WESTERN POWER DISTRIBUTION INNOVATION TEAM

# BALANCING ACT CONFERENCE

## ONE BIRDCAGE WALK

26TH NOVEMBER 2019

**ROGER HEY**
**WPD – DSO SYSTEMS & PROJECTS MANAGER**

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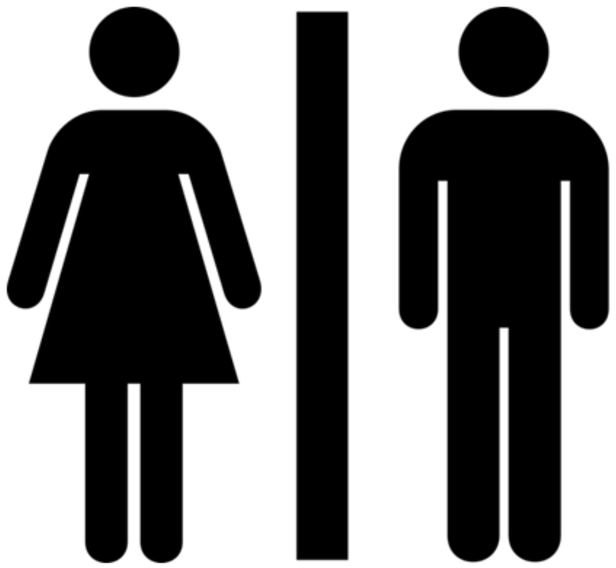
# HOUSEKEEPING

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# AGENDA

10.00 – Welcome & Introduction

10.10 – MADE (Multi-Asset Demand Execution)

10.55 – Refreshments

11.15 – Next Generation Wireless Analysis

11.55 – Lunch & Networking

12.55 – EFFS (Electricity Flexibility and Forecasting System)

13.40 – OpenLV – Introduction, Background & Method 1

14.10 – Refreshments

14.25 – OpenLV – Method 2 & 3

15.10 – Innovation Forward Plan

15.30 – Close

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# INNOVATION OBJECTIVES

The objectives of WPD's innovation programme are to:

- Develop new *smart* techniques that will accommodate increased load, storage and generation (Distributed Energy Resources – DER) at lower costs/quicker connections than conventional reinforcement.
- Facilitate regional and local energy markets; including local flexibility services.
- Improve business performance against one or more of our core goals of safety, customer service, reliability, the environment or cost effectiveness.
- Ensure solutions are compatible with the existing network.
- Deliver solutions so that they become business as usual.
- Provide long term, whole system outcomes and value for money for consumers.
- Assist the UK to reduce carbon emissions and combat climate change.

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# MULTI ASSET DEMAND EXECUTION (MADE)

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**MATT WATSON**
**INNOVATION & LOW CARBON ENGINEER**

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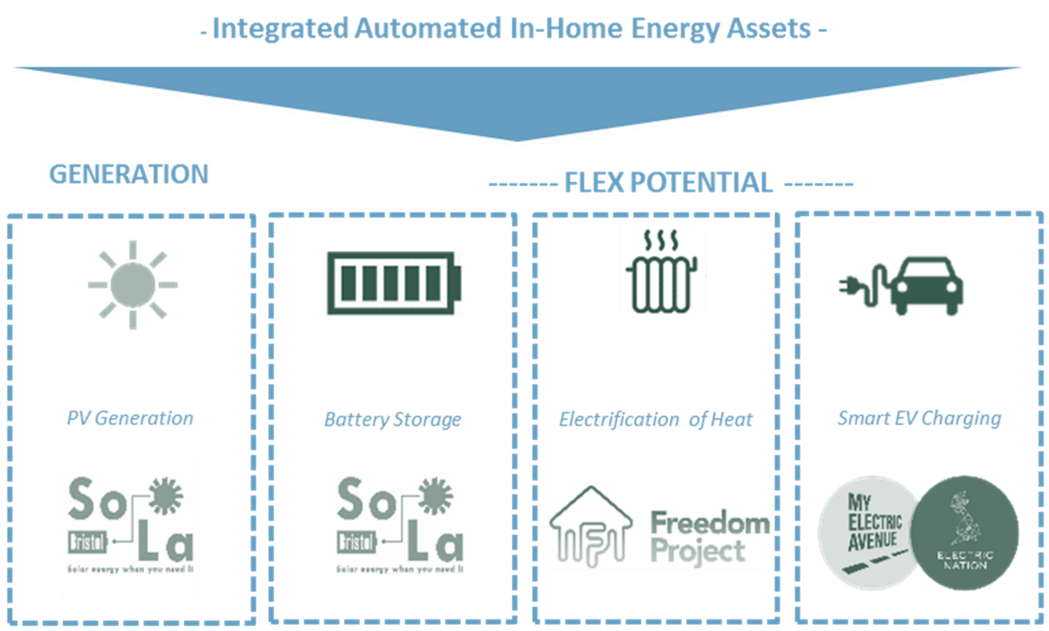
# AGENDA

- Introduction to MADE;
- Analysis of related previous projects: SoLa Bristol, FREEDOM and Electric Nation;
- Domestic level/techno-economic Modelling;
- Local Network Modelling;
- GB Network Modelling;
- Summary of  Customer Engagement;
- Business model framework;
- MADE control: Field trial;
- Summary;
- Project next Steps; &
- Q&A.

# INTRODUCTION

A world-first project that investigates the network, consumer and broader energy system implications of high volume deployments of combinations of Low Carbon Technologies (LCT).

- The project is being delivered by PassivSystems who are be supported by Wales and West Utilities, Everoze, Imperial College London and Delta EE;
- An 18 month project, broken down into 6 work packages;
- The Multi Asset Demand Execution (MADE) project should provide initial insights and evidence to demonstrate the concept as well as informing any future larger-scale project; &
- A five-home technology feasibility trial will be used to explore live inter-asset coordination and validate the modelled learning.




MADE Concept Overview

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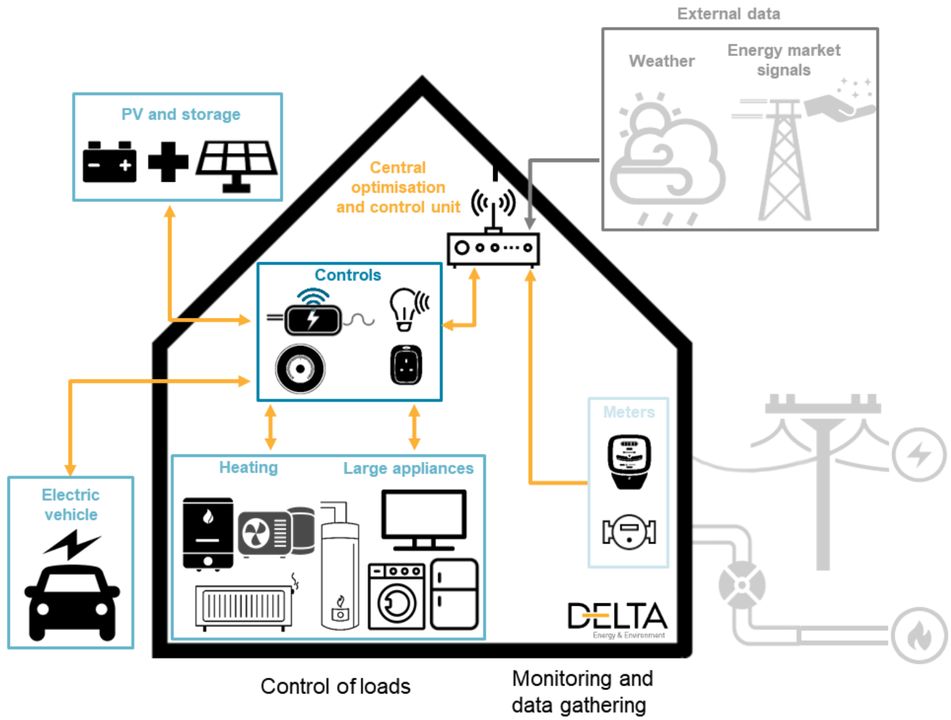
# ANALYSIS OF DATASETS FROM PREVIOUS PROJECTS

Previous NIA projects provided a useful data source for information on the (LCTs) individually:

- Sola Bristol: insight into combined battery and solar PV operation;
- FREEDOM: understanding of the consumer acceptance of hybrid heating systems as well as gas and electricity demands;
- Electric Nation: domestic consumer EV charging use as well as how time of use incentives influence charging habits but lead to further complications: requiring network demand management and coordinated control between households; &
- No previous projects have addressed operation of all the energy assets considered under the MADE project in combination.



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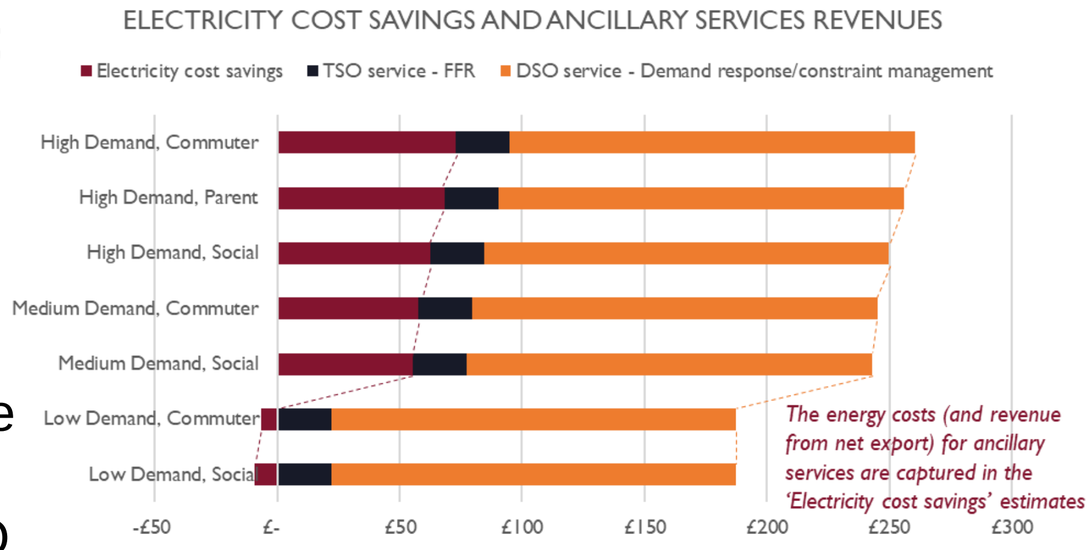
# THE VALUE OF DOMESTIC FLEXIBILITY

Domestic flexibility is a notable value opportunity, with the MADE concept bringing in possible savings of up to £260 p.a per household, under best conditions.
The key conclusions regarding from Everoze's techno-economic modelling at a domestic level are as follows:

- Value from peak shifting is sensitive to consumer type;
- Value from peak shifting is tempered by additional energy imports for ancillary services;
- Low demand/EV utilisation customer types are only attractive for DSO services;
- DSO services form a key part of the value stack, but are subject to large variance in value depending on the local network constraints and service need;
- Coordinated FLEX can help maximise value from DSO service opportunities; &
- FFR is a less attractive value proposition.




**Estimate Value of Coordinated Response**

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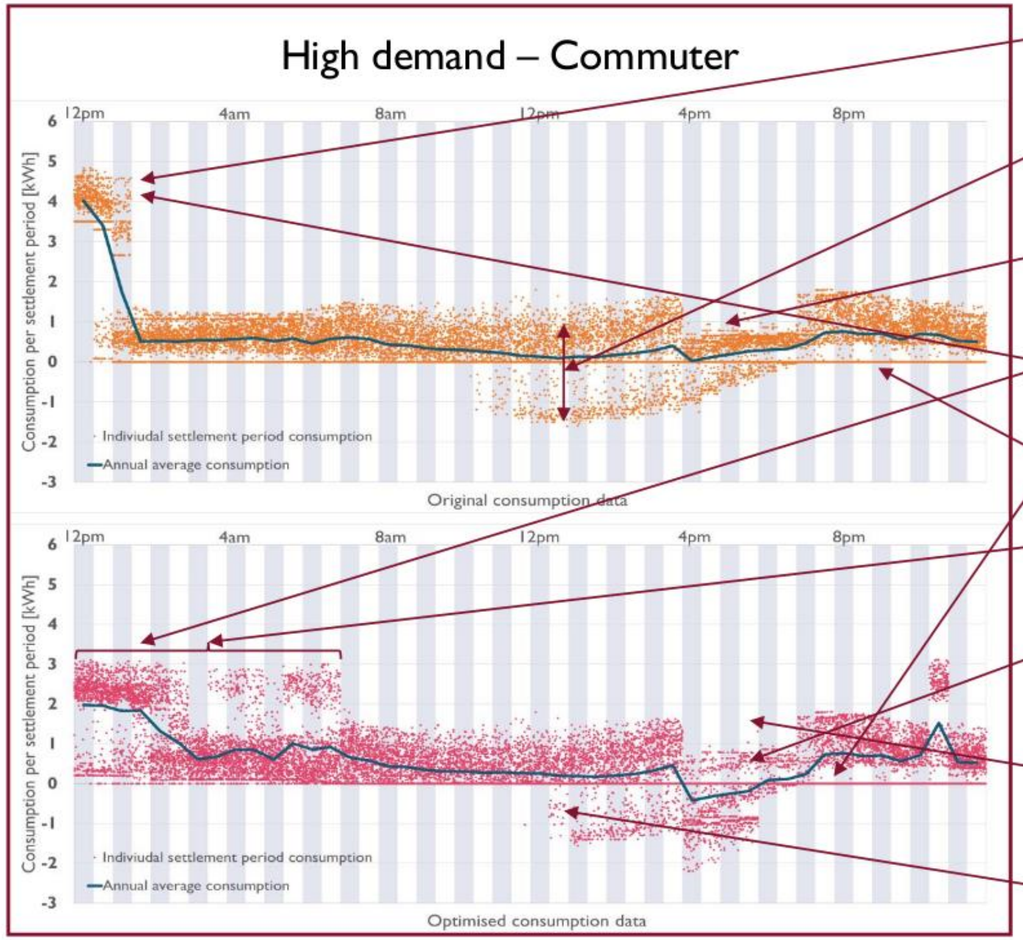
# INTEGRATED LCT CONTROL: LOAD SHIFTING

Domestic FLEX offers material peak load shifting potential for the DSO – between 35-40% reduction in peak loads on the network compared to the Baseline Case (based on half- hourly data):




Under a smart charging regime (considering the smart charging consultation guidelines) , EV charging commences at midnight.

Biggest spread in the day due to solar generation variation. In reality, there will be more spread in the general consumption pattern of the household.

Lower peak-time loads in Baseline Case is from ASHP optimisation – heating loads supplied by gas boiler when energy price is higher

The EV charging loads are the key driver for peak loads at the residential property. Optimising timing and power level of EV charging results in the reduction of peak loads on the grid.

Property consumption during off-peak periods met from surplus solar available on certain summer days.

Overnight charging of the EV and the battery – charging times are coordinated to ensure the loads on the network are not compounded

Almost no consumption of electricity from the grid during evening peak period with significant exports to capture revenue from DSO services.

During weekends, the available price spread is much lower than during the weekdays and so peak-shifting is done using surplus solar generation only (where available)

Reduction in surplus solar exports as the battery improves utilisation of surplus solar generation for self-consumption and load shifting.

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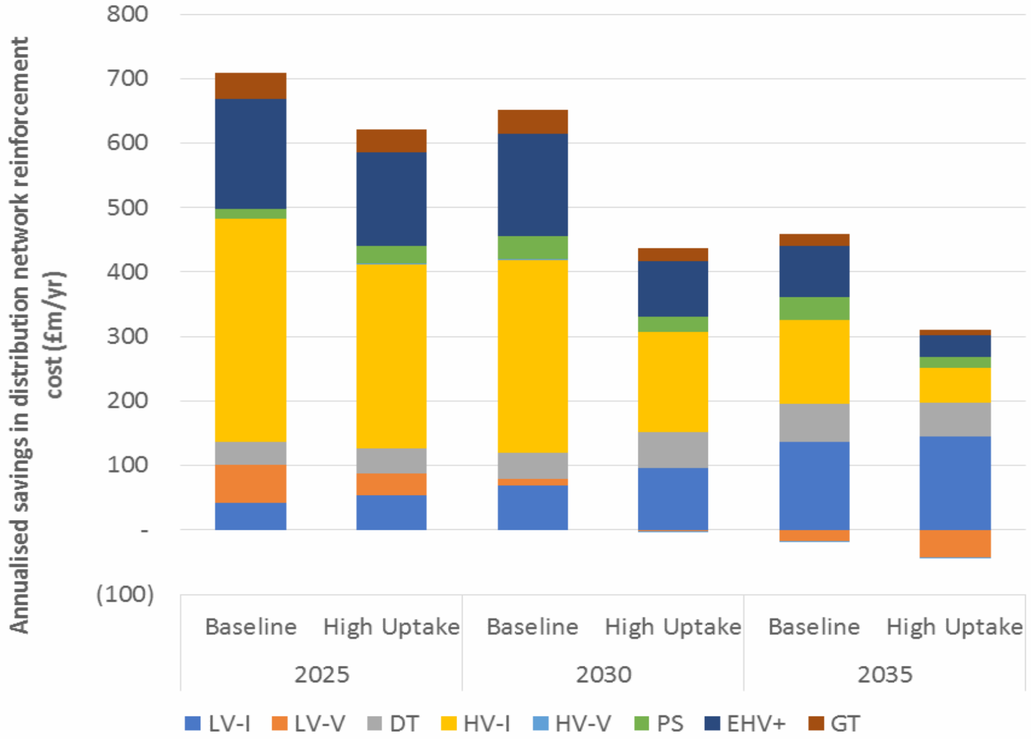
# DSO BENEFITS OF INTEGRATED LCT CONTROL

The results show that the distribution network benefits of distributed flexibility can reach up to around £700m per year in annualised reinforcement cost, and are spread across LV, HV and EHV levels. These are compared against increased future costs rather than current spend levels.

Reinforcement cost savings diminish when looking further into the future to around £300-450m by 2035, which results from a very high penetration of EVs and HHPs assumed in that time horizon, so that energy requirements become more prominent than power requirements.

The potential savings are still substantial even at high penetrations, and are combined with an increased potential for whole-system savings.




**Annualised Savings in UK Distribution Network Reinforcement**

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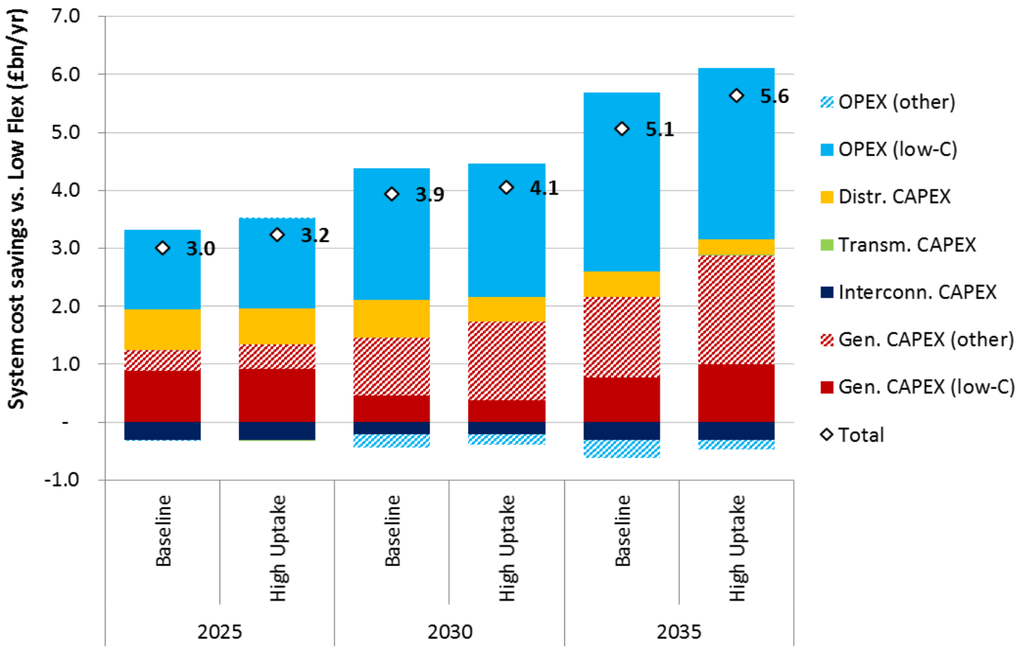
# WHOLE-SYSTEM BENEFITS OF INTEGRATED LCT CONTROL

Imperial College modelled multiple LCTs within the home that are integrated with smart control at GB Whole-System Network level. The benefits are significant and can exceed £5.6bn per year in the 2035 horizon. The analysis assumes that fully flexible EV charging including V2G would be a component.

The main categories of cost savings through integrated LCTs with smart control include:

- Reduced investment cost of generation (low carbon and conventional);
- Reduced investment cost of distribution networks;
- Reduced operating cost of low-carbon generation.

It should be noted that these benefits do not consider the costs of coordinated control system implementation, as such, these present the best case views of the benefits.

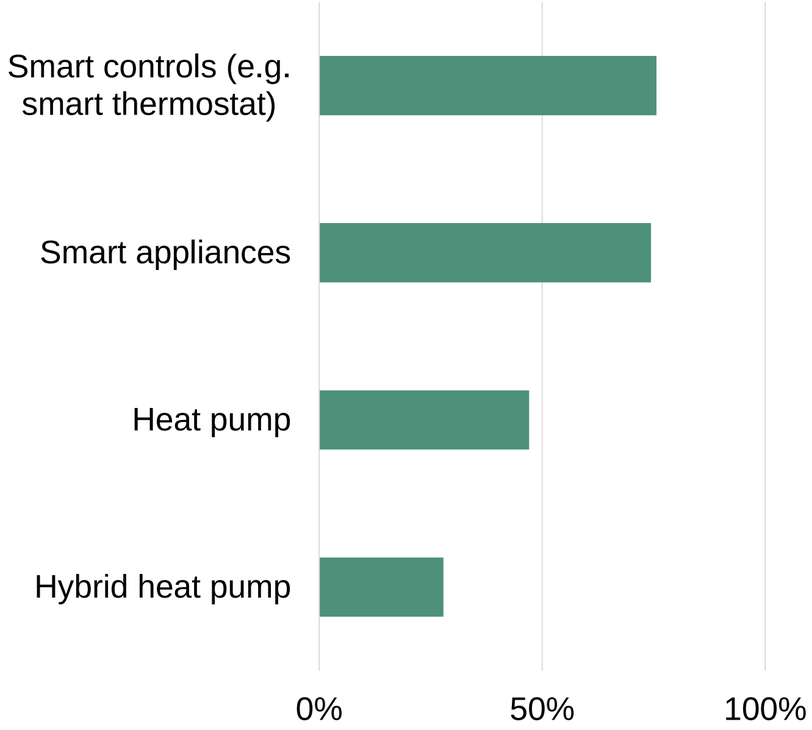



**Annualised System Cost Savings**

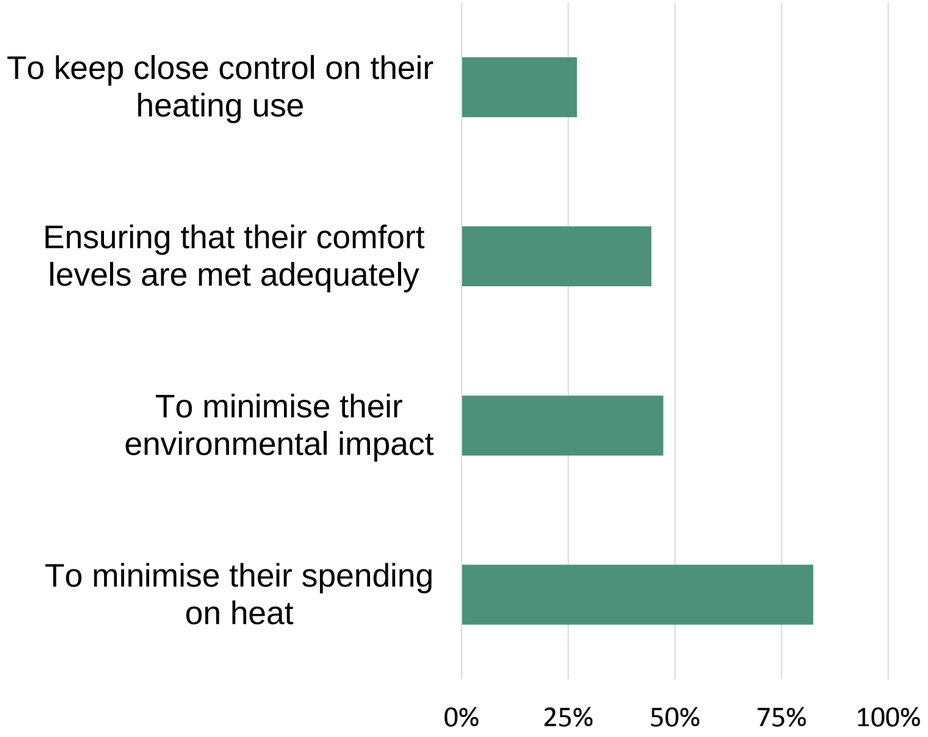
# MADE PRIMARY CUSTOMER RESEARCH

Customer research is key to modelling the MADE concept and business model development.

**Awareness respondents had of the different technologies**:




**Reasons give as to why respondents pay attention to the amount of heat they use:**



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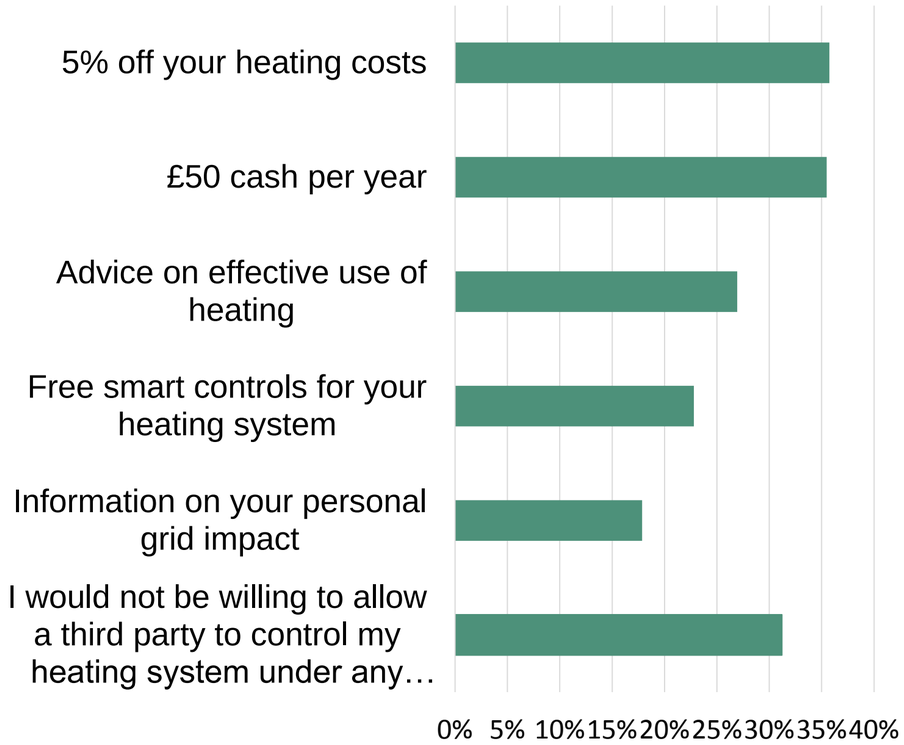
# MADE PRIMARY CUSTOMER RESEARCH

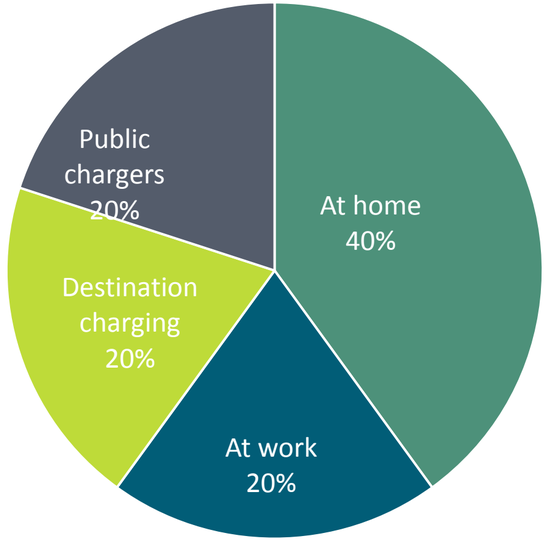
## 3rd party control and location of charging are key concepts to understand.

Types of incentives that would encourage homeowners to allow third party control of their heating system:

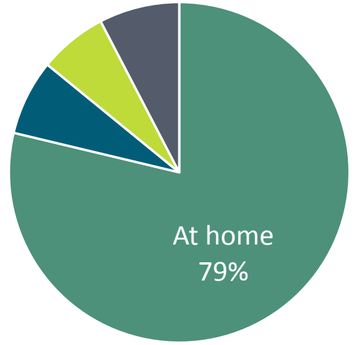



Over half (65%) of EV owners are ‘quite’ or ‘very concerned’ about third parties having the ability to control the charging regime of their EVs.

