DSOF & NIA Project Call Event

8th February 2019

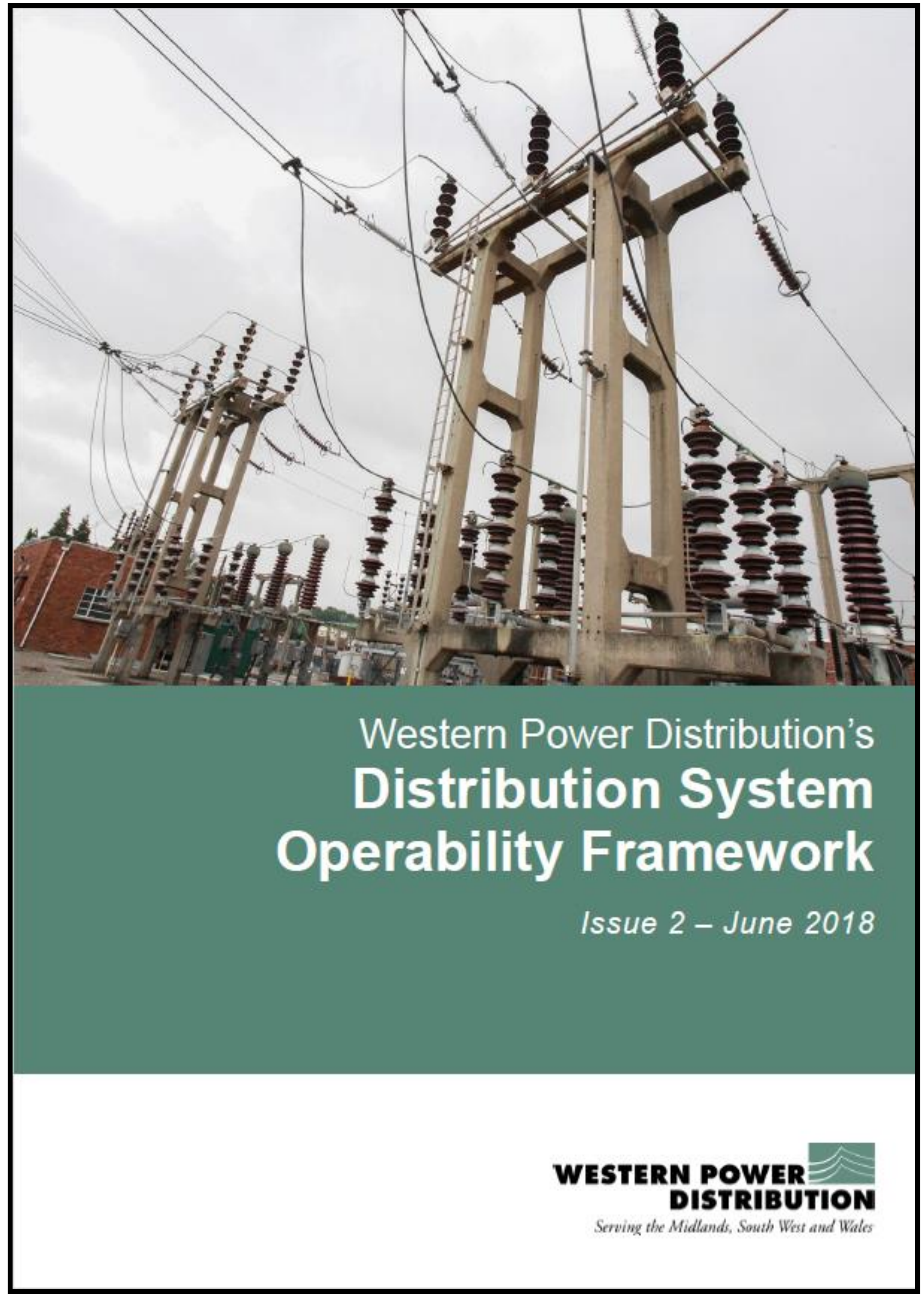
WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

Agenda & Format

- **Welcome & Housekeeping**
- **Introduction to the Distribution System Operability Framework**
  Oliver Spink, Network Strategy Engineer
- **Changing Load Profiles**
  David Tuffery, Network Strategy Engineer
- **Whole System Fault Level**
  Clive Goodman, Network Strategy Engineer
- **Innovation Strategy & NIA Project Call**
  Jonathan Berry, Innovation & Low Carbon Networks Engineer
- **Q&A**

Introduction to Distribution System Operability Framework (DSOF)

Oliver Spink, Network Strategy Engineer

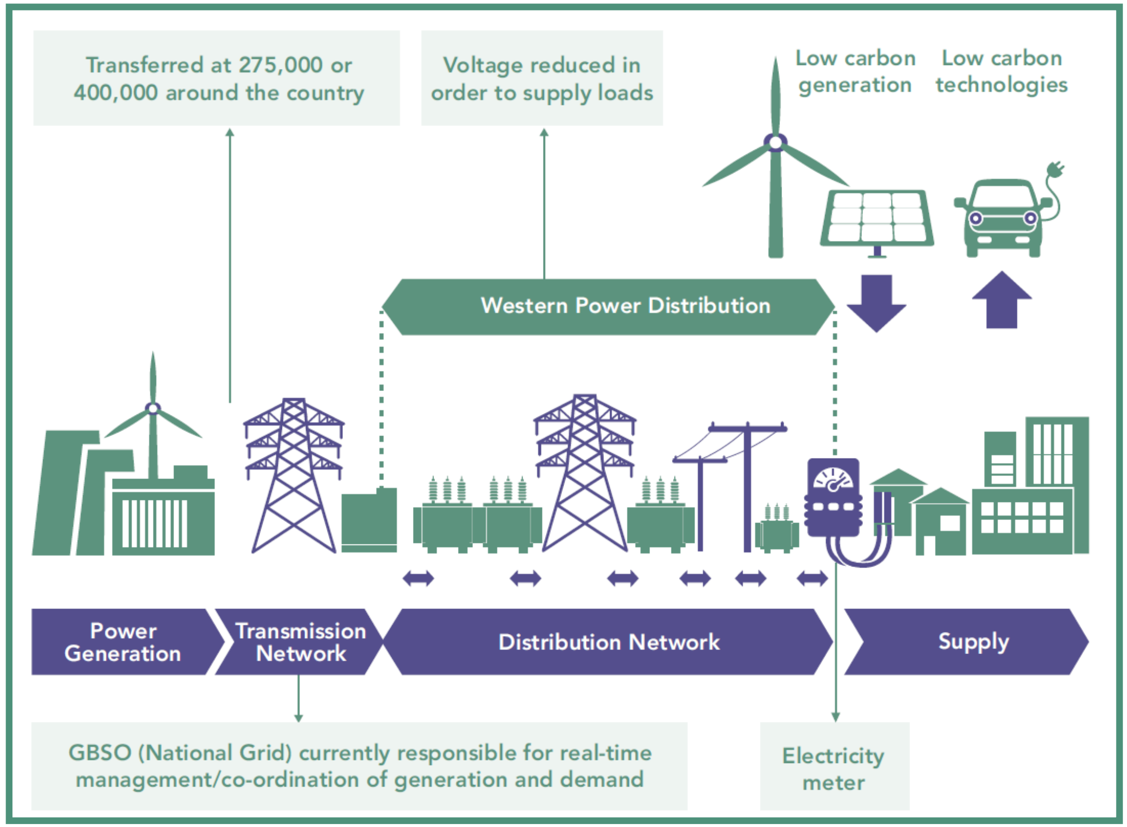


Aims and Objectives

The DSOF aims to highlight some of the technical and commercial challenges facing Distribution Network Operators as they become Distribution System Operators.

Changing Electricity Network

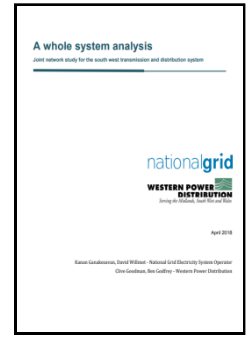
DSO Transition

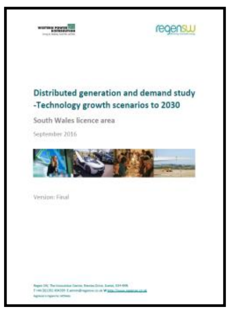


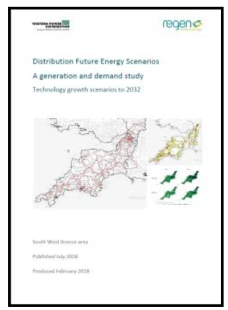
Where does the DSOF sit?

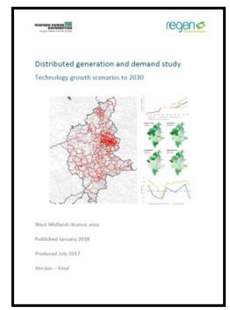
Network Strategy publications:

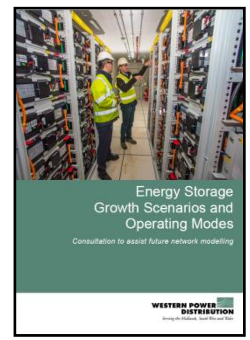
- Distribution Future Energy Scenarios (DFES)
- Strategic Investment Options: Shaping Subtransmission
- Regional Development Programmes
- DSO Strategy
- Energy Storage Investment
- Signposting and Flexibility

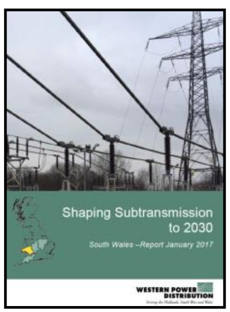


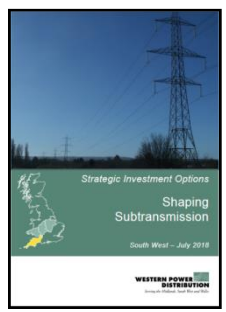


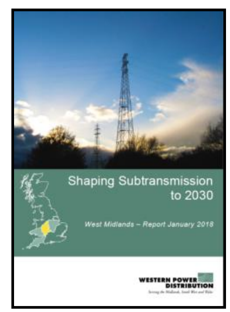












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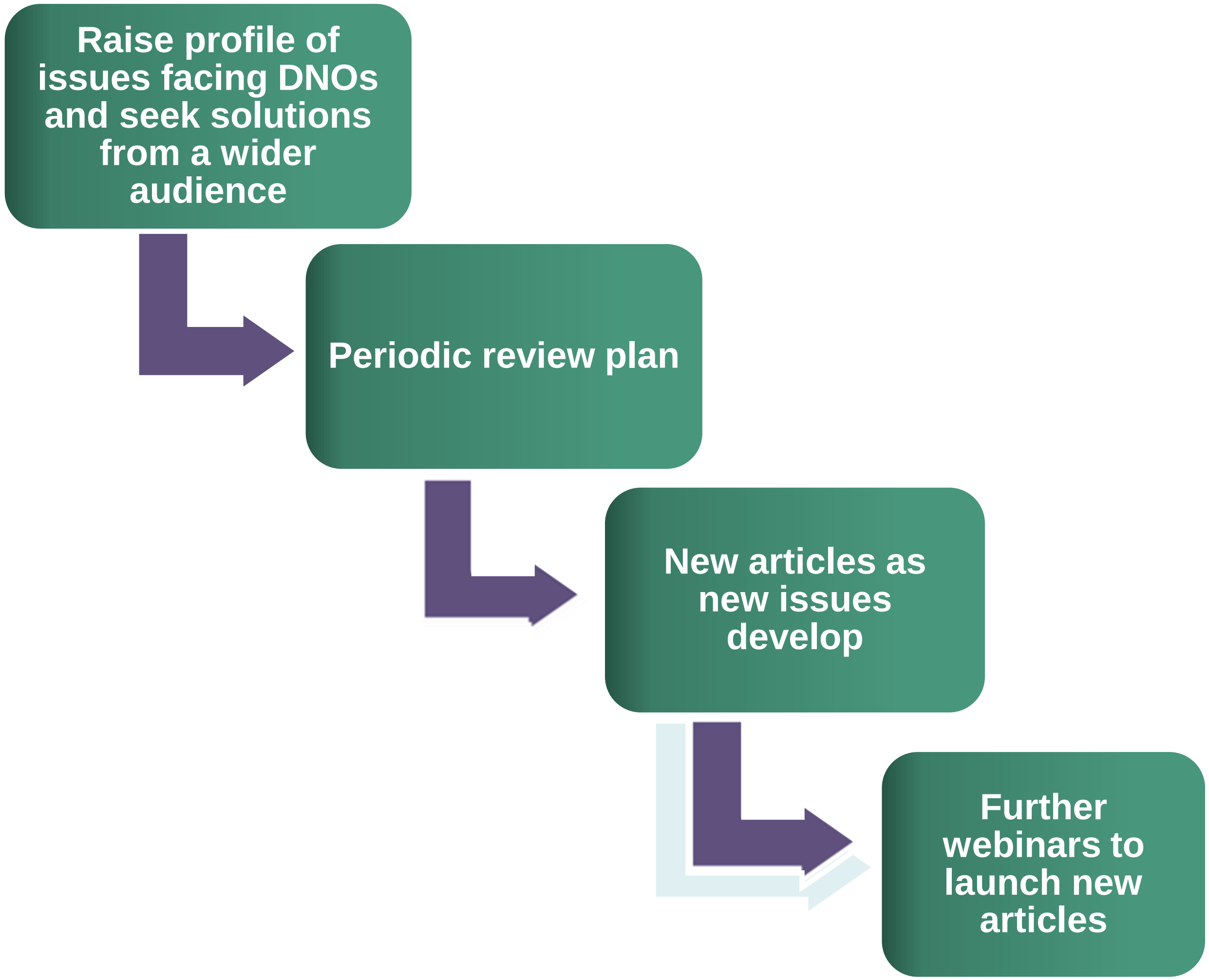
DSOF Changes for 2018/19

