WESTERN POWER DISTRIBUTION

INNOVATION

NEXT GENERATION NETWORKS

Balancing Act Conference

Thursday 5th October 2017

Park Plaza, Westminster

Customer Engagement/Behaviours Panel Session

Chair – Andrew Neeves, Engage Consulting.

Panellists:

Rachel Coxcoon, Centre for Sustainable Energy.

Nick Brooks, OLEV.

Alan Collinson, SP Energy Networks.

Nigel Turvey, Western Power Distribution.

Open LV
Your local electricity data

Opening up the smart grid:

Making energy usage data open access for the first time

5 October 2017 I Balancing Act

Delivered by:
ea technology

WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

Your invitation to access your local electricity data

- How OpenLV fits into Western Power Distribution's innovation plan
  - Mark Dale, Western Power Distribution
- What is OpenLV?
  - Richard Potter, EA Technology
- OpenLV – engaging with communities
  - Rachel Coxcoon, CSE
- OpenLV – engaging with business and academia
  - Gill Nowell, EA Technology
- OpenLV - the movie
- Q&A

OpenLV Your local electricity data

How OpenLV fits within Western Power Distribution's innovation plan

Mark Dale, Western Power Distribution

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WESTERN POWER DISTRIBUTION
INNOVATION

NEW

WESTERN POWER DISTRIBUTION HARP
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
WESTERN POWER DISTRIBUTION EFFS
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

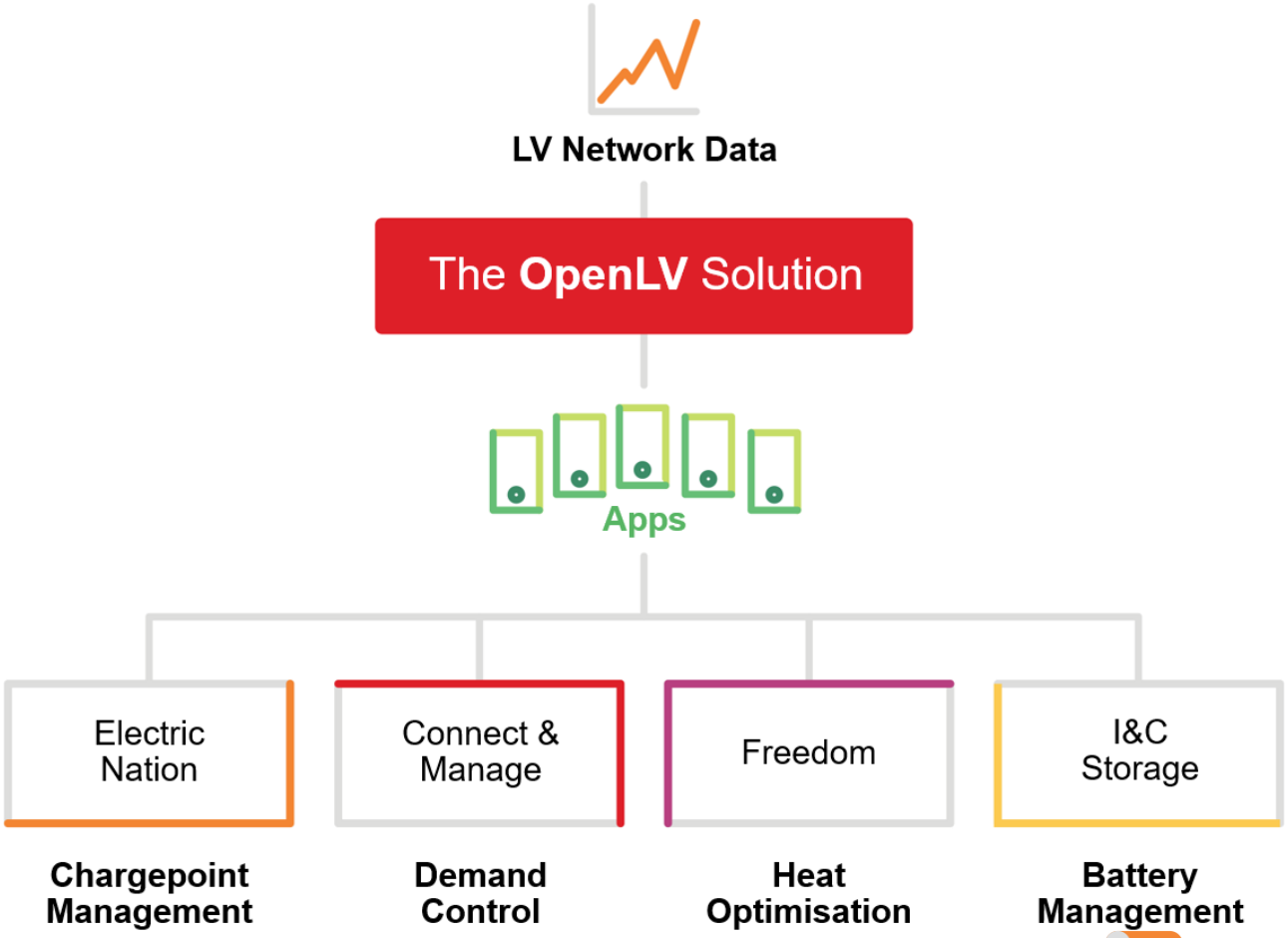
- Reliability
- Forecasting
- DSO
- DSR
- GBSO Interface
- Efficiency
- SHE and Security

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
- Electric Nation *(formerly CarConnect)*
- Industrial & Commercial Storage
- Smart Systems and Heat[2]
- 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
- Losses Investigation

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

Low Voltage (LV) Network Innovation



Open LV

The project team

WESTERN POWER DISTRIBUTION

regen
transforming energy

Centre for Sustainable Energy

nccgroup

impulse
INDUSTRIAL COMPUTING | EMBEDDED SOLUTIONS

ea technology

Promote
Marketing & communication

Lucy Electric

GRIDKEY

Open LV Your local electricity data

What is OpenLV?

Richard Potter, EA Technology

Delivered by:

ea technology

WESTERN POWER DISTRIBUTION

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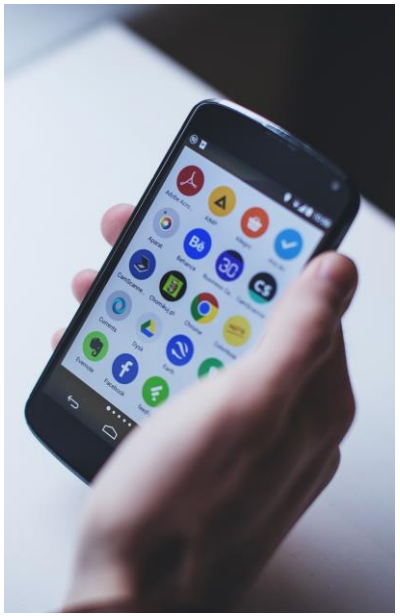
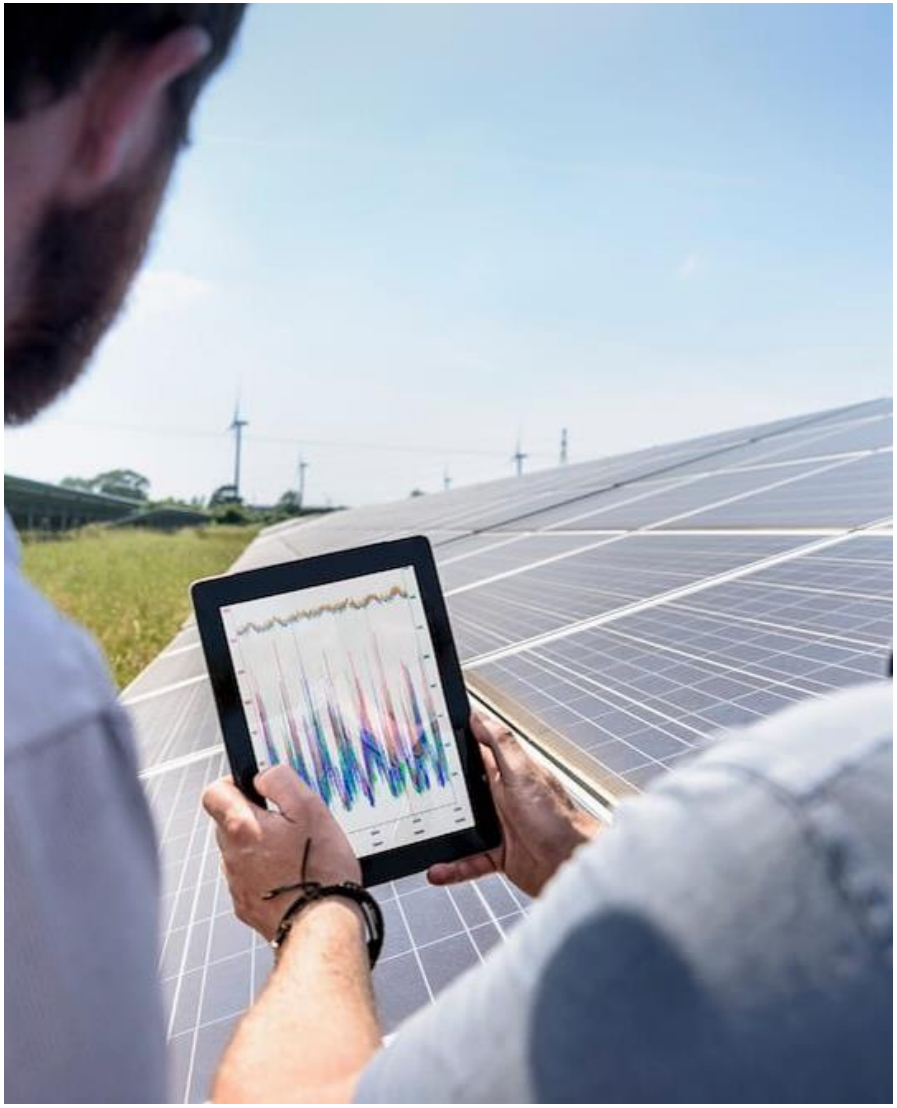
Project overview

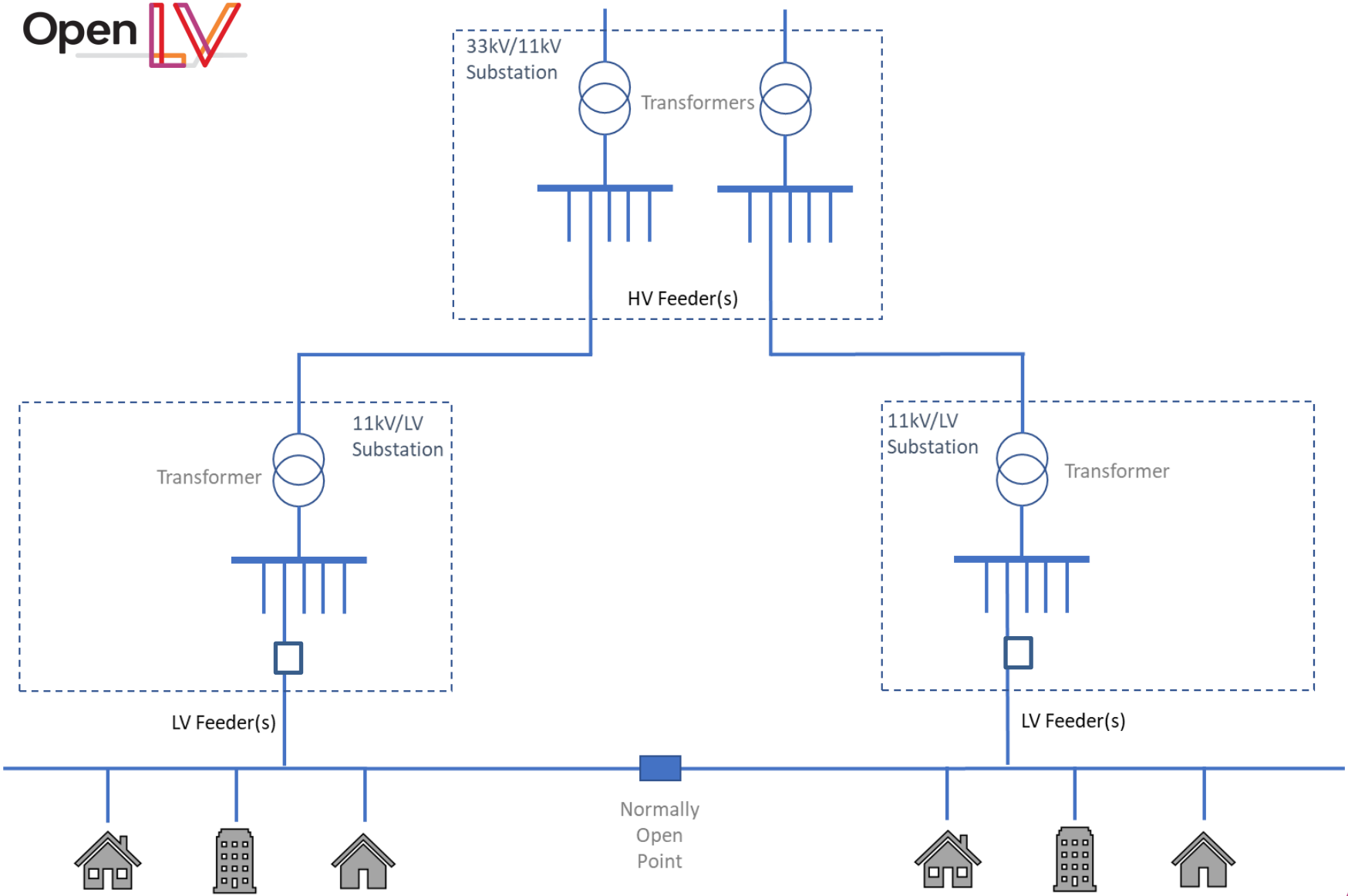
- Project Aims:
  - To trial an open, flexible platform that could be deployed to every Low Voltage (LV) substation in Great Britain
  - To demonstrate the platform's ability to provide benefits to the network, customers, commercial entities and research organisations
- Timescales: December 2016 to April 2020
- Funding Source: Network Innovation Competition
- Value: £5,925,000
- Project host: Western Power Distribution
- Delivery Lead: EA Technology

The concept





Systems Architecture



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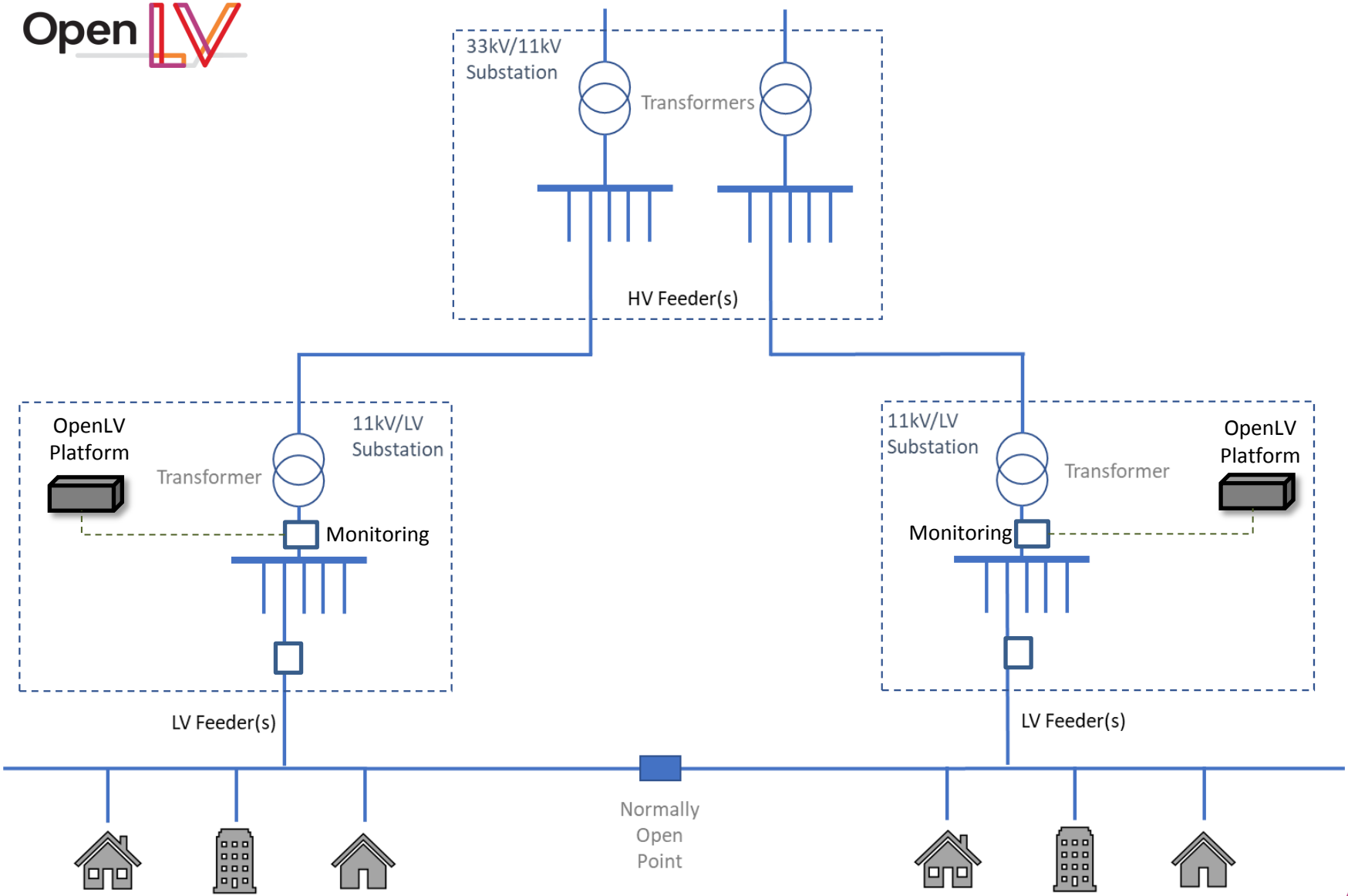

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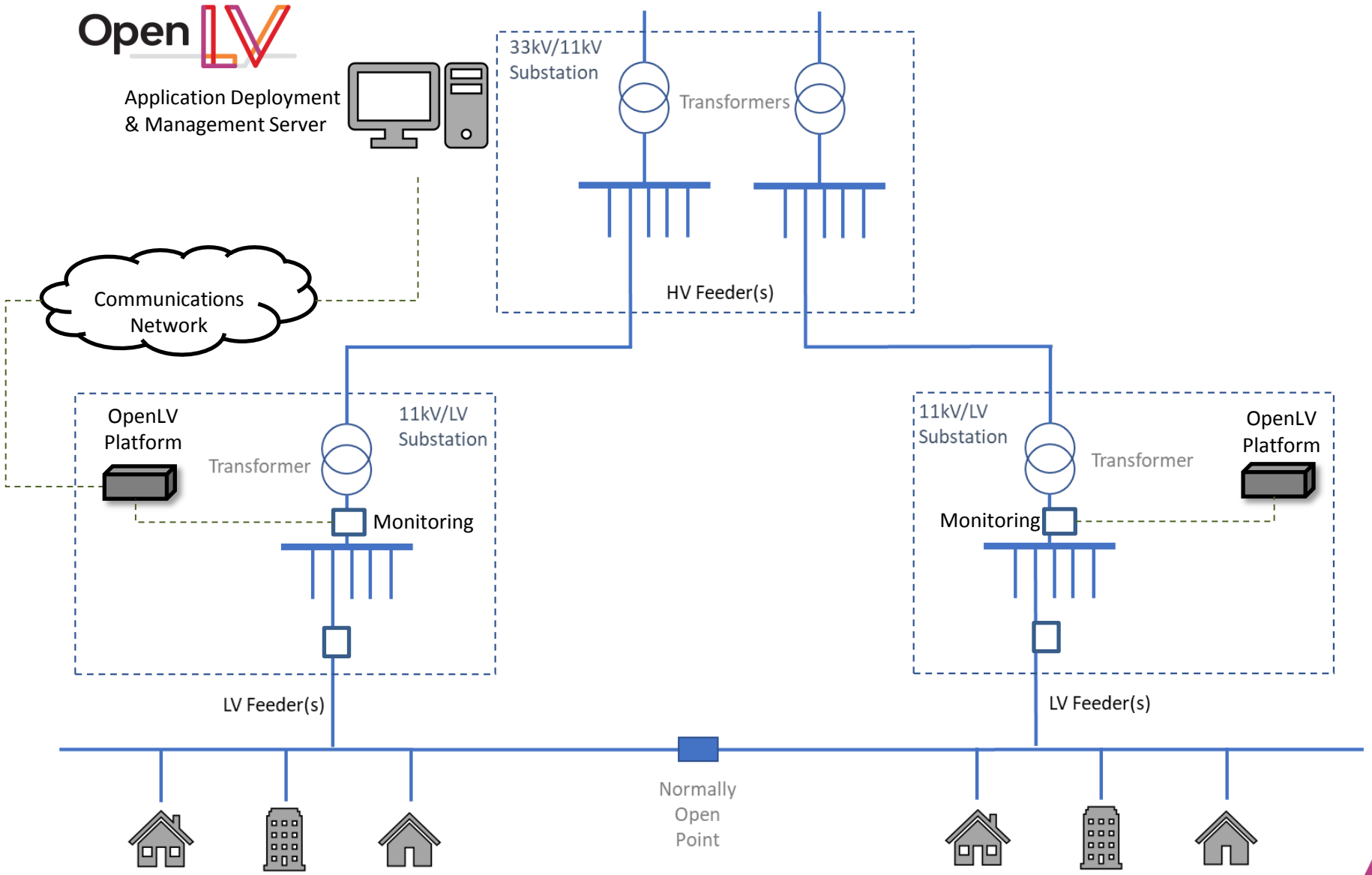

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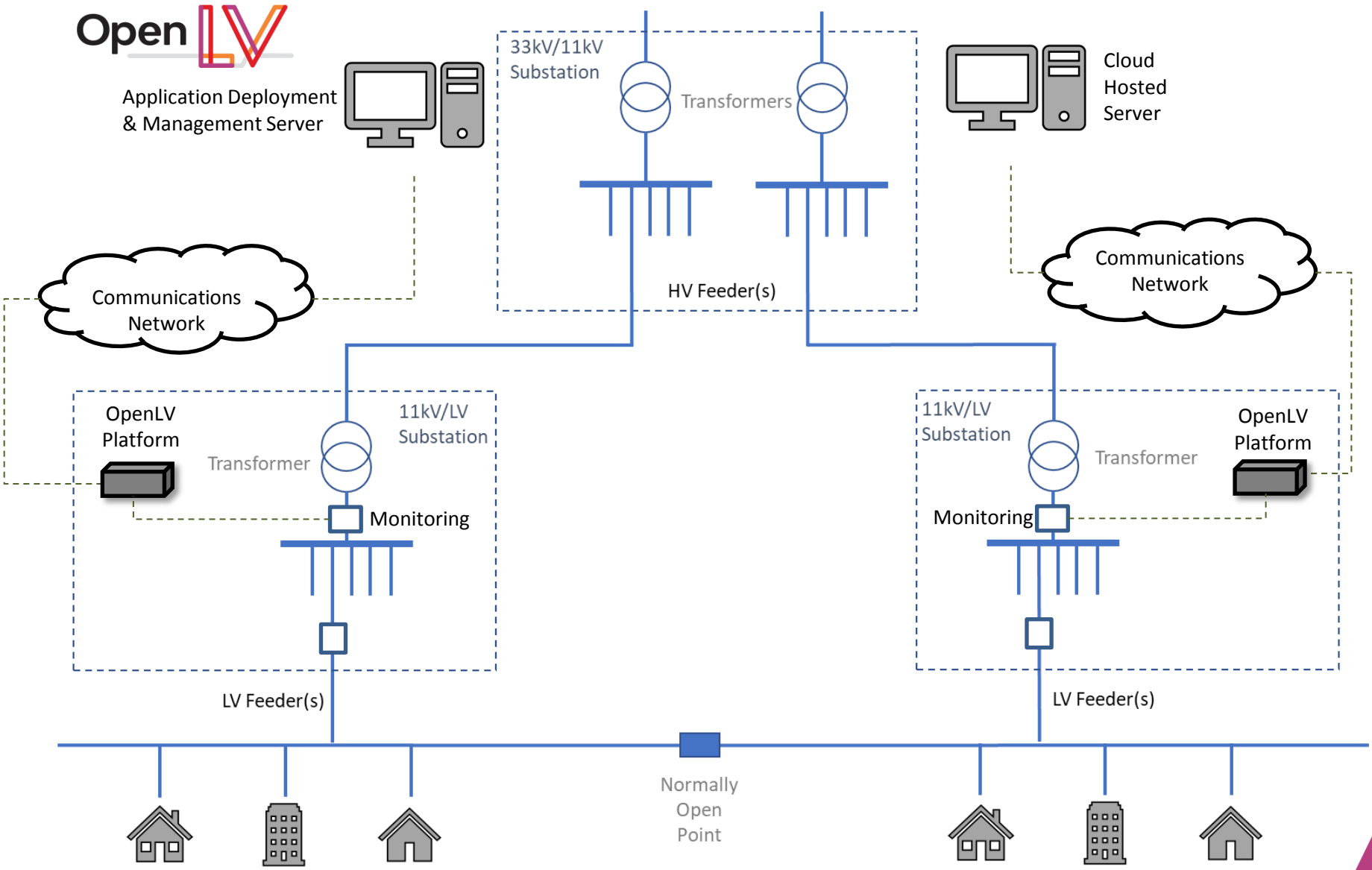

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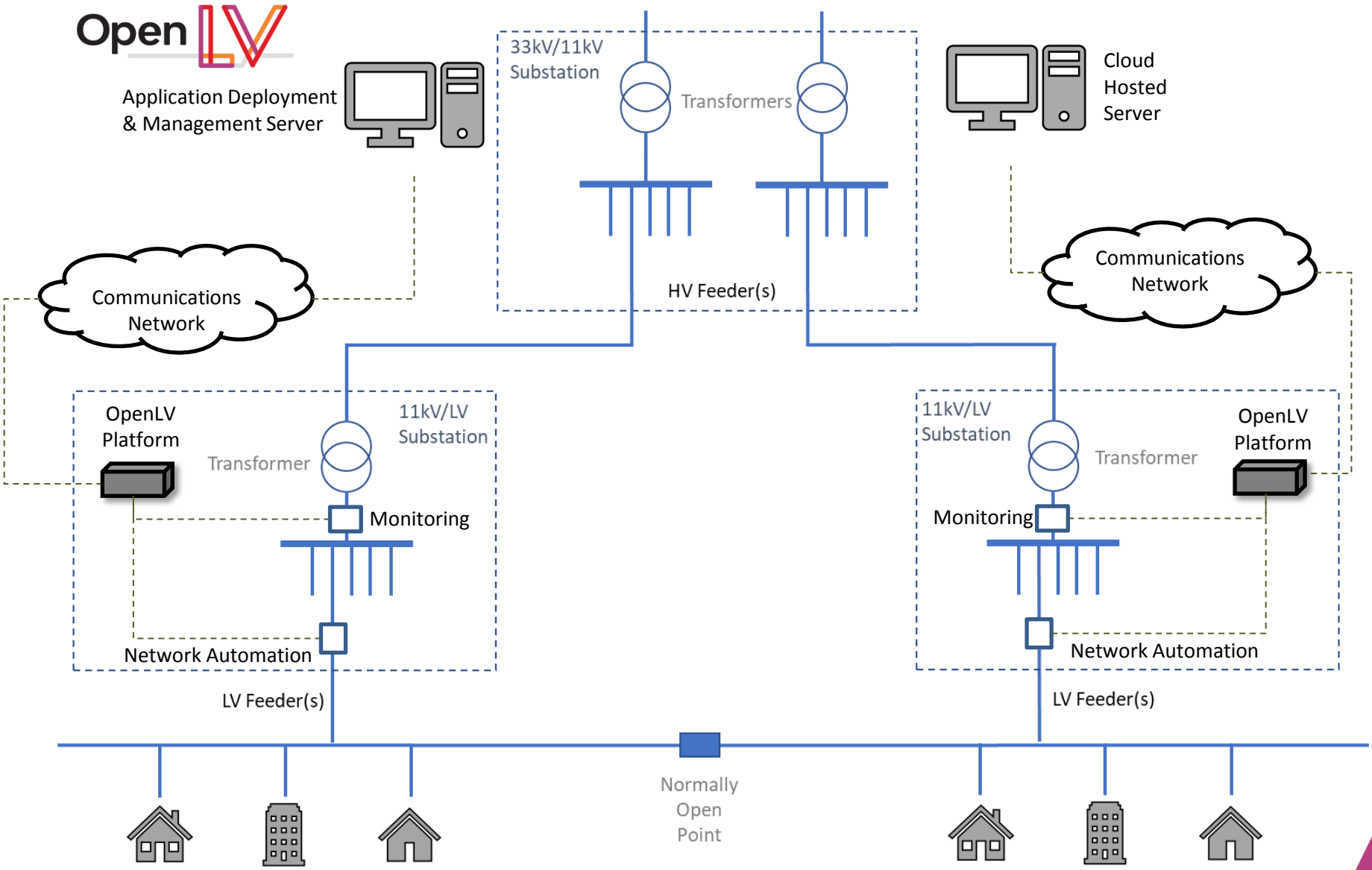

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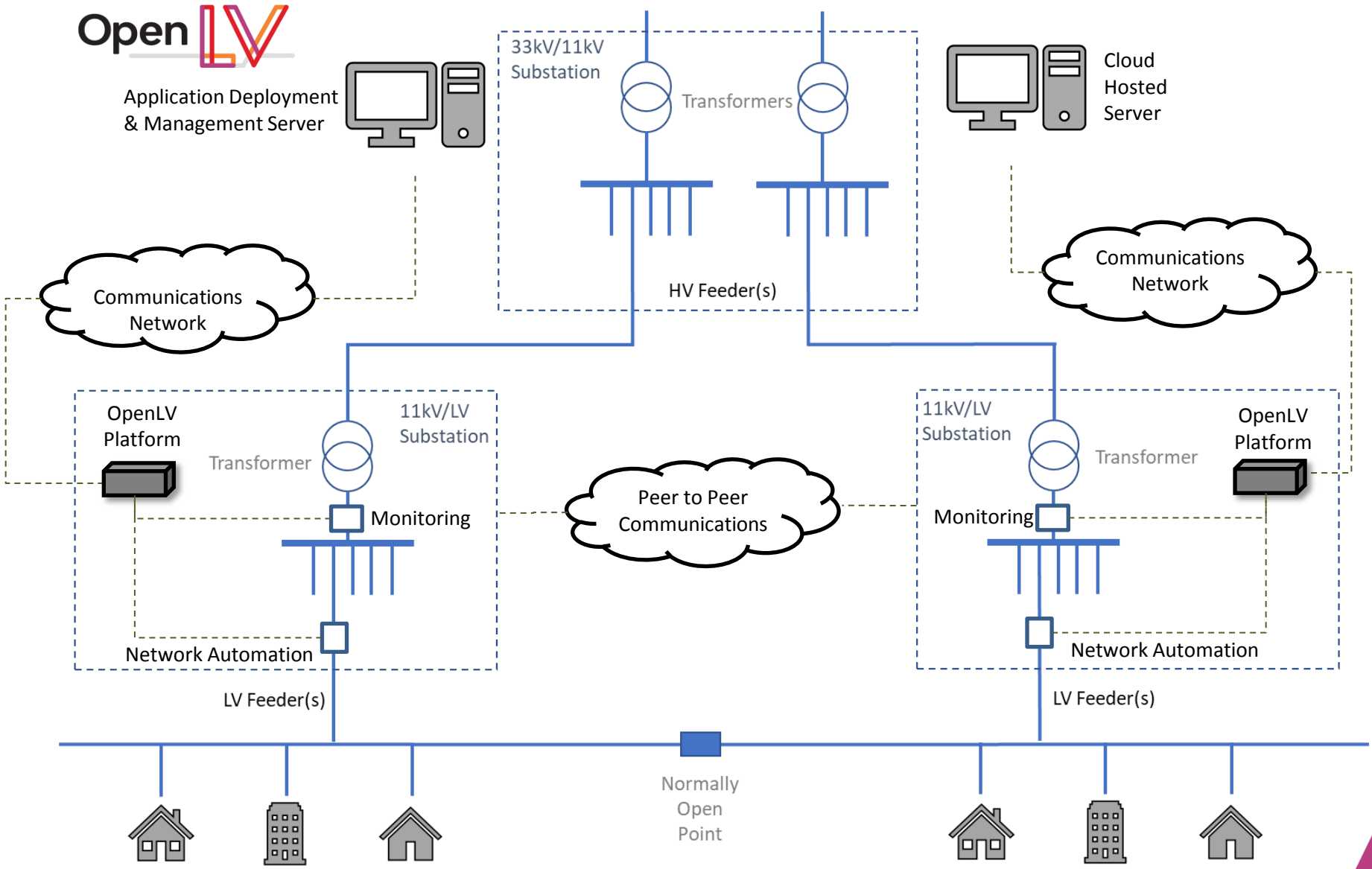
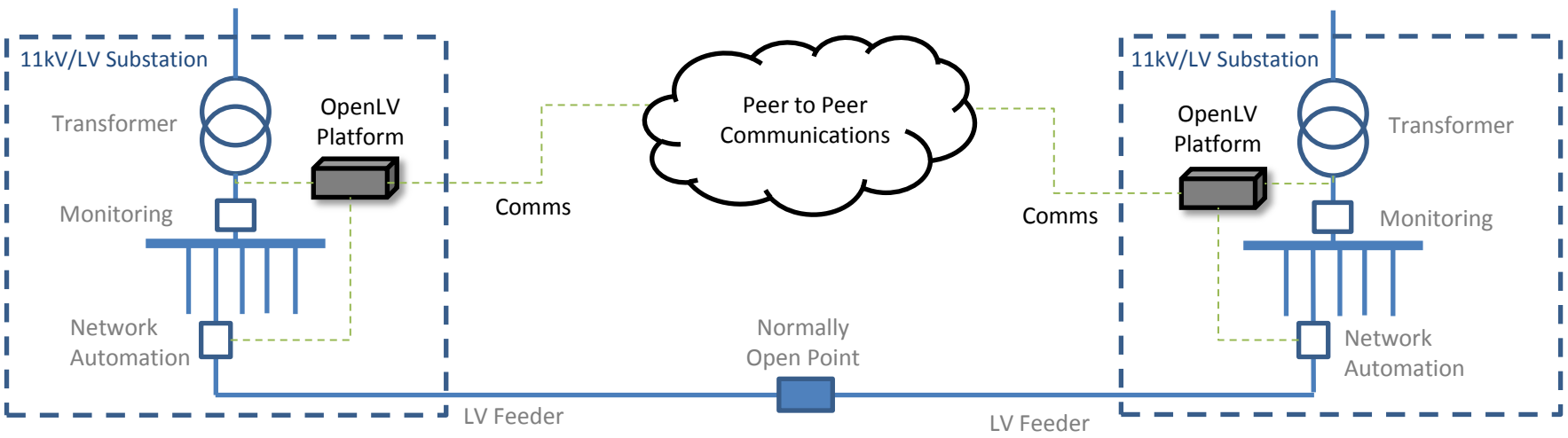


Releasing additional capacity



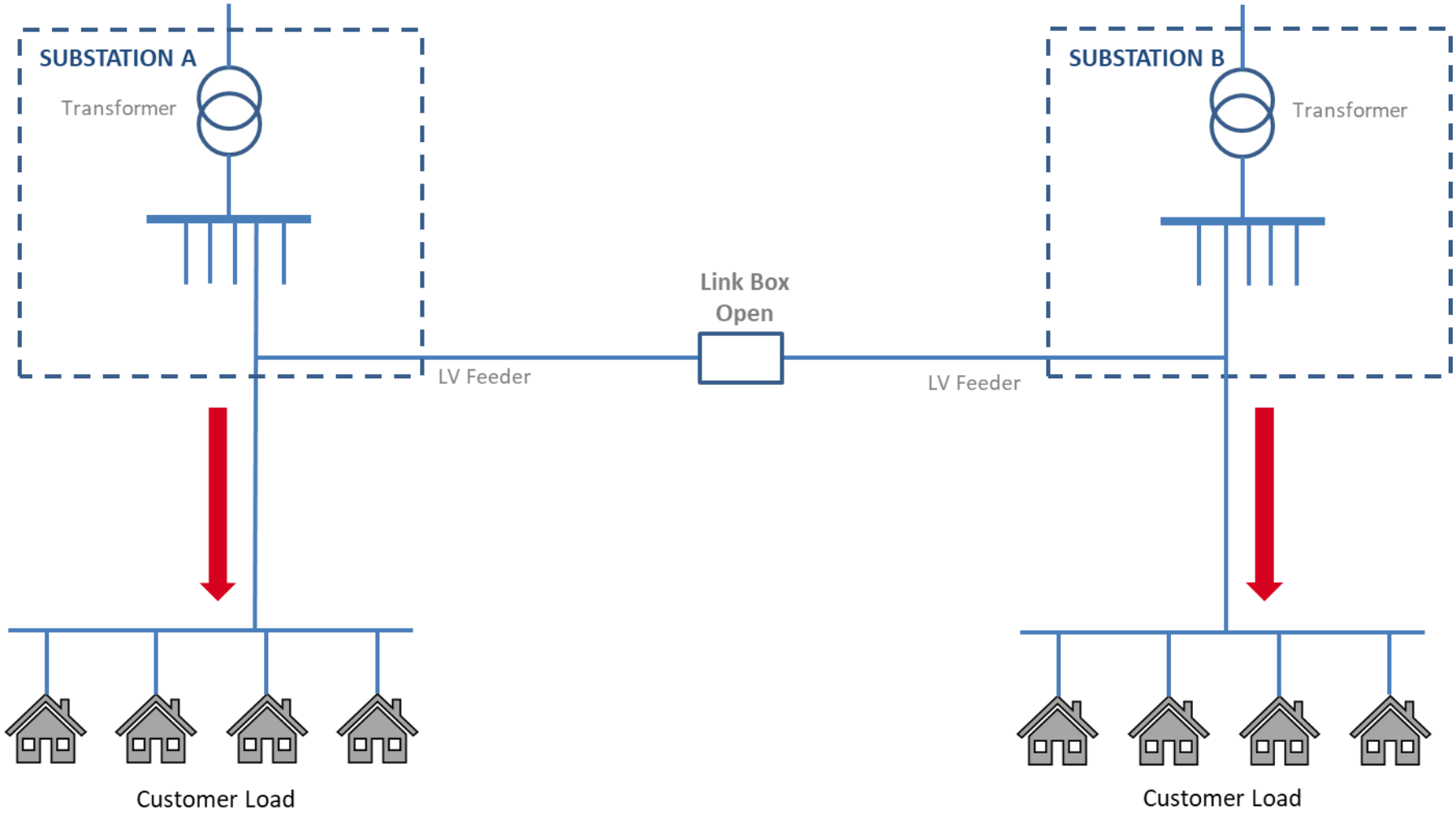
What

- 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

Meshing the network



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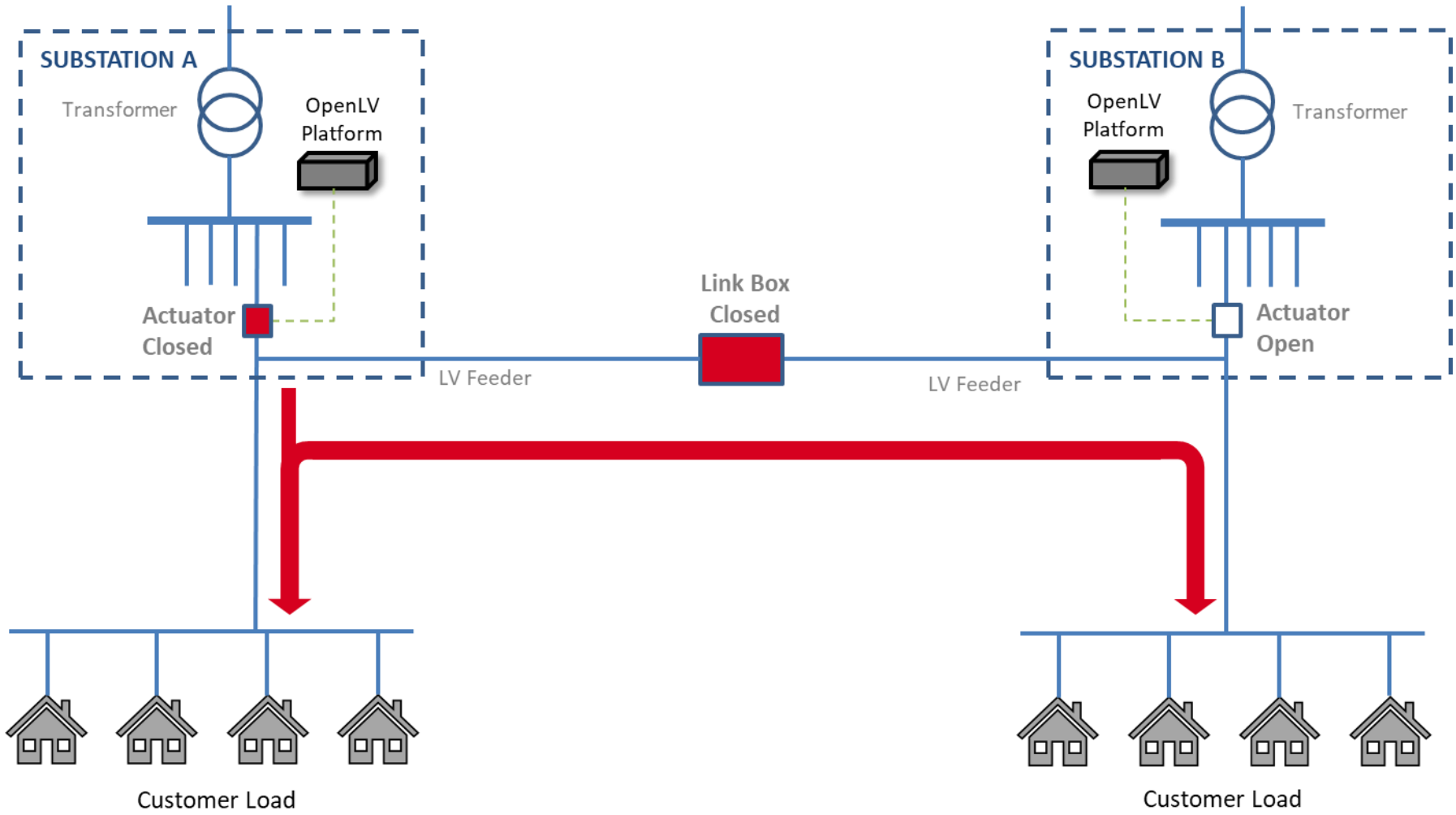