**Charging locations of current EV owners:**




**Charging locations of prospective EV drivers**




**Expectations ≠ reality**

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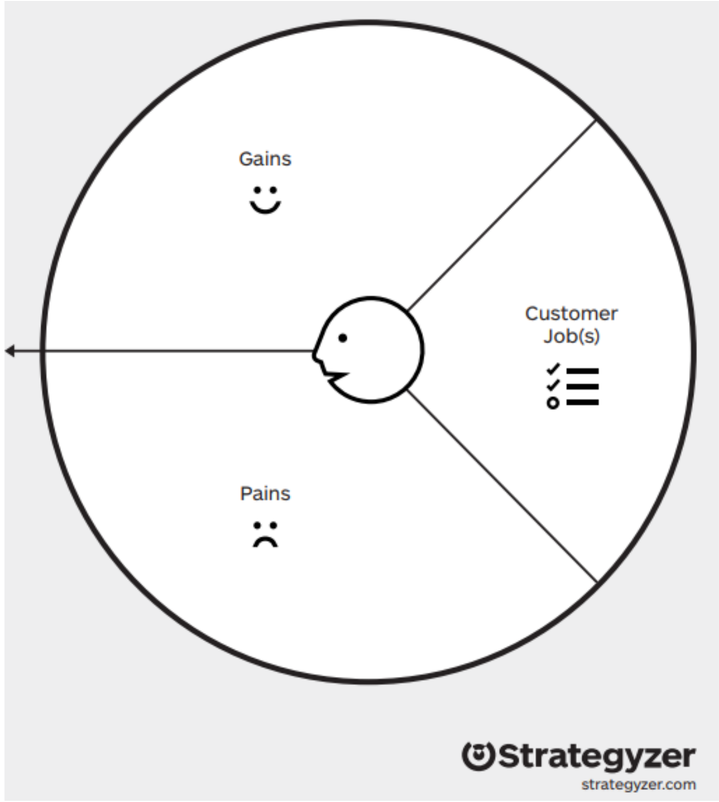
# WHY THE FOCUS ON BUSINESS MODELS?

It is important to look beyond technology to support the MADE concept in the long-term.

- Interaction with technology will depend on the business model;
- UK home owners are price driven;
- We need successful business models to make MADE a reality in the long-term; &
- Successful business models can be developed in the short term using synthetic value streams.

These propositions are built upon a well used framework for developing business models and customer propositions, and build on insight taken from studying similar business models.



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# BUSINESS MODEL FRAMEWORK

Theoretical customer propositions for a large scale deployment trial.

| | Fixed Monthly Costs | Low Price Energy Tariffs | Credit Payments | Social Housing |
|---|---|---|---|---|
| **Energy Supply** | Included within a fixed monthly fee | Included - paid per unit used | Bought separately by customer | Any of the three previous |
| **Customer Value Stream** | ❑ **Low fixed monthly price for energy** (based on level of existing usage or similar) | ❑ **Low price tariff for energy** | ❑ **Monthly or periodic credit payment** for being involved in the project | ❑ **Monthly or periodic credit payment** for being involved in the project NB – social housing provider owns all the technologies |

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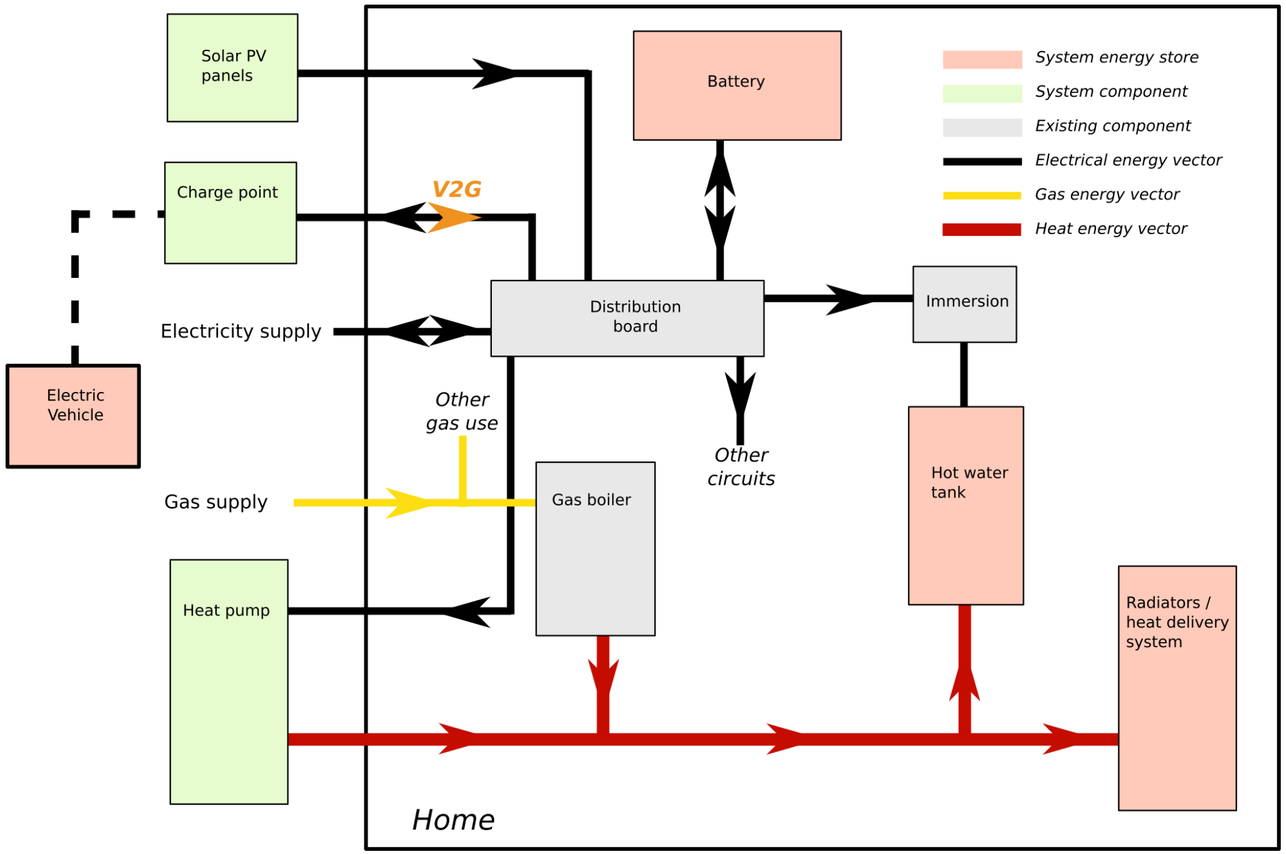
# MADE CONTROL: FIELD TRIAL

Control system needs to coordinate multiple assets to drive the best value for the consumer and the grid.

- They must ensure consumer heating and hot water requirements are met at all times;
- Four controllable assets, with three different energy vectors and four different energy stores;
- PassivSystems predictive optimisation technology can solve this challenge, making the trade-offs quantitatively; &
- Integration with PassivSystems energy management platform for inter-home coordination and peak load shifting.



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# MADE CONTROL: TECHNICAL TRIAL

**Five homes have been chosen for the technical trial (2019-2020 heating season).**

- Most homes have existing low carbon assets and are located in the South West or South Wales;
- All homes will be heated by a hybrid heating system; most have a hot water tank providing extra energy storage capacity;
- Homes have had solar PV and a 5kWh domestic battery installed; &
- Homes have had an EV charger installed and have been provided with an EV.

**Phase 1: Baseline operation .**

- Assets operating largely independently.

**Phase 2: National-scale grid drivers.**

- Time-of-use tariffs expected to synchronise assets and increase peak demand.

**Phase 3: In-home asset coordination.**

- Shifting the timing of energy storage to benefit the householder.

**Phase 4: Local grid interventions.**

- Demonstrate capability to reduce peak demand through inter-home coordination.

# SUMMARY

Project partners have gained valuable insights into the nature of the combination of EV and hybrid heating system loads while utilising PV generation and storage, when operated in:

1. A standard controls regime;
2. An enhanced control regime that seeks to optimise consumer value; &
3. A regime that provides project partners with the ability to amend the demand profile to meet the needs of described use cases.

Knowledge has been generated in the understanding of how the combination of in-home flexible multiple energy asset aggregation (EV, hybrid heating system and solar PV generation) can:

1. Generate value for the individual participant;
2. Provide value to the wider system;
3. Be deployed via a range of business models for domestic aggregators and energy suppliers; &
4. Be deployed technically via a coordinated control system.

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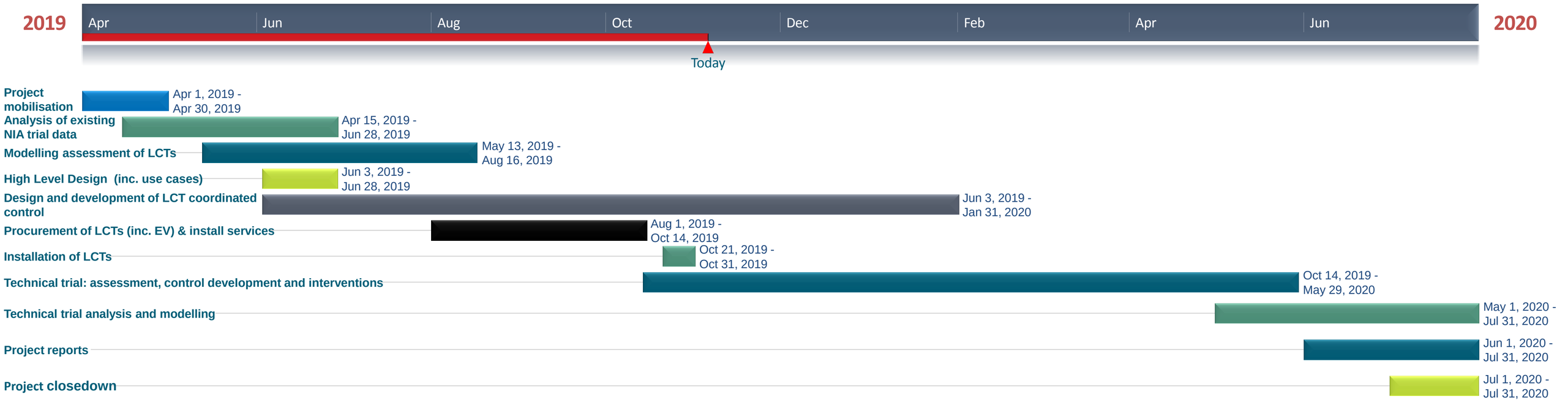
# NEXT STEPS

- Monitor and gather data;
- Integrate optimised control with LCTs;
- Refine controls based on LCT performance; &
- Re-model: home level, local level and national level based on real world performance data.



# THANK YOU FOR LISTENING

## ANY QUESTIONS?

**MATT WATSON**
WPD - INNOVATION & LOW CARBON NETWORKS ENGINEER
**mwatson@westernpower.co.uk**

# REFRESHMENTS BREAK

# RESUME AT 11.15

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# NEXT GENERATION WIRELESS ANALYSIS

## BALANCING ACT CONFERENCE

26TH NOVEMBER 2019

FAITHFUL CHANDA - INNOVATION & LOW CARBON NETWORKS ENGINEER [WPD]
RICHARD LUKE - CHIEF OPERATING OFFICER [JRC]

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# AGENDA

- Introduction
- Scope
- Overview of the NIA Next Generation Wireless Project
- Objectives
- Results
- Conclusions
- Network cost
- Benefits of improved connectivity
- Next steps

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# INTRODUCTION

- NIA funded Project
- £259,901.00
- Start date of project: 3rd September 2018
- End date of project: 30th October 2019
- Project partners: The Joint Radio Company (JRC)

# PROJECT SCOPE

- Project examined the feasibility of using commercial 4G/LTE (4th Generation Mobile - Long Term Evolution) technology to support enhanced operational telecommunications connectivity, facilitating more comprehensive and real-time visibility & control of the electricity network

- Examined the extent to which existing WPD assets could be re-deployed to optimise the cost-effectiveness of new enhanced wireless solutions

- The goal of the project was to enable increased flexibility of the distribution network allowing connection of more renewable generation and storage.

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# OVERVIEW OF CURRENT NIA WIRELESS PROJECT

**WPD's network:**

- Serves 7.9 million customers
- Covers 55,500 km square kilometre service area
- Consists of:
  - 92,000km overhead lines
  - 129,000km underground cables
  - 185,000 transformers


**Selected West Midlands & South West as representative of WPD area**

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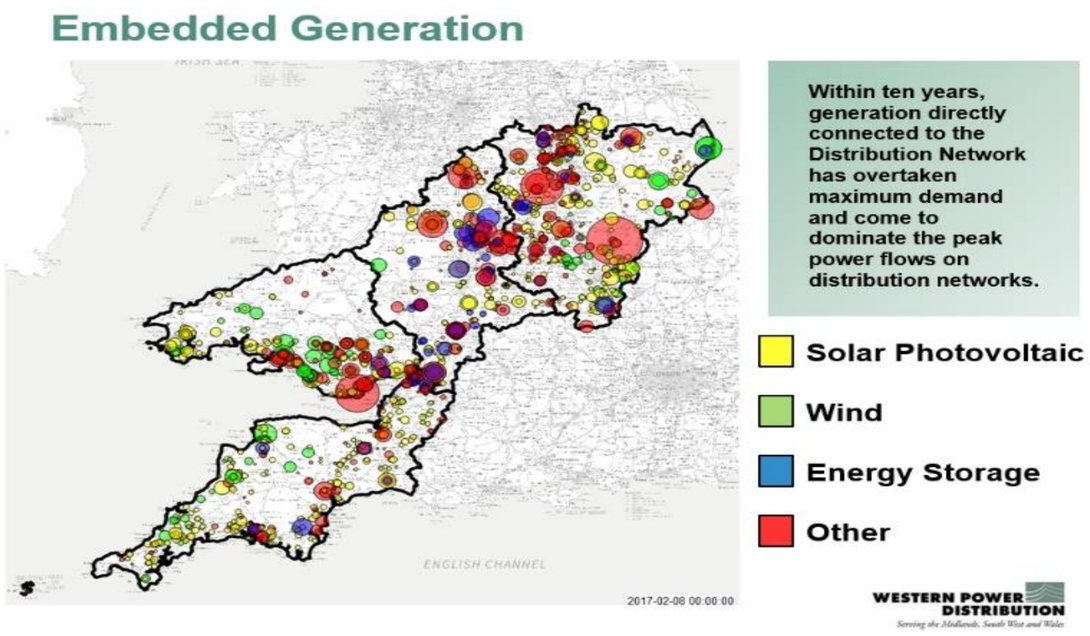
# OVERVIEW OF PROJECT

**Increased Diversity of Supply & Demand**
The need for enhanced communications capability

- Distributed Generation
- Enhanced Demand, EVs
- Enhanced asset visibility and control
- Wireless enables rapid and cost-effective deployment
- New technology offers enhanced bandwidths
- Enabling a diversity of data streams from hundreds of thousands of geographically dispersed points




**Concluded that as a first approximation to focus connectivity on substations (190,000 of them)**

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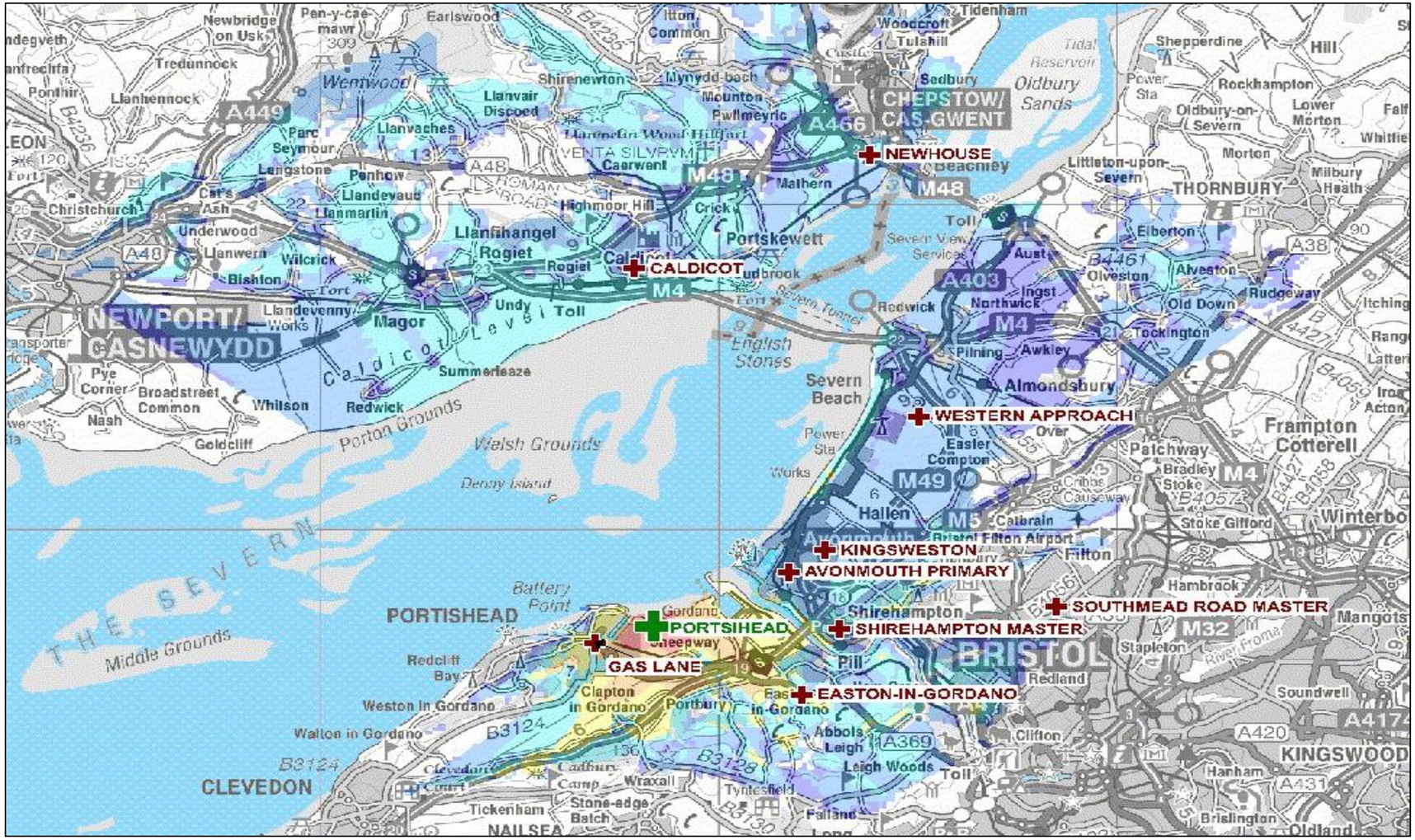
# OVERVIEW OF PROJECT

**Performance based on Tri-sector eLTE trial at Portishead using 3MHz TDD channel at 416 MHz**



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# OVERVIEW OF PROJECT

**Tri-sector 416 MHz LTE base station mast at Portishead Bulk Supply Point**

**Diversity reception LTE antennas at Kings Weston primary substation**

**LTE analysis based on WPD trial around Portishead Substation**

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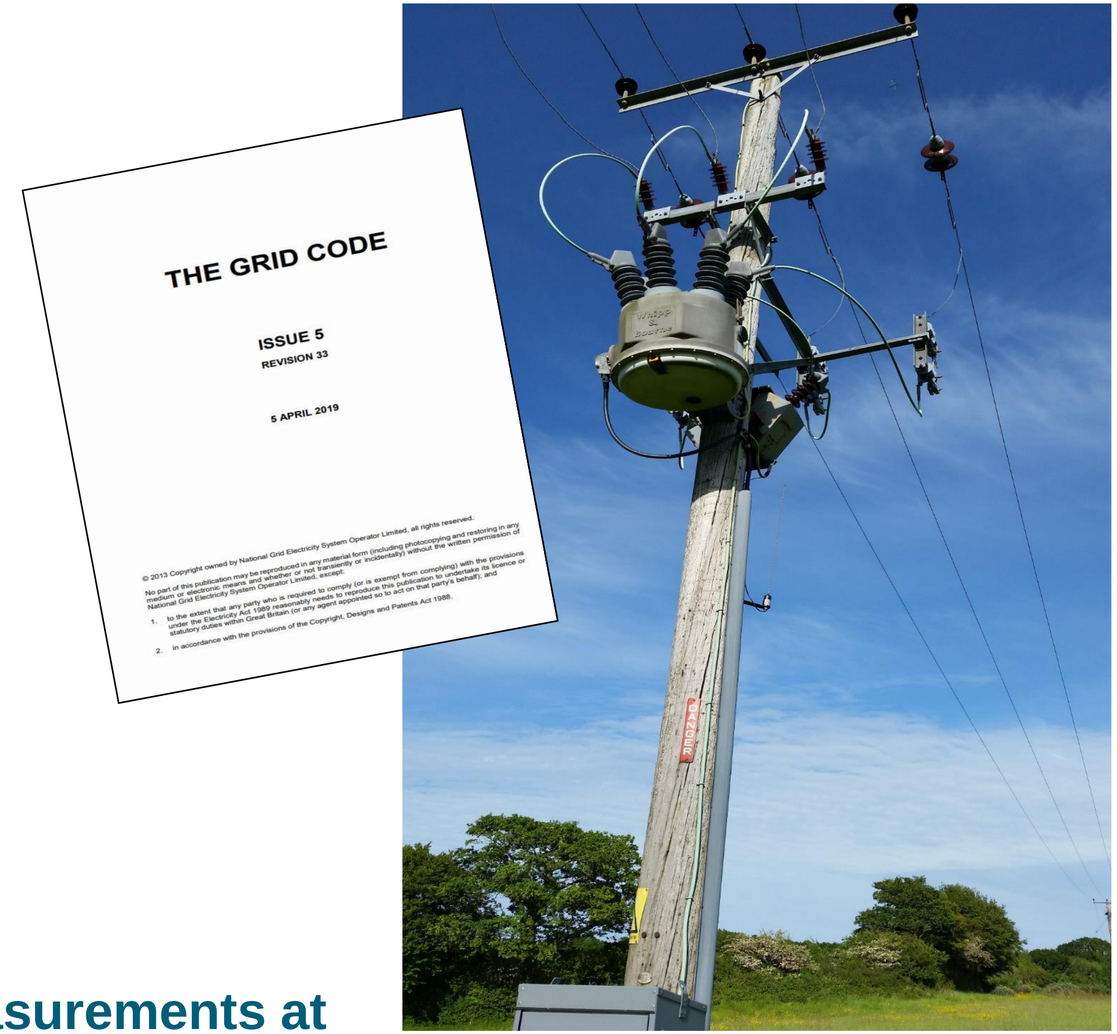
# OBJECTIVES

**Enabling Network Functionality**
Facilitating the DNO to DSO Transition

Active Network Management & enhanced real time monitoring;

- Real & reactive power flows at strategic locations in network;
- Direction of power flows for both real & reactive power;
- Voltage magnitude & phase angle;
- Switchgear status, operations and failures;
- Transformer tap positions;
- Protection operations;
- Automation;
- Power quality data capability: and
- Asset condition monitoring.




**DSO transition requires continuous analogue measurements at more regular intervals than previously plus more alarms & controls**

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# OBJECTIVES

**Total number of bits: (6144 bits per 'analogue' measurement)**

| | Number of Sites | Analogue measurements per site | Total Number of Analogue Measurements | Proportion of Total Analogue Measurements | Single Substation kBits | All Substations GBits |
|---|---|---|---|---|---|---|
| **Primary Substations** | 1600 | 50 | 80000 | 1.6% | 307.2 | 0.5 |
| **Distribution Substation** | 193000 | 25 | 4825000 | 98.4% | 153.6 | 29.6 |
| | 194600 | | 4905000 | | | 30.1 |

**Digital data discounted from initial analysis as insignificant compared to analogue requirements**

**Average data volume** **154.9 kbits per substation**

## Estimate of the amount of data required to be uploaded when connectivity is restored following an interruption

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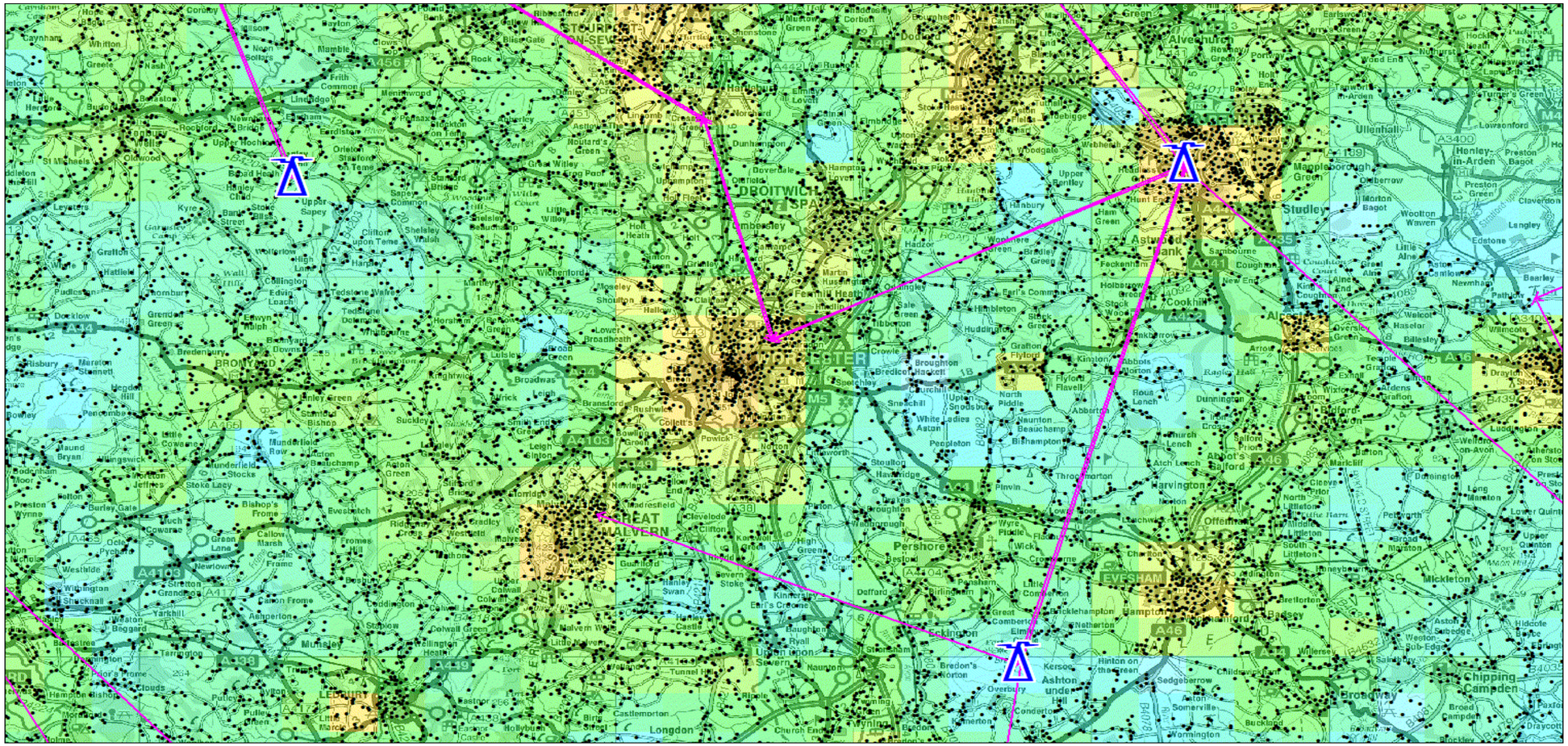
# OBJECTIVES