DSOF Topic	Assets	Network Operations	Customers
Introduction, background and supplementary information	√		
Network modelling and Analysis	√	√	√
Network Monitoring and Visibility	√	√	
Data and Forecasting	√	√	√
Arc Suppression Coils	√	√	
Low Frequency Demand Disconnection	√	√	√
Flexibility Services	√	√	√
Power Quality	√	√	√
Loss of Mains Protection		√	√
Changing Load Profiles	√	√	√
Whole System Fault Level **NEW FOR 2019**	√	√	

www.westernpower.co.uk/dsof

DSOF - Next Steps



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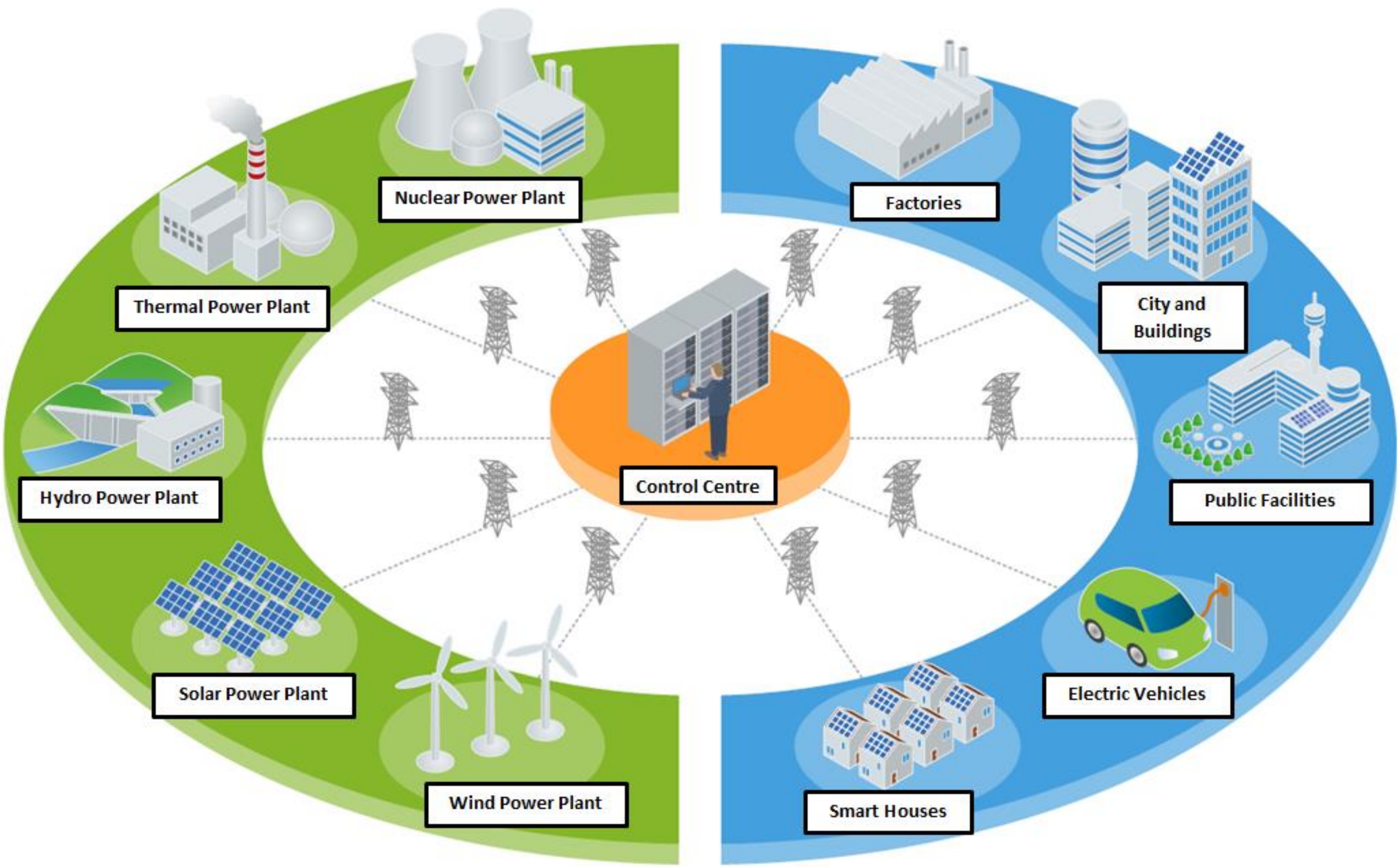

Changing Load Profiles

David Tuffery, Network Strategy Engineer

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Overview

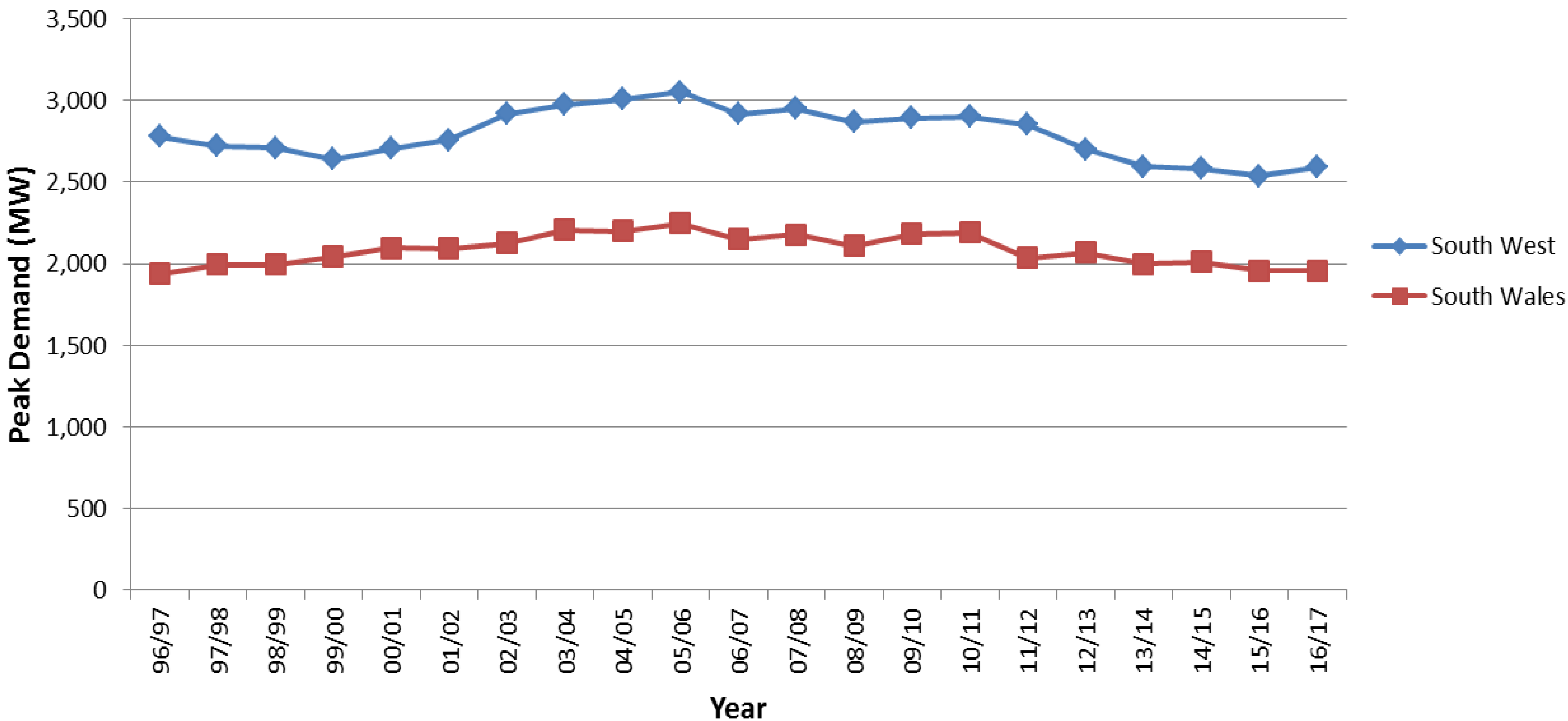
- Traditional network design
- Demand categorisation
- DFES demand and technology forecasts
- Electric Vehicles (EVs)
- Heat pumps
- Battery storage
- Case study
- Solutions and future challenges

Network Design

- Traditional distribution network design was almost entirely demand driven
- Peak demand normally typically occurs during a winter evening
- Factors that impact network loading are:
  - Time of day
  - Ambient temperature (heating/cooling)
  - Sunlight hours
  - Transport
  - Weekday, weekend and public holidays
  - Major events such as sporting events
  - Generation export
- The peak demand on the network has remained relatively constant

Historic Peak Demand

- Appliance efficiency and the increase in property thermal insulation offsetting demand growth



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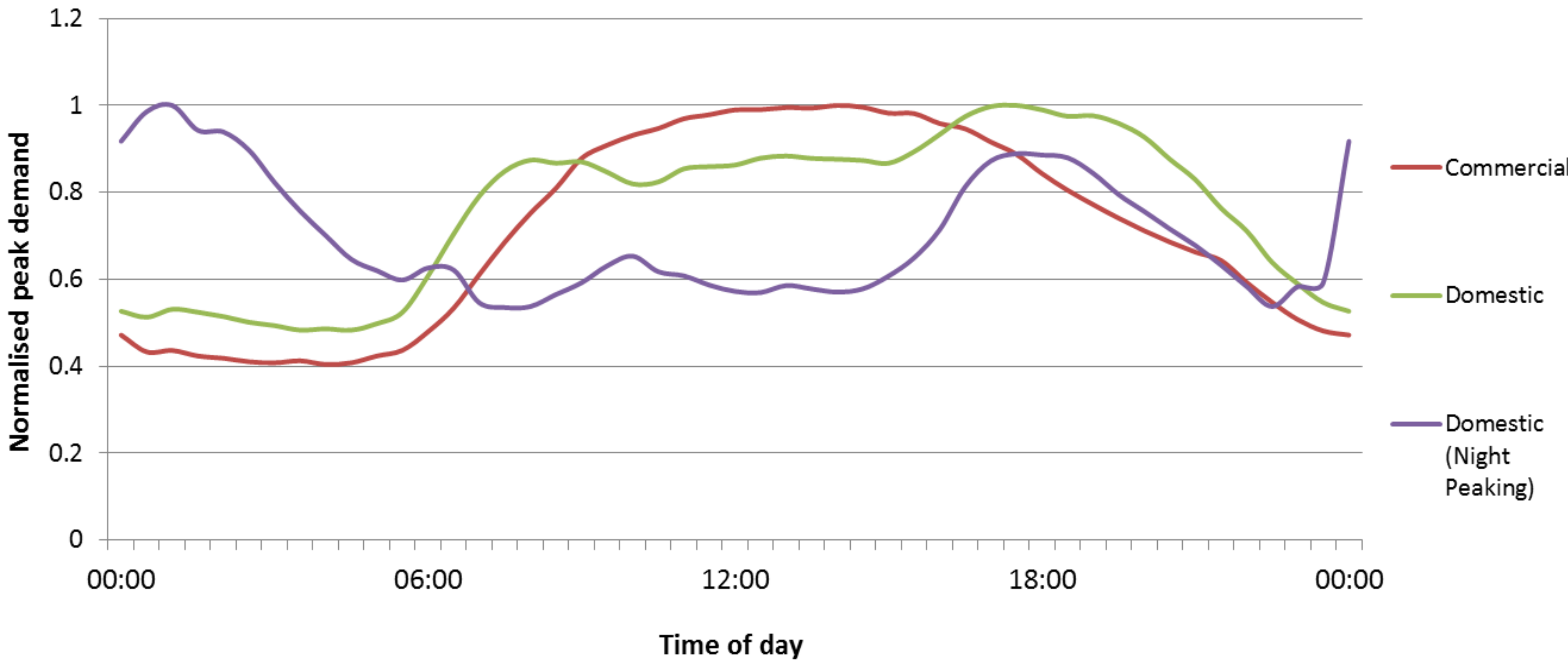
Demand Types

- The underlying demand profile of a substation is predominately influenced by the breakdown of commercial, industrial and domestic properties that are fed out of them. Demand Profiles that are commonly seen are:



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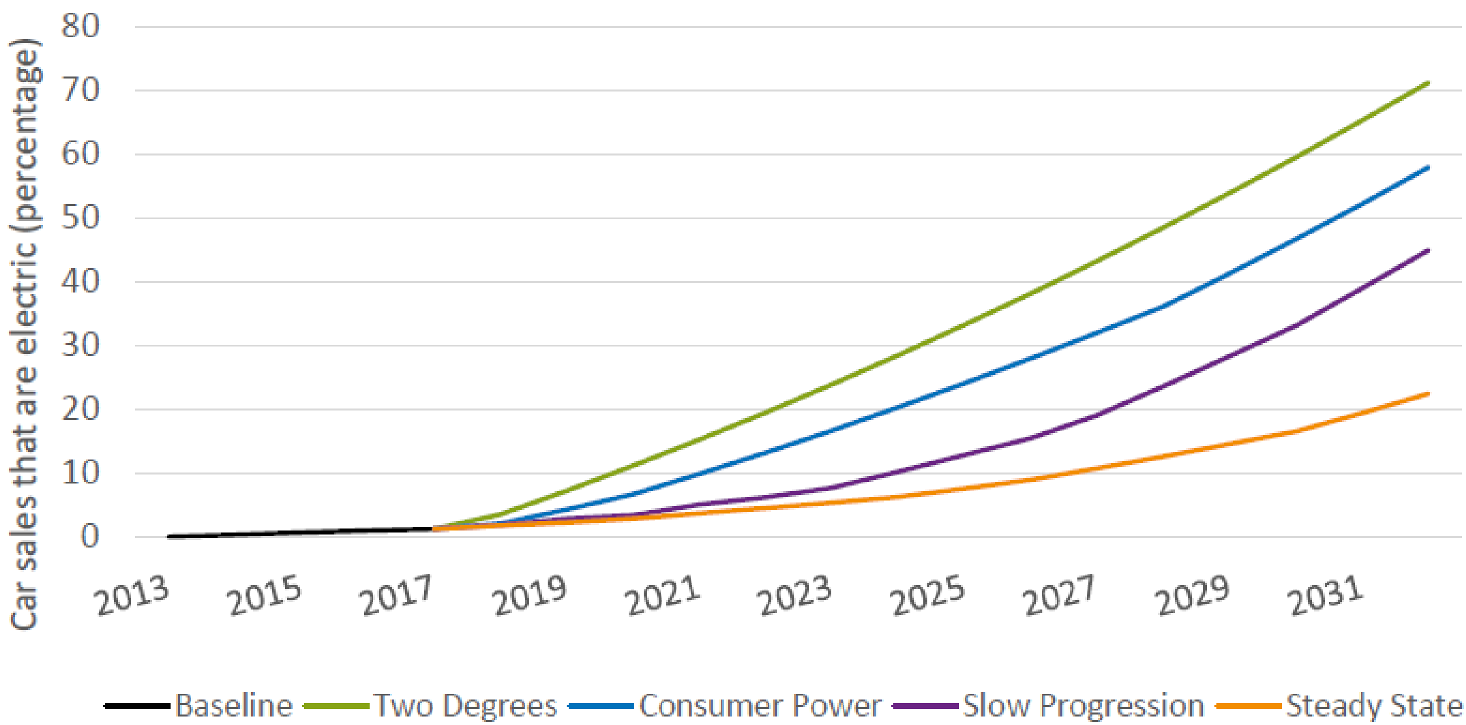
Network Impact – Emerging Demand

- The latest round of Regen forecasts assess the demand and generation technologies detailed below

Electricity Generation Technologies	New Demand Technologies
• Solar PV – ground mounted • Solar PV – roof mounted • Onshore wind – large scale • Onshore wind – small scale • Anaerobic digestion (AD) – electricity production • Hydropower • Energy from waste (EfW) • Diesel • Gas • Other generation • Deep geothermal • Floating wind • Tidal steam and wave energy	• Electric vehicles • Heat pumps (domestic) • Domestic air conditioning **Conventional Demand Technologies** • Domestic • Industrial and Commercial (I&C) **Energy (electricity) storage** • High Energy Commercial and Industrial • Domestic and community own use • Energy trader • Generation co-location • Reserve service • Response service

