Power Potential

Final Showcase

Thursday 24 June 2021

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Agenda

12:30	Welcome	Julian Leslie and Barry Hatton
12:40	Reflections on Power Potential	Dame Fiona Woolf
12:45	Power Potential learning and insights	
	• Why Power Potential (5 min)	Dr Biljana Stojkovska
	• Recap of the project (5 min)	Dr Rita Shaw
	• Key Learnings	
	○ Technical (10 min)	Dr Rita Shaw and Dr Biljana Stojkovska
	○ Commercial (10 min)	David Preston and Dr Biljana Stojkovska
	○ System (10 min)	Dr Rita Shaw
13:30	Q&A	Project team
14:00	Looking forward	Dr Biljana Stojkovska, Dr Rita Shaw
14:10	Conclusion	Project team
14:15	Event close	

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Welcome

Chair
Julian Leslie
Head of Networks
National Grid ESO

Barry Hatton
Director of Asset Management
UK Power Networks

Dame Fiona Woolf
Chair of Power Potential's
Regional Market Advisory Panel

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Reflections on Power Potential

Dame Fiona Woolf DBE, DL

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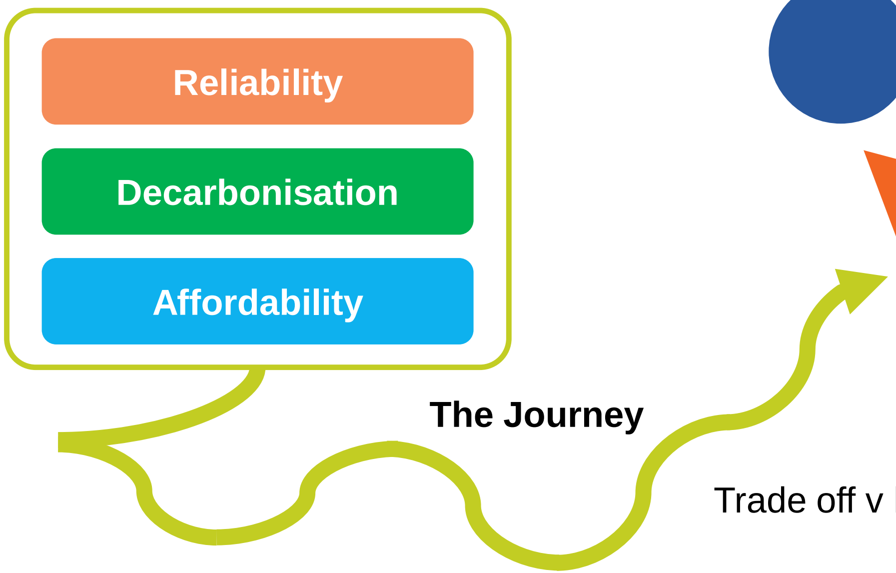
The “Trilemma” of electricity market design

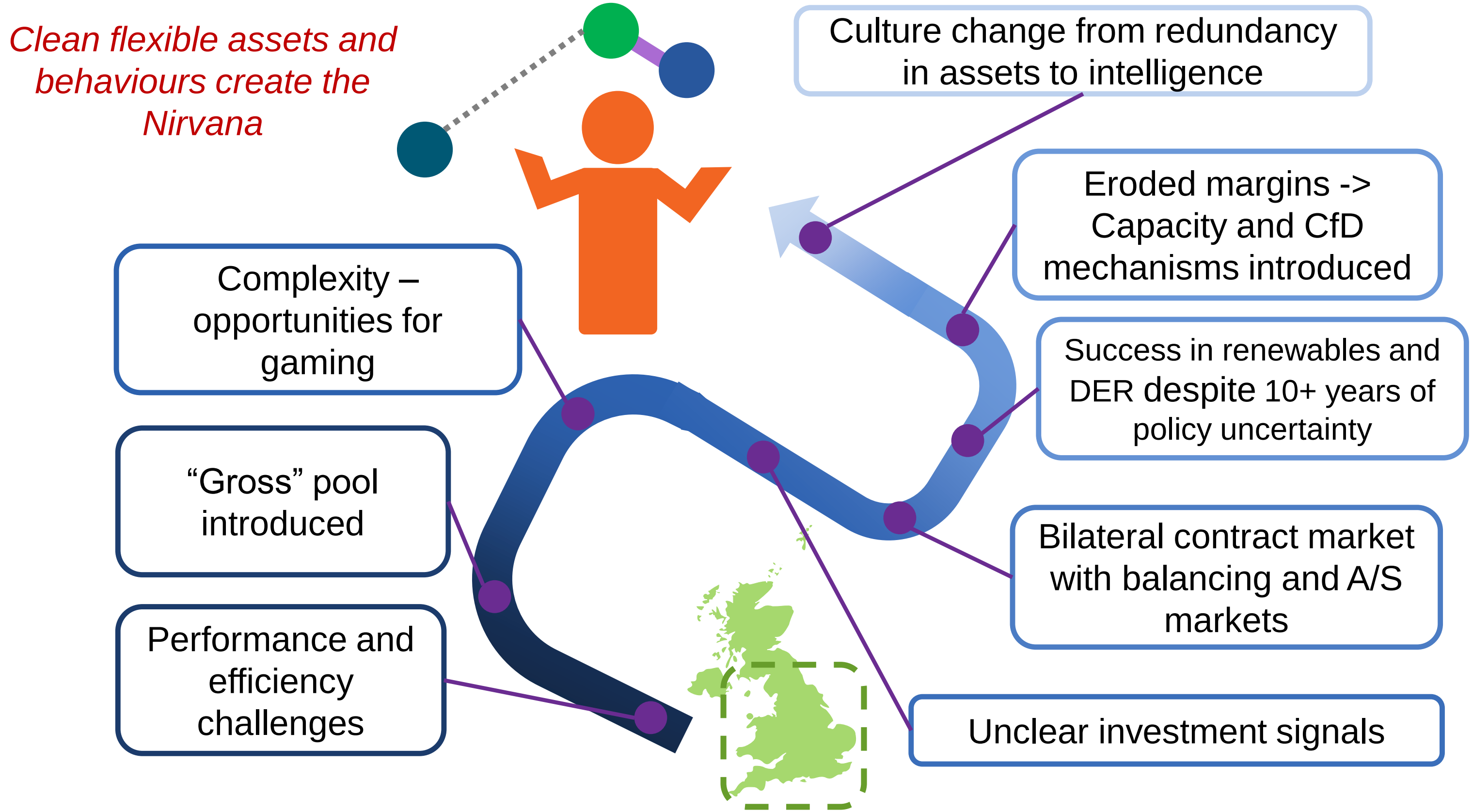
The “Trilemma”
Simultaneously juggling
three competing objectives:



Achieving the “Nirvana”
of market objectives

Trade off v keeping all balls in the air

The long and winding road to Nirvana in England & Wales



Power Potential Unwrapped

- The Power Potential project was a world first trial in using Distributed Energy Resources (DER) in distribution networks to provide dynamic voltage control to the transmission system – a combined technical, commercial and business solution
- Technical – it provides reactive power for system voltage support and active power support for constraint management and system balancing
- Commercial – it creates a new regional reactive power market from DERs
- Business – involves the creation of a Distribution System Operator (DSO) model
- A whole-system approach can be beneficial for everyone from network operators to generators to end consumers – proof of concept trial
- On the path to cleaner, smarter flexibility

Culture change - lessons learned

- Collaboration between companies with different functions and backgrounds is key
- Each network is different
- Innovation has to be tempered with keeping the lights on
- Exploring the individual needs of potential participants is fundamental
- Software development can be a headache (issues such as cyber security, confidentiality and access to data are a hidden complexity)
- Network reinforcement may be deferred rather than avoided , but keeping the options open has value
- Trials of a market-based solution does not automatically guarantee success or its application to other aspects of the electricity supply chain but it is worth doing for the learning

Using what is in the store cupboard

The Pantry of Design *Ingredients*

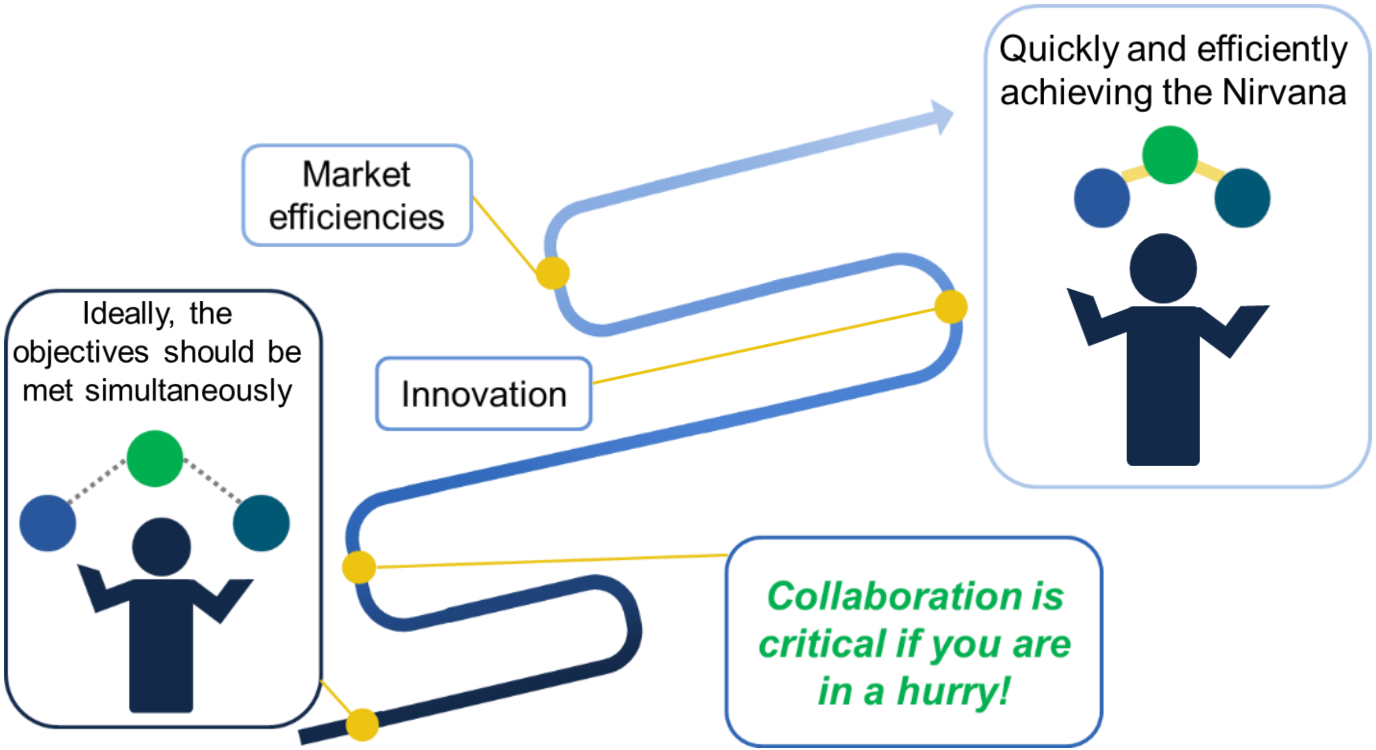
Each market should judiciously form design ingredients into a recipe based on their unique circumstances…

versus

The Bookshelf of Design *Cookbooks*

…rather than mix incompatible design ingredients from different recipes

Collaboration is the name of the game



Why Power Potential?