**All substations mapped together with existing WPD telecoms assets to assess how to provide connectivity**

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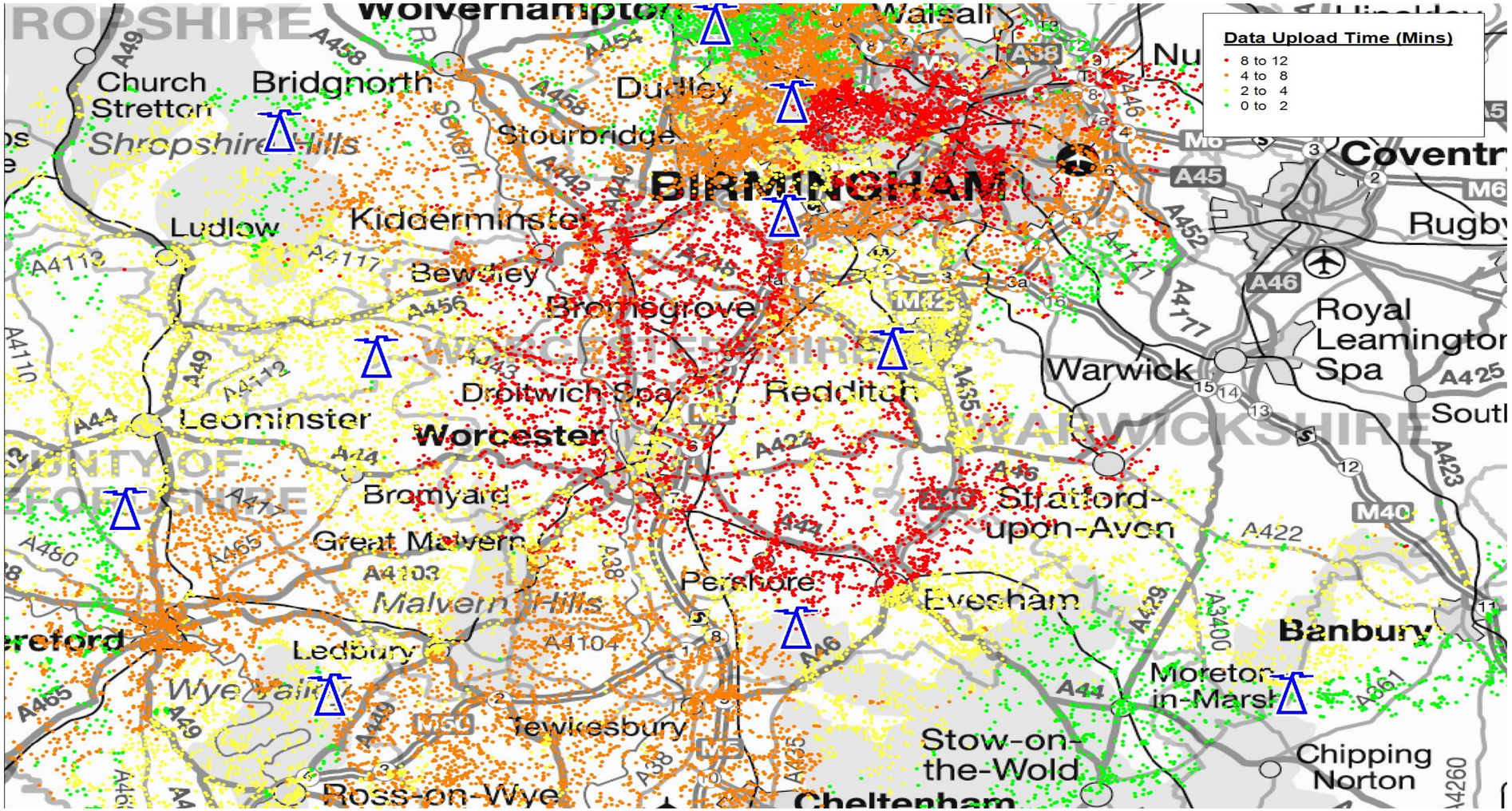
# RESULTS – WEST MIDLANDS

**Initial analysis of Birmingham area illustrating capacity issues**



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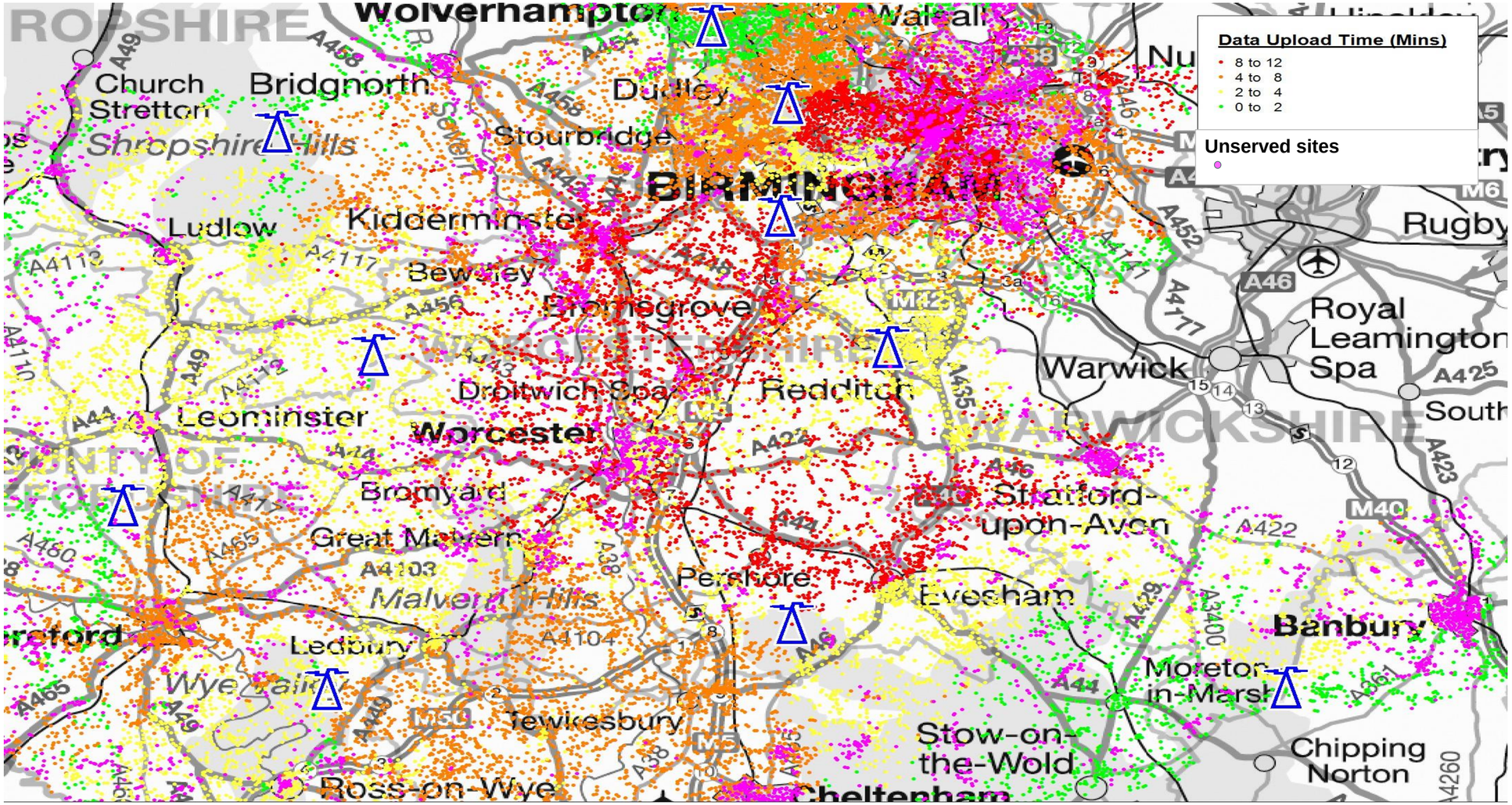
# RESULTS – WEST MIDLANDS

**Initial analysis of Birmingham area illustrating coverage issues**



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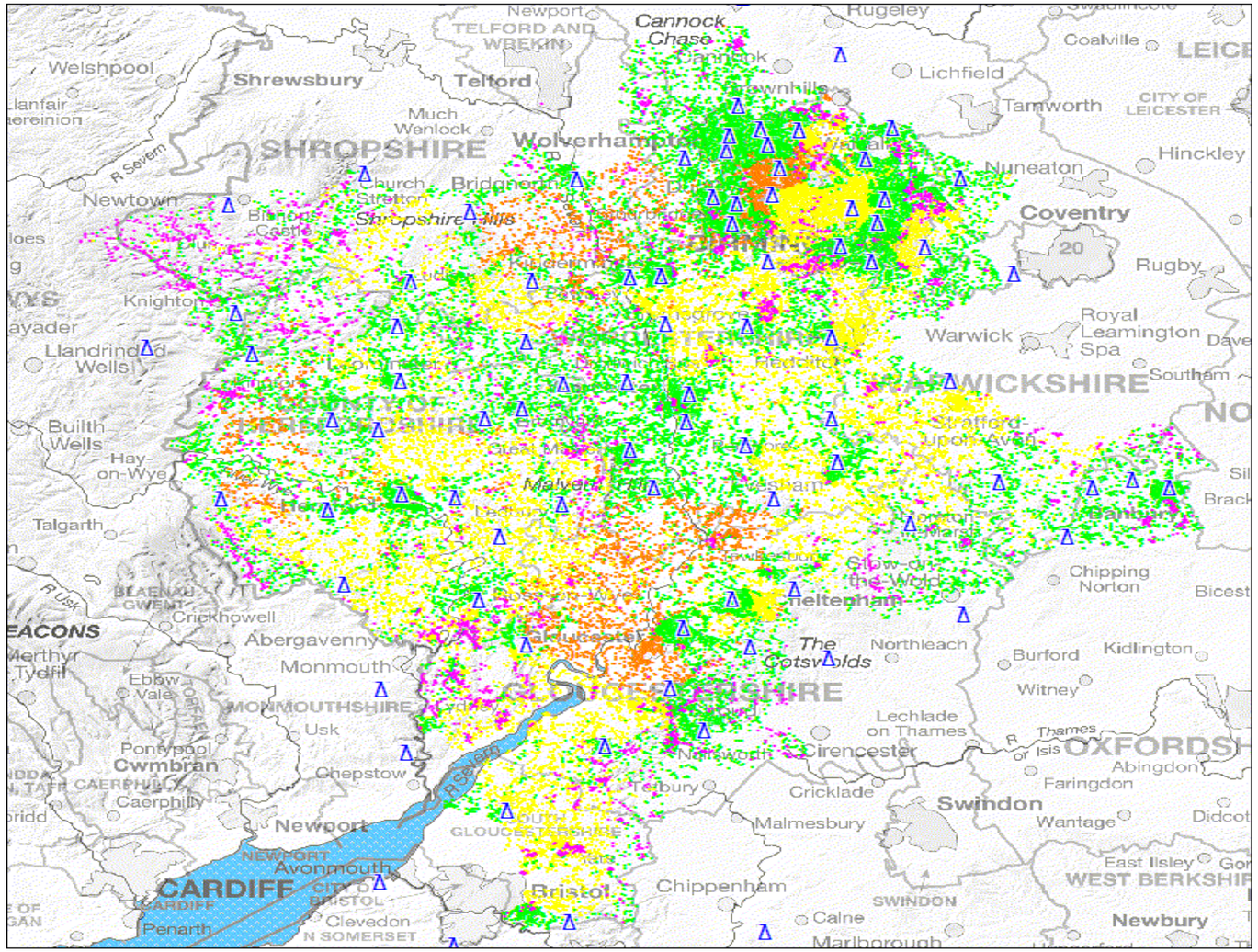
# RESULTS – WEST MIDLANDS

**Analysis of West Midlands area showing final solution**

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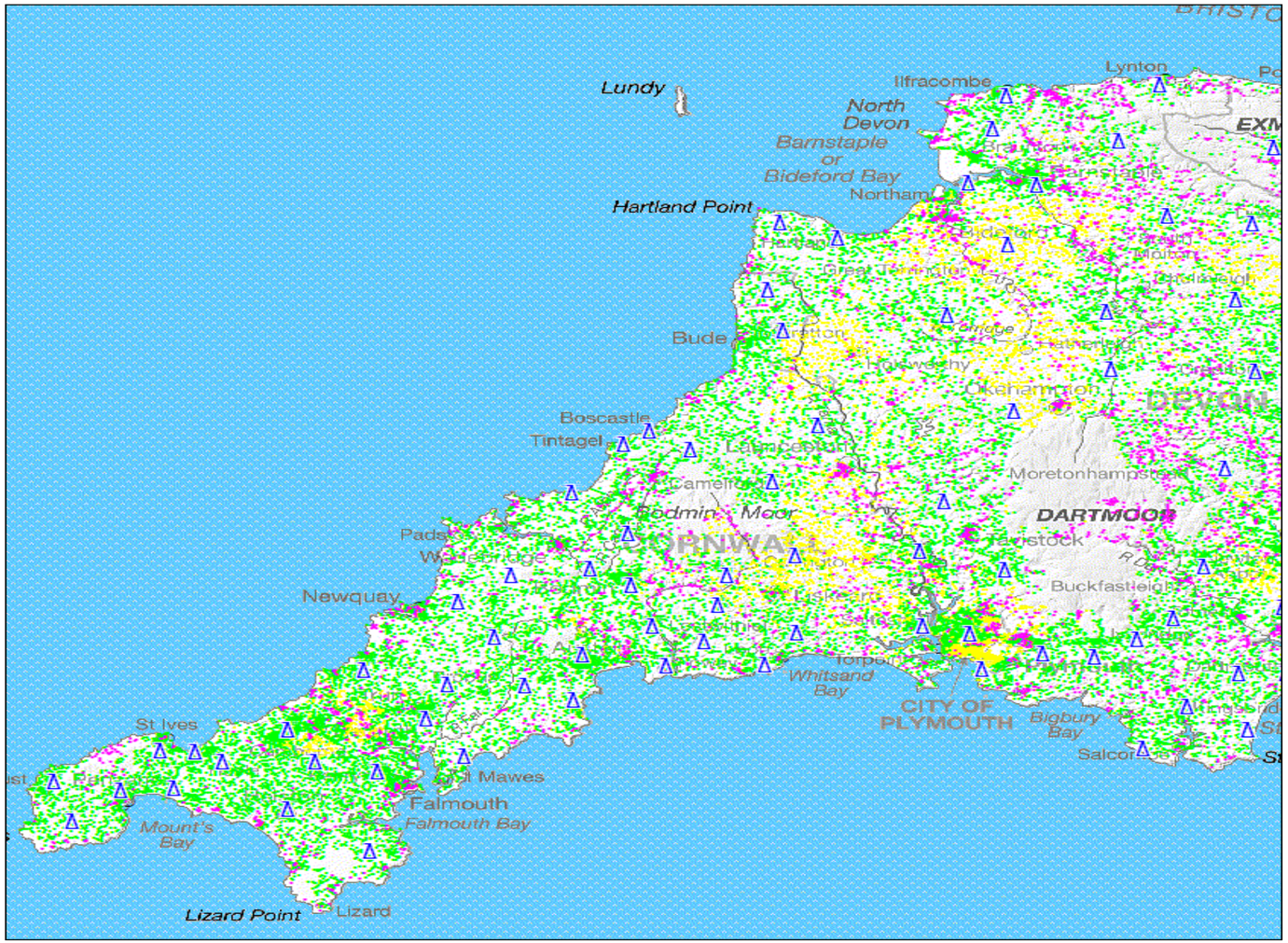
# RESULTS – DEVON & CORNWALL

**Analysis of far South-West showing final solution**

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# RESULTS – BASE STATIONS

| | Scanning Telemetry | DMR | Primary Substation | WPD Depot | Microwave Link | New/Third Party | Total |
|---|---|---|---|---|---|---|---|
| West Midlands | 28 | 15 | 40 | 1 | 2 | 4 | 90 |
| South West | 38 | 6 | 69 | 1 | 0 | 25 | 139 |

**Base stations sites required to achieve roughly 90% coverage of all substations in an area can still be mainly based on WPD assets**

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# RESULTS – COVERAGE

**Target of 90% coverage of all substations can be achieved**

| West Midlands | Primary | Distribution | Total |
|---|---|---|---|
| No. of Substations | 198 | 40863 | 41061 |
| Served: Antenna 2m agl | | | |
| 249 Sectors | Primary | Distribution | Total |
| | 183 | 37232 | 37415 |
| | 92.4 % | 91.1 % | 91.1 % |

| South West | Primary | Distribution | Total |
|---|---|---|---|
| No. of Substations | 545 | 53036 | 53581 |
| Served: Antenna 2m agl antenna | | | |
| 403 Sectors | Primary | Distribution | Total |
| | 510 | 47123 | 47633 |
| | 93.6 % | 88.9 % | 88.9 % |

NOTE: Transmitters are defined in terms of ‘sectors’ not base stations (which may have up to six sectors)

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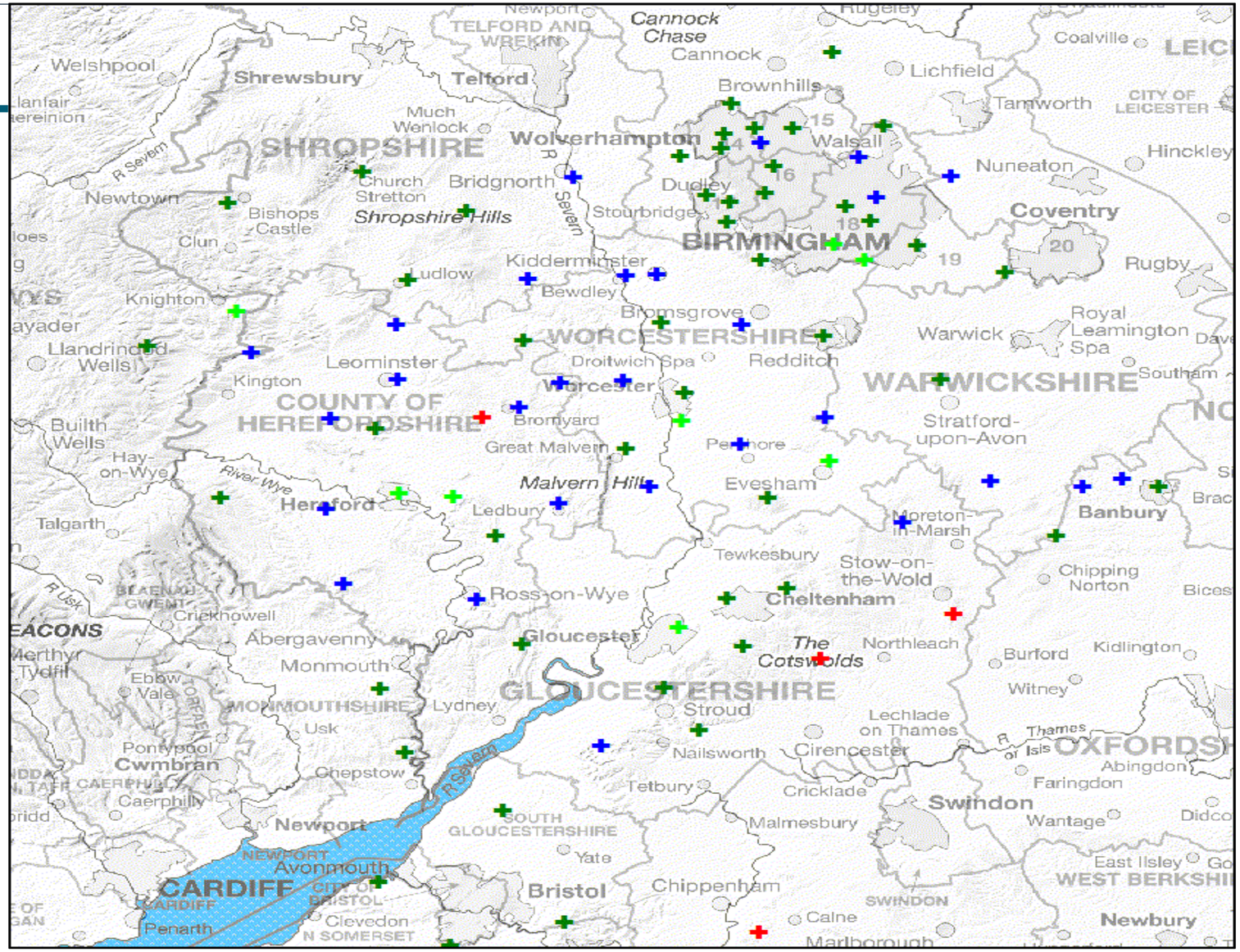
# RESULTS – BACKHAUL

**Backhaul is manageable in West Midlands**




**Backhaul Feed Status**

- Existing Microwave Link
- Existing Fibre Link
- Link Solution Required
- New Microwave Link Possible

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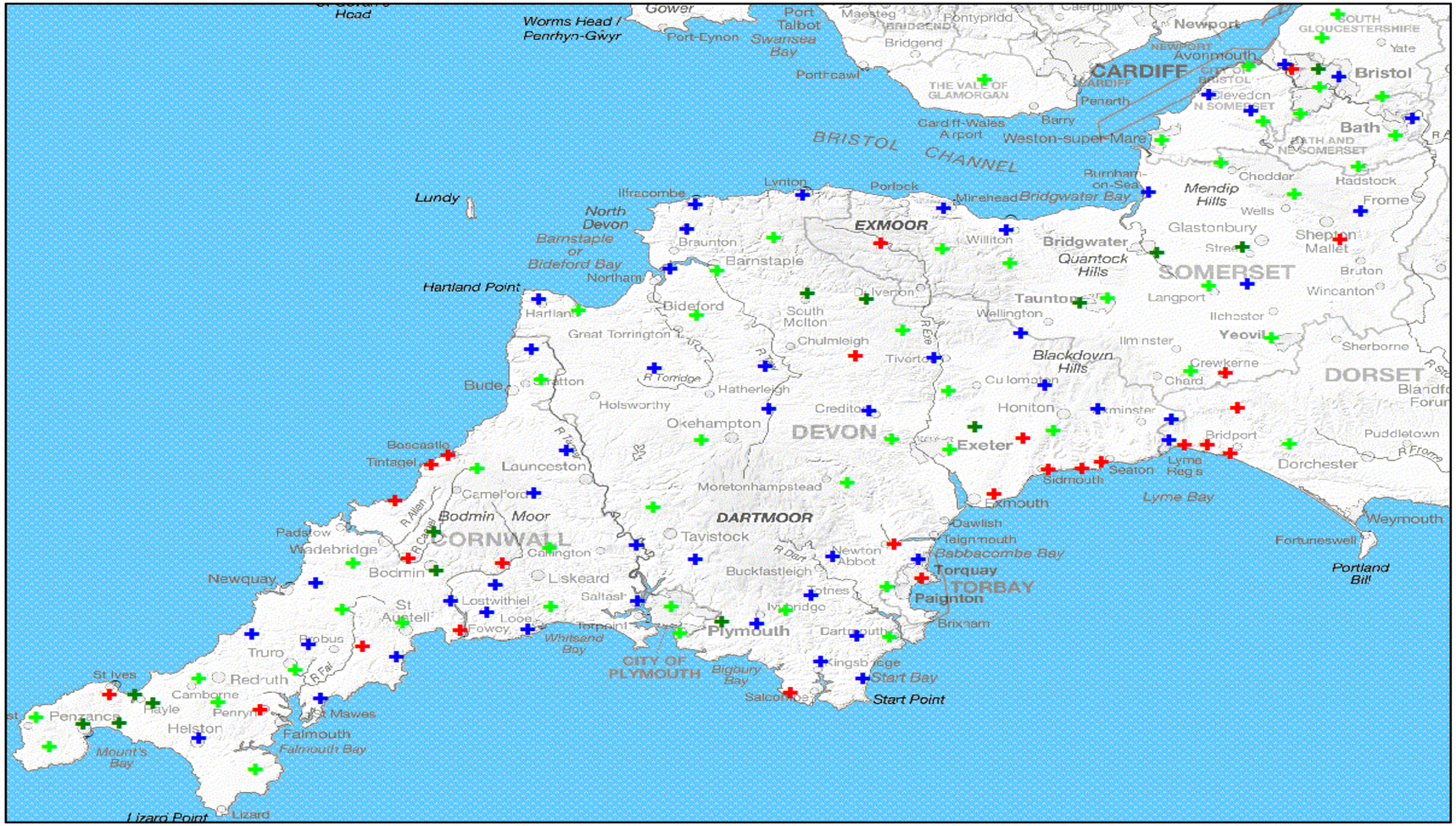
# RESULTS – BACKHAUL

**Backhaul is more challenging in South-West**




**Backhaul Feed Status**

- Existing Microwave Link
- Existing Fibre Link
- Link Solution Required
- New Microwave Link Possible

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# CONCLUSIONS

- Coverage more of an issue in rural areas, capacity in urban areas.
- Current model predicts coverage of 90% of all WPD substations.
- Majority of radio sites required for the new wireless network can be sourced from existing WPD estate, leveraging existing WPD assets, easing ‘out of hours’ access when required, and making it easier to deliver redundant backhaul routing and resilient power supplies.
- Directional antennas at outstations not favoured due to installation costs, vandalism concerns and possible loss of resilience.
- Outstation antenna height of 2m above ground level used for analysis.
- Serving remaining 10% of sites will require careful judgement between benefit of the data recovered from remote sites, cost of additional base stations and use of directional antennas at increased height.
- Additional sites & backhaul carry added benefits as WPD may need these for increased SCADA in any eventuality.
- 2 x 3 MHz for LTE (or 1 x 5 MHz for eLTE) required for wireless network.

[5MHz TDD channel to avoid installing MIMO antennas at outstations & interference.]

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# CONCLUSIONS - ANTENNAS

**Height and form of outstation antenna major influence on coverage**

**Typical Ground-mounted 11kV – 400/230V distribution substation**

**Flat profile antenna mounted on roof of GRP cabinet**

**Whip antenna mounted on pole below live electrical apparatus**

**Pole-mounted 11kV – 400/230V distribution substation**

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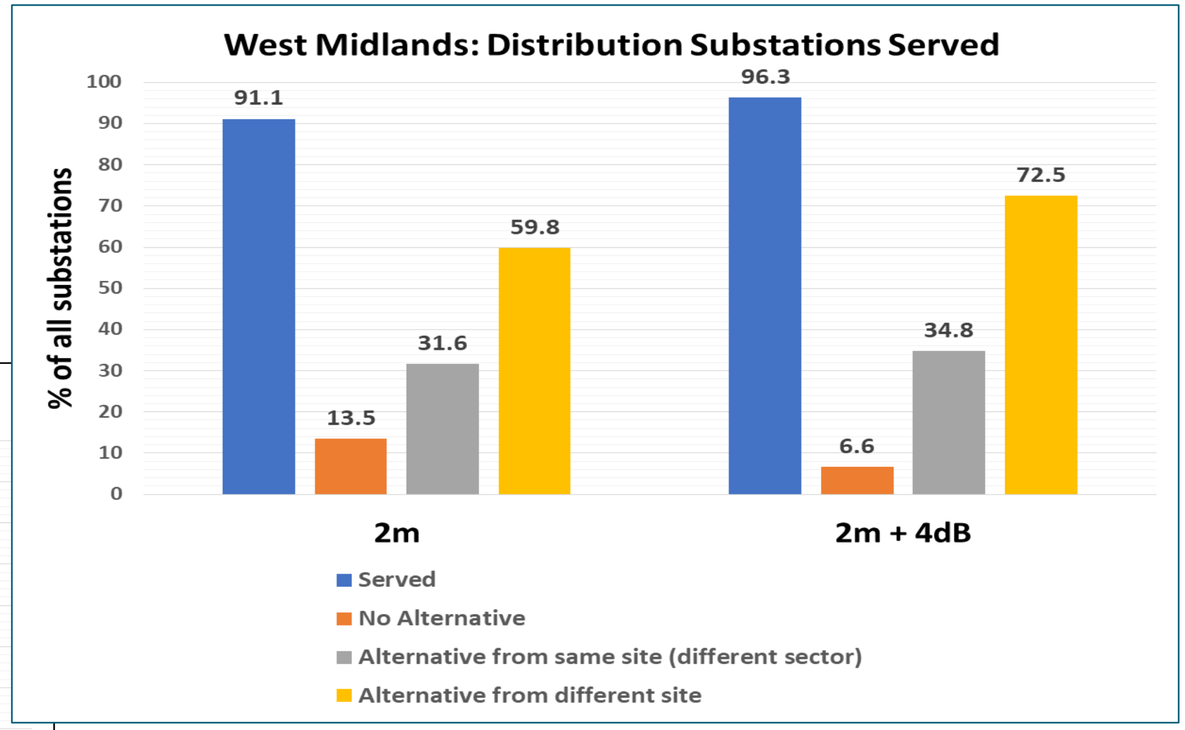
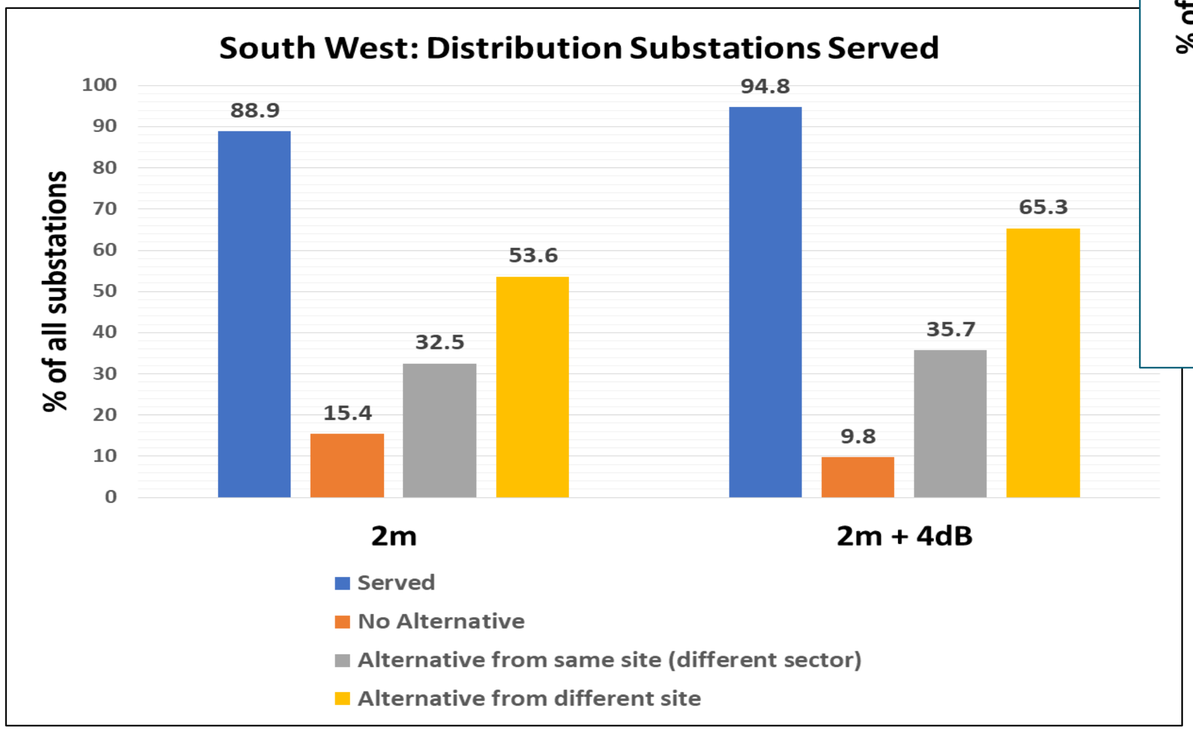
# CONCLUSIONS - RESILIENCE




**Omni-directional outstation antennas will provide greater resilience**

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# BENEFITS OF IMPROVED CONNECTIVITY

- Enhanced awareness of network flows
- More active management to reduce instability.
- Enables flexibility by facilitating dynamically adding and removing power or time shifting energy demand.
- More actively manage power flows from distributed generation resulting in more stability and less curtailment.
- Enhanced switchgear control aligned to greater visibility of customers off supply enabling quicker re-energisation and avoiding delays associated with engineer visit.
- Disturbance monitoring to highlight any unusual activity or abnormalities on the network to investigate the cause.
- Avoiding network re-enforcement.

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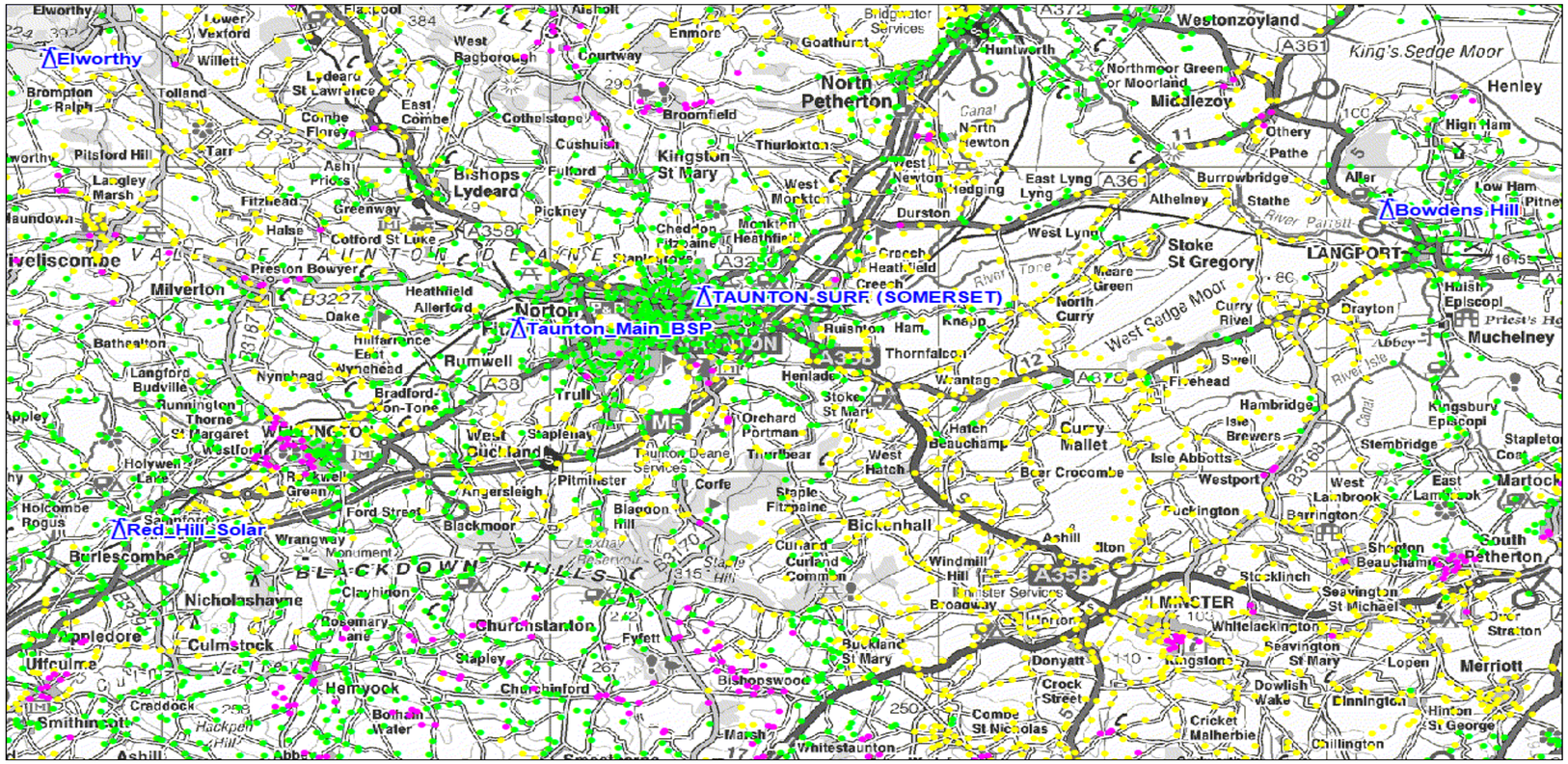
# NEXT STEPS

- Further LTE trial in Taunton area to:
  - Validate coverage modelling and data rate assumptions
  - Investigate interference effects from overlapping coverage
  - Trial multi-vendor interworking
  - Assess potential for mobile data & wide-area voice operation




- Engaged with Ofcom, Government & other utilities to facilitate spectrum access
- Compare data requirements with other DNO analyses

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# A DATE FOR YOUR DIARY

**Wednesday 18 March 2020**

LTE Seminar - Taunton (*Comms for the Electricity Industry*)

To register your interest for this seminar, please email:
wpdlteseminar@westernpower.co.uk


***Next Generation Wireless Telecoms Project Team***

# THANK YOU FOR LISTENING

## ANY QUESTIONS?

**FAITHFUL CHANDA - INNOVATION & LOW CARBON NETWORKS ENGINEER [WPD]**
**RICHARD LUKE - CHIEF OPERATING OFFICER [JRC]**

# LUNCH BREAK

# RESUME AT 12.55

WESTERN POWER DISTRIBUTION INNOVATION TEAM

# ELECTRICITY FLEXIBILITY & FORECASTING SYSTEM

## BALANCING ACT CONFERENCE

26TH NOVEMBER 2019

**JENNY WOODRUFF**
**INNOVATION & LOW CARBON NETWORKS ENGINEER**

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# AGENDA

- Background
- Progress
- Design overview
- Forecasting
- Next steps
- Q&A

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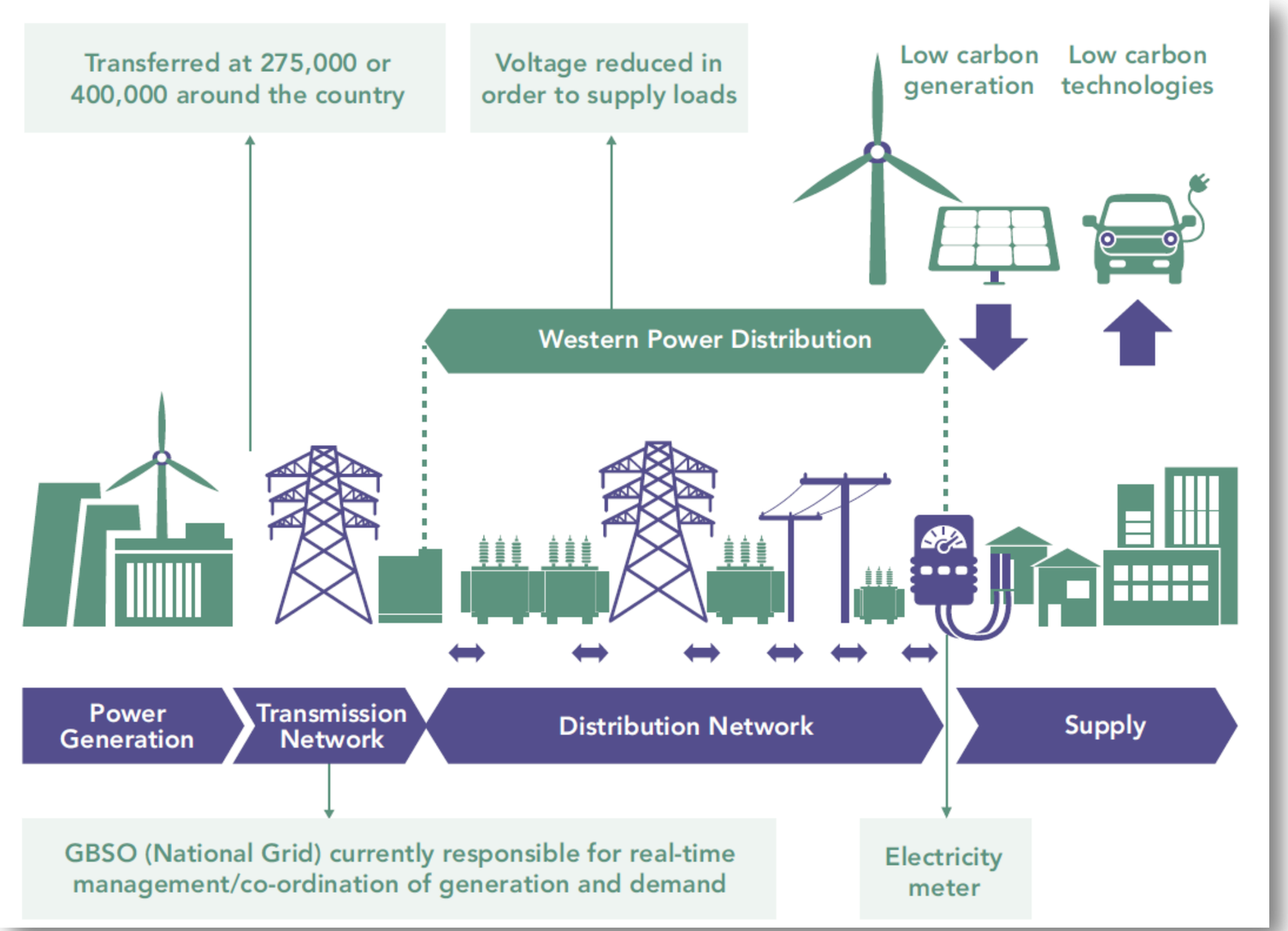
# BACKGROUND

New low carbon technologies are making the system more complex and variable.

Our networks are becoming smarter and more active to enable greater volumes of generation, storage and LCTs to connect.

Flexibility services offer an alternative to reinforcement. While ESO services are well established they are relatively new for DNOs.



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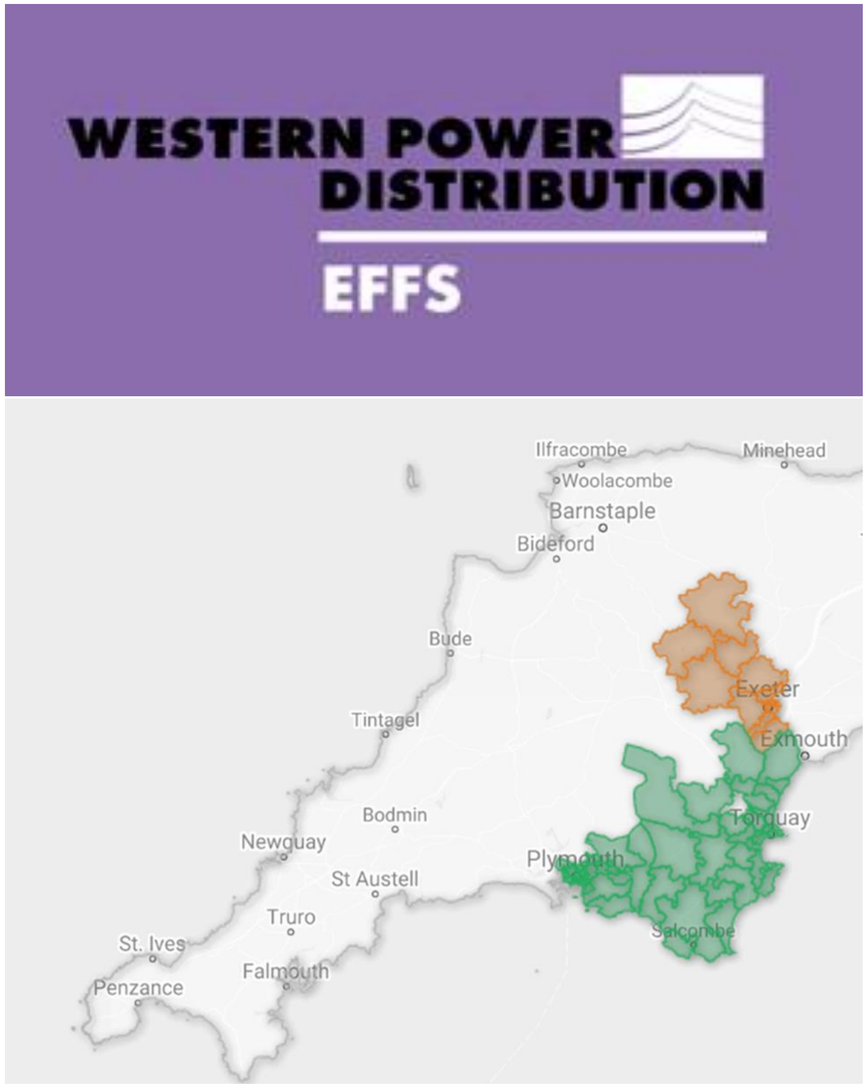
# WHAT IS EFFS?

- NIC funded 3-year project
- Explores DSO business requirements for flexibility services and how software systems could support these
- Develop & trial a system
- Focused on 132kV and 33kV networks
- Co-ordinated DSO/ESO dispatch & procurement (Open Networks Future World B)
- Trial covers South West region



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# T.E.F. COLLABORATION

- Three NIC bids in same year relating to DS transition.
- Ofgem required the projects to collaborate analyse overlaps, reduce costs, maximise learning etc. before final authorisation in Sept 2018.
- Ongoing co-operation and collaboration.
- Monthly Project Delivery Board meetings.
- Combined stage-gate with Ofgem in Feb 2020.

**FUSION**

- 5 year project
- Physical trials in East Fife
- Based on USEF market models, drawing on Open Network learning
- Trialling commoditised local demand-side flexibility

**transition**

- 5 year project
- Physical trials in Oxfordshire Based on Open Network market models, drawing on USEF learning
- Trialling of local energy flexibility and the facilitation of peer to peer trading

**WESTERN POWER DISTRIBUTION EFFS**

- 3 year project
- Learning will feed into the Cornwall Local Energy Market
- Based on Open Network market models, drawing on USEF learning
- Forecasting and data communication focused

# PROJECT PARTNERS

- AMT-SYBEX – consultancy services and reconfiguration of their Affinity Networkflow software product
- National Grid ESO – input on co-ordination process

**Access to Flexibility Services**

- Cornwall Local Energy Market – operated by Centrica
- PowerShift – operated by EDF Energy
- Flexible Power – operated by WPD

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# PROGRESS

| Workstream | Description | H1 2018 | H2 2018 | H1 2019 | H2 2019 | H1 2020 | H2 2020 | H1 2021 | H2 2021 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Forecasting Evaluation, Co-ordination and Requirements | Ofgem Approval | | Gateway Review 1 | | T.E.F. stage gate | | | |
| 2 | System Design, Development, System Test | | | | | Gateway Review 2 | | | |
| 3 | Onsite Testing, Trials and Conflict Management | | | | | | | Gateway Review 3 | |
| 4 | Collaboration and Knowledge Dissemination | | | | | | | | Closedown Report |

| Milestones complete |
|---|
| Mobilisation |
| Forecasting Evaluation & Validation |
| DSO Requirements Specification |
| Gateway review 1 |
| System Design Documents |

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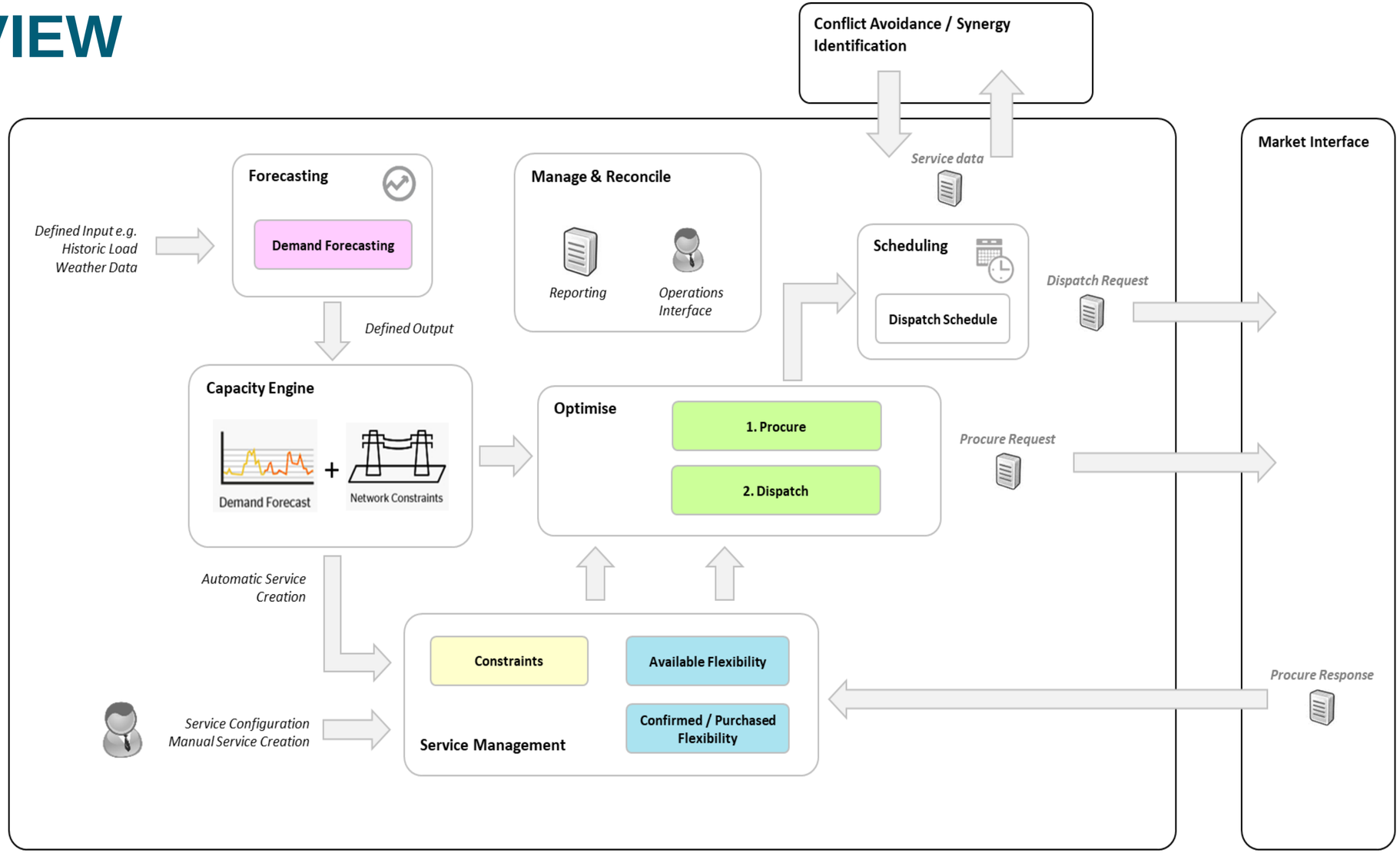
# DESIGN OVERVIEW

- Forecasting
- Capacity engine
- Service management
- Optimisation
- Scheduling
- Market interface
- Conflict avoidance & synergy identification
- Reporting



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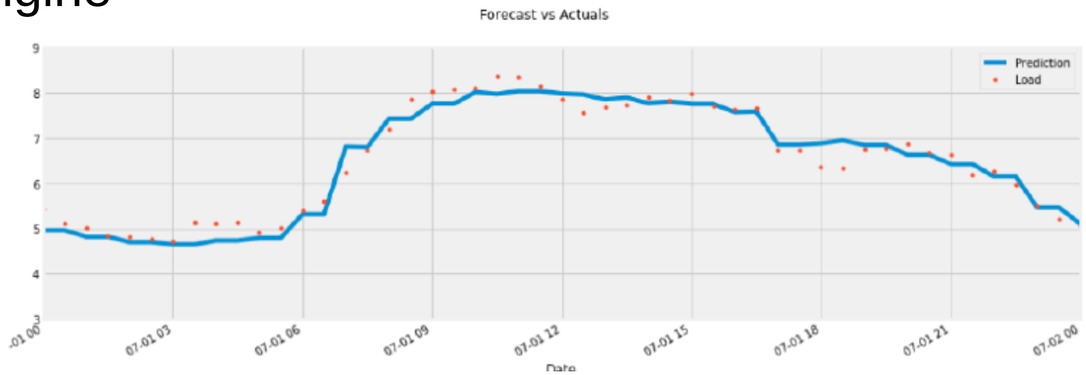
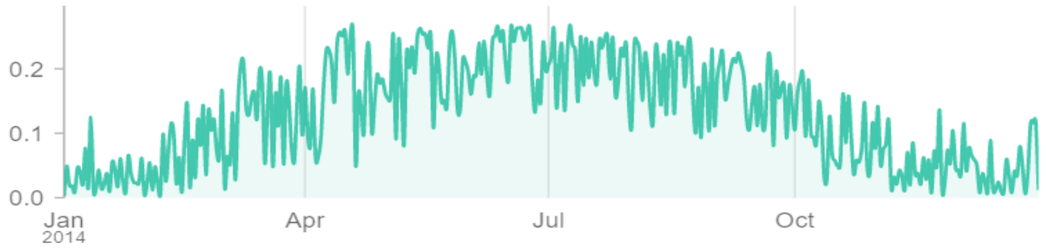
# DESIGN OVERVIEW - FORECASTING

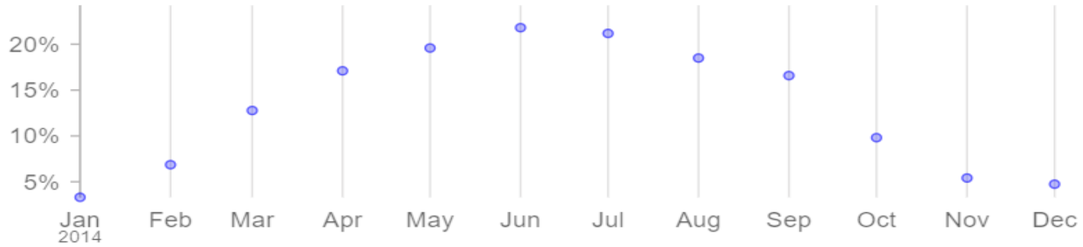
- Half hourly average demand & generation values
- Primary busbars / busbar sections and 33 kV or 132kV connected customers
- Range of time horizons from day-ahead to six-months ahead.
- Input to capacity assessment by the Capacity Engine




Daily mean




Monthly capacity factor



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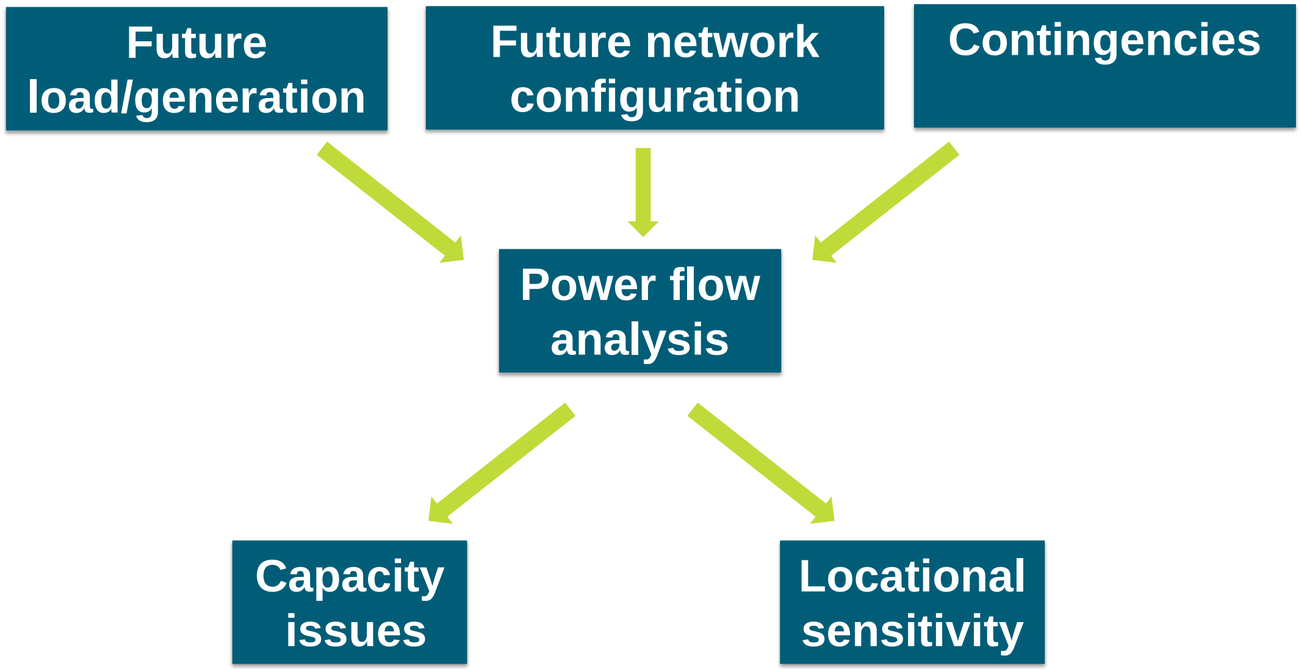
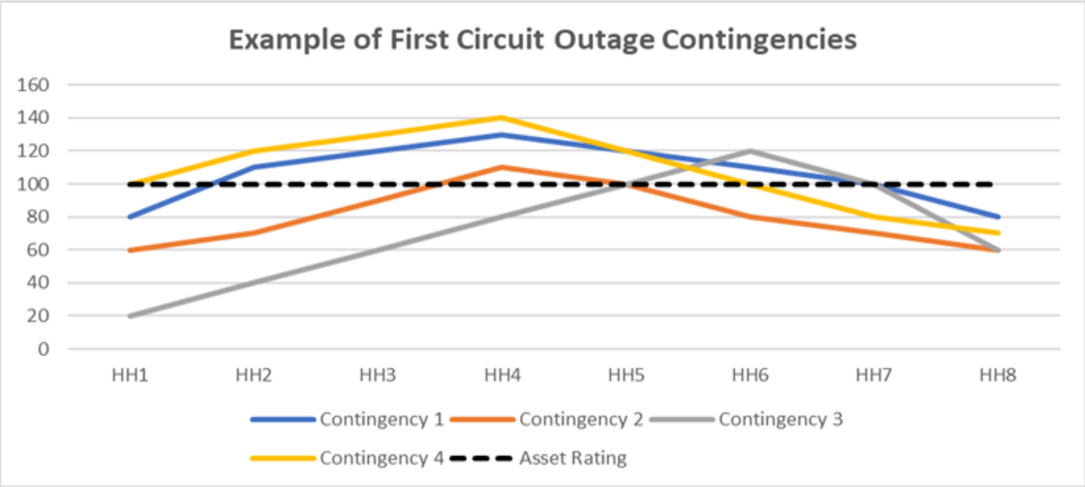
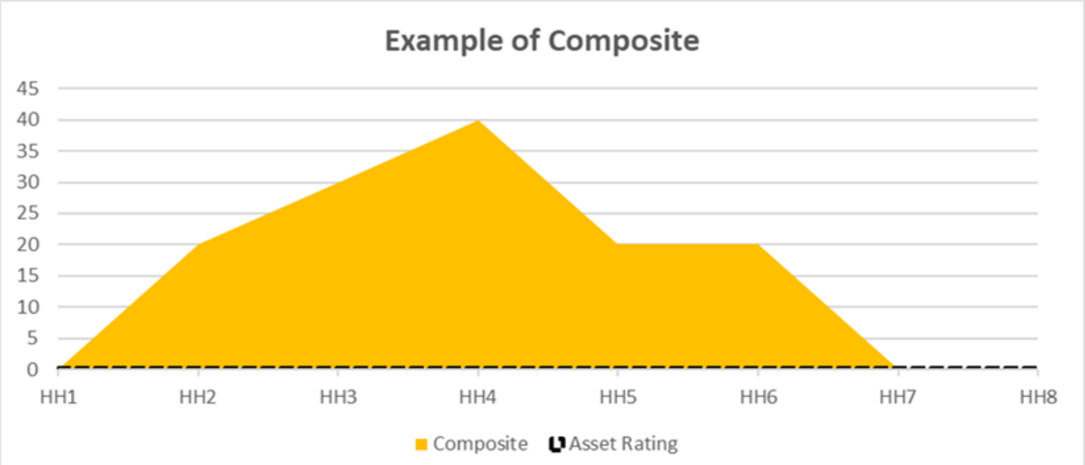
# DESIGN OVERVIEW – CAPACITY ENGINE



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# DESIGN OVERVIEW– SERVICE MANAGEMENT

- Definition of service types and allowed values.
- Management of service instance lifecycle and associated statuses.

| Service Characteristics | Scheduled Constraint Management | Pre-fault Constraint Management | Post-fault Constraint Management | Restoration Support |
|---|---|---|---|---|
| When to act | Pre-fault | Pre-fault | Post-fault | Post-fault |
| Triggering action | Time | DSO forecast; or Asset Loading | Network Fault | Network Fault |
| Certainty of utilisation | Very certain | Uncertain | Uncertain | Very uncertain |
| Efficiency of utilisation | Low | Medium | High | Low |
| Risk to network assets | Low | Medium | High | Low |
| Frequency of use | High | Medium | Low | Low |

# DESIGN OVERVIEW – OPTIMISATION

Ensures the best selection of services (assumes supply exceeds demand).

Linear optimisation engine included in Networkflow software currently.

Multiple factors can be included such as

- Minimum delivery capacity / delivery duration / ramping criteria
- Cost
- Reliability
- Maximum values to allocate to individual provider or platform

Tiebreakers to promote sharing participation among  all market participants rather than favouring established players.

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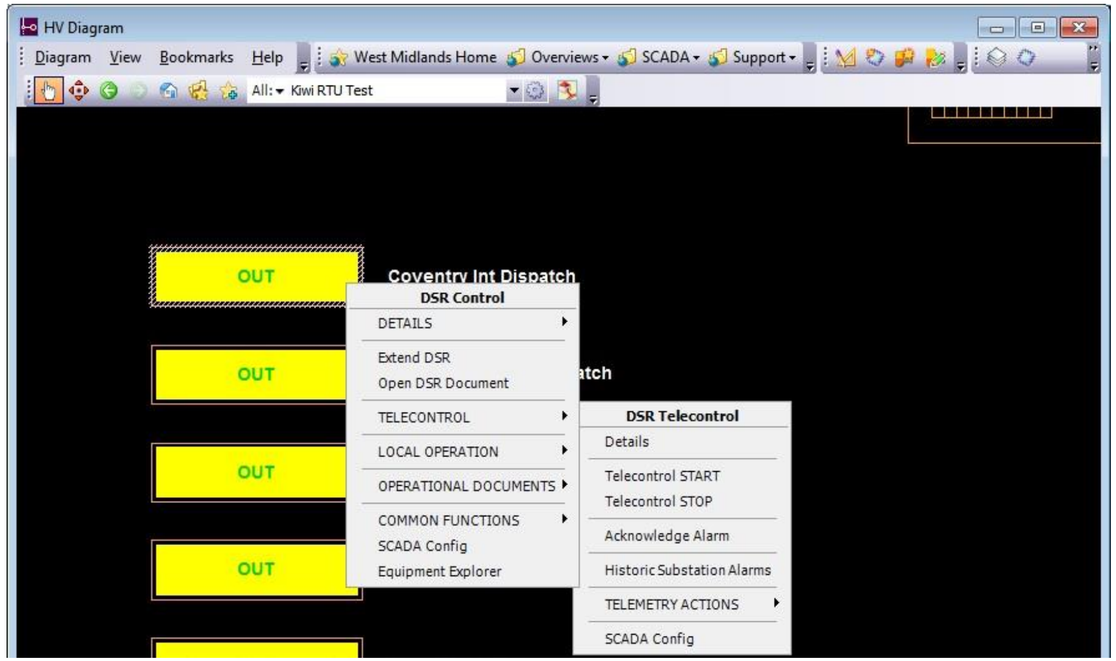
# DESIGN OVERVIEW – SCHEDULING

The scheduling function ensures that notifications are sent to market platforms to dispatch their services.

This includes an interface with the control room system to simplify post-fault dispatch.




**Existing Control Room Interface**

**Post Fault Service Dispatch Pathway**

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# DESIGN OVERVIEW – CONFLICT AVOIDANCE

Identification depends on conflict type

| Conflict Type | Identification method |
|---|---|
| Double Booking | Asset ID |
| • Opposing service impact<br>• Transfer location of impact | Network Hierarchy<br>Future Network<br>Hierarchy / network model |
| • Negating service impact<br>• Breach capacity limit | Power Flow Analysis |

Resolution Matrix

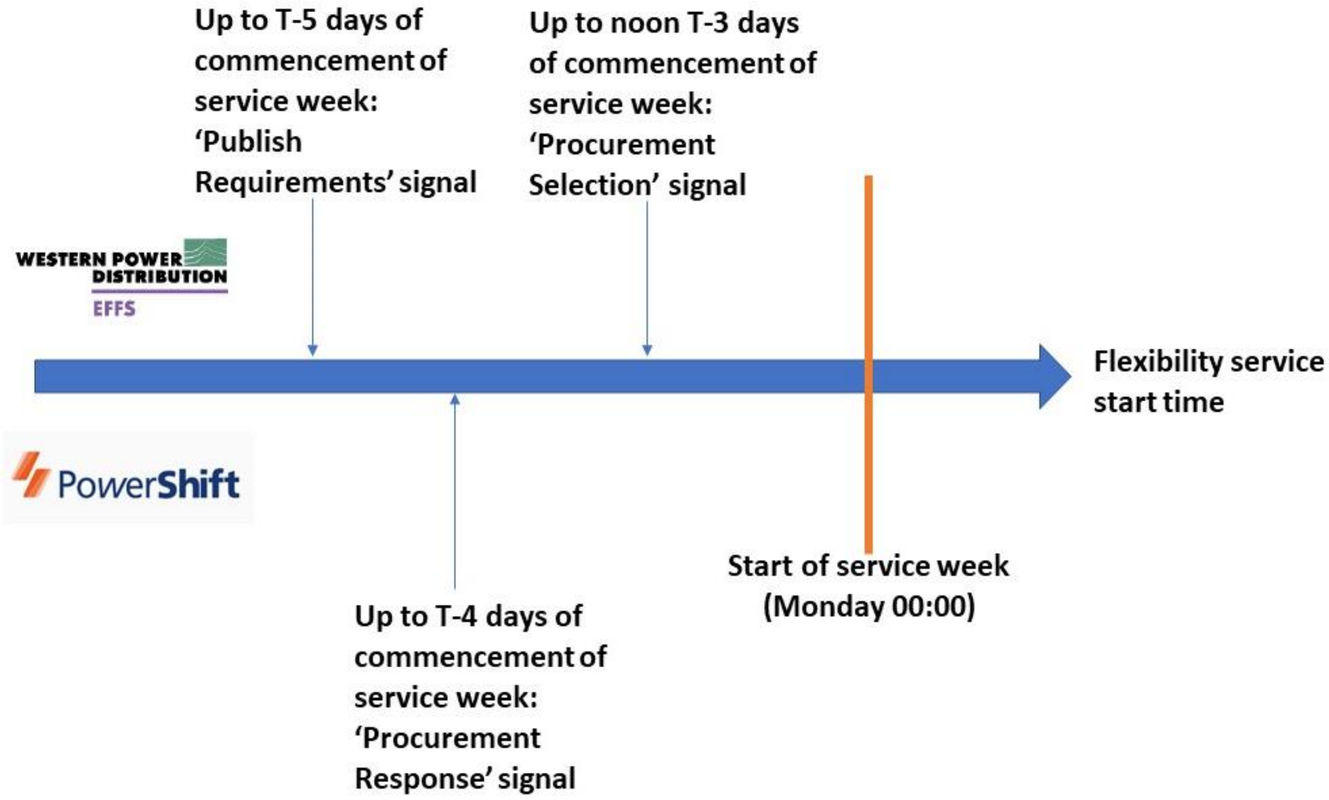
| | DSO Service | | | |
|---|---|---|---|---|
| **National Grid ESO Service** | **Scheduled constraint management** | **Pre-fault constraint management** | **Post fault constraint management** | **Restoration support** |
| **Pre-fault** | Resolution Algorithm A | Resolution Algorithm B | Resolution Algorithm B | Resolution Algorithm B |
| **Post fault Locational** | Resolution Algorithm A | Resolution Algorithm C | Resolution Algorithm C | Resolution Algorithm C |
| **Post fault non locational** | Resolution Algorithm D | Resolution Algorithm E | Resolution Algorithm F | Resolution Algorithm G |

Algorithms likely to reflect network status ( e.g. ESO priority under low system margin conditions ) , locational relevance, cost of alternatives.

# DESIGN OVERVIEW – MARKET INTERFACE

Exchange of information

- Publish purchase requirements
- Receive offers
- Notify selected providers
- Real-time dispatch notifications for post-fault event services



# DESIGN OVERVIEW – REPORTING

Standard reports have been specified to support:

- Comparison of commitments against budget
- Market analysis / market development tracking

e.g.

- Indicative spends to date
- Average costs of flexibility
- Average Flexibility Platform response times
- Forecasting accuracy

These reports will be exported to enable customised reporting in other packages. Any bespoke / custom reports that are identified as required during the trials will be written by system administrator.

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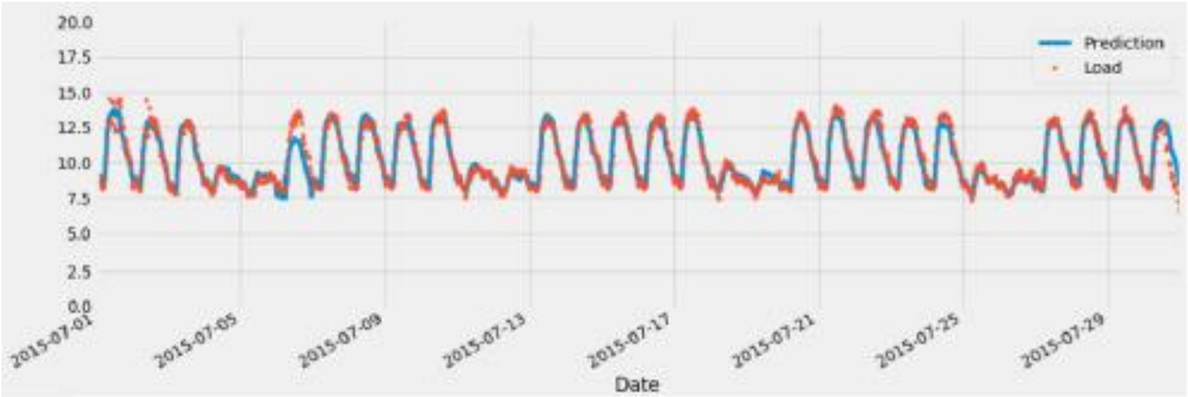
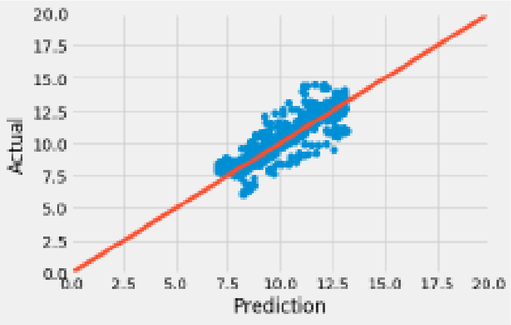
# FORECASTING – SMARTER GRID SOLUTIONS

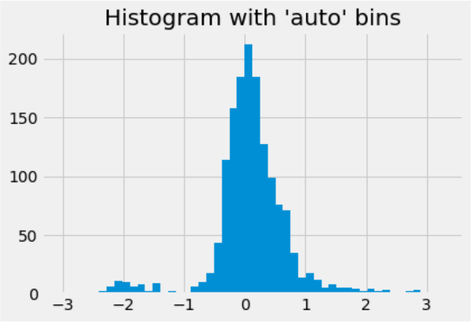
| | |
|---|---|
| **Methods** | • ARIMA<br>• Long short term memory<br>• XG boost |
| **Time Horizons** | • Day –ahead<br>• Week-ahead<br>• Month-ahead<br>• Six Months-ahead |
| **Locations** | • Primary<br>• BSP<br>• GSP<br>• Generator<br>• Large Load Customer |

BSP 1 month ahead




| MSE | MAE | RMSE | MAPE |
|---|---|---|---|
| 0.418 | 0.416 | 0.647 | 4.085 |



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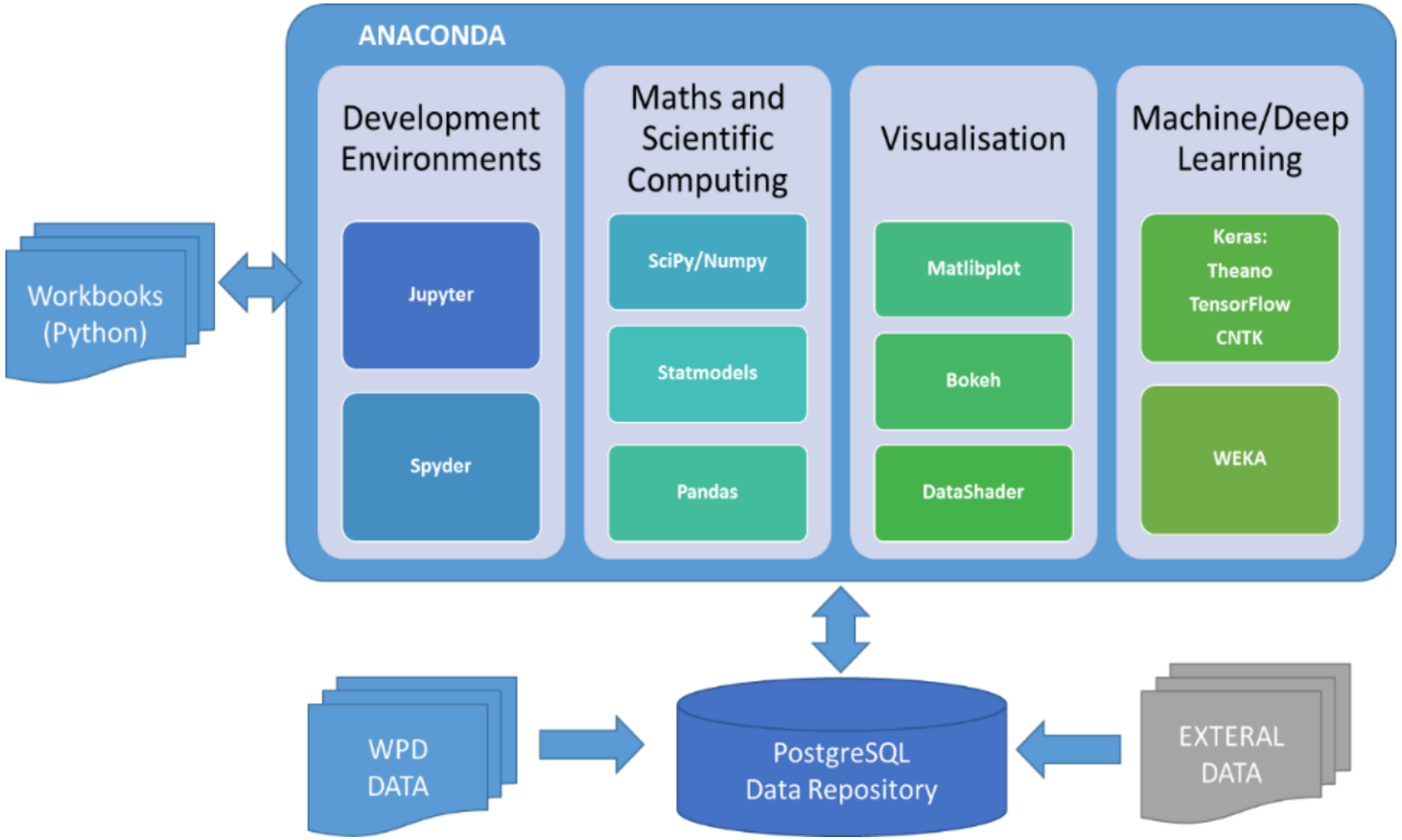
# FORECASTING – CAPITA

- Replicated open source tool chain
- Validated results
- Expanded set of forecast locations
- Provided recommendations for implementation



# FORECASTING – NEXT STEPS

The project intends to further explore:

- Data cleansing and substitution
- Modification of models to use weather forecasts as well as historic weather data
- Explore available engineering models and how to select appropriate model with available data
- Data adjustments to forecast what is not measured

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# EFFS NEXT STEPS

- Dissemination of project learning to date at relevant events
- Production of the T.E.F. stage gate report with our partners SPEN FUSION and SSEN TRANSITION

Build phase activities:

- AMT-SYBEX reconfiguration of Networkflow
- WPD reconfiguration of existing systems

| Trial Objectives |
| --- |
| Demonstrate full range of functionality in real life. End-to-end testing. |
| Demonstrate optimisation within and over a range of platforms |
| Demonstrate conflict identification and resolution in practice, plus supporting data exchanges. |
| Evaluate forecasting performance over a larger sample size and duration |

# THANK YOU FOR LISTENING

## ANY QUESTIONS?

**JENNY WOODRUFF**
**INNOVATION & LOW CARBON NETWORKS ENGINEER**

WESTERN POWER DISTRIBUTION INNOVATION TEAM

# OPENLV

## BALANCING ACT CONFERENCE

## 26TH NOVEMBER 2019

**SAM ROSSI ASHTON**
**INNOVATION & LOW CARBON NETWORKS ENGINEER**

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# FORMAT

- Introduction to OpenLV
- Background to OpenLV
- Method 1 Learning
- Method 2 Learning
- Method 3 Learning
- Panel for questions

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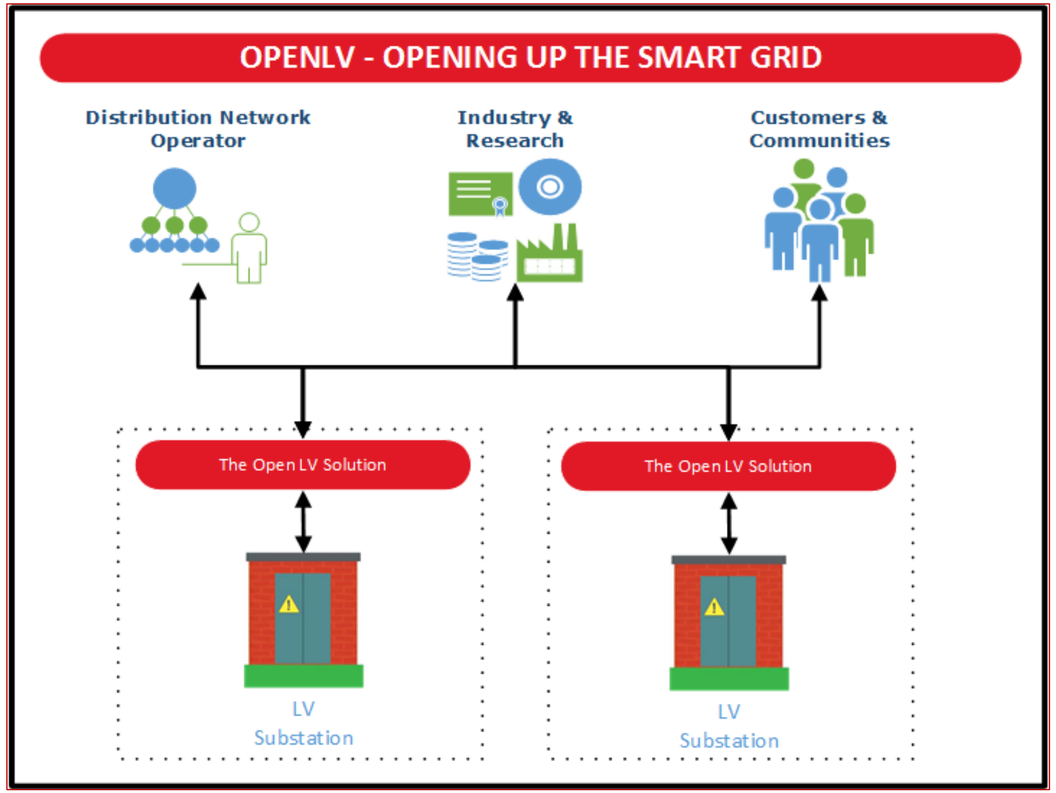
# OVERVIEW

Apps have revolutionised the way in which we use various electronic devices, enabling solutions that suit specific consumer needs to be deployed at scale.  This concept could be used by the electricity industry.

OpenLV has trialled this by developing an open, flexible platform that could ultimately be deployed at every low voltage (LV) substation.



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# PROJECT METHODS

## 1. Network Capacity Uplift

Increase the capacity of the LV network - prove how network control/ automated meshing can be carried out, effectively and securely, via a highly decentralised architecture.

## 2. Community Engagement

Test the value of providing LV network data and an open platform to communities, who want to be part of a smarter grid.

## 3. OpenLV Extensibility

Enable third-parties to develop Apps to improve network performance, and facilitate non-traditional business models and support the uptake LCTs.

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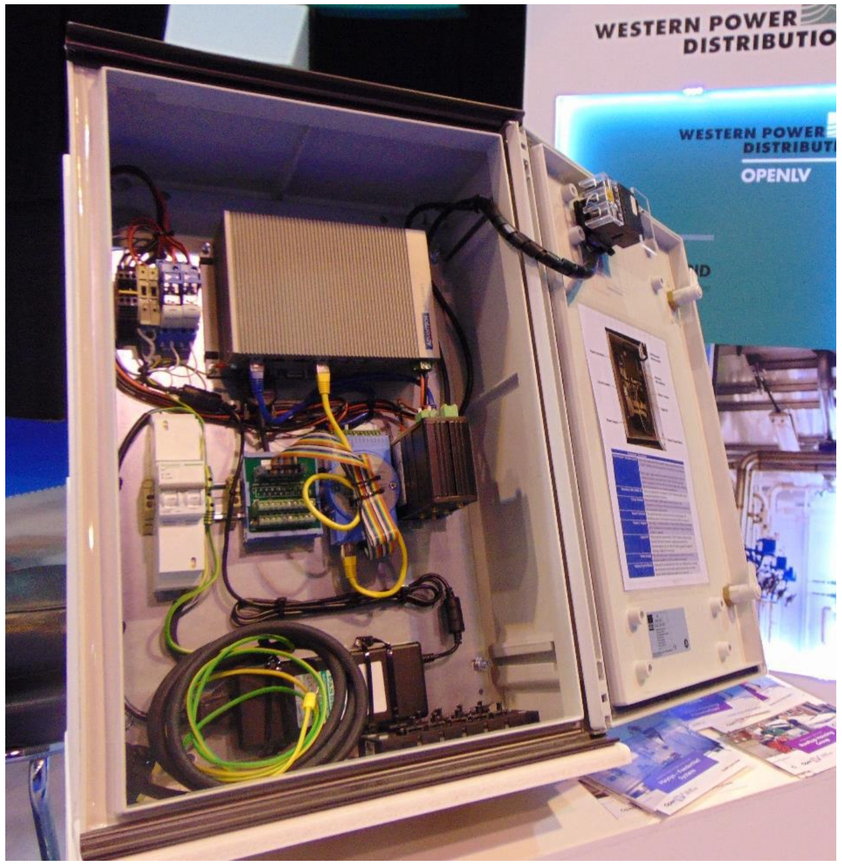
# DEVICE AND PLATFORM

An intelligent substation device that can support software Apps from multiple vendors, providing a low cost hub that, once deployed, can adopt additional functions;

A secure platform that enables the intelligent substation devices to be remotely managed and enables LV network data to be accessed by community groups and third party organisations.



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# SUCCESS

## EMPOWERED COMMUNITIES

Providing accessible data that has helped third parties (you) to better:

- understand energy behaviour;
- manage energy consumption; and
- reduce environmental impacts.

## FACILITATED NEW BUSINESS MODELS

Apps developed could now be used to support non-traditional business models where third parties can deploy new solutions using better understanding of the network.

## IMPROVED THE NETWORK FOR CUSTOMERS

Project data has been used to improve the network by optimising the deployment of community-owned LCTs, and released capacity on the network.

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# GOING FORWARD

## NEW APPS

WPD is upgrading the community groups' systems so that they are fit for post-project activity. The systems can facilitate the ongoing development of apps.

## NEW PARTIES

WPD is developing an offering whereby new community groups will be able to access to the functionality of the CSE app post-project.

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# OVERVIEW

## Project Aims:

- Open up live data from electricity networks
- Trial an open, flexible platform that could be deployed to every LV substation in Great Britain
- Show how 3rd parties can develop software applications to be deployed in LV substations
- Demonstrate the platform's ability to provide benefits to the network, operators, community groups and wider industry

**Funding:** Network Innovation Competition

**Delivery:** WPD & EA Technology

**Timescales:** December 2016 to May 2020

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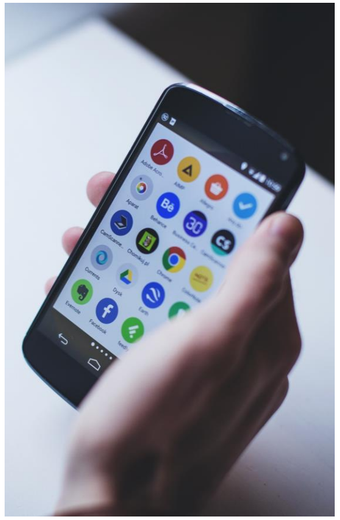
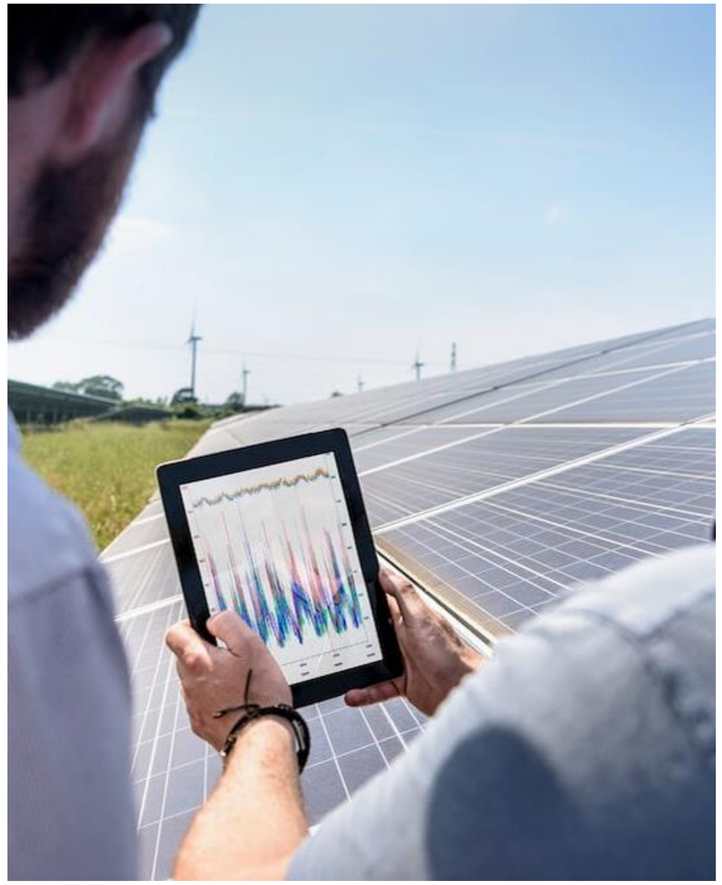
# THE CONCEPT



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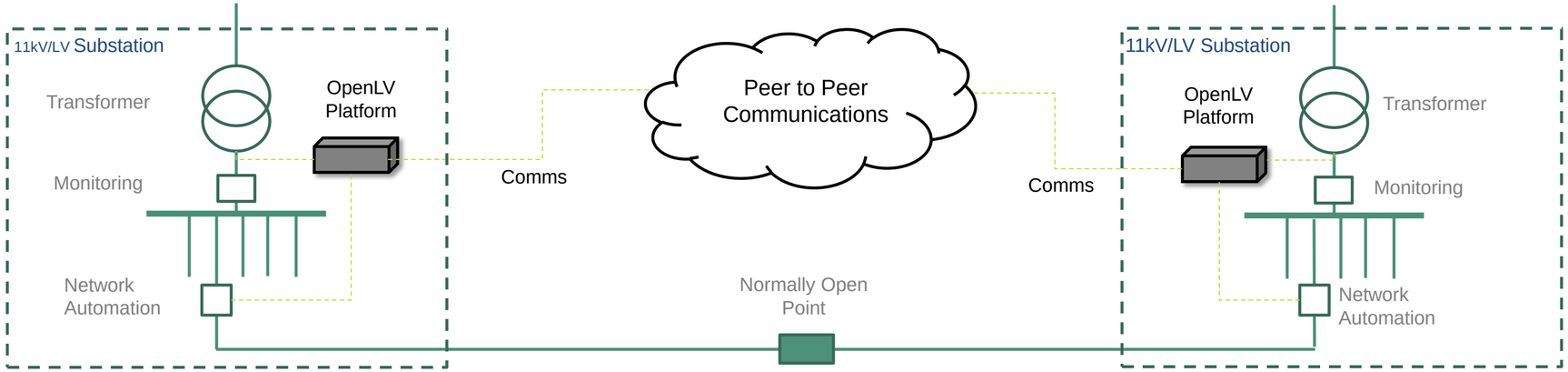
# RELEASING ADDITIONAL CAPACITY




## What

- Check network capacity against RTTR of transformer; when breached, close two radial circuits to mesh the LV network
- Deploy two proven techniques
  - ‘Dynamic Thermal Ratings app’ and
  - ‘Network Meshing app’

## How

- Assess WPD’s network to identify candidate circuits
- Target a range of LV networks
- Deploy LV-CAP™ to 60 substations
- Deploy network automation to 10 substations (5 pairs)
- Monitor how the solution operates over the trial period
- Assess and report on performance

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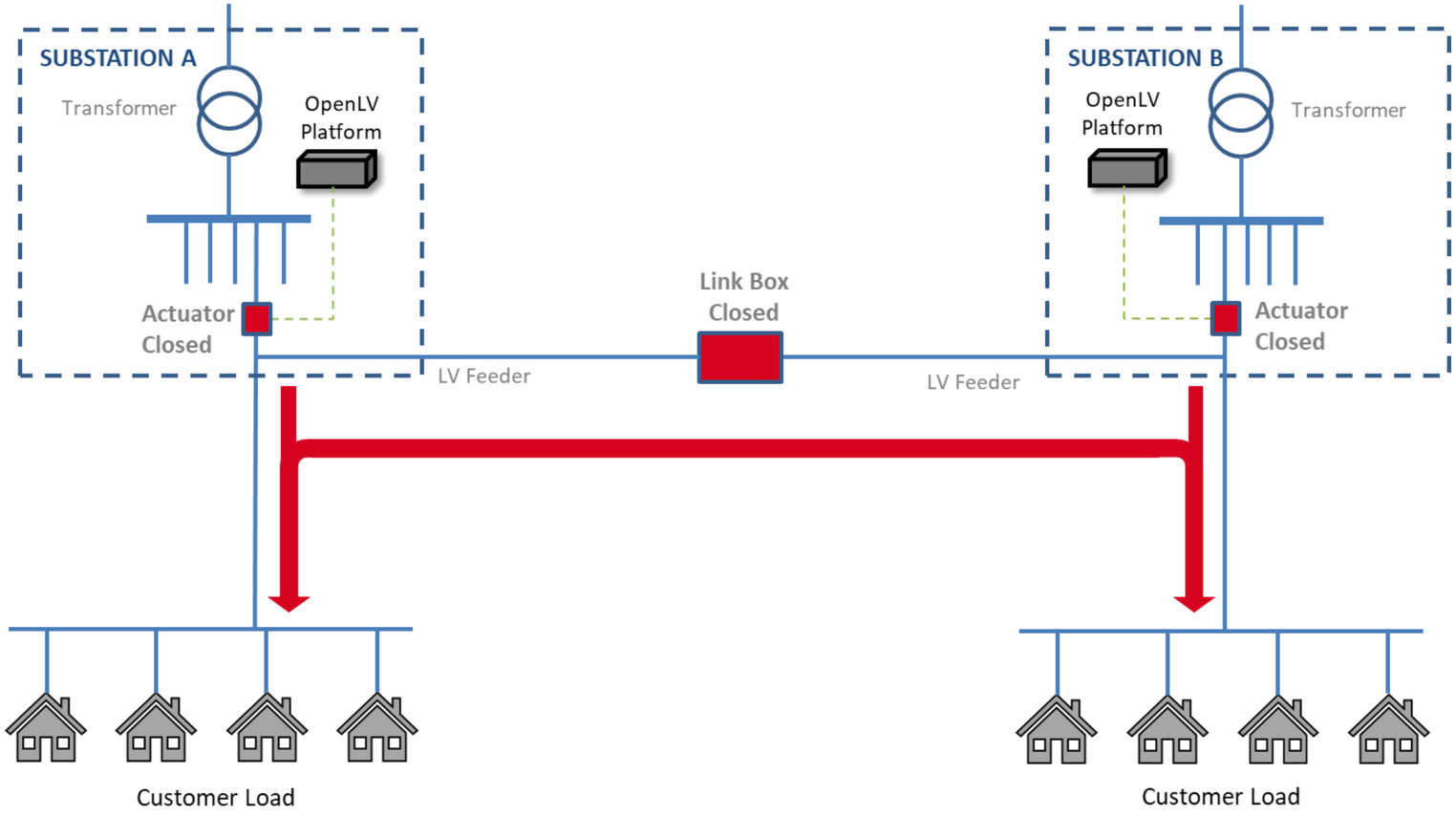
# MESHING THE NETWORK



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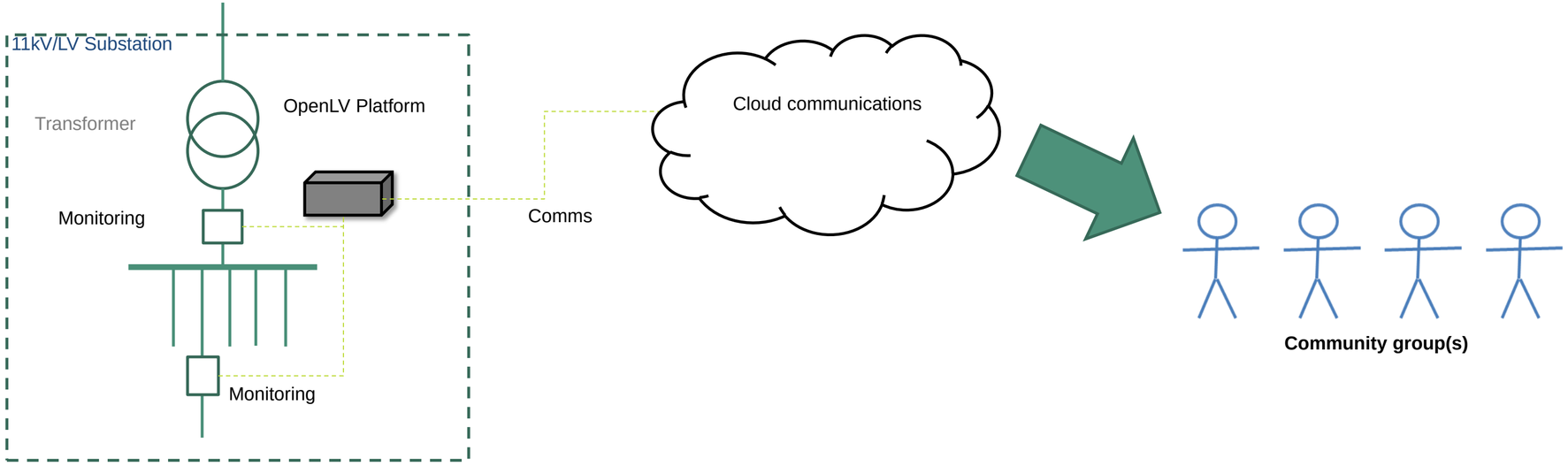
# COMMUNITY ENGAGEMENT




## What

- To work with key community groups to understand whether apps can be developed and installed on the platform
- Identify funding sources that customers / communities can use to develop specific apps

## How

- Community engagement to promote availability of platform / LV network data
- Make available 10 LV-CAP™ units for deployment
- Funding to develop specific apps to be raised outside of the project budget, e.g. public funding / private sector

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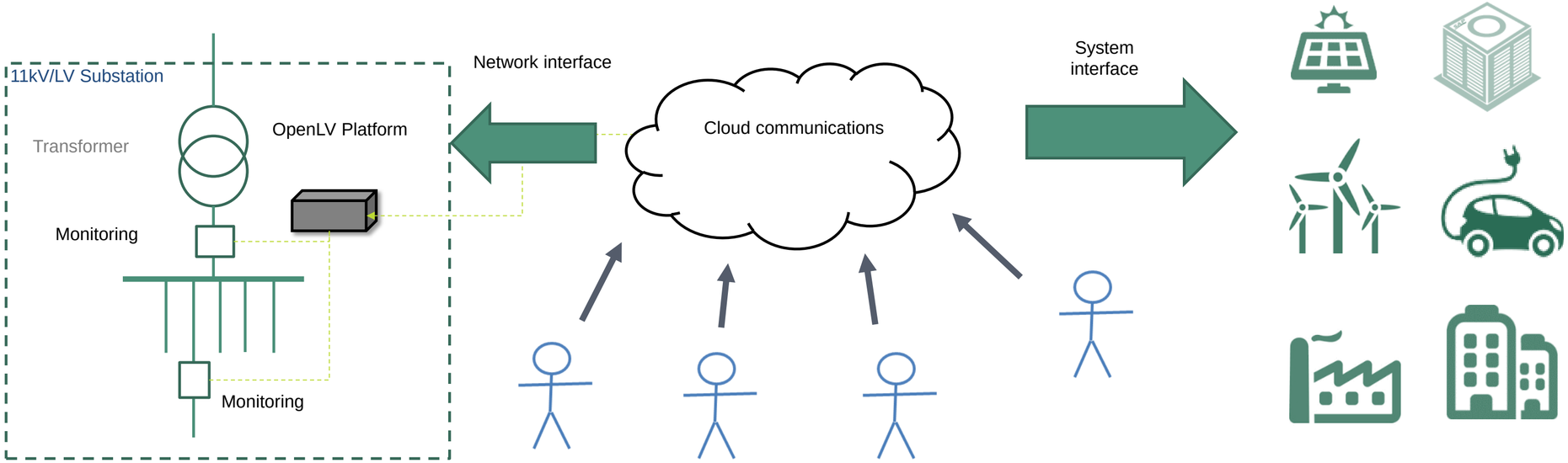
# BUSINESS & ACADEMIA




## What

- To enable companies to develop innovative algorithms and applications for either the DNO, or its customers

## How

- Publicise the opportunity to 3rd parties
- Make available 10 LV-CAP™ devices for substation deployment
- Funding to develop specific apps to be raised outside of the project budget

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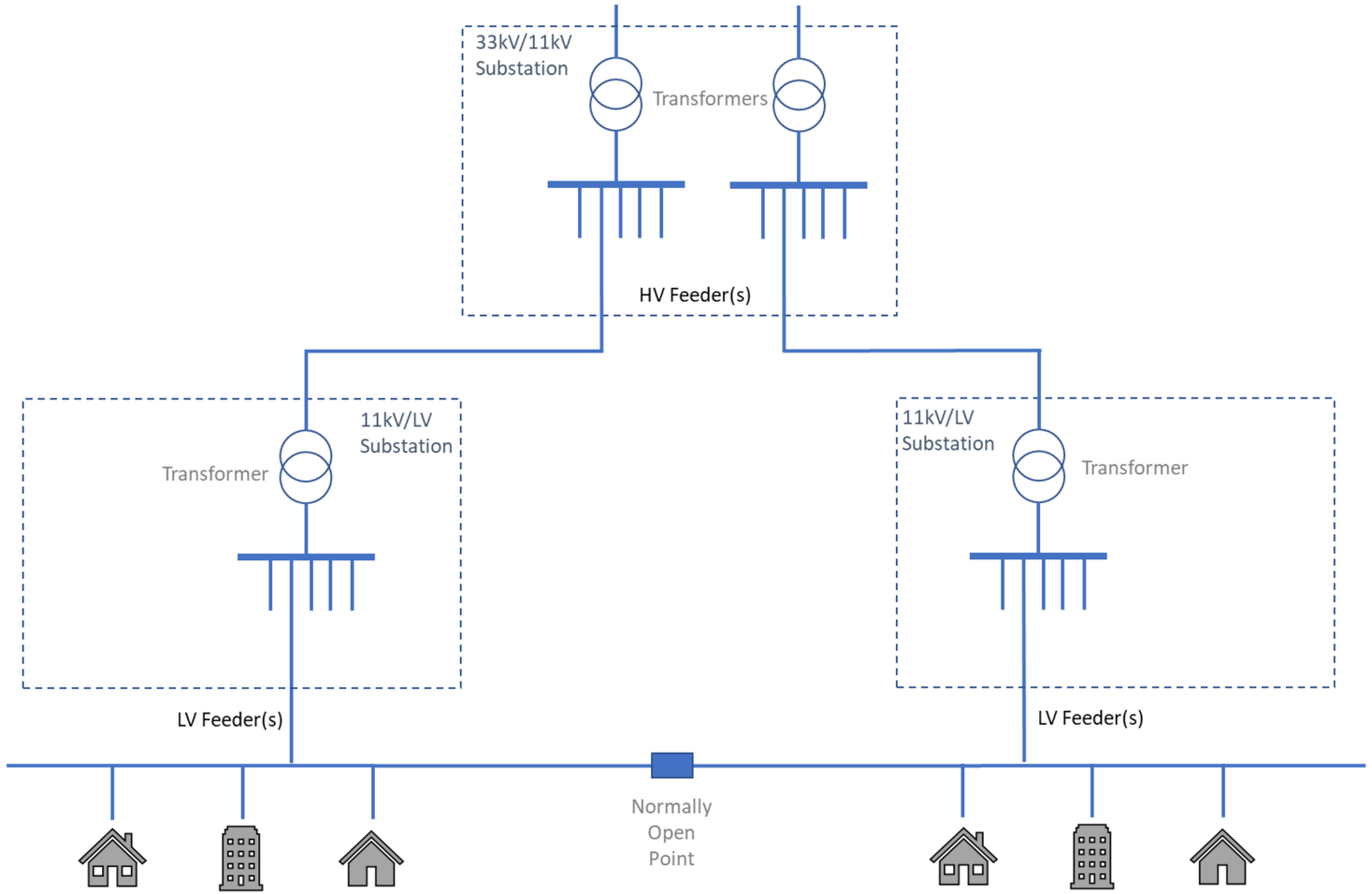
# SYSTEM ARCHITECTURE



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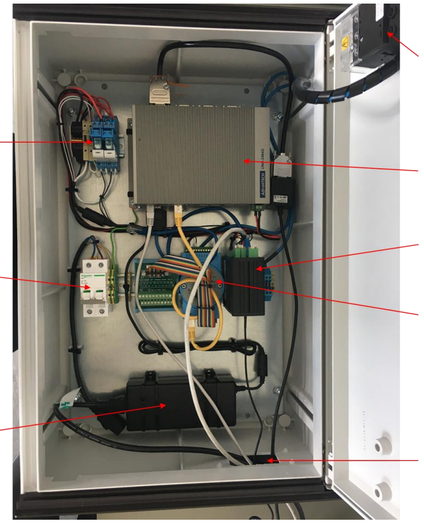
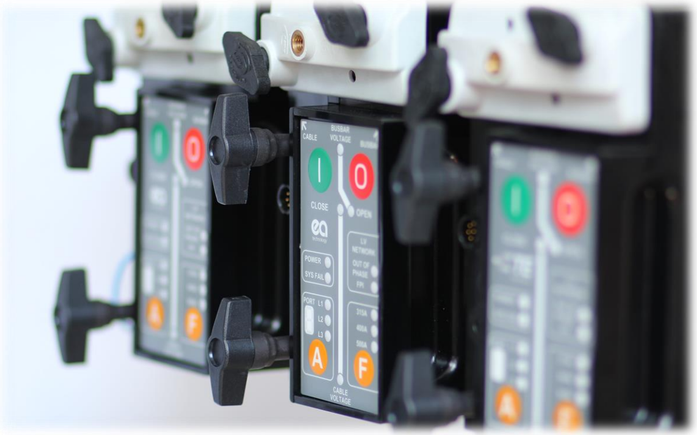
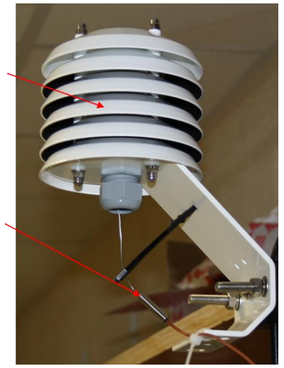
# OPENLV HARDWARE

- Intelligent Substation Device (ISD) Enclosure
  - LV-CAP™ platform
  - Communications
- Monitoring
  - Lucy Electric GridKey MCU520
  - Thermocouple sensors
- LV Network Automation
  - ALVIN Reclose™ devices



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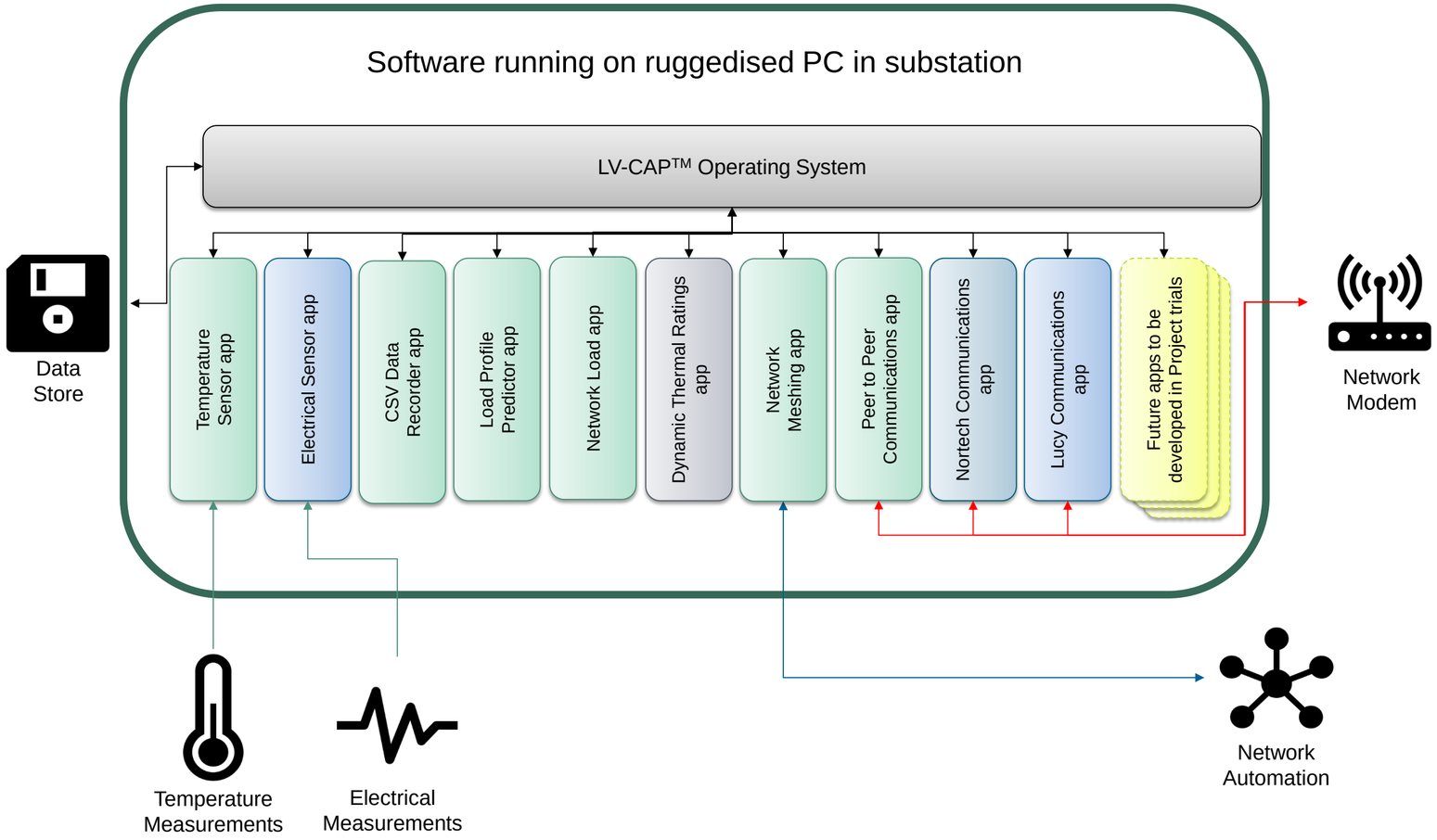
# OPENLV SOFTWARE



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# WHEN ARE WE DOING IT?

## Phase 1 Mobilise & Procure

- Set Up full Project Team (Jan-17 to Jul-17)

## Phase 2 Design & Build

- Central Infrastructure (Mar-17 to Sep-17)
- Initial Field Tests (Oct-17 to Jan-18)
- Hardware Available for All Methods (Dec-17)

## Phase 3 Trial, Consolidate & Share

- Project Trial Period (Mar-18 to Oct-19)
- Reporting and Dissemination (Nov-19 to Apr-20)

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# CORE DELIVERABLES

**1. Specification, design and Factory Acceptance Testing** of the overall Solution (Oct-17)

**2. Detailed trial design** identification of target networks and assessment of market potential (May-18)

**3. Learning from deployment** of the Solution & standard guidelines for app development (Feb-19)

**4. Learning from the project trials** (Jan-20)

**5. Knowledge capture, dissemination & transfer to BaU** (Apr-20)

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# KEY COMPANIES/SUPPLIERS

WESTERN POWER DISTRIBUTION

regen transforming energy

Centre for Sustainable Energy

nccgroup

impulse
INDUSTRIAL COMPUTING | EMBEDDED SOLUTIONS

nortech
... simple and elegant solutions for monitoring remote assets reliably and economically

ea technology

Promote
Marketing & communication

Lucy Electric

GRIDKEY

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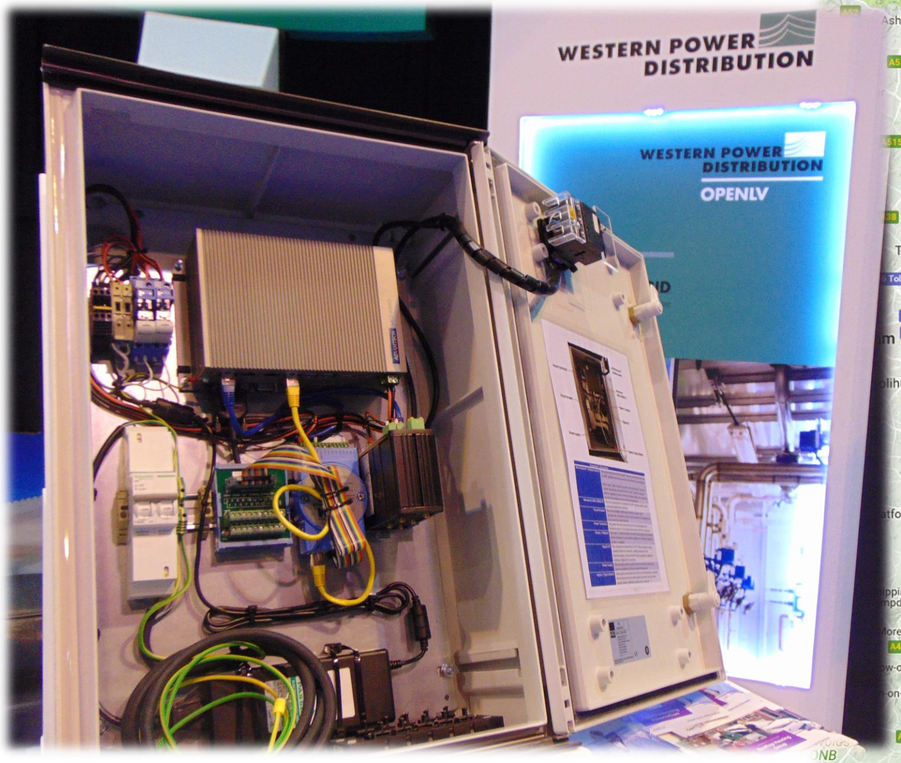
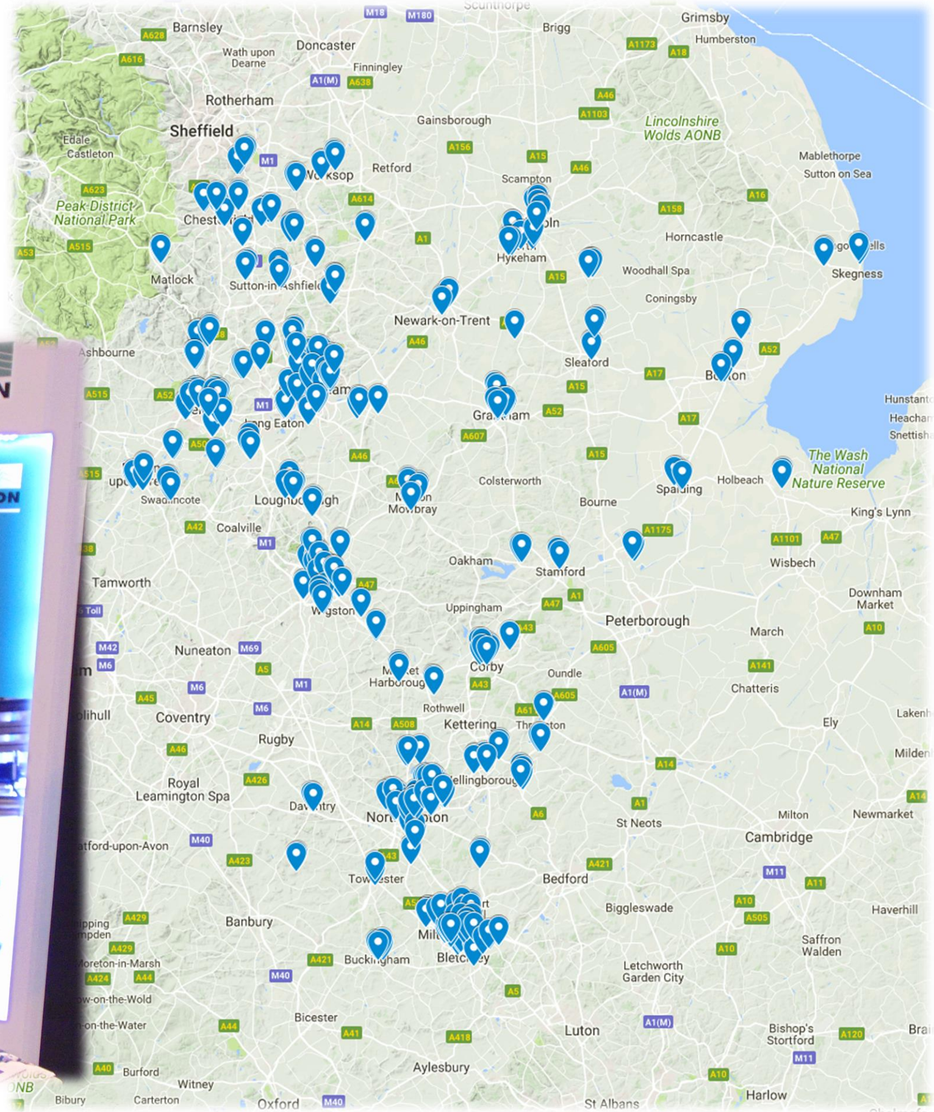
# OPENLV : METHOD 1 - PURPOSE

- Network Assessment
- Capacity Release
- BAU Comparison
- Plus additional specific technical learning.



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# OPENLV: METHOD 1 - DEPLOYMENTS

## Simulation Units

## Autonomous


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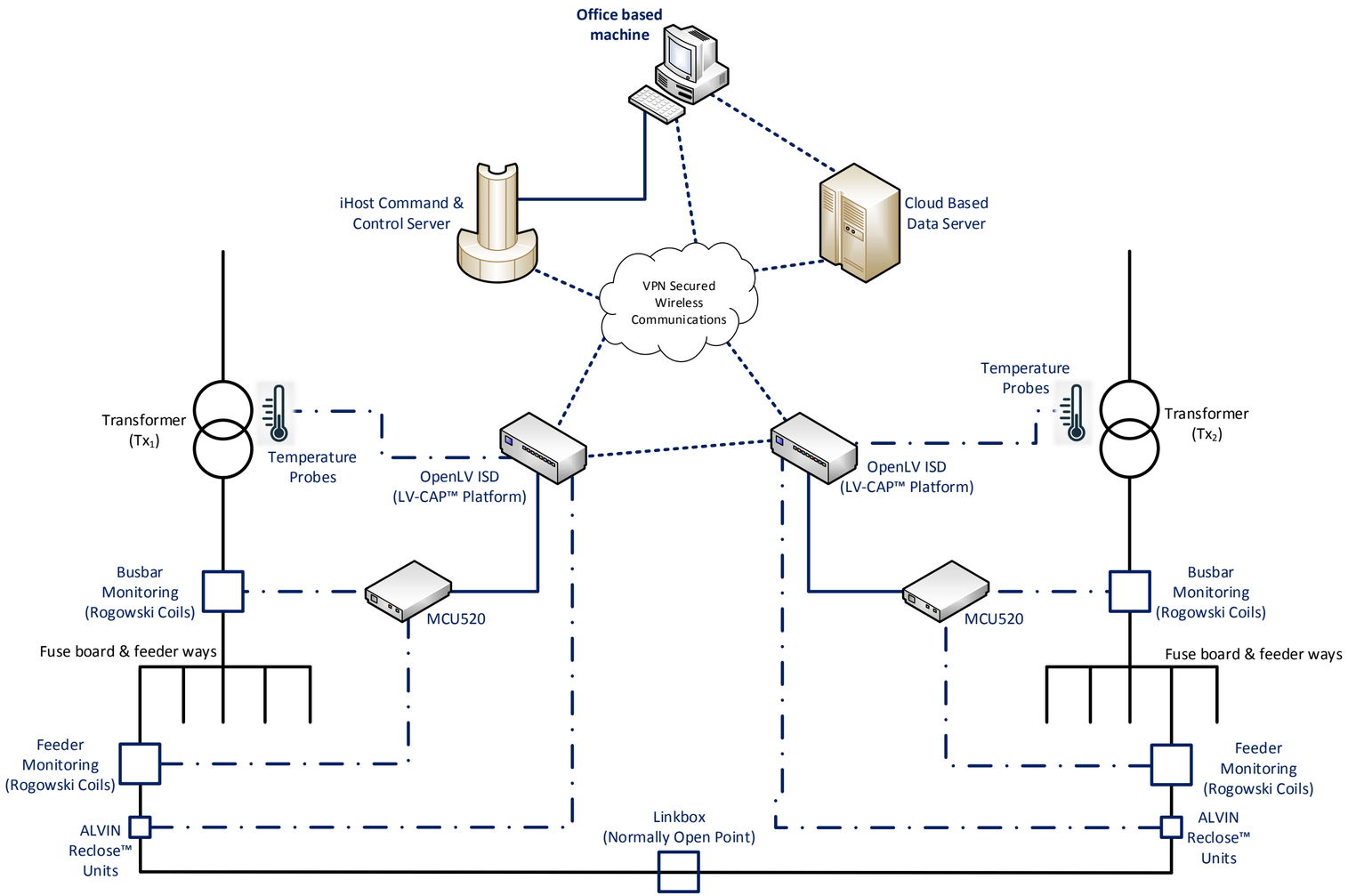
# OPENLV: METHOD 1 – AUTOMATED SWITCHING METHODOLOGY



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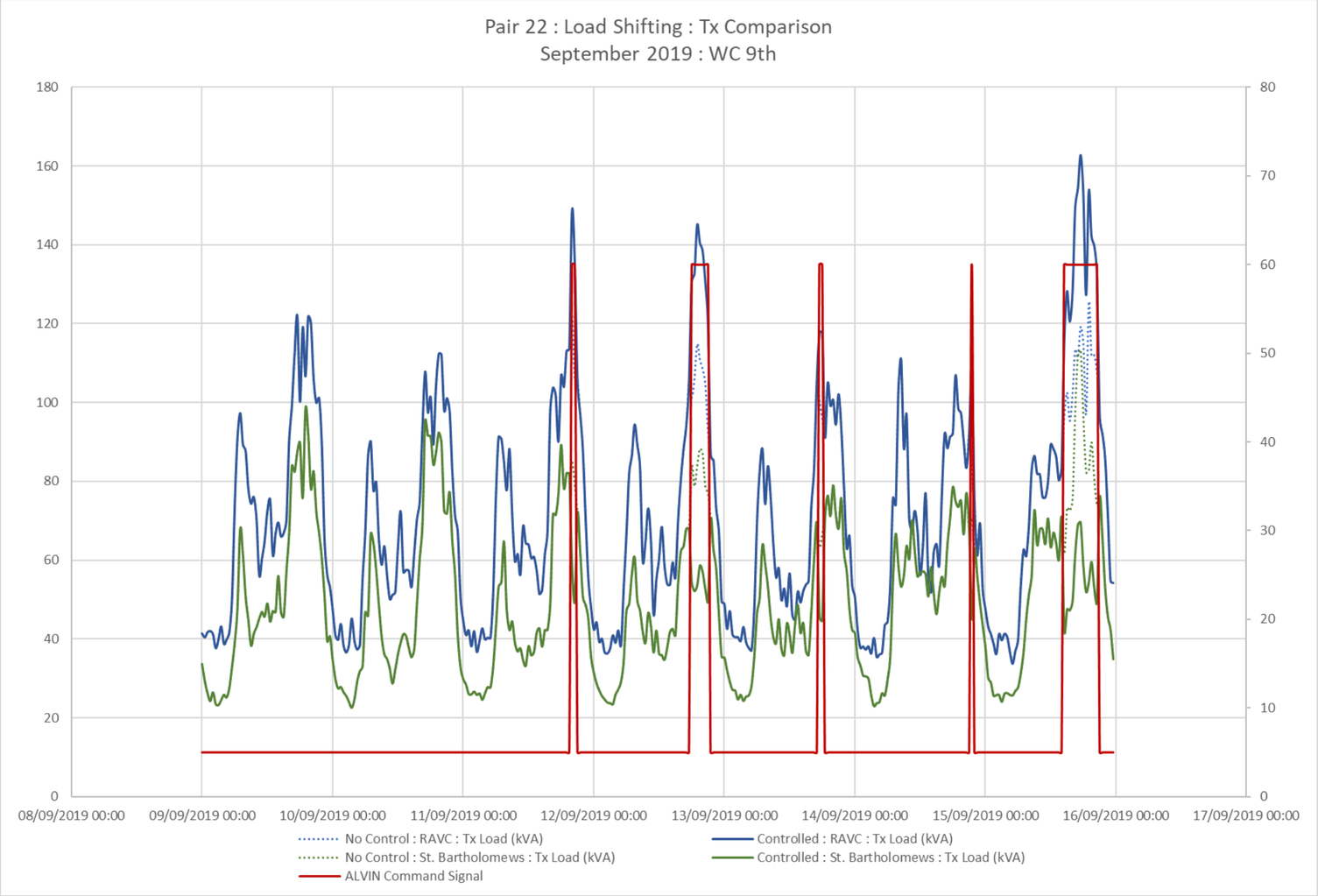
# OPENLV: METHOD 1 – AUTOMATED SWITCHING



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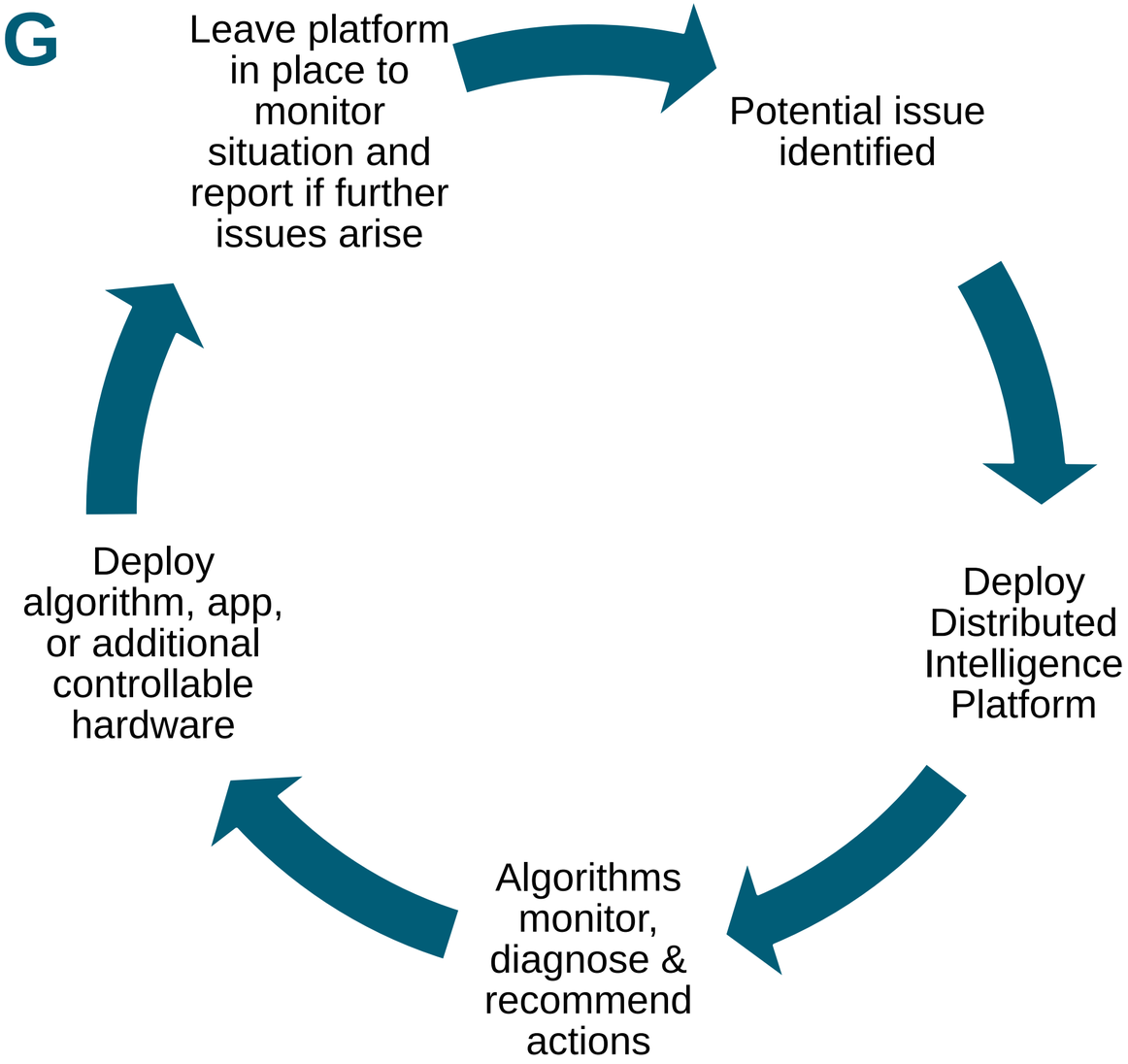
# OPENLV: METHOD 1 – LEARNING

- Method 1 specific:
  - Meshing network as a standalone operation.
  - Dynamic Thermal Rating.
  - Predicting and responding.

- But…
  - Active control sites were chosen to test the ‘proof of concept’ in a safe manner.
  - Not representative of locations that may require support.

- Distributed Intelligence works
  - Reduced data transmission.
  - Deployable to areas with suboptimal communications.
  - Configurable to suit the needs of individual substations.
  - Measurable benefits without human interaction.



# REFRESHMENTS BREAK

# RESUME AT 14.25

WESTERN POWER DISTRIBUTION INNOVATION TEAM

# OPENLV METHOD 2 & 3

## BALANCING ACT CONFERENCE

26TH NOVEMBER 2019

SAM ROSSI ASHTON - INNOVATION & LOW CARBON NETWORKS ENGINEER

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# OVERVIEW OF APPROACH

- 60 community groups expressed interest
- 7 community groups selected
- 10 LV-CAP units made available
- Docker app development
- Community web app development
- Helping community groups interpret the data


centre for sustainable energy

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# PARTICIPATING ORGANISATIONS

| Community Organisation | Location of Trial |
|---|---|
| Bath and West Community Energy (BWCE) | Bear Flat, Bath |
| Exeter Community Energy Ltd (ECOE) | Topsham, near Exeter |
| Marshfield Energy Group | Marshfield Village, South Glos. |
| Owen Square Community Energy (OSCE) | Easton, Bristol |
| Rooftop Housing Group Ltd. | Bishop’s Cleeve, Cheltenham |
| Tamar Energy Community (TCE) | Tavistock, Devon |
| Yealm Community Energy (YCE) | Newton Ferrers, Devon |


**Community group locations (purple markers)**

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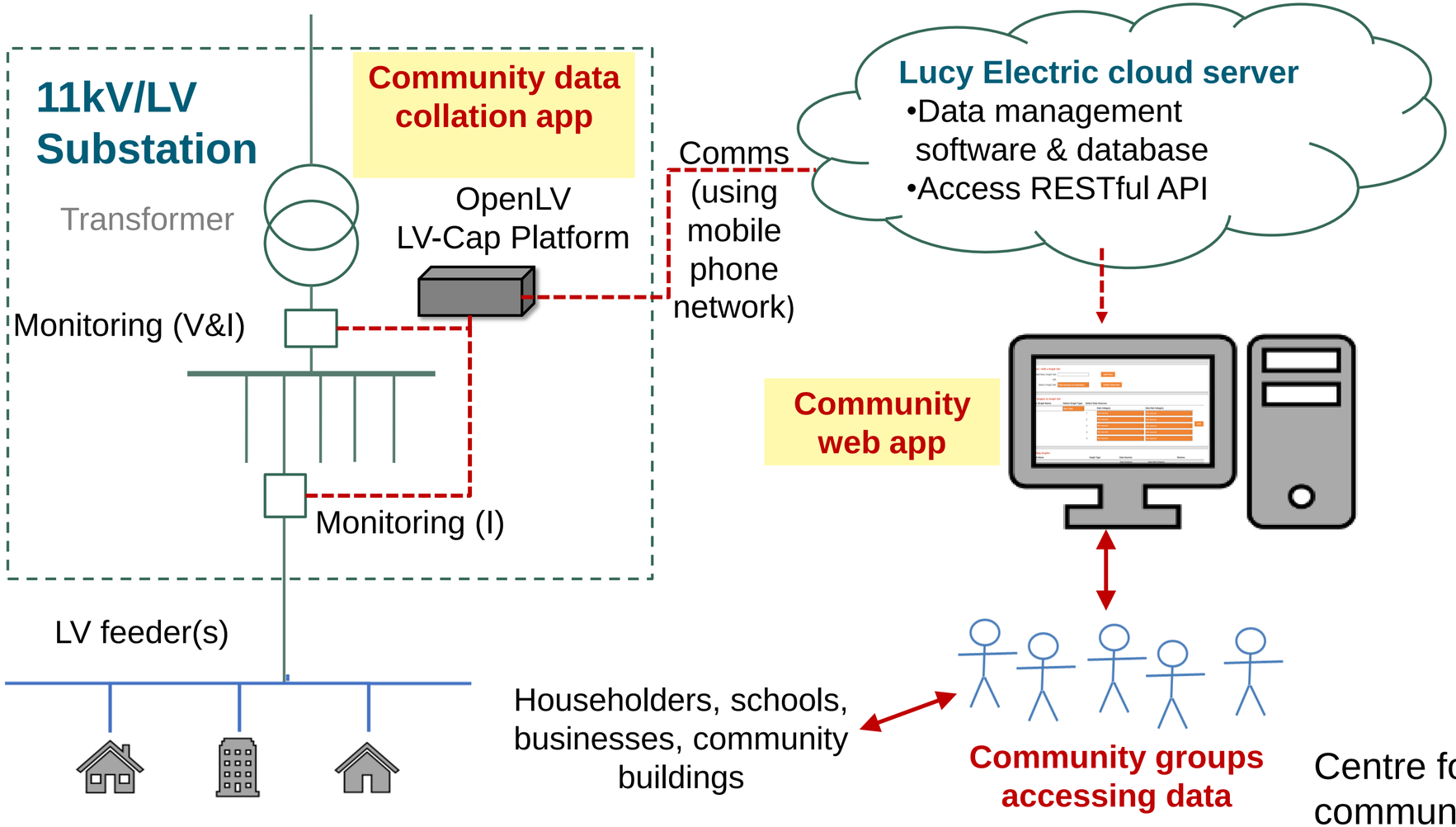
# COMMUNITY APPLICATIONS




Centre for Sustainable Energy community apps shown in yellow

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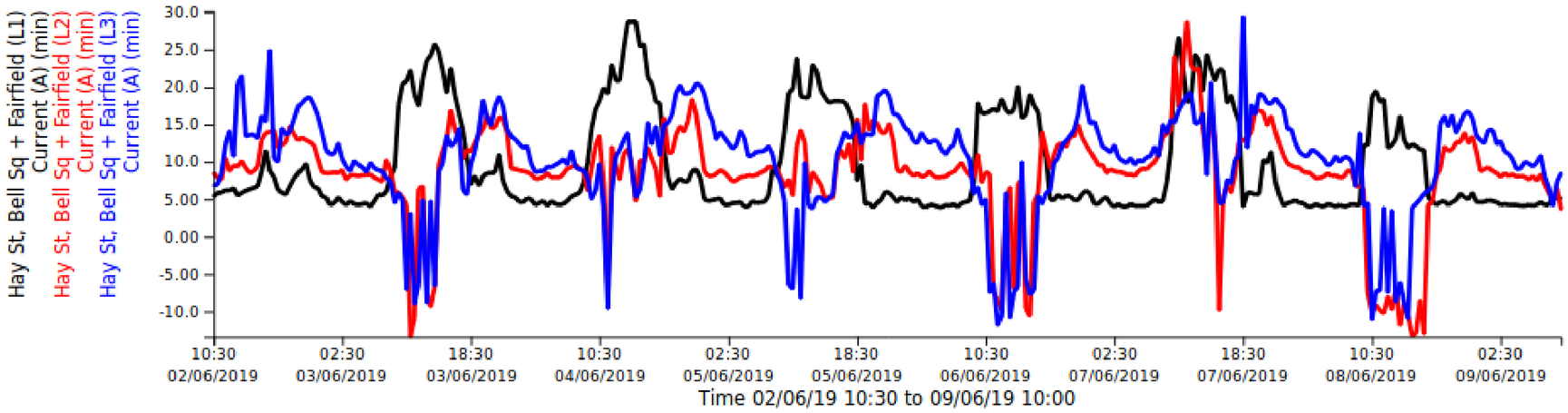
# COMMUNITY DOCKER APP FEATURES

- Deployed into substations via the OpenLV LV-Cap systems
- Collates electrical & temperature measurement readings over 30 minute intervals
- Available readings are voltage, phase, current & temperature and derived values, power & energy; Current is signed and power and energy are divided into active and reactive
- App generates min, mean, max, standard deviation and count outputs for each measurement type
- As deployment to substations takes some time, the approach used was minimise the number of deployments by creating as simple an app as possible, treating each measurement type identically and doing more complex processing after the data is transferred from substations

Current



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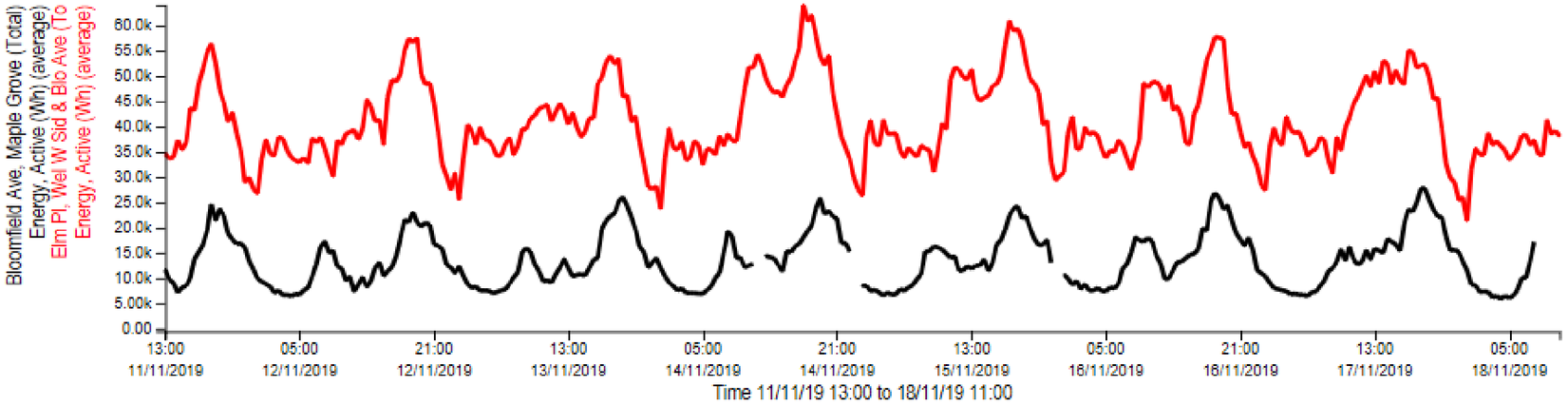
# COMMUNITY WEB APP FEATURES

- Collect measurement data from the Docker app via the Lucy cloud system
- Visualise the data through configurable line & bar graphs and smileys
- Set up and model different electricity tariffs, inc. time-of-use
- Send alerts, receive reverse-alerts
- Amalgamate data from multiple sources
- Embed graphs into community group websites using html iframe
- Export data via a RESTful JSON API and via HTML tables
- Accessibility

- Access 3rd party APIs to give:
  - Grid carbon production for energy used by combining active energy with grid carbon intensity
  - Local renewable energy generation data (where centrally monitored)
  - Estimate local (unmonitored) solar PV generation
  - Local battery storage statistics



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# HOW THE DATA FACILITATED PROJECTS

- Delivering school workshops and public events
- Embedding graphs in community websites
- Alerts used for awareness raising
- Comparing local electricity use with renewable energy generation
- Generating support for future renewable energy installations
- Helping with behaviour change initiatives and switching to time of use tariffs
- Informing future energy strategies
- Assessing impact of EV rollout and implications for local charging
- Looking at where EV charging points could be installed
- Exploring potential to use demand shifting to move to more electrification of heat
- Investigating future potential for selling aggregated flexibility services

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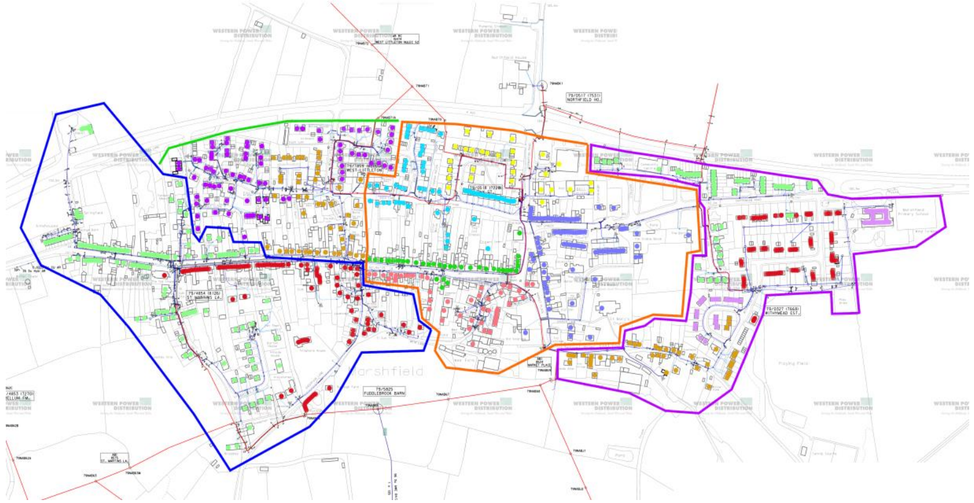
# MARSHFIELD DATA ANALYSIS CONCLUSIONS

- It could be possible to install a further **138 5kWp solar PV installations**
- If this were all installed, together with existing PV and wind generation in the village, the yield could be around **830MWh electricity per year**
- On average, this would provide for about **16% of the EV charging demand** if EVs were used for all current journeys, or 100% of travel by e-bike
- **106 EV charge points could be installed** allowing ‘charging on demand’
- **Battery storage could be used to balance out peaks** in generation and demand, but may not be the most cost effective way to reduce carbon emissions
- Switching residents **to time of use tariffs will help to reduce carbon emissions and electricity costs** (on average by £60 from a standard tariff, and by £95 from Economy 7)

**Marshfield: A village of approx. 750 houses in rural South Gloucestershire**

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# OVERALL KEY FINDINGS

- LV electricity data can be accessed via web apps and can result in benefits for communities
- High level of interest from communities in accessing electricity data
- Selection of substations more complicated than anticipated
- Neighbourhood boundaries differ to substation coverage
- Feeder maps seen as a useful resource for engagement
- Community development work takes time
- Data losses impacted on levels of engagement
- Understanding of electricity data is not high amongst the general public
- Relatable narratives are needed to explain the data
- Few voluntary groups have the expertise and resources for complex software development work

# OPENLV METHOD 2

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## 1. TRANSPARENCY VALUE

## 2. ENGAGEMENT VALUE

## 3. FLEXIBILITY VALUE

regen
transforming energy

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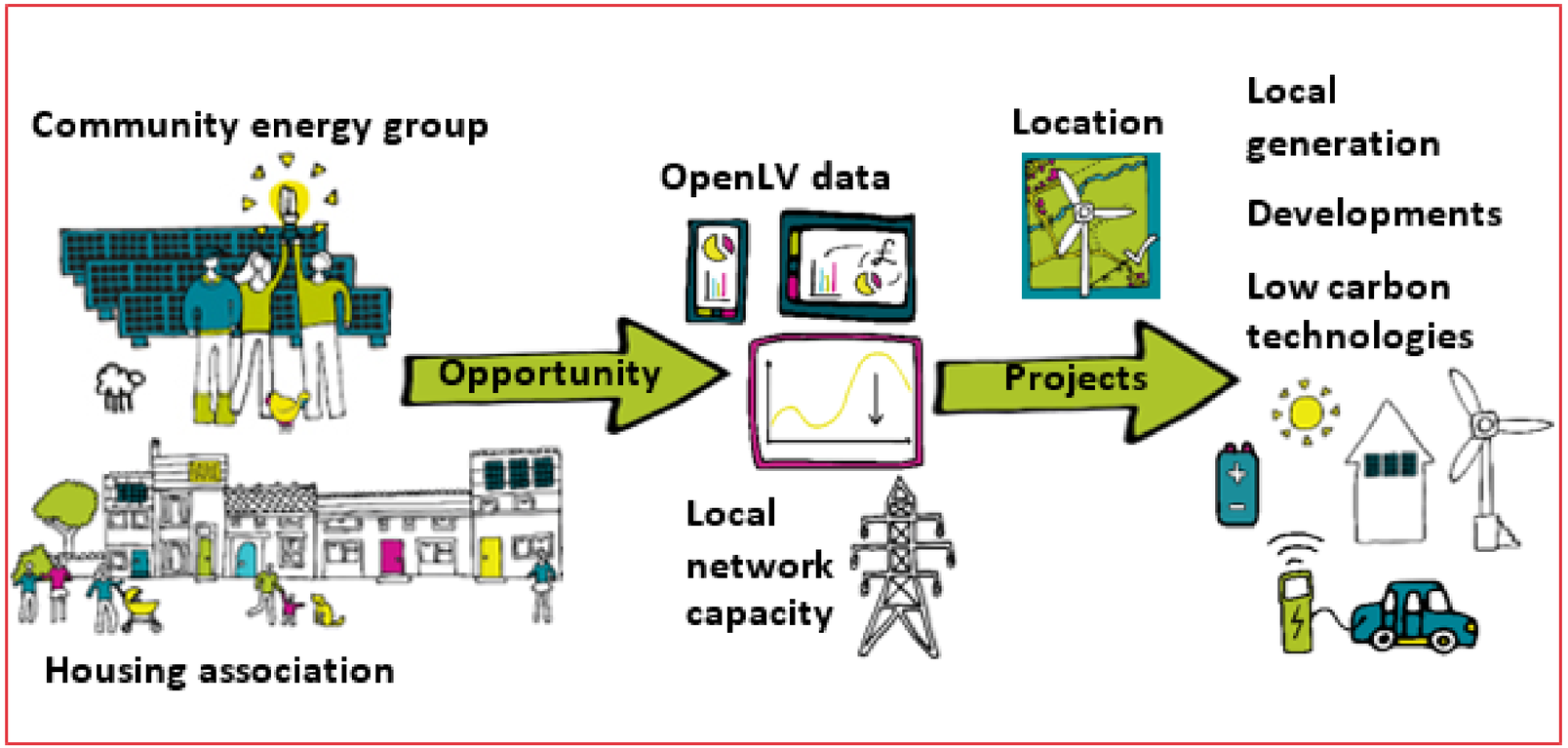
# TRANSPARENCY VALUE

**Communities use OpenLV data to locally assess their plans for distribution connected projects and investments.**

- Owen Square and Marshfield Village
- Rooftop Housing Group
- Contextual information (e.g. local spare capacity



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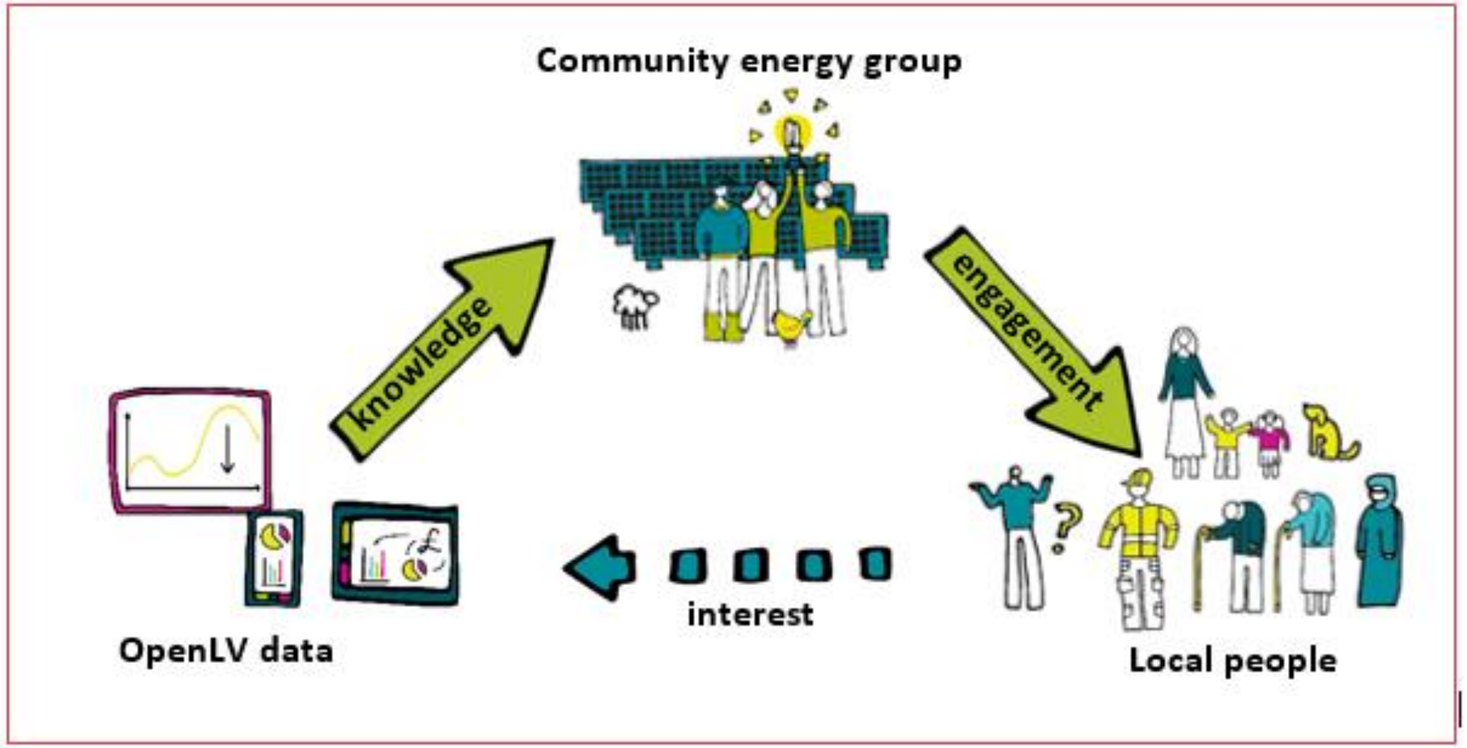
# ENGAGEMENT VALUE

**OpenLV data helps build community knowledge on energy use and energy infrastructure.**

- TEC, Yealm
- Shows people how they are connected as a community and interest those not naturally interested in energy
- A community smart meter
- Understanding need for TOUT or smart charging and community impacts
- Need some level of existing knowledge



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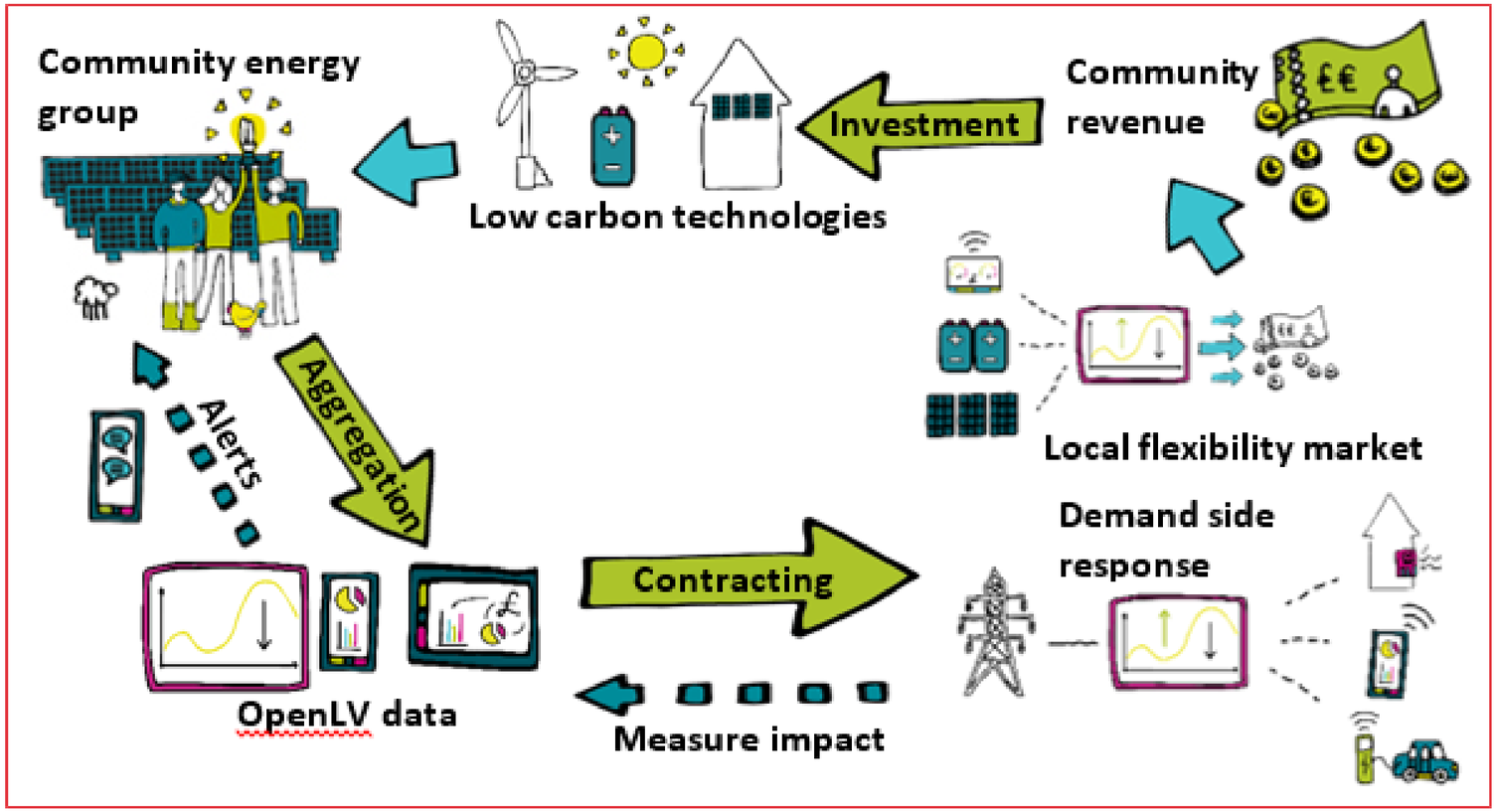
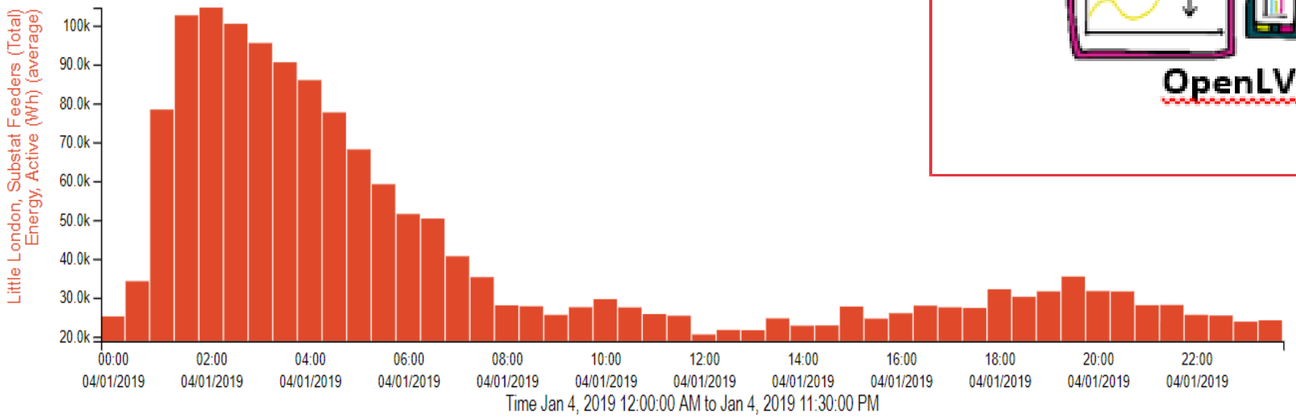
# FLEXIBILITY VALUE

**OpenLV data and functionality supports community level aggregation and coordination of community level demand-side response.**

- BWCE, WHG
- Theoretical work as a community aggregator with benefits back to the community
- Cost saving over traditional aggregation
- Would rely on having significant loads, EVs etc.



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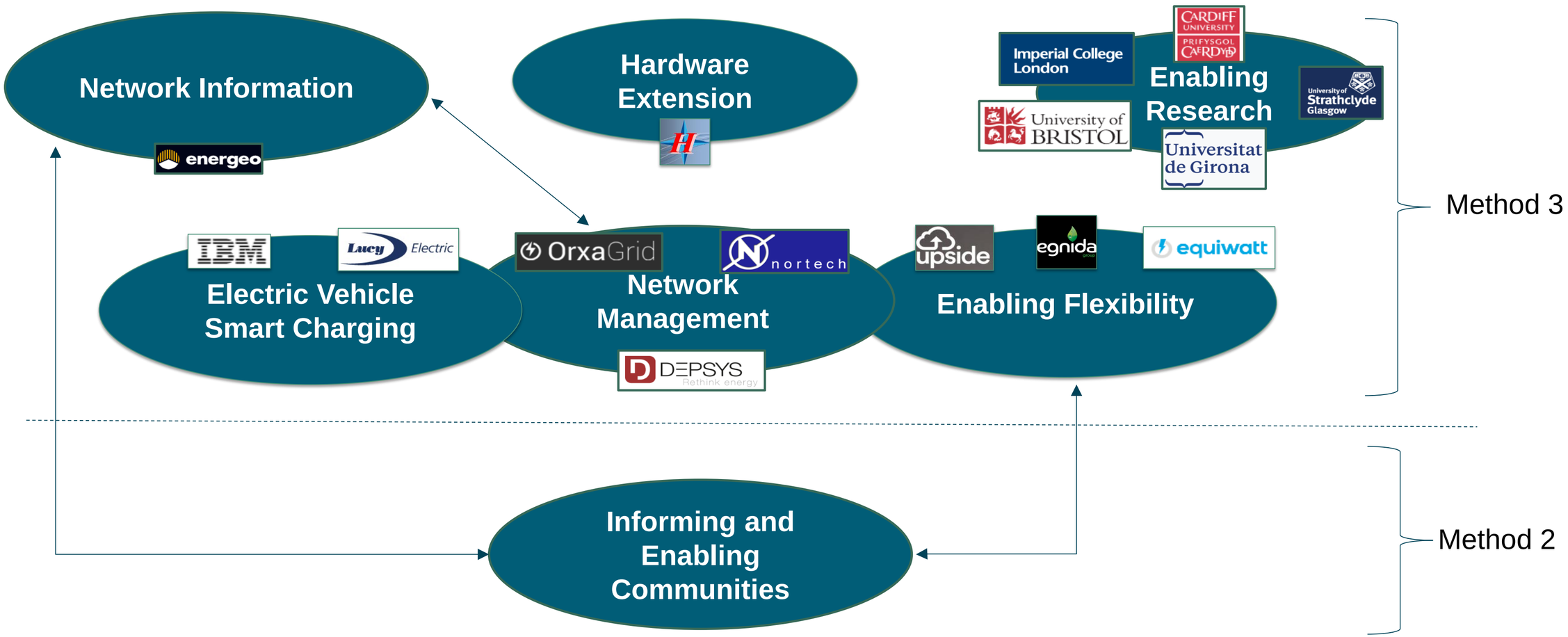
# METHOD 2 & 3: COMMUNITY, BUSINESS'S & ACADEMIA – USE CASES



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# WHAT HAVE WE LEARNT?

Do people want to use data?

How difficult was development?

Are people willing to develop apps?

How was the data used?

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# CASE STUDY – PRXA FRID – VOLTAGE FORECASTING APPLICATION

OrxaGrid

London South Bank University

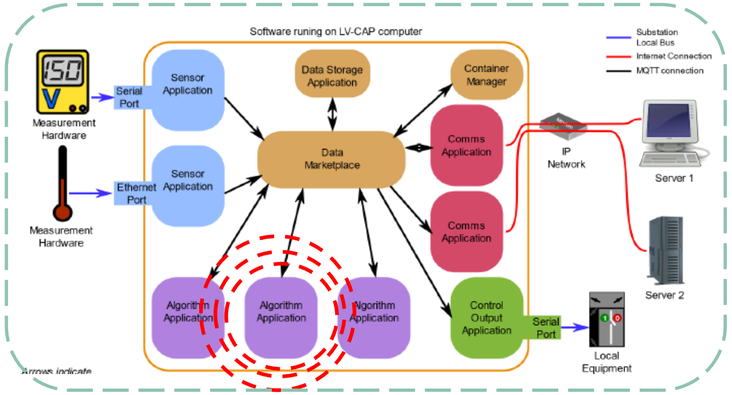
**Key Features**

Day ahead half-hourly voltage orecast
Alerts raised for predicted ESQCR violations
Supervised offline batch training
Incremental online learning model

**Constraints**

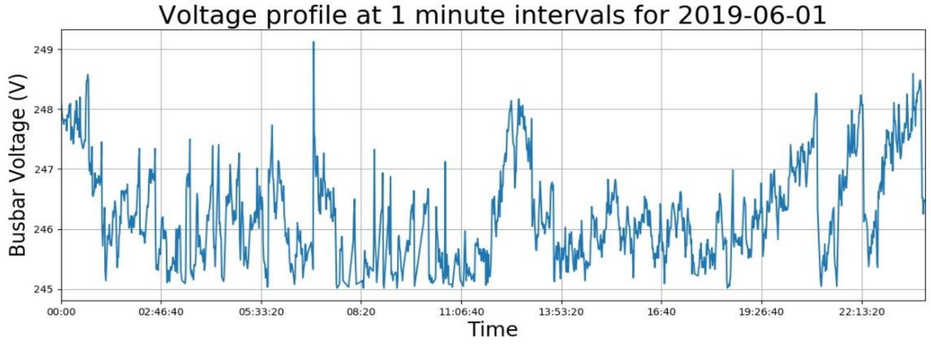
- No external APIs (weather forecast)
- Limited compute resource (RAM, CPU, disk)

Containerised Deployment

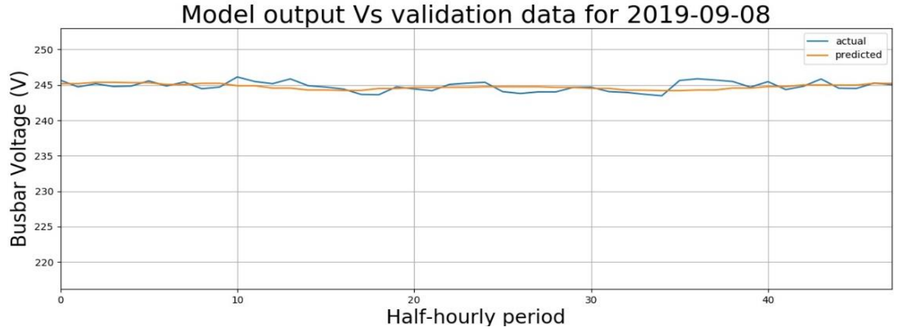



Our Application

**Inputs**




**Outputs**




**Result**

- Root Mean Square Error: 0.668 V
- Confidence: +/- 1.433 V

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# CASE STUDY – ORXA GRID

**OpenLV platform aspects used**

- Sensor outputs
- Compute resources of server
- Data marketplace
- Development tools

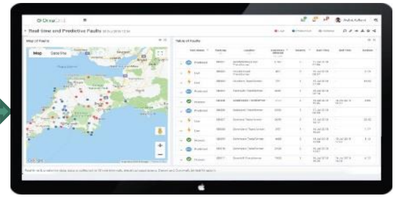
**Challenges**

- Asynchronous performance
  - Data and commands at same time
- New technologies to learn
  - Docker, MQTT
- No real-time access to outputs or log files

**How was the data used**

- Raise automated alerts on predicted voltage
- Sags / swells
  - Tap changer stucK


LV-CAP (algorithms) → OpenLV Cloud API →



**Successes**

- Accepted as method 3 participant
- Completed data share agreement
- Adapted our algorithm for OpenLV
- Passed tests
- Deployed

**Next steps**

- Adapt more of our algorithms onto OpenLV framework
- Configure our hardware to work with OpenLV
- Publish on results achieved
- Partner with other contributors
- Explore connecting OpenLV API to our dashboards

**BAU advantage**

- Develop once for multiple customers
- Deploy at scale
- Focus on algorithms, not infrastructure

OrxaGrid

London South Bank University
EST 1892

# THANK YOU FOR LISTENING

## ANY QUESTIONS?

**SAM ROSSI ASHTON - INNOVATION & LOW CARBON NETWORKS ENGINEER**

WESTERN POWER DISTRIBUTION INNOVATION TEAM

# INNOVATION FORWARD PLAN

## BALANCING ACT CONFERENCE

## 26TH NOVEMBER 2019

JONATHAN BERRY – INNOVATION MANAGER

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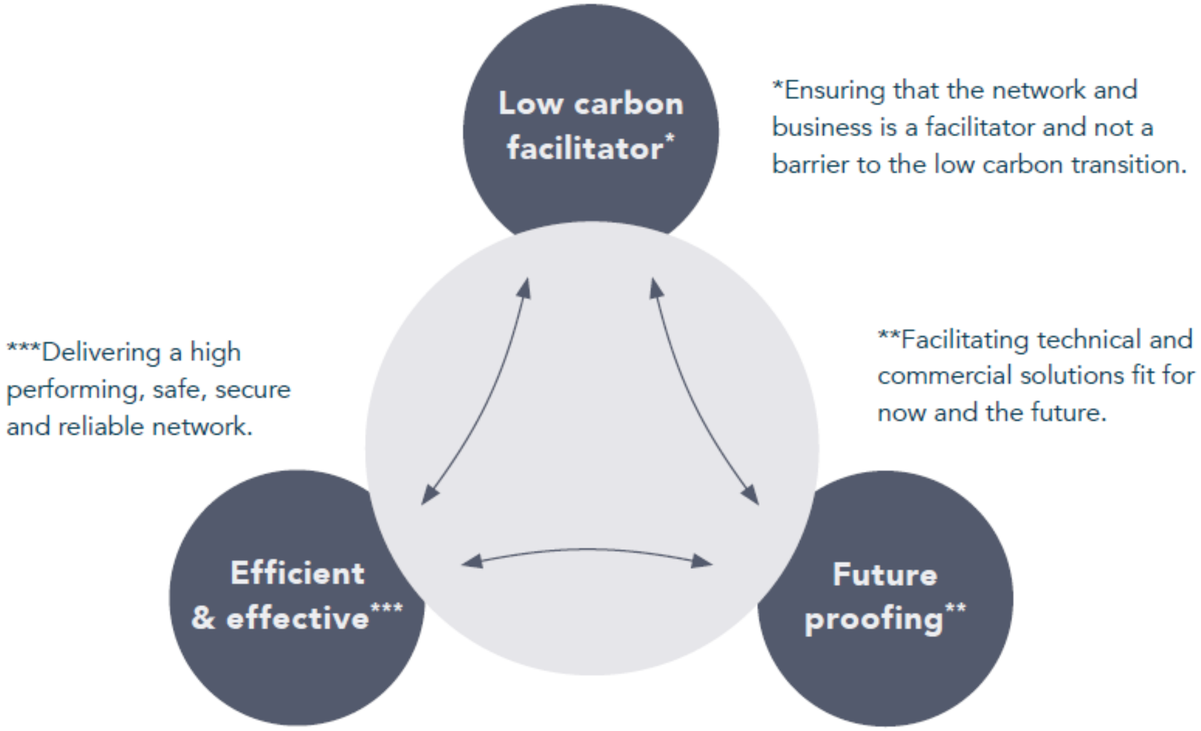
# INNOVATION STRATEGY

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# INNOVATION STRATEGY

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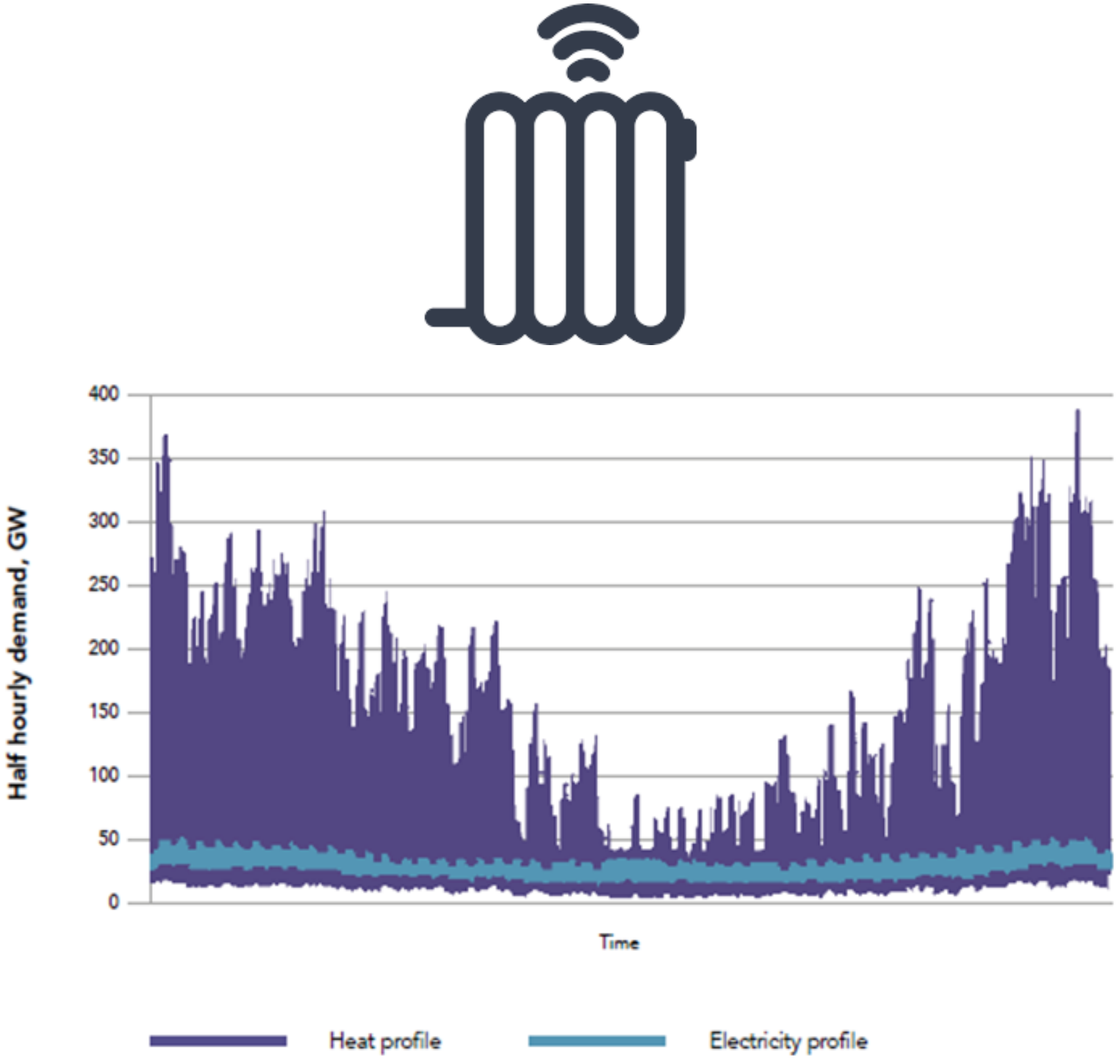
# INNOVATION FORWARD PLAN

- Heat Pump Profiles
- Flexibility from Heat
- Facilitating Hydrogen




*Half hourly heat and electricity demand profiles over a 12 month period*

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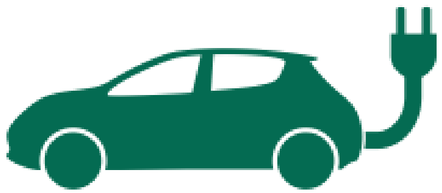
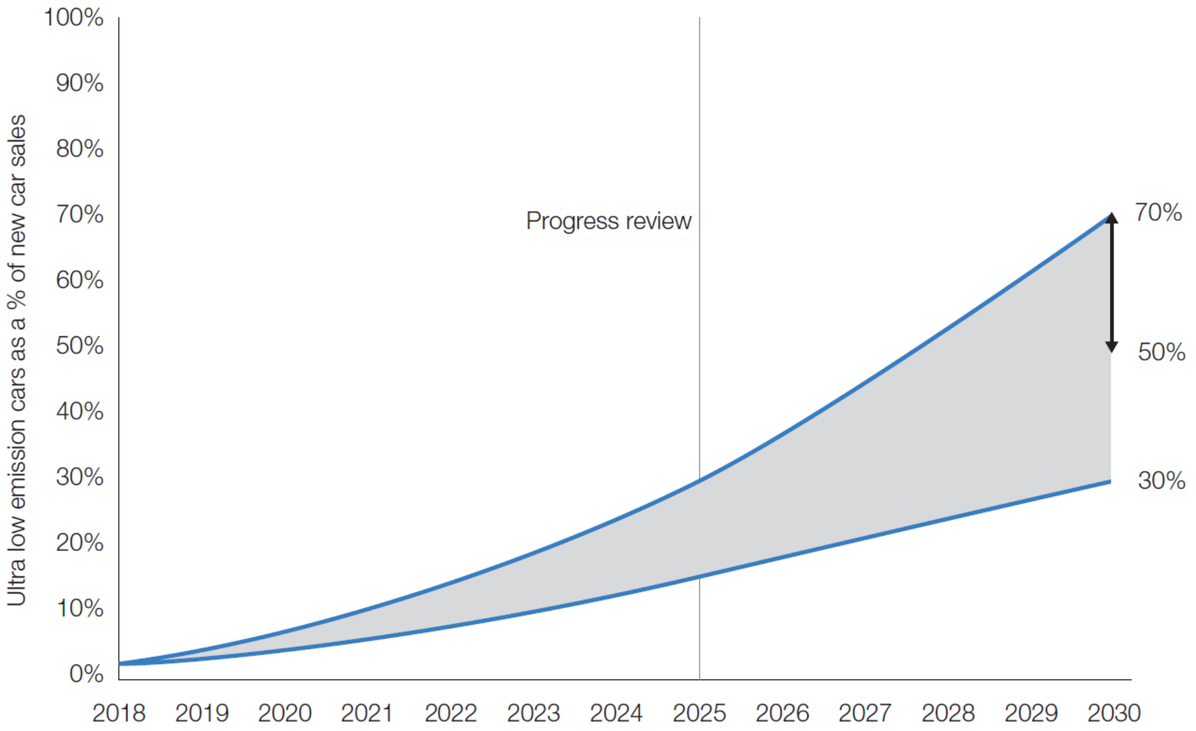
# INNOVATION FORWARD PLAN



- On-street Charging Solutions
- Electrification of Freight
- EV Filling Stations

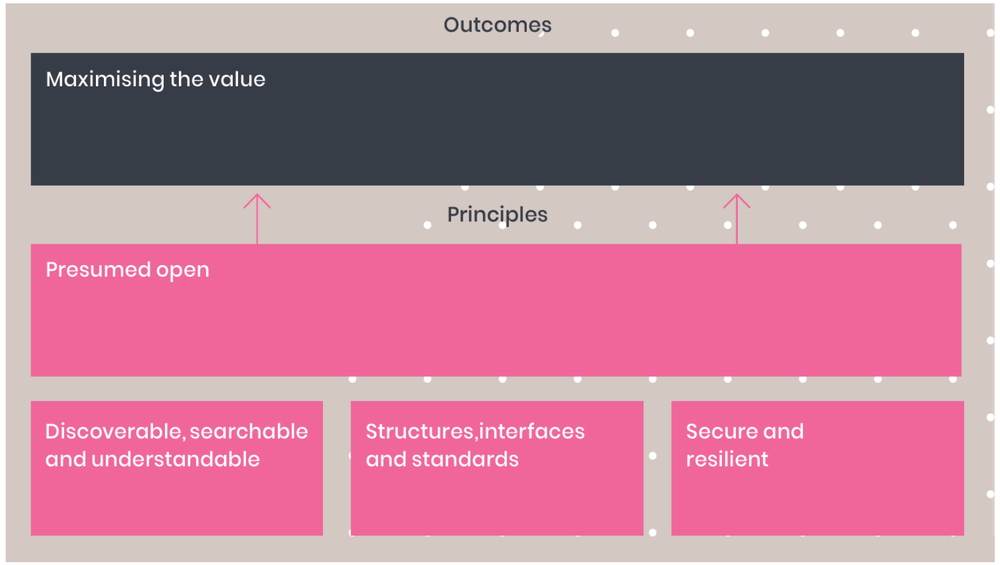



*Illustrative ultra low emissions car uptake trajectory as a percentage of new car sales*

*Road to Zero Strategy*

# INNOVATION FORWARD PLAN

- New Data
- Existing Data
- Openness




*Maximising the Value of Data – Recommendation 2*

*Energy Data Task Force Report*

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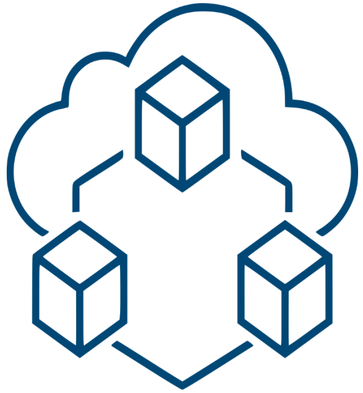
# NIA CALLS

- Existing Data
  - Focussed on increased network knowledge to inform fault and failure prediction
- Call opens – 6th January
- Call closes – 14th February



- All priority areas
  - Heat
  - Transport
  - Data
- Call opens – 6th April
- Call closes – 8th May

# THANK YOU FOR ATTENDING

# HAVE A SAFE JOURNEY