Electric Vehicle Car Sales

- Electric Vehicle uptake from the latest South West DFES report



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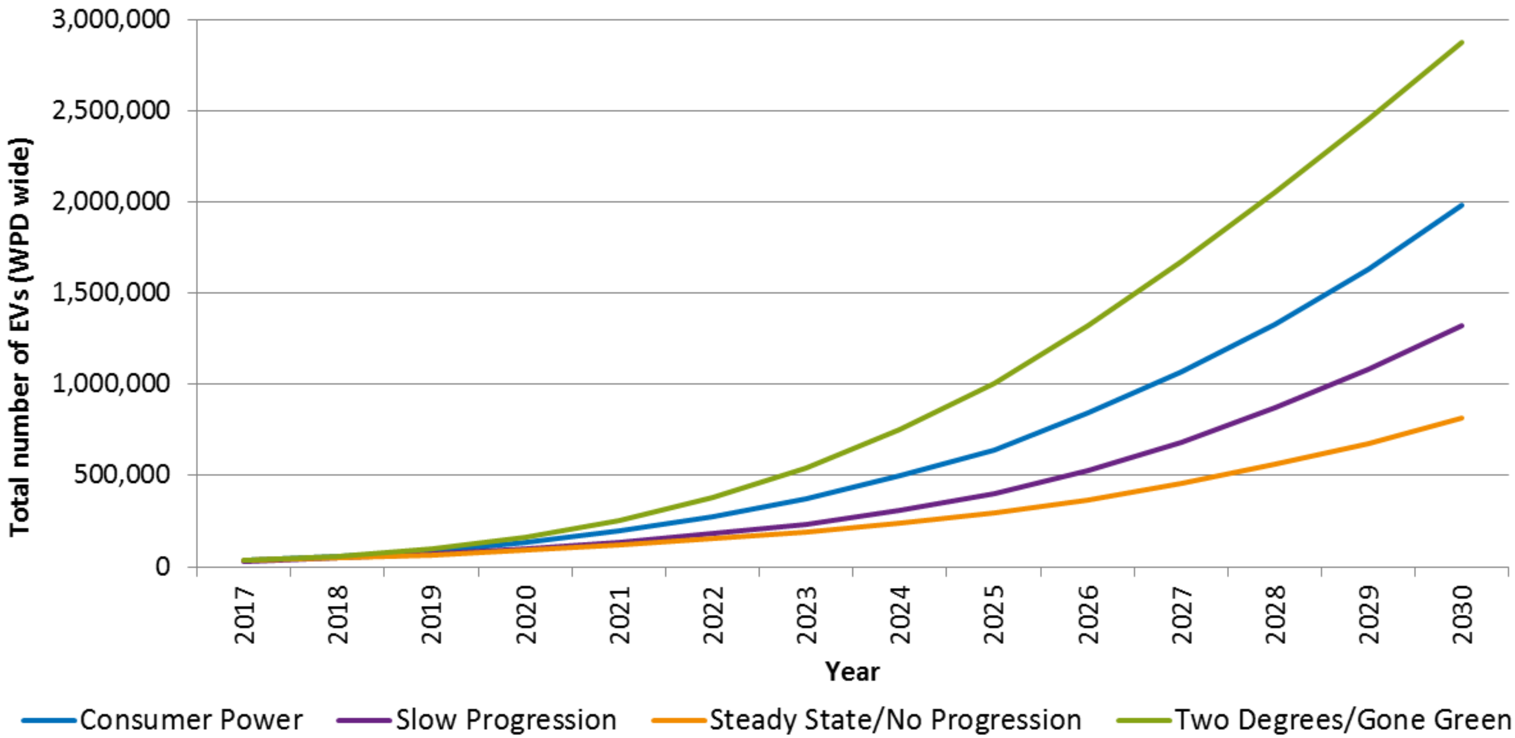
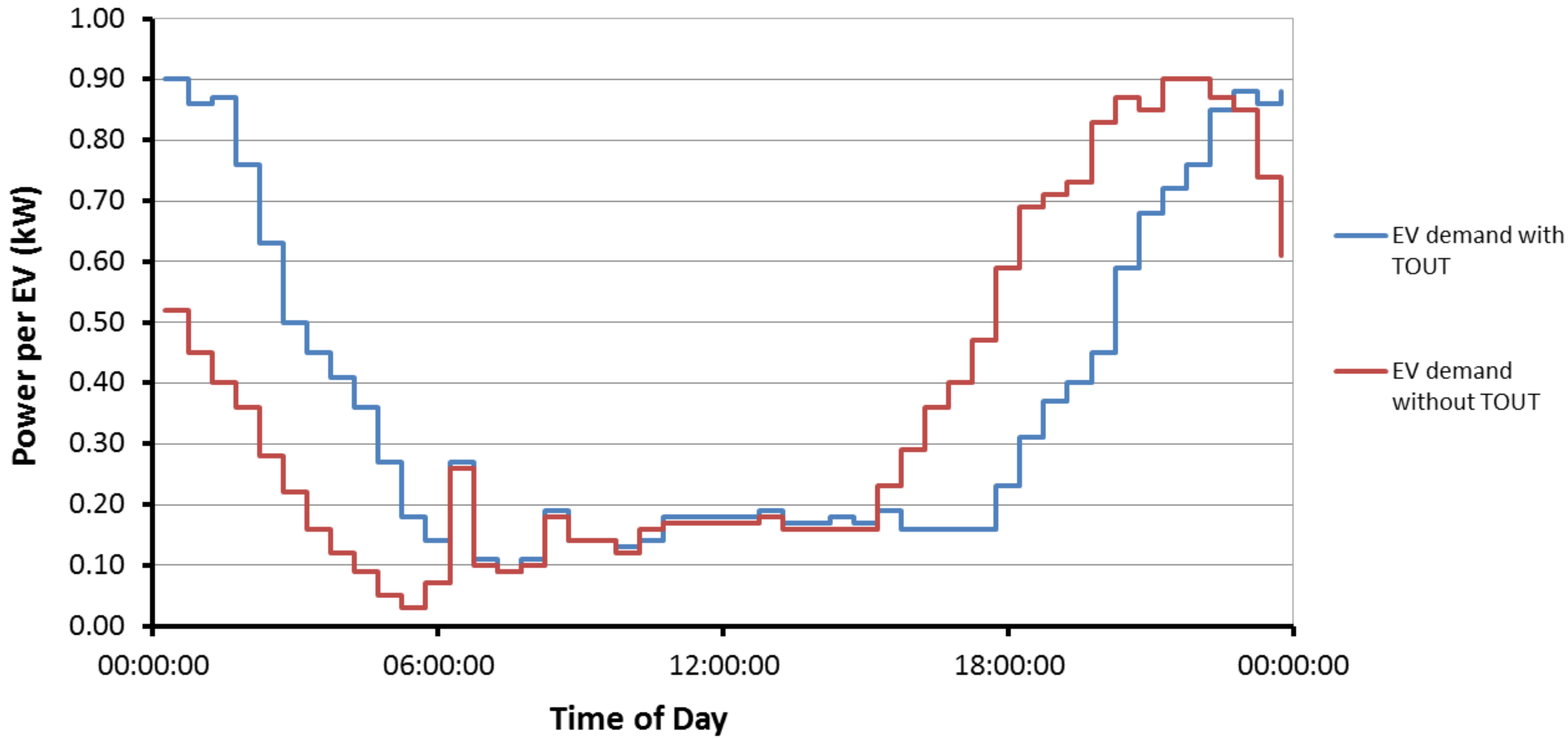
Electric Vehicle Numbers



Electric Vehicle Charging Profiles



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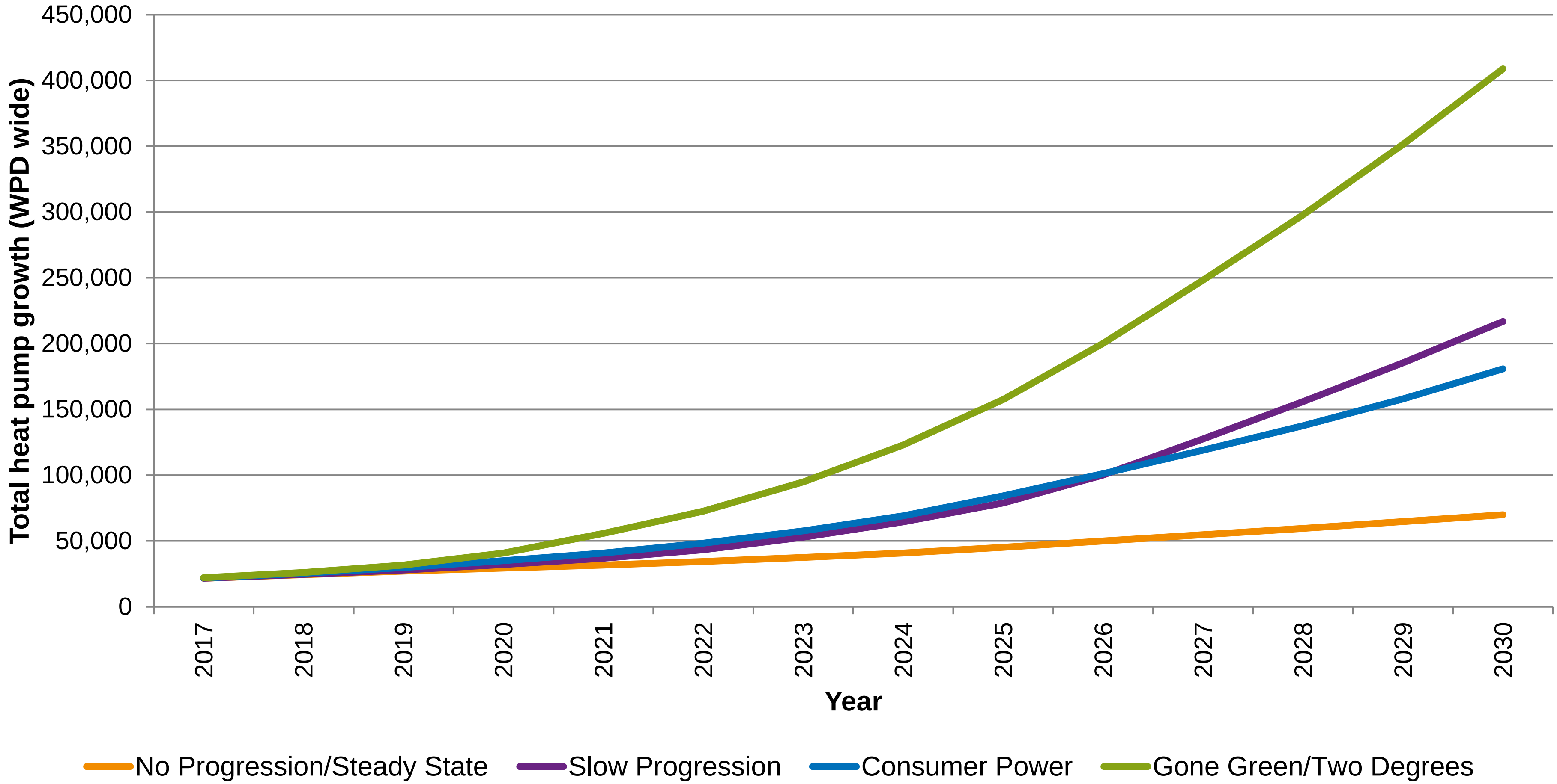
Heat Pump Forecasts



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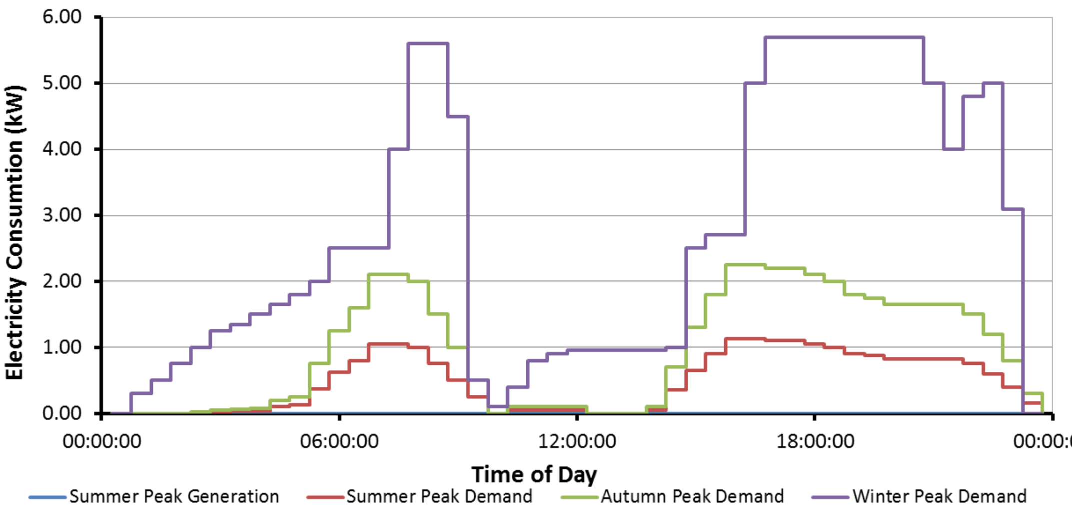
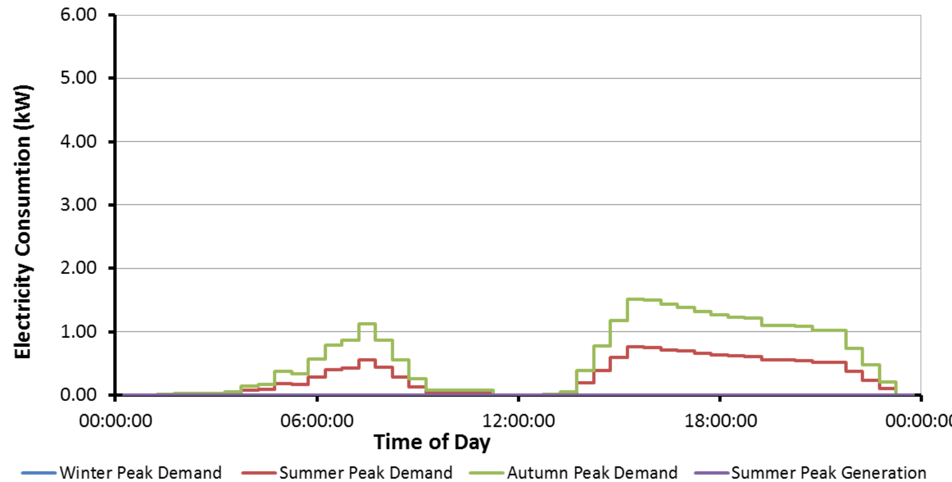
Heat Pump Profiles

- The profiles for heat pumps were derived from the Electricity North West Limited (ENWL) Network Innovation Allowance (NIA) funded study: Managing the Impact of Electrification of Heat, dated March 2017.