Dr Biljana Stojkovska
Power Potential Lead
National Grid ESO

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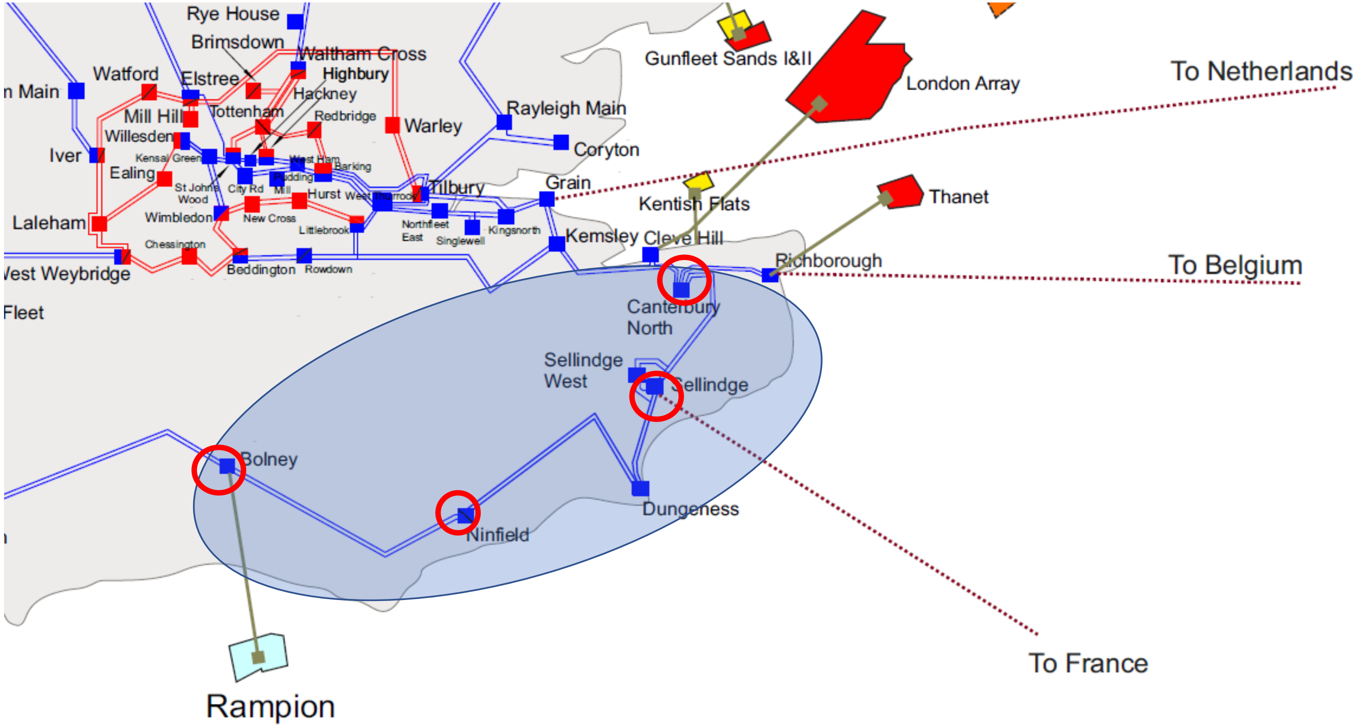
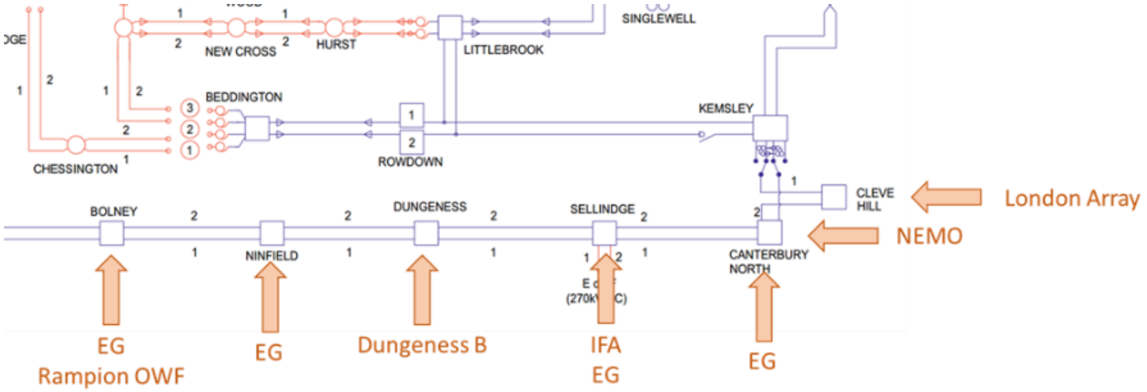
Power Potential Unwrapped

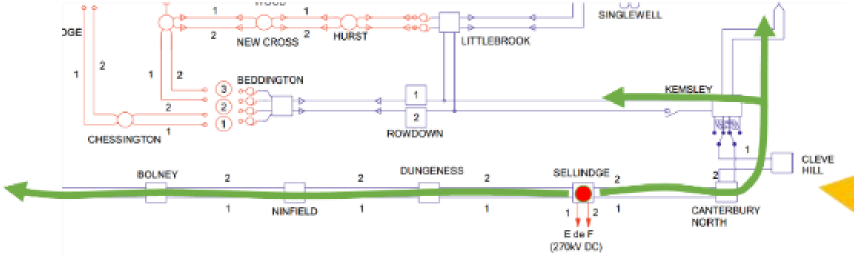
- A world first trial to provide dynamic voltage control to transmission
- Identifying new and flexible resources
- A whole-system approach is beneficial for everyone

Power Potential Trial Region

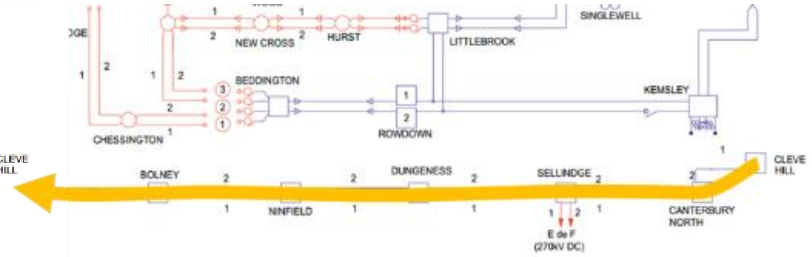


Why Power Potential?



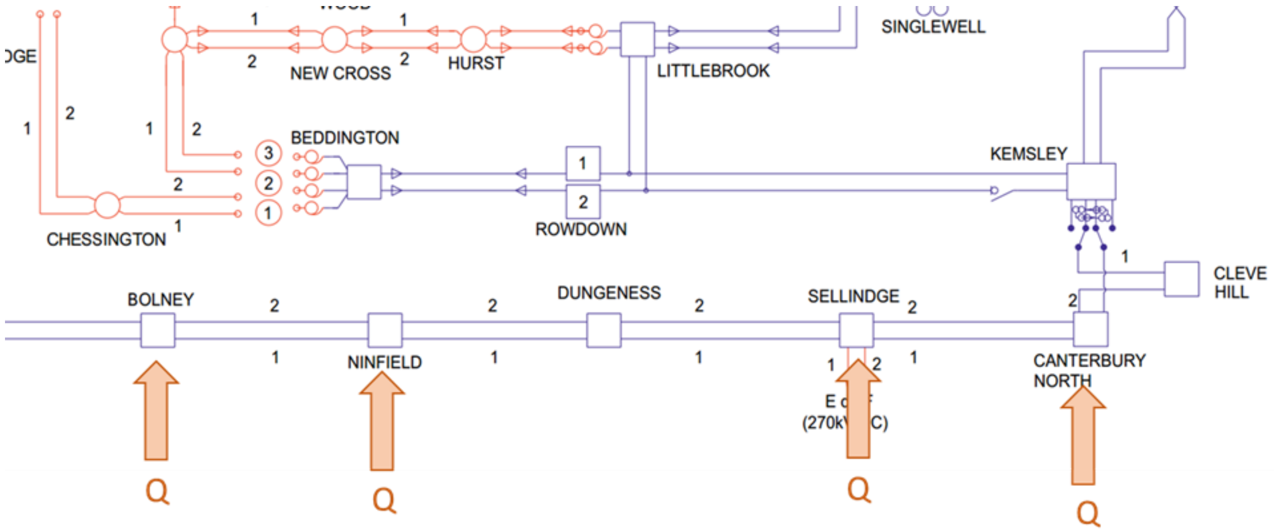


Intact system



Contingency system

The How



1. **Technical solution**
   - Dynamic voltage control from DER
   - MW re-dispatch for constraint management and balancing
2. **Commercial solution**
   - Establishing new reactive power market from DER

Project

Recap

Dr Rita Shaw

Power Potential Lead

UK Power Networks

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Power Potential to *Power Provided*

- Created a live DERMS
- Integrated with DER and operational Distribution and Transmission
- 5 DER: 1 solar, 2 battery, 2 wind
- 30 users accessed DERMS
- Reflected effectiveness at Grid Supply Points
- Kept distribution network secure

Distributed Energy Resources Management System (DERMS)

