 4.7MVA CHP Disconnected Bus-Section Z-Y Open
10.675 to 12.189	4.7MVA CHP Disconnected Bus-Section Z-Y Open
≤10.674	Bus-Section Z-Y Open

Fault Level Soft Intertrip -

Trial Customer

- Curtailment

Mitigating Action	Av. No. of Actions per Year	Average Length of Action (Minutes)	Typical Times When Action May be Required	
800kVA Gas Generator Disconnected	1.16	3	9.30am	2.30pm to 4.30pm
4.7MVA CHP Disconnected	2.52			

- Costs

  FLM Solution = £91k

  Conventional = Approx. £300k & Three Years

- Updated policies, offer letter, connection agreement and curtailment studies

WESTERN POWER DISTRIBUTION

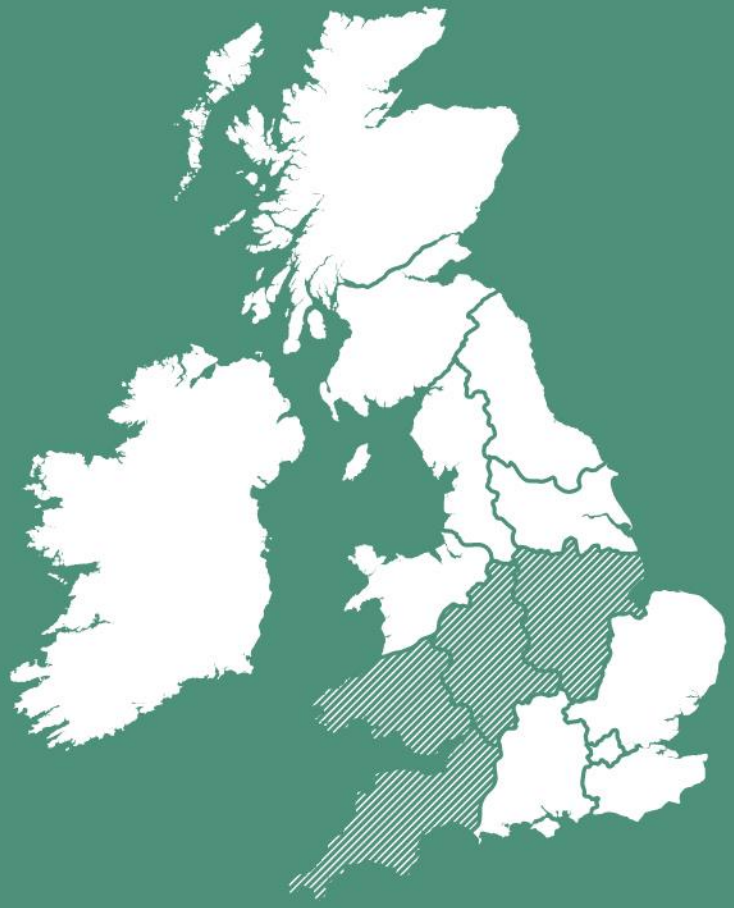
INNOVATION

NEXT GENERATION NETWORKS

Alternative Connections LV Connect & Manage

Balancing Act Conference

11th May 2017



Samuel Jupe MEng PhD CEng MIET
Network Innovation Manager,
Nortech Management Limited

WESTERN POWER DISTRIBUTION
INNOVATION

WESTERN POWER DISTRIBUTION FLEXDGRID

WESTERN POWER DISTRIBUTION PLUGS AND SOCKETS

WESTERN POWER DISTRIBUTION SOLA BRISTOL

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WESTERN POWER DISTRIBUTION NETWORK EQUILIBRIUM

WESTERN POWER DISTRIBUTION SMART ENERGY ISLES

WESTERN POWER DISTRIBUTION NETWORK TEMPLATES

WESTERN POWER DISTRIBUTION FALCON

Future Networks Programme

Assets

- Telemetry
- Decision support
- Improved assets
- New assets
- Flexibility
- Automation
- Incident response

Customers

- New connections
- Upgrades
- Information
- Self Serve
- Products/Service
- Tariffs
- Communities

Operations

- Reliability
- Forecasting
- DSO
- DSR
- GBSO Interface
- Efficiency
- SHE and Security

Network and Customer Data

- Airborne Inspections
- AIRSTART[1]
- Telecoms Analysis
- Superconducting Cable
- SF6 Alternatives
- MVDC Test Lab
- Smart Energy Laboratory
- Statistical Ratings
- Primary Network Power Quality Analysis
- Hybrid Heat Pump Demonstration
- Hydrogen Heat & Fleet
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- HV Voltage Control
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- Project SYNC
- Project ENTIRE
- Smart Meter data for Network Operations
- Distribution Operability Framework
- Times Series Data Quality
- Voltage Reduction Analysis
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- Smart Systems and Heat[2]

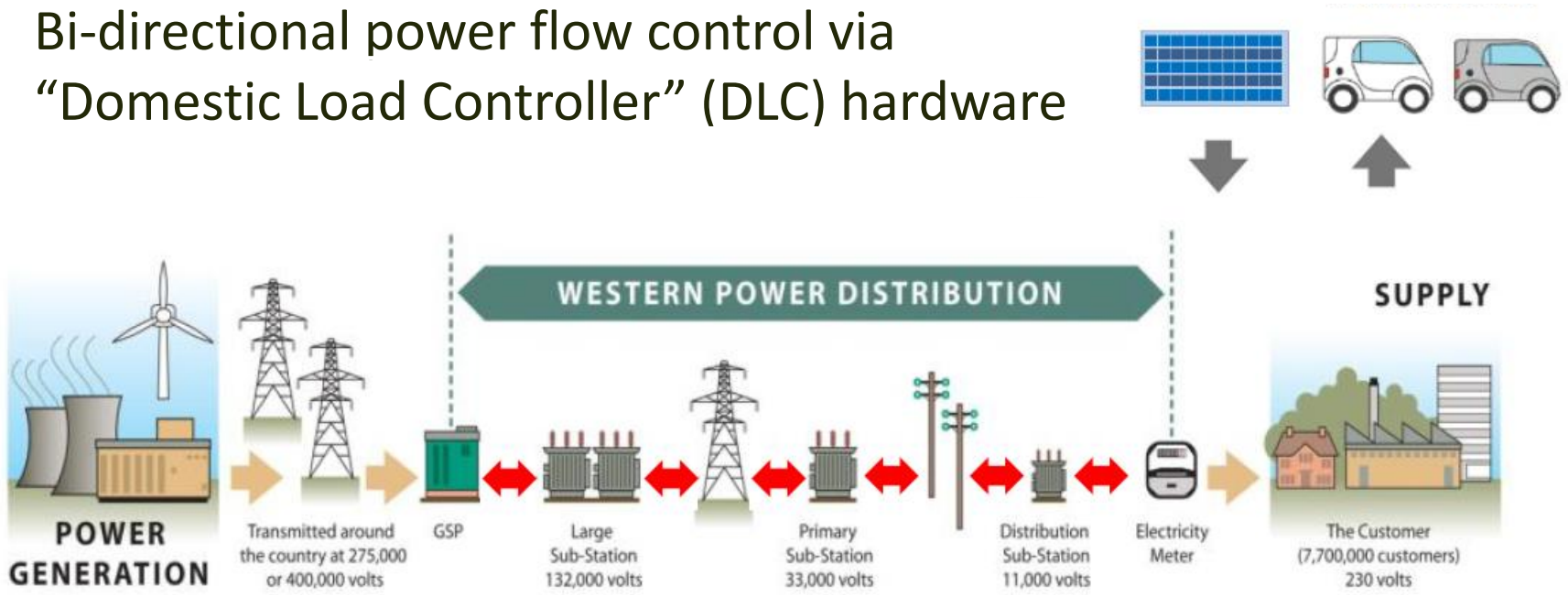
Note: 1 – Funded by Aerospace Technology Institution; Note 2 – Funded by the Energy Systems Catapult

Overview

1. Project Outline
2. Objectives
3. Progress to Date
4. Next Steps

Project Outline

- £1.7m project
- Accelerate connection of LCTs (storage, EVs, heat pumps)
- Bi-directional power flow control via "Domestic Load Controller" (DLC) hardware



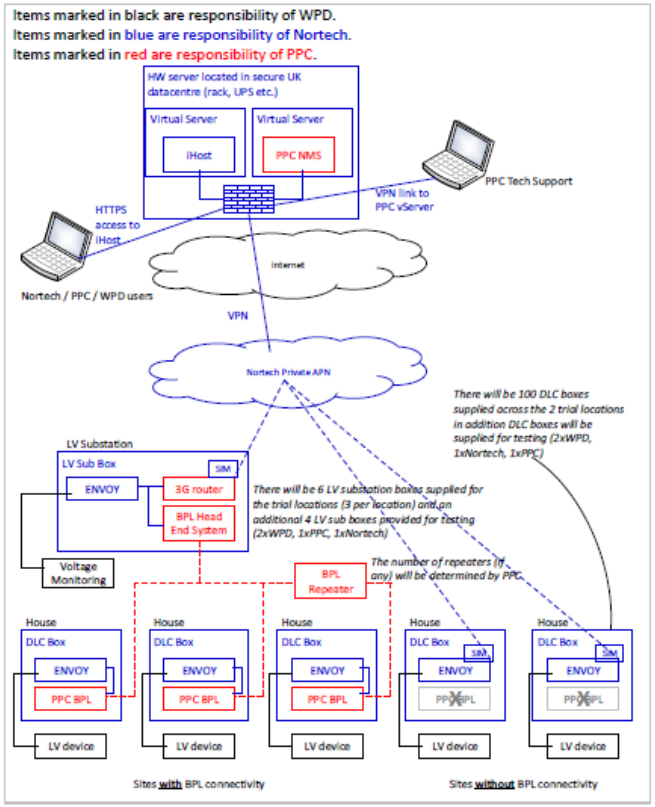
Objectives

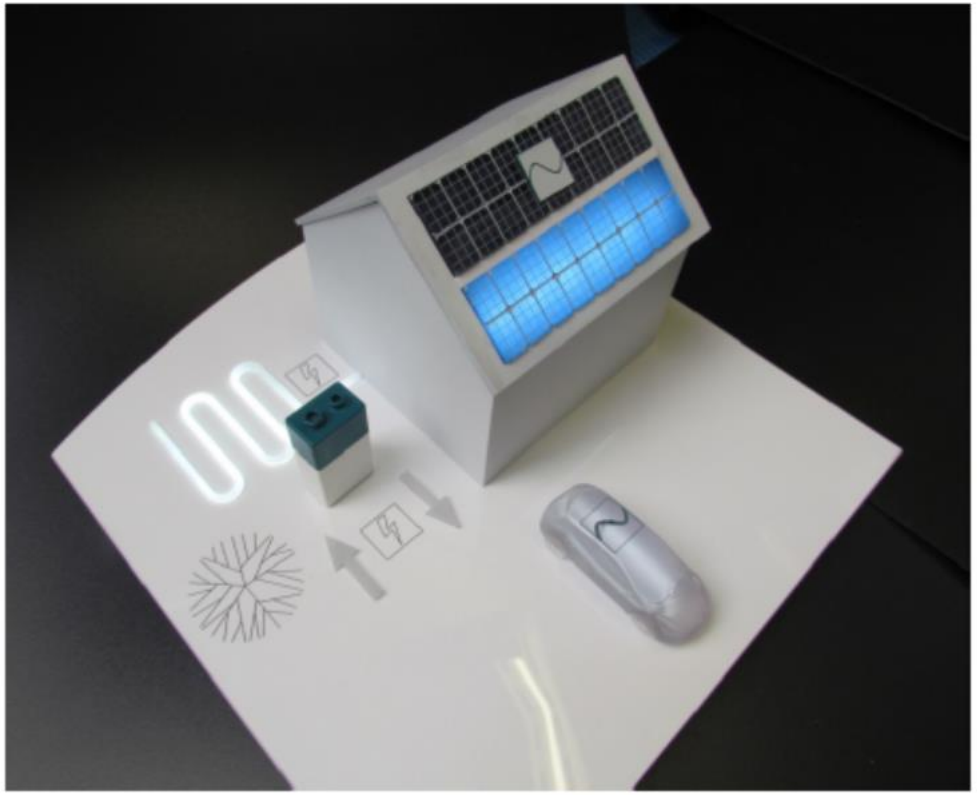
The project objectives are to trial and demonstrate:

1. Broadband over powerline (substation to customers' homes)
2. ANM solutions with intelligence distributed into the LV network
3. ANM solutions, as a short or long term alternative to network reinforcement
4. New business processes, based on proven, off-the-shelf technology, which can be quickly and cost effectively deployed

Progress to Date

Modelling → **Monitoring** → **Mitigation**



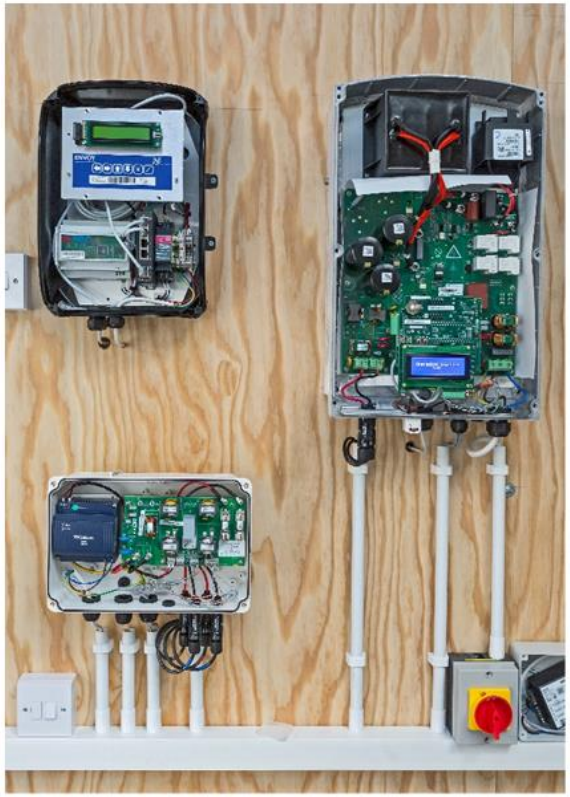


Progress to Date

Modelling | Monitoring | Mitigation

LV Substation

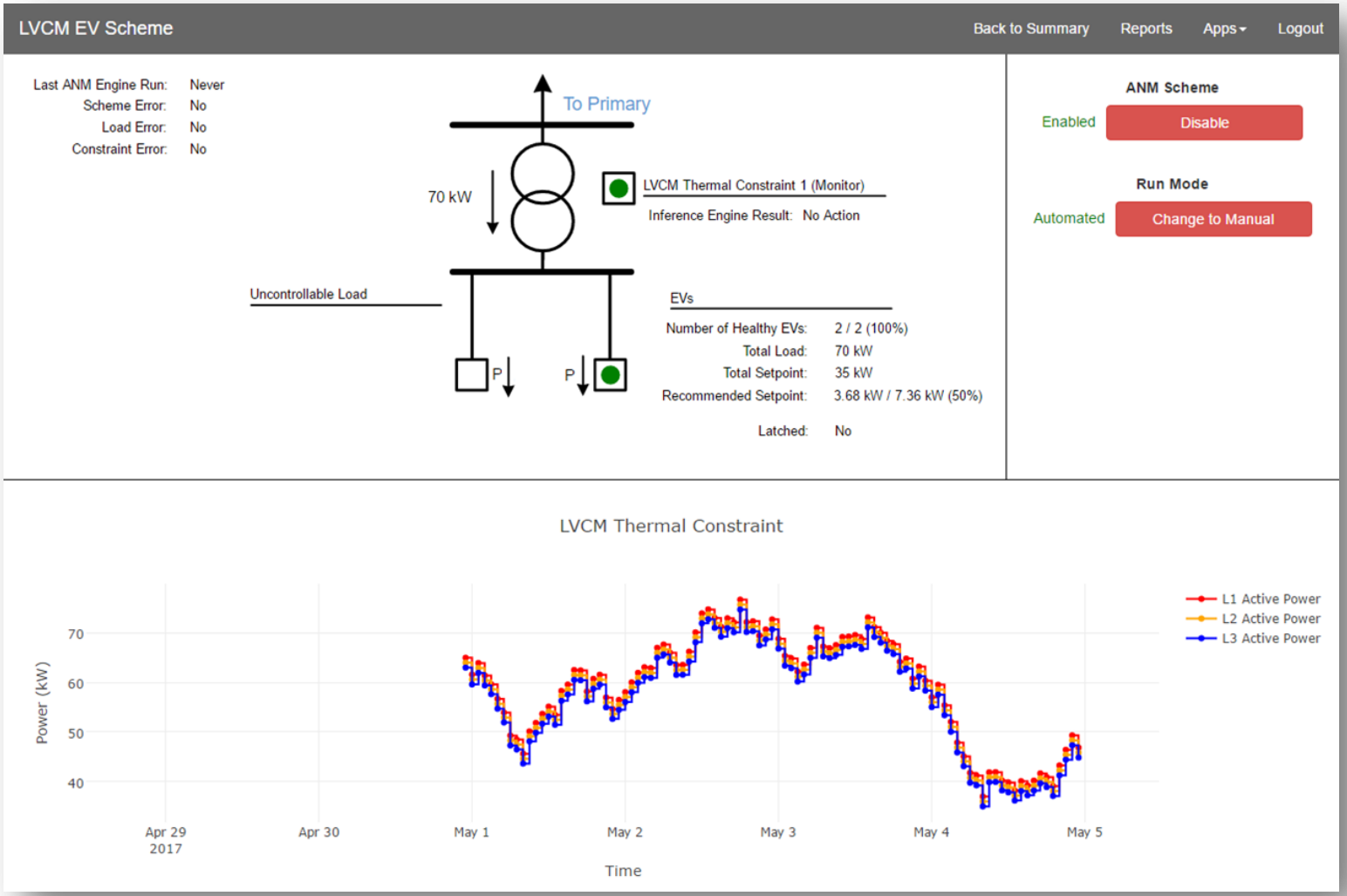
Domestic
PV + Storage



Progress to Date

Modelling → Monitoring → **Mitigation**

Progress to Date



Next Steps

1. Commission demonstrator
2. Customer engagement
3. Deploy and trial solution
4. Develop policies for Business-as-Usual adoption

Summary

1. Project Outline
2. Objectives
3. Progress to Date
4. Next Steps

THANKS FOR LISTENING

WESTERN POWER DISTRIBUTION

Serving the Midlands, South West and Wales

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WESTERN POWER DISTRIBUTION

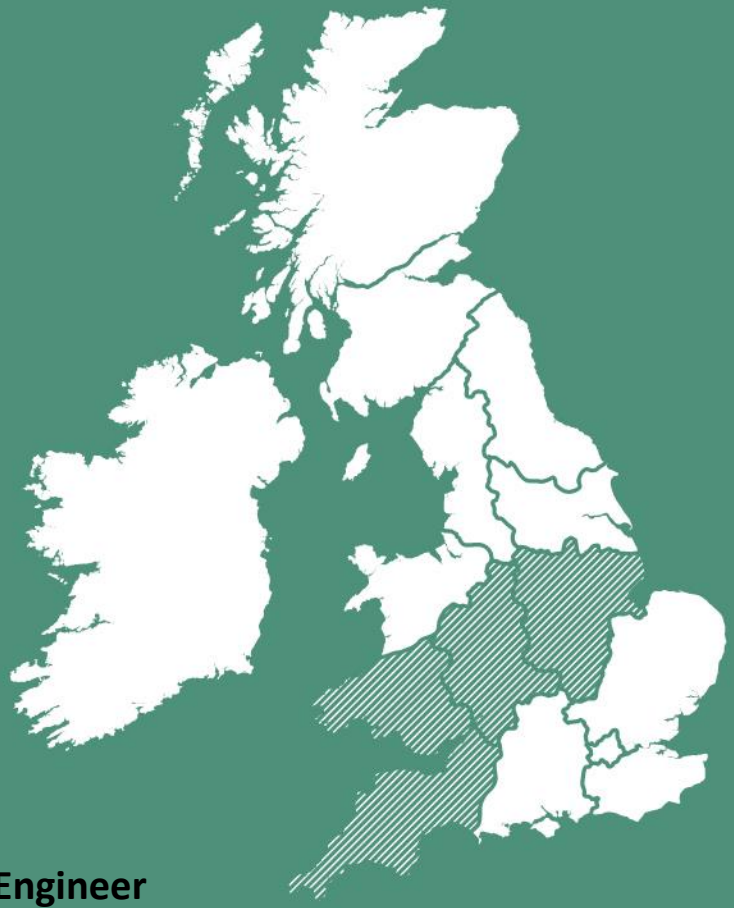
INNOVATION

NEXT GENERATION NETWORKS

DSO - Data & Communications

Balancing Act Conference

Thursday 11th May 2017



Jenny Woodruff, Innovation & Low Carbon Networks Engineer

Gary McElroy, Infrastructure Manager

WESTERN POWER DISTRIBUTION
INNOVATION

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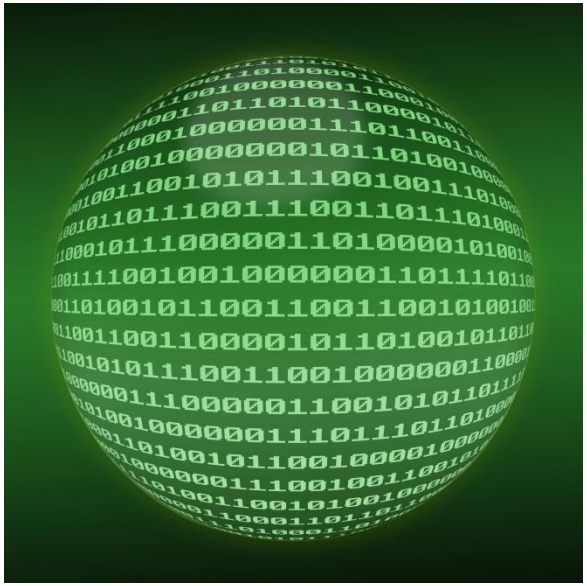
Agenda

- Data requirements for a DSO
- WPD projects
- Q&A
- Discussion



DSO Requirements

1. Understand the impact of potential load/ generation growth on the network.
2. Understand opportunities for using flexibility services
3. Be able to procure and execute flexibility services
4. Co-ordinate more effectively with third parties by sharing information
5. Enhance our telecoms network to enable a more actively managed network

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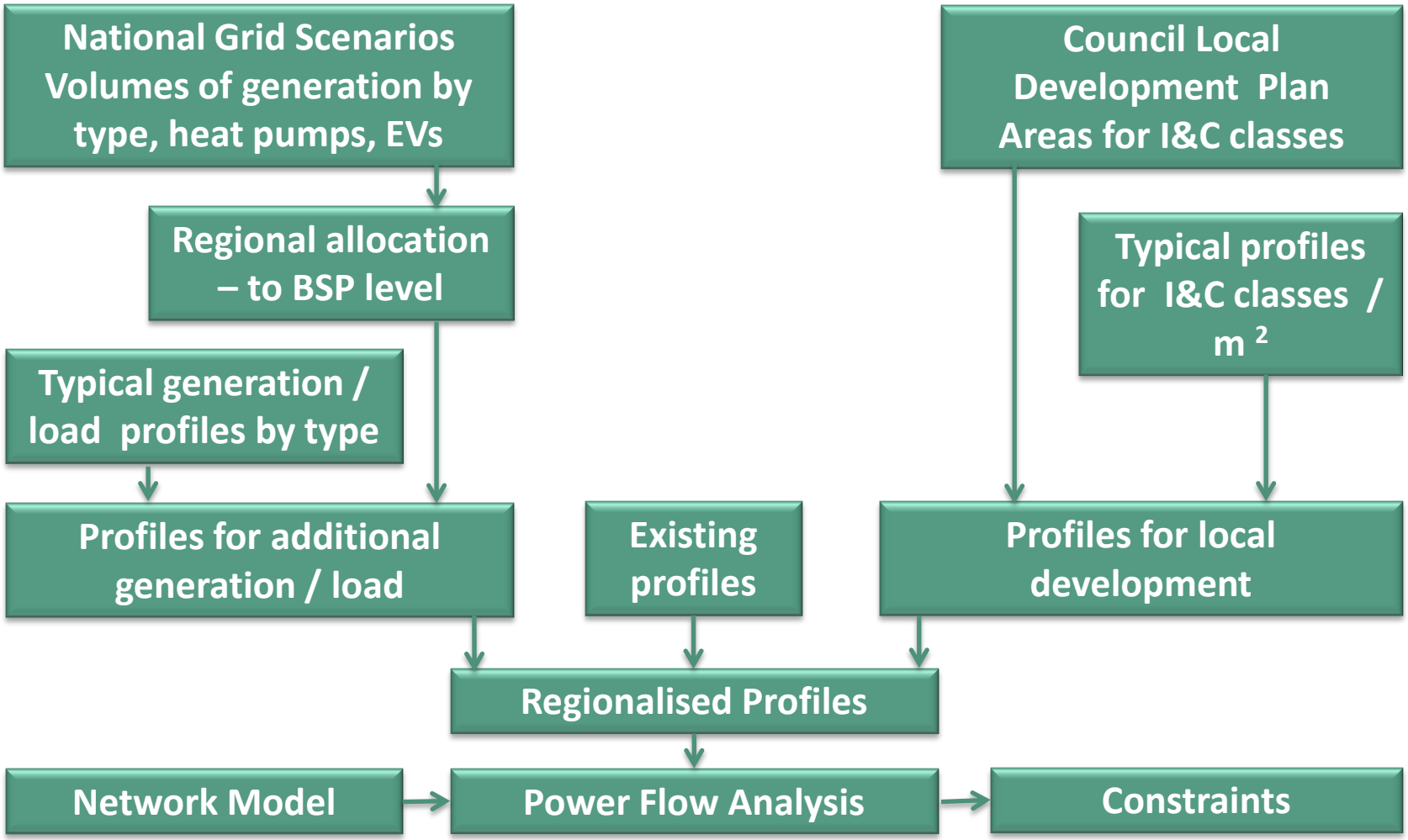
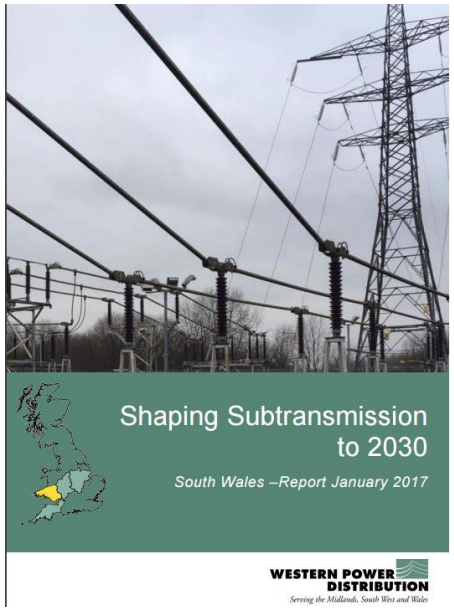
Long Term Forecasting



Sub Transmission reports



Published reports should help with alignment of assumptions for other infrastructure planning.

	Rate 1 (Peak/Red) Units (MWh)	Rate 2 (Off-Peak/Amber) Units (MWh)	Rate 3 (Green) Units (MWh)	MPANs	Import Capacity (kVA)	Reactive Power units (MVArh)
Domestic	3,391,429	176,357	-	1,033,972	-	-
Other LV NHH (incl. Unmetered)	1,293,397	225,205	123,810	83,042	-	-
Other LV HH	114,045	721,339	540,284	3,997	659,615	113,950
HV (incl. LV Substation)	159,684	963,473	900,253	677	706,379	142,887
LV Generation	23,061	1,132	1,197	289	-	2,110
HV Generation	120,916	57,665	64,975	87	-	1,750
Total	5,102,532	2,145,170	1,630,518	1,122,064	1,365,994	260,697

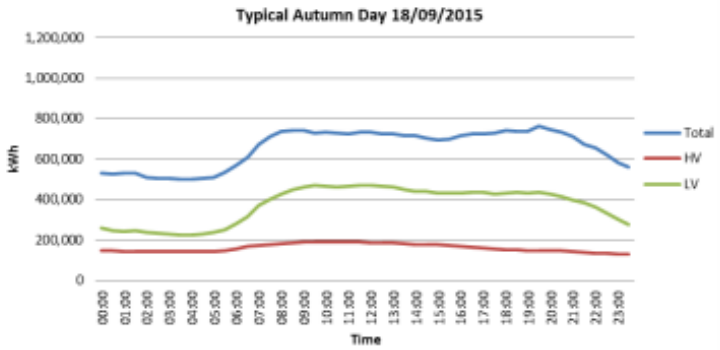
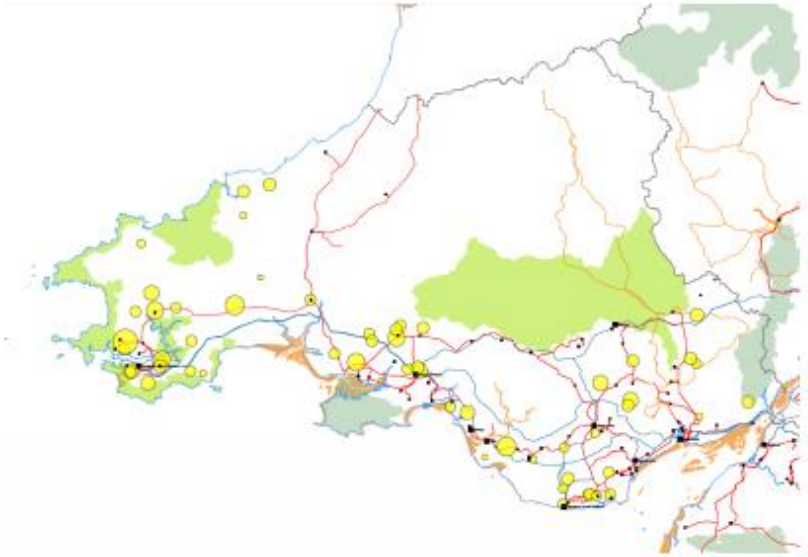


Figure 6: Typical Autumn day energy usage profile



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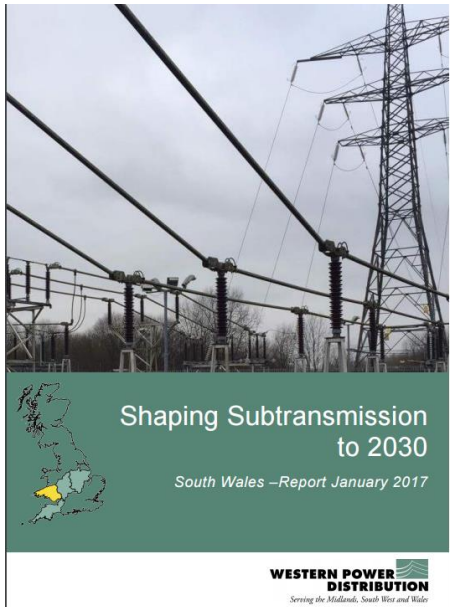

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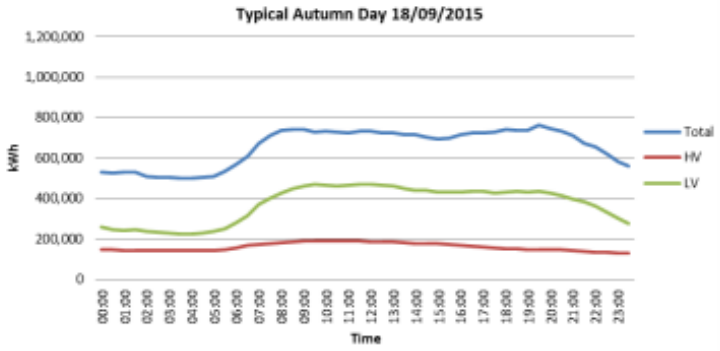

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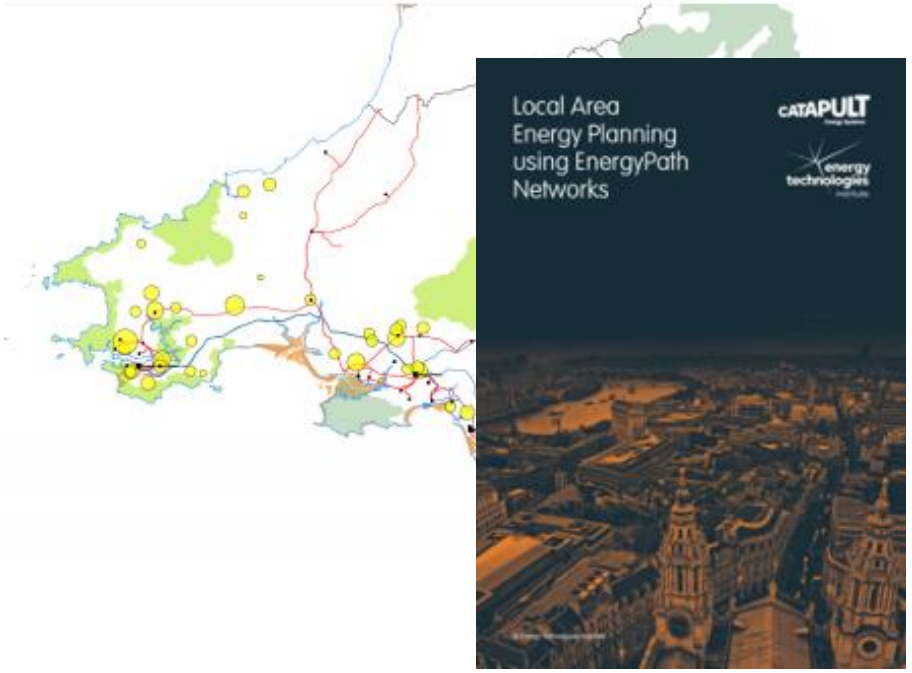

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Understand opportunities for flexibility services

- Forecasting options evaluation
- Flexibility requirements assessment
- Third Party Co-ordination
- Systems Requirements
- Optimal systems configuration
- Implement and Test

Electricity Flexibility and Forecasting System (EFFS)

- NIC bid with AMT Sybex
- Long and short term tools
- Suppler, Aggregator, TSO involvement

DSO Requirements

1. Understand the impact of potential load/ generation growth on the network.
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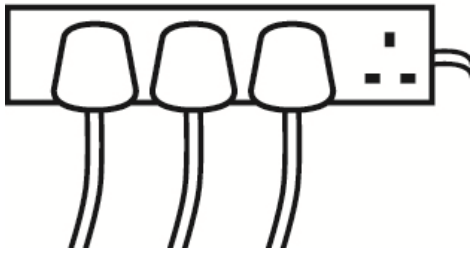
Plugs & Socket / Cornwall Local Energy Market

Platform for trading flexibility services



DNO, SO, TO, Aggregators, Suppliers,
Generators connect to the “Socket” via “Plugs”

- Notify flexibility services requirements
- Flexibility service trading
- Notify use of flexibility services

centrica

nationalgrid

UNIVERSITY OF EXETER

Parallel projects working together

Plugs and Socket	Cornwall Local Energy Market
WPD Element will be NIA funded	European Regional Development Fund
Development of “D” Plug, Participation in Trial.	Development of Socket. Installing micro CHP, storage, telecoms . Academic analysis via Exeter University. Market modelling. Local Energy Market.
Expected to be under £1m (Not yet tendered for IT development work)	£19m

IPR issues around trading platform avoided.

Use cases & market models

Seasonal Constraint
Mid Winter or Summer

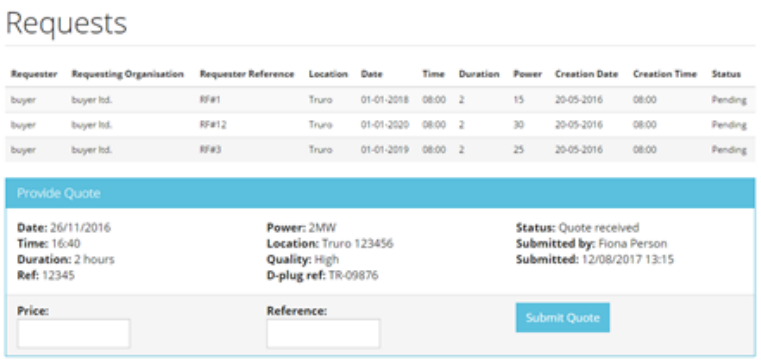
Maintenance Window Extension

Autumn

Post Fault
Any time of year,

Different market models

- Procurement style
- Spot Market
- Nodal Pricing model



Simulating constraints on 33kV, 132kV Transformer / Circuit

DSO Requirements

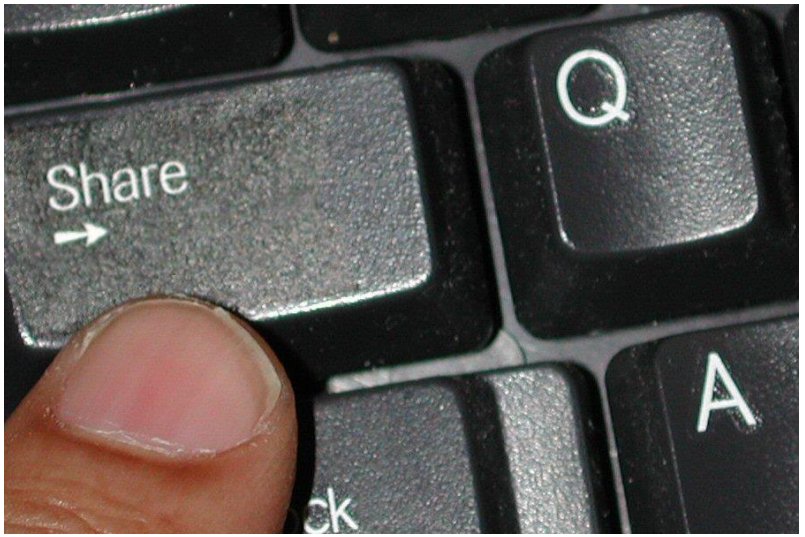
1. Understand the impact of potential load/ generation growth on the network.
2. Understand opportunities for using flexibility services
3. Be able to procure and execute flexibility services
4. Co-ordinate more effectively with third parties by sharing information
5. Enhance our telecoms network to enable a more actively managed network

4) Co-ordinate effectively by sharing information

Plugs & Socket and EFFS - co-ordination of flexibility services.

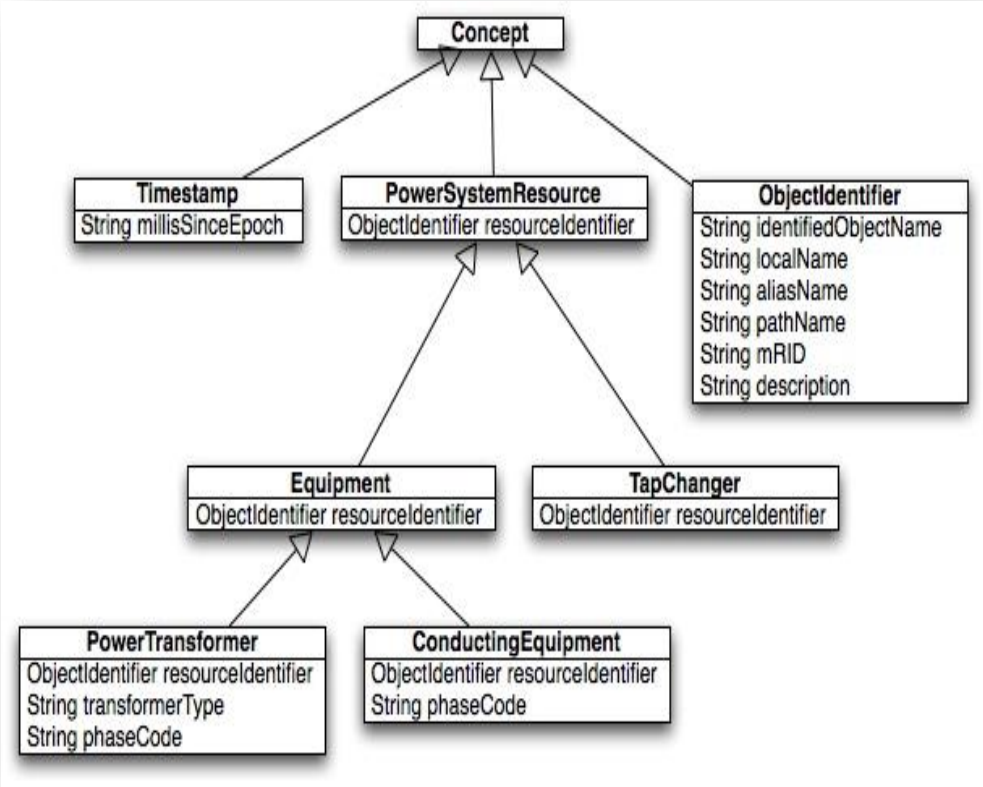
Additional access to data is being provided by;

- Common Information Model
- Open LV
- Capacity Maps



Common Information Model

- Import of data into new software tools
- Merging network models
- Data exchange with third parties
  - Plus their evaluation
- CIM message based system interface



CIM progress

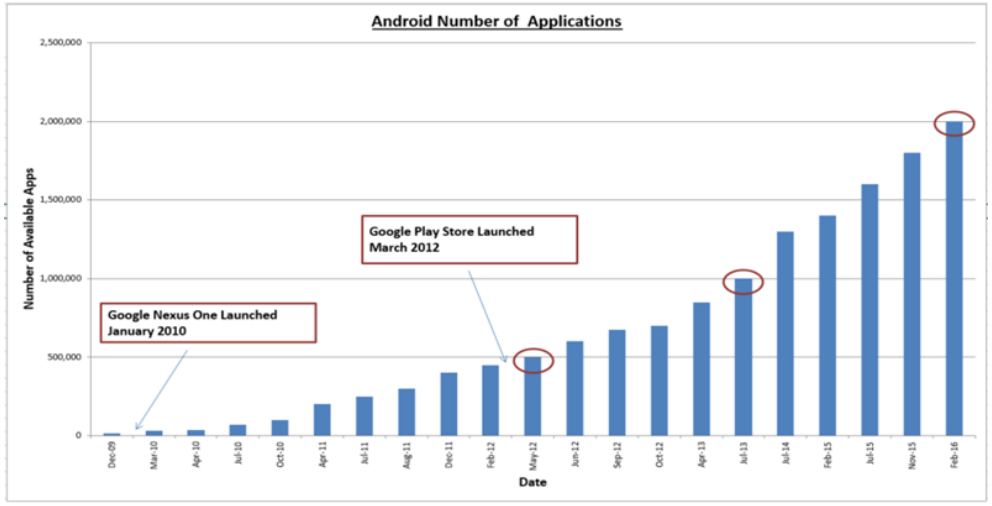
- Data loaded from three core systems (POF/EMU/CROWN),
- Transformation process to canonical model commenced – initial POF & EMU conversions started,
- Servers in place, remote access in place, software being installed,
- Initial data correlation in progress,
- Commenced identification of quality issues within data,
- Business liaison being established,
- Data dictionary for POF/EMU/CROWN populated.

Open LV - The concept

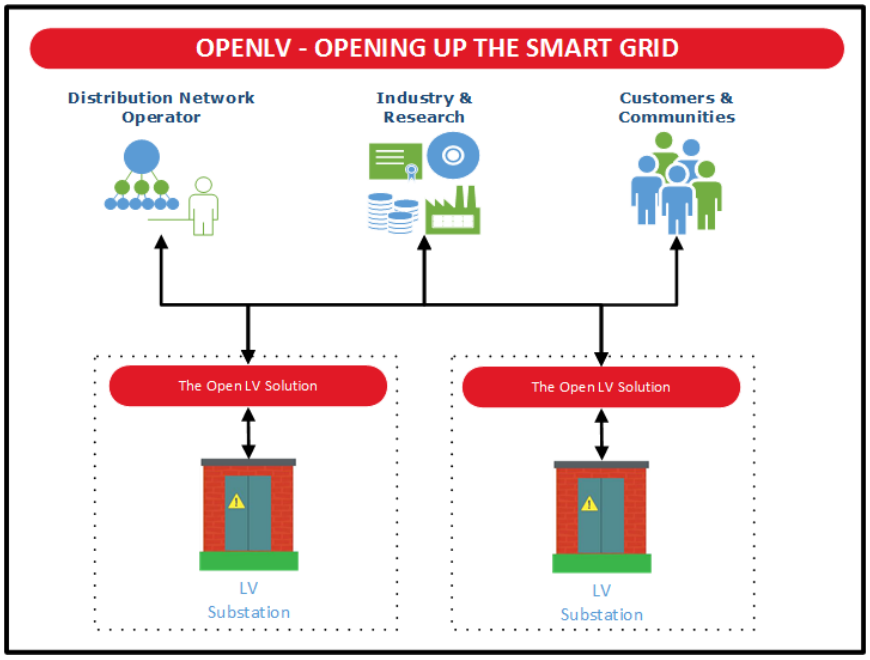
Smartphones have been around for less than 10 years

The platforms are interesting....but it's all about <u>what they offer.</u>

Since that time, there has been an exponential increase in the Apps we use and we each use a unique set of Apps to suit our individual needs…increasingly to manage our energy use.



OpenLV: Proving the Platform; Creating an Eco-system; Stimulating a Market

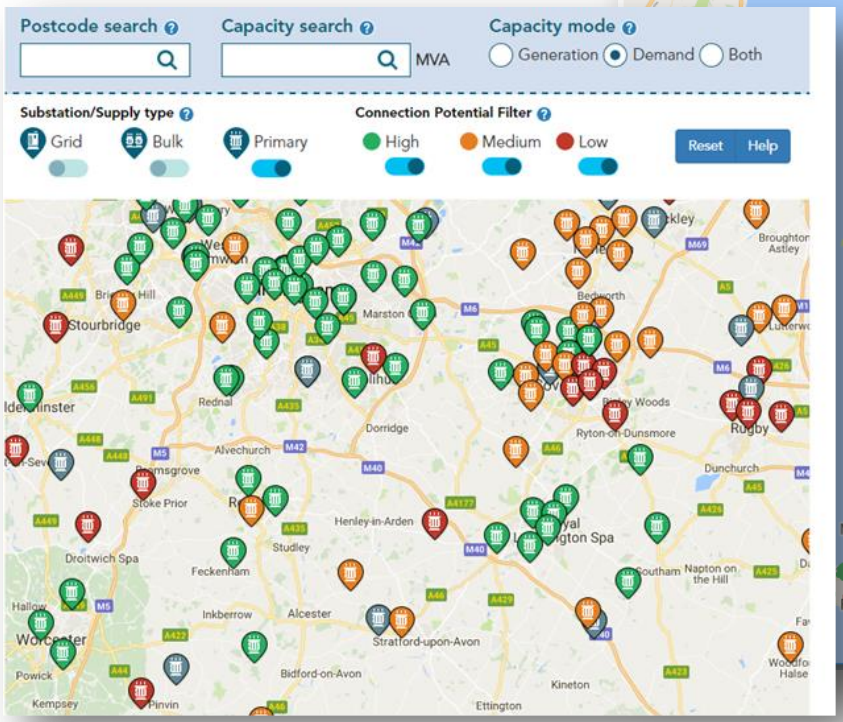


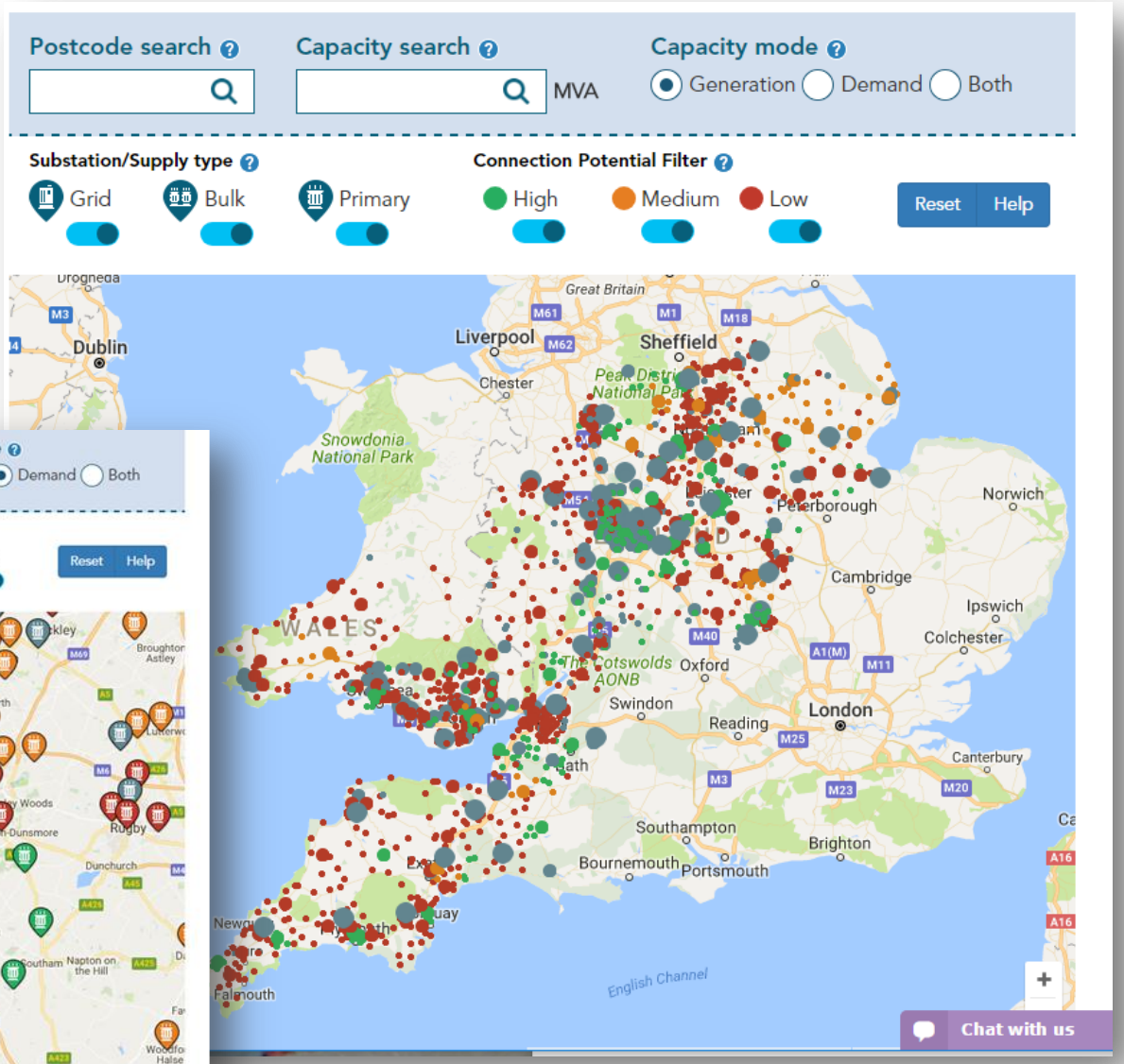
Some example Apps:

- What's My Community Demand
- LCT take-up monitoring & prediction
- Real Time Thermal Rating – Transformers
- Real Time Thermal Rating – Cables
- DSR for managed EV charging
- Automated Voltage Management
- Distributed generation control
- Community Alerts to request reduction or increase in load
- Automated energy storage control
- Industrial standby generation control

Capacity Maps

Combines data for assets, connections pipeline and LTDS. Headrooms calculated for Demand, Generation & Fault level. Worst case drives display.

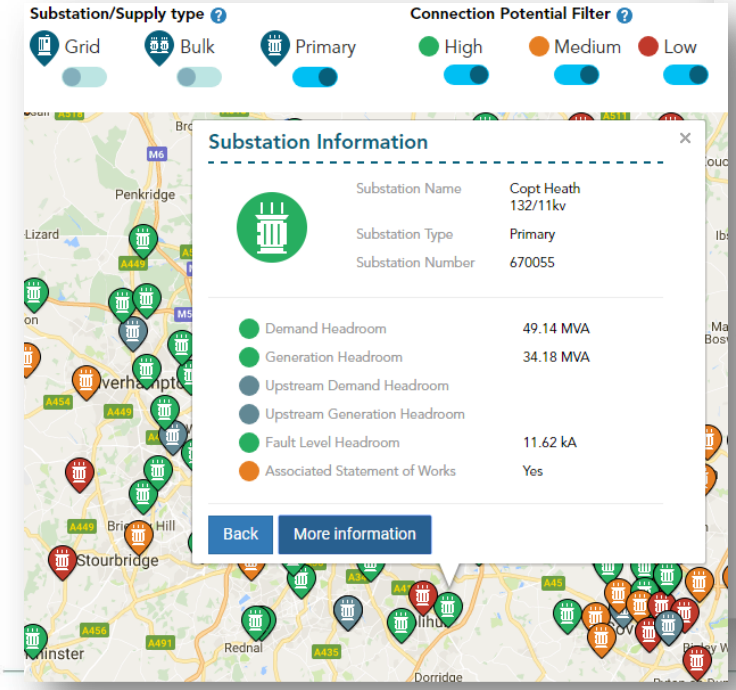


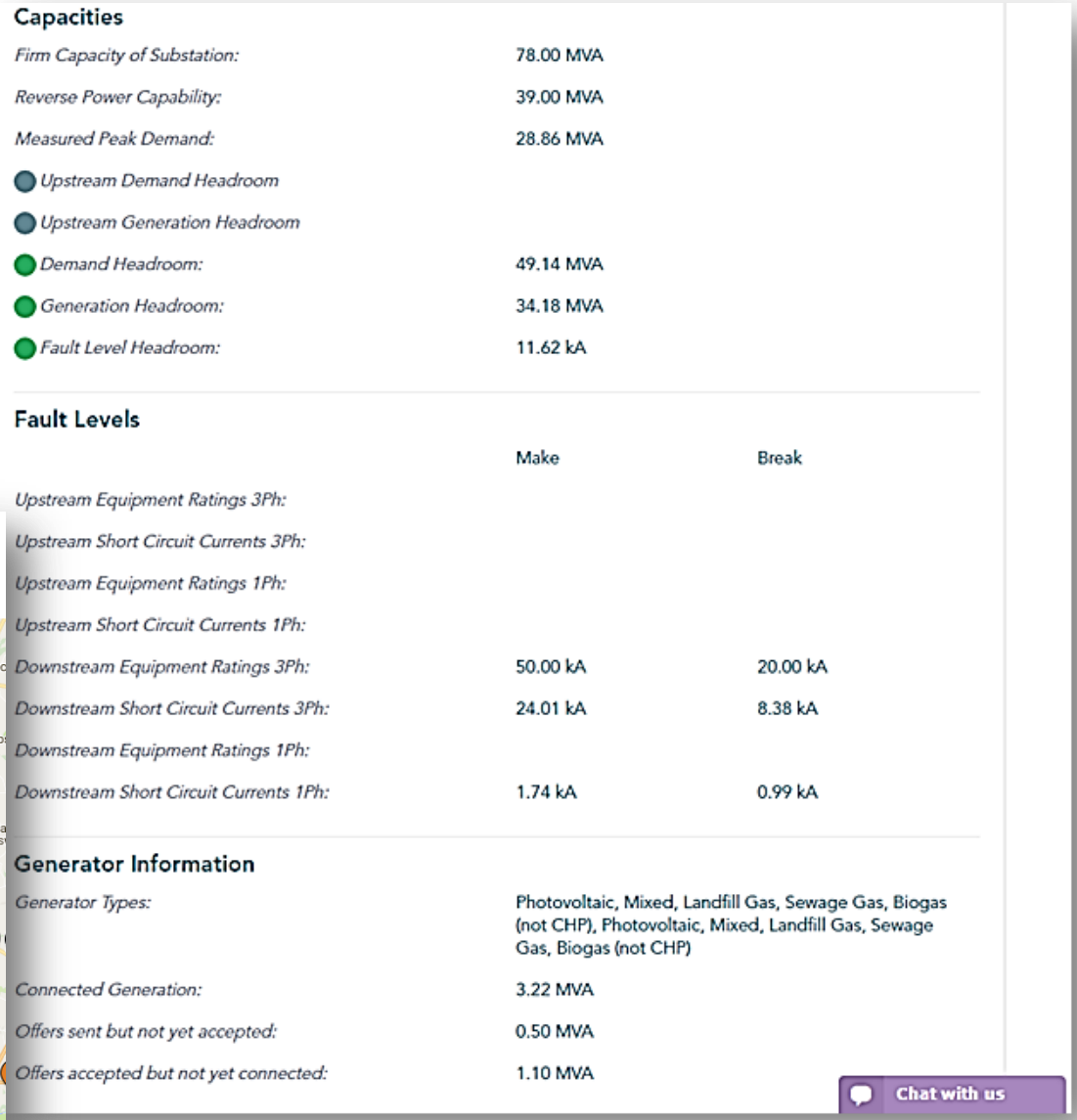


Capacity Maps

Green >25%
Amber 10-25%
Red <10%

Upstream limitations reflected downstream.
Override by Primary System Design team





Capacities

Firm Capacity of Substation:	78.00 MVA
Reverse Power Capability:	39.00 MVA
Measured Peak Demand:	28.86 MVA
Upstream Demand Headroom	
Upstream Generation Headroom	
Demand Headroom:	49.14 MVA
Generation Headroom:	34.18 MVA
Fault Level Headroom:	11.62 kA

Fault Levels

	Make	Break
Upstream Equipment Ratings 3Ph:		
Upstream Short Circuit Currents 3Ph:		
Upstream Equipment Ratings 1Ph:		
Upstream Short Circuit Currents 1Ph:		
Downstream Equipment Ratings 3Ph:	50.00 kA	20.00 kA
Downstream Short Circuit Currents 3Ph:	24.01 kA	8.38 kA
Downstream Equipment Ratings 1Ph:		
Downstream Short Circuit Currents 1Ph:	1.74 kA	0.99 kA

Generator Information

Generator Types:	Photovoltaic, Mixed, Landfill Gas, Sewage Gas, Biogas (not CHP), Photovoltaic, Mixed, Landfill Gas, Sewage Gas, Biogas (not CHP)
Connected Generation:	3.22 MVA
Offers sent but not yet accepted:	0.50 MVA
Offers accepted but not yet connected:	1.10 MVA

Chat with us

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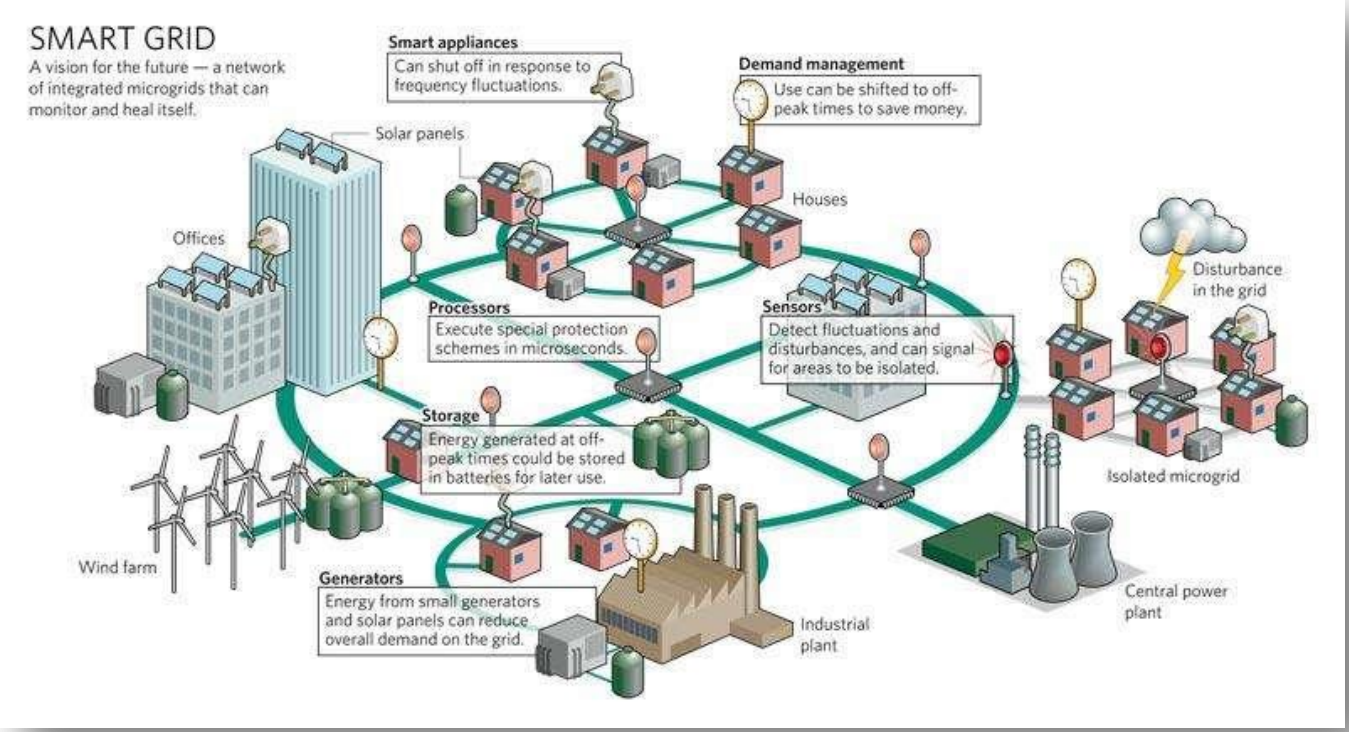


A NEXUS is:

- Means of Connection
- A Connected Series or Group
- A Tie
- A Link
- The Core or Centre

Priorities in Assessing the Categorisation for Smart Grid Solutions

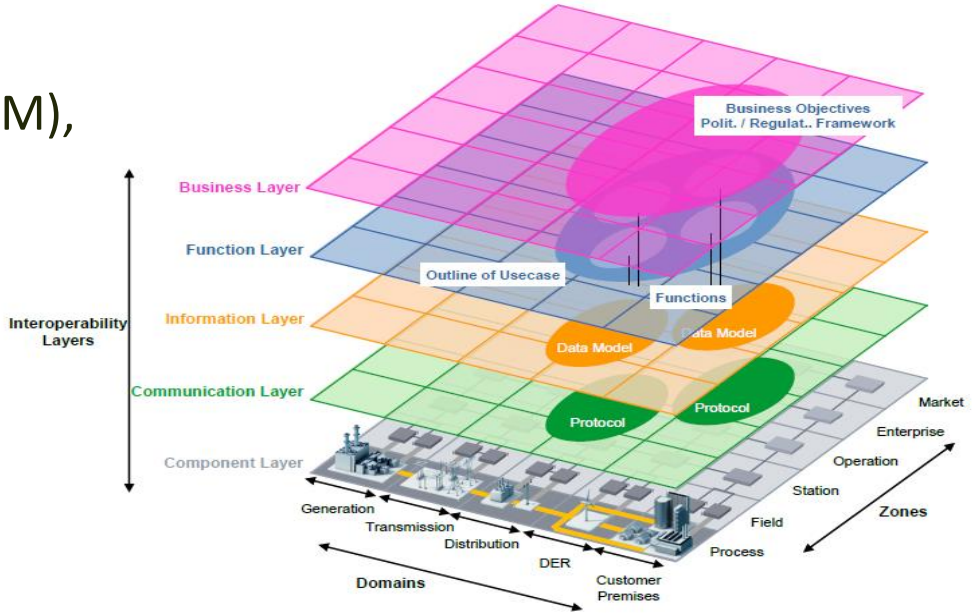
- Relevance and Applicability to WPD;
  - Short term alignment with organisation.
  - Longer term strategic view.
- Relevance and Applicability to the wider UK DNO community;
  - Implications of ED1 & ED2 and the transition to a DSO model and regulatory approach;
- Alignment and Interoperability with International DNO and DSO standards;
  - Learning from activities and alignment coming from DSO's and related organisations;
  - Flexibility to apply learning and lessons from international utilities in a seamless manner;

Assessment Approach

- Desk research on most relevant sources and authorities to determine Smart Grid categorisation,
- Based on publications by various authorities seek to extract existing categories and structures,
- Review and consider the positives and negatives of each of these categorisations ,
- Consider the telecoms specific attributes that may need to be incorporated or associated with the process of Telecom Template development ,
- Determine whether there are any other gaps in the existing categorisation.

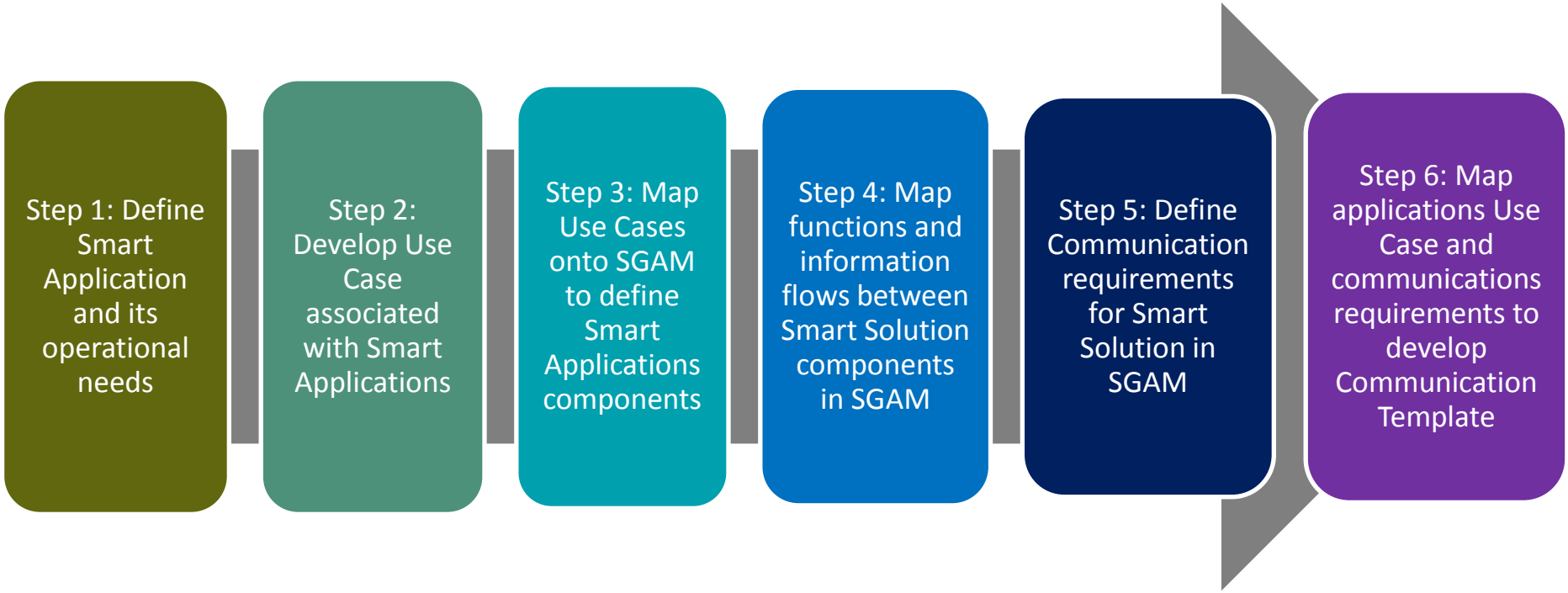
Developing the Communication Template

- For each Smart Grid Solution, a set of Use Cases is created including the Functional & Non-Functional Operational Requirements.
- These requirements determine the communications technology options to develop the Communications Template.
- Each Use Case is formulated using the combination of two development models;
  - The Smart Grid,
  - Architectural Model (SGAM),
  - The EA Transform.



Developing a Communications Template

6 stage process



Q&A

THANKS FOR LISTENING

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