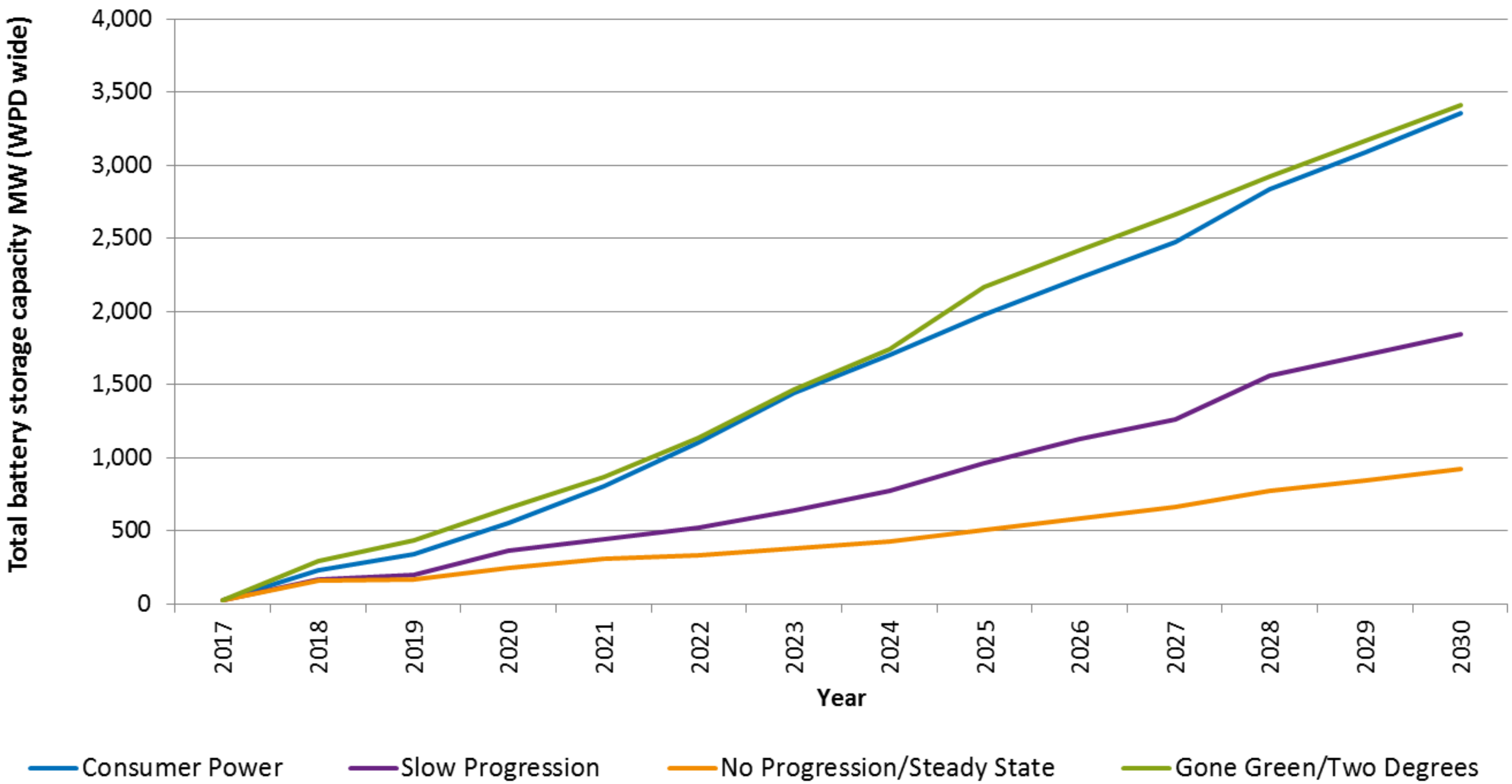
Electric backup



Gas backup (hybrid)



Battery Storage



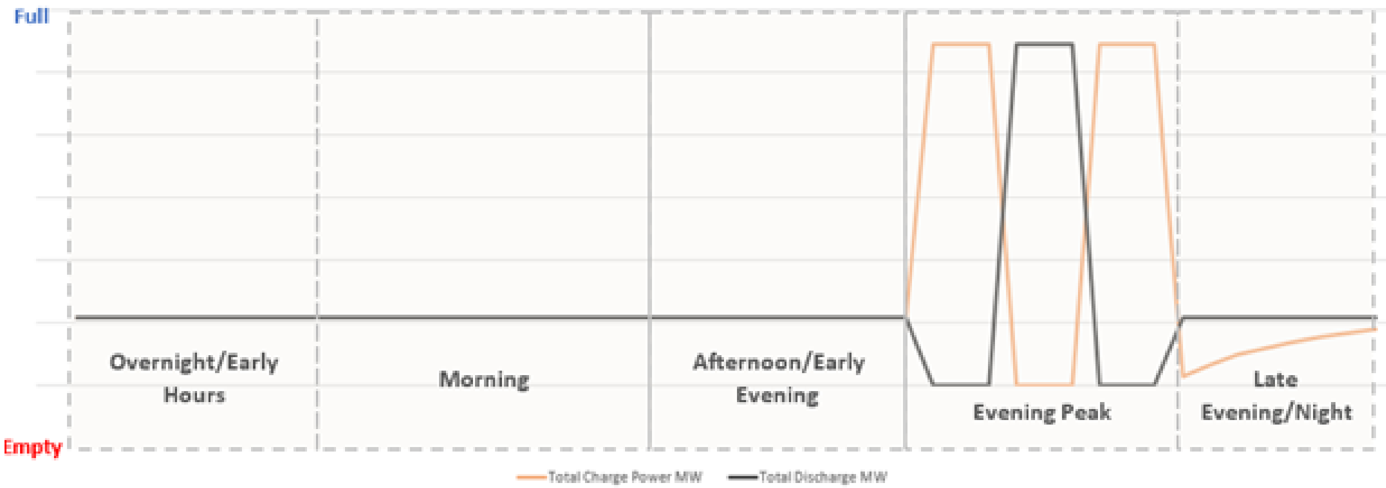
Battery Storage – Business Models

Taken from WPD's Storage Consultation paper (2017):

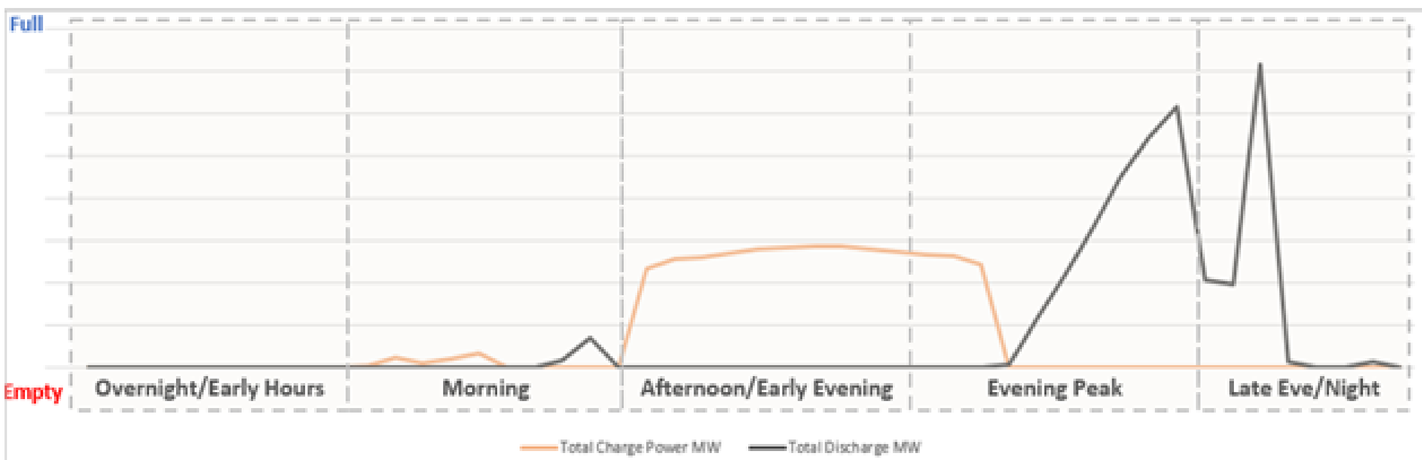
- **Response Service -** Providing higher value ancillary services to transmission and distribution network operators
- **Reserve Service -** Specifically aiming to provide short/medium term reserve capacity for network balancing services
- **Commercial and Industrial -** Located with a higher energy user (with or without on-site generation) to avoid peak energy costs, and peak transmission and distribution network charges while providing energy continuity
- **Domestic and Community -** Domestic, community or small commercial scale storage designed to maximise own use of generated electricity and avoid peak electricity costs
- **Generation Co-location -** Storage co-located with variable energy generation in order to a) price/time shift or b) peak shave to avoid grid curtailment or reinforcement costs

Battery Storage – Profile Examples

Operating Mode: Network Auxiliary Services + Network Peak



Operating Mode: Generation Peak Shaving (Solar PV)



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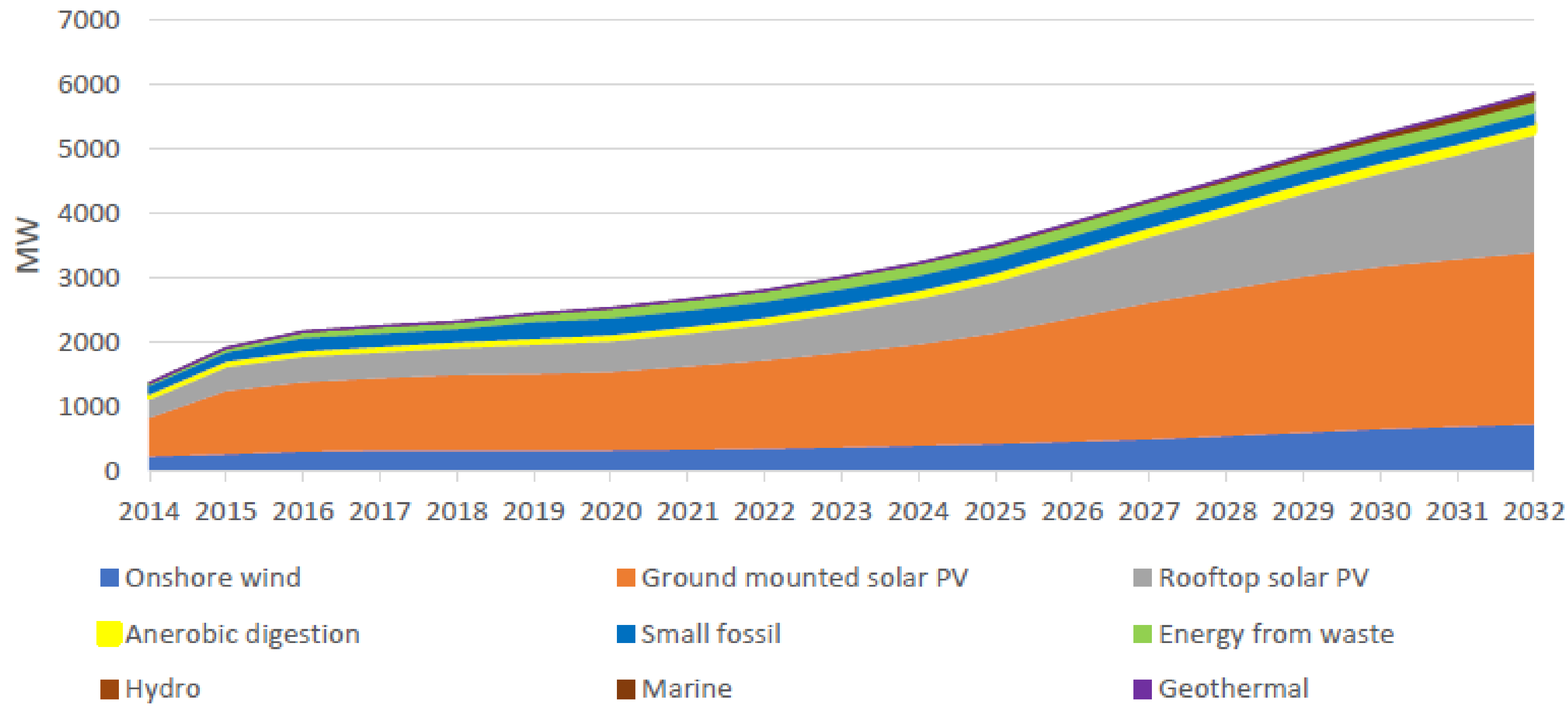
South West Generation Growth – Two Degrees



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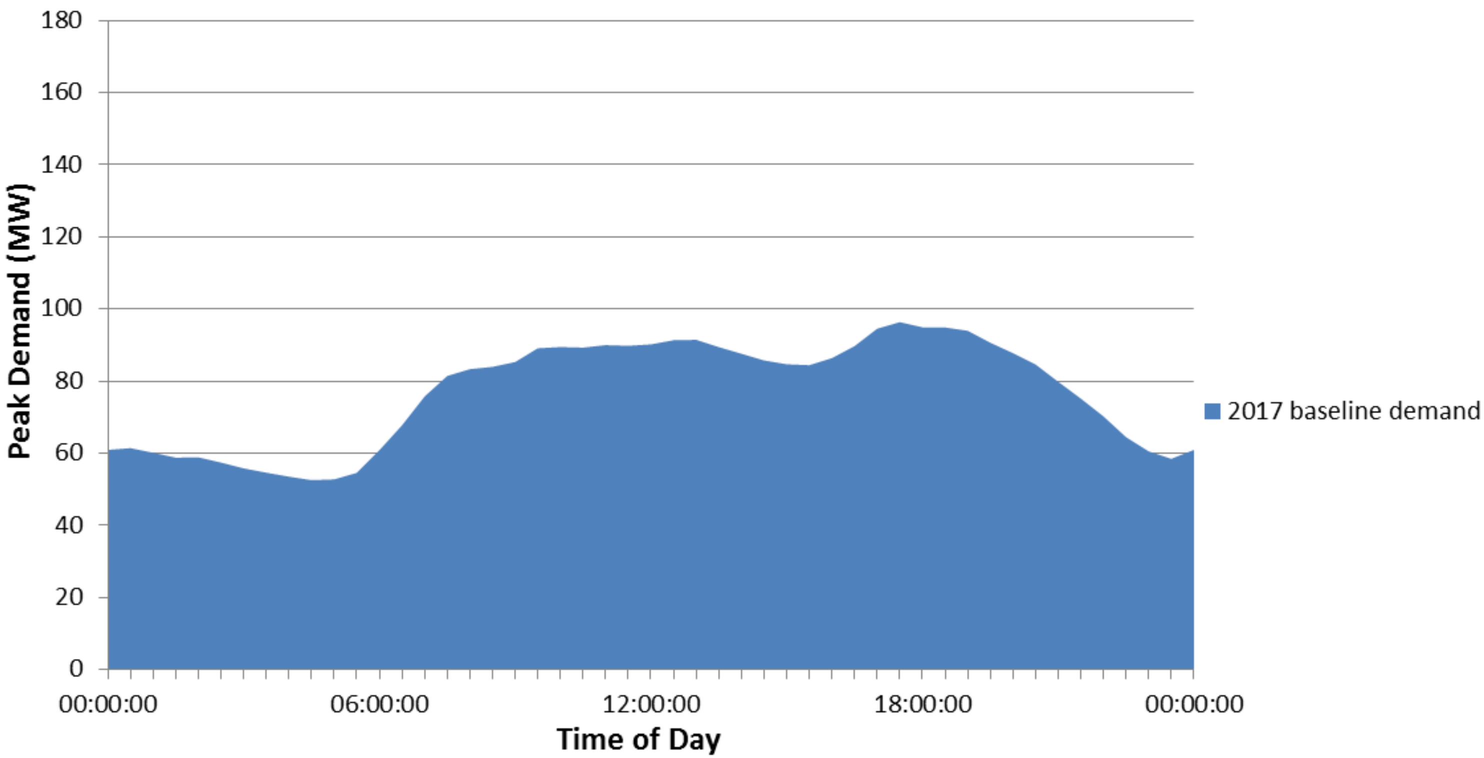
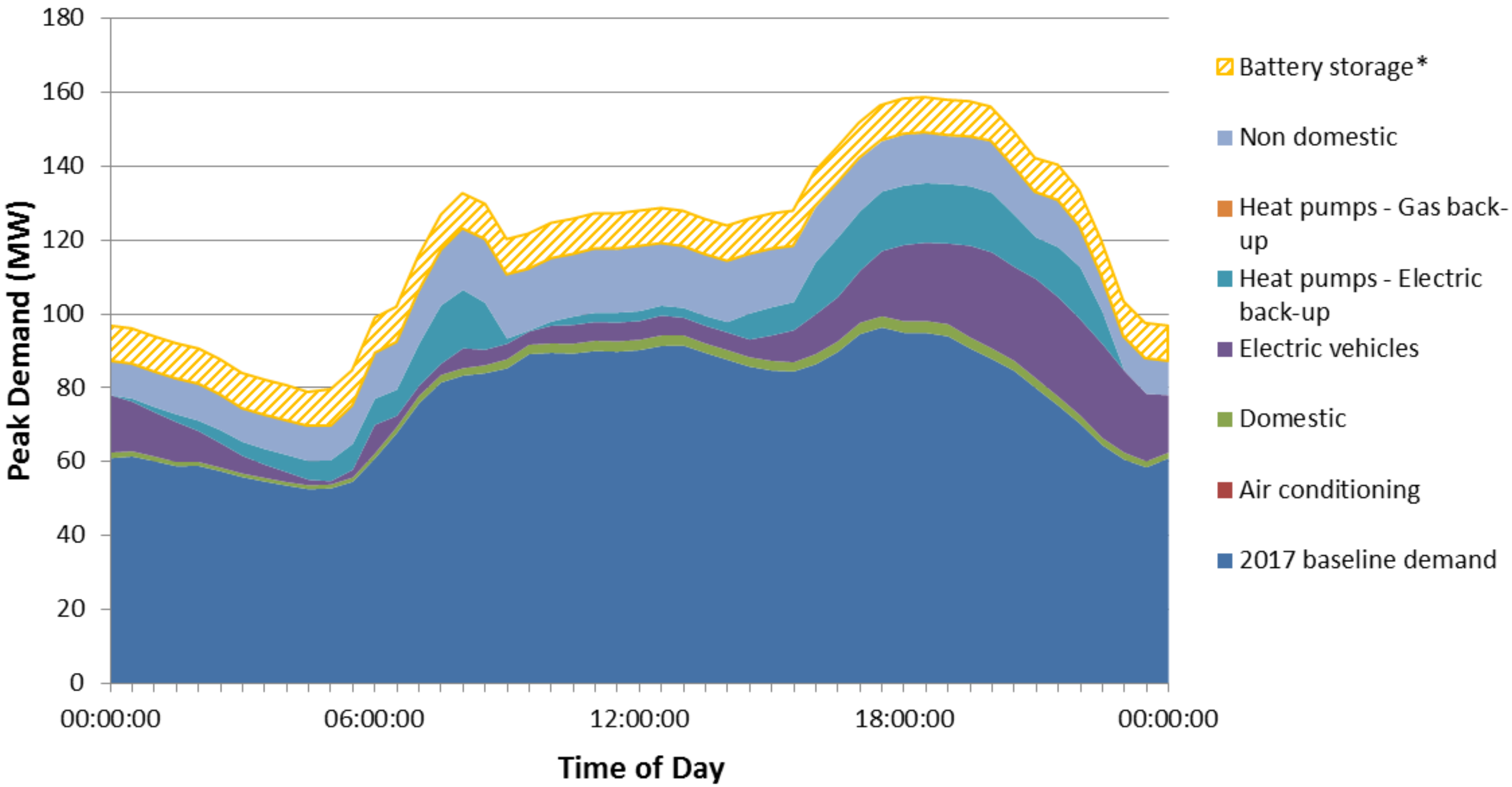
BSP Case Study