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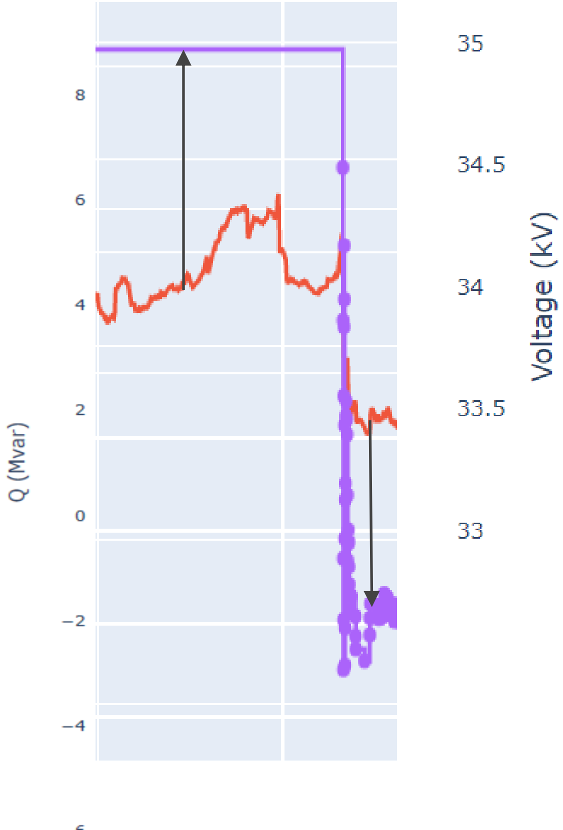
How DERMS manages each DER in voltage control

DERMS instructs a DER into voltage control mode, then issues voltage setpoints for service



$V_{setpoint}$ sent to DER

Measured V_{local}

Voltage difference

-> reactive power output at DER @4% of rating

DERMS' request at DER based on ESO's request at the Grid Supply Point

Live demonstration

Collective NGESO-UKPN-DER

Per DER

Pre-requisites

Commissioning

Capability Test

Mandatory Trial

Wave 1
Technical trials

Demonstrated concept

Ran end-to-end system, 8 weeks 24/7

Response following change in measured transmission voltage and set point

DER received fee based on number of hours available

Wave 2
Market trials

Applied Wave 1 learning
Enabled competitive bids

Daily auctions, 1772 hours

Bids presented to ESO reflecting DER effectiveness

DER paid based on day-ahead accepted price and delivered service

Power Potential delivered

- Delivered by staged approach, commitment, flexibility
- Overcame significant challenges and adapted, including COVID-19 restrictions
- Identified route to Business As Usual development and application
- Trial supported by NGESO, UK Power Networks, DER teams and ZIV Automation

World-first regional reactive power market

Principles of T & D operators enabling DER to deliver dynamic voltage control for transmission, integrated operationally

Co-ordinated DSO dispatch for ESO of MW and Mvar from a DER

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Technical Learning

Dr Rita Shaw and
Dr Biljana Stojkovska

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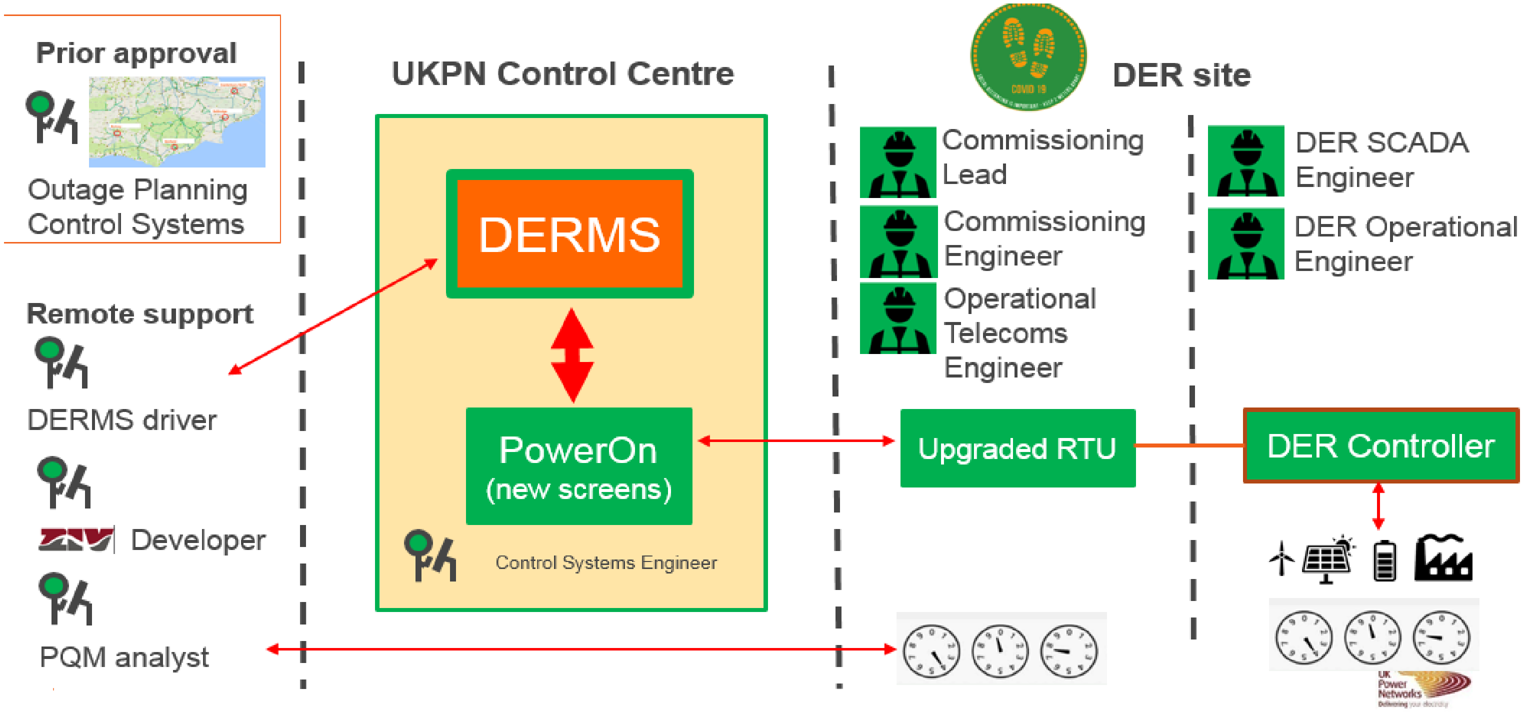
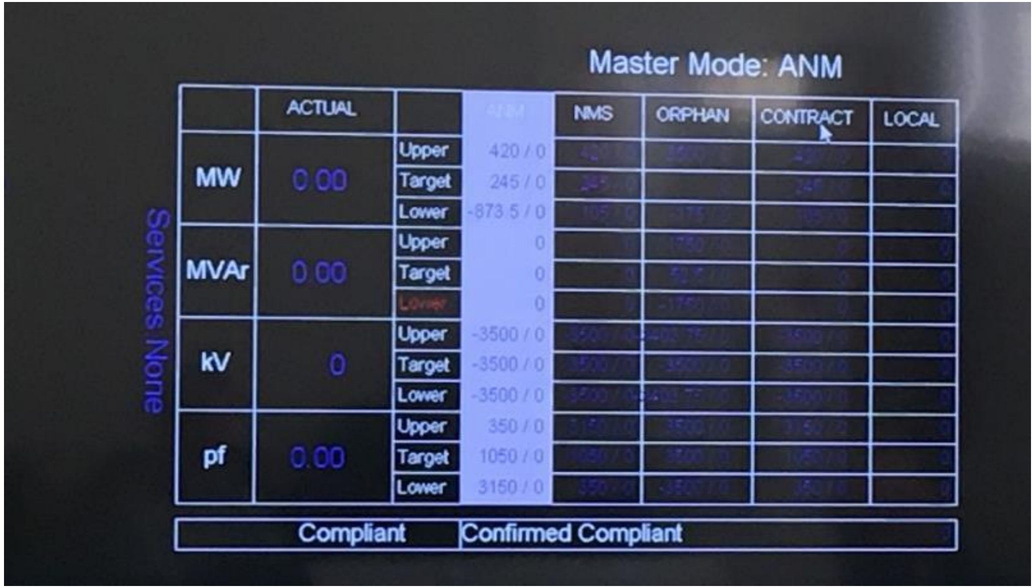
DER commissioning – procedures created for site and Control