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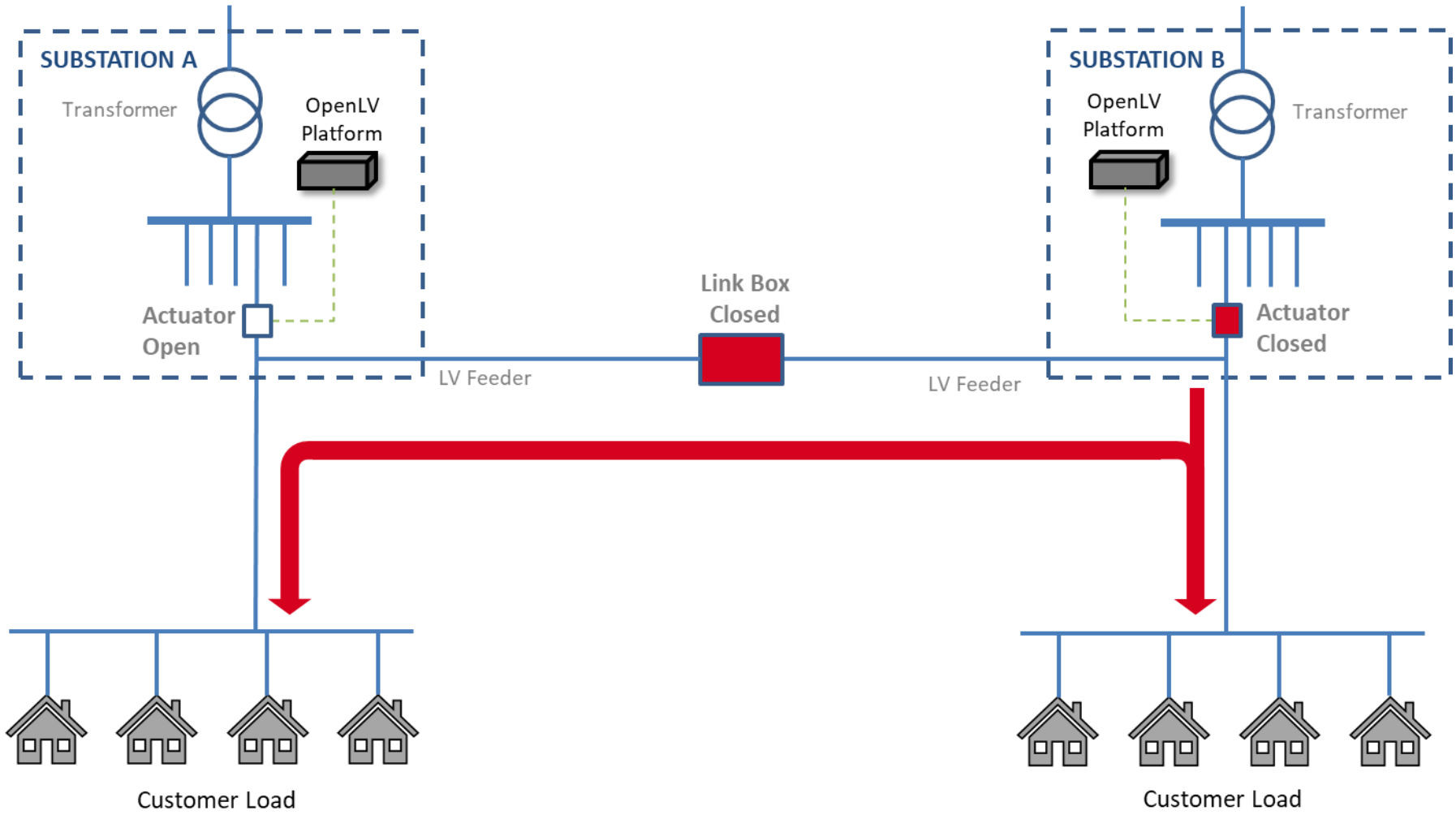

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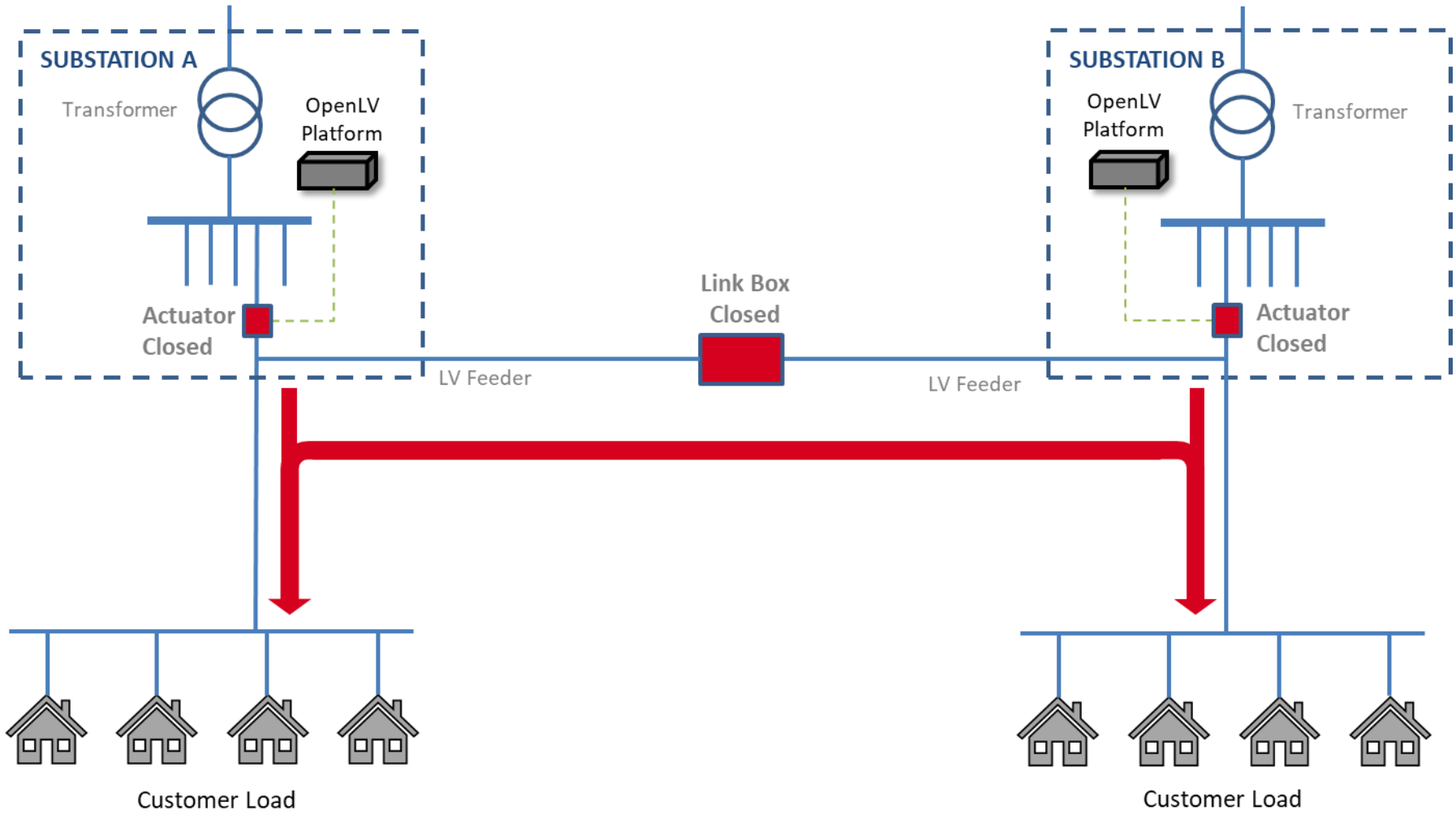
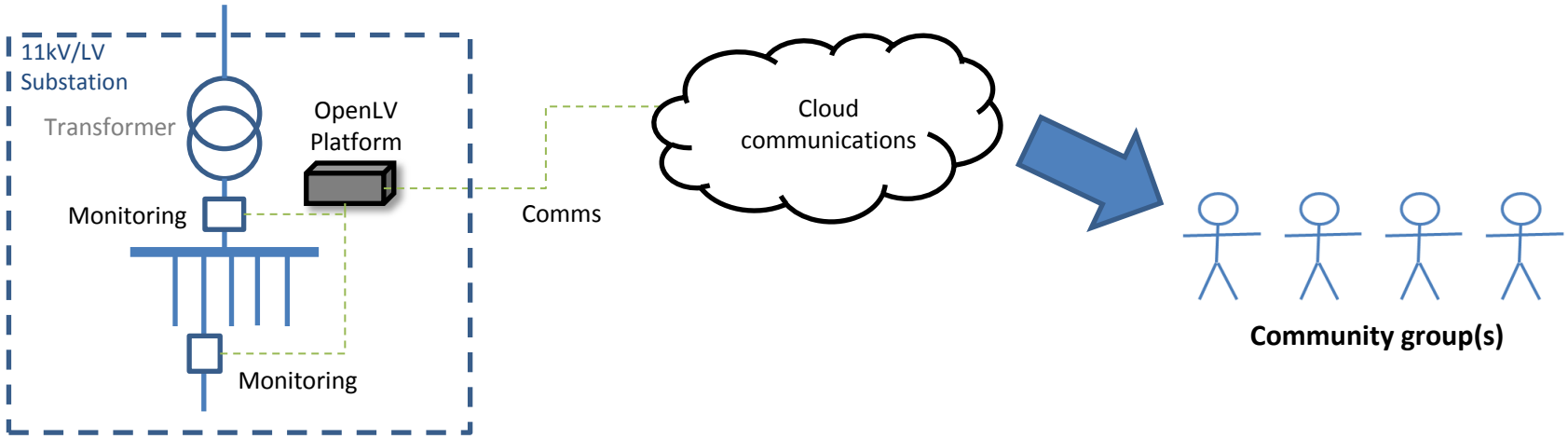


Community engagement



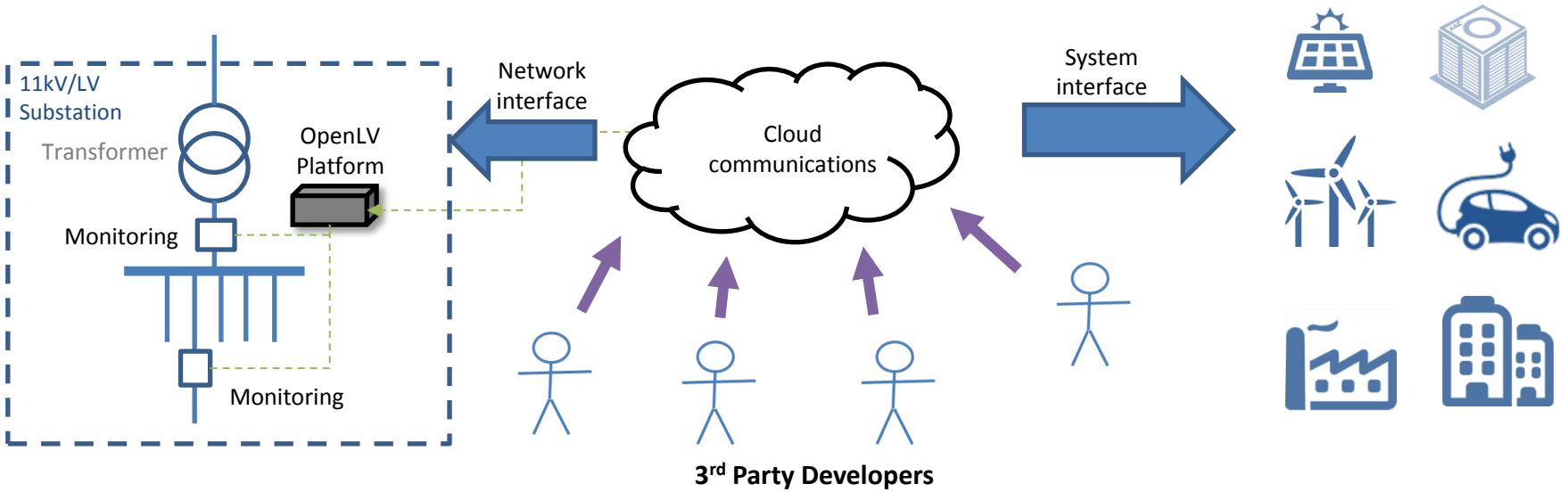
What

- 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

Business & Academia



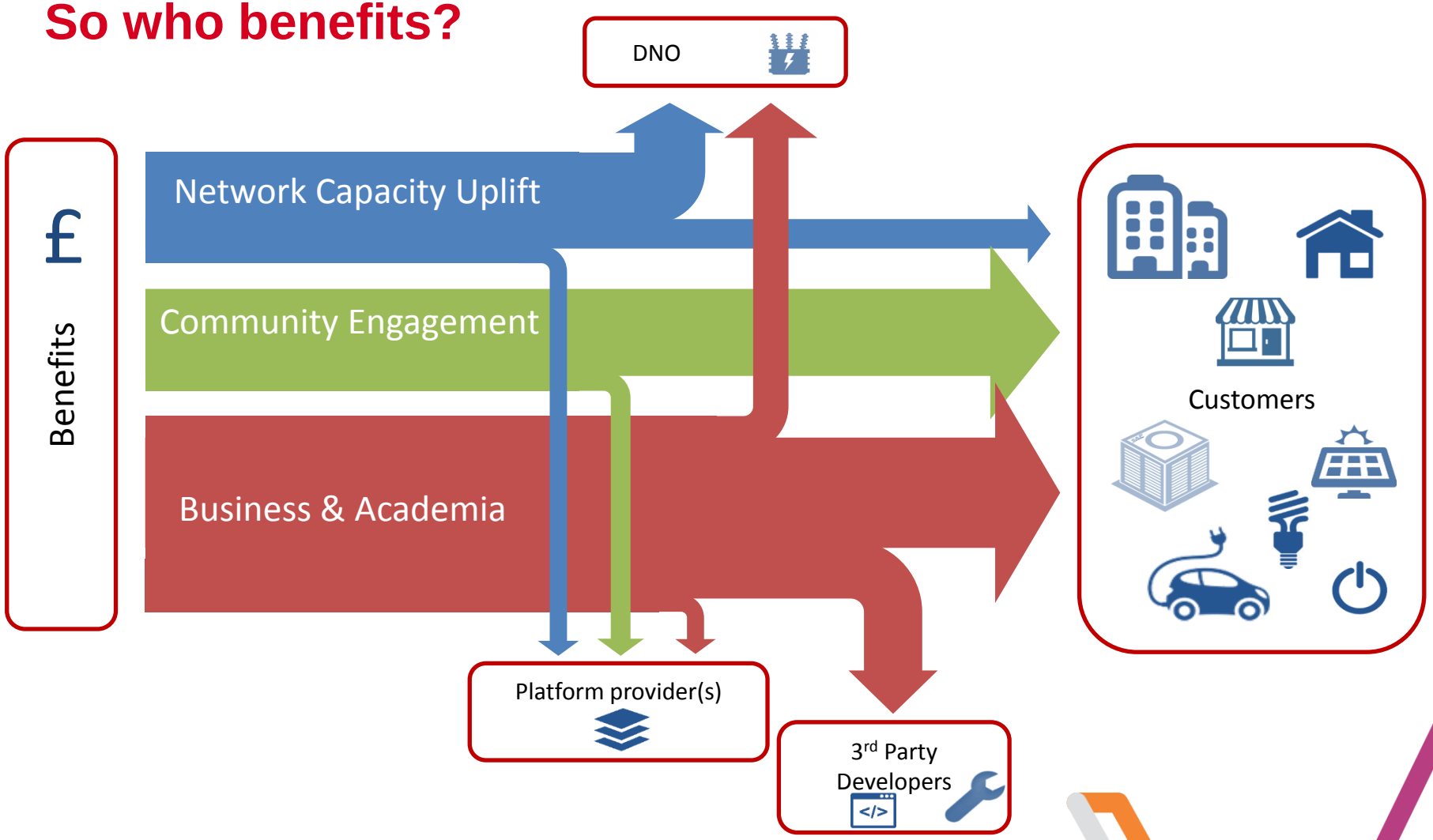
What

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

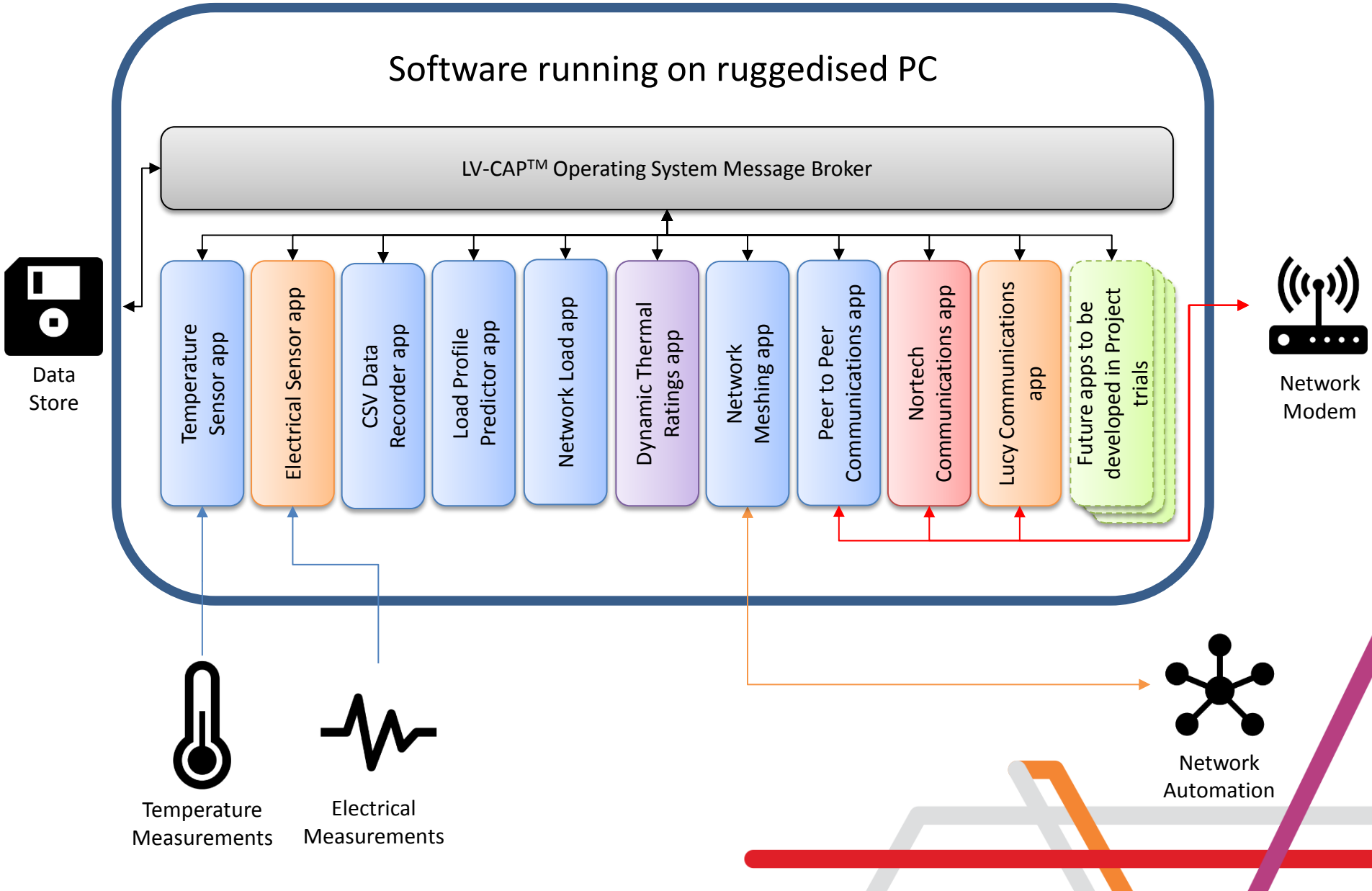
How

- 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

So who benefits?



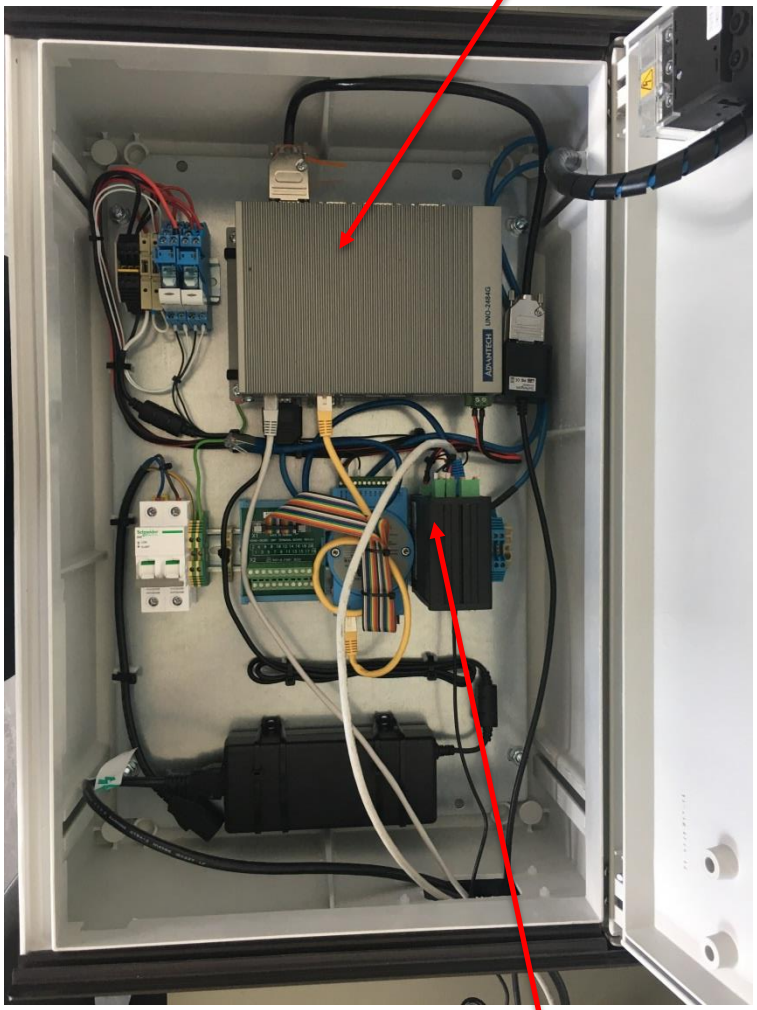
The star of the show



The hardware

Ruggedised PC

Network Automation Isolation switch



Padlock hasp

Network Modem

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 Jun-19)

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 Business as Usual** (Apr-20)

Key achievements to date

- **Commercials:** Complete
- **Customer Engagement Plan:** Complete
- **Data Protection Strategy:** Complete
- **6 Month Project Progress Report:**
  Delivered in June
- **Trial equipment:** Test units built
- **Acceptance Testing**: On-going
- **Marketing & PR:** Website live
- **Trial Recruitment:** We are open for business!

Open LV Your local electricity data

Engaging with communities

Rachel Coxcoon, CSE

Delivered by:

ea technology

WESTERN POWER DISTRIBUTION

Serving the Midlands, South West and Wales

10 LV-CAP™ devices are available for deployment in WPD substations, for communities

CSE's role in OpenLV

- Recruit and assist community groups to understand how best they can use LV data
- Support community groups to understand technical limitations and possibilities
- Support community groups to develop app proposals
- Secure funding for programmer time
- Support communities in deployment and testing

Initial survey to community groups – our approach

- The OpenLV project is making electricity network data ‘open access’ for the first time ever, inviting innovation from within communities themselves.
- CSE issued a survey to its stakeholder community database June 2016.
- The survey was open for one month.
- 51 complete responses received (3 outside WPD area)
- Good spread across WPD licence areas
- Majority from community energy groups (34), of which 22 own generating assets

Response to 'pre-formed' app ideas given in survey

	Very interested	Neutral	Not interested	Total
Understanding community electricity demand	92% (44)	6% (3)	2% (1)	48
Connecting low carbon technologies to the LV grid	91% (43)	9% (4)	0% (0)	47
Community alerts to request reduction or increase in electricity usage	72% (34)	19% (9)	9% (4)	47
Demand side response for managed electric vehicle charging	63% (30)	31% (15)	6% (3)	48
Community information alerts	66% (29)	34% (15)	0% (0)	44
Automated electricity storage control	56% (27)	38% (18)	6% (3)	48

Survey results

46 high-level app ideas proposed in addition to interest in pre-formed ideas, including:

- "*CO_2 energy production - when is it best to use low CO2 energy?"*
- *"We have installed 414 kW of rooftop PV in our community and are interested in knowing how its output hour by hour relates to demand in our agricultural area."*
- *"It would be interesting to be able to correlate with wholesale prices, i.e. how much effect renewable generation is having on wholesale and triad prices"*
- *"Neighbourhood planning; measuring data to drive low carbon city/carbon reduction, addressing fuel poverty."*

Next steps with community groups

- 2- stream Expression of Interest process – community energy groups and those with no energy background (opens November)
- 4 finalists selected by Feb/March, then supported community consultation events to bring in wider participation.
- App design workshops with key community members – May – June 2018
- App development phase – June – September 2018
- Trial – September 2018 – June 2019

Issues to bear in mind if you're thinking of applying...

- **Timetable** – trial timetable is only 10 months and there is limited time for baseline data collection. Apps that need months of baseline data before design and development unlikely to be successful.
- **Geographic scale** – only 10 LV-CAP™ units available. Even small villages might have 5-7 substations. What can be achieved with 3 kits in your area?
- **Who benefits?** - apps that create private benefit but little community buy-in won't be successful, nor those that are unlikely to lead to network efficiencies if rolled out.

Open LV Your local electricity data

Engaging with business and academia

Gill Nowell, EA Technology

Delivered by: ea technology

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10 LV-CAP™ devices are available for deployment in WPD substations, for business and academia

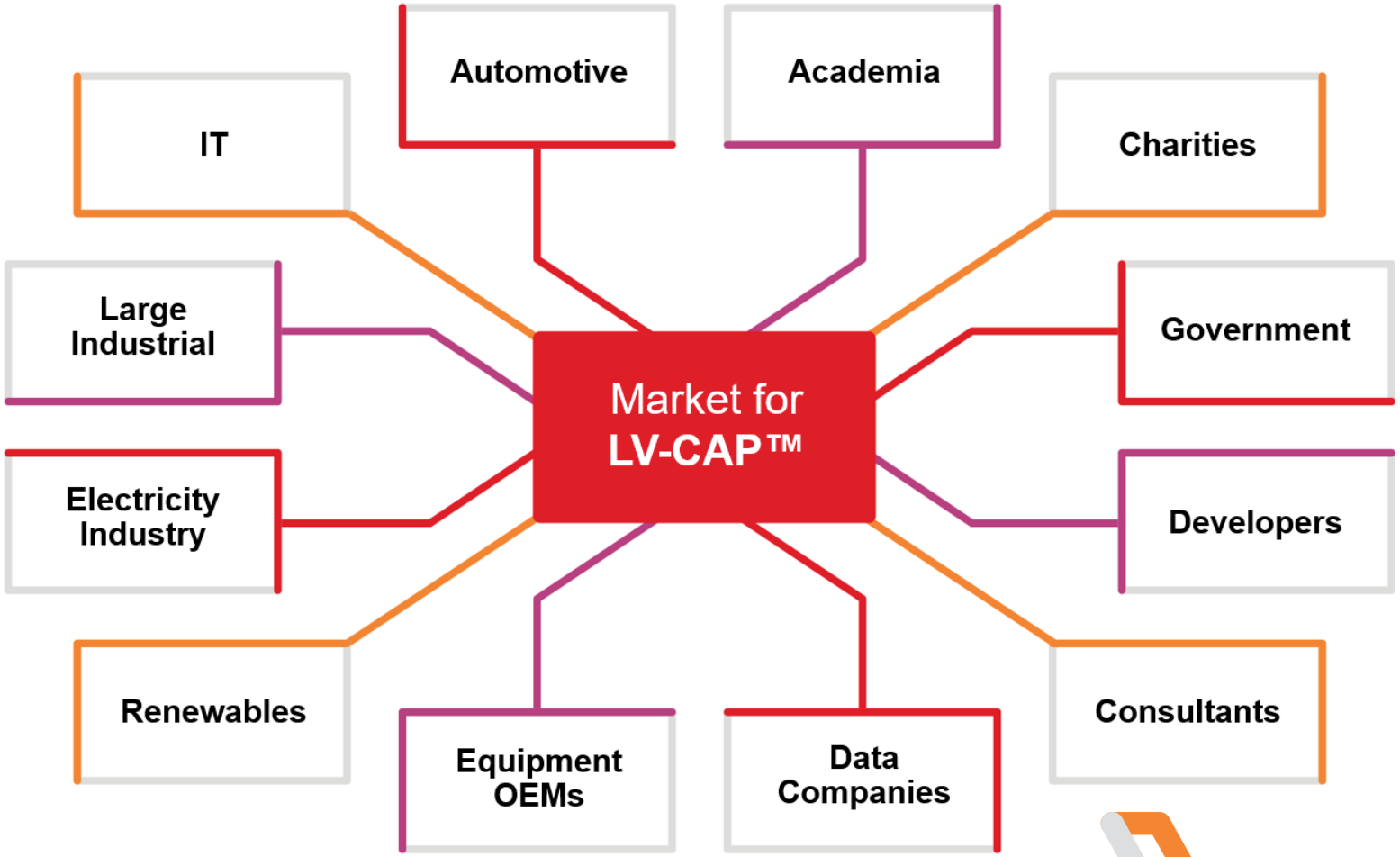
Engagement approach

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

- Strategic approach to publicise the opportunity to business and academia
- Make available standard app ‘container’ for third parties to use for their development
- Make available 10 LV-CAP™ devices for substation deployment
- Funding to develop specific apps to be raised outside of the project budget, e.g. private sector

- >30 organisations have indicated interest already

Stakeholder groups



Survey to register interest

- Emailed to 900 stakeholders
- Circulated via project team's networks and newsletters
- Twitter @OpenLV_ & LinkedIn
- PR issued to energy / electricity, renewables, I.T. media
- 30+ interested parties
- All information treated as confidential

Survey link:

https://openlv.net/about/the-project/for-business-and-academia/

Business and academia engagement process

- Step 1: Register your interest by completing the survey (16/10/17)
- Step 2: Engage with OpenLV team (10/17 – 01/18)
- Step 3: Successful applicants notified that an LV-CAP™ device is available for use with their app / electricity data use purposes (01/18)
- Step 4: App development (02/18 – 07/18)
- Step 5: OpenLV trials commence – apps tested on the LV-CAP™ platform (09/18)
- Step 6: OpenLV trials close (07/19)

Open LV Your local electricity data

Get involved in OpenLV

www.openlv.net/

@OpenLV_

OpenLV@eatechnology.com

Thank you

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ELECTRIC NATION

YOUR ELECTRIC VEHICLE YOUR SMART CHARGE

@ElectricNation_

COLLABORATION PARTNERS

ea technology

driveelectric electric car leasing

Lucy Electric

TRL

WESTERN POWER DISTRIBUTION

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Introduction

Mark Dale
Innovation Manager
Western Power Distribution

Nick Storer
Daniel Hollingworth
EA Technology

Today

- Why do we need smart charging?
- Introduction to Electric Nation
- Monitoring
- Mitigation
- Modelling

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INNOVATION

WESTERN POWER DISTRIBUTION FLEXDGRID

WESTERN POWER DISTRIBUTION PLUGS AND SOCKETS

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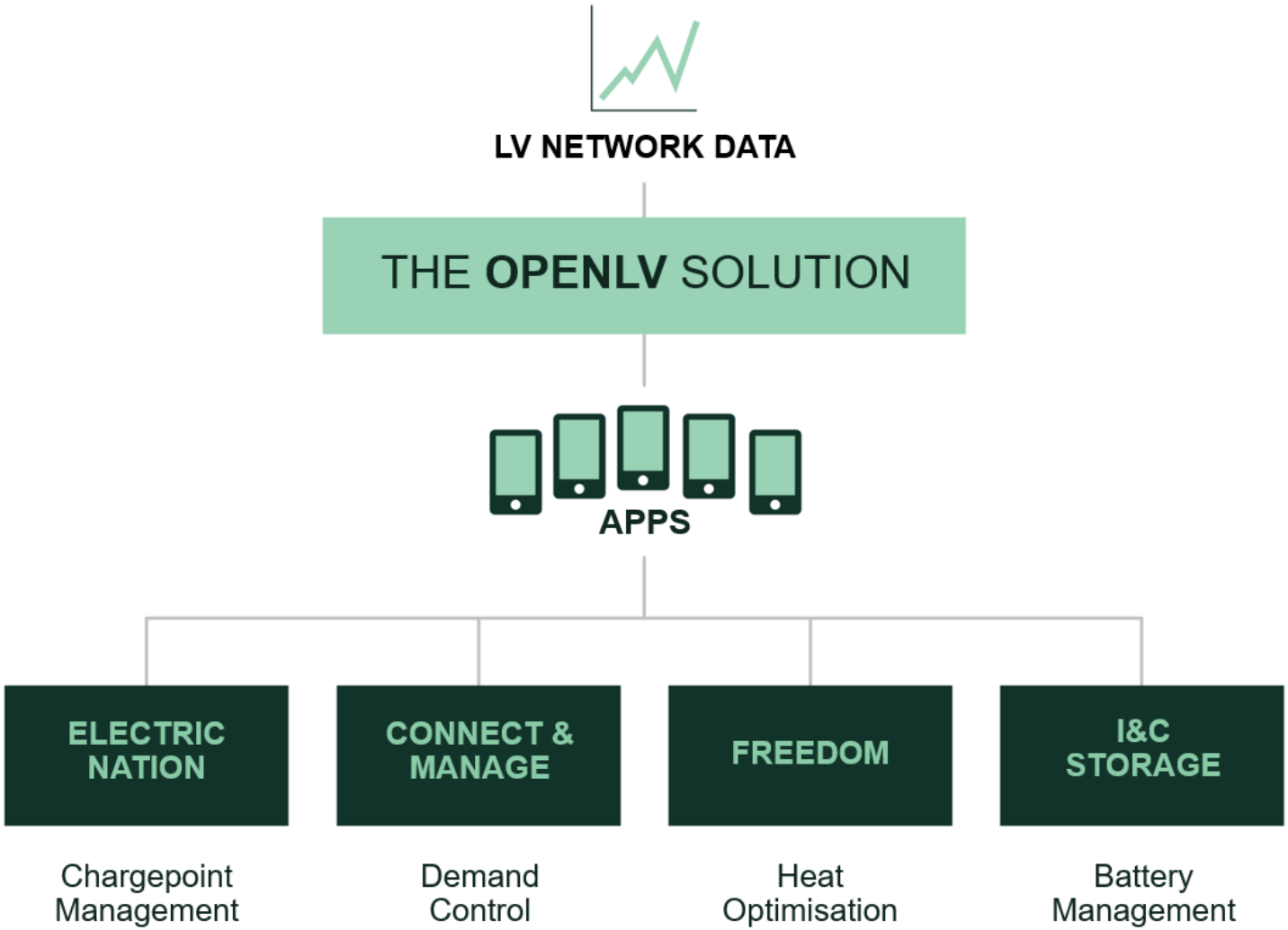
ELECTRIC NATION

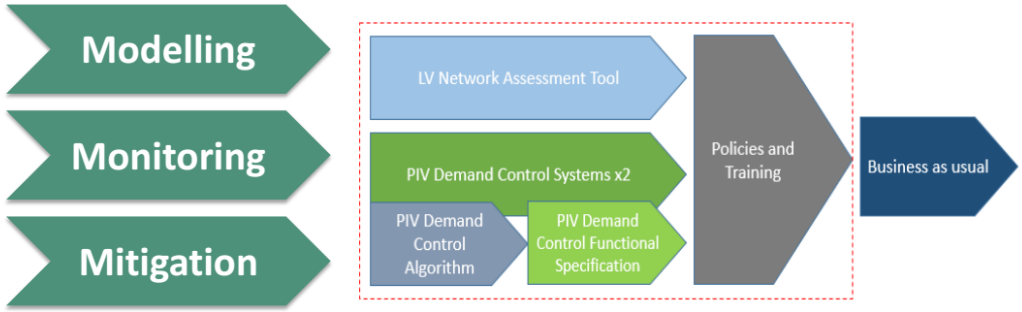
LOW VOLTAGE (LV) NETWORK INNOVATION



ELECTRIC NATION

Proving the benefits of smart EV charging for both customers and local power networks

The world's largest EV trial (500-700 participants)	3 year project (2016-2019)
Involving all types of plug in vehicles (PHEV/EV)	Conceived, designed, and led by EA Technology



COLLABORATION PARTNERS

ea technology · driveelectric electric car leasing · Lucy Electric · TRL

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ELECTRIC NATION

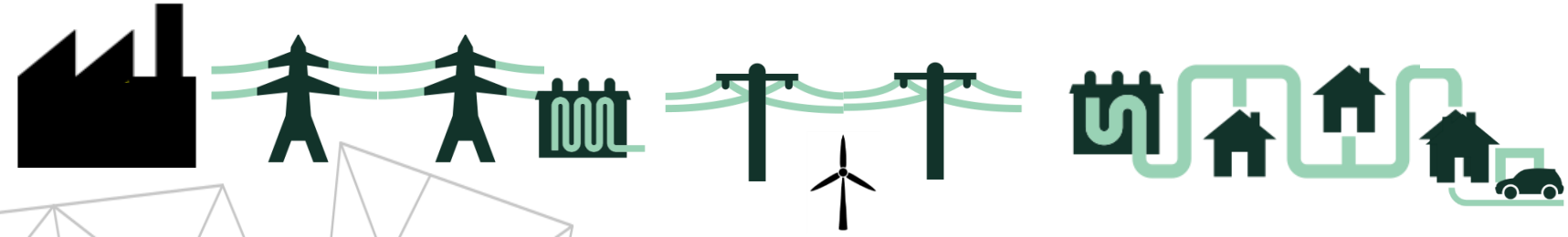
YOUR ELECTRIC VEHICLE YOUR SMART CHARGE

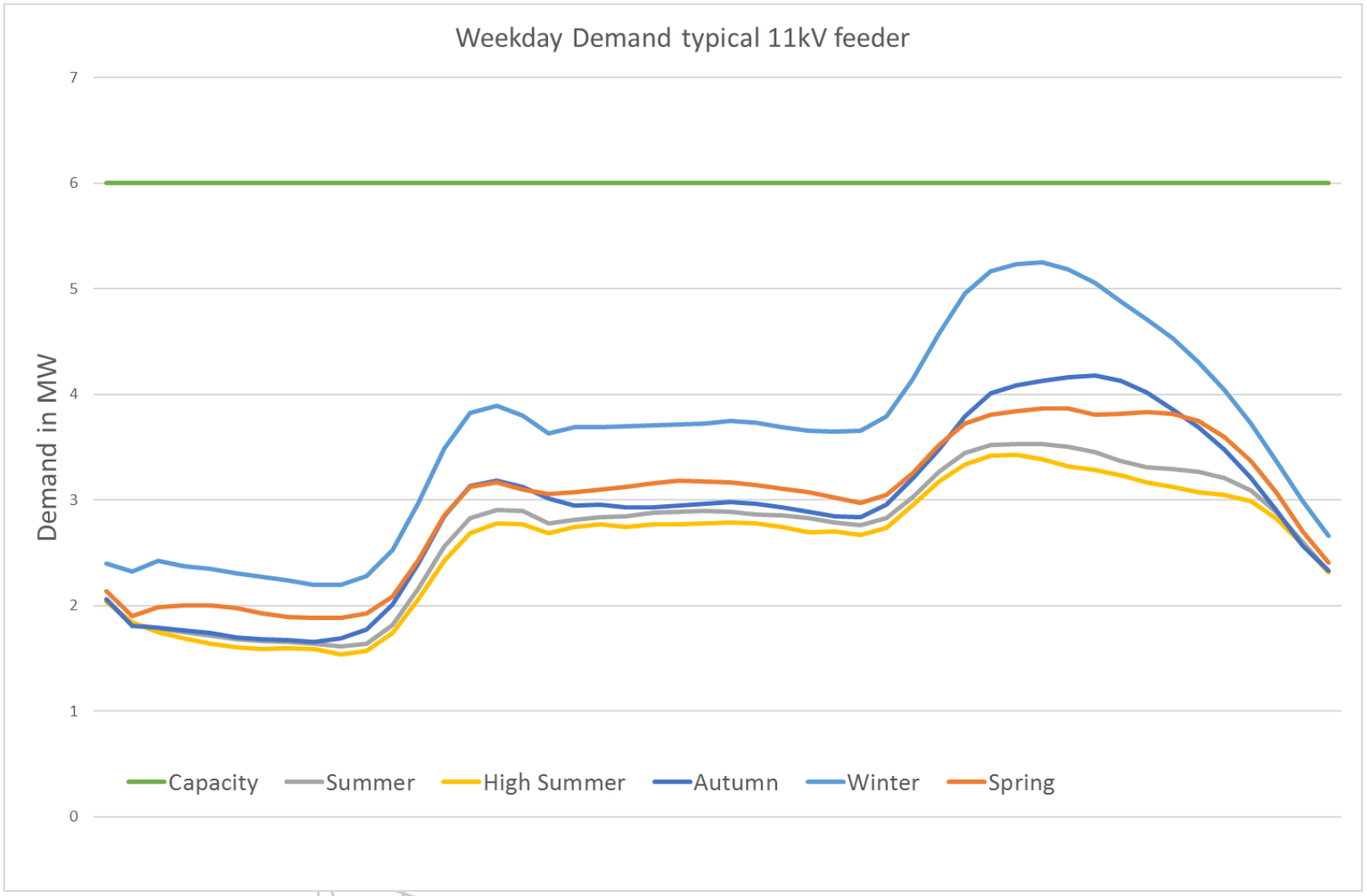
MONITORING

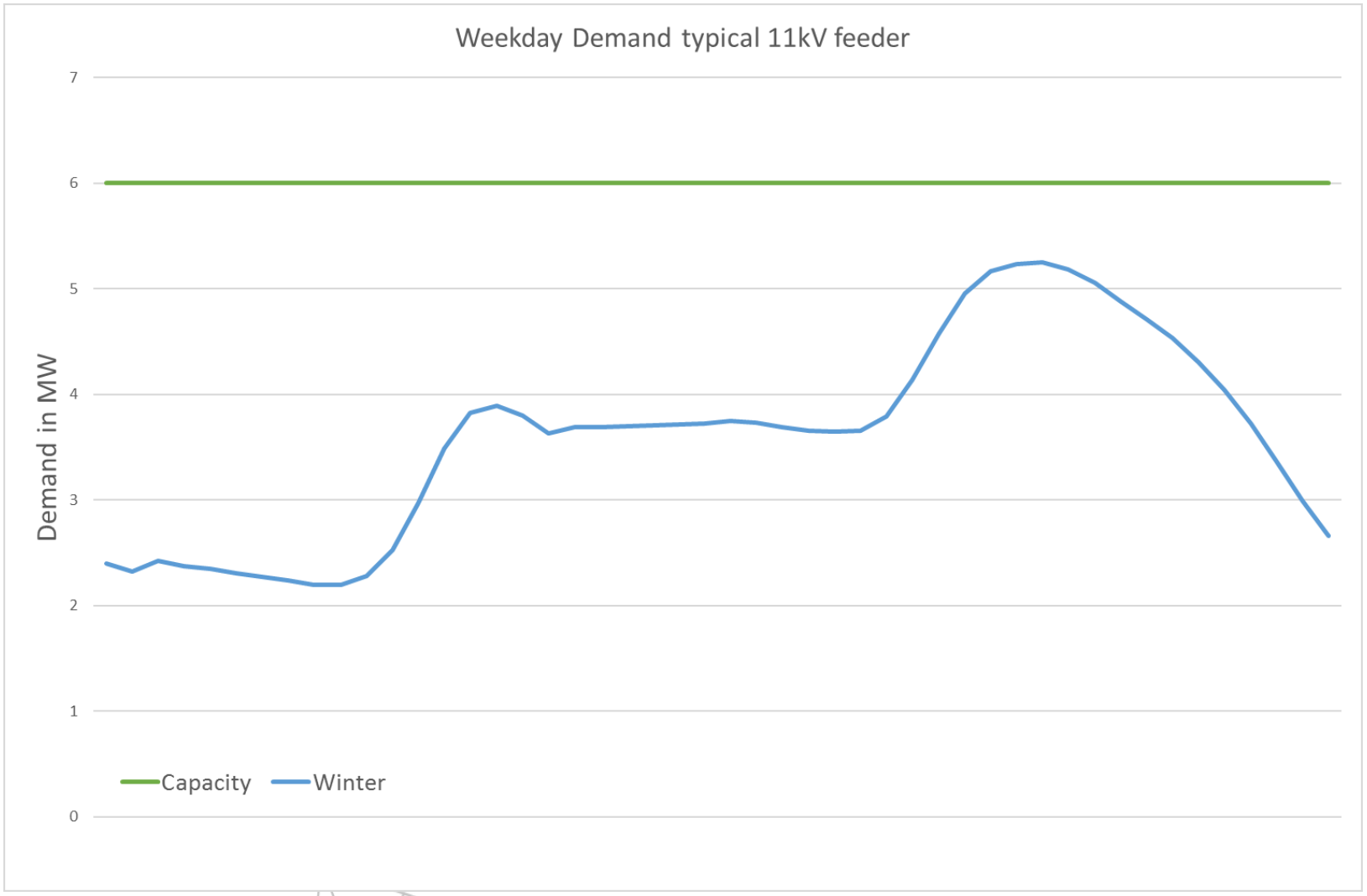
IS EV CHARGING CAUSING EXCESSIVE DEMAND?

Why do we need smart charging?

- EVs will require the generation and transmission of additional electricity to charge up:
  - Challenges for the generation industry and National Grid
  - And Distribution Network Operators in their networks down to 11kV network level
- For Distribution Network Operator's on 11 kV and LV networks EV loads may overload these networks – in certain seasons and times of day
- Additional loading on LV networks would result in at least 30% of these networks in GB requiring investment by 2050 costing at least £2.2bn *(My Electric Avenue)*
- Investment = upgrade/replace these networks – disruption affecting all of us
- Costs of upgrades go onto customer bills – a hidden cost of EV ownership?
- **Smart charging could reduce/delay or avoid the need to upgrade/replace networks**
- **UK Government looking to mandate smart charging**
  - **This project will provide evidence whether it will work**




Weekday Demand typical 11kV feeder
Demand in MW
7
6
5
4
3
2
1
0
Capacity
Summer
High Summer
Autumn
Winter
Spring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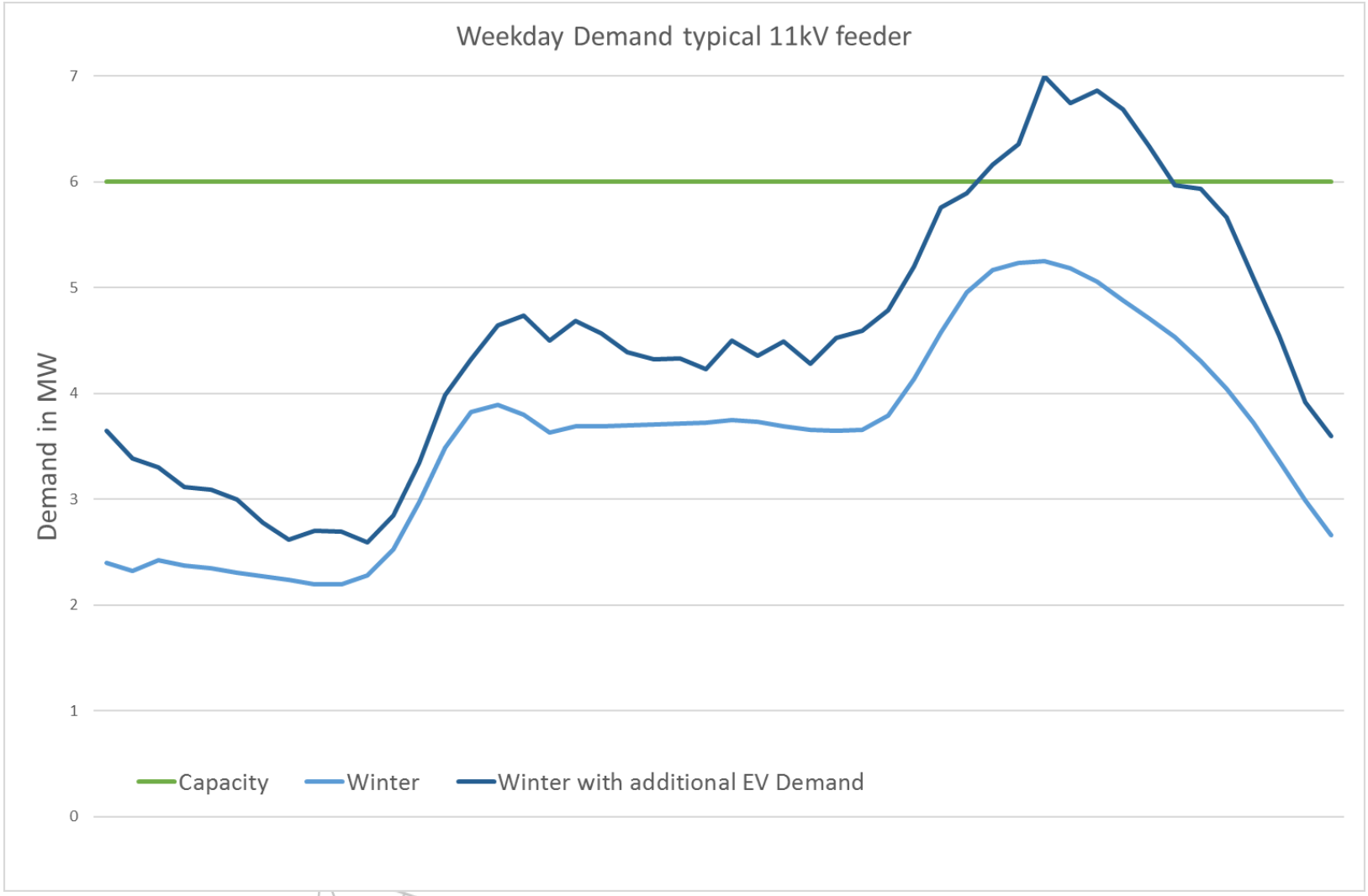
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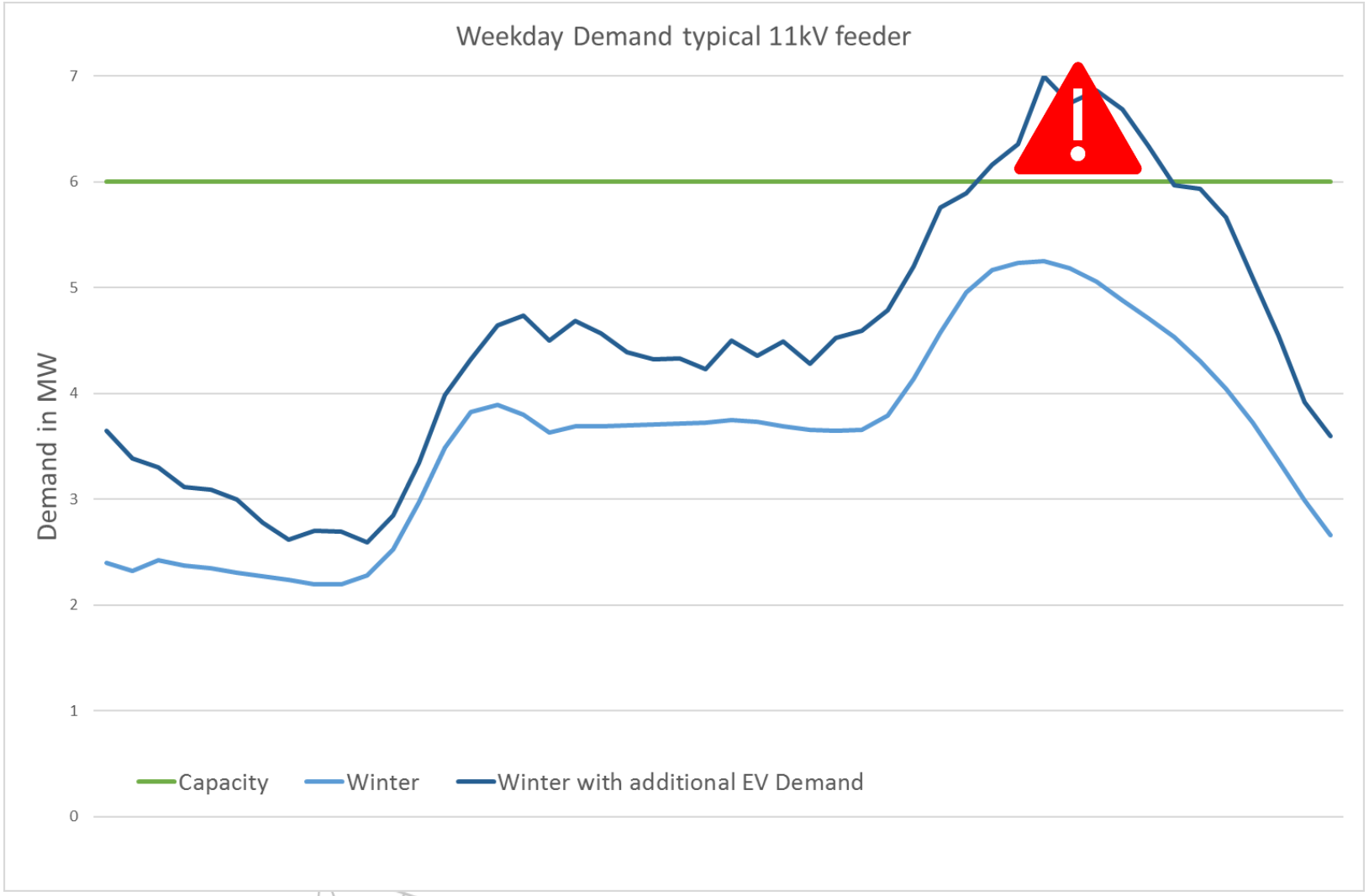
Winter with additional EV Demand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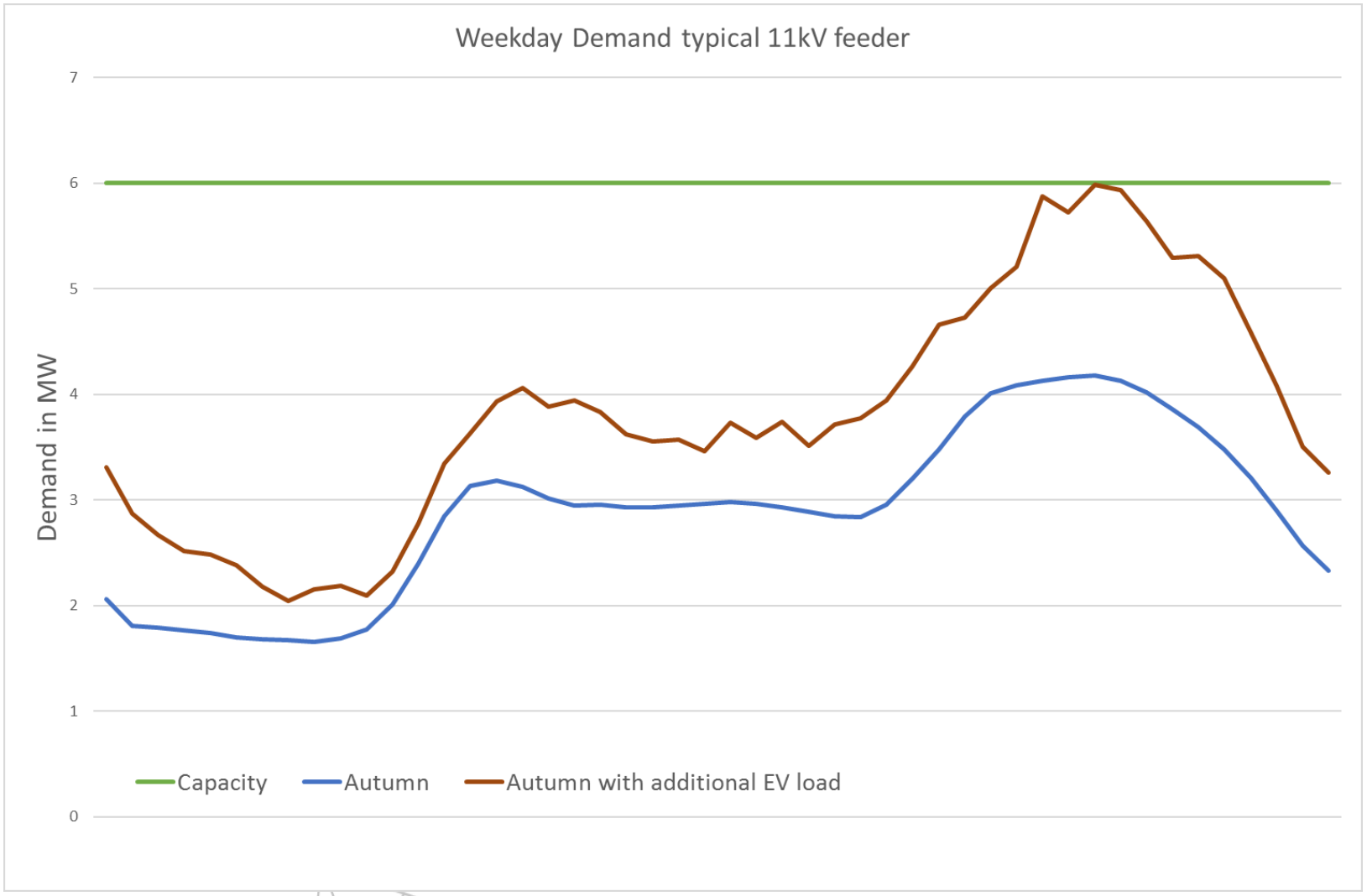
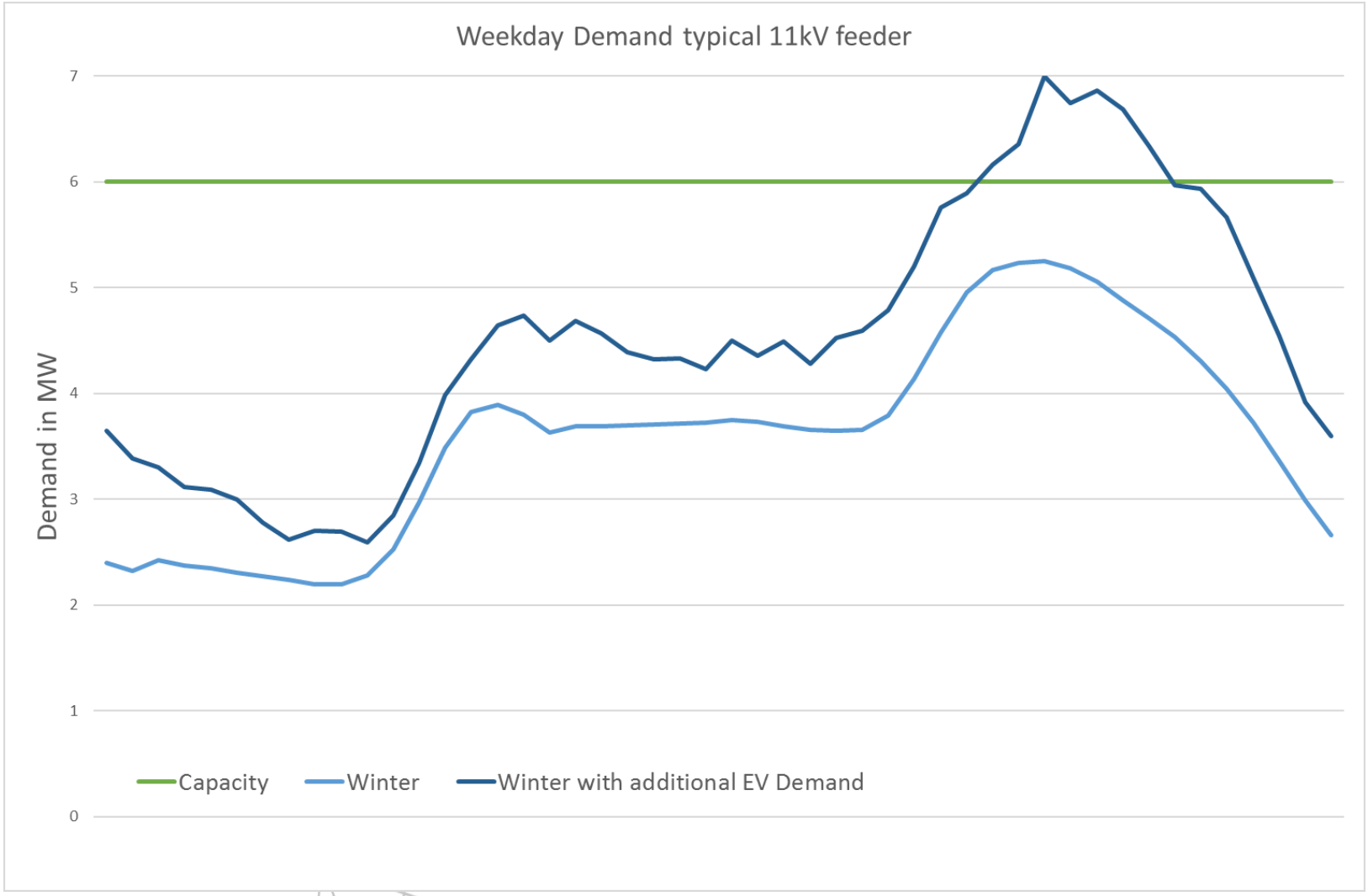
Winter
Winter with additional EV Demand


Weekday Demand typical 11kV feeder
Demand in MW
7
6
5
4
3
2
1
0
Capacity
Autumn
Autumn with additional EV load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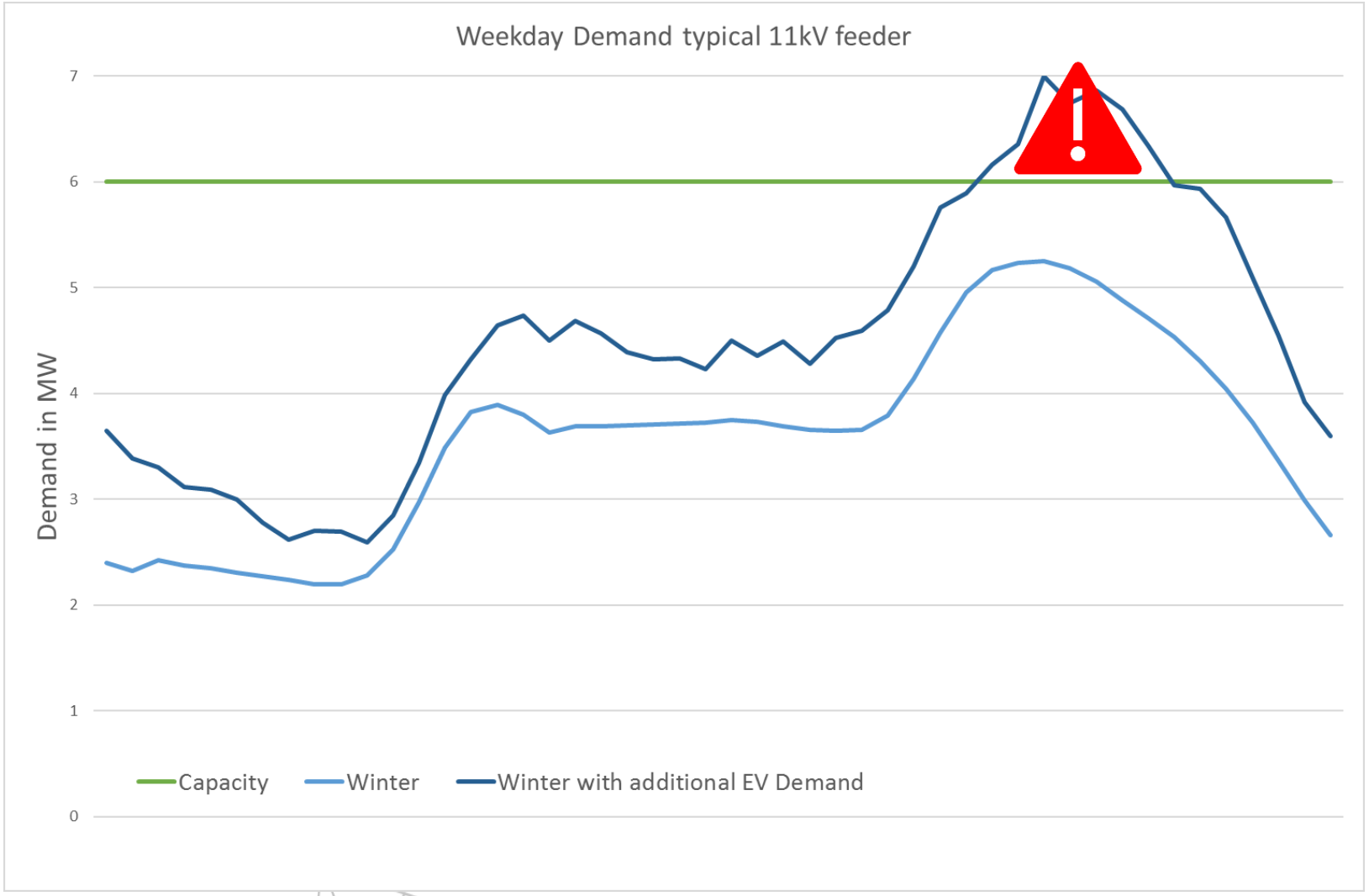
Winter
Winter with additional EV Demand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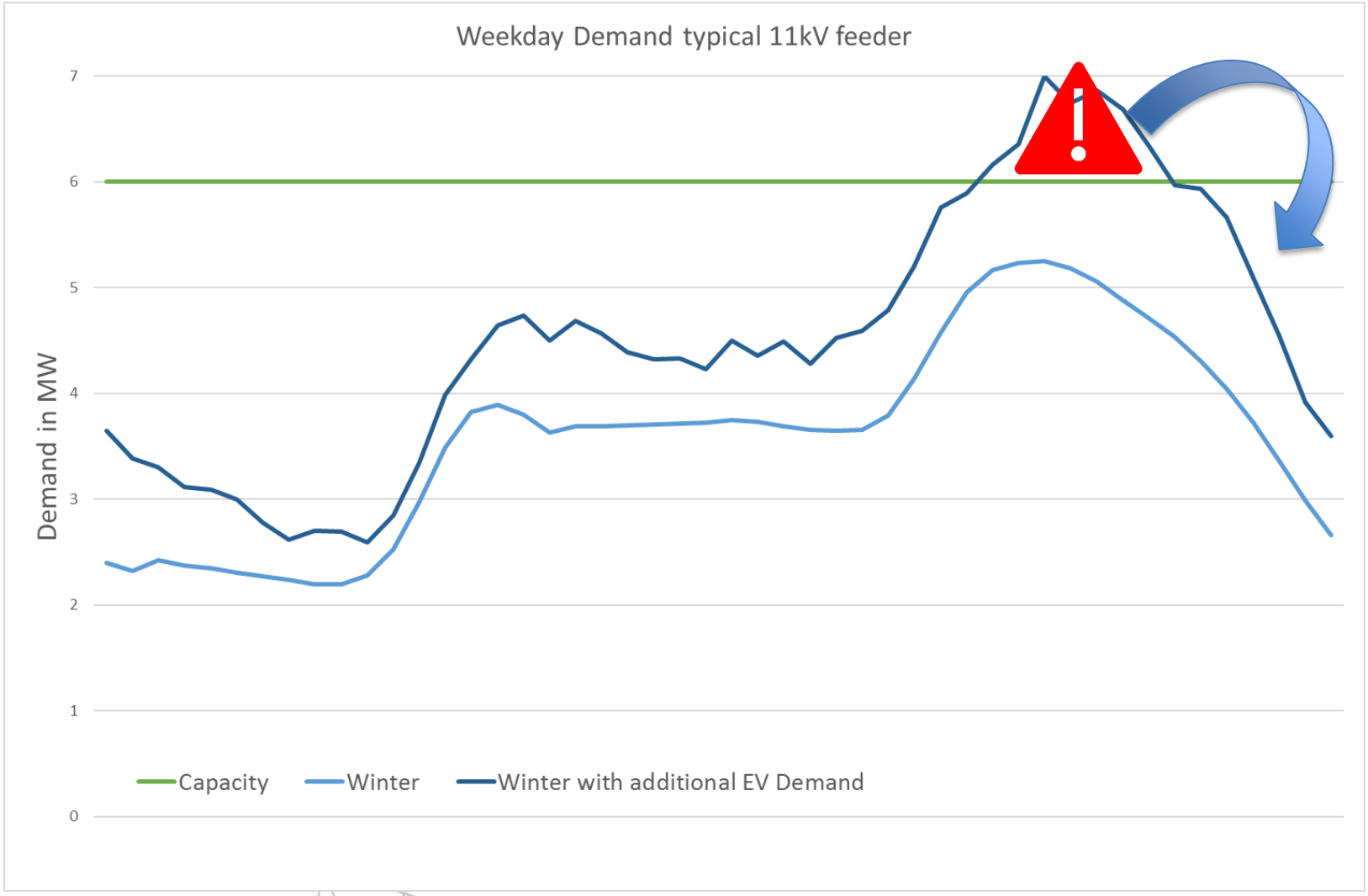

Weekday Demand typical 11kV feeder
Demand in MW
7
6
5
4
3
2
1
0
Capacity
Winter
Winter with additional EV Demand

Monitoring – Lucy Electric GridKey

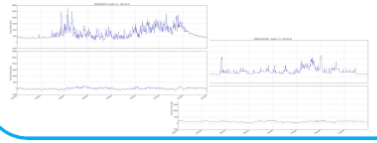
- Using Lucy Electric GridKey's monitoring equipment
- Initial data gathering exercise carried out at Millbrook Proving Ground.
  - Capturing EV resistive load signatures on LV feeders
  - Variety of charging cycles with a variety of commercial vehicles

- Next step - develop algorithm to detect probability of EVs on the network.
  - Statistical model used initially, combining general load of a substation and injecting vehicle load signatures.
  - Using data where it is known if EVs are present/not present to validate results.

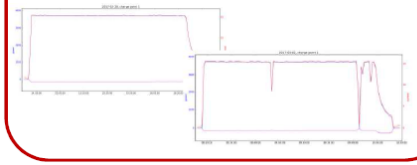
Further development of algorithm to include neural net approach to improve performance – increased detection probability / decreased false detection.

Output to potentially be integrated into other programmes such as OpenLV – providing load data for EV demand management services.

general load signals from random substations



vehicle load signatures from Millbrook



GridKey MCU520

ELECTRIC NATION

YOUR ELECTRIC VEHICLE YOUR SMART CHARGE

MITIGATION

CUSTOMER TRIAL SMART CHARGING

Test system (1)

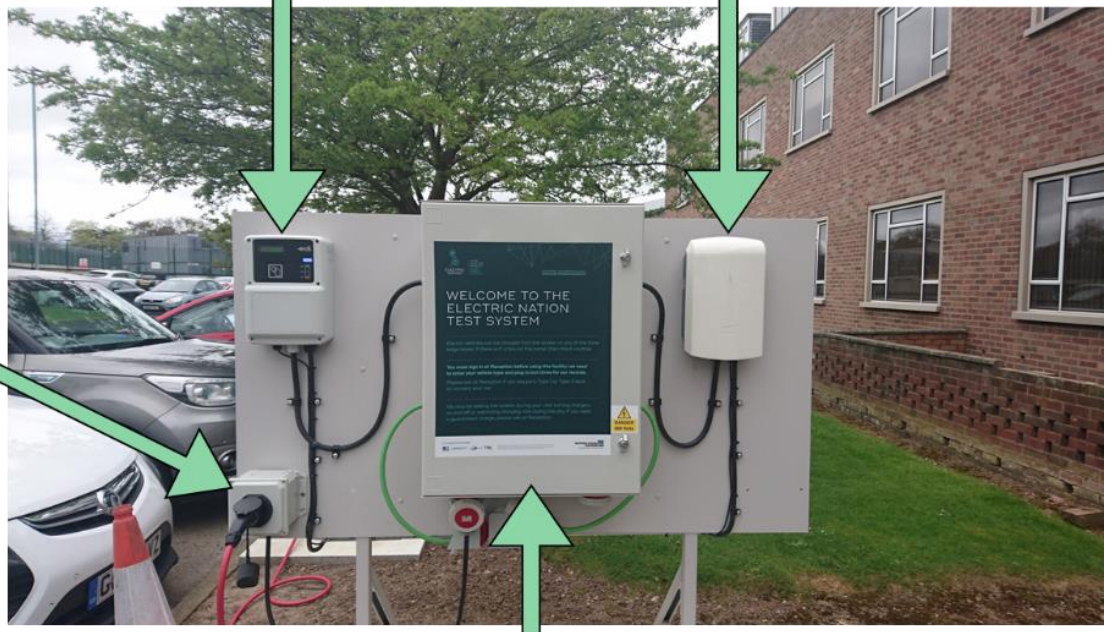
- Test system designed, built and commissioned by end September 2016
- Purpose of the test system:
  - Test smart charging algorithms before release to trial participants
  - Check the response of different cars to demand control
- During 1st year of the project:
  - 1st algorithm configurations for GreenFlux and CrowdCharge successfully tested ready for deployment
  - 10 makes/models of EVs tested
- Details reported in Algorithm Development and Testing report – available online: https://www.westernpowerinnovation.co.uk/Document-library/2017/CarConnect/CarConnect-Algorithm-Development-and-Testing.aspx

Test system (2)

APT Charger – controlled by CrowdCharge

ICU Charger – controlled by Greenflux

‘Moveable Charge Panels’ – used to control where vehicles can plug in (e.g. all connected to APT chargers for a CrowdCharge group test)



Monitoring Box containing circuits and data loggers

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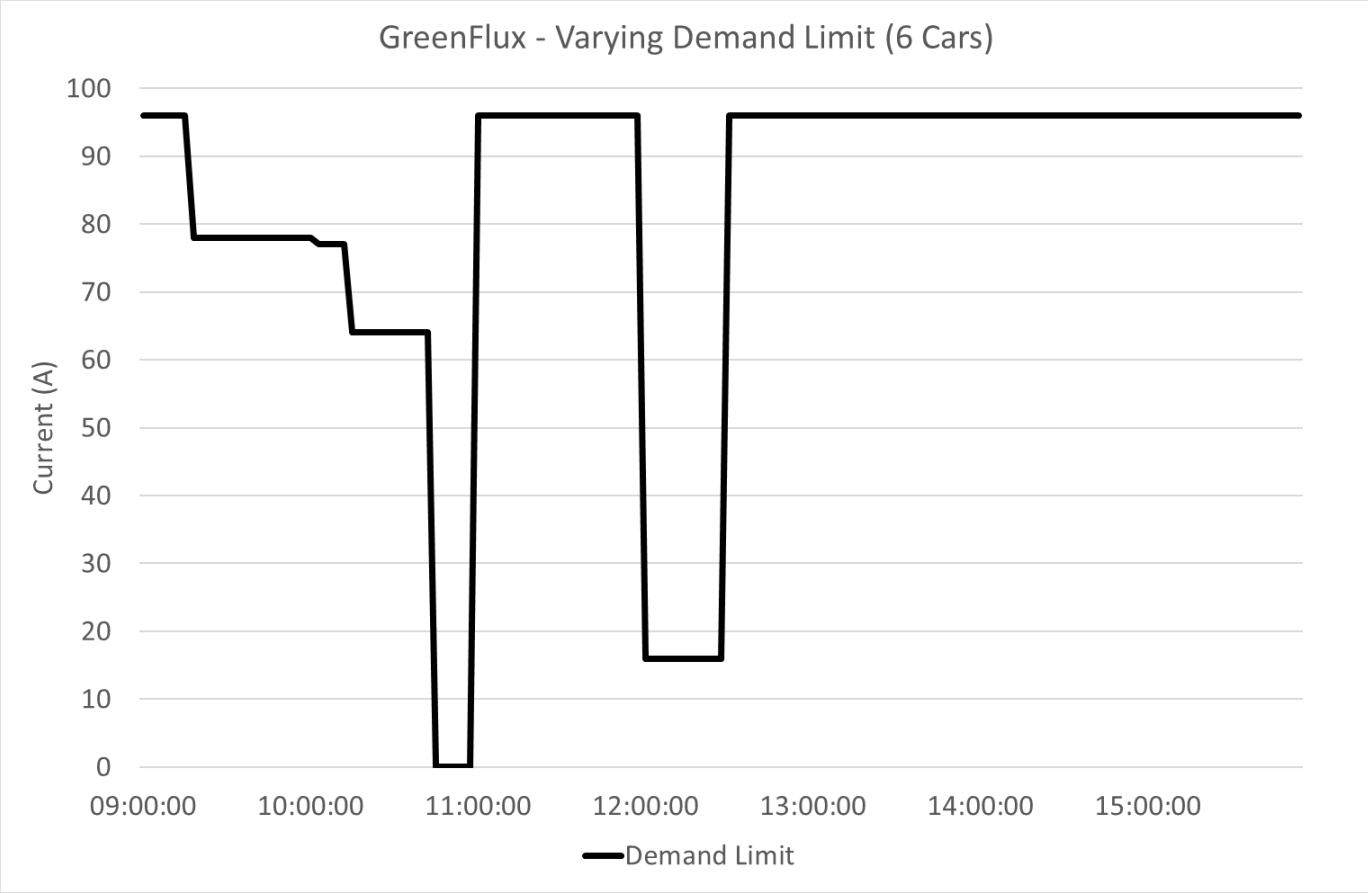
Test system – smart charging in action

For more test results: https://www.westernpowerinnovation.co.uk/Document-library/2017/CarConnect/CarConnect-Algorithm-Development-and-Testing.aspx

ELECTRIC NATION

Test system – smart charging in action



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ELECTRIC NATION

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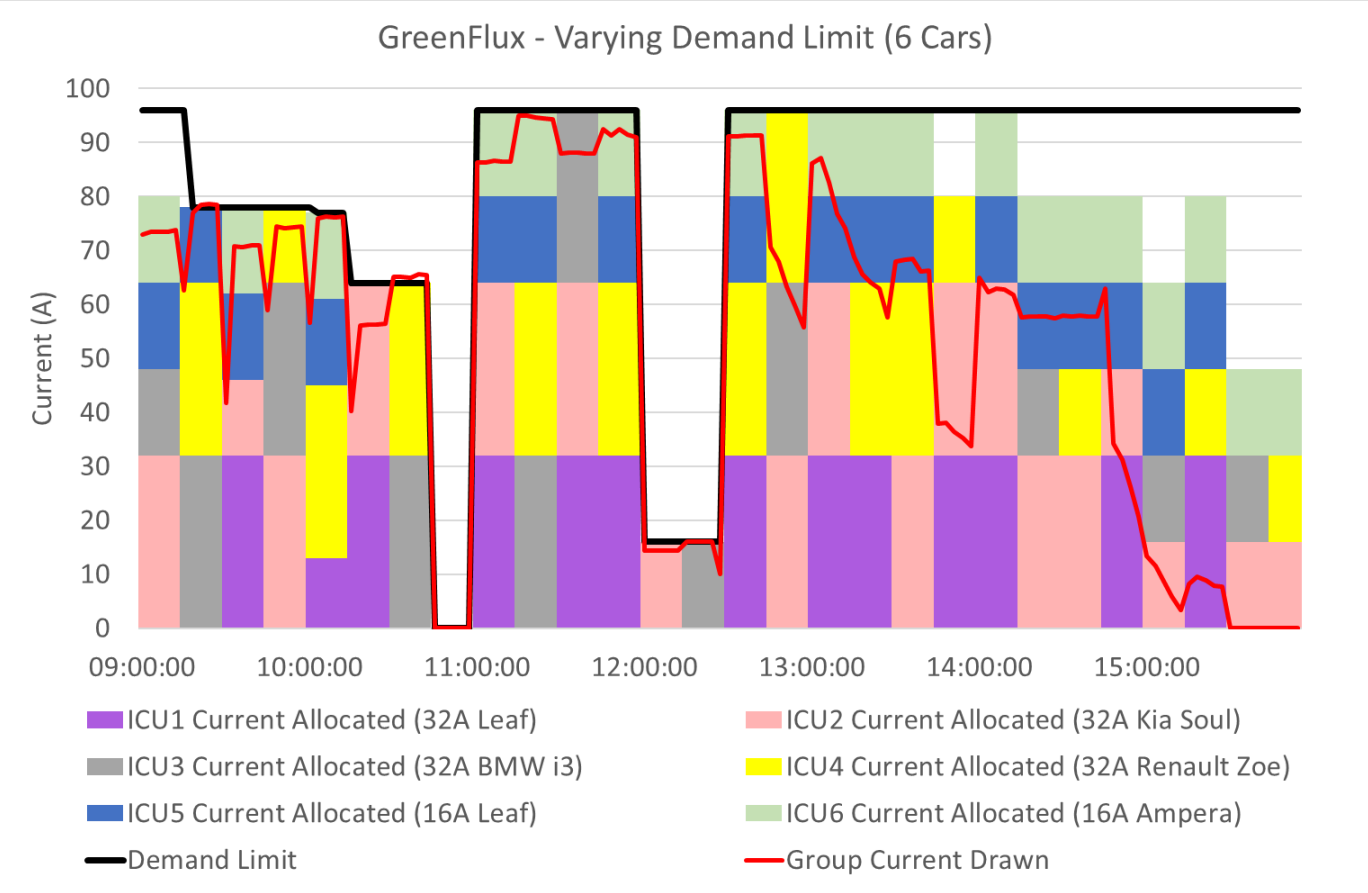

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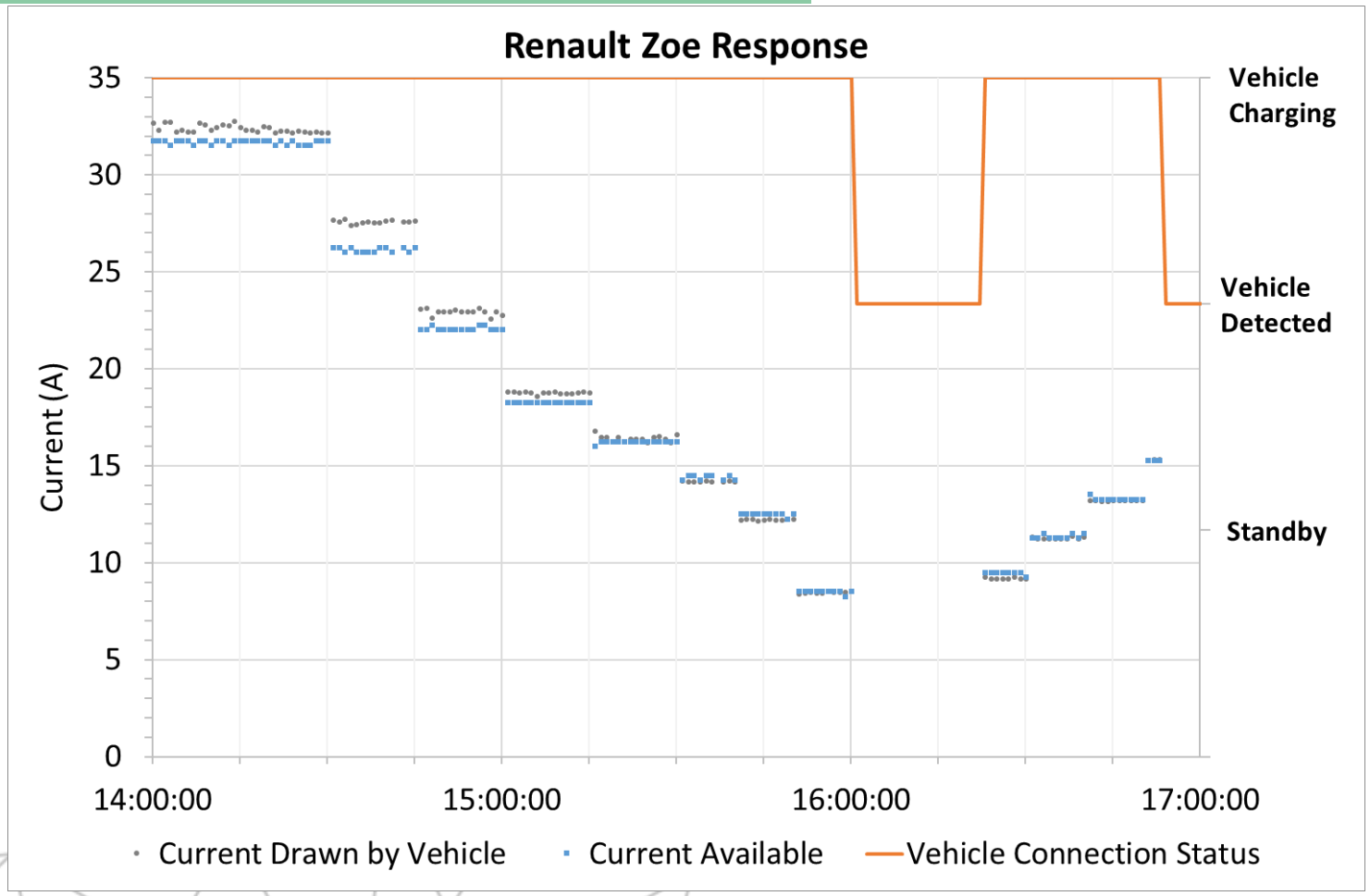
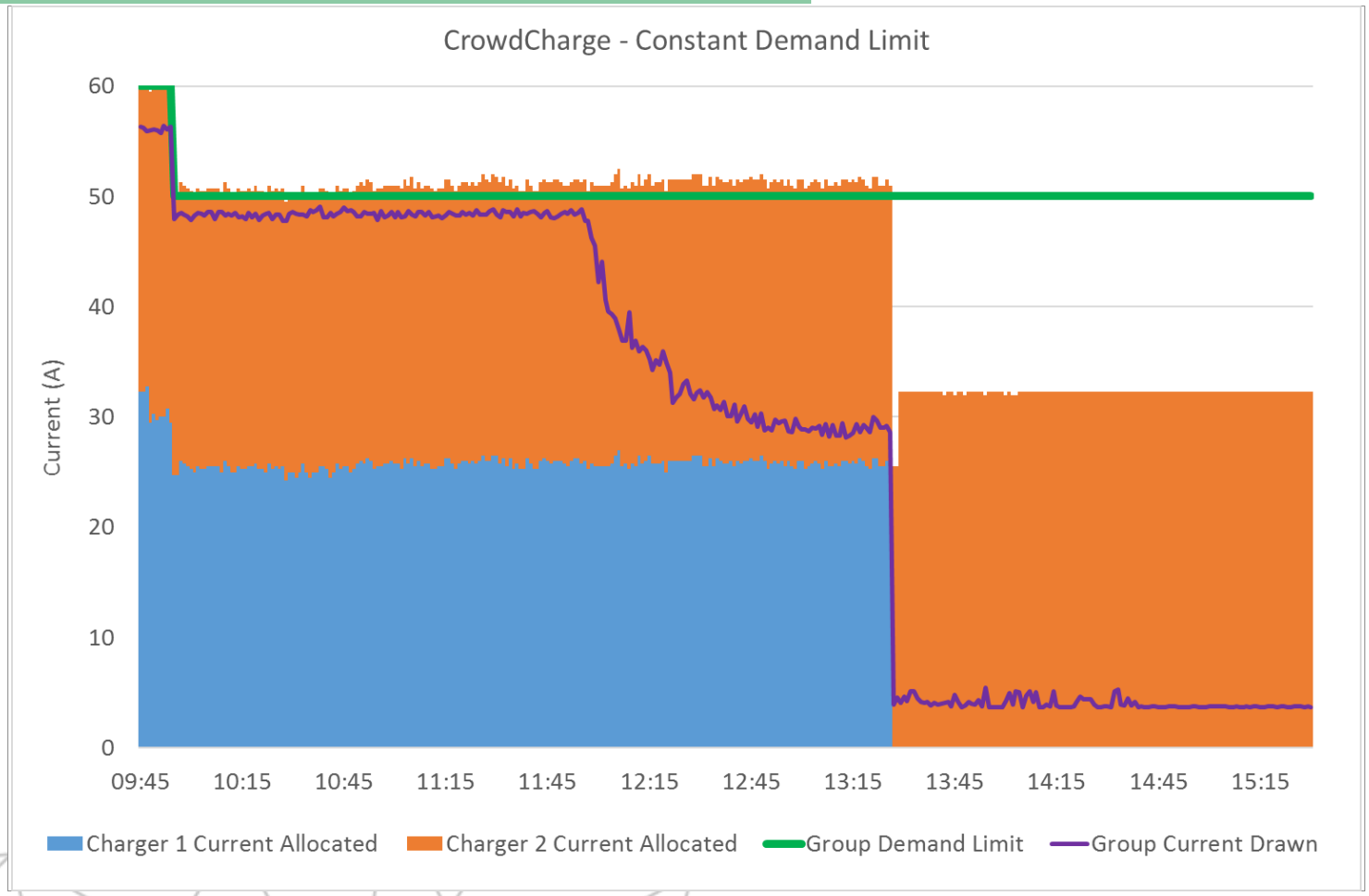
Test system results - Examples



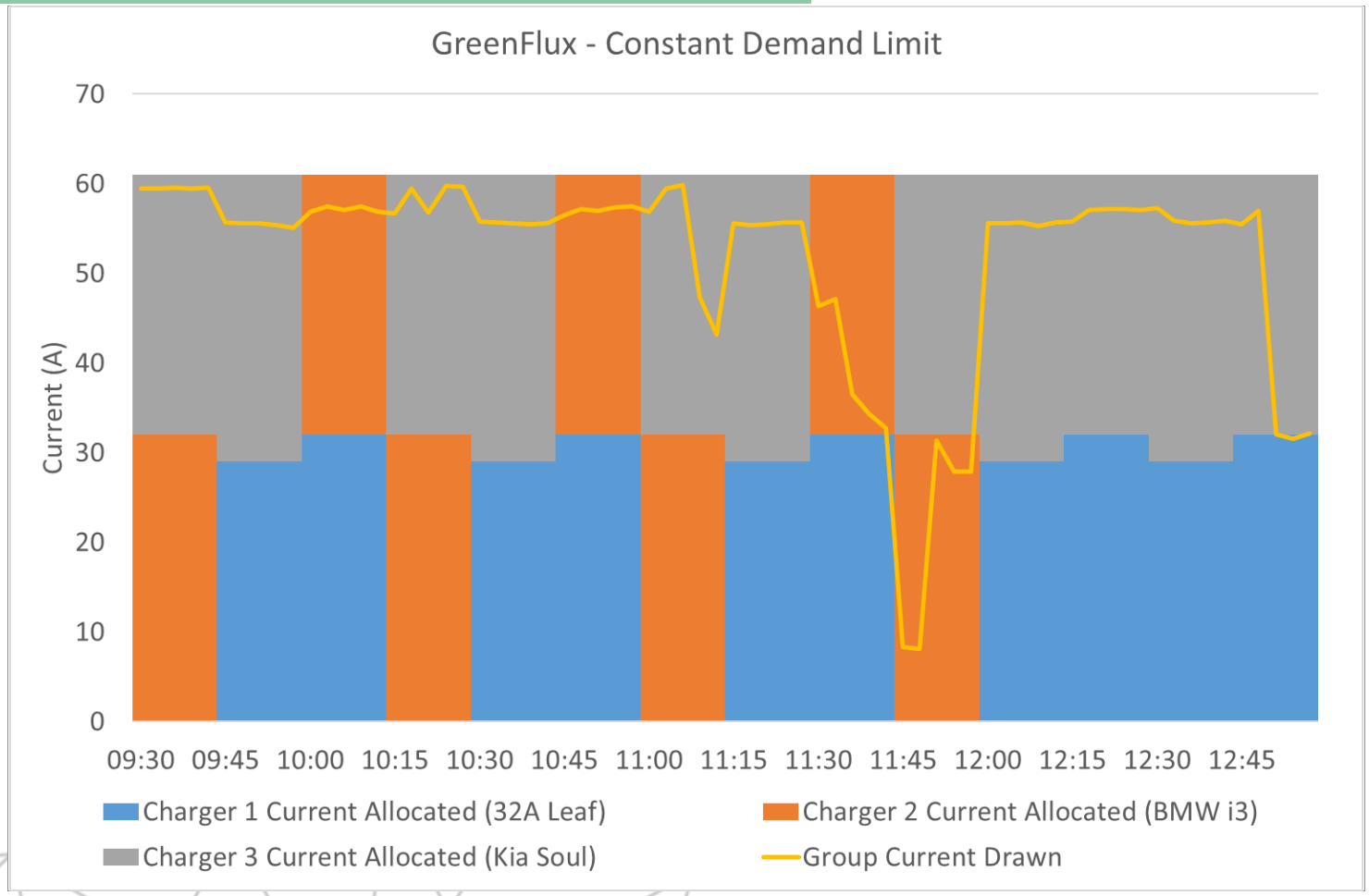
ELECTRIC NATION

Test system results - Examples



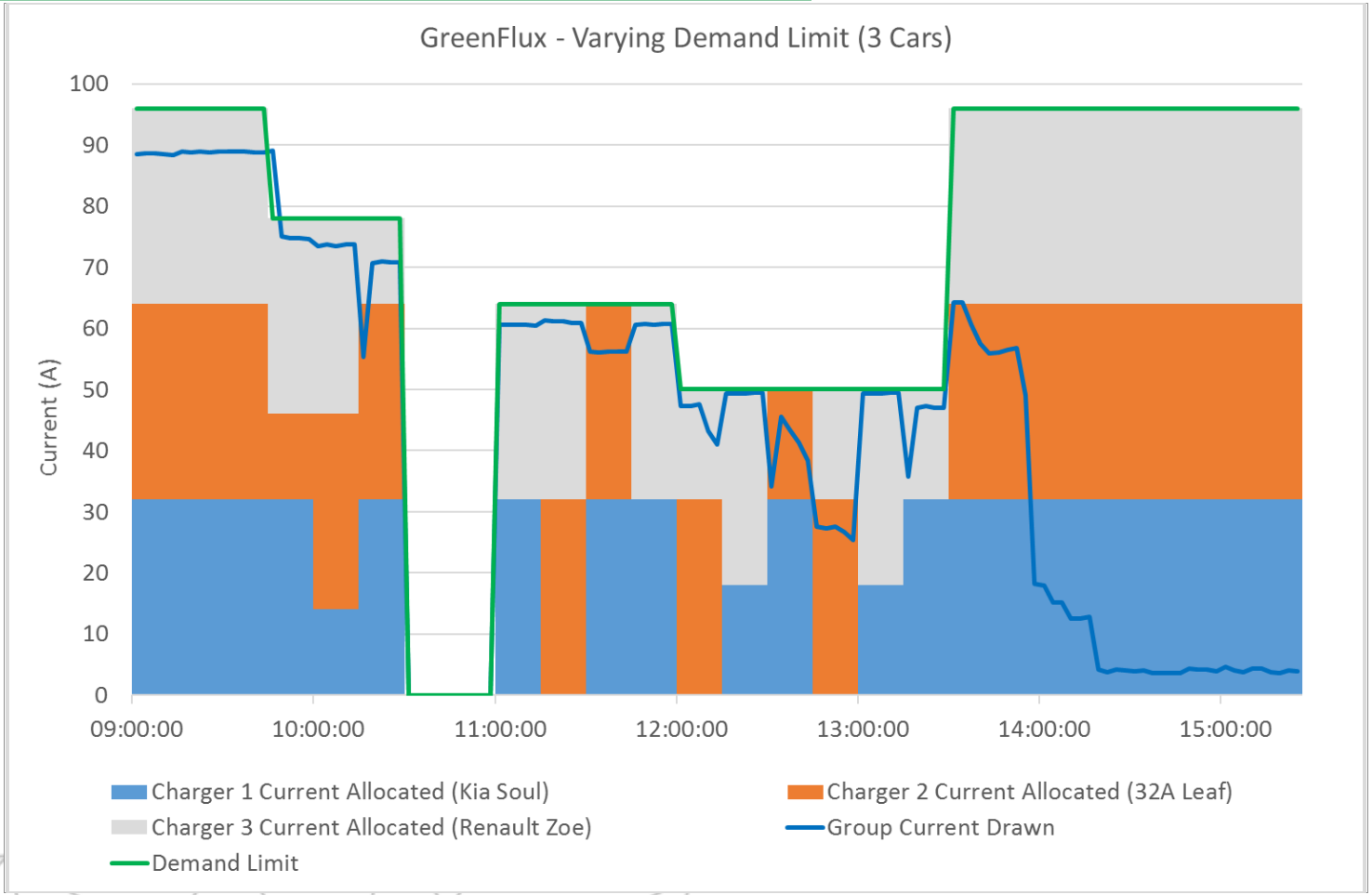
ELECTRIC NATION

Test system results - Examples



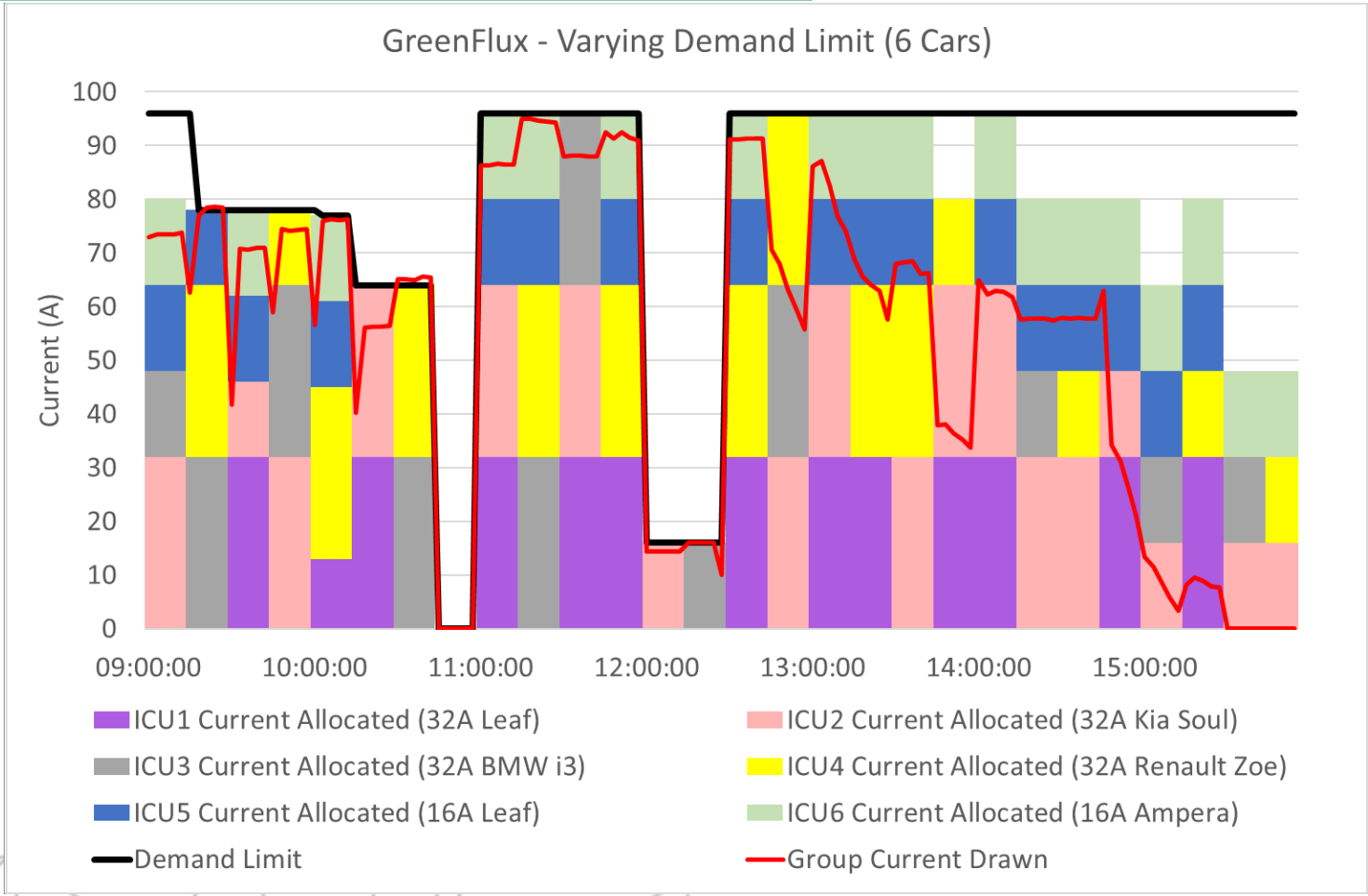
ELECTRIC NATION

Test system results - Examples

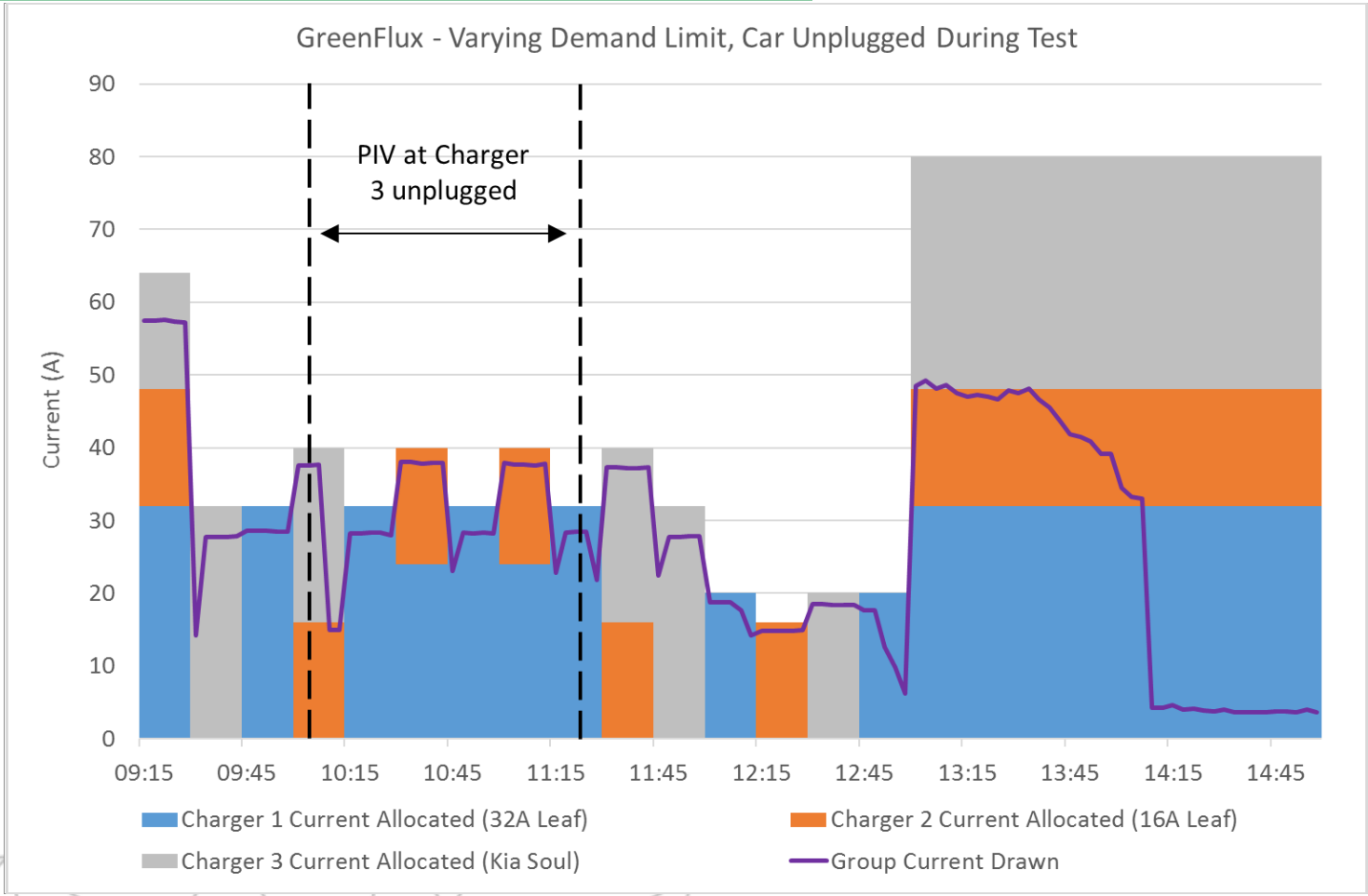


ELECTRIC NATION

Test system results - Examples



Test system results - Examples



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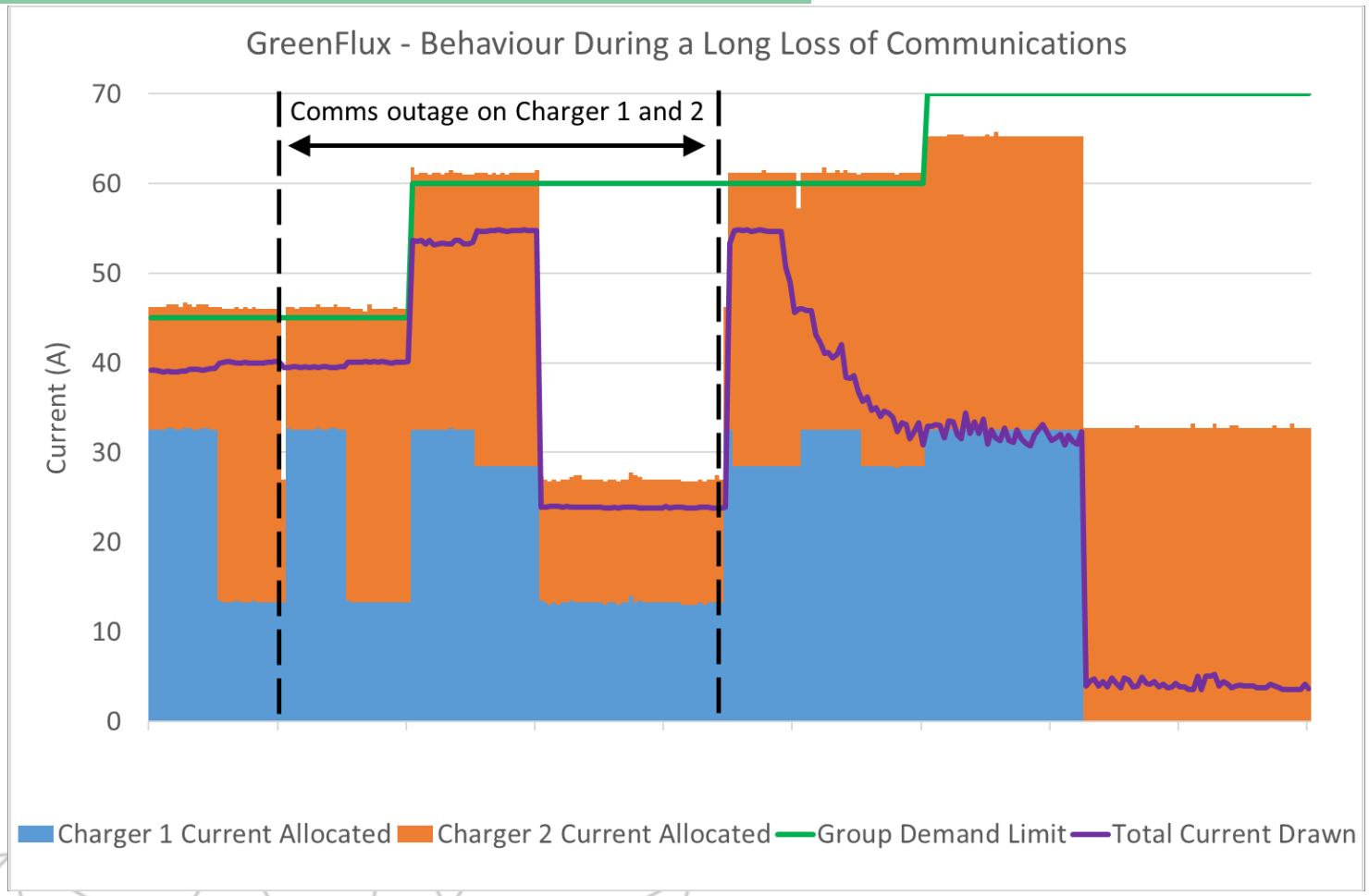


Pilot installations

- Purpose of pilot installations is to test:
  - Ordering and installation procedures
  - Communications in household scenario
  - Sheltered environment to test any troubleshooting
- 10 pilot installations in November and early December 2016
- Learning used to inform installer training before main trial began

ELECTRIC NATION

Marketing and PR – The strategy

- Underpins and supports all recruitment and dissemination activity
- All project partners engaged in the process
- Established key communication messages
- Recommendations:
  - DriveElectric to encourage people taking out new plug-in leases to take part
  - Need to encourage manufacturers, and critically their dealers, to promote the project
  - Wider marketing, communication and PR, ultimately targeting all people who may be considering buying a plug-in vehicle in the near future
- Managing customer expectations critical
- Go Ultra Low partners key

Gearing up to project launch

- Branding established
- Professional images
- Website developed (four weeks!)
- Electric Nation short video produced
- Social media accounts set up
  - 853 followers
- Press release template agreed
- E-newsletter template created
- LCV2016 exhibition stand panels produced
- Customer information and welcome packs
- Posters produced
- Electric Nation desktop model
- Guide for WPD call centre staff
- PR & social media protocols for partners
- Project launched at Cenex LCV, September 2016
  - Fully Charged film on Electric Nation achieved 33,777 views

ELECTRIC NATION

BE PART OF THE ELECTRIC NATION COMMUNITY

If you're buying or leasing an electric vehicle (EV) – including pure electric and plug-in hybrid – you're invited to become part of the Electric Nation community. If you join Electric Nation you will get a free* smart charger. The Electric Nation project is trialling a smart charging solution so you'll also be helping to make sure our electricity networks can cope with the increasing numbers of electric vehicles expected in the future. Participation in the Electric Nation trial will be limited to those living in the Midlands, South West and South Wales.

*Subject to eligibility and conditions, please see the Electric Nation website for more information

ABOUT ELECTRIC NATION

The Electric Nation project aims to provide local electricity network operators with the tools to ensure that their networks can cope with charging increasing numbers of electric vehicles, whilst avoiding the expense and disruption of digging up roads to replace cables.

FOR MORE INFORMATION AND TO CHECK ELIGIBILITY

WWW.ELECTRICNATION.ORG.UK
0333 300 1050
ELECTRICNATION@DRIVE-ELECTRIC.CO.UK

COLLABORATION PARTNERS

Electric Nation is the customer-facing brand of CarConnect, a Western Power Distribution (WPD) and Network Innovation Allowance funded project. WPD's collaboration partners in the project are EA Technology, DriveElectric, Lucy Electric GridKey and TRL.

WESTERN POWER DISTRIBUTION

ELECTRIC NATION
YOUR ELECTRIC VEHICLE YOUR SMART CHARGE

BUYING OR LEASING AN ELECTRIC VEHICLE? GET A FREE UPGRADE TO A HOME SMART CHARGER

WESTERN POWER DISTRIBUTION

ELECTRIC NATION
YOUR ELECTRIC VEHICLE YOUR SMART CHARGE

CUSTOMER INFORMATION PACK

WESTERN POWER DISTRIBUTION

ELECTRIC NATION IS TRIALLING A SOLUTION TO MANAGE EV CHARGING CHALLENGES

The UK electricity system has sufficient capacity to deliver energy to electric vehicles, however recent research suggests that if clusters of EVs develop in local areas and they're all charged simultaneously then some local electricity networks may require costly reinforcement.

A smart charging system, such as the one being trialled in Electric Nation, could alleviate the stress on the electricity network caused by clusters of EVs charging at the same time.

Electric Nation is recruiting 500 to 700 people buying or leasing any model of EV (including pure electric or plug-in hybrid) to take part in the largest trial of its kind.

WILL GET A FREE* SMART CHARGER INSTALLED

BENEFITS INCLUDE:

- This smart charger is one of the latest, most intelligent on the market
- It can give you data on your charging history
- The smart charger will be capable of providing demand control services, including altering the rate of charging of your car
- The smart charger has a power rating of 7kW, which can charge an EV up to twice as fast as a 3kW home charge point, if the vehicle is capable of being charged at this rate
- The smart charger is much faster and safer than charging from a domestic three pin socket
- It will have the latest functionality as software updates can be carried out remotely
- Issues with your smart charger can be diagnosed and often fixed remotely.

The smart charger is yours to keep after the end of the Electric Nation trial.

*Subject to eligibility and conditions, please see the Electric Nation website for more information

WHAT WILL THE TRIAL INVOLVE?

- Trial participants will charge their vehicles using the smart charger provided when they need to charge their EV at home. The smart charger may reduce or pause charging from time to time, albeit with the aim of providing the charge that you need to use your EV.
- Some participants will have access to a mobile device app which allows them to enter information about their journey preferences and receive information about when they've charged their car and any times when their charging may be controlled.
- Participants will be required to take part in customer research designed to investigate their experience of owning an EV and of charging it, including the acceptability of the charge control solution. This will take the form of surveys and interviews.

Marketing & PR - Supporting trial recruitment

- Maintaining / updating materials
- Responsive to all recruitment needs
- Social film
- 25+ project news items on http://www.electricnation.org.uk/
- 70+ industry news items on the website
- 7 press releases sent out to mass media / targeted regional and local media
  - First installs covered in Milton Keynes, Nottingham (GUL areas)
  - 3,250 media cross-industry contacts
- Brochure specifically designed for Renault to support recruitment via dealers
- Branding for test rig and smart charger stickers
- Weekly marketing and PR support for DriveElectric recruitment events
- Blogs

Marketing & PR – dissemination activity

Project e-newsletters x 5

Customer e-newsletters x 3 (for DriveElectric)

Focused events across automotive, electricity and policy stakeholder audiences:

- EV Network Group
- LCNI 2016
- V2G Workshops
- REA Connected Systems
- New Energy Forum
- Smart Energy Marketplace
- All Energy
- Infrastructure event
- Powering the Low Emission Future
- Cenex LCV2017
- Balancing Act
- UK EV Policy event
- LCNI

Recruitment

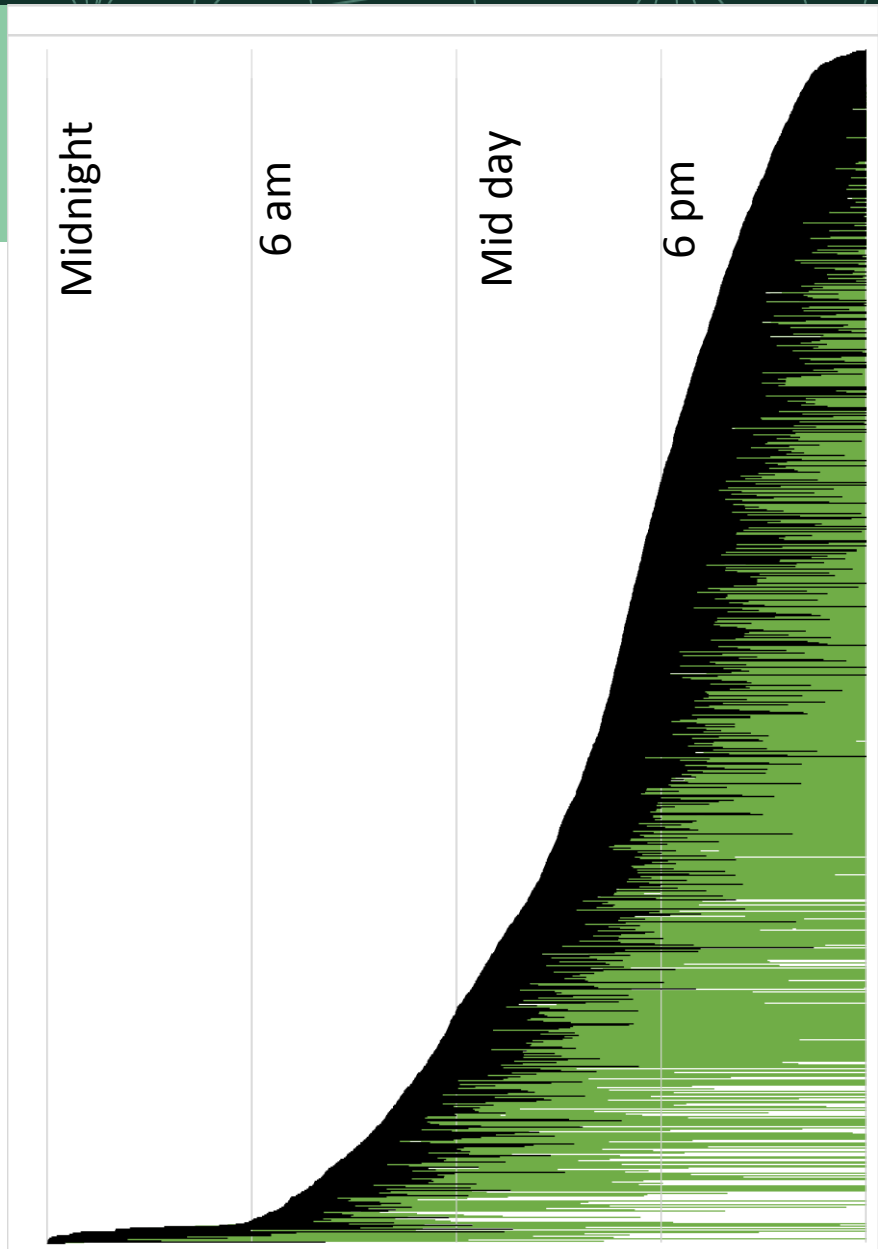
- Promotion events
- Website
- Referrals
  - Dealers
  - Installers
- Expression of interest
  - Eligibility check
- Installation self survey
  - Installer approval

Installation

- Electrical Installations
  - Mostly Successful
  - Maximum Demand issues…
- Communications - Challenging!
  - GreenFlux/ICU: 80% availability
  - CrowdCharge/APT: 40% →60%
- Hardware/firmware
  - Faults & changes
- Broadband Internet
  - Reliability
  - WiFi link
- Customer behaviour

Customer trial

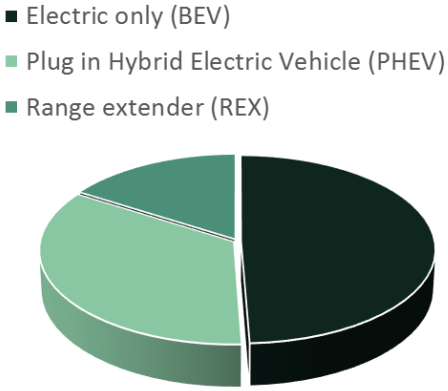
- 2017 – getting cohort built
  - Charge at will → demand management
- What we hope to get
  - Data to identify factors that influence customer behaviour under demand management
    - Size of battery vs EV use
    - PHEV vs BEV
- Use this to design further trials in 2018
  - Including more sophisticated DM systems
  - Customer interaction
  - SOC data

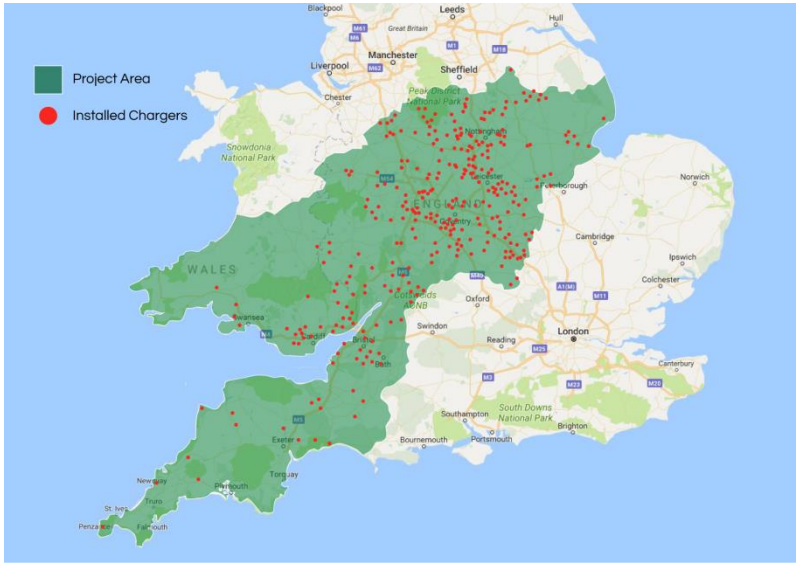


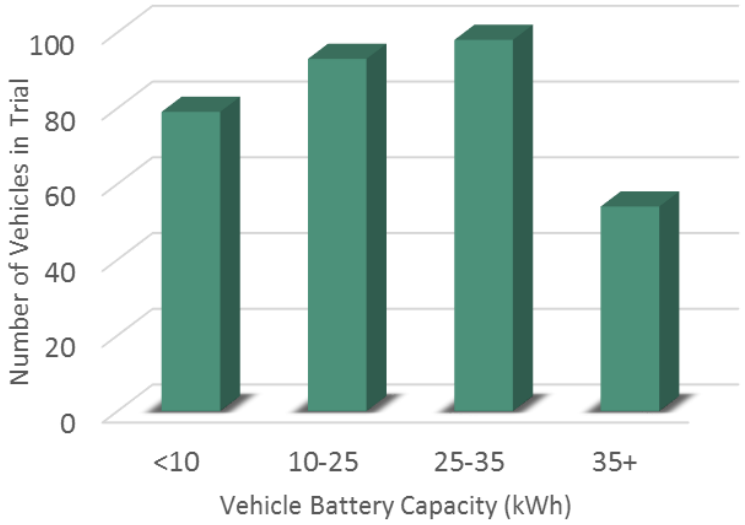
ELECTRIC NATION

The world's largest EV trial

- 400 chargers (and counting)installed throughout WPD's licence areas
- 40 different makes/models of EV
- Over 5,500 charging events captured already leading to 66,452 hours of charging data



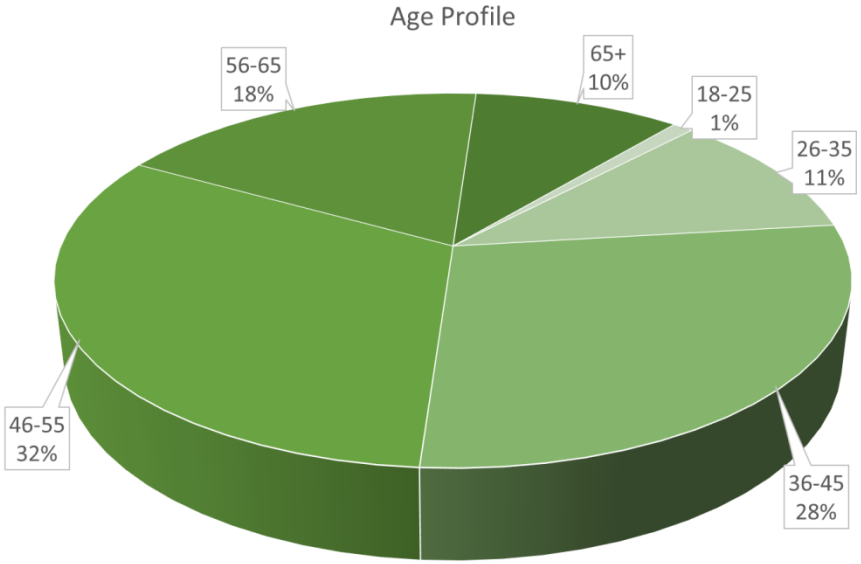


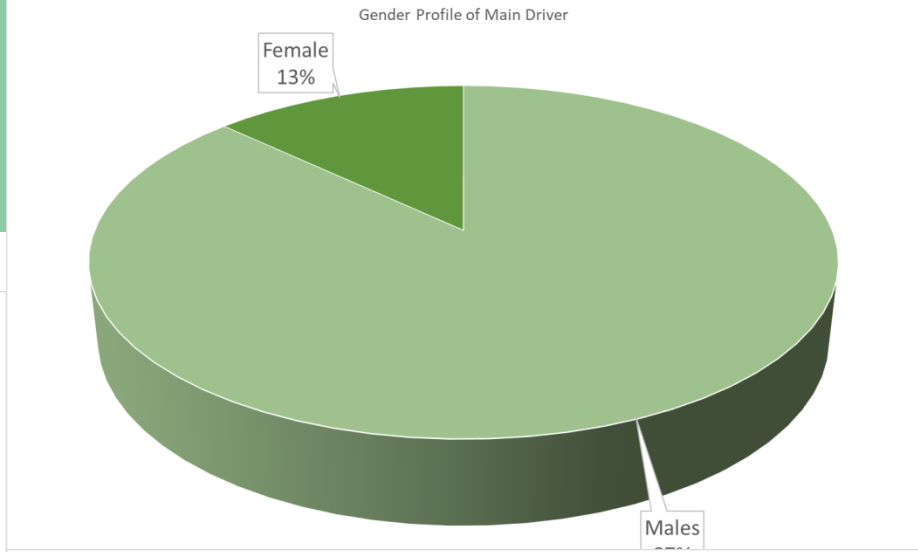


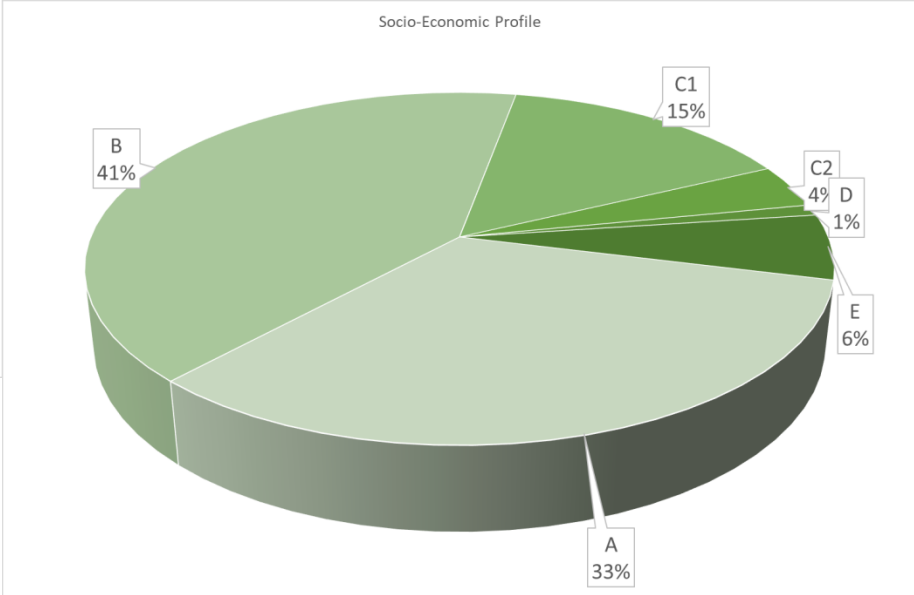
BMW TESLA NISSAN MITSUBISHI

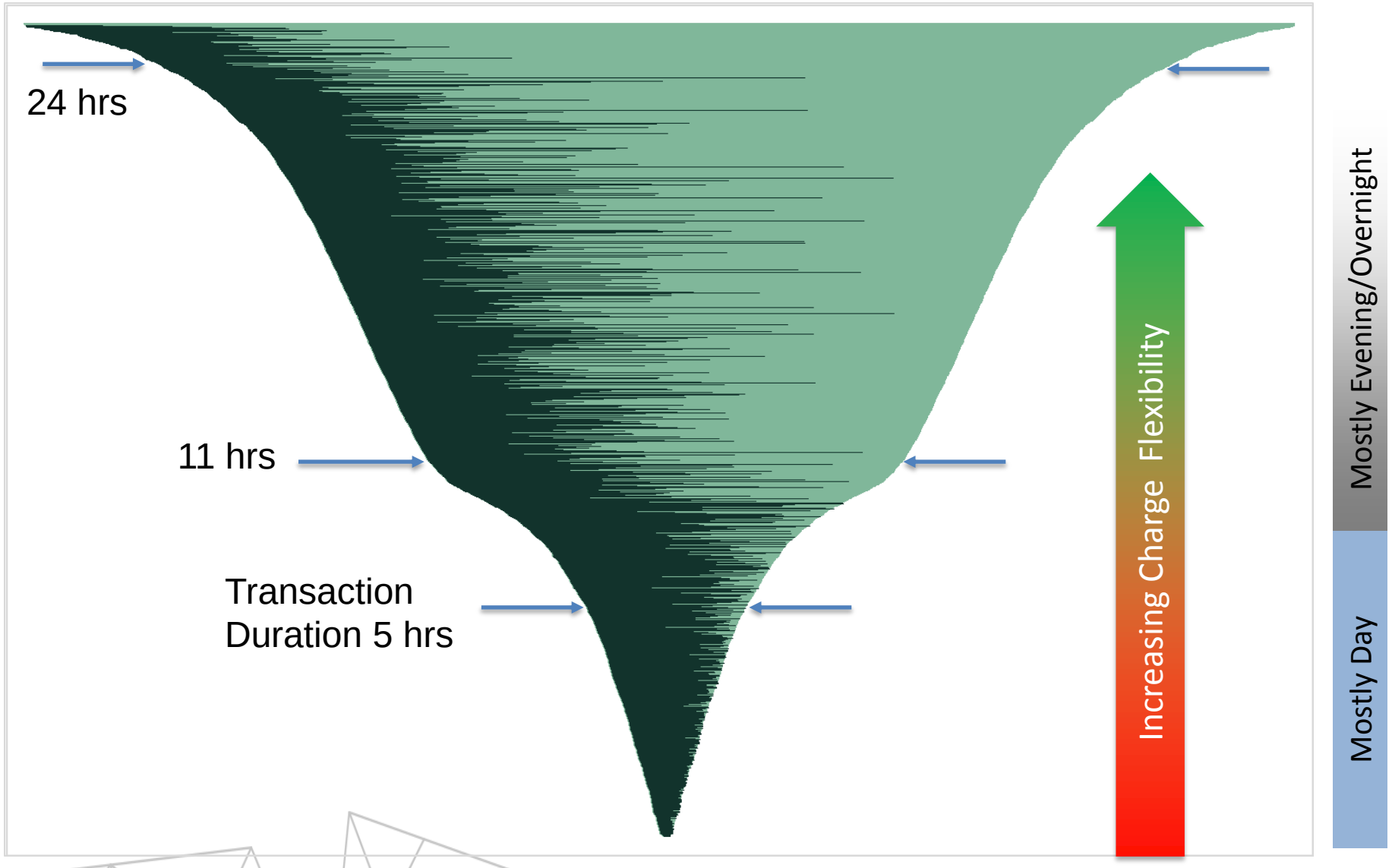
ELECTRIC NATION

Trial Cohort

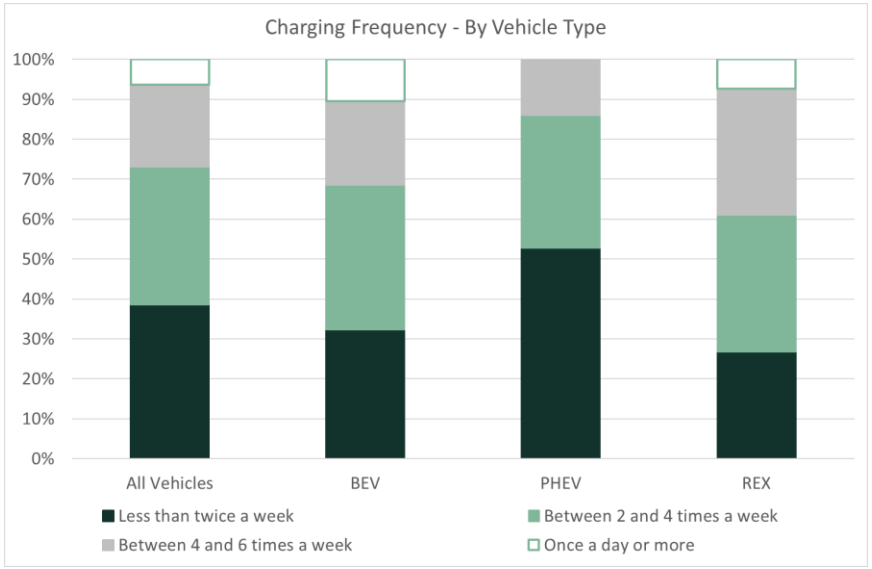


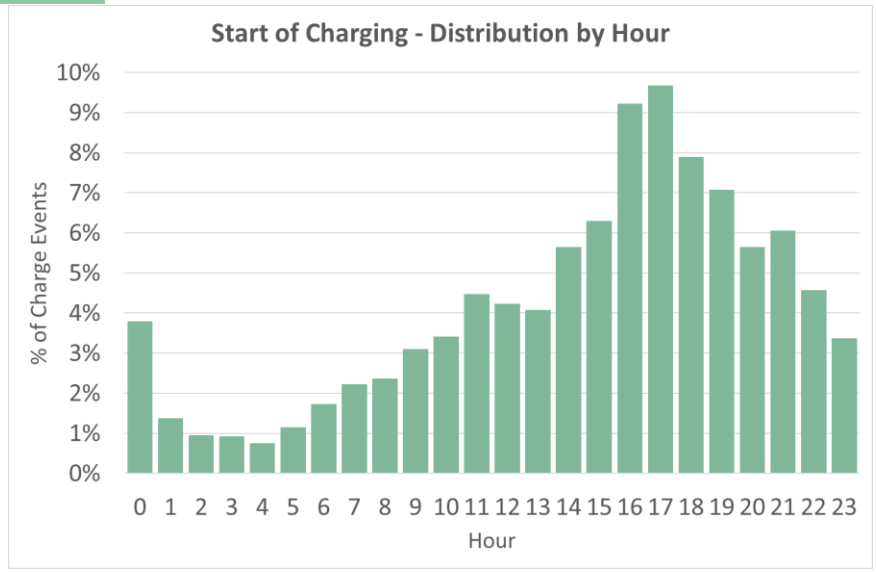





24 hrs
11 hrs
Transaction Duration 5 hrs
Increasing Charge Flexibility
Mostly Evening/Overnight
Mostly Day

What's the additional load from Plug-In Vehicles?





- Very few people plug in every day, or even most days
- The majority is less than 4 times a week
- PHEV drivers (so far) appear to charge less frequently

- Peak of charging events occurring in the early evening
- Some charging begins at night – mainly using timers (plug-in is earlier)
- Some charging begins in the middle of the day

Vehicle to Grid (V2G)

- What is it?
  - Charging equipment that allows an EV to act as a small scale generator
  - Could provide an additional source of flexibility – benefits for decentralising generation and increasing use of renewables
- Electric Nation will be testing a single phase domestic scale V2G charger late 2017/early 2018
- Aim to get a pilot scale customer deployment mid 2018 to investigate potential benefits of domestic V2G to distribution networks
  - Voltage support
  - Thermal/Load management
- Customers could benefit from V2G
  - Supplying special power services to the electricity network & grid
  - Generating income to offset cost of EV ownership

ELECTRIC NATION

YOUR ELECTRIC VEHICLE YOUR SMART CHARGE

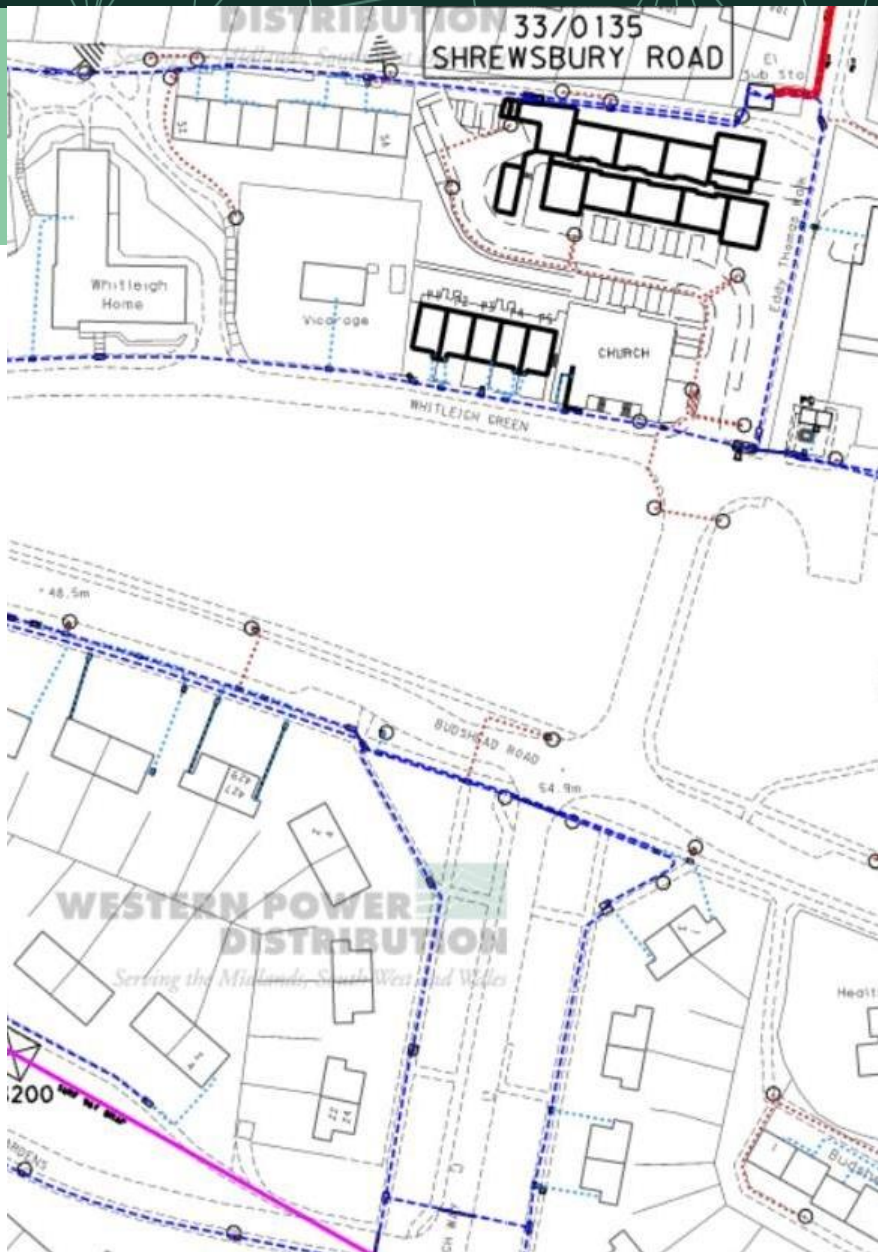
MODELLING

NETWORK ASSESSMENT TOOL

ELECTRIC NATION

Network Assessment Tool - The problem

- EV charging will lead to overloads in some cases
- DNOs can't implement solutions overnight – they need early warning
- Key questions:
  - How many networks will need reinforcement?
  - When will it be needed?
  - Which solution is the most cost effective?
- Answering complex questions usually needs good data



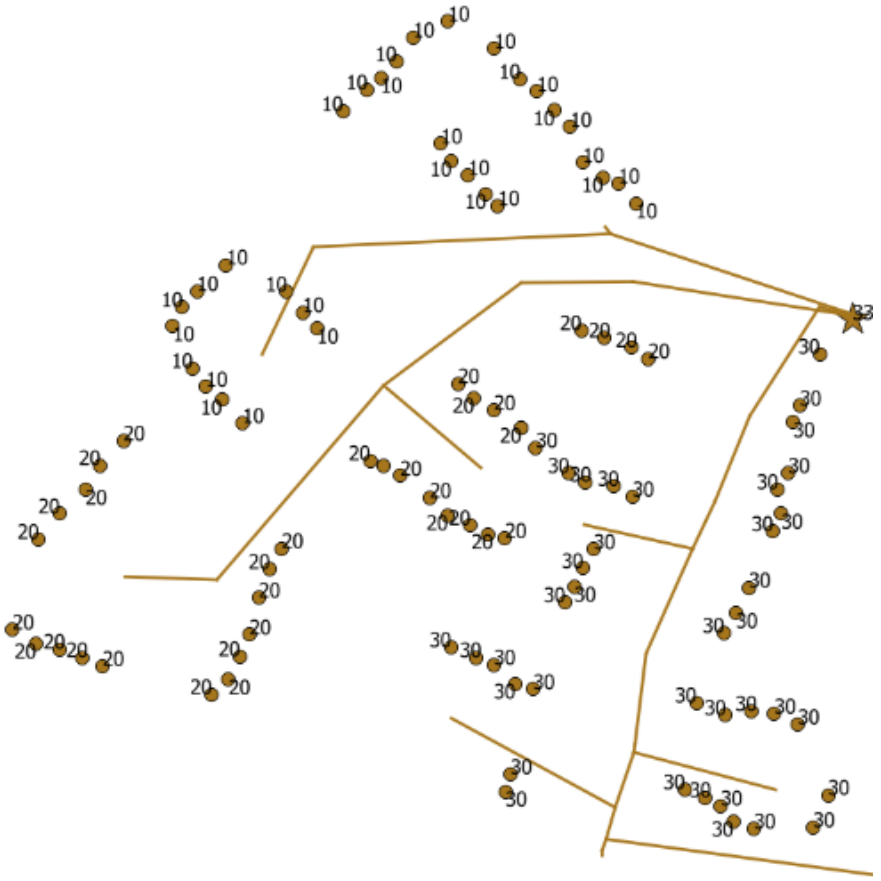
Network Assessment Tool - What is it?

- A modelling tool that can assess:
  - Likelihood of overload and voltage excursion
  - Range of scenarios
    - EV uptake / time
    - Usage characteristics
    - Consumer car choices
- Two main areas:
  1. Network-wide overview
  2. Detailed analysis and solution guidance

What we have done with available data (1)

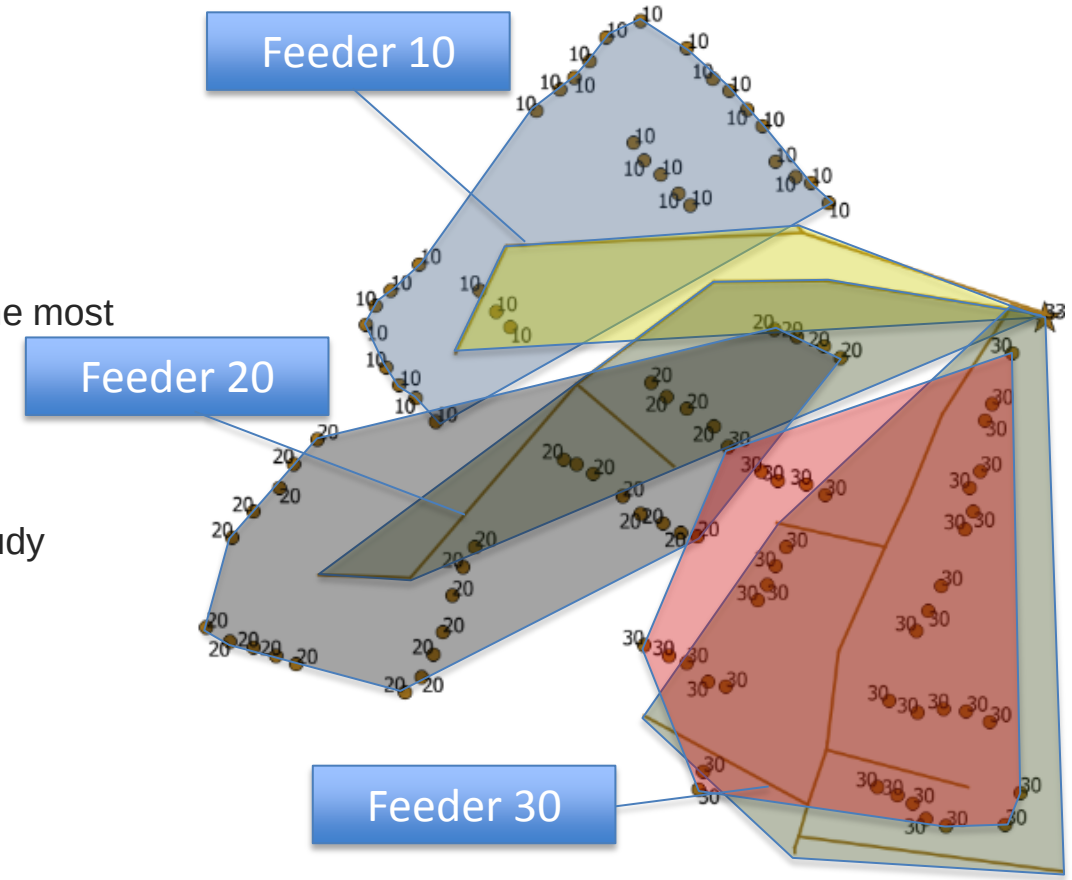
Developed spatial algorithms to build network connectivity

- Filling in the missing links
  - Identify first legs from substation
  - “Connect” cables
  - Customers to cable routes…



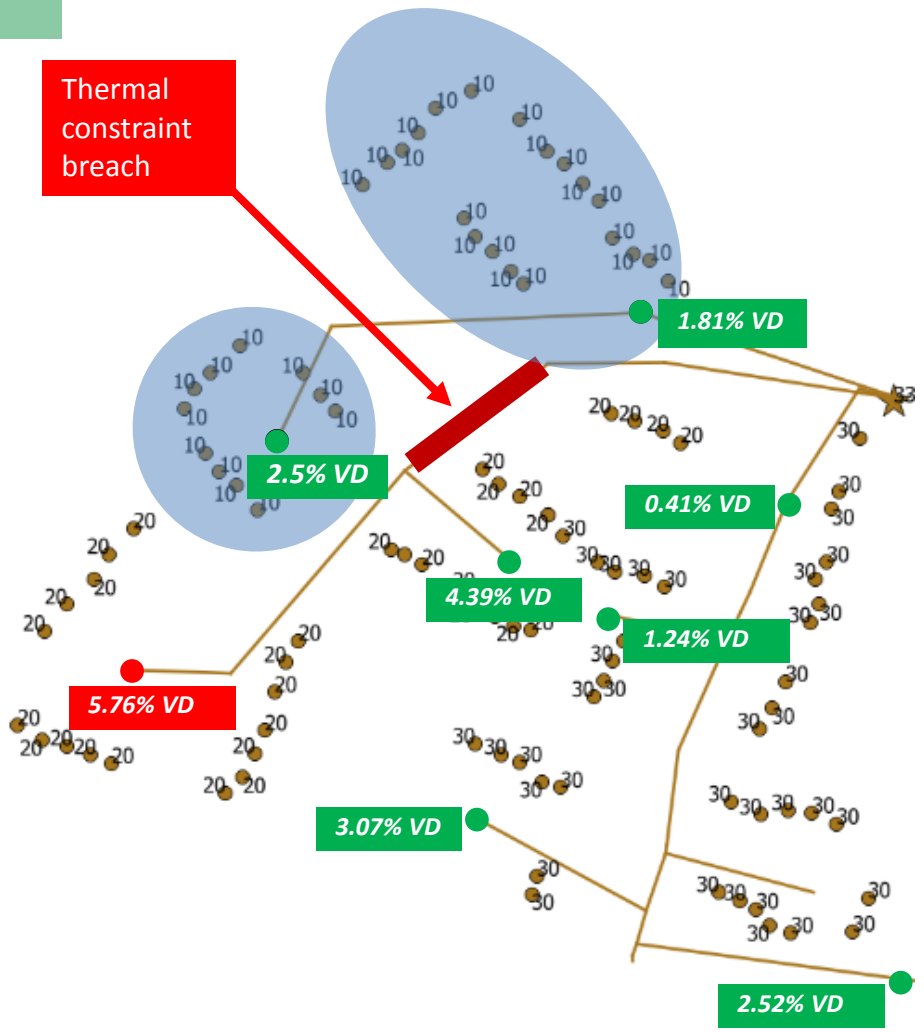
What we have done with available data (2)

- Spatial algorithms also associate
  - Customers groups to feeders
  - Can identify NOP locations
- Applied this to a sample pool of data
  - Iterate through this process to find the most suitable algorithm set and order
- All this enables…
  - Better understanding of network characteristics to allow a network study

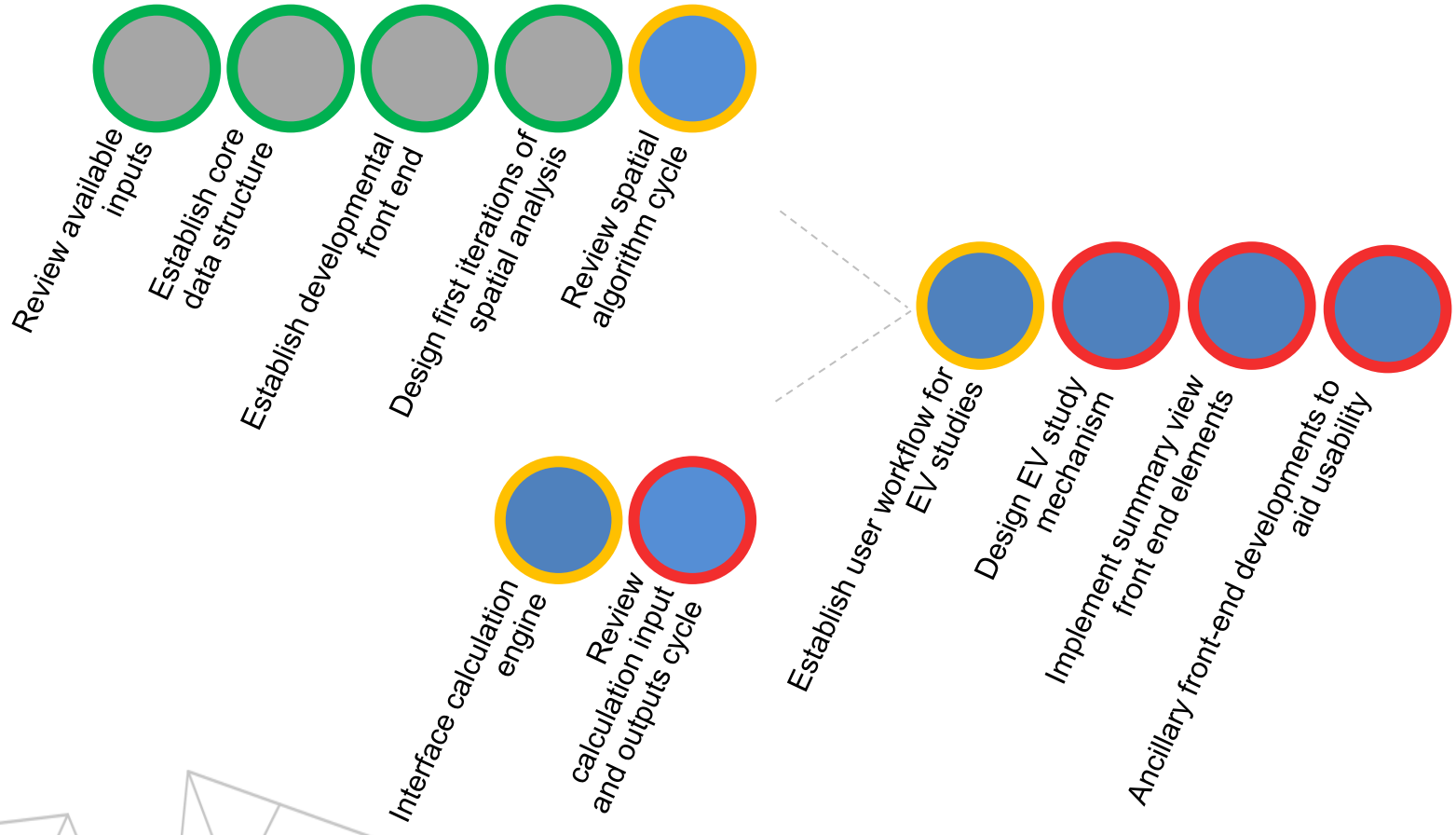


Network Assessment

- DEBUT calculation engine to calculate
  - Expected voltage drops
  - Thermal utilisation
- Present scenarios
- WPD use DEBUT as a design tool
  - Assessment is aligned with their standard practice

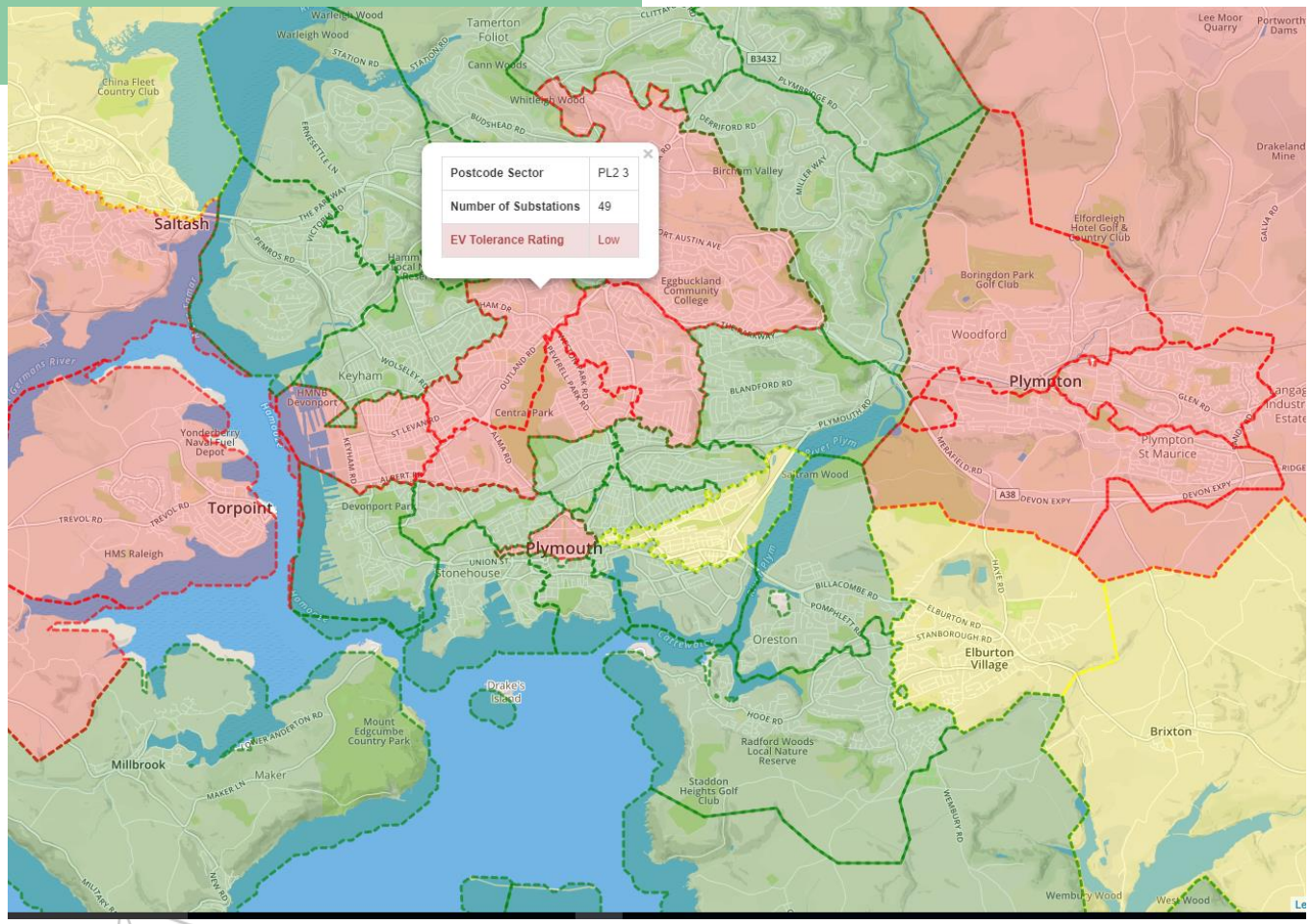


Resultant development path



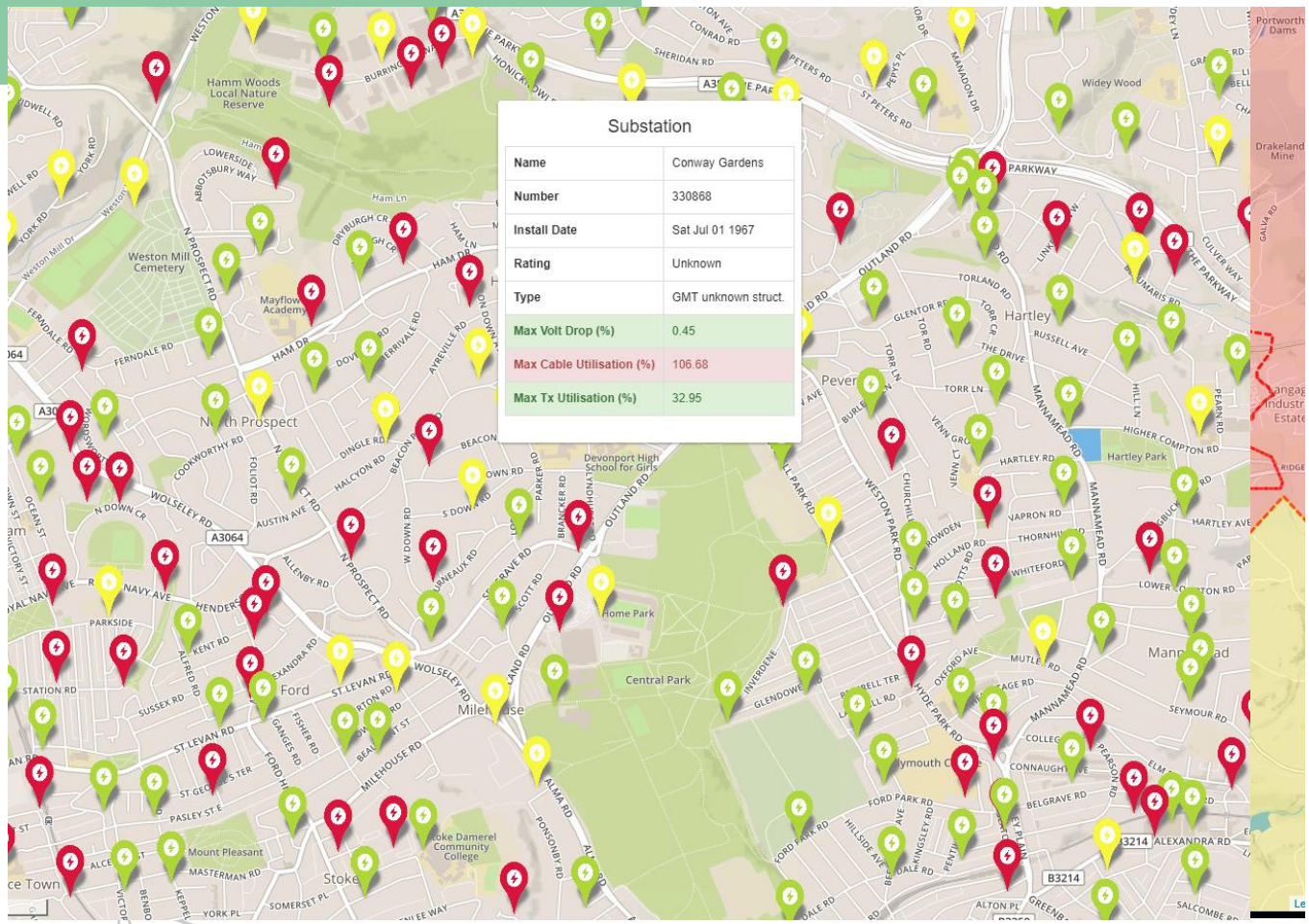
ELECTRIC NATION

Zooming in



ELECTRIC NATION

Zooming in



Highlighting potential problem feeders

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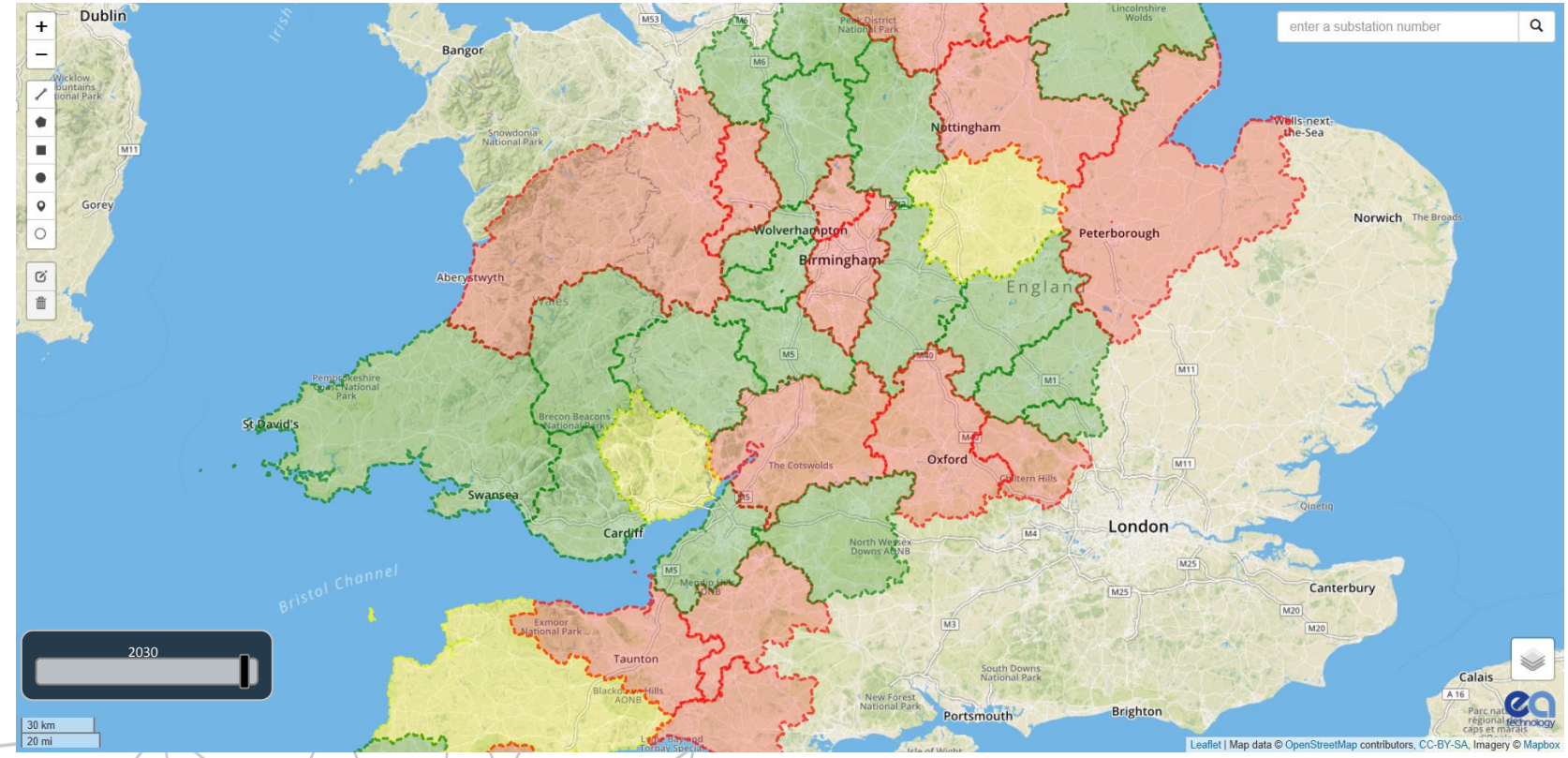
The user journey

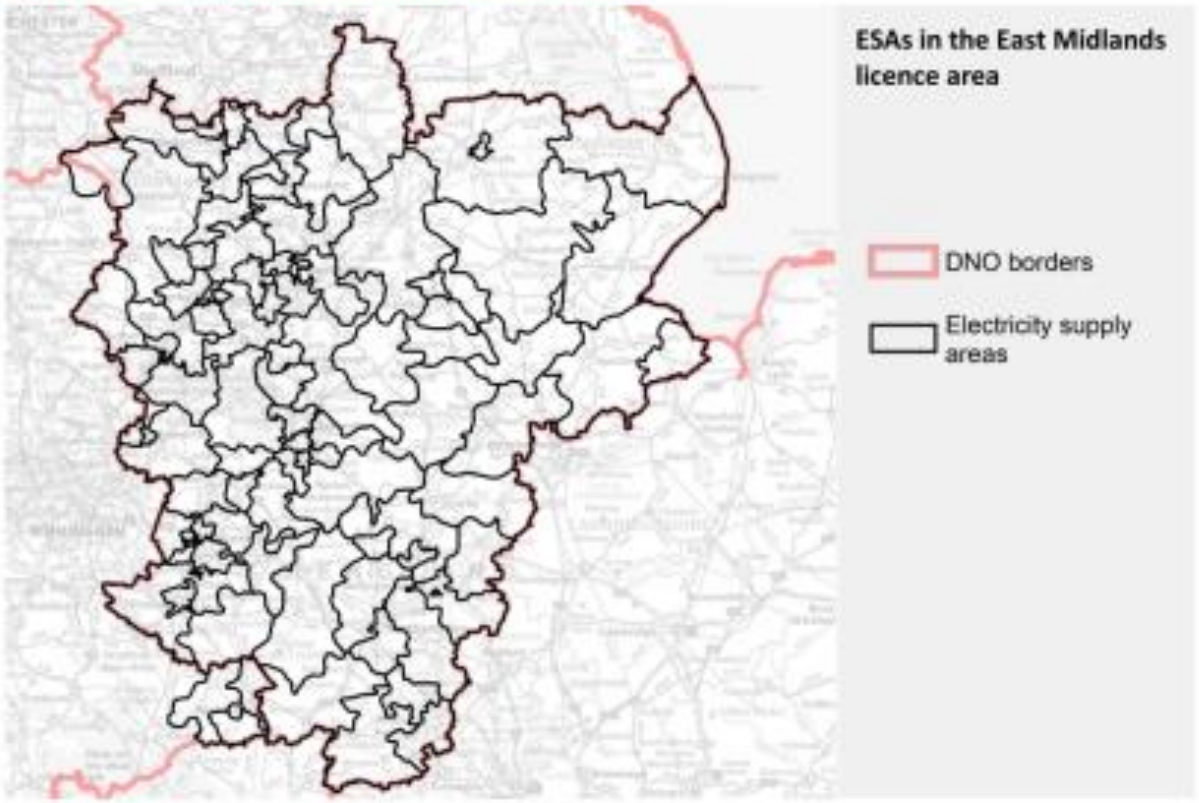
Tolerance indications:

- *Number of network breaches*
- *Ability to accept EVs*



More likely to go down ESA route

Figure 2: Electricity supply areas in the East Midlands licence area



Network licence area.

Source RegenSW for WPD

EV forecasting

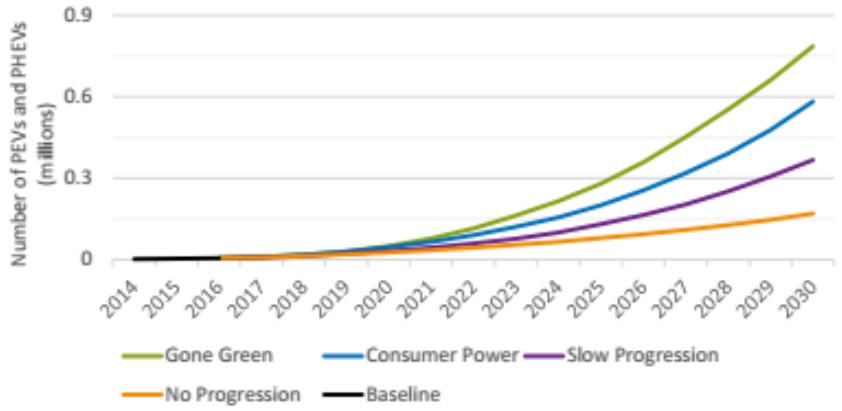
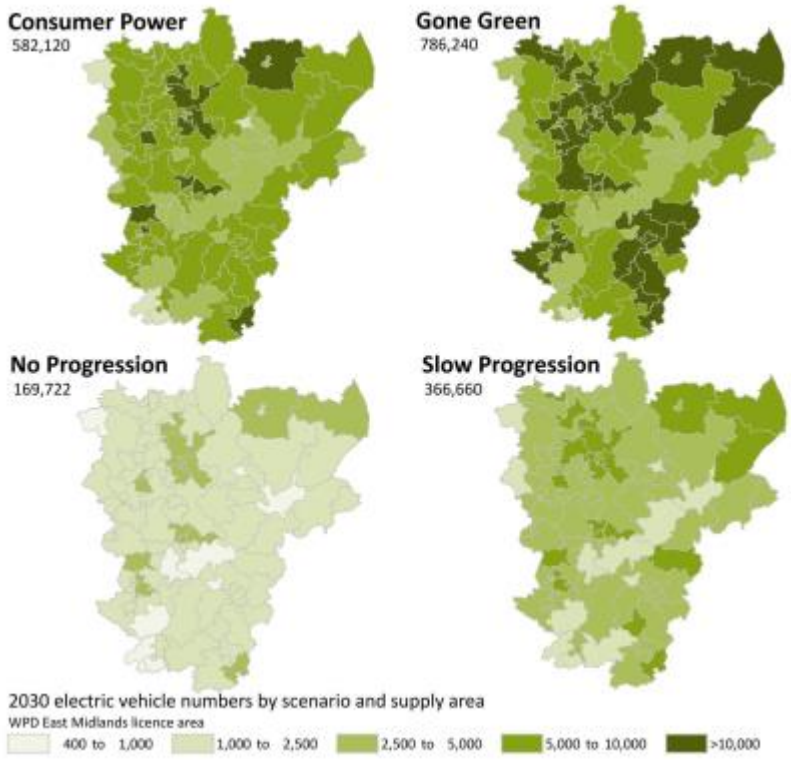


Table 37: Cumulative number of pure electric vehicles and plug-in electric vehicles in WPD licence area

	Baseline	2020	2025	2030
Gone Green	5,023	49,663	279,600	786,240
Consumer Power	5,023	45,463	199,800	582,120
Slow Progression	5,023	31,969	130,302	366,660
No Progression	5,023	26,245	79,002	169,722

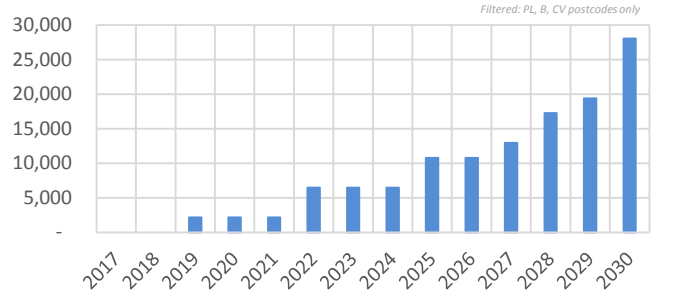
Figure 45: Distribution of electric vehicle numbers in 2030



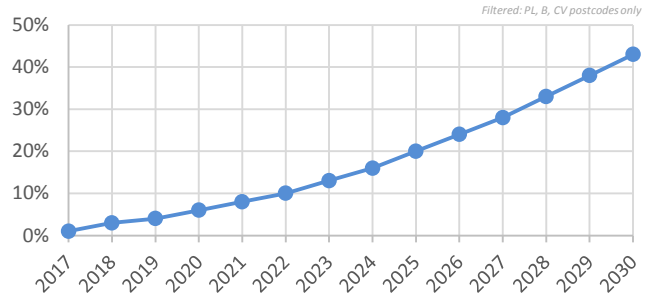
Source RegenSW for WPD

Tabular Views – reporting & data export

Statutory voltage legroom breaches (absolute feeder volume)



EV uptake volumes (% mpan penetration)

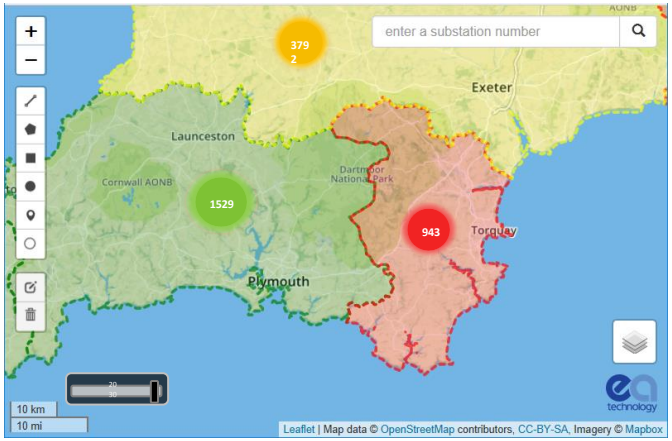


Filter results by Postcode

PL (5804)	☑
HR (5560)	☐
SA (2006)	☐
TQ (2576)	☐
EX (8064)	☐
WR (1843)	☐
B (3562)	☑

Substation Number	Name	Score #	Graph
330005	Morwellham Gen Stn	10	☐
332880	Marine Environmt Com	7	☐
333598	Dartmoor Prison	9	☐
332992	Becton Dickinson	3	☐
333445	Sifam Fibre Optics	6	☐
333084	Tecamec	1	☐
333064	Tesco Woolwell	5	☐

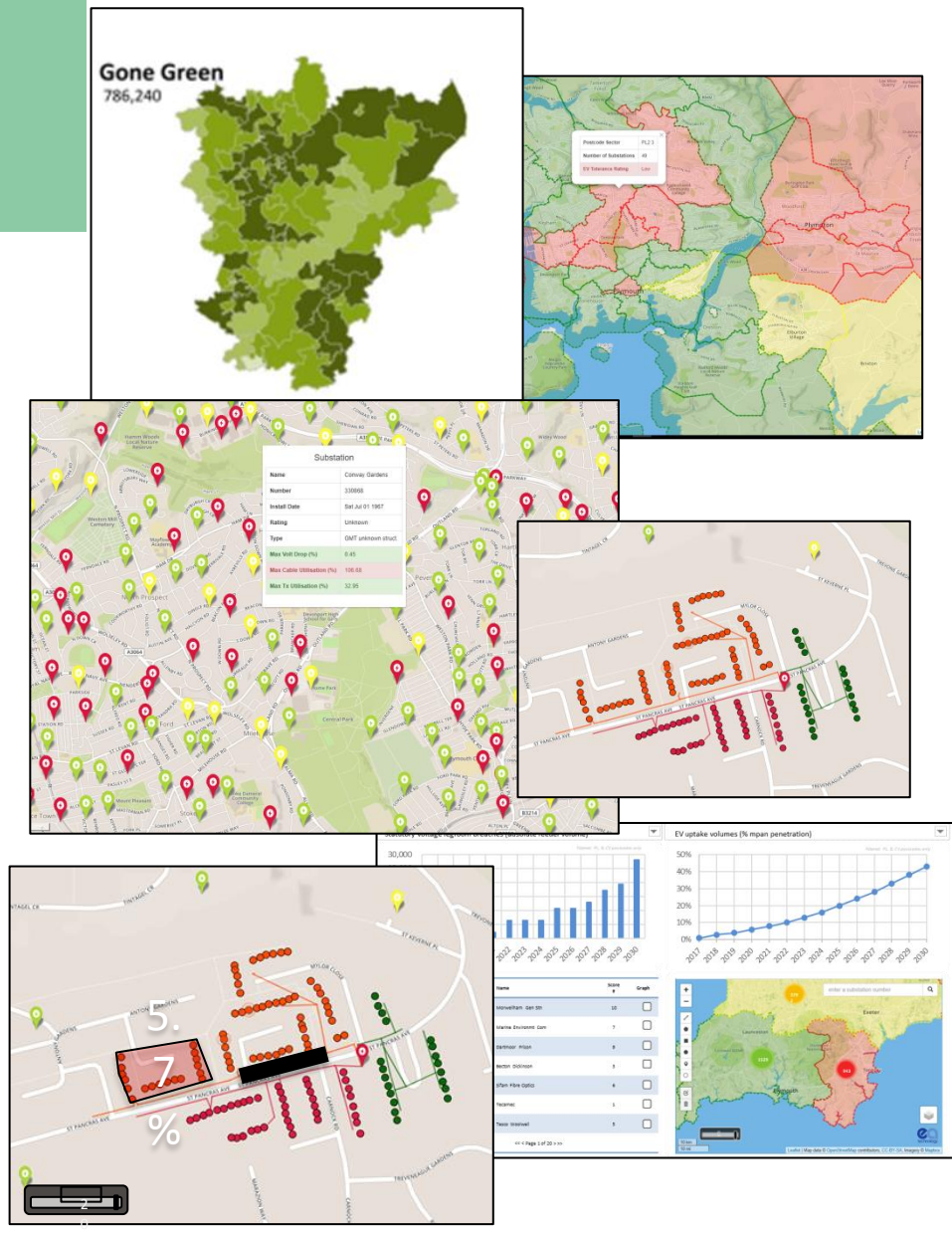
<< < Page 1 of 20 > >>



Auto-filtered by the boundaries of the viewable map area, postcode filter overrides viewable map area when checked

Further development

- Network assessment algorithm
- Building in EV forecasting
- EV penetration effects on networks
- Evaluation of solutions (e.g. Smart Charging)



In summary – Electric Nation will…

- Establish a method for identifying EV contribution to high loads on LV Networks
- Demonstrate how smart charging could enable EV owners to charge at home while minimising increasing electricity bills, and whether this is acceptable to EV owners
- Show charger manufacturers and the whole electricity sector how smart chargers can work in the home and the value of this, including V2G
- Develop an LV network assessment tool that will identify parts of networks that are susceptible to growing levels of EV charging
  - And assess whether smart charging can mitigate this impact
    - To enable WPD to defer, minimise or avoid reinforcement works
- Inform Government thinking on smart charging

Introduction, Progress & Looking Ahead

Lucy Mason – Wales & West Utilities

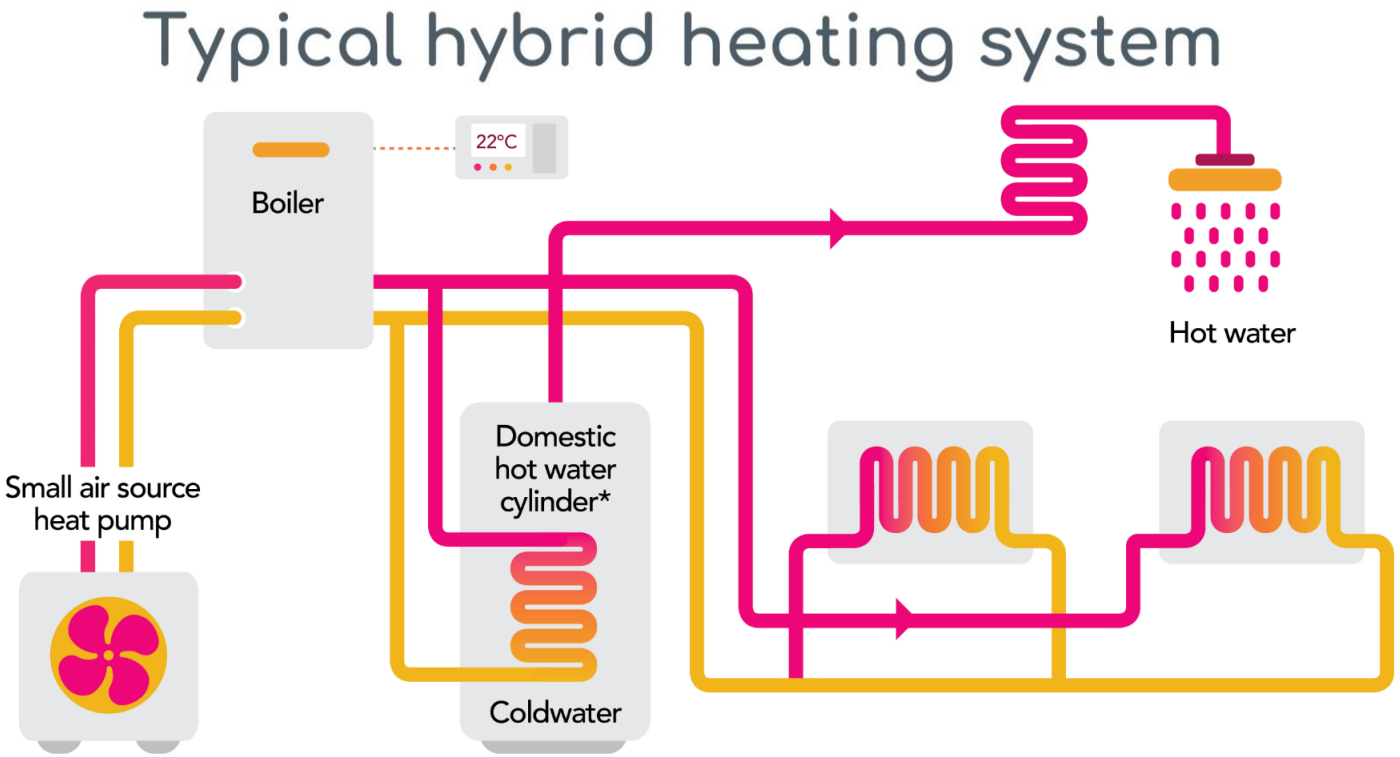
Tom Veli - PassivSystems

Freedom Project

Flexible Residential Energy Efficiency, Demand Optimisation & Management

Introduction

- £5.2m project to evaluate hybrid heating systems
- Install systems into 75 homes in 2017 in Bridgend, South Wales



Project Partners

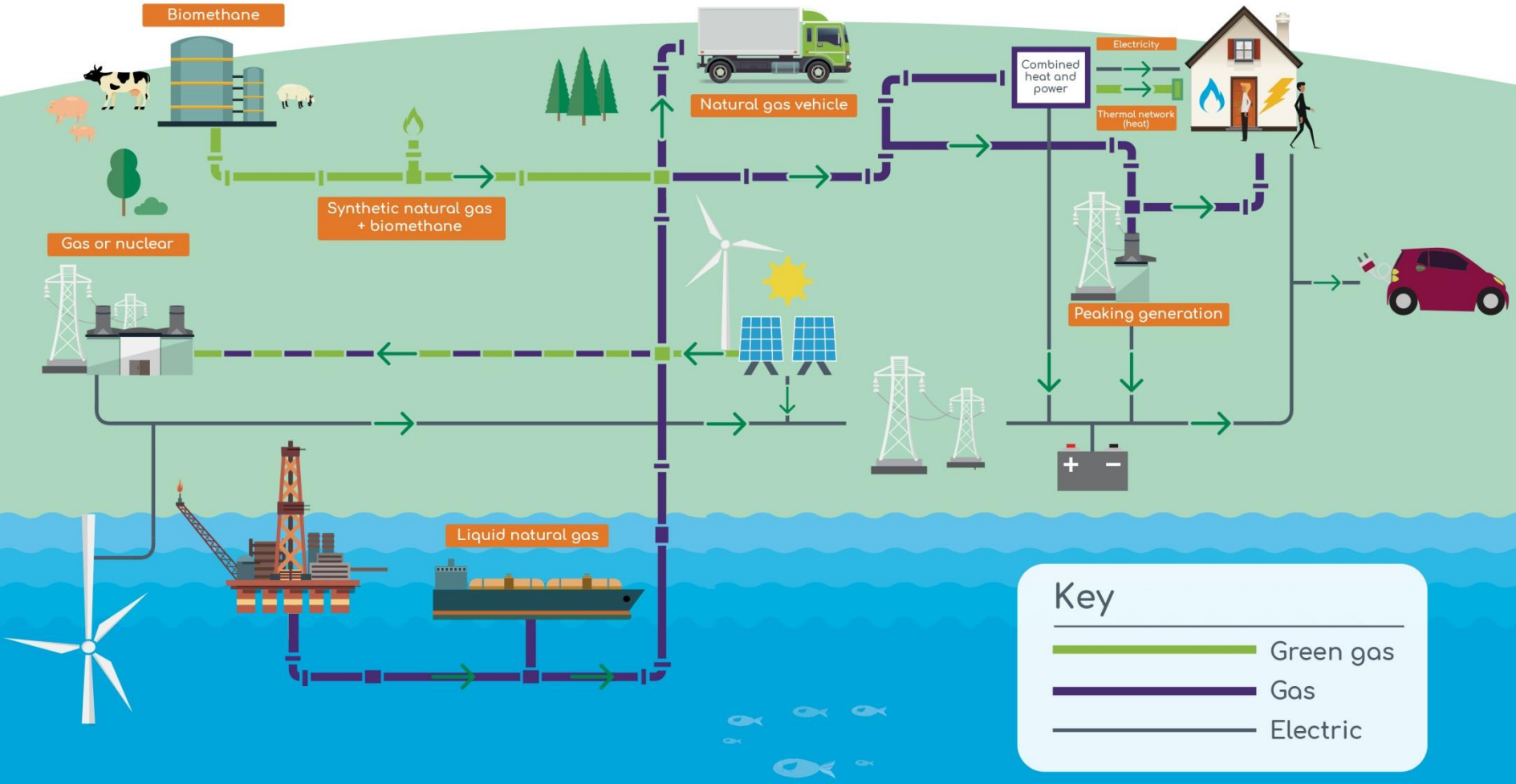
- Gas distribution system operator
- Electricity distribution system operator
- Project Management & control development
- Consumer trust& technology adoption strategies
- Data analysis & gas and electricity network impact modelling
- Technology & market assessment, policy implications

Intro to Wales & West Utilities

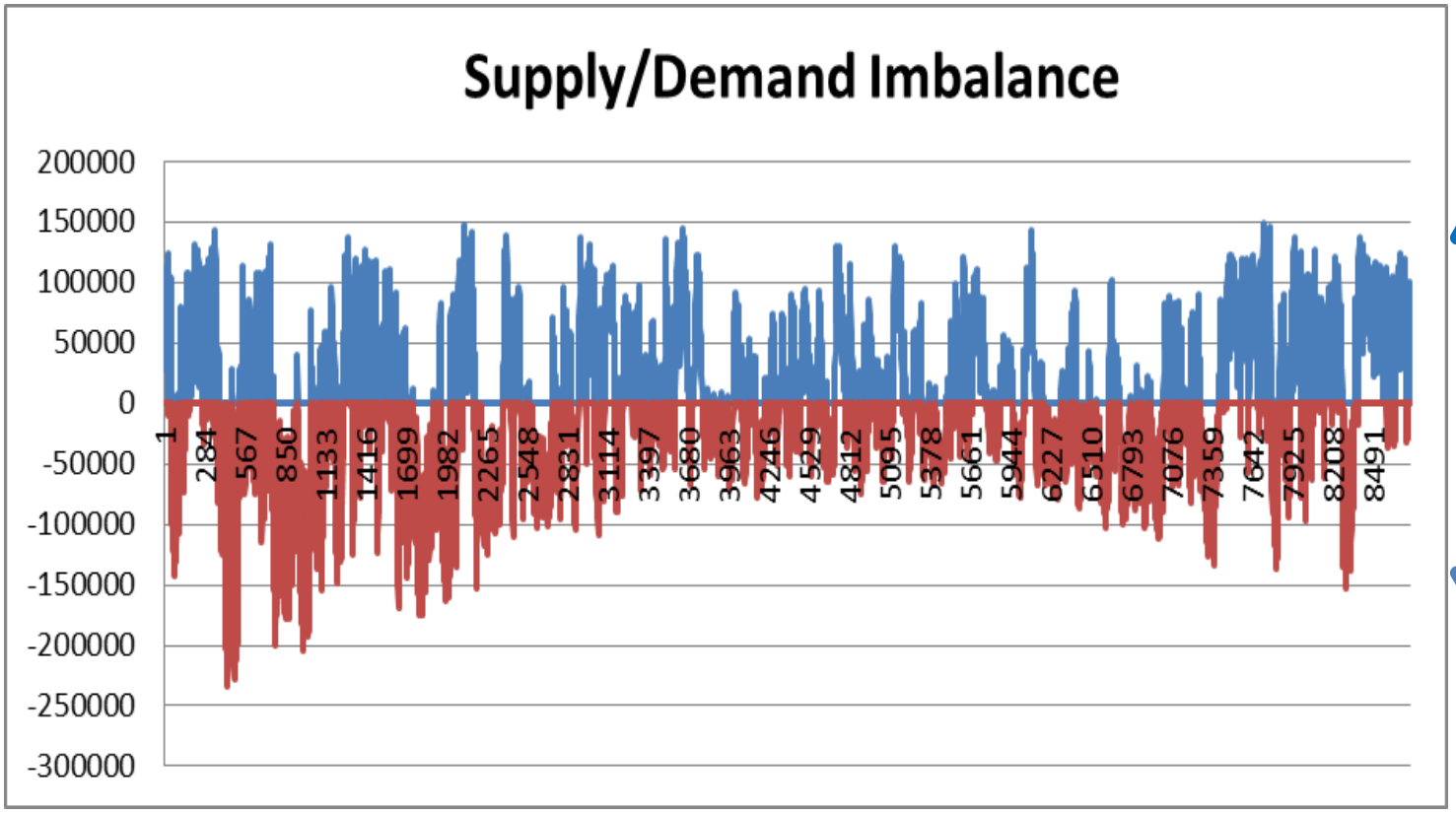
- Gas DSO & emergency service for Wales & south west of England
- We have 35,000km of pipes serving a population of c.7.5m (20% of UK)
- We have 30 power stations connected with 1.2 GW total capacity
- We have 17 green gas and 17 fossil gas connections to our network
- Our green gas connected capacity is 3x Swansea Tidal Lagoons
- We deploy 58GWh of storage each day, utilising 3x 1.5GWh gas batteries
- We invest £2m/wk into our future low-cost, green gas & H_2-ready network

Whole Energy System Approach

- Freedom brings efficient integration into the home



Hybrid Green Heating



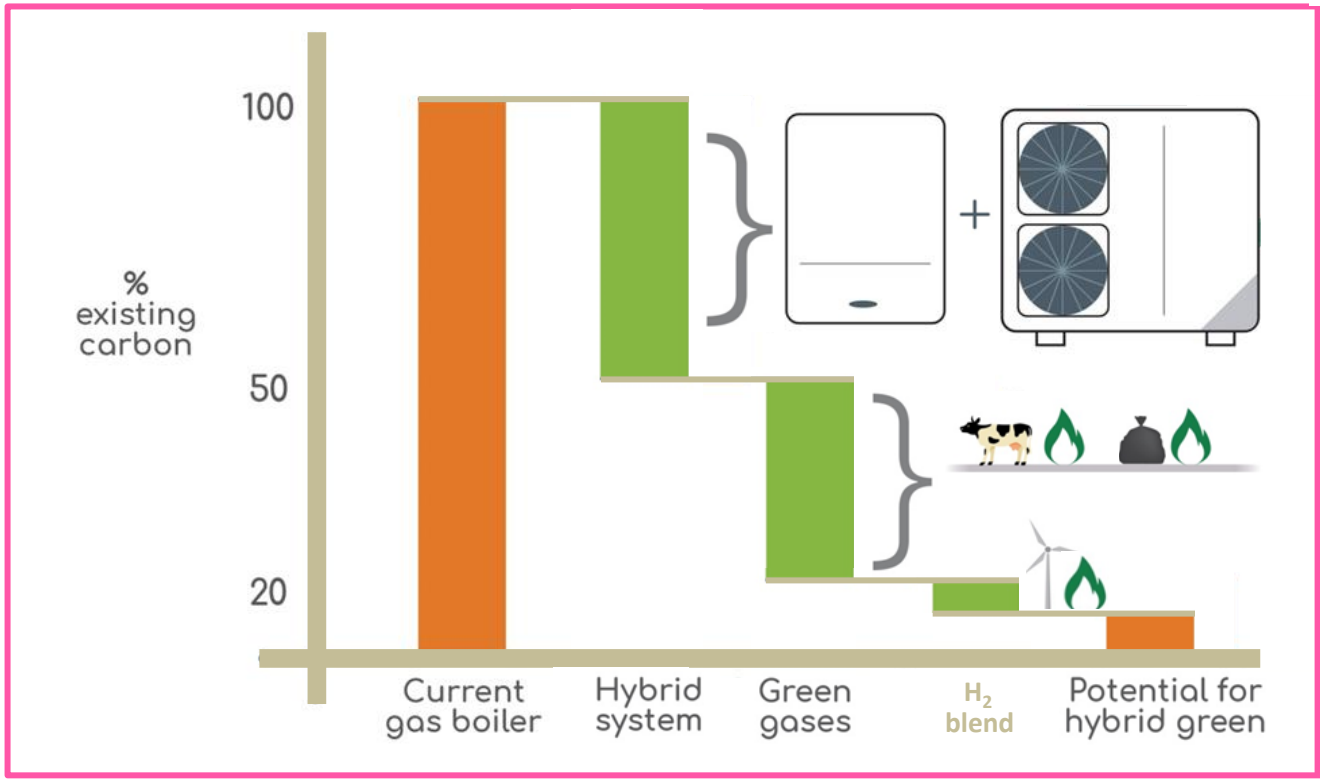
Use Electricity: cheap & low carbon

Could deliver circa **50-70%** reduction in gas throughput

Use Gas: cheap, flexibly available & greening

Waterfall – Hybrid Green Heat

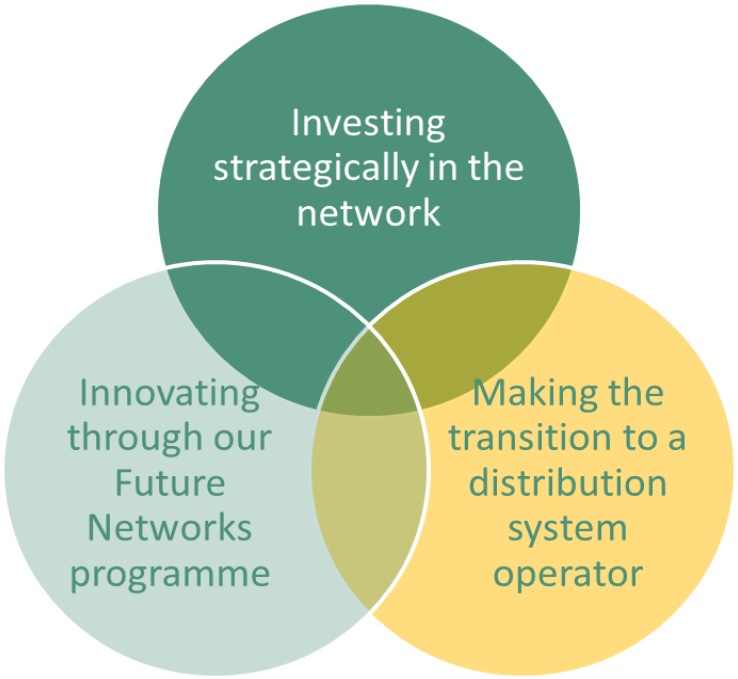
- A no-regrets pathway to decarbonise domestic heat by 87-100%



The Role of Heat Pumps

Future Energy Potential

- Heat pumps are a small but growing part of the UK energy market
- In significant numbers could place a significant additional demand on the electricity network
- Especially at peak times
- Important for the decarbonisation of heat energy generation in the UK



Heat Pumps Growth – South Wales

Scenario	2016	2020	2025	2030
Gone Green	1,928	5,480	32,469	74,631
Consumer Power	1,928	4,440	15,768	39,842
Slow Progression	1,928	3,680	16,699	38,343
No Progression	1,928	2,673	4,947	8,648

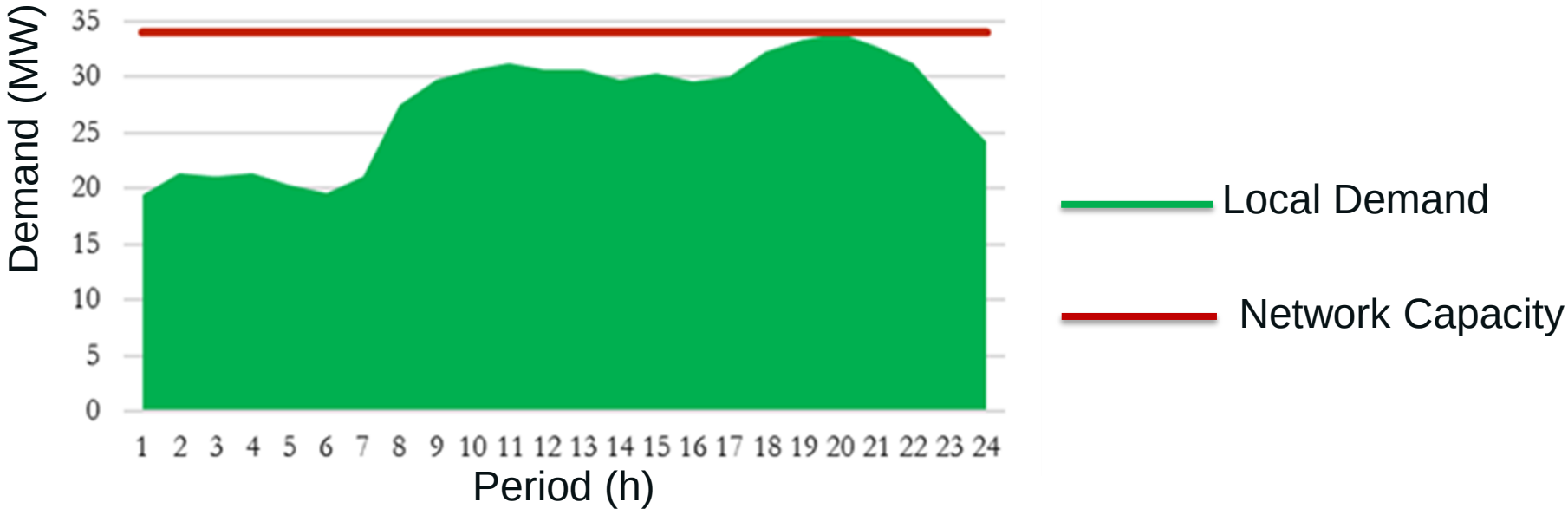
Heat Pumps Growth in MW – South Wales

Scenario	2016	2020	2025	2030
Gone Green	8.2	19.1	97.1	202.0
Consumer Power	8.2	15.9	48.7	111.4
Slow Progression	8.2	14.5	61.4	139.3
No Progression	8.2	10.9	19.0	32.4

Local Electricity Demand

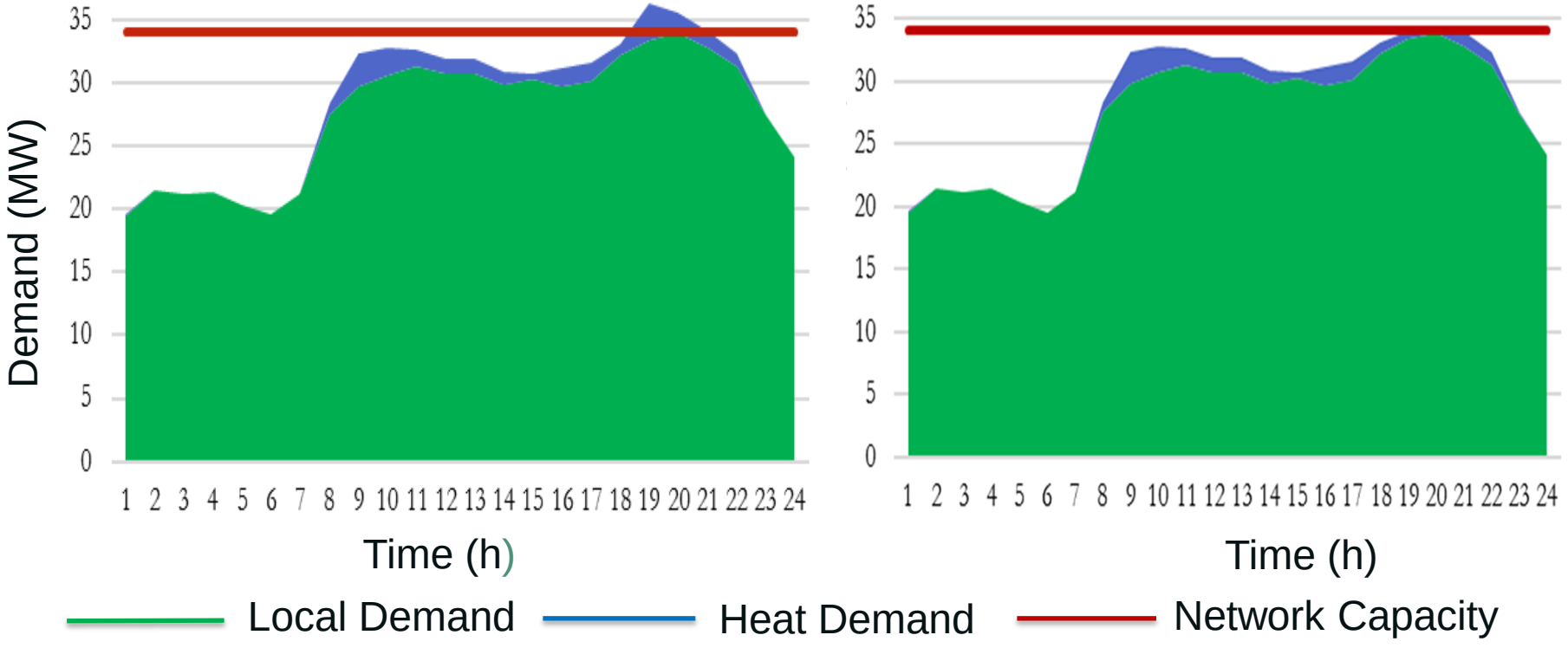
Between 18:00 and 22:00hr:

- Primary substation demand is at peak
- Nearly overloading the primary substation
- Adding electrification of residential heat demand will overload the distribution network



Supporting the DN

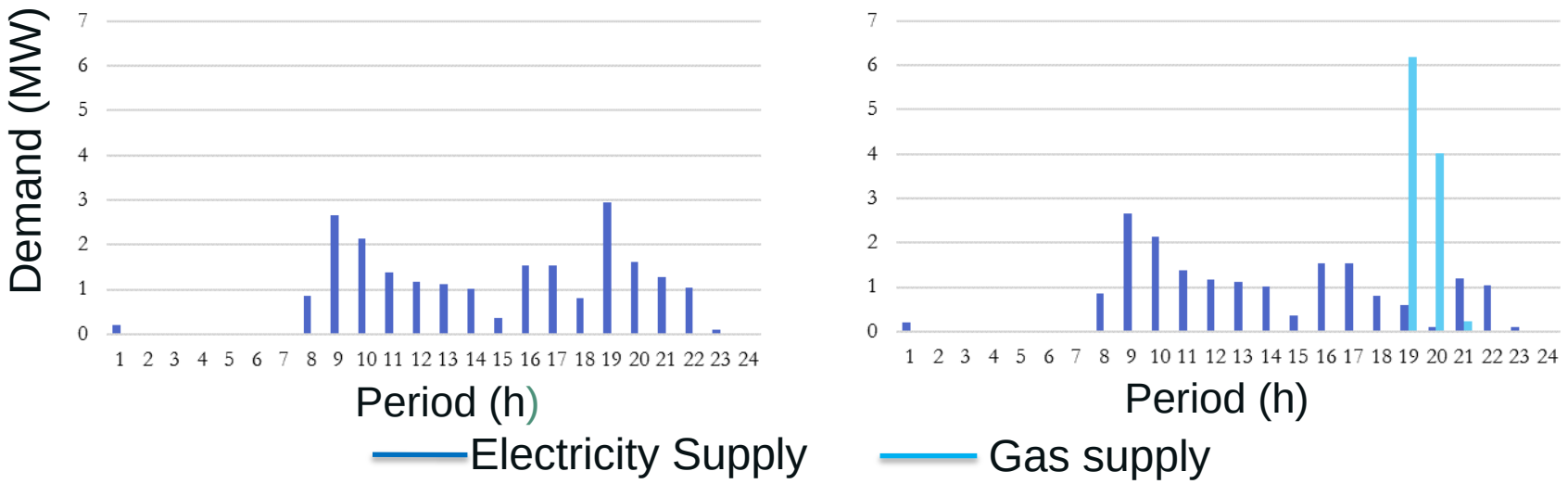
- At peak demand, HHP can switch energy supply from electricity to gas
- Reduce additional demand at the distribution networks to defer network reinforcements



Defer Reinforcement

Hybrid heat systems can offer dual fuel flexibility

- Can be exploited to support network operation
- Defer reinforcements, without compromising end-user's comfort levels
- Switch energy supply to gas for heat during peak electricity demand on the DN
- Reduce the additional demand at the distribution network due to heat requirements



Project Aim

- Mimic a dense commercial hybrid system deployment in a Demand Side Response driven market and understand:
  - Technologies
  - Commercial drivers
  - Energy system impacts
  - Consumer interactions & behaviours

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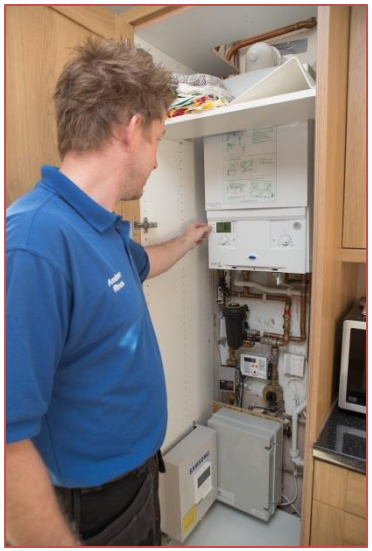
- Mimic a dense commercial hybrid system deployment in a Demand Side Response driven market and understand:
  - Technologies
  - Commercial drivers
  - Energy system impacts
  - Consumer interactions & behaviours

- In order to inform:
  - Policy
  - Standards
  - Commercialisation plans
  - Network management responses.

Project Objectives

- Use the ability of the hybrid heating system to allow **smart switching between gas and electric load** to provide fuel arbitrage and highly flexible demand response services.
- Demonstrate the **consumer cost, carbon and energy system security benefits** of large-scale deployment of hybrid heating systems.
- Gain insights into the means of **balancing the interests of the consumer, supplier, and network operators** when seeking to derive value from the demand flexibility.

Samsung Heat Pump – 5kw



Daikin – 5kw

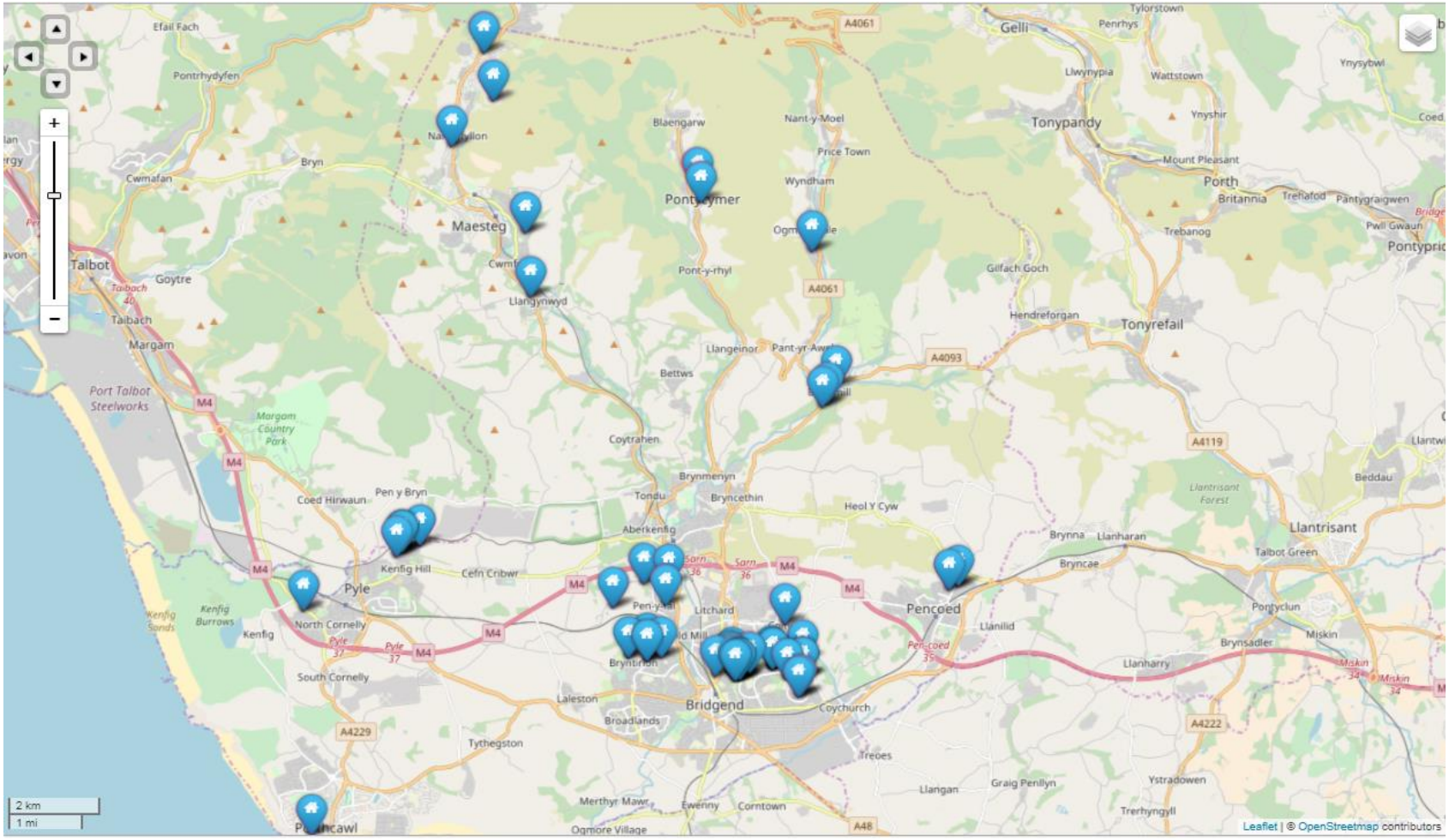
MasterTherm Heat Pump – 8kw

Installation Update

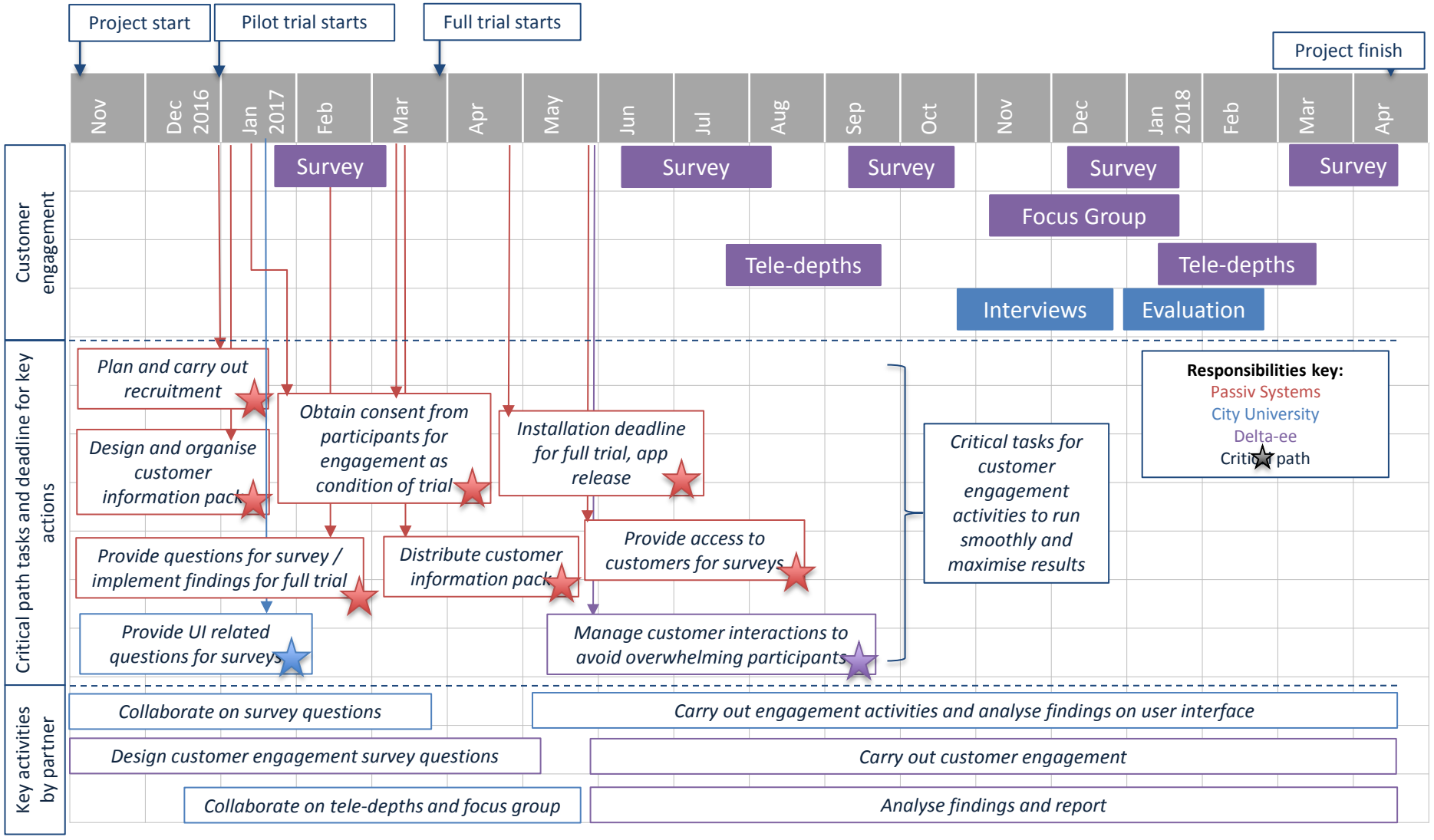
- Installations are ongoing, now exceeding 60 units. Expected totals:
  - 17 x Daikin Combined Unit (WDS Green Energy installer)
  - 16 x Samsung & Worcester Bosch Boiler (Spire Renewables installer)
  - 42 x MasterTherm & Vaillant Boiler (Thermal Earth installer)

  - 40 in social housing, 35 in private homes.
  - Representation of UK housing stock.
  - Combination of replacement boilers, retrofit to existing boilers and system boilers.
  - 73 on gas grid, 2 off gas grid and using Calor.

Locations


Efail Fach
Pontrhydyfen
Cwmafan
Bryn
Talbot
Goytre
Taibach
Margam
Port Talbot Steelworks
Margam Country Park
Maesteg
Llangynwyd
Blaengarw
Nant-y-Moel
Price Town
Wyndham
Pontycymer
Pont-y-rhyl
A4061
Gelli
Penrhys
Tylorstown
Llwynypia
Wattstown
Ynysybwl
Tonypandy
Ynyshir
Mount Pleasant
Porth
Britannia
Trehafod
Pantygraigwen
Pwll Gwaun
Trebanog
Gilfach Goch
Hendreforgan
Tonyrefail
Llangeinor
Pant-yr-Awel
Bettws
A4093
A4119
Llantrisant Forest
Beddau
Llantrisant
Talbot Green
Brynna
Llanharan
Bryncae
Pencoed
Llanilid
Pontyclun
Brynsadler
Miskin
Llanharry
Heol Y Cyw
Brynmenyn
Tondu
Bryncethin
Aberkenfig
Coytrahen
Coed Hirwaun
Pen y Bryn
Kenfig Hill
Cefn Cribwr
Pyle
North Cornelly
Kenfig
Kenfig Burrows
Kenfig Sands
South Cornelly
Litchard
Bryntirion
Laleston
Broadlands
Bridgend
Coychurch
Tythegston
Treoes
Llangan
Graig Penllyn
Ystradowen
Trerhyngyll
Merthyr Mawr
Ewenny
Corntown
Ogmore Village
A4229
A48
M4
2 km
1 mi
Leaflet | © OpenStreetMap contributors

Customer Engagement Framework



Looking ahead…

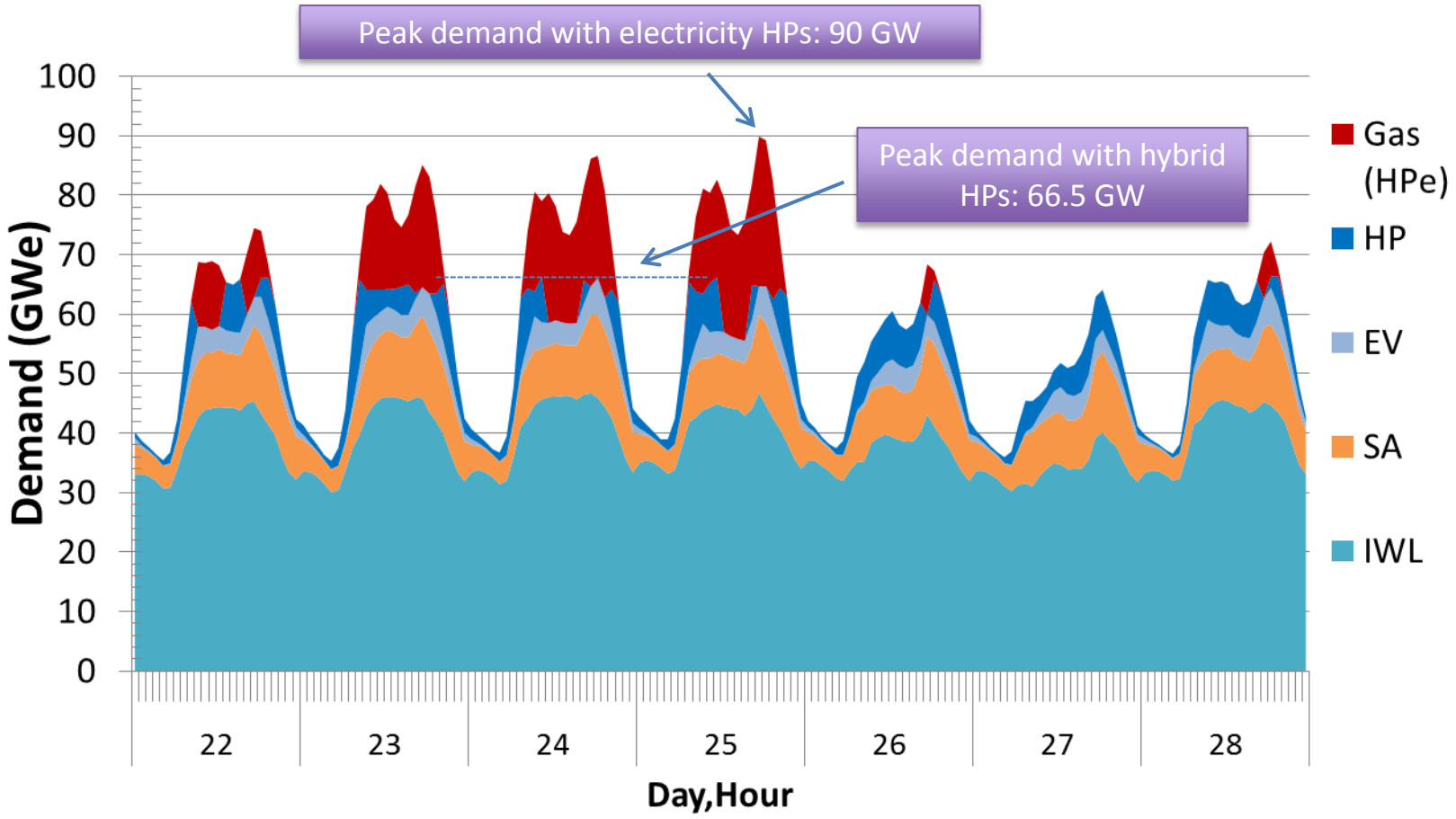
- Monitor hybrid heat pump performances
- Hybrid heat pump experiments/scenarios
- Network modelling
- Bridgend/South Wales
- UK Network
- Homeowner/Tenant surveys and interviews
- Hybrid Heat Pump – Value framework
- Hybrid Heat Pump – DNO/GDNO – Business models
- Hybrid Heat Pump – Future impact
- Quarterly updates with Government/BEIS
- Dissemination

Impact of Hybrid Heat Pumps on gas and electricity systems

Focus on quantification of system wide benefits and business case for hybrid heat pumps

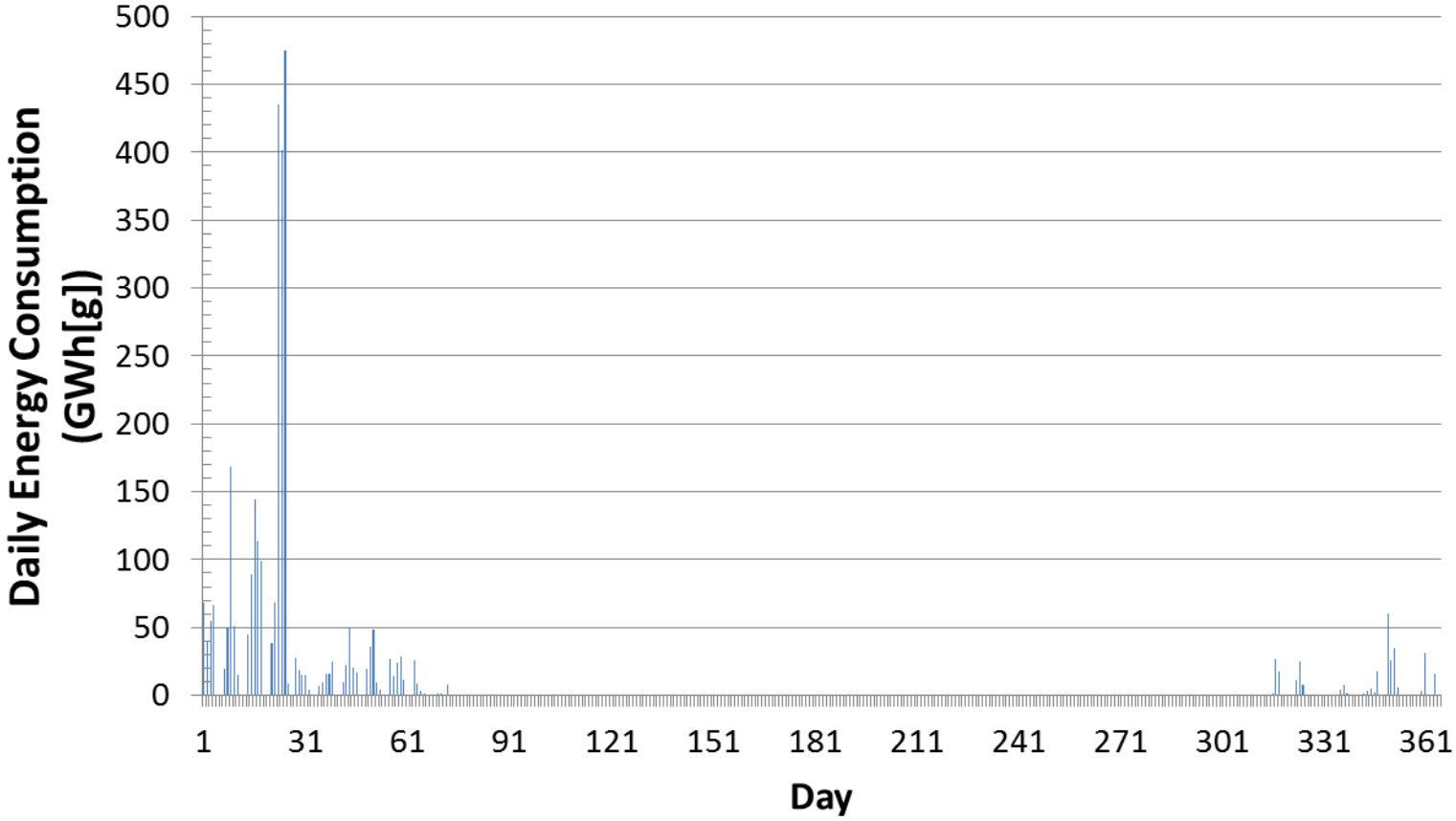
- **Key modelling areas:**
  1. Assessment **whole-system benefits** of hybrid heat pumps
  2. Impact of hybrid heat pumps on **electricity distribution networks**
  3. Impact of hybrid heat pumps on **gas distribution networks**
  4. Multi-service **business models** for hybrid heat pumps

Impact of Hybrid Heat Pumps on electricity peak demand



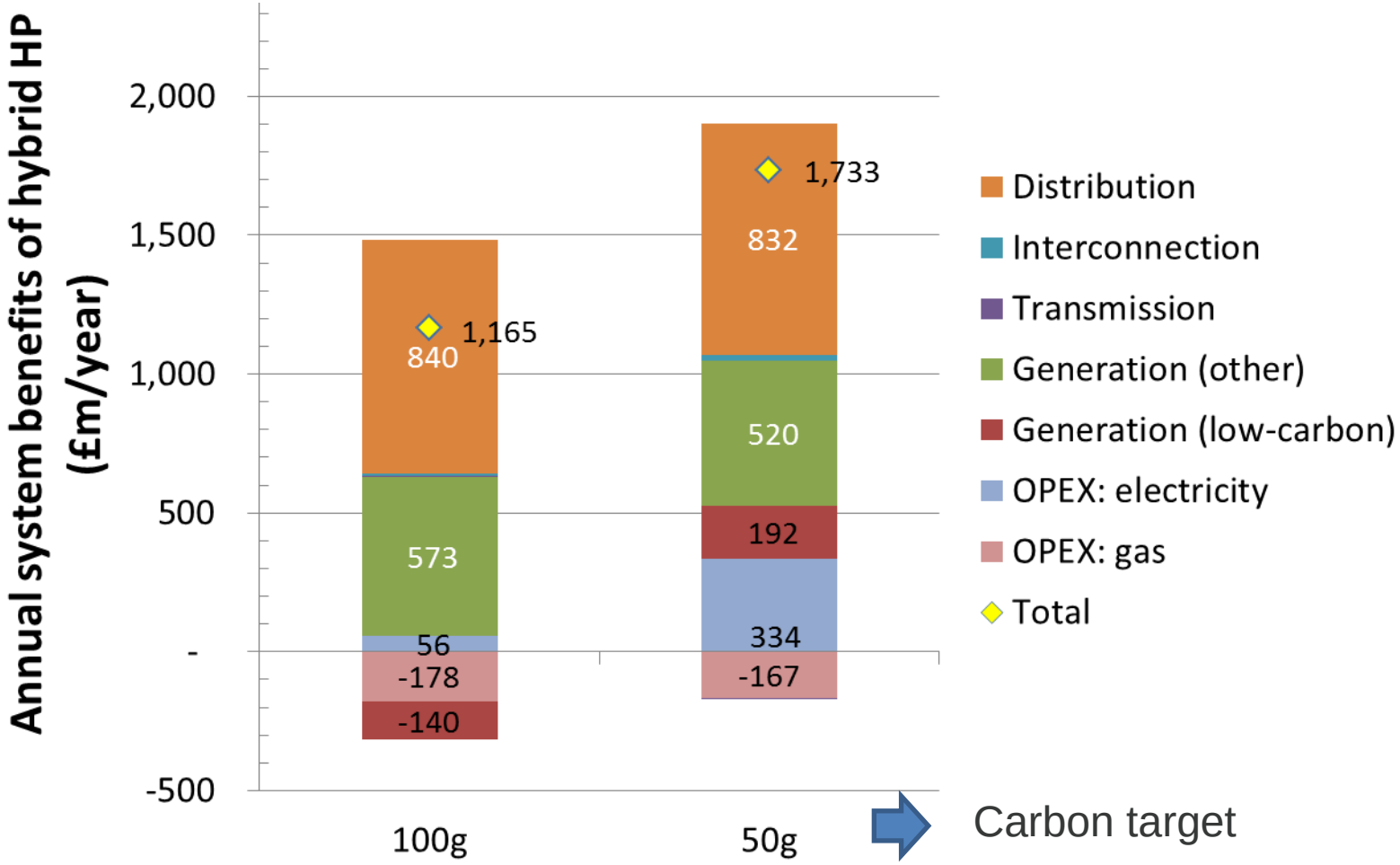
Gas consumption of HHPs

Use of gas dominated during winter peak demand



UK system wide benefits of Hybrid HPs

System benefits of HHPs compared to electric HPs are considerable



Key Messages

- Offers a trilemma solution
  - Affordability:
    - Provides **lowest cost heat** – system trades on live wholesale cost of gas & electricity on behalf of consumer
    - Testing potential for **zero capital cost** to consumer
    - Simulated to create value – **not reliant on incentives**
  - Sustainability:
    - Favours **low carbon** electricity, topped up by gas
    - Compounds the benefits of a **greening gas network**

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    - **Storage & flexibility in gas network** fills intermittent troughs

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WESTERN POWER DISTRIBUTION

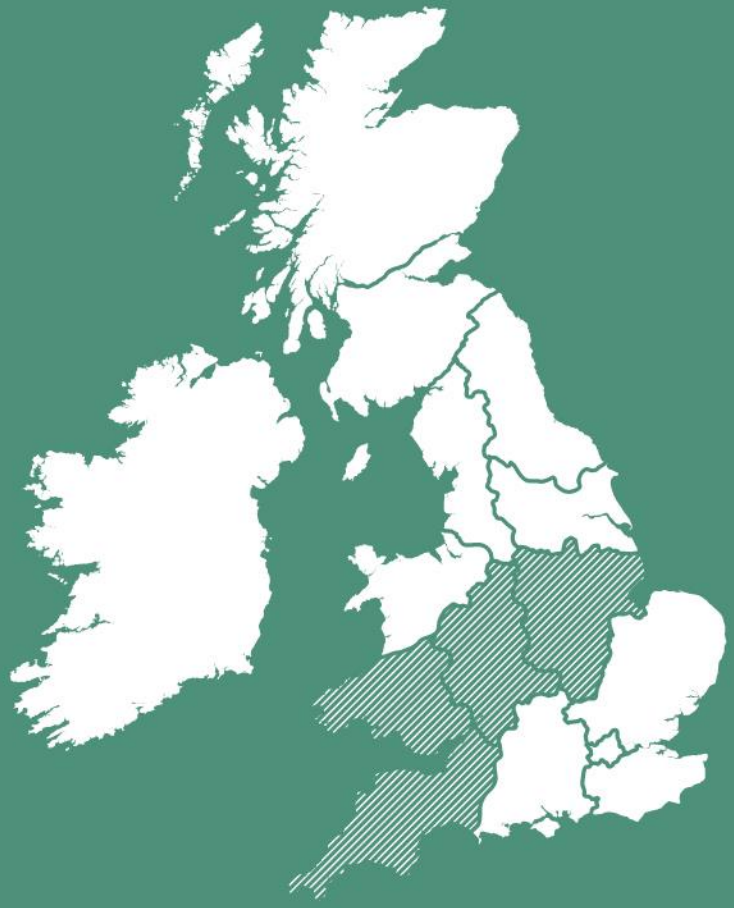
INNOVATION

NEXT GENERATION NETWORKS

Balancing Act Conference

Thursday 5th October 2017

Park Plaza, Westminster



Faithful Chanda

Innovation & Low Carbon Networks Engineer

NEW

WESTERN POWER DISTRIBUTION HARP

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

WESTERN POWER DISTRIBUTION EFFS

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**
- **Electric Nation** *(formerly CarConnect)*
- **Industrial & Commercial Storage**
- **Smart Systems and Heat**[2]
- **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**
- **Losses Investigation**

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

Project Aims & Objectives

- Promote innovation, flexibility and non-network solutions
- Engage with Industrial and Commercial Customers to test Energy Storage Systems
- Determining the scope of terms and conditions and practical implications of using batteries on the LV networks
- Attitudinal analysis and performance assessment of participants within the commercial environment
- Development of new policies, processes and systems to support commercial deployment of Energy Storage Systems
- Provide knowledge to inform new regulations.

How do we intend to do this?

Through:

- Deployment of battery units on the network
- Conducting a live trial and performance monitoring of an innovative Energy System Solution through a suite of demonstrations
- Design, development and testing of different algorithms to maximise system benefits
- Regulatory and policy recommendations for future services

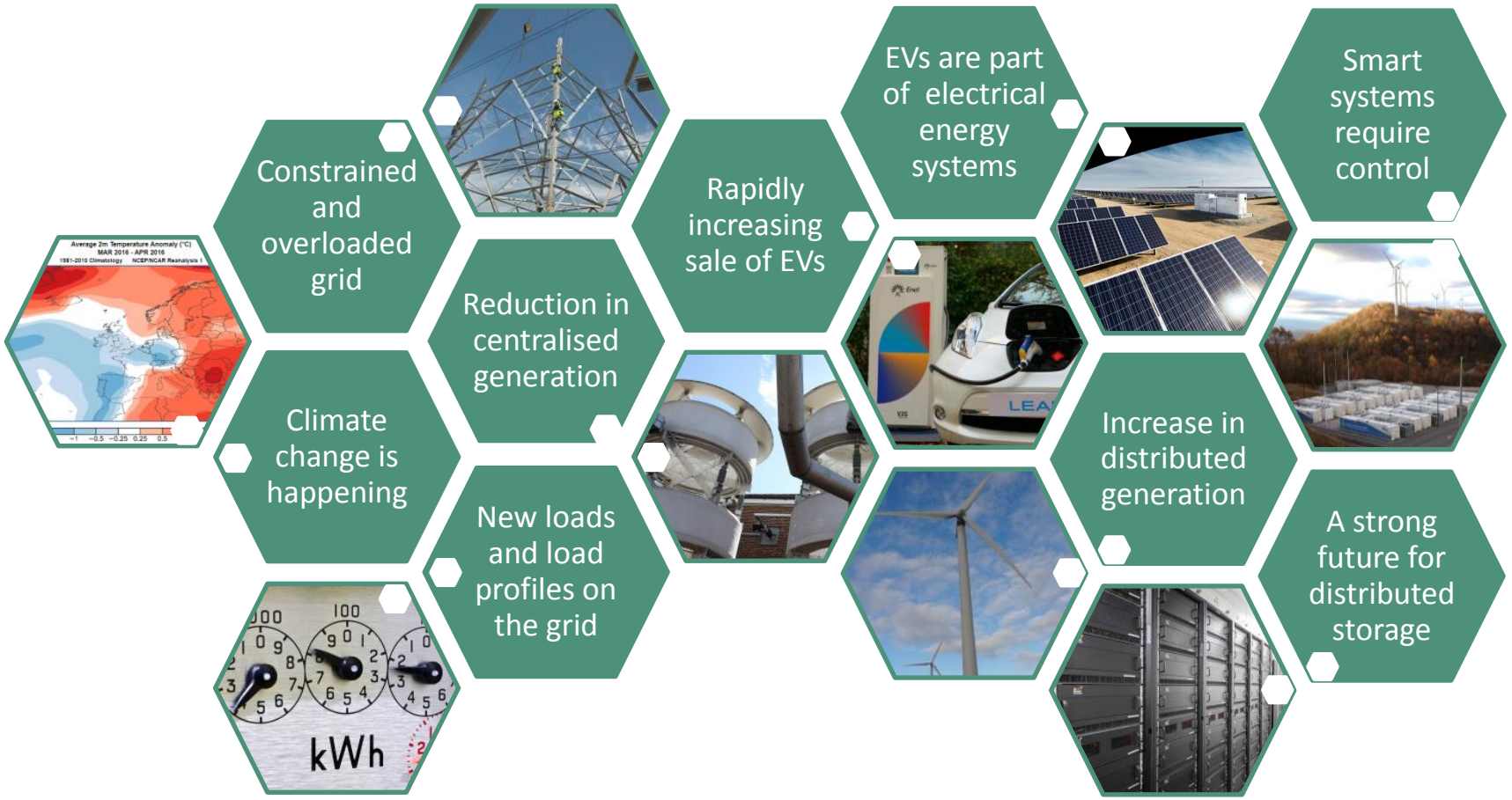
Methodology

In our own depots/sites

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

Context

Network Issues



Why are we interested in Storage?

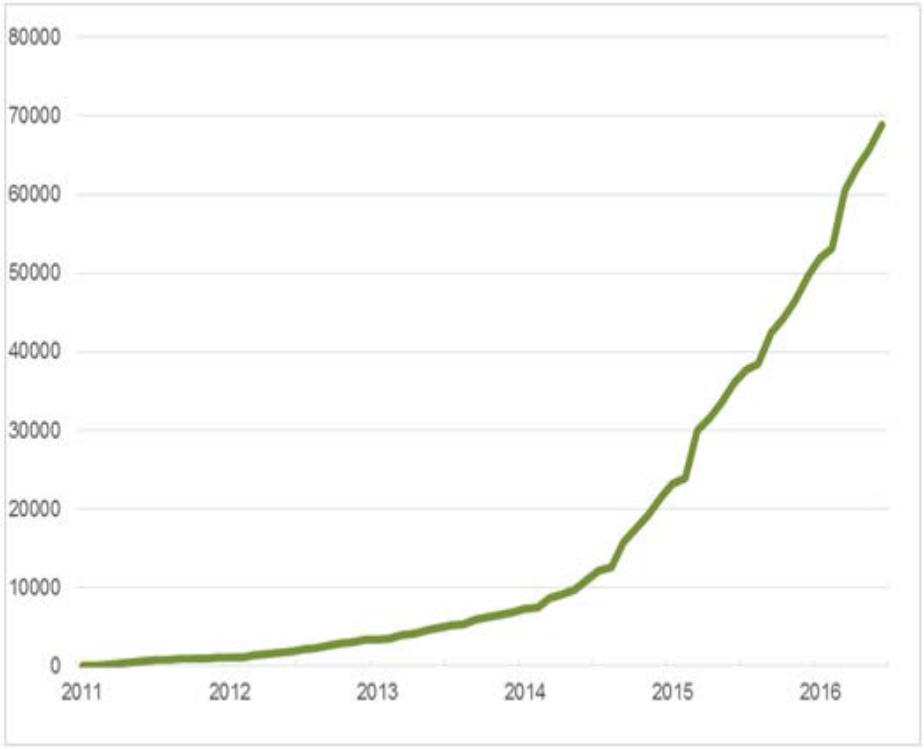
Keeping the lights on	• Assists in power system stability – frequency and voltage • Deploy multiple purposes
Facilitating the Low Carbon transition	• Enables the connection of intermittent renewable generation • Provides fast response
Keeping electricity bill as low as possible	• Enables the deferment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

Our Storage System

- Project Partner: Tesla
- NIA funded project - £365,000
- Contract signed 3rd March 2017
- 4 WPD trial sites
- 1 x Energy Storage System of 50kW/210kWh
  - 1 x Powerpack Inverter or Bi-directional Power Conversion System (PCS)
  - 1 x Powerpack – Rechargeable Lithium-ion
  - 1x Site Master Controller (SMC)
- Annual Maintenance cost £2,000 (approx.)
- Finishes Dec 2018

A typical demand increase in EVs

- From the start of data collection (Q2, 2012) the cumulative Electri Vehicle (EV) data shows a sustai and dramatic growth of the EV ca and van market
- In Q2, 2012, there were 3,000 registered EV's on the road
- By Q2, 2014, this had rose to ove 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

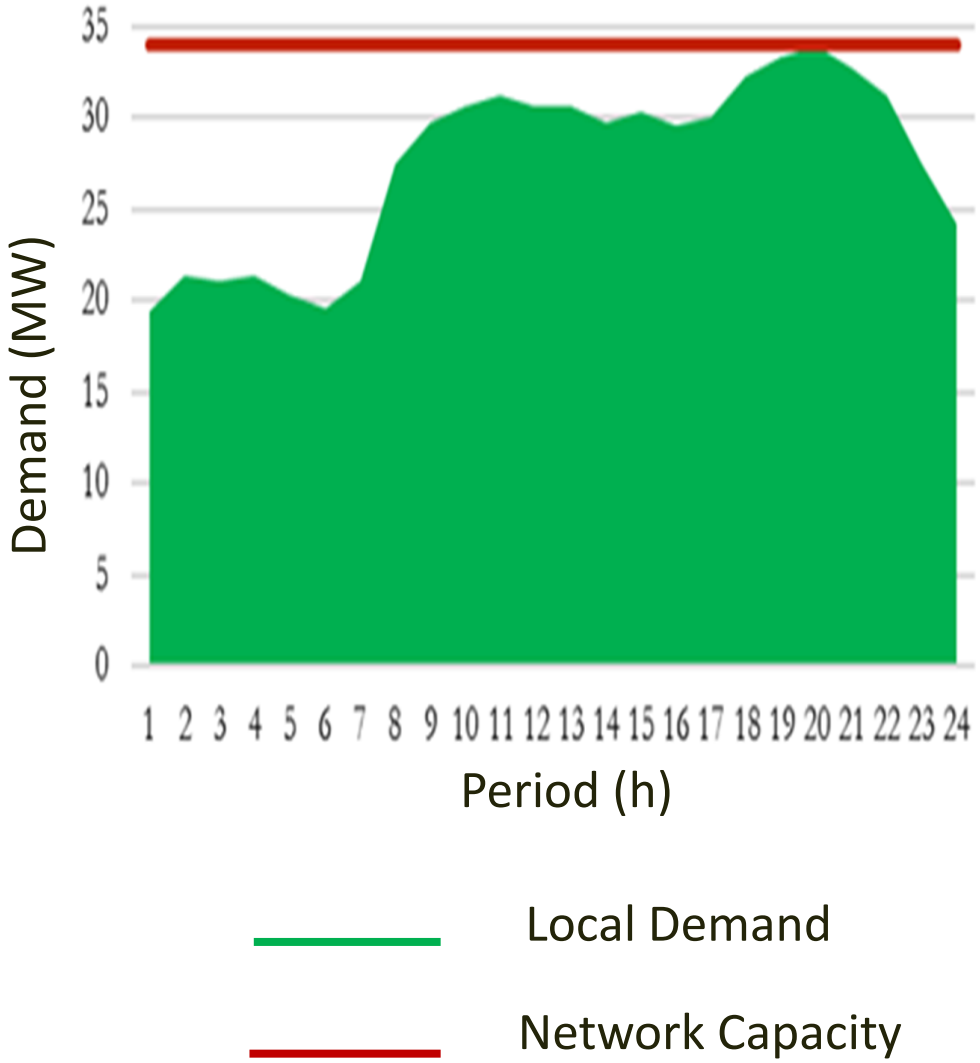
- Statement: There is an increase in demand for electric vehicles.
- The grid can do one of three things to cope with this demand:

Option 1: Introduce more capacity to the grid through generation and expand the networks capacity.
Option 2: Introduce more flexible generation in order to deal with spikes seen from chargers.
Option 3: 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.*

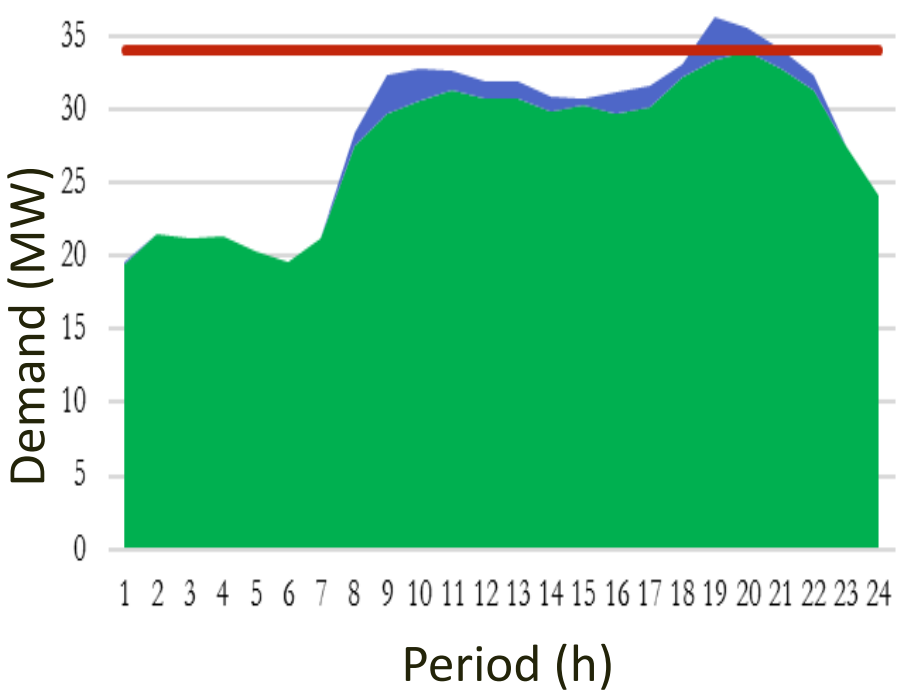
Local Electricity Demand

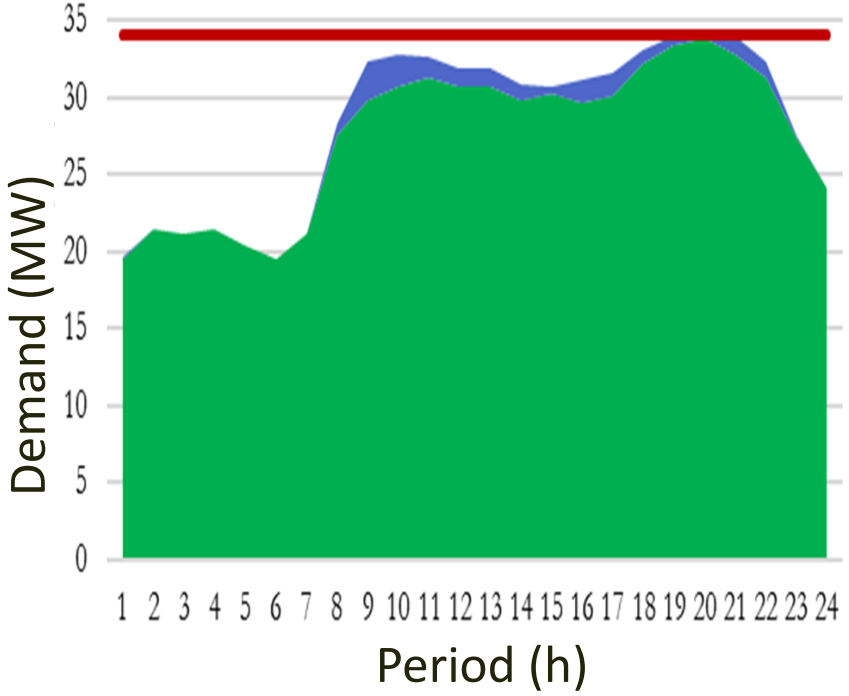
- Between 18:00 and 22:00hrs:
  - Primary substation demand is at peak.
  - Nearly overloading the primary substation.
- Adding electrification of residential heat demand and EVs will overload the distribution network .



Supporting the Distribution Network

- At peak demand, Storage can be used to eliminate peaks.
- Reduce additional demand at the distribution networks to defer network reinforcements.

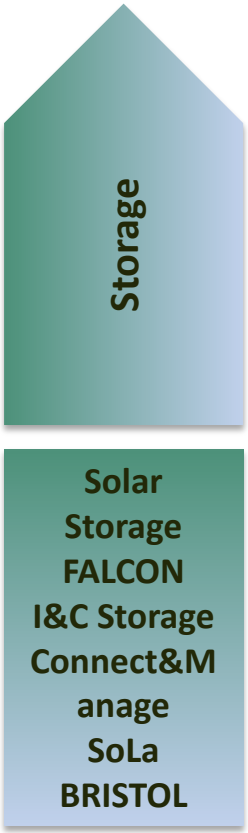




Local Demand Extra Demand Network Capacity

Our response – WPD Innovation Projects

DSO Flexibility from Energy Storage



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

Trial sites


Boston
Spilsby
EAST MIDLANDS
Cardiff
WEST MIDLANDS
SOUTH WEST
Taunton

Site works

- Delivery of the Energy Storage units to site – June 2017.
- Civil works - Preparation of the plinth for installation.
- Electrical connections:
  - **Spilsby** – Electrical connections - 27th of July.
    - No shutdown required.
  - **Boston** – Electrical connections - 25th of July.
    - Shutdown for at least 3hrs.
    - Onsite generator to run.
  - **Cardiff** – Weekend of 29/30th July.
    - Fabricating extension busbar for connection.
    - Shutdown for at least 3hrs.
    - Onsite generator to run.
  - **Taunton** - Start 21st August, finish October.
- <u>In all cases Tesla Commissioning after 10 days of install.</u>

Matters that came to light!

- Safety Fencing required at all the sites.
- G59 considerations & Witness Testing.
- Variations:
  - Boston – Site Meter + CTs.
  - Spilsby – Site Meter + CTs.
  - Cardiff :
    - Removal of stairs.
    - Install Frequency Meter.
  - Taunton – Backup functionality and install Islanding Controller SEL-700G0 24VDC, 2W – grid protection.

Project 1 - Spilsby

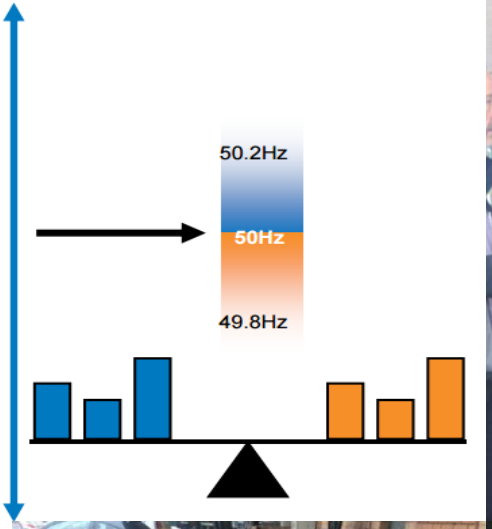
Application: Peak Shaving.

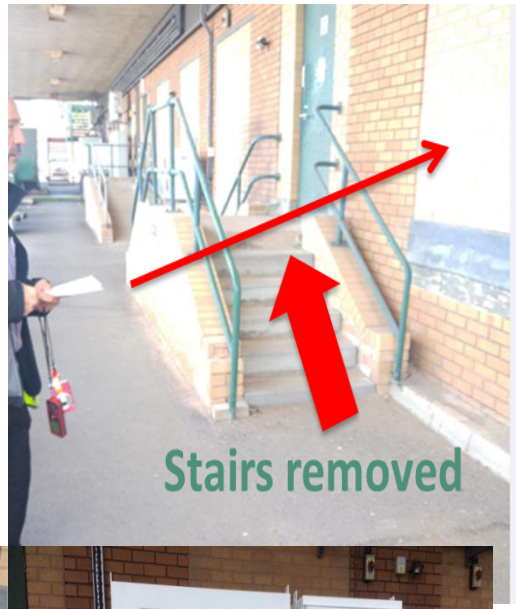
- Requirements:
  - Load profile available.
  - Peaky load profile.
  - Site Meter.

Project 2 - Cardiff

Application: UK "standard" battery storage approach.

- Combination of: FFR, DUOS and TRIAD avoidance.
- Requirements:
  - ✓ Frequency Meter installed at Cardiff to perform this operation.
  - ✓Stairs removed to make way for concrete plinth.





Project 3 - Taunton

Application: Demonstrating Backup/Islanding

- Test Bed (Backup, PV interaction, etc.).
- Requirements:
  - Connection into a sub-section of a site that facilitates on/off switching).
  - PV inverters facilitate frequency dependent power control.
  - Site Meter.
  - Special relay will be installed.

Project 4 - Boston

Application: Active control by WPD

- Demonstrating combinations of the above plus other benefits.
- Requirements:
  - Site Meter has been installed.
  - Interface between WPD control and Tesla Powerpack Controller through Nortech's control architecture.
- Experience: ILC installed as part of the LV Connect and Manage project at WPD Hereford depot.

Additional control architecture - Boston

Nortech will:

- Supply an Industrial Load Controller (ILC) system.
- Integrate the ILC system with Tesla's Powerpack battery energy storage system.
- Commission the system, demonstrating four-quadrant control of the Powerpack.
- Implement control algorithms that demonstrate the benefits of I & C storage systems…

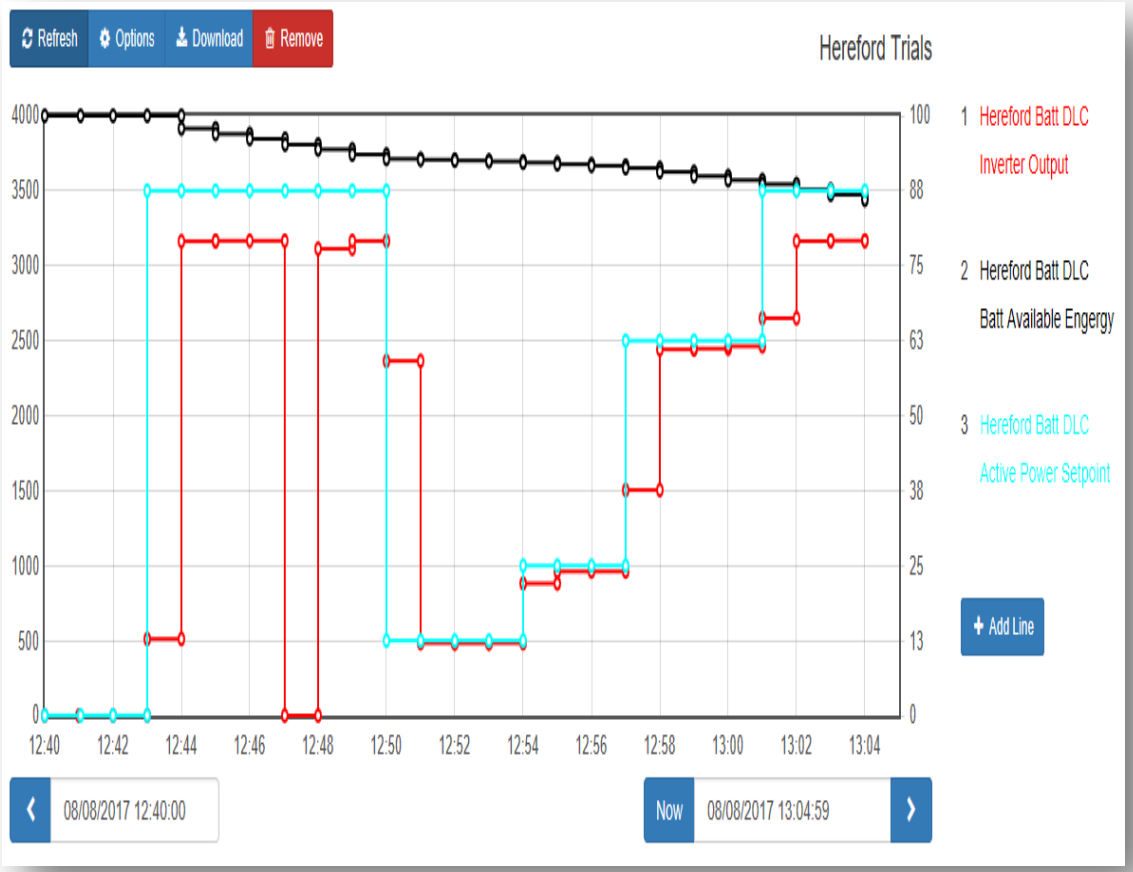
Additional control architecture - Boston

For example:

- Making the Boston site self-sufficient (as far as possible within the constraints of the PV and storage system), reducing the costs of importing electricity.
- Demonstrating the technical feasibility of operating the site at constant load, constant power factor, constant voltage etc. – all of which could underpin future DSO services.
- Support the system providing monitoring and control services for a 24-month duration.

Witness Test Results – PowerWall Hereford depot

- Nortech's solution will allow WPD to independently monitor and control the system.
- Operating the site at constant load, constant power factor, constant voltage.

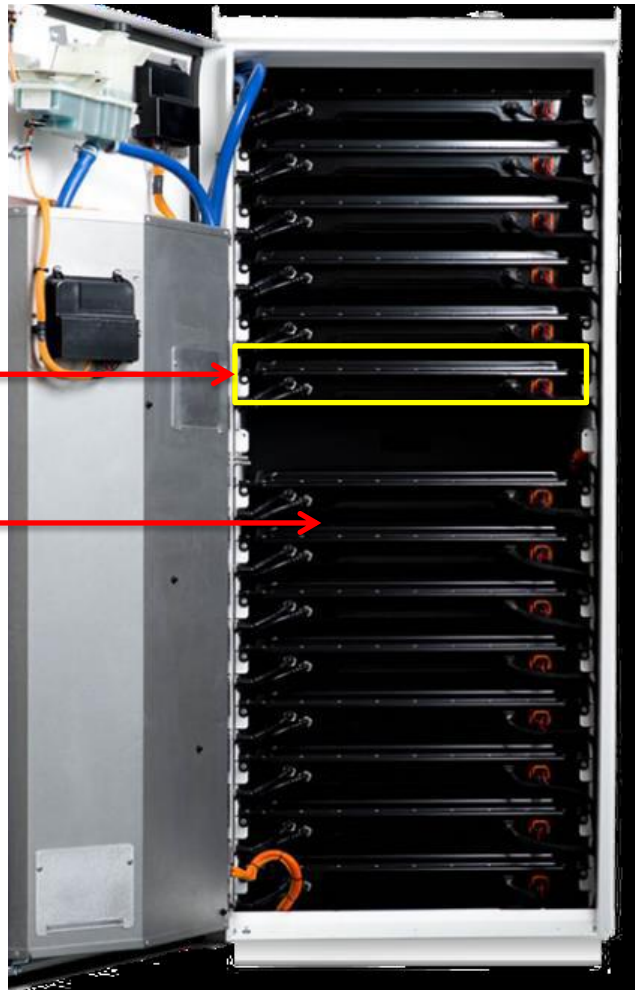


Powerpack System 50kW, 210kWh - Components

DC Disconnect switch

- Shutdown
  - For an emergency or,
  - unknown behaviour or,
  - a planned shutdown

Powerpack Unit – 1 Enclosure



Pod

Powerpack
-16 Pods

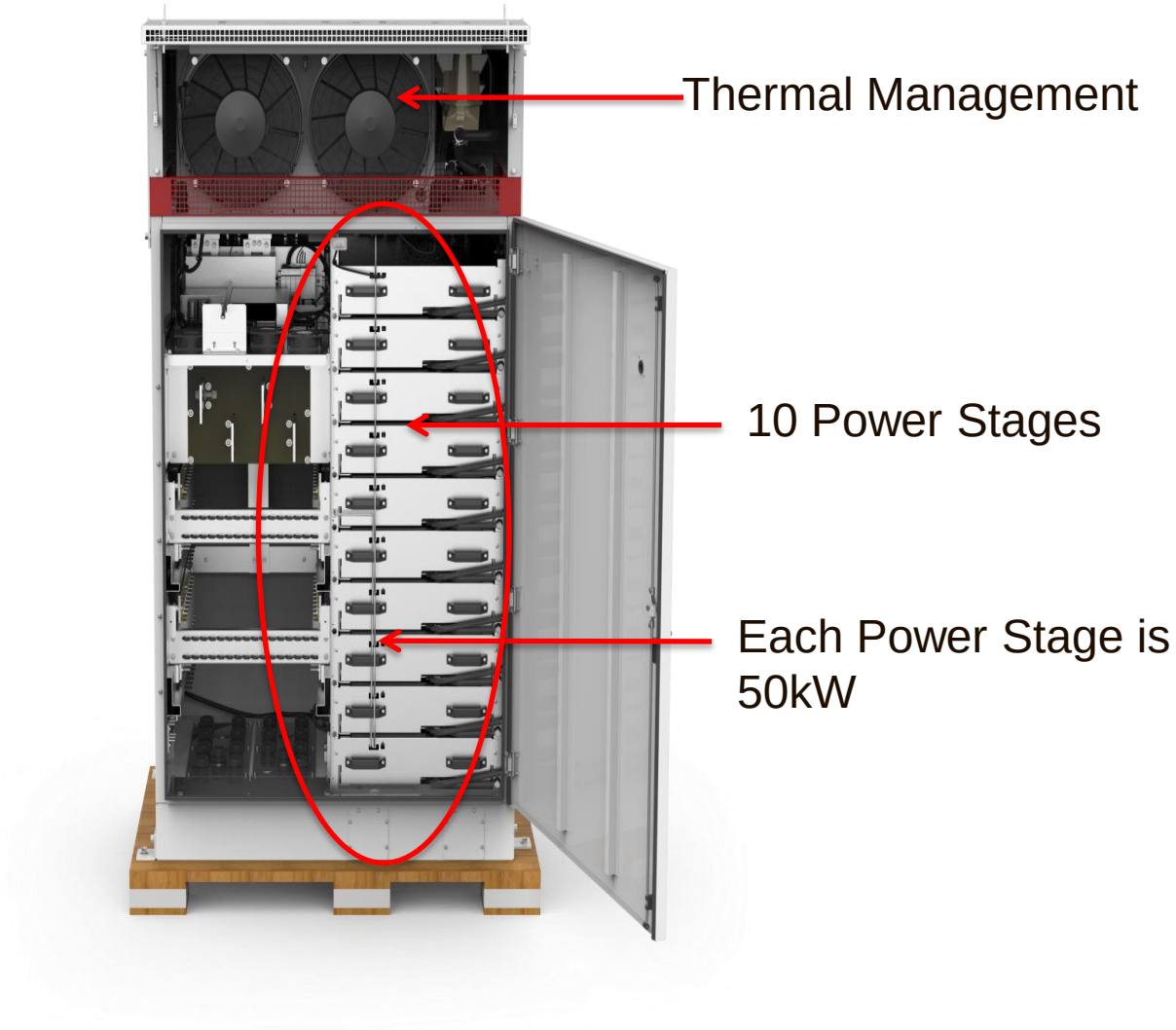
Battery
Cells

1 x 1 Pod

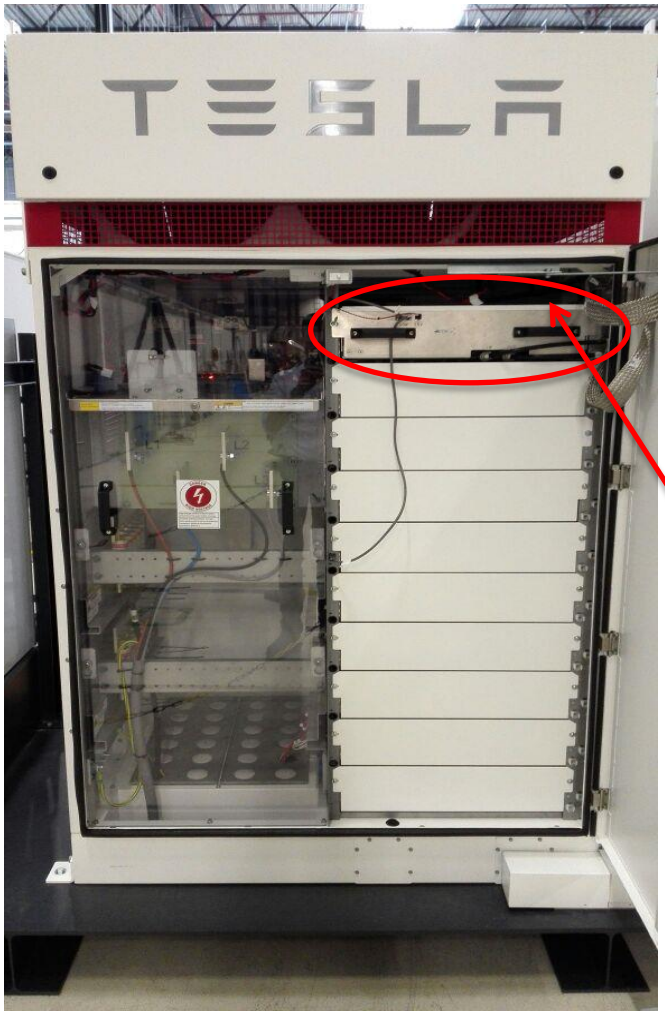
16 x Pods
connected
in parallel in each
enclosure

16 x

Powerpack Inverter
Up to 10 Power Stages in 1 Enclosure – Demo only

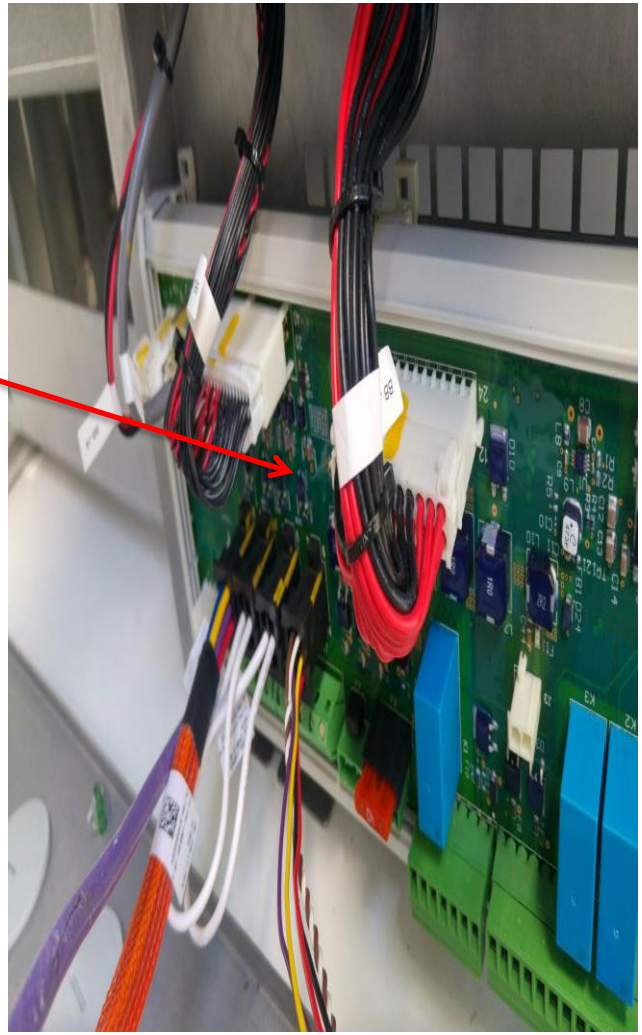


Powerpack Inverter – Only 1 Power Stage in all our systems



Internal Electronics of a Power Stage

1 Power Stage = 50kW



Switch room layout – Lamby Way, Cardiff

Components layout - Switch room arrangement - Cardiff

Site Master Controller

Battery Isolation Switch

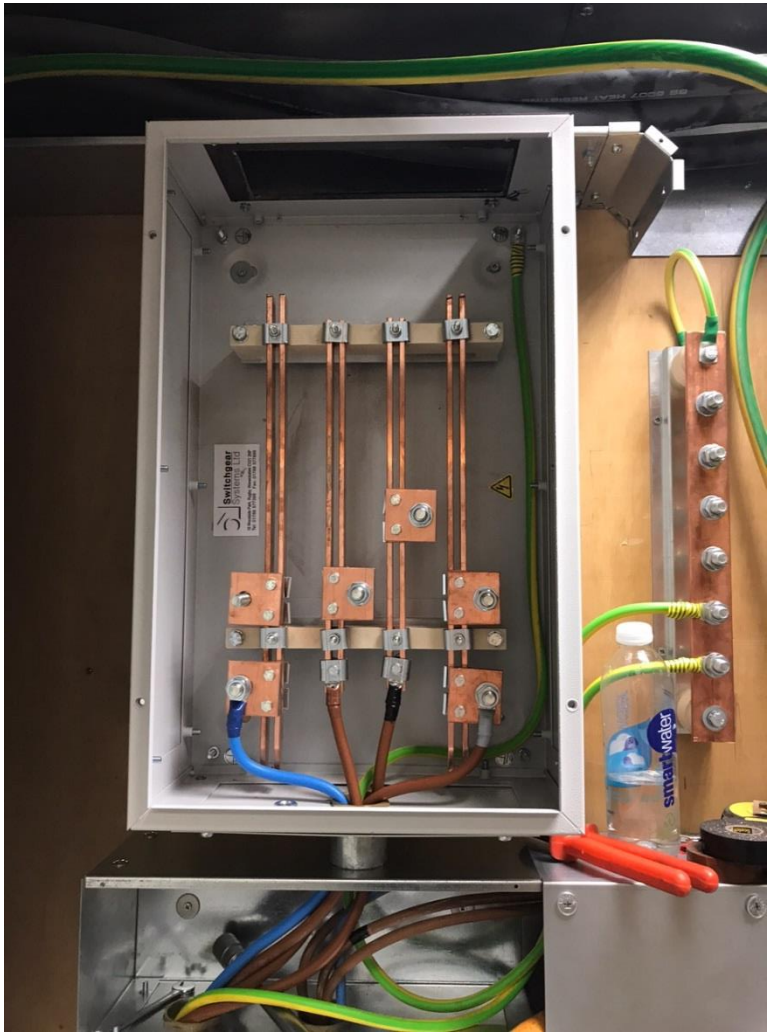
New Busbar (installed due to limited space in the Main Distribution Box)

Main Distribution Box (insufficient space)

G59 Control & Relay Panel

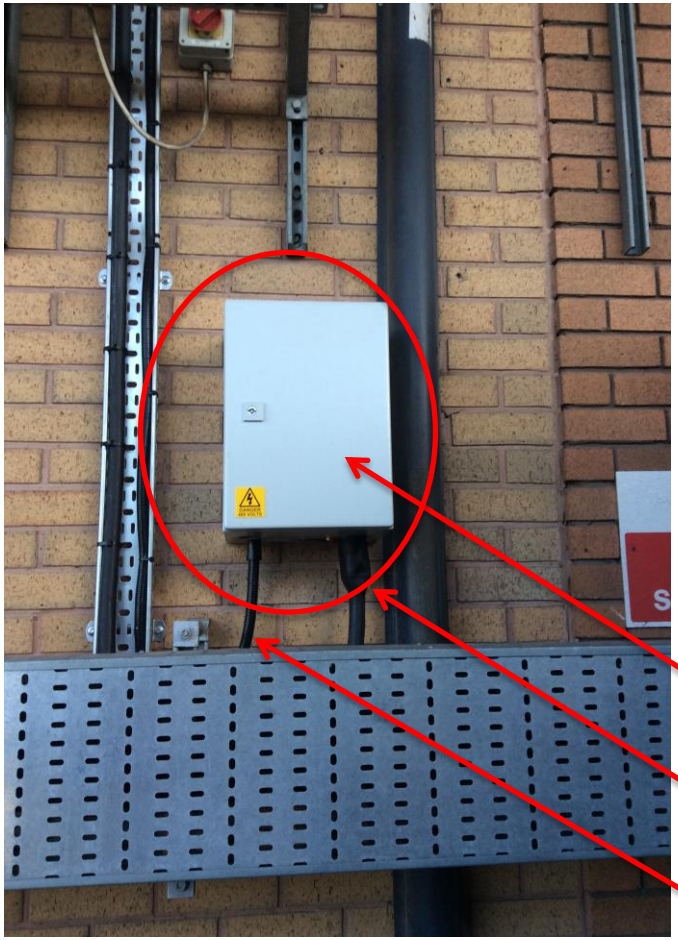
New busbar – Installed to provide capacity

Busbar – Inside the new busbar



Battery Isolation Switch

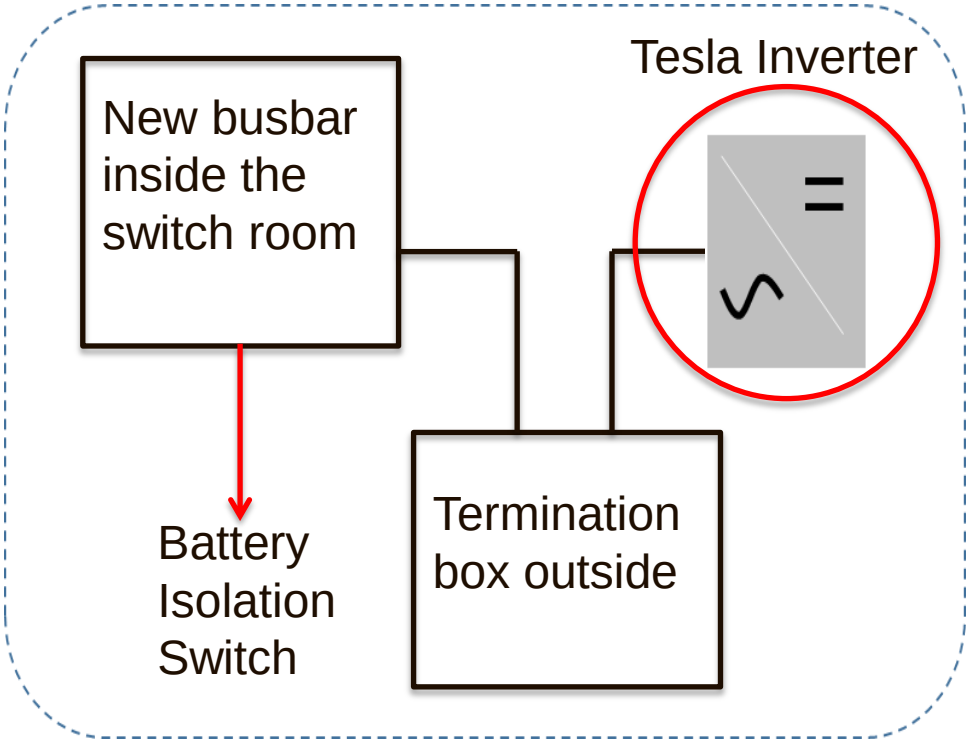
Termination Box outside the building



Termination box

AC conductor

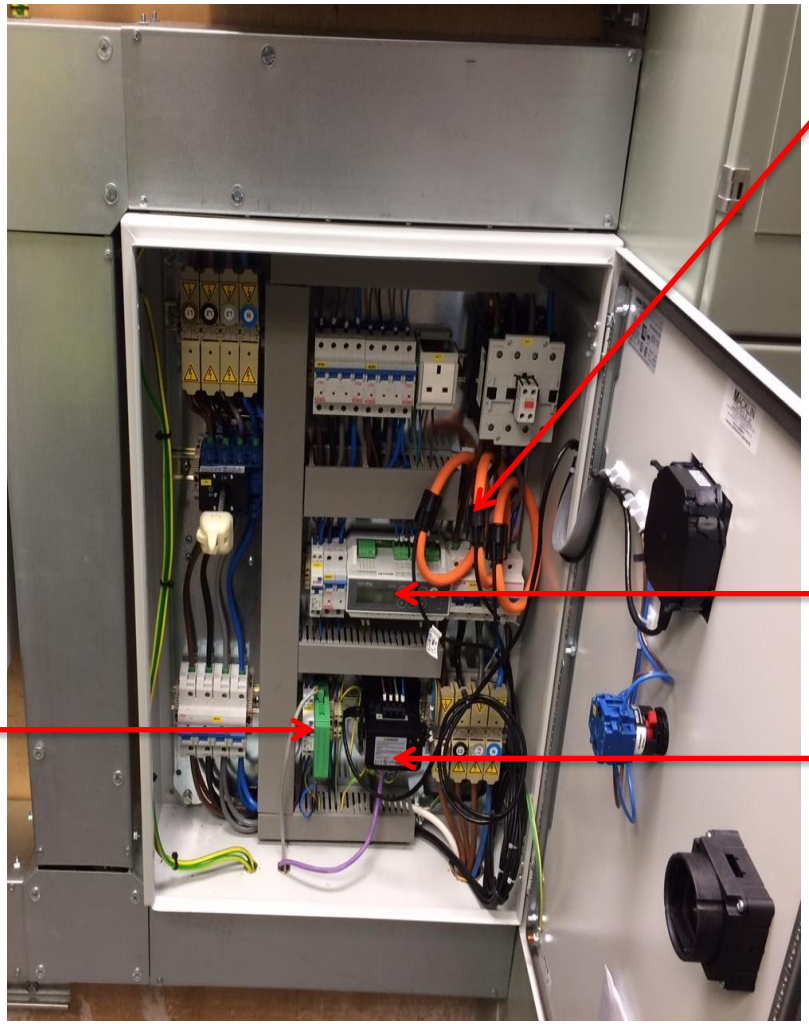
Comms cable harness



G59 Control & Relay Panel

- The customer (WPD) usually owns the G59 protection.
- As a minimum, G59 protection includes:
  - Under Voltage Protection,
  - Over Voltage Protection,
  - Under Frequency Protection,
  - Over Frequency Protection.

Inside the G59 Control & Relay Panel



Remote display for Battery Meter - G59 Control & Relay Panel

Remote display for the Battery Meter

Energy meters

- Two types - can be used in two roles:

Battery Meter

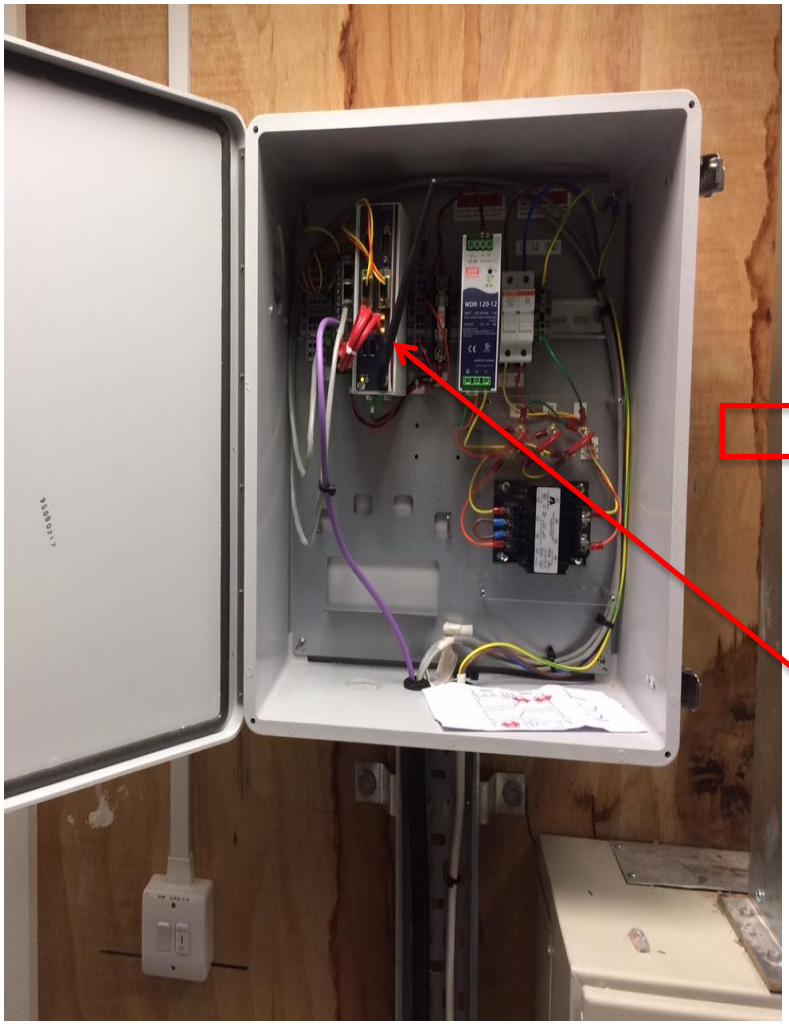
  - Measures the Powerpack system throughput.
  - Measures the AC power & energy output of the system.

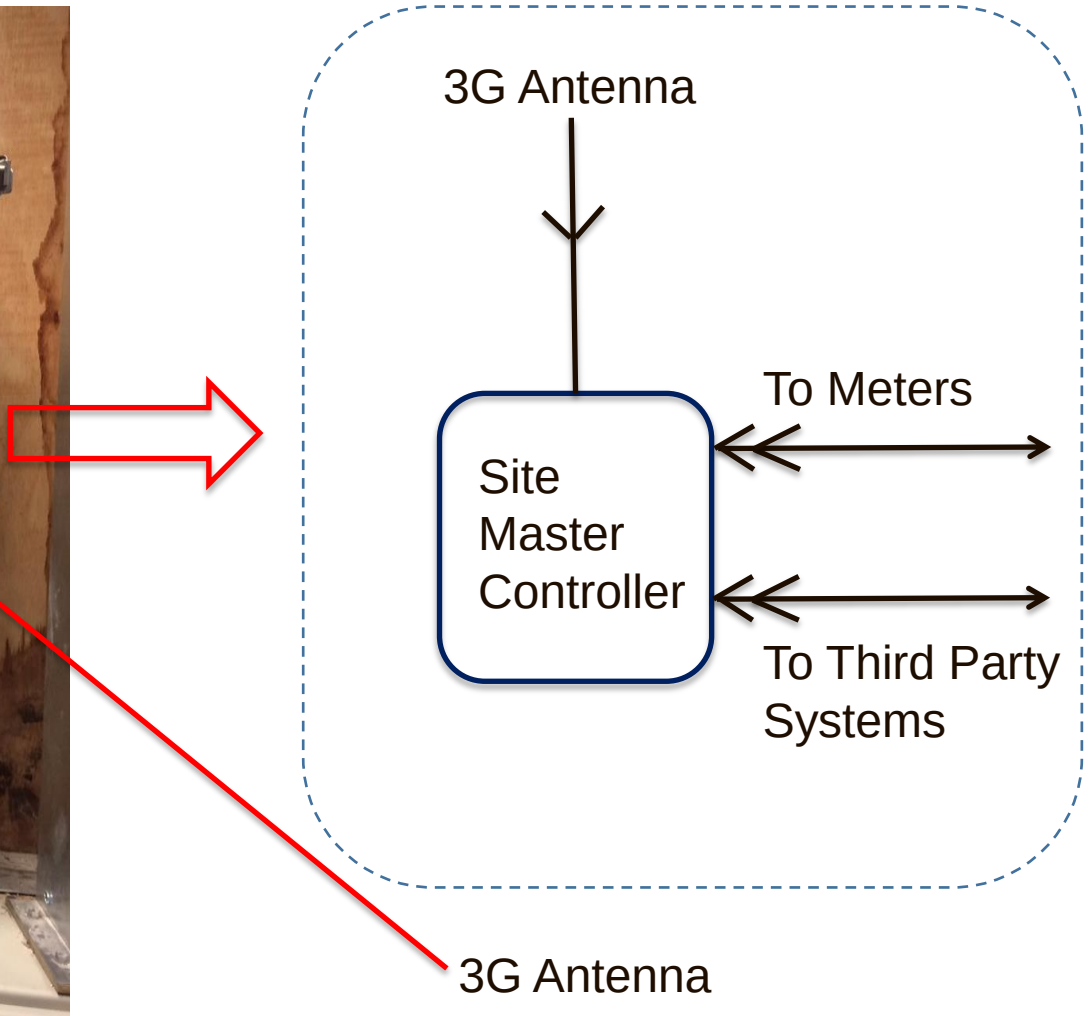
Site Meter

  - Measure the entire site.
  - Measures the site net load with the Powerpacks system included.
  - Typically located adjacent to the utility meter.
  - Optional.

Site Master Controller (SMC)

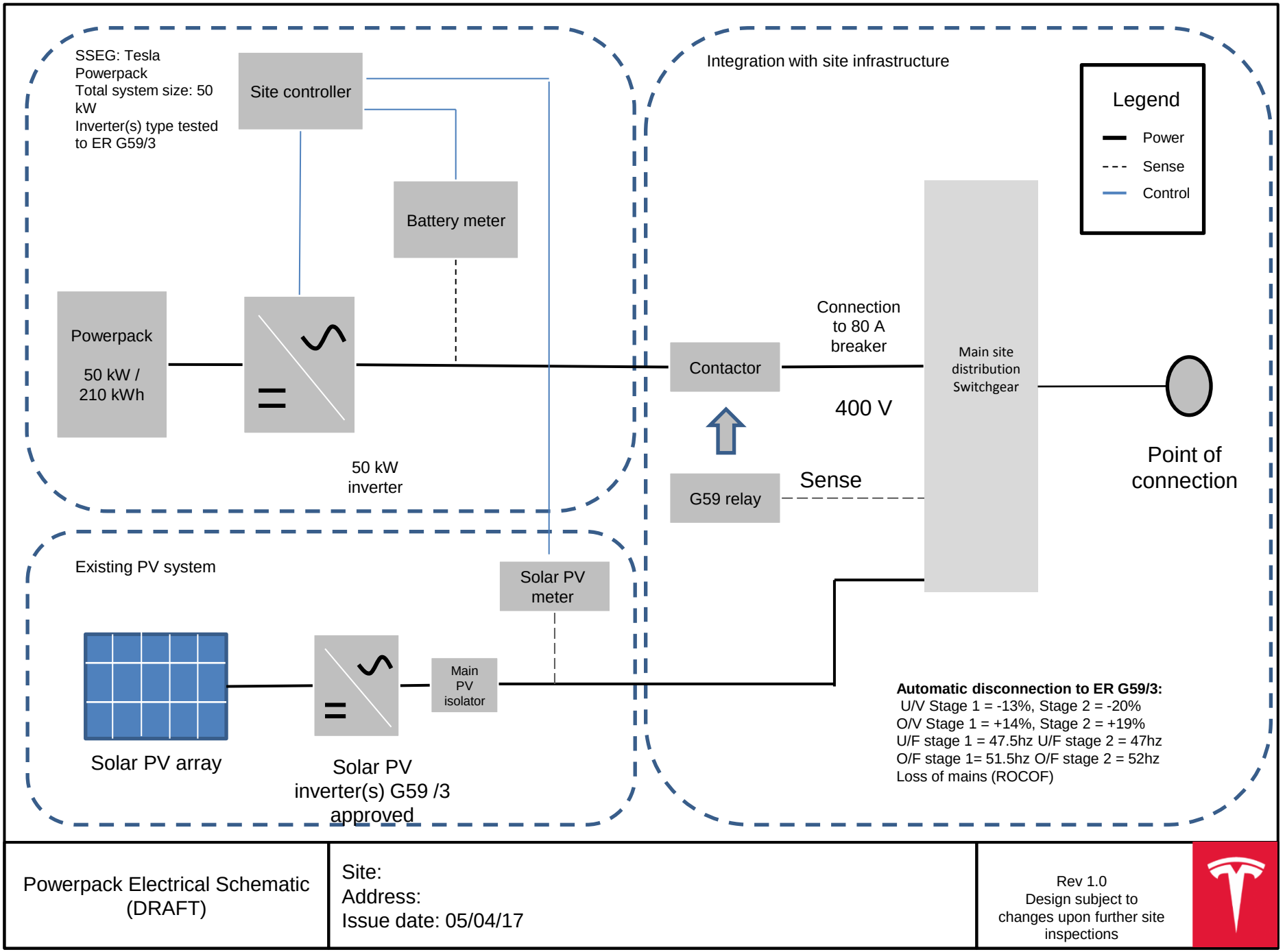
Site Master Controller – Internal wiring





What is a Site Master Controller (SMC)?

- SMC – capable of a wide range of applications;
  - Controls the entire energy storage site.
  - Single node through which the system can communicate with Tesla servers and other third party interfaces.
  - Capable of collecting data from all equipment installed on site.
  - Running algorithms.
  - Main data concentrator for the site.



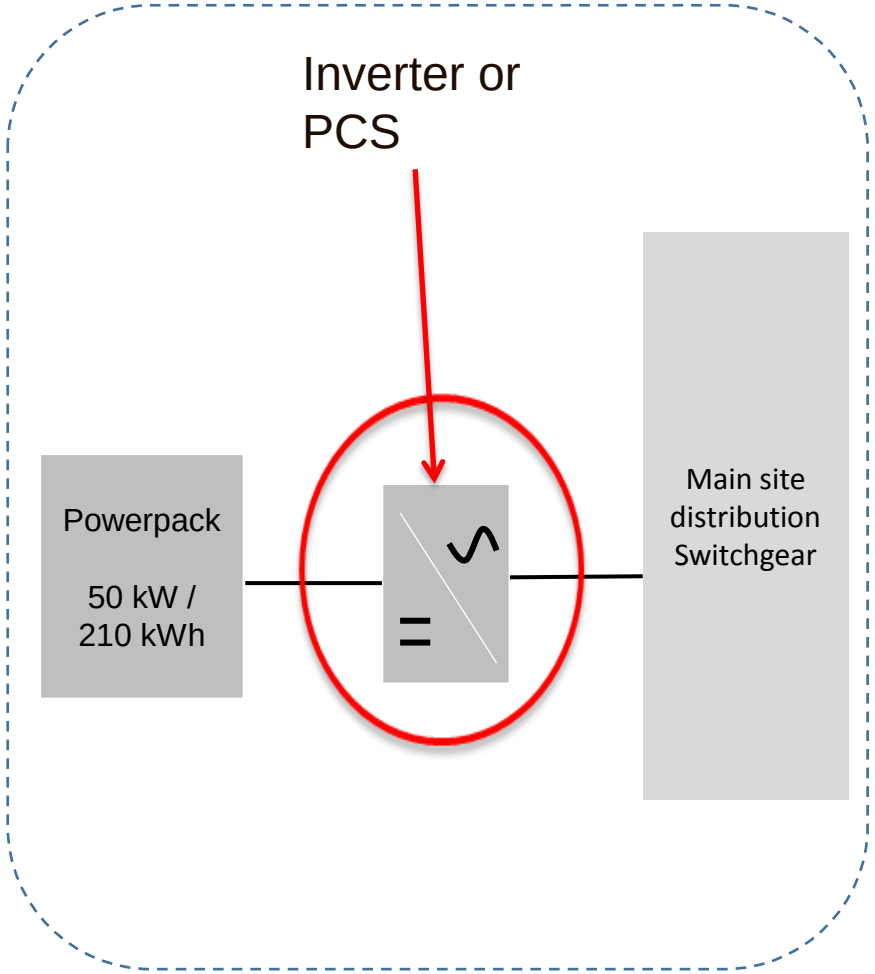
Powerpack Electrical Schematic (DRAFT)	Site: Address: Issue date: 05/04/17	Rev 1.0 Design subject to changes upon further site inspections

Project Plan

Project phase / milestone	Date
Procurement	Oct – Jan 2017
Design	Jan 2017– Present
Build	June 2017 – Aug 2017
Testing usage cases	Aug 2017 – Nov 2017
Results analysis	Dec 2017– June 2018
Project closedown	Dec 2018

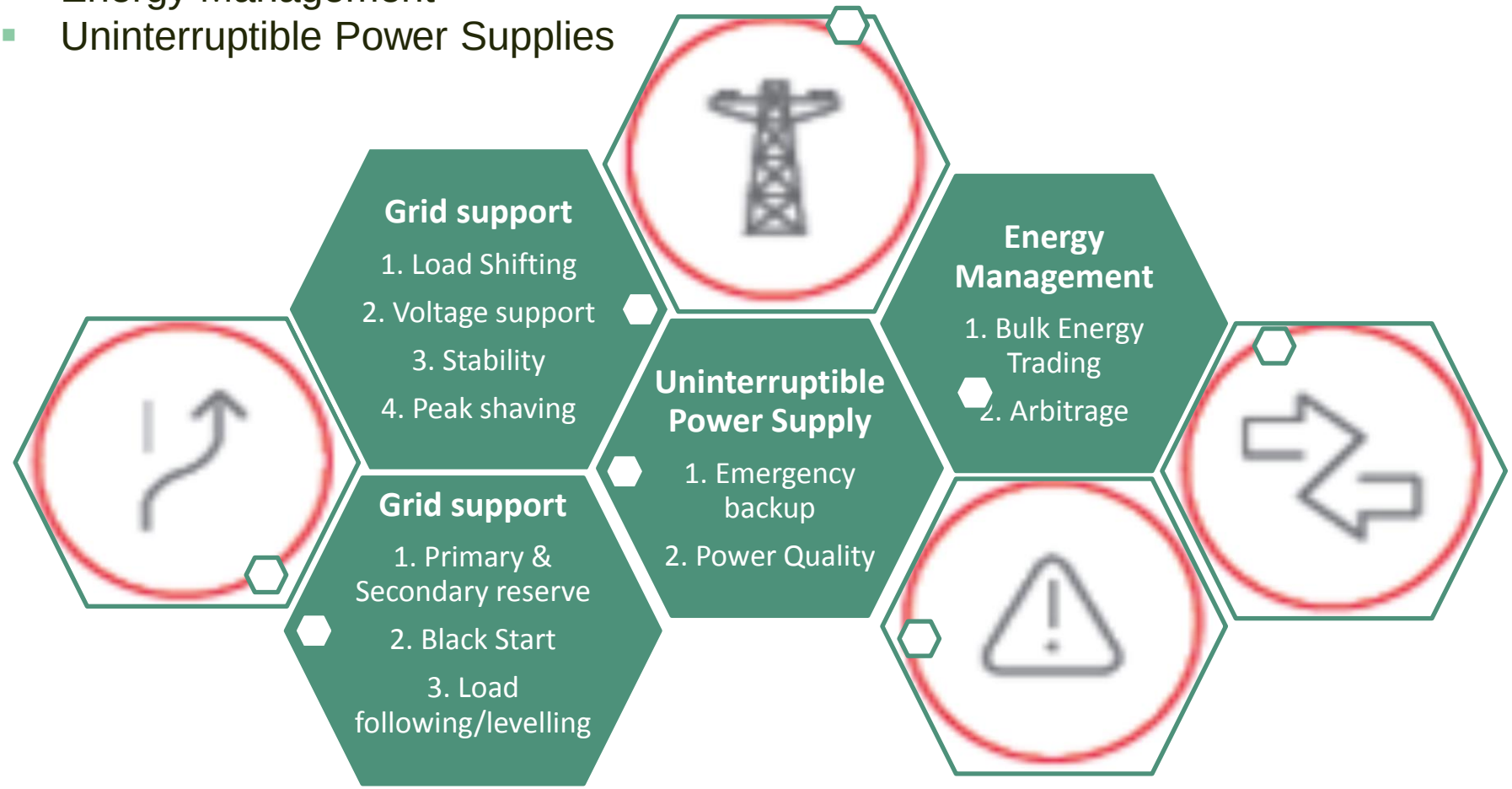
Summary

- Modular
- Fully integrated AC coupled system
- Powerpack is a combination of:
  - 16 Pods connected in parallel
  - In a single enclosure
- Inverter or PCS:
  - Bidirectional
  - Couples the Powerpack system with the grid
- Site Master Controller (SMC) – capable of a wide range of applications
  - Main data concentrator for the site



In general we can use the Tesla Powerpacks for….

- Grid Support
- Energy Management
- Uninterruptible Power Supplies



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