- This case study is to highlight some of the challenges of changing load profiles from the disruptive technologies described above and the increase in conventional demand.



BSP Peak Demand 2030 Two Degrees



*Batteries are modelled as importing for the entire period, whilst this is not representative of how a battery could operate, without certainty of when and how they will operate, it must be assumed they could import at any point. Storage is ignored for any energy comparisons.

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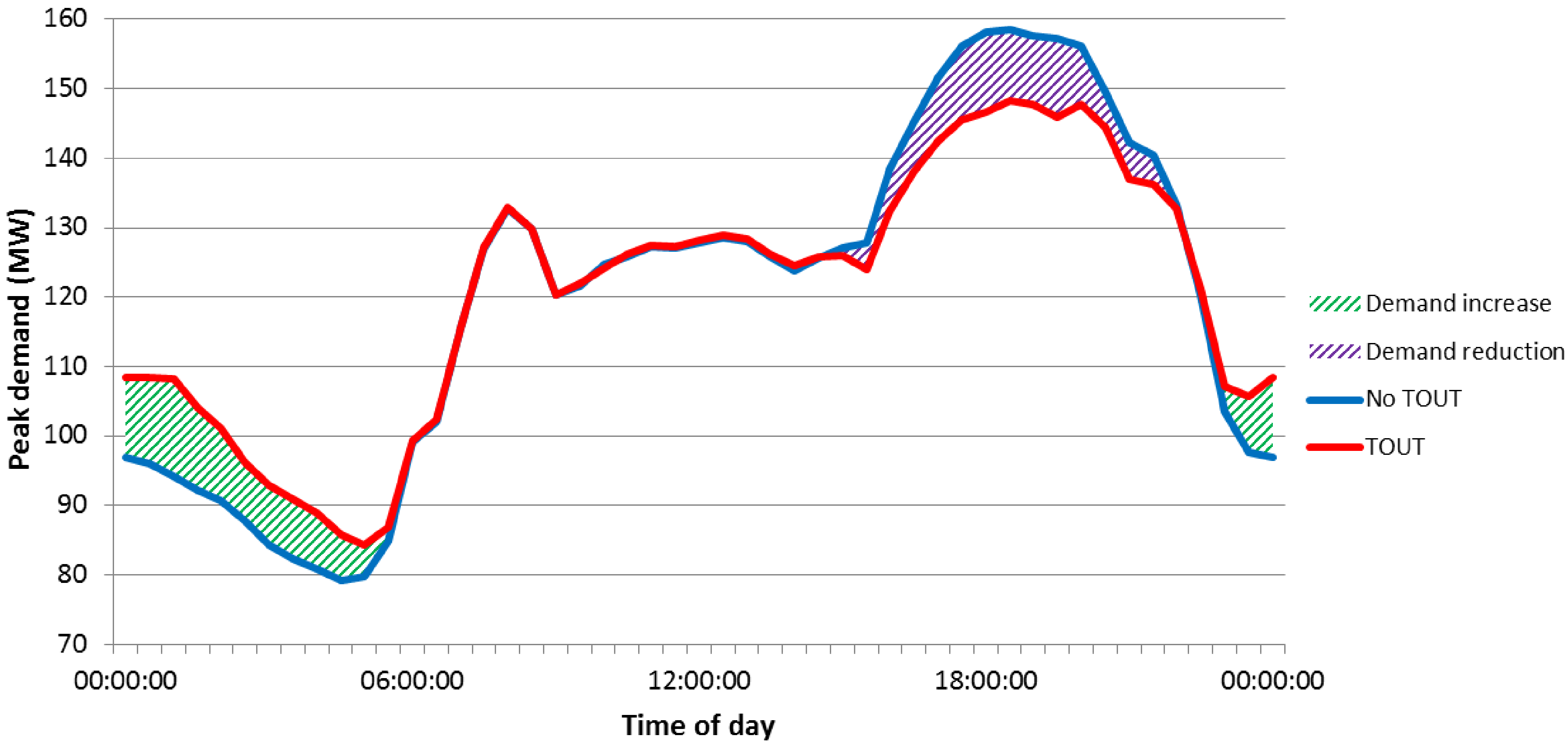
Electric Vehicle - Time of use Tariffs (TOUT)

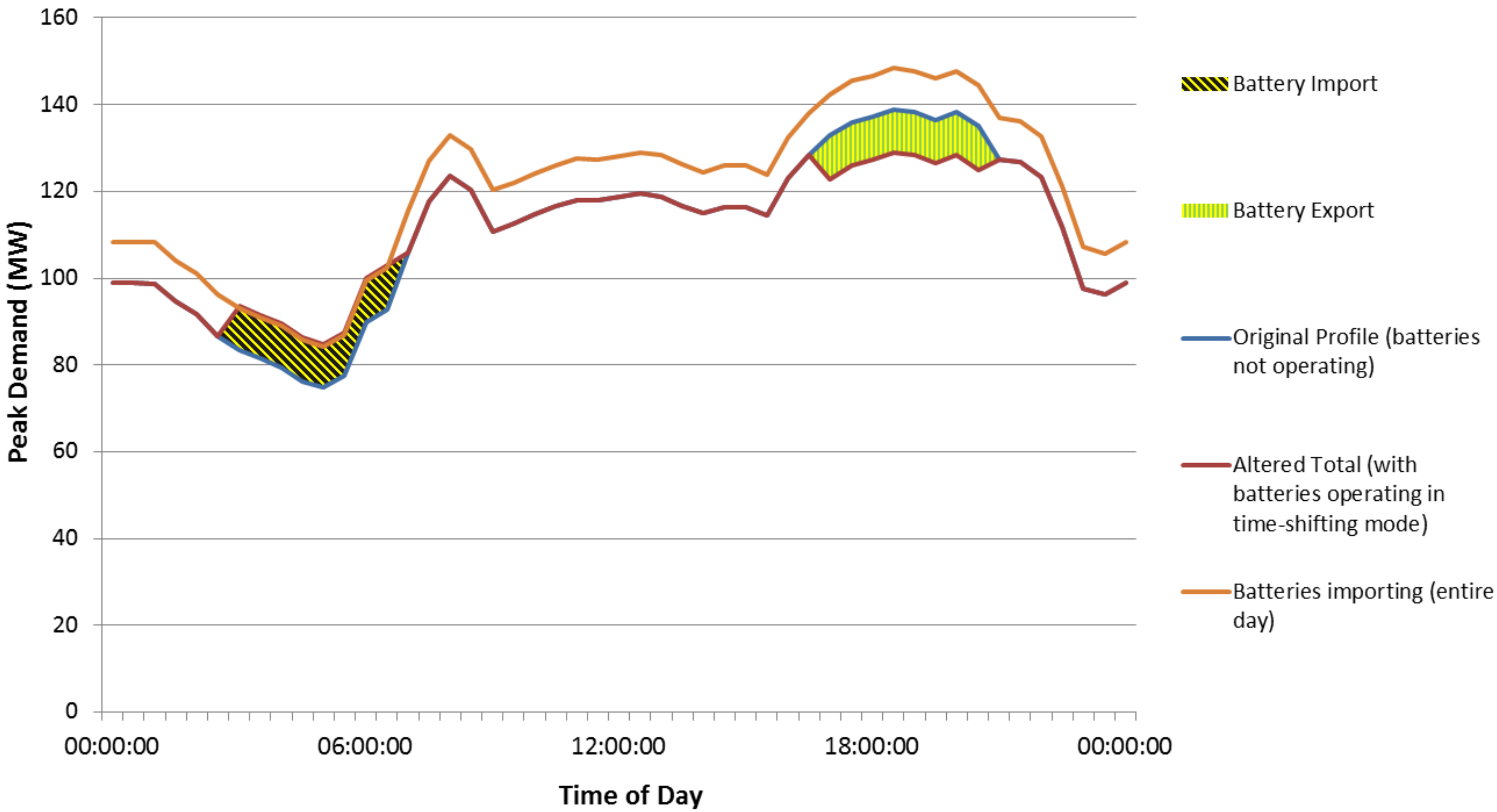


Impact of DG

Case study BSP installed capacity by generation type by 2030 under Two Degrees

Technology	Installed Capacity (MW)	Technology Type
Anaerobic digestion	2.5	Non-intermittent
Battery storage	9.5	Storage
Hydropower	0.037	Non-intermittent
Onshore wind	0.37	Intermittent
Other generation	21.1	Non-intermittent
Ground mounted PV	3.2	Intermittent
Rooftop PV	37.0	Intermittent

Battery Storage



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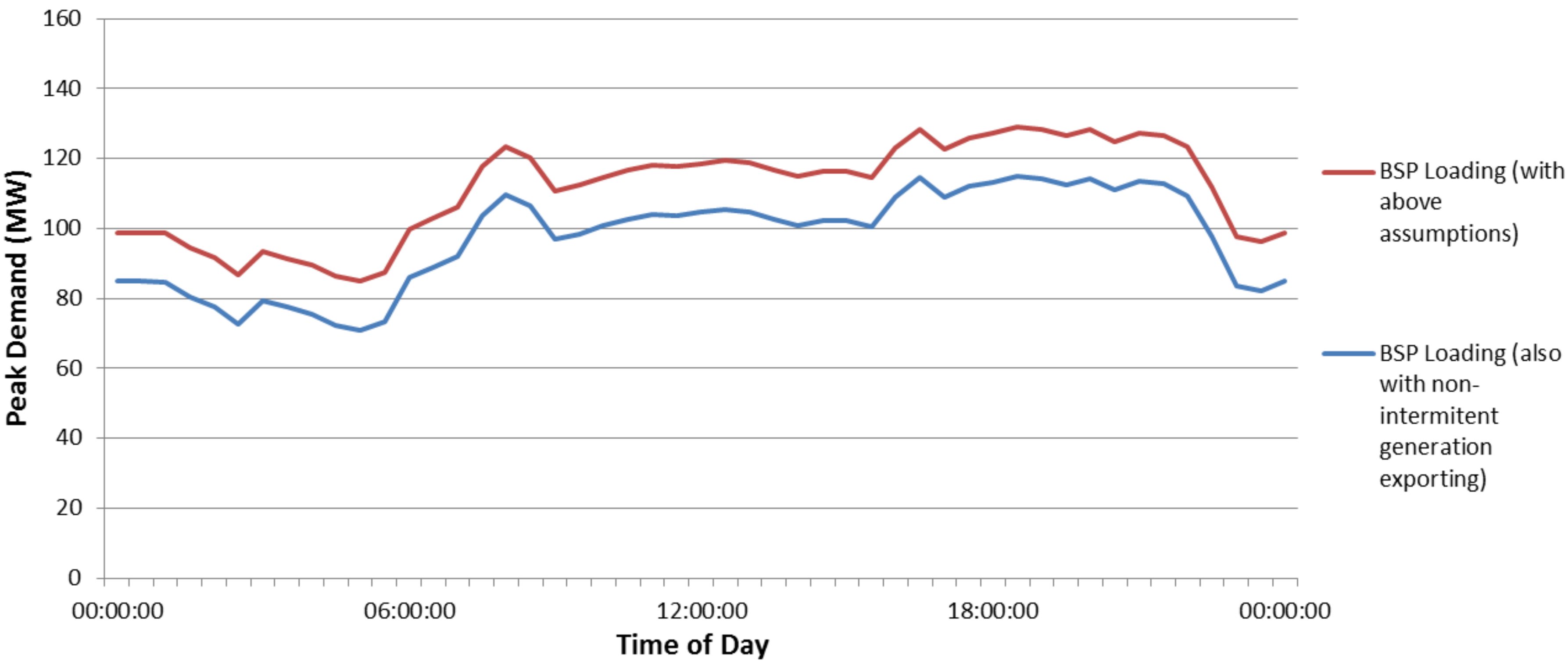
Non-Intermittent Generation



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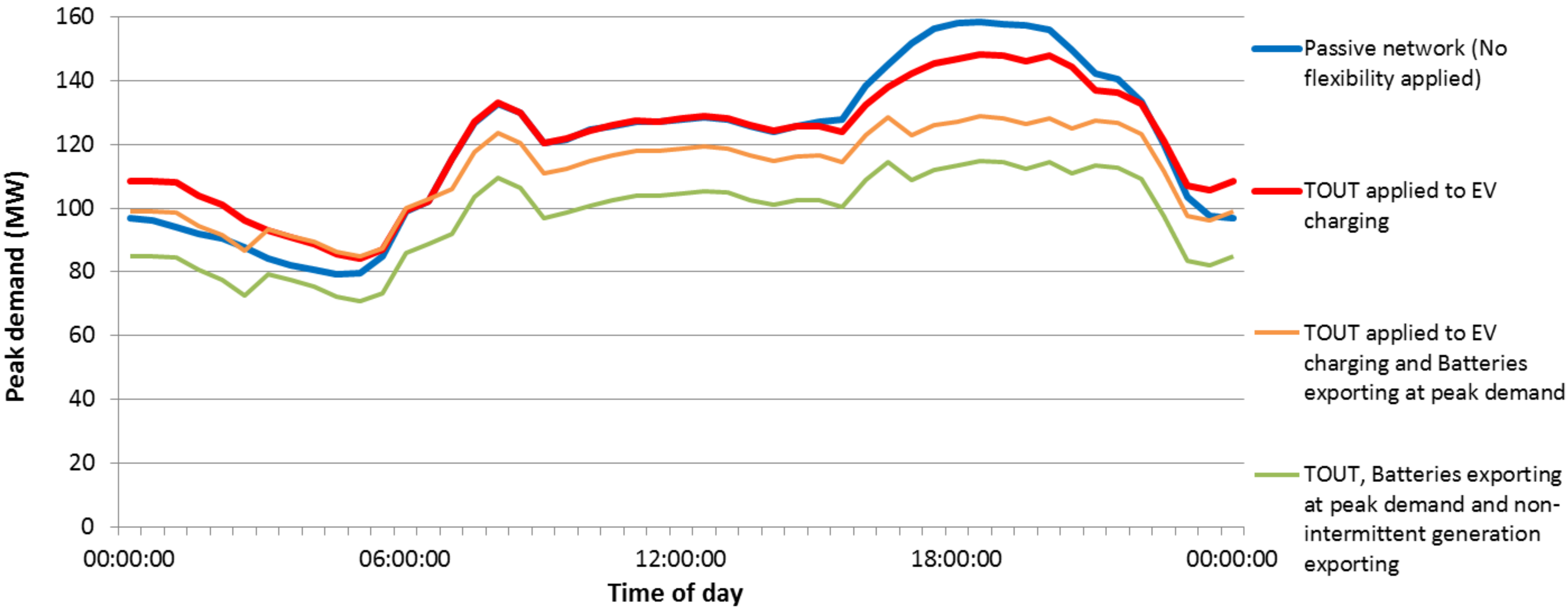
Impact on Peak Demand