Control Engineer Visibility on PowerOn



Remote Terminal Unit mimic

Technical learning about enabling DER service

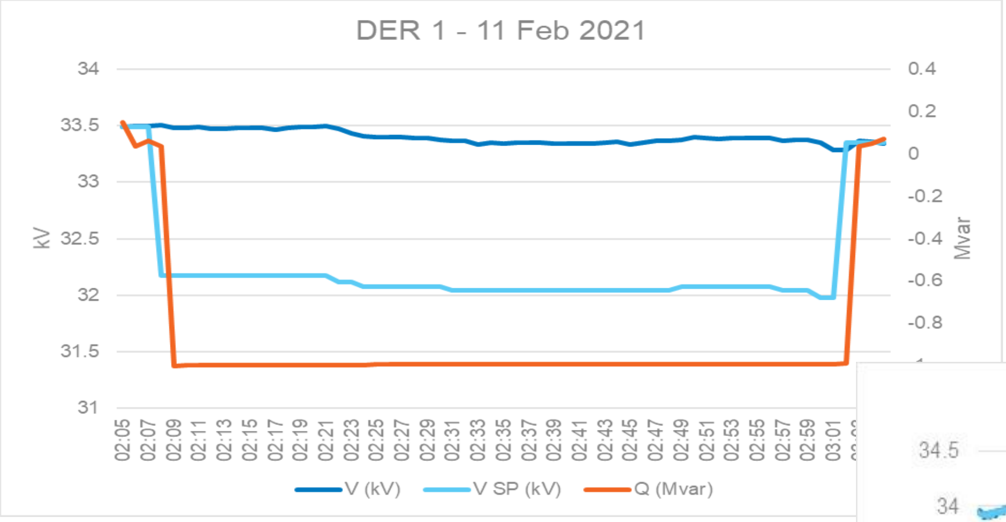
Project team

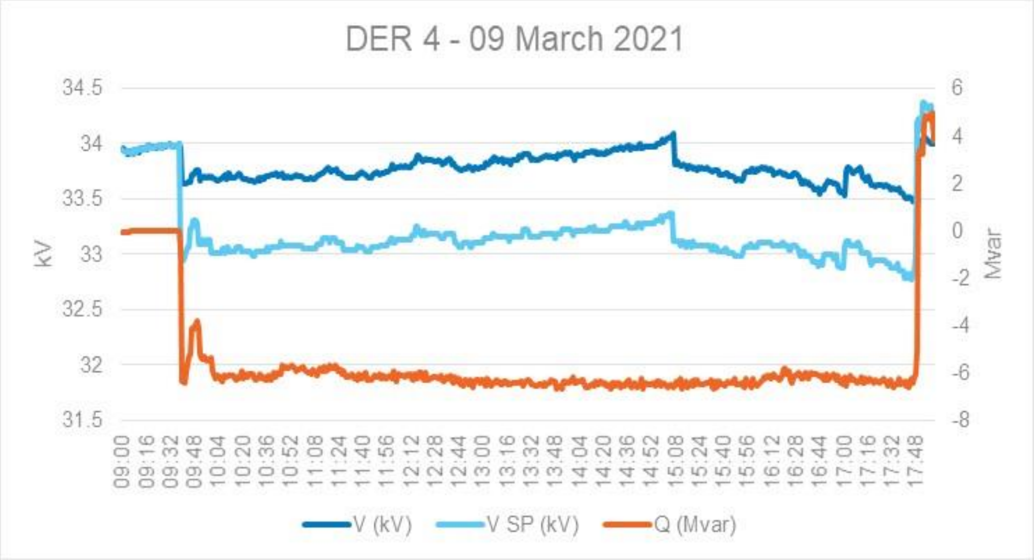
- Integration, delivery, operation of the systems and processes

Participating DER

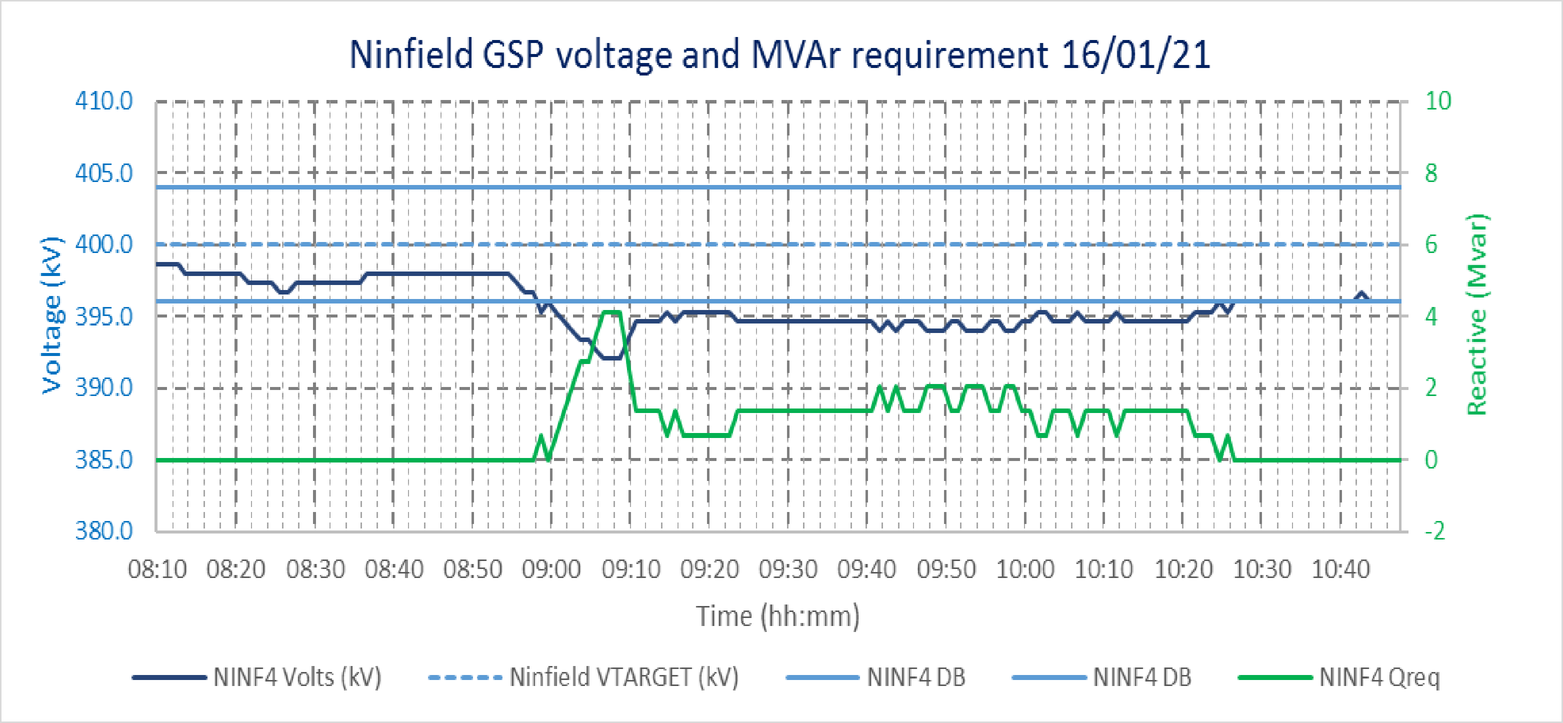
- Operation in voltage droop control – changes to inverters, warranties with their suppliers
- Adapting controllers for fast response – challenge to achieve Mvar range in 2-5s
- Interfacing with distribution network control
- Delivery alongside their other services, and active power service

Examples of initial DER response then steady delivery

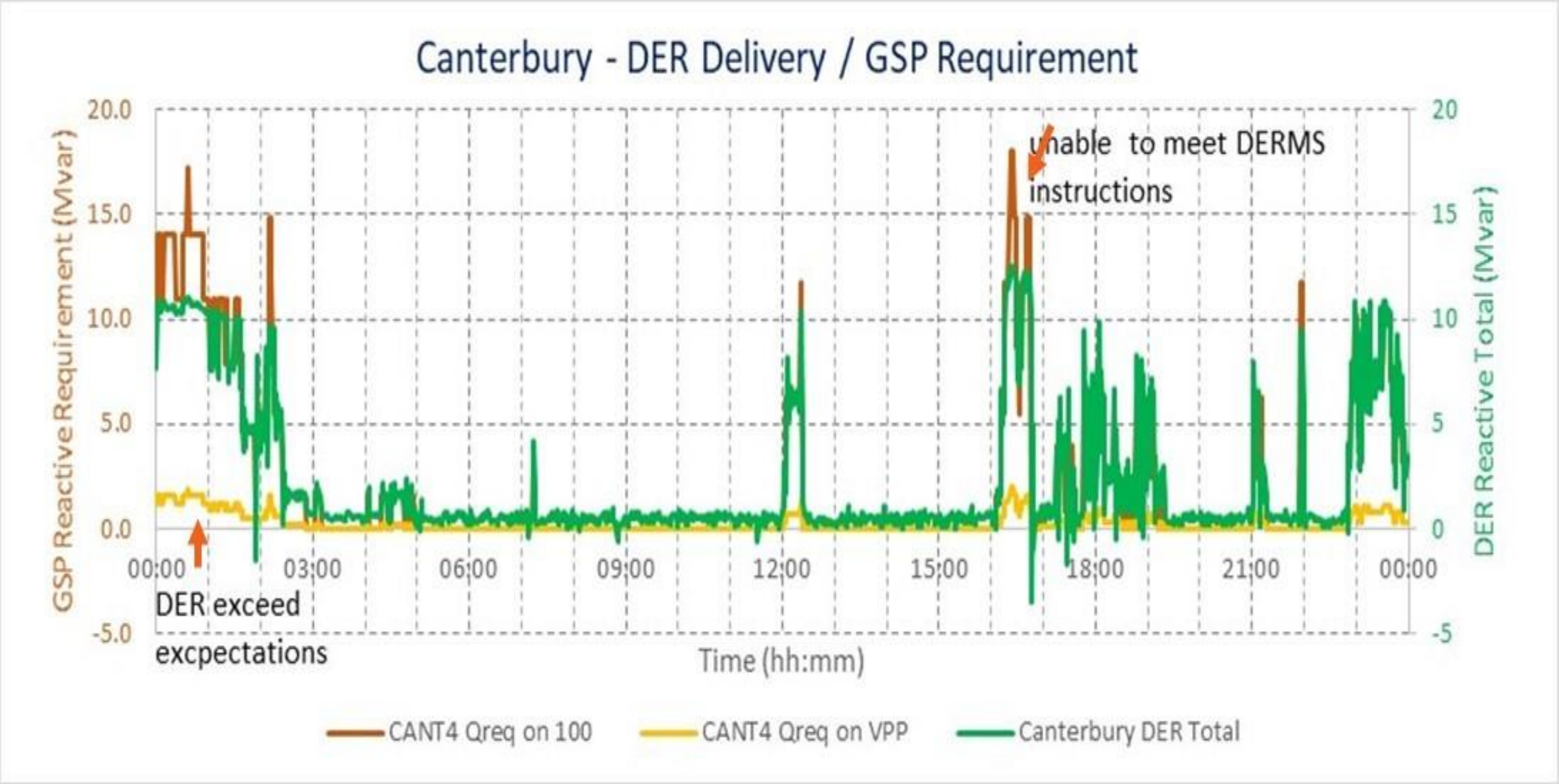




Calculation of expected reactive power delivery by VPP



Expected vs required reactive power delivery by VPP



Solutions to achieve a proportional response from DER

- Virtual Power Plant (VPP) reaches a maximum delivery for a very small 0.3% fall in GSP voltage rather than a 4% fall in GSP voltage
- Hence there is no capability left to secure a post-fault fall in system voltage and there is no proportional service response
- The issue is that the current DERMS design assumes a nominal 100Mvar ‘Q’ base at the GSP, so the DER is unable to deliver for larger voltage changes
- Potential DERMS changes in post-trials:
  - Auto/manual function to allow for either manual configuration of the Q Base by the user or
  - Capability for DERMS to automatically calculate Q Base

Simultaneous Active and Reactive Power Dispatch

- DER can successfully simultaneously deliver active and reactive power
- 2 DER took part: difficult to draw wide conclusions

  - Importance of configuration of the DER controller
  - Expected Operating Level (EOL) could lead to unexpected delivery
  - Reactive power service was prioritised over active power for one DER
  - No significant conflicts with Firm Frequency Response (FFR) and Enhanced Frequency Response (EFR) markets

Commercial Learning

David Preston and
Dr Biljana Stojkovska
National Grid ESO

UK Power Networks
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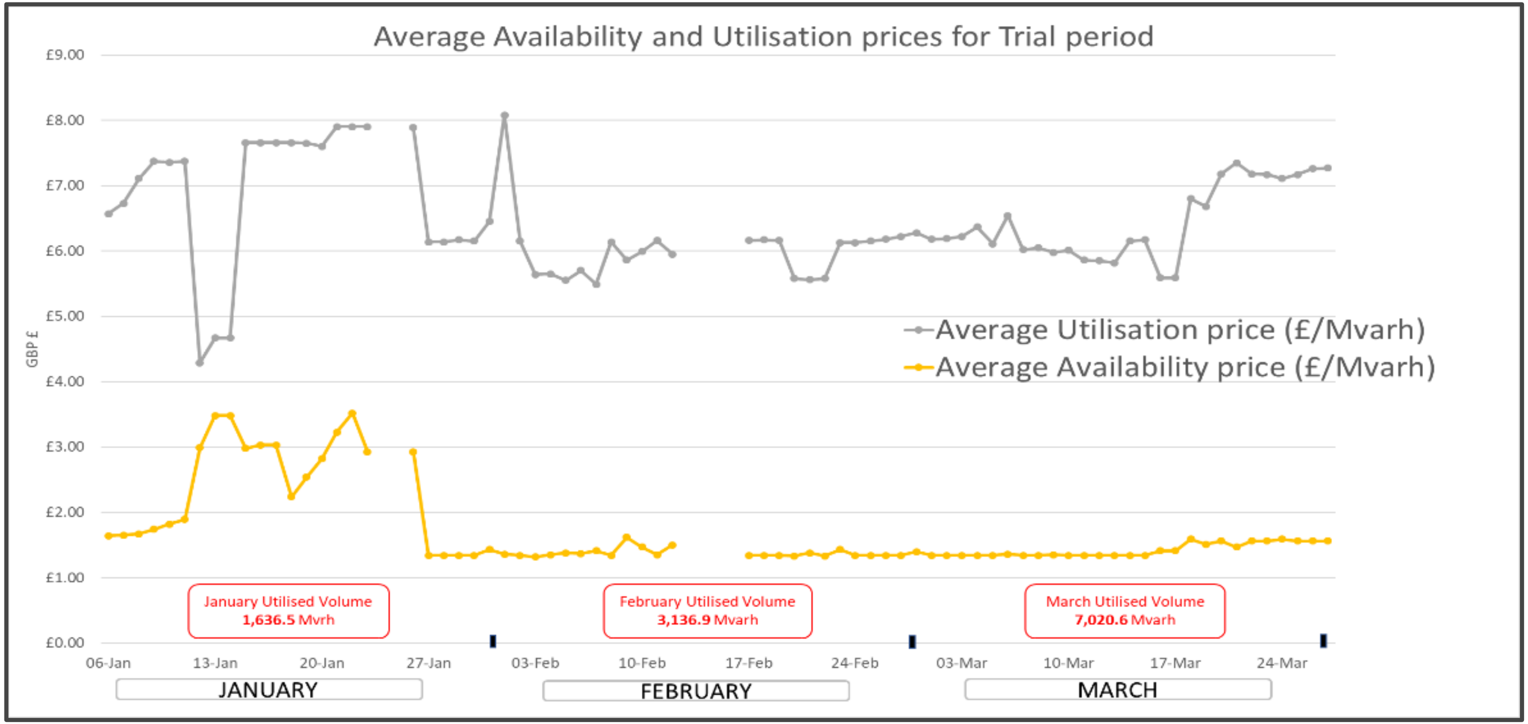
Power Potential – Commercial trial

Outlines the aims and objectives of the commercial trial (wave 2) with the key areas / elements and processes within

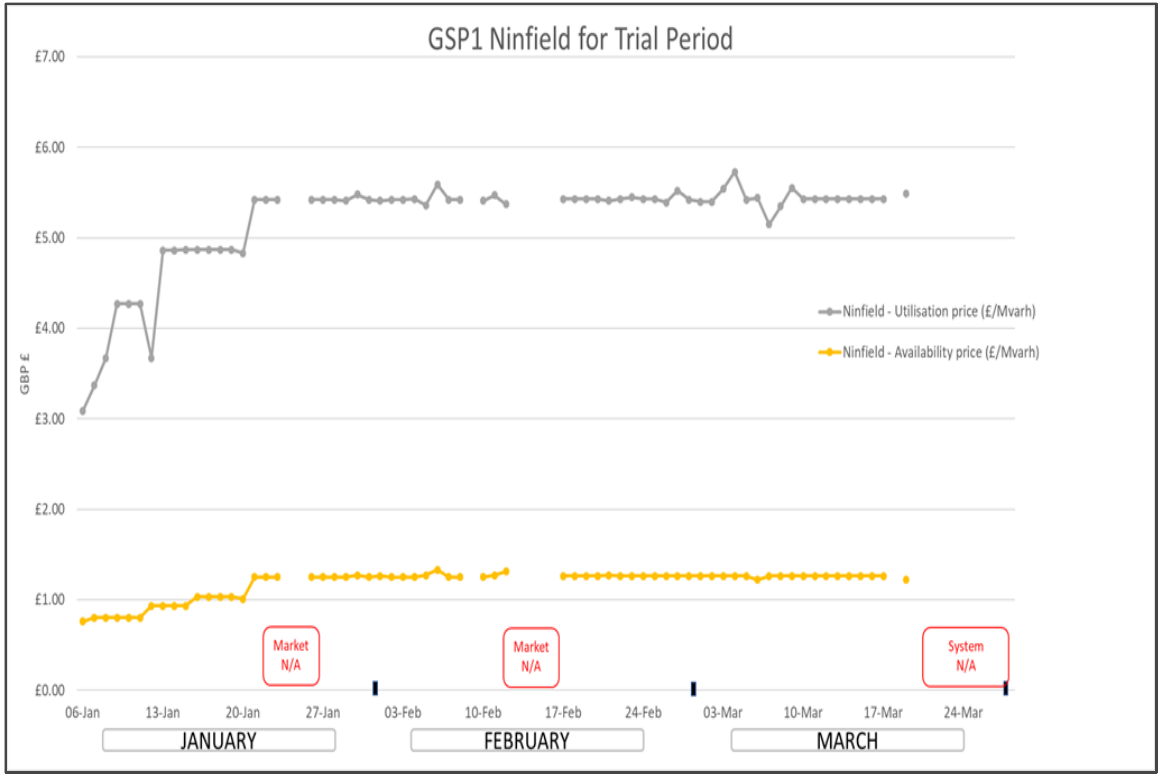
Aims and Objectives	Competitive bidding among participants, to facilitate “price discovery” from DER, within the limitations of the trial budget, allowing DER to freely bid both utilisation and availability prices.
Duration & Participation levels	5th January – 28th March, with 4 participants (solar, battery, wind x 2), representing 3 VPPs (Bolney, Ninfield & Canterbury North). DER had opportunity to bid for and potentially provide a service in a total of 1,772 operational market hours.
DERMS	DER utilise the DERMS Web Interface to submit their Power Potential bids be informed of acceptance or rejection – with the reason why.
Assessment and Nomination	Nominations for service provision were made with the aim of accepting the most economic VPPs whilst operating within the budgetary constraints.
Service Delivery	Based on the results of the auction DER expected to make the unit available and respond to voltage set point instructions.
Market Reporting	Weekly report providing an aggregated view of data relevant for trial participants to support the auction process.
Settlements	Monthly settlement process among NGESO – UK Power Networks and DER.

Wave 2 Trial Results – Summary

Weekly accepted availability and utilisation prices across the 3 VPPs for the trial period and volumes utilised for each month.



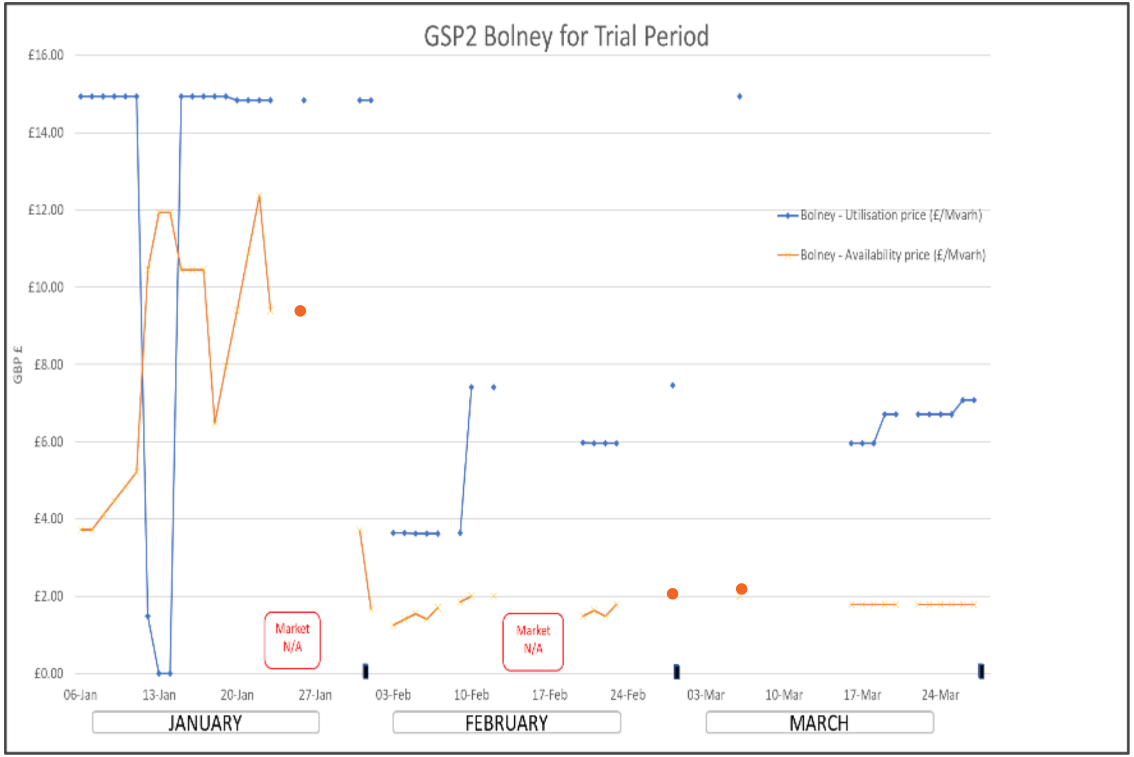
Wave 2 Trial Results – Ninfield



GSP 1 – Ninfield (Solar & Wind)