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Network Impact

- Case Study BSP has two 45/90 MVA (ONAN/OFAF)
- Winter cyclic rating of 117 MVA
- Traditional network assumptions show reinforcement would be required
- Peak Demand in baseline is 98 MW
- Two Degrees 2030 without flexibility up to 158 MW
- Flexibility detailed in case study could reduce this to 118 MVA
- Other flexibility options could include Demand Side Response (DSR)
- There will be a limit where flexibility will not be sufficient to resolve technical issues such as:
  - Reduction in asset ratings due to a reduction in cyclic nature of load
  - Thermal overloads

Short Term Solutions

- Improved Demand and Generation forecasting
  - Including emerging technologies
- Better understanding of emerging technology operating regimes. Current and completed WPD innovation projects include:
  - **Electric Nation**
  - **Freedom**
  - **Demand Side Response (ENTIRE)**
- Currently signposting for flexibility
- Transition to time-series powerflow analysis

Future Challenges

- EV charging profiles for HGVs, LGVs, fleet vehicles and motorcycles
- Storage operating behaviours for different storage operating modes and markets
- Improvement of monitoring on the lower voltages
- Reassessment of how the changing load profile will affect existing cyclic ratings
- Limits of flexibility and the process to run a detailed CBA to determine the best time to reinforce
- Flexibility contractual arrangements

Fault Level Management

Clive Goodman, Network Strategy Engineer

Fault Level Management

2017 DSOF highlighted the impact on fault levels due to:

- The shift in the generation mix from large synchronous transmission connected generation to smaller scale non-synchronous units connected to the distribution system.

- Increase in generation using a power electronic converter interface producing lower fault currents compared to rotating machines

- Increase in average steady state fault levels on the distribution network

Fault levels need to be carefully managed to ensure safety, correct operation of protection schemes and provide a high level of power quality

Whole system short circuit levels

With the support of the Electricity Networks Association's Open Network Project a working group was set up between

nationalgridESO

SP ENERGY NETWORKS

electricity north west
Bringing energy to your door

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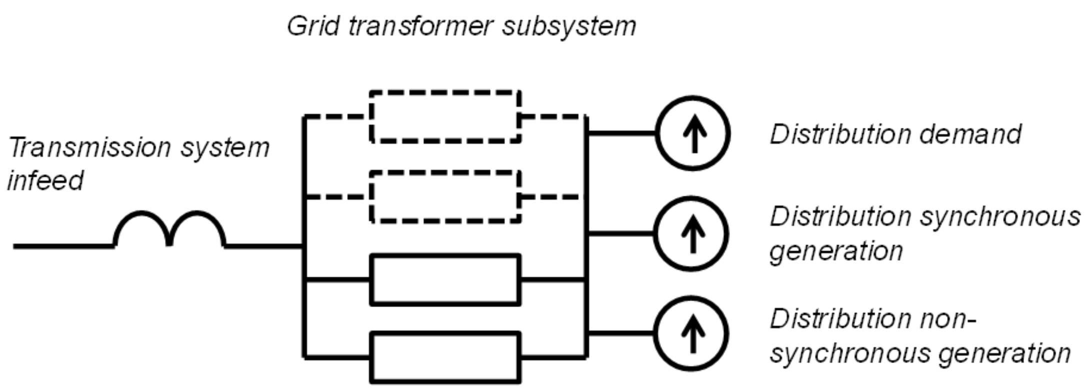
who in collaboration have investigated the impact of the decline in synchronous generation capacity in the transmission system and an increase in non-synchronous generation (eg. Wind & Solar PV) to the whole system

Network Issues

- Historically the Short Circuit Level (SCL) contribution to the distribution network has come from the transmission side
- Transmission system SCL predominantly from large synchronous generators
- Increase in non-synchronous generation will cause transmission system to operate at lower SCL more frequently
- Increase in distribution system connected generation will increase the contribution to SCL on the distribution system
- If SCL is too low or not sustained protection systems may not correctly operate

Methodology

4 Generic network configurations between transmission and distribution voltage levels (400/132, 275/33, 400/66 & 132/33kV) were considered using an impedance based model to calculate the variation in SCL over a year

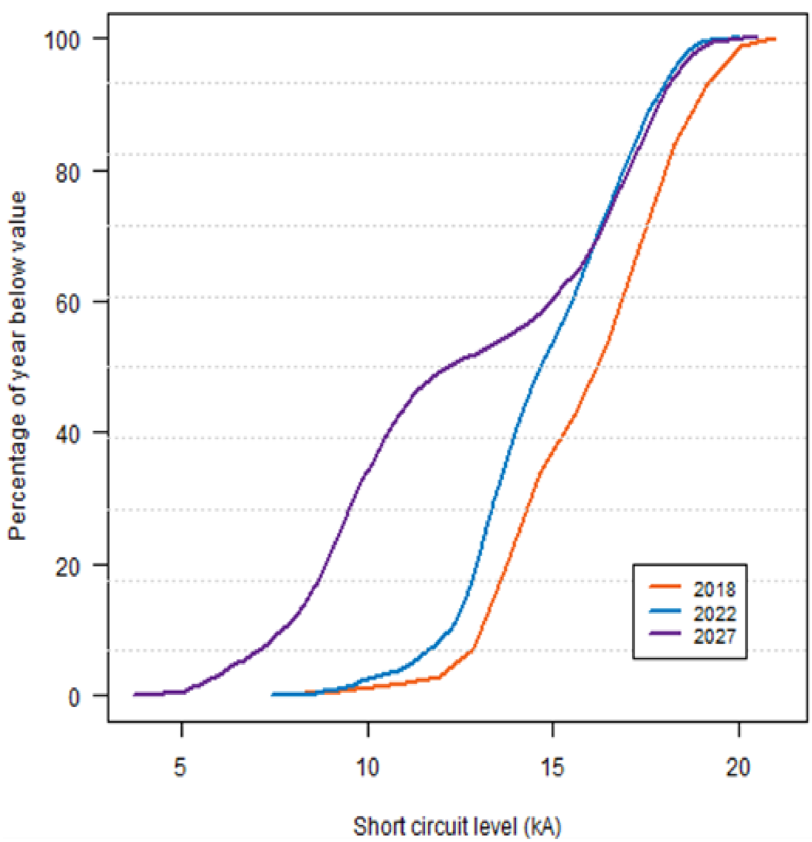


Inputs/Assumptions

Fault Infeeds:

- Transmission infeed (hourly) forecasts for 3 sample years 2018, 2022 & 2027 based on transmission generation & demand dispatch for sample area with high non-synchronous generation
- Demand 1pu per MVA on LV busbar
- Synchronous Generation 5pu per MVA on LV busbar
- Non-Synchronous Generation 0pu to 1.5pu per MVA on LV busbar

Transmission SCL Infeed

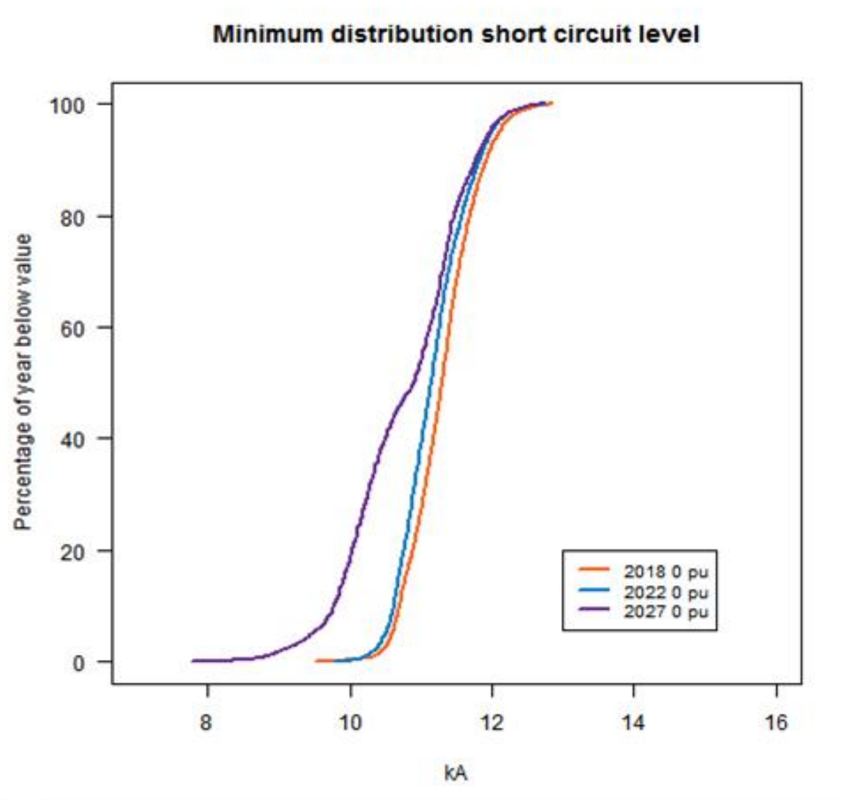


Transmission SCL declines over the next decade.

Wider variation in 2027 compared to 2018

Reduced SCLs for longer periods in 2027 compared to 2018

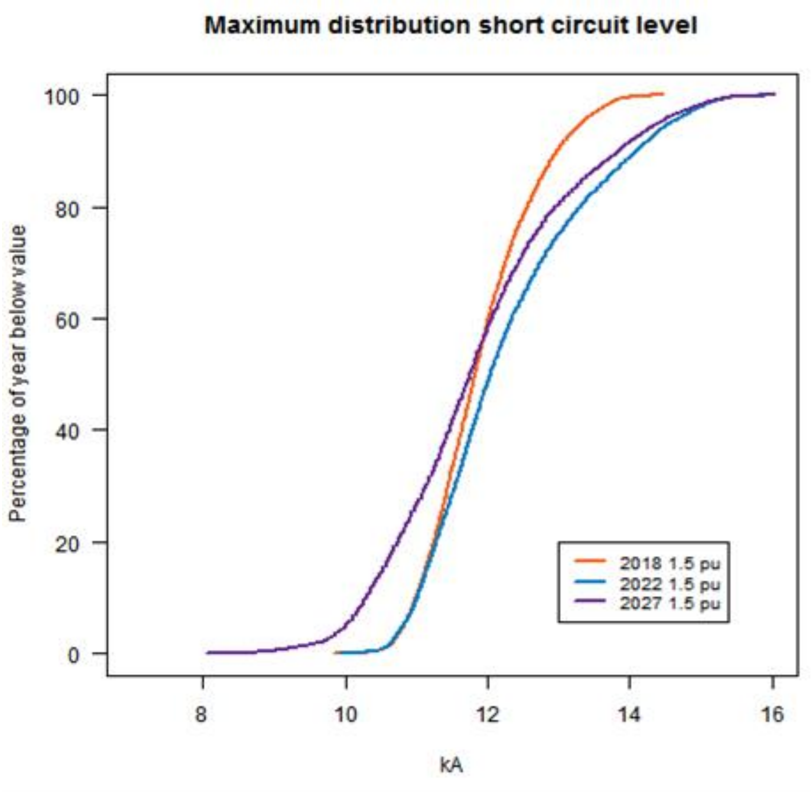
Impact of non-synchronous generation on minimum short circuit level at distribution level



Reduction in Minimum SCL in 2027 compared to 2018

Wider range of SCLs in 2027 compared to 2018

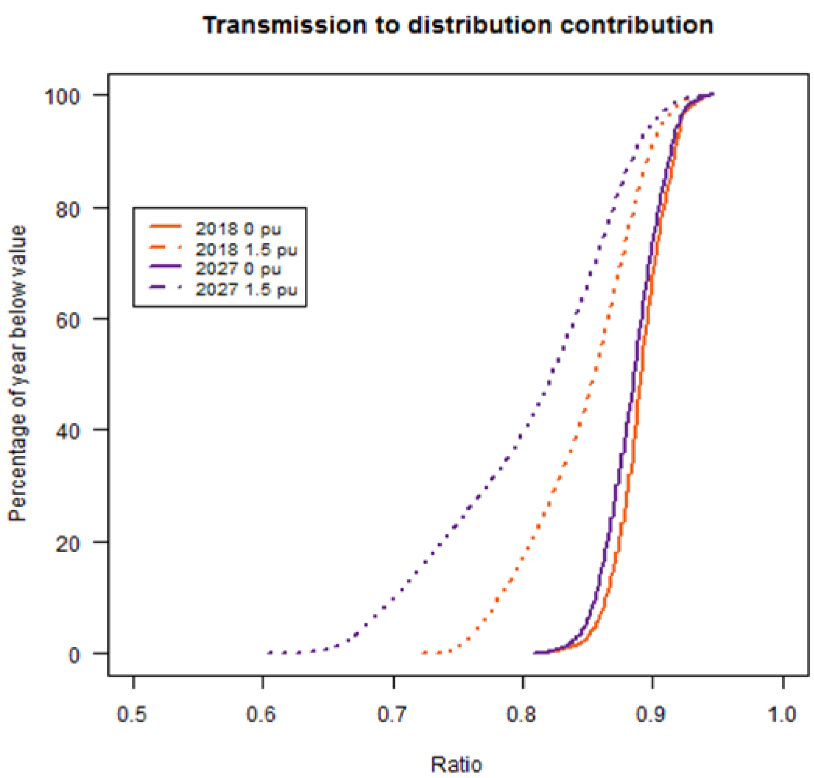
Impact of non-synchronous generation on maximum short circuit level at distribution level