- Average accepted availability price **£1.18** /Mvar/h
- Average accepted utilisation price **£4.17 /**Mvarh
- Volume utilised **5453** Mvar
- Service hours accepted **1508**
- Days not procured **10**

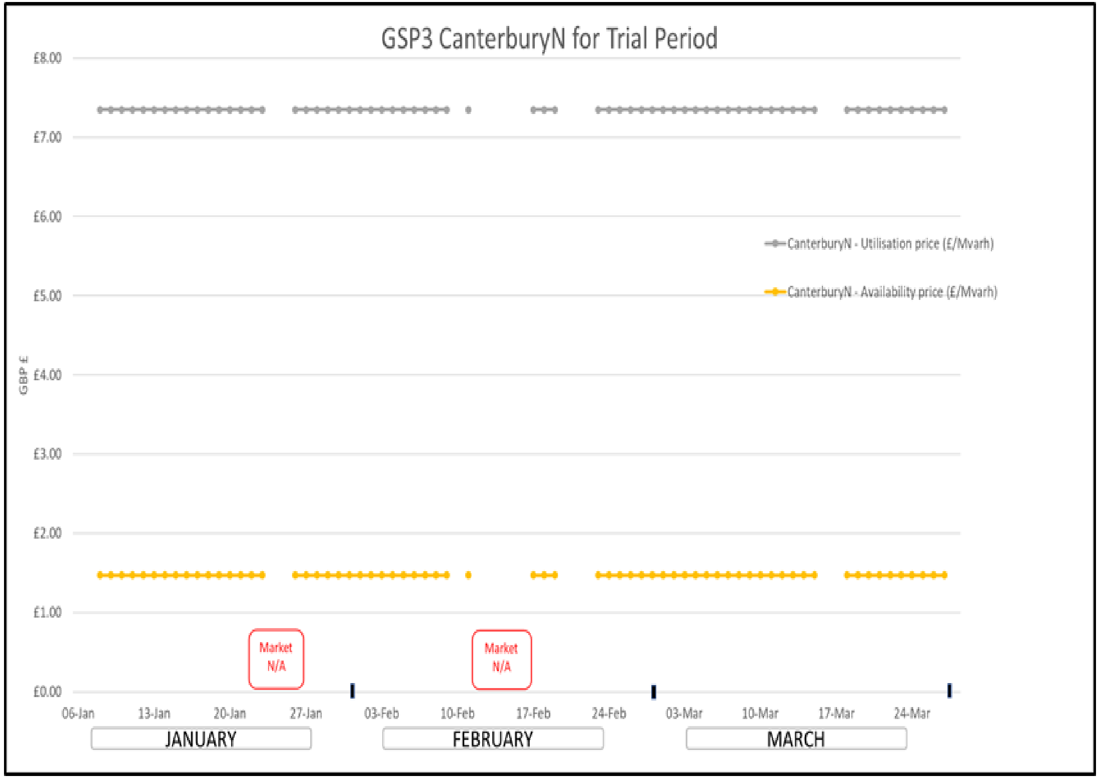
Wave 2 Trial Results – Bolney



GSP 2 – Bolney (Battery)

- Average accepted availability price **£4.58** /Mvar/h
- Average utilisation price **£9.35** /Mvarh
- Volume utilised **1503** Mvar
- Service hours accepted **996**
- Days not procured **29**

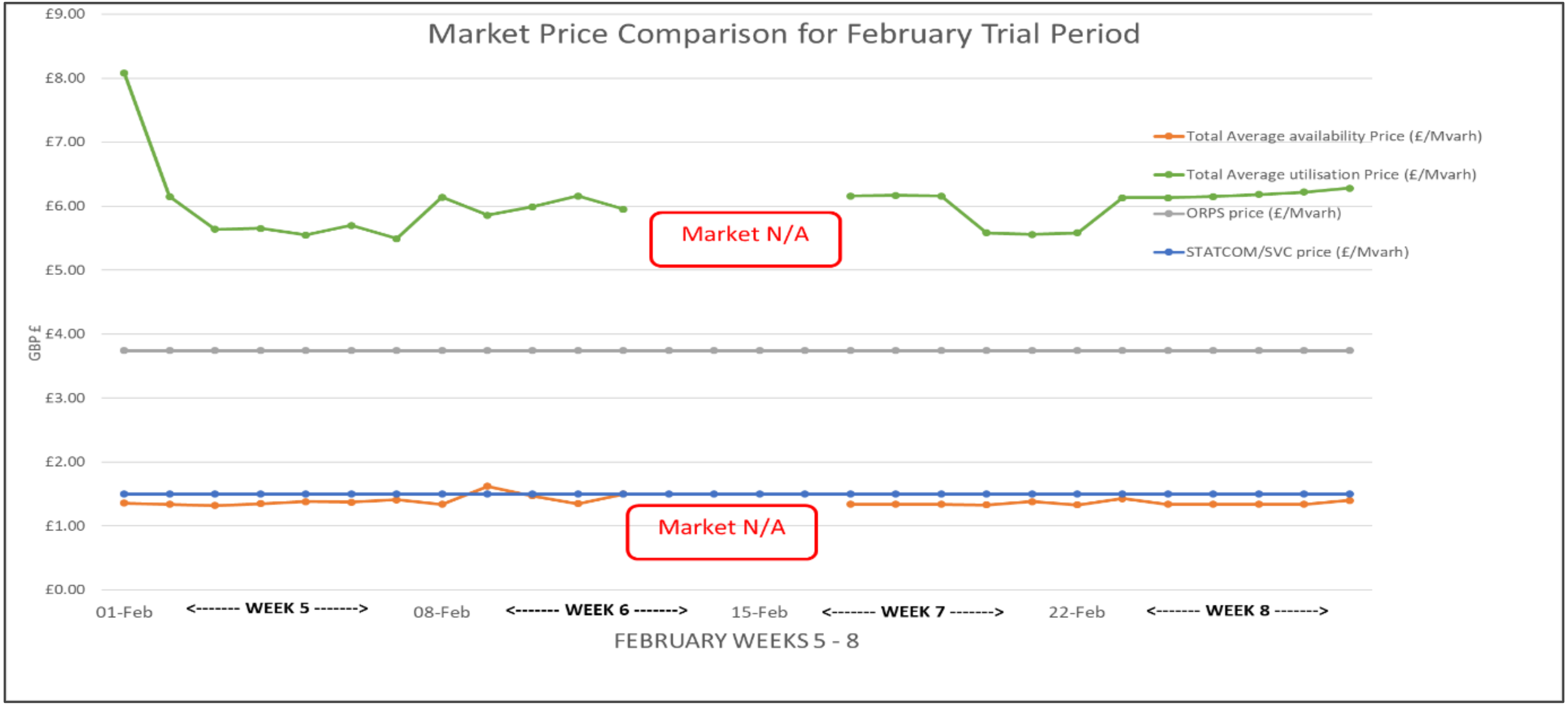
Wave 2 Trial Results – Canterbury North



GSP 3 – Canterbury North (Wind)

- Average accepted availability price **£1.47** /Mvar/h
- Average utilisation price **£7.35** /Mvarh
- Volume utilised **4838** Mvar
- Service hours accepted **1566**
- Days not procured **6.3**

Reactive Power Market Price Comparison



Key Areas for Improvement / Further Consideration

The project captured some key aspects of the current commercial arrangements, framework and processes that require further consideration to support an enduring service.

Additional Market Data	DER utilisation vs alternative sources	DER Contractual Framework	Nomination & Assessment Methodology
DNO roles and responsibilities	Procurement Timeframes	Conflict of Services	Accommodation of additional DER

Cost Benefit Analysis (CBA) - Cambridge University

- The CBA has been calculated using a Net Present Value methodology, compared against the cost of building transmission connected STATCOMs

With DER only

year	%DER Participation			
	25 %	50%	75%	100%
	(£m)	(£m)	(£m)	(£m)
2020	1.0	1.0	1.3	2.5
2030	3.9	6.6	8.3	9.0
2040	6.4	10.6	12.3	14.2
2050	**8.7**	**14.1**	**17.0**	**19.5**

With DER & network optimisation

year	%DER Participation			
	25 %	50%	75%	100%
	(£m)	(£m)	(£m)	(£m)
2020	3.4	3.4	3.4	4.8
2030	16.0	18.4	18.9	20.7
2040	25.0	29.0	30.1	32.3
2050	**32.0**	**36.7**	**39.4**	**42.3**

Based on average accepted availability price £1.46/Mvar/h and average accepted utilisation price of £4.8/Mvarh

Cost Benefit Analysis - Replication Studies

- The replication studies demonstrate the expansion of the Power Potential project could save energy consumers over £96m by 2050 when rolled out to 19 transmission voltage zones within Great Britain and to £161m for DER sized above 100MW

With DER up to 100MW

	% DER Participation			
year	25%	50%	75%	100%
	Benefit (£m)	Benefit (£m)	Benefit (£m)	Benefit (£m)
2020	5.0	5.0	6.5	12.6
2030	20.2	34.1	42.9	46.5
2040	31.7	52.6	61.0	70.4
2050	43.1	69.9	84.3	96.7

With DER below and above 100 MW

	% DER Participation			
year	25%	50%	75%	100%
	Benefit (£m)	Benefit (£m)	Benefit (£m)	Benefit (£m)
2020	11.5	11.5	15.0	28.9
2030	40.5	68.6	86.3	93.5
2040	56.0	92.7	107.5	124.2
2050	72.1	116.9	140.9	161.7