Increase in Maximum SCL in 2027 compared to 2018

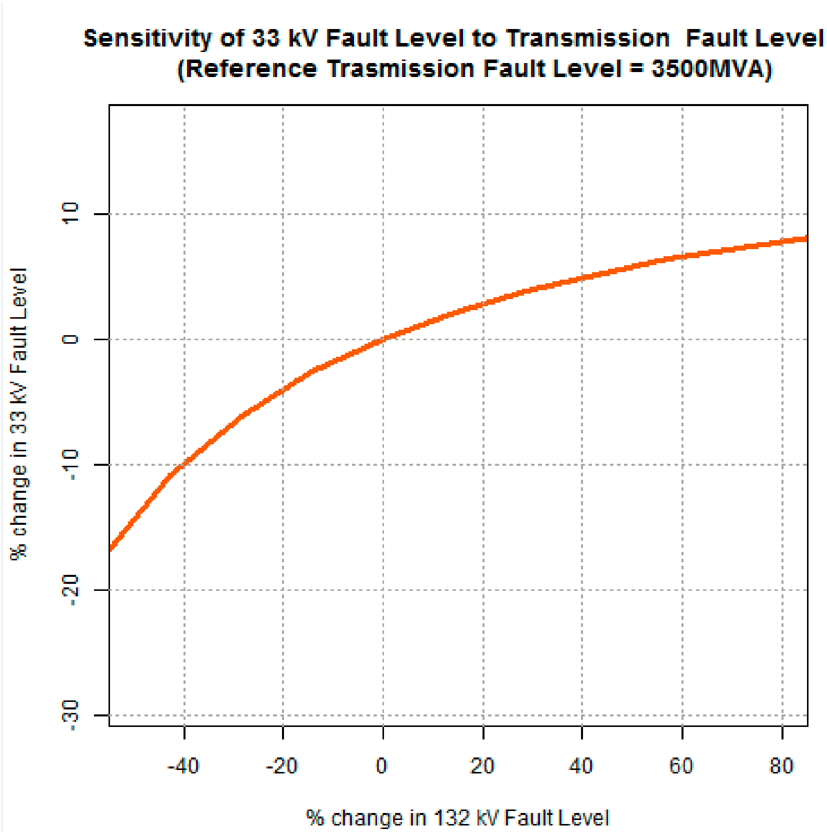
Wider range of SCLs in 2027 compared to 2018

Impact of transmission short circuit level on distribution network



Proportional contribution of transmission system towards distribution SCL is decreasing due to growth in distributed generation and decline in transmission fault levels

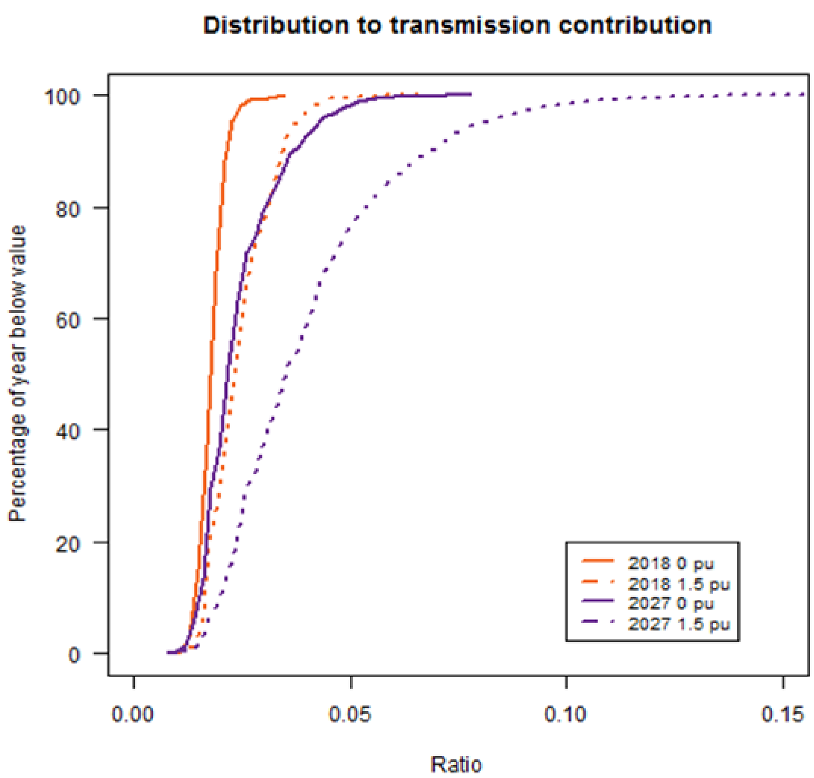
Distribution SCL Sensitivity



Decline in transmission upon distribution SCL is moderated by the impedance of the grid transformer

50% decrease in transmission SCL results in 15% decrease in distribution SCL

Impact of distribution short circuit level on transmission network



Growth in Distributed Generation increases the maximum fault level contribution from distribution to transmission

Growth in Demand and distributed generation will slightly increase fault infeed from the distribution network

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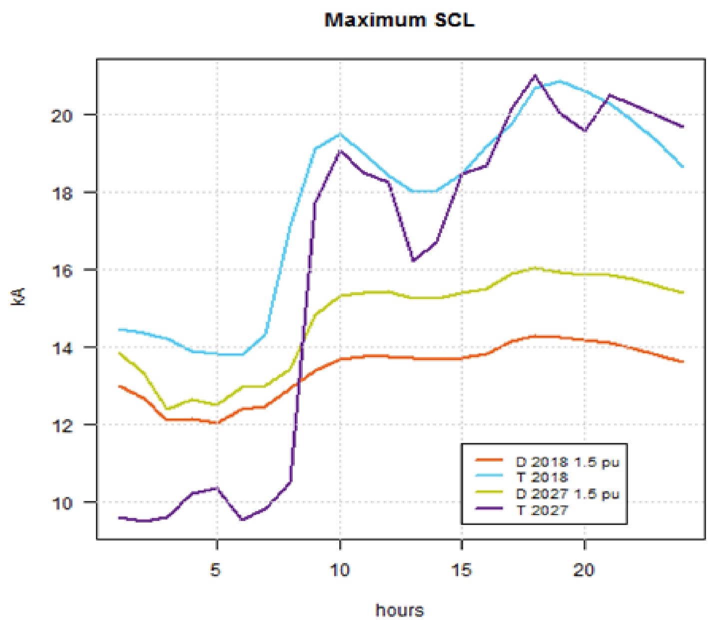
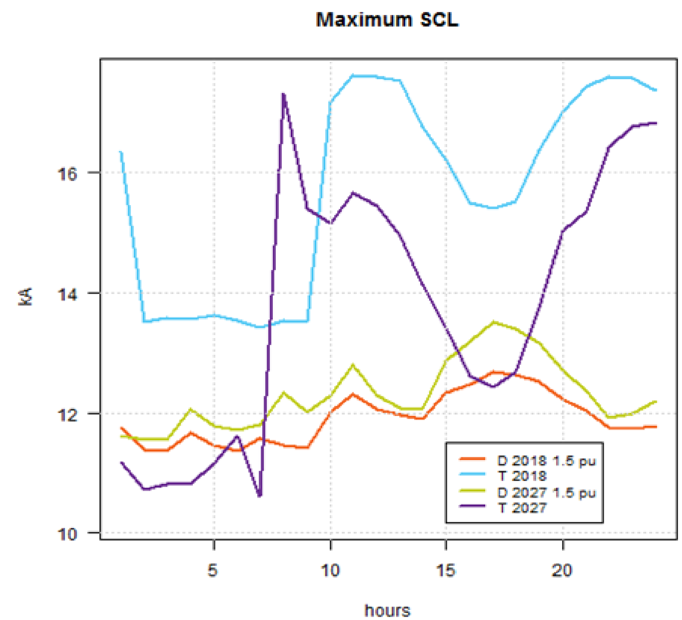
Seasonal variation in maximum SCL

Transmission SCL higher in winter compared to summer due to higher demand and transmission connected generation

Winter



Summer



Conclusions

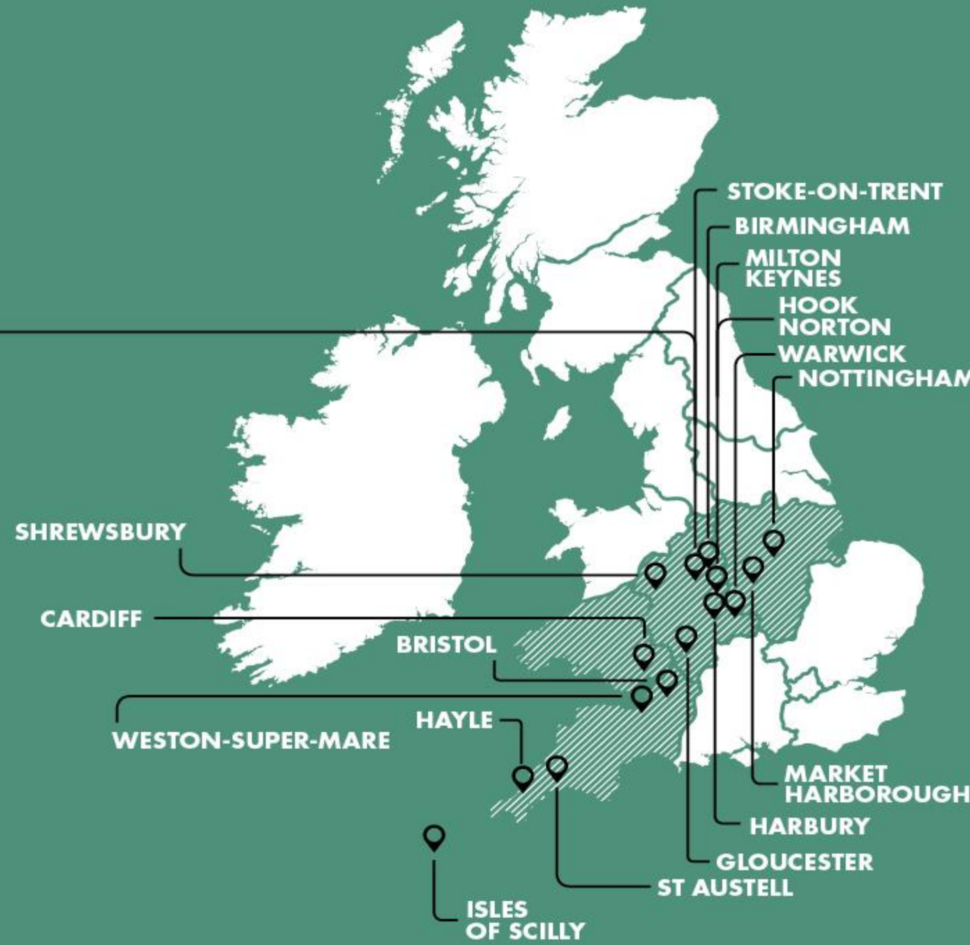
- Transmission fault levels in future years expected to stay at lower levels for longer periods
- Decline in Transmission fault levels will lead to a reduction in the minimum distribution fault level
- Increase in maximum distribution fault at times of peak demand due to growth in demand and distributed generation
- Decrease in the proportional contribution of transmission SCL towards maximum distribution SCL
- Minimal change in the proportional contribution of transmission SCL towards minimum distribution SCL
- Increase in the proportional contribution of distribution SCL towards maximum and minimum transmission SCL
- The variation of SCL within a day and within a year will require moving away from using a peak or average infeed value for analysis
- Existing inverter based technologies are not reliable in providing sustained levels of fault current and should be ignored for minimum SCL calculations

Future Considerations

- Distribution SCLs will become more important to the transmission system in the future
- Enhanced understanding of how transmission and distribution networks perform and interact in varying year round conditions (particularly minimum conditions)
- Existing industry guidelines focus on peak network conditions
- Need to improve and enhance standards to provide guidance on minimum network conditions.

WESTERN POWER DISTRIBUTION
INNOVATION

NEXT GENERATION NETWORKS



NIA Call 2019

Jonathan Berry
Innovation and Low Carbon Networks

Agenda

- ❑ Introduction
- ❑ Innovation Programme
- ❑ Update on NIA Call 2018
- ❑ Innovation Strategy and Future Challenges
- ❑ NIA Call 2019
  - ❑ Four Challenges
  - ❑ What are we looking for?
  - ❑ Timelines

WESTERN POWER DISTRIBUTION INNOVATION

WESTERN POWER DISTRIBUTION EFFS

WESTERN POWER DISTRIBUTION NETWORK EQUILIBRIUM

WESTERN POWER DISTRIBUTION OPEN LV

WESTERN POWER DISTRIBUTION SMART ENERGY ISLES

WESTERN POWER DISTRIBUTION PLUGS AND SOCKETS

Future Networks Programme

Assets

- Management of distribution assets
- Exploitation of asset & network information
- Developing Smart Grid Technology

Customers

- Distributed Generation
- Connecting Electric Vehicles
- Adopting Battery Storage
- Facilitating Flexibility

Operations

- Maintaining Reliability
- Strategic Forecasting
- Transitioning to DSO
- Operational Efficiency

Network and Customer Data

Network Improvements and System Operability

- Improved Statistical Ratings for OHL
- DEDUCE
- Primary Networks Power Quality Analysis
- Stochastic Load Flow
- LCT Detection
- Network Islanding
- Common Information Model
- Harmonic Mitigation
- Virtual STATCOM

Transition to a Low Carbon Future

- Virtual Telemetry
- Solar Storage
- LV Connect & Manage
- FREEDOM
- Electric Nation (formerly CarConnect)
- Industrial & Commercial Storage
- Hydrogen Heat & Fleet

New technologies and commercial evolution

- MVDC
- 5G Design
- OHL Director
- Entire
- LV Fault Location
- On-street EV Charging

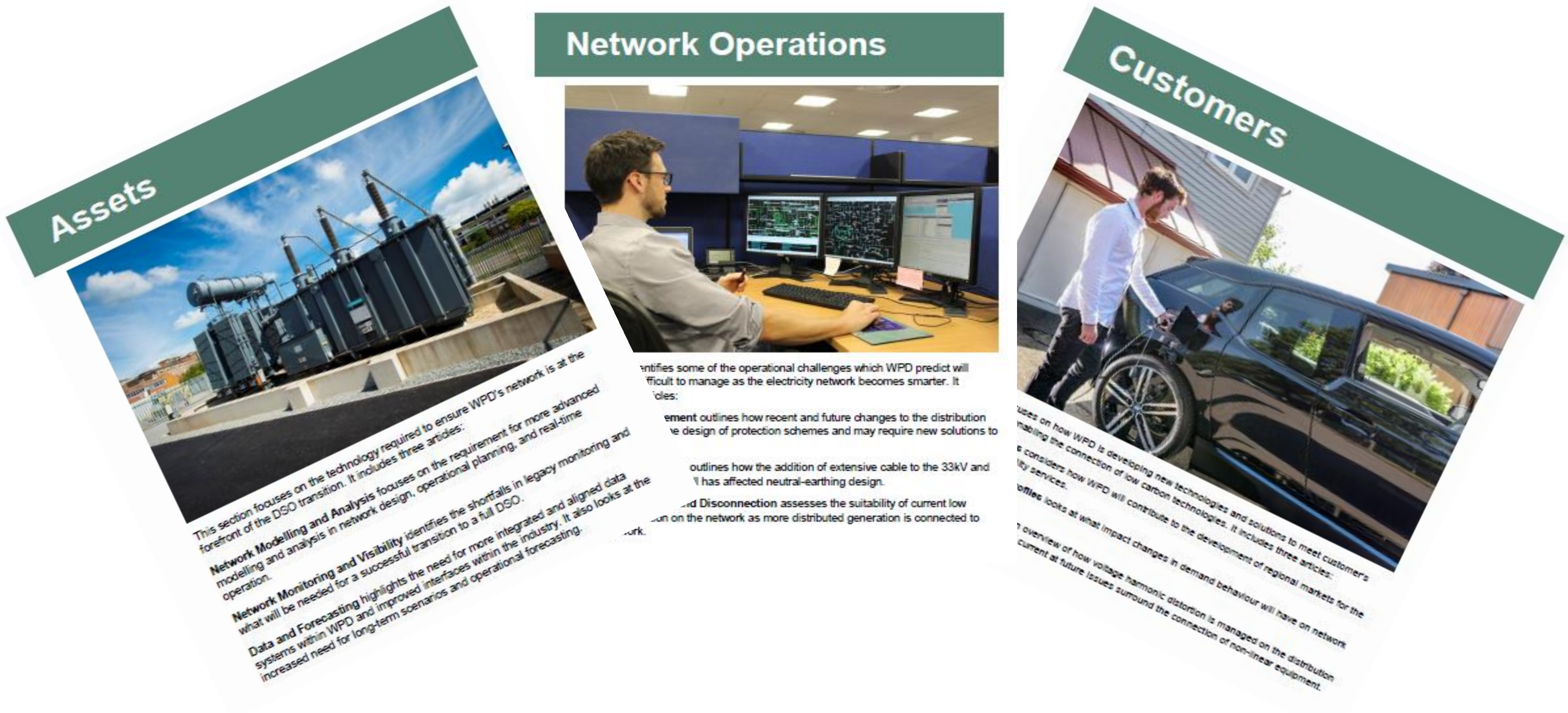
Customer and Stakeholder Focus

- Power Electronic FLM
- Power Electronic FCL
- Self System Design
- New Build Standards
- LCT Response
- Carbon Portal