System

Learning

Dr Rita Shaw

Dr Biljana Stojkovska

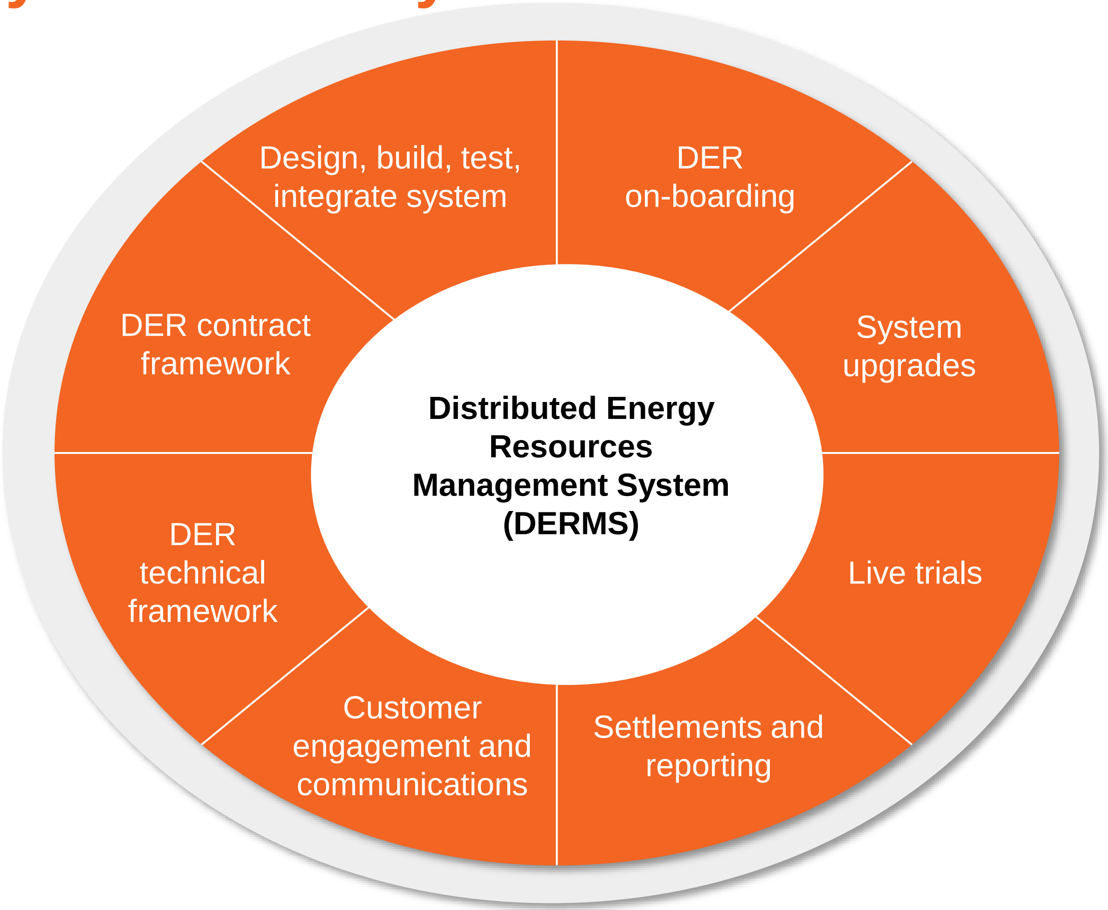
Live system demonstration

DER operating in voltage control under DERMS instruction to form a VPP for transmission

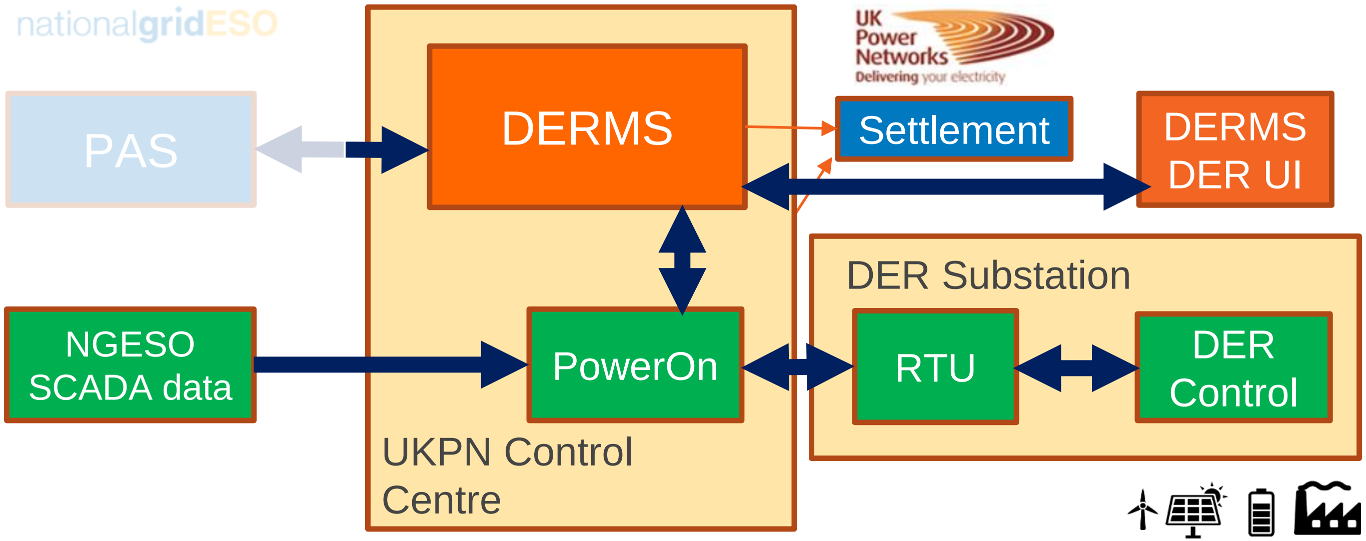
Technical service and market solution enabled by a DSO DERMS reflecting altered DER connection agreements, new service contracts and linked to NGESO systems

Day-ahead procurement for delivery **in 4hr service windows**, settlement in arrears

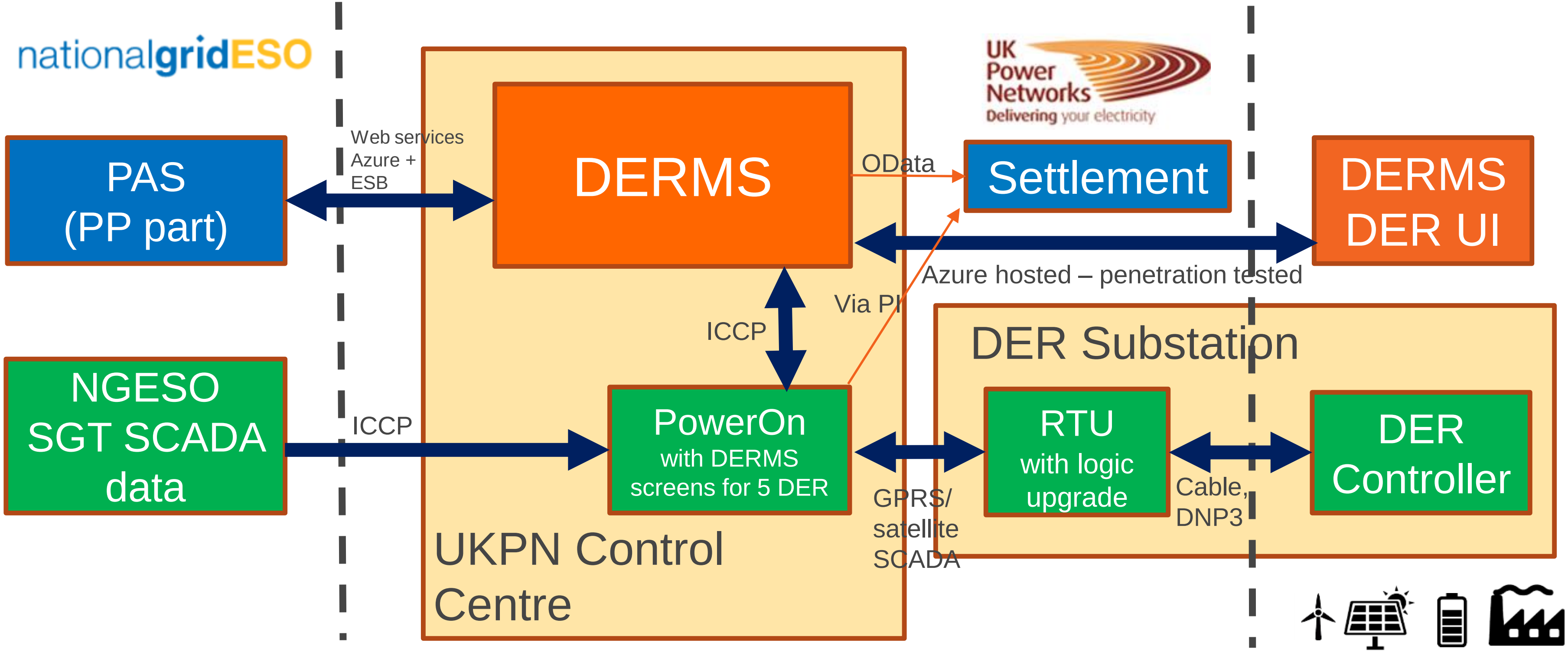
Approach to system delivery



Solution overview



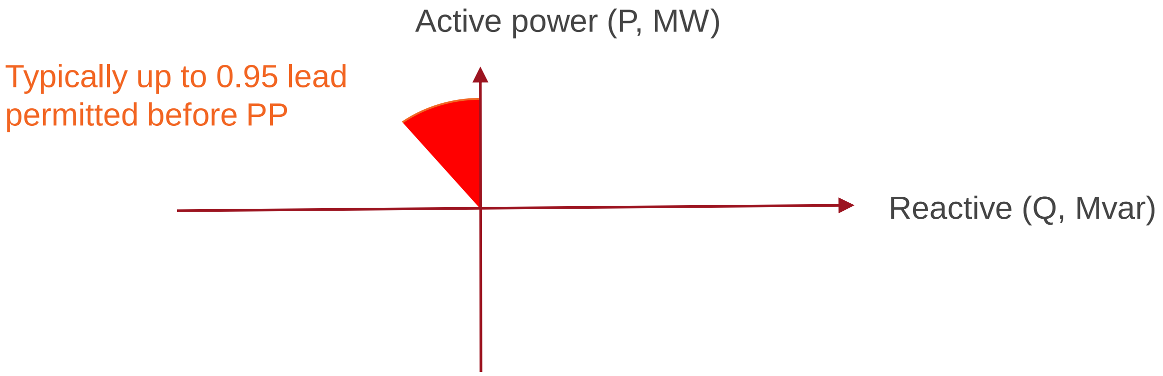
Power Potential – learning from integrating 20+ elements



Live and test systems, with redundant site

PQ operating envelope defined for each DER

- DER offers reactive range (Q, Mvar) at each active power level (P, MW)
- Operating range reviewed by UK Power Networks for safe network operation
- Implemented in contracts
- **Wider range enabled by DERMS monitoring and control**



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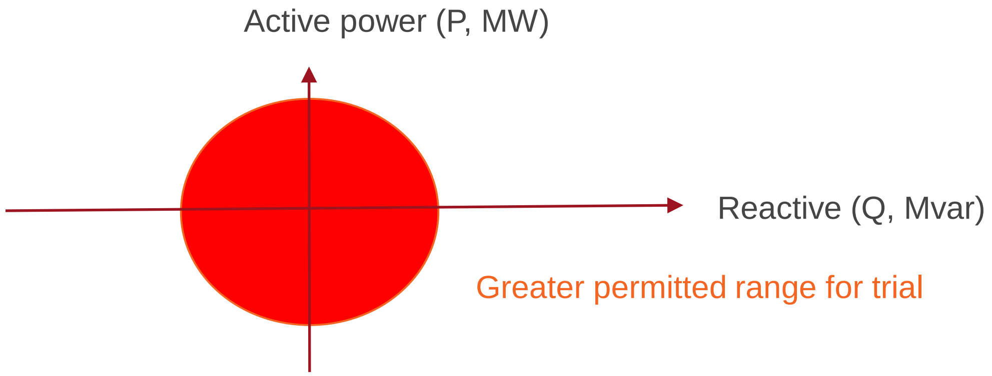


System learning in trial

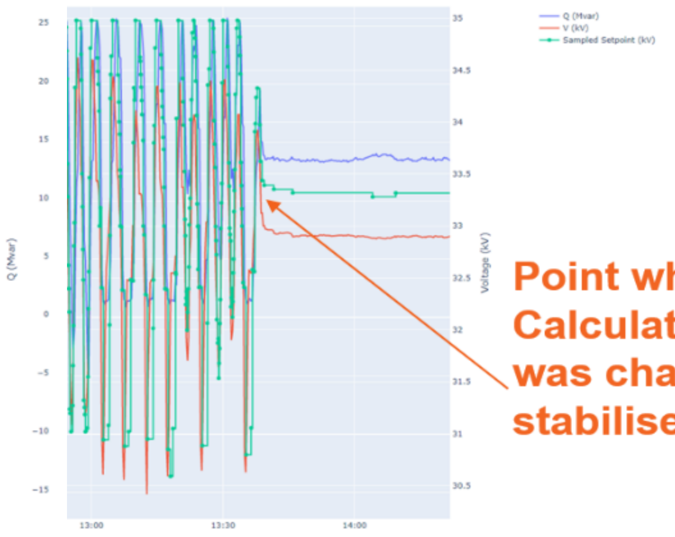
- ✓ **Integration and technical function demonstrated end-to-end**
- ✓ Revised active power limits / PQ envelopes agreed with customers

- ✓ **In trials – delivered multiple DERMS, PAS, process improvements and defect fixes**
  - Reduced data traffic DERMS-DER – changed integration design, and log caches
  - PAS-DERMS interaction – default to no acceptance, visibility of comms interruptions
  - Improvements to reduce team's manual support, and improve web interface
  - Improved stability of the service delivery
- ❑ **For a BAU transition - identified multiple DERMS, PAS and process improvements**
  - Scale of requested Q at GSP (delivering response proportional to GSP voltage delta)
  - Improved end-to-end visibility of service availability during delivery – NGESO-UKPN-DER
  - Nomination process improvements / end-to-end test

Systems Learning – from Wave 1 trials applied to Wave 2

Reduce oscillations in service delivery

1) DERMS voltage set point calculation method



Point where Setpoint Calculation method was changed to stabilise DER.

2) DERMS controller tuning per GSP

PAS Key Learning and Improvements

Key learning:

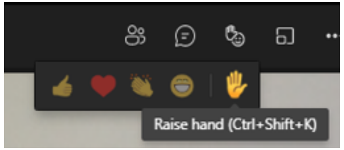
- Visibility to NGESO control room of when DERMS is on outage, or when DER are out of voltage control – and visibility to UK Power Networks when PAS is unavailable
- Full End to End testing of nomination process is required prior to the start of service delivery
- Potential need of visibility of DER data to confirm the information presented in PAS

Improvements:

- To provide visibility to NGESO control room for service dispatch
- Wider access to Control Room planned outage scheduled

Q & A

Please raise your hand to ask a question, we will introduce you



or add your question to the meeting chat

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Looking Forward

Dr Biljana Stojkovska

Dr Rita Shaw

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Power Potential Next Steps

DER feedback on next steps:

- Maintain momentum, learnings have been valuable.
- With some improvements the service can work. Liquidity is essential

Identify the interactions between Power Potential and other NGESO & UK Power Networks projects:

- Regional Development Programmes (RDP)
- Reactive Market Reform
- DSO role development

Power Potential Next Steps

Link to Regional Development Programmes (RDP)

- RDPs are initiatives that look at the complex interactions between distribution and transmission networks in areas with large amounts of transmission connections and distributed energy resources, which are leading to a capacity shortfall.

- The south-coast RDP between NGESO and UK Power Networks has been running for five years, and is now developing new markets for transmission thermal constraint management services in a similar geographic location to Power Potential.

- Agreement between UK Power Networks and NGESO to incorporate the Power Potential services to potentially expand the future scope of the RDP

Reactive Reform - Market Design Project

- To address the challenges, we are facing for system voltage control, the NGESO are now exploring market-based solutions through a reactive market design project to assess whether a market could be developed
- Enabling more across technologies and connection types to provide reactive power services in the right locations to maintain system voltage security and drive down the overall reactive costs to maximise consumer benefits.
- Three key focus areas for analysis and design work are:

Technical Analysis: Identification of System Need for procurement

Market Analysis: Market Readiness and Technical & Commercial Viability

Commercial Analysis: Procurement Strategy

- Project is currently in the stage of establishing the scope and detailed plan, and will adopt the collaborative approach of co-creating the solution with industry and will share the further engagement plan shortly
- Project will also consider the output from other projects includes power potential and pathfinder etc to see if any learning could feed into the future market design work

Building DSO and Power Potential capability for future

PP trial commercial framework

- Back-to-back contractual mechanism – NGESO-UKPN and UKPN-DER
- Pass-through of service payments NGESO->UKPN-> DER
- System delivery and support costs were provided by innovation project + partners
  - *This approach supported the trial learning objectives*

To enable PP for BAU, new processes, contracts and system changes (T and D)

- Leverage project learning, to identify what from PP to progress in the new RDP systems

For UK Power Networks, PP/RDP are part of our Distribution System Operator roles

- Submitting plans to Ofgem for related allowances and performance incentives for 2023-28
- Creating the necessary technical and market functionalities for DSO products e.g.
  - Enabling whole system solutions
  - Coordination to resolve complexities, optimise dispatch and mitigate conflicts
  - Facilitating participation of more DER
  - Neutral market facilitation

Next steps for UK Power Networks

A future suite of smart network products enabled by our DERMS DSO platform

DSO PLATFORM

Distributed Energy Resources Management System (DERMS)

Embedded smart grid programmes

- **Flexible connections**
- **Flexibility services**
- **RDP services**

Innovation projects

- **Active Response**
- **Power Potential**
- **Optimise Prime**

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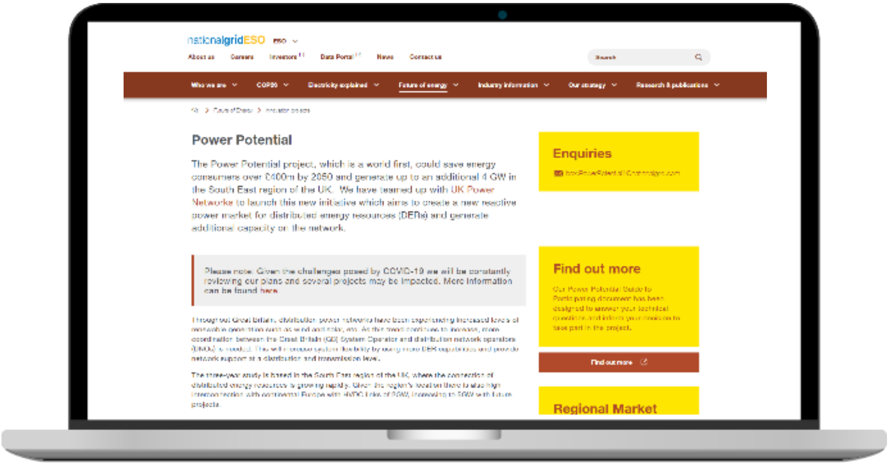
Project outputs on the website

https://www.nationalgrideso.com/future-energy/projects/power-potential

- **Project reports (SDRCs) –** Design (9.1 and 9.2), Commercial approach (9.3), Customer, system and process readiness (9.4), CBA (9.5), Trials and BAU (9.6), DSO risk-reward (9.7) & academic reports from Imperial College and Cambridge University.
- **Technical references:** Initial DER technical characteristics spreadsheet, DER technical requirements, DER test specification, DER interface schedule, DNO commissioning procedure, DNO Control procedure, Mandatory Trial guidelines, Aggregator design study
- **Commercial / contractual references:** Market Procedures, DER Framework Agreement, Variation to the Connection Agreement, Reactive Power commercial procedures.

WEBSITE

https://www.nationalgrideso.com/future-energy/projects/power-potential



EMAIL

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Thank you

Slides are on the website

Feedback form, please complete

Final Showcase Event - Feedback form

Close down report will be on the website on 2 August 2021

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Power Potential

Final Showcase

Thursday 24 June 2021

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