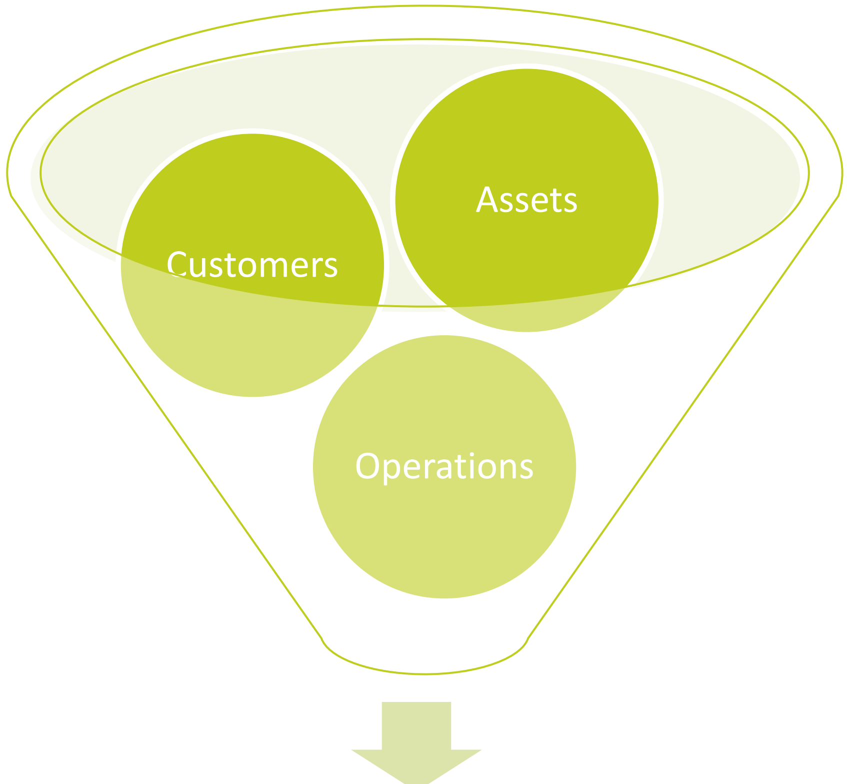
Safety, Health and Environment

- Simulated Training
- SF6 Alternatives
- Robot Trades
- LV Sensitive Earth Fault Protection
- Wildlife Protection
- Losses Investigation
- Advanced Vegetation Management
- Visual Data Processing

NIA Third Party Call - 2018

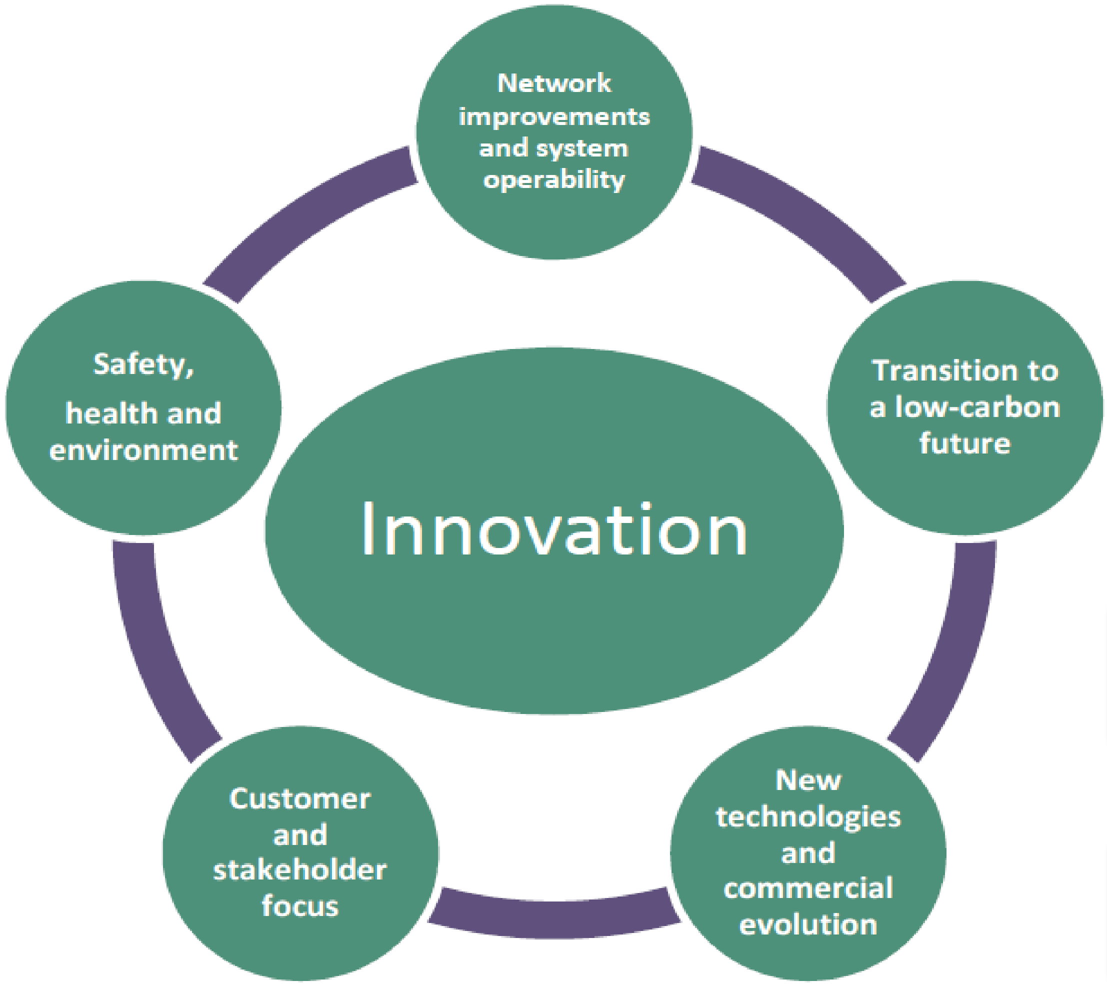


NIA Third Party Call - 2018



8 NIA Projects now live

Innovation Strategy and Future Challenges



WPD Innovation Strategy

ENA Innovation Strategy

Innovation Strategy and Future Challenges

Facilitate change

- Ensure resilience of the system under emergency conditions
- Enable real-time visibility of the LV network
- Develop solutions that interact with customers
- Improve flexibility services to customers with mutual benefit
- Coordinate the deployment of EV charging points
- Maximise benefits of network services provided by electric vehicles and storage
- Identify and counter internal and external cyber threats
- Use smart technologies to maximise capacity within the power system
- Make network information more readily available
- Development of safer and more efficient working practices

Now until 2019

Smarter Networks

- Develop forecasting methodologies for changing behavioural patterns and new technologies
- Develop asset inspection techniques that reduce manual workload
- Develop means to manage tighter capacity margins and develop market signals for new investment
- Effectively utilise all available data to counter potential threats to the system
- Provide aligned, financial incentives through innovative or flexible tariffs
- Facilitate new customer-focused products and services from suppliers

2019 to 2022

Whole System

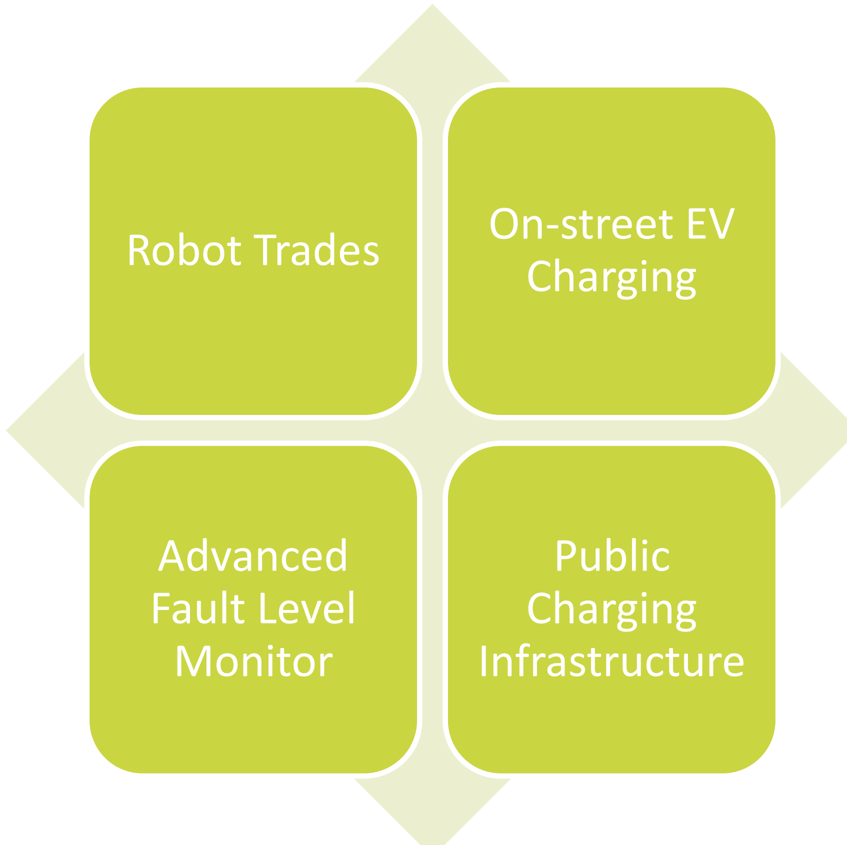
- Collaborate with other energy sectors (including gas, transport and heat) to optimise across multiple sites and vectors
- Expand planning and operational activities to incorporate heat, transport and gas
- Manage significant penetration of EVs and electrified heat
- Increase use of artificial intelligence to make decisions on a more dynamic network

2022 onwards

WESTERN POWER DISTRIBUTION
INNOVATION

NIA Call - 2019

- Focusses on four challenges



NIA Call - 2019

- Robot Trades

A large part of our business is centred on staff operating, maintaining and repairing our physical assets to ensure the supplies to customers is as reliable as possible. The repairing of faults and the physical locating of faults is often a time consuming and physical exercise.

This project will explore the capabilities of robots to identify faults on the LV network, expose the faulted cable and prepare the cable to be repaired. This will have benefits to both the safety of the operational staff from locating and exposing faulted assets and will also reduce the time taken for customers supplies to be reconnected.

NIA Call - 2019

- On-street EV Charging

As the proliferation of EVs continues the need for additional charging solutions will intensify. To date EV charging has centred on a car parking environment or within driveways of homes. A great number of the current housing stock does not have driveways and this project will investigate a solution to this challenge.

The solution will centre on the development of new or utilisation of existing, in a different format, technology to provide the dense power requirements of EV charging in a small form factor that makes it suitable and applicable for installation on pavements, grass verges etc. for the purpose of on-street charging.

NIA Call - 2019

- Advanced Fault Level Monitor

As the connection of distribution generation on the HV network continues to increase so too does the variability of the fault level on the system, which is currently difficult to understand in real-time.

Building on the developments of through the FlexDGrid project, where a mechanical FLM device was developed and tested, this project will focus on the use of power electronic technologies (or other) to develop a small form factor, accurate FLM, which can be quickly installed and is portable to be redeployable as the needs of the network change.

NIA Call - 2019

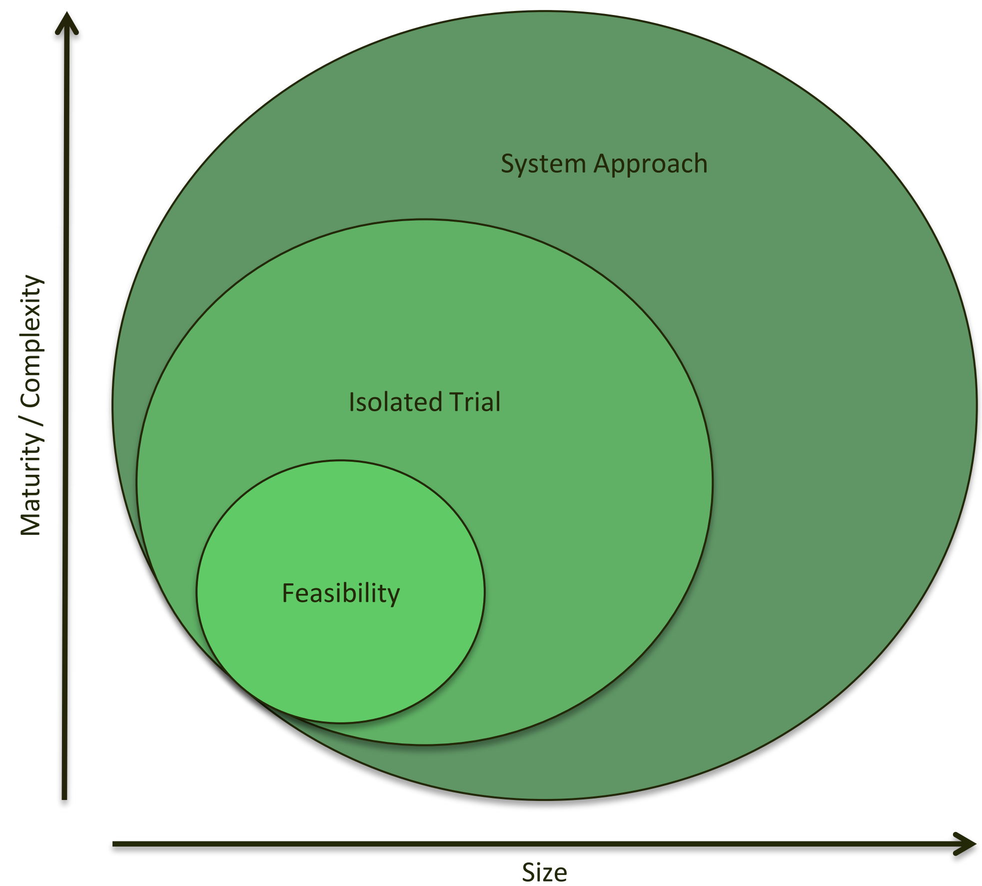
- Public Charging Infrastructure

The need for public transportation, such as buses and taxis, to transition to electric from traditional fuel sources means that dense public vehicle charging infrastructure is required.

How a large number of public vehicles are suitably charged in an area or areas of a town and city to facilitate the goals of moving to all-electric vehicles is to be explored. This project should consider the balance between infrastructure investment and charging models and mechanisms to optimise the investment and utilisation of assets.

What are we looking for?

- Looking for a range of projects covering the areas and themes



WESTERN POWER DISTRIBUTION INNOVATION

Conclusion

- Clear and defined projects (not concepts or boxes)
- Identified deliverables, outputs and outcomes
- Capability and capacity to manage and deliver

Submissions due by 1st March via Google Form

Click to go to Google Form

Any Questions?

Further Collaboration

All our reports, webinars and presentations are published online at:
http://www.westernpower.co.uk/netstrat

If you have any questions in relation to WPD’s Network Strategy work, please contact WPD on the details below:

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WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales