Power Potential: Energising Reactive Power for a Changing Power Grid

Presented by :

- Dr Biljana Stojkovska
- Dr Inma Martínez Sanz
- Tatiana Ustinova

For power system expertise

7th of November 2018, National Grid, Warwick UK

Dr Biljana Stojkovska

Innovation Manager, National Grid ESO

Outline

1. Introduction
2. Power Potential solution and services
3. Background concept: Virtual Power Plant
4. Power Potential technical solution: DERMS
   - Main system components
   - Control structure
   - Simulation results
5. Power Potential IT Architecture & DERMS integration
6. Testing
7. DER journey to trials
8. Conclusions and lessons learnt

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CIGRE UK Women's Network
Vision & Mission

Vision:

1. "Promoting value of woman in engineering and helping every female engineer to have an equal opportunity to meet their full potential in their career"

Mission:

1. To create a pathway for female engineers to have a valued career within the UK/Energy Supply Industry/ Energy sector
2. To support female engineers in their career to thrive within their preferred environment
3. To actively work as an organisation to address the negative bias against female engineers, providing equal opportunity.
4. To expand membership and outreach to a wider female audience with diverse backgrounds.

Achievements in 2016

Launch of CIGRE UKWN
March 2016

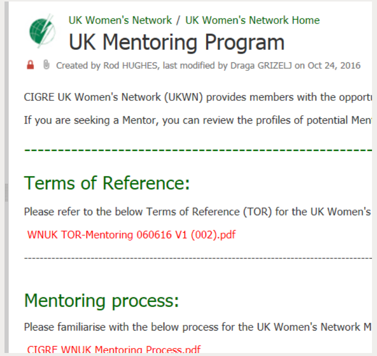
Story Book Published

Structure & Steering Committee

CIGRE Paris: Women in
Engineering Forum

Successful 1st Networking Event
Hosted by ABB

Mentoring Platform Launch


UK Women's Network / UK Women's Network Home

UK Mentoring Program

Created by Rod HUGHES, last modified by Draga GRIZELJ on Oct 24, 2016

CIGRE UK Women's Network (UKWN) provides members with the opportu

If you are seeking a Mentor, you can review the profiles of potential Men

Terms of Reference:

Please refer to the below Terms of Reference (TOR) for the UK Women's

WNUK TOR-Mentoring 060616 V1 (002).pdf

Mentoring process:

Please familiarise with the below process for the UK Women's Network M

CIGRE WNUK Mentoring Process.pdf

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Achievements in 2017

"Career development", Feb 2017, event hosted by Mott Macdonald

"How to build your networks", April 2017, event hosted by Enzen

"Standing out with confidence", November 2017, event hosted by Imperial College

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CIGRE UKWN: Next Steps

1. **Energy Digitalisation and how to build resilience**
   - 6 November 2018, London, hosted by Accenture
   - Panel of speakers & professional workshops on resilience
2. **Development of Agile / Sprint Development Methodology**

More information is available on our website:

www.cigre.org.uk/womens-network/

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Power Potential Unwrapped

- The Power Potential project is a world first trial using distributed energy resources in distribution networks to provide dynamic voltage control to the transmission system

- A whole-system approach can be beneficial for everyone from network operators to generators to end consumers

Power Potential - Key facts

Funding mechanism: Ofgem Network Innovation Competition (NIC)

Project Lead

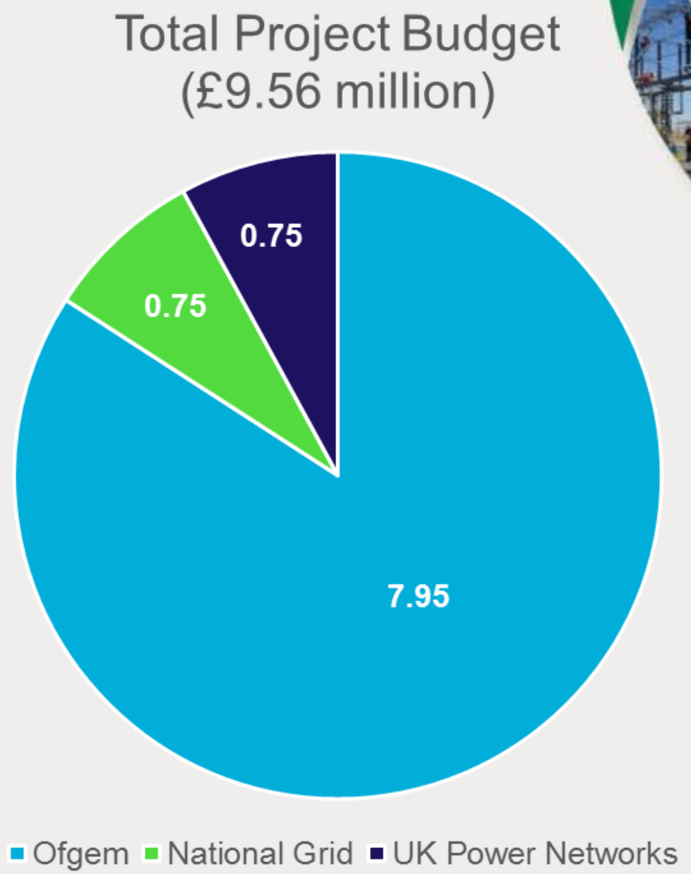
nationalgridESO

In partnership with:

UK Power Networks
Delivering your electricity

Start Date: Jan 2017

End Date: Dec 2019



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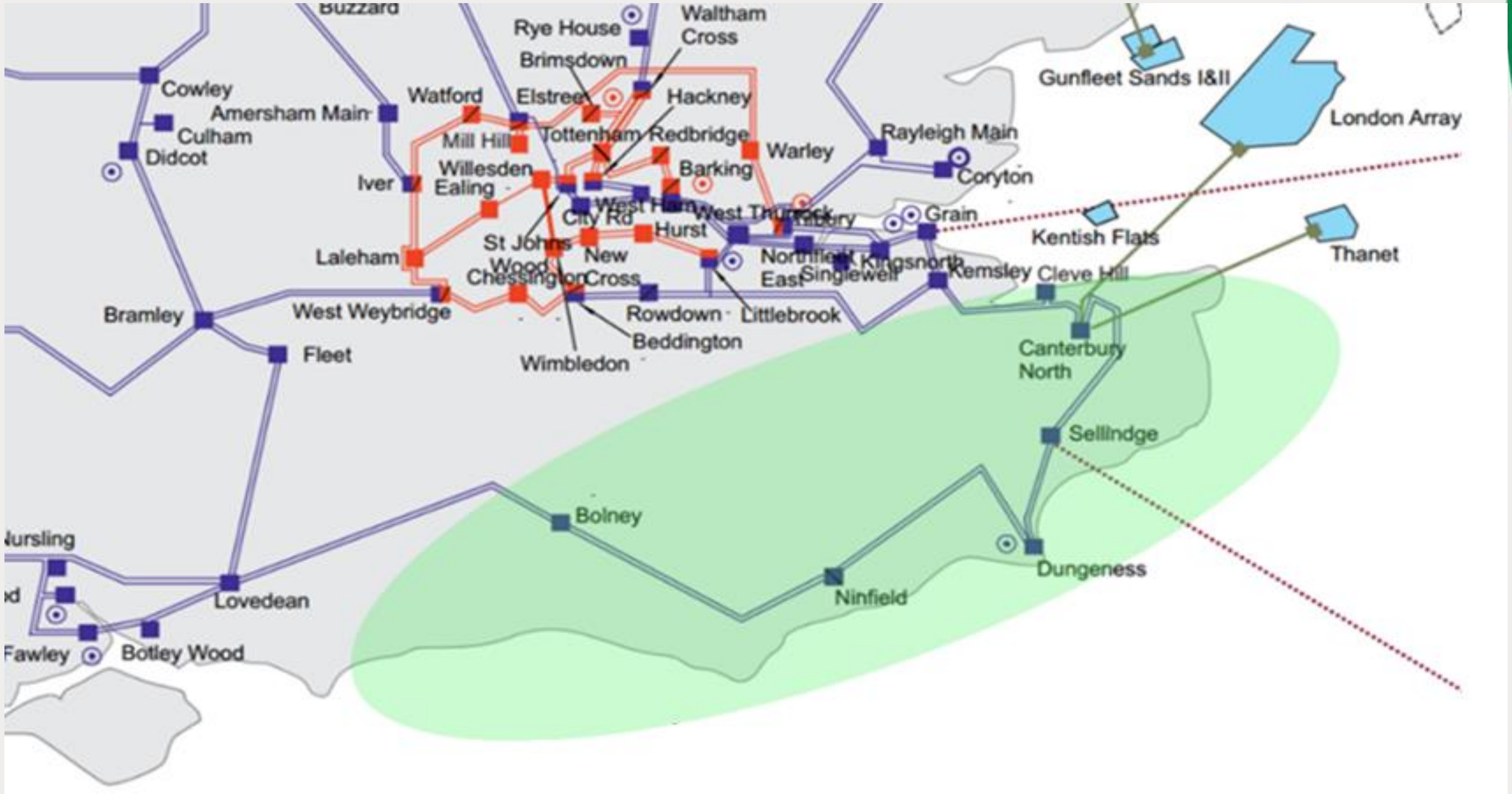
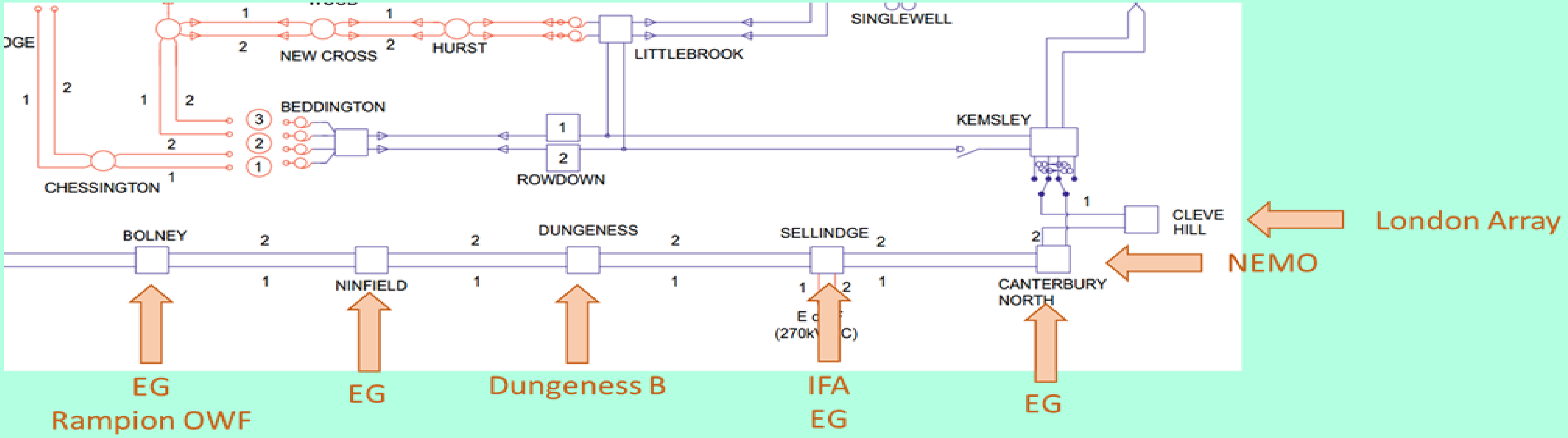
Area of Focus

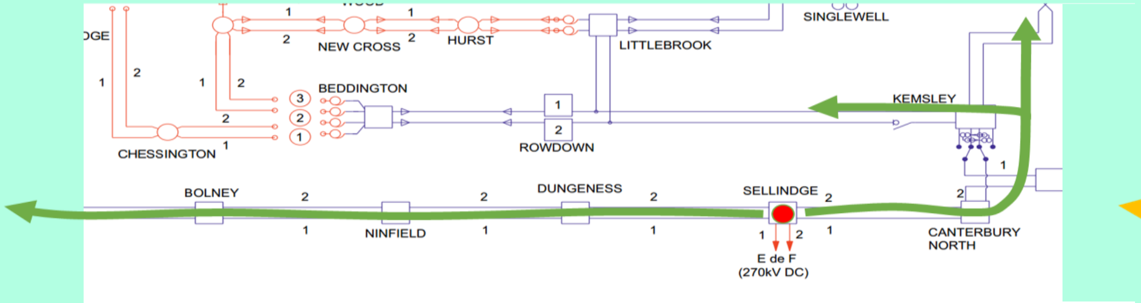


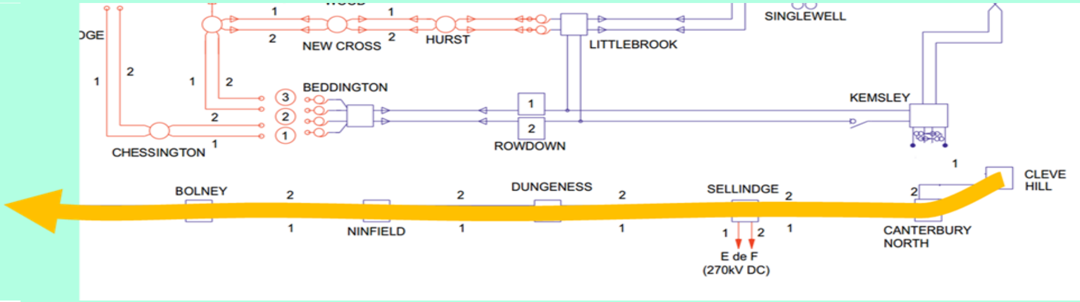
275 kV

400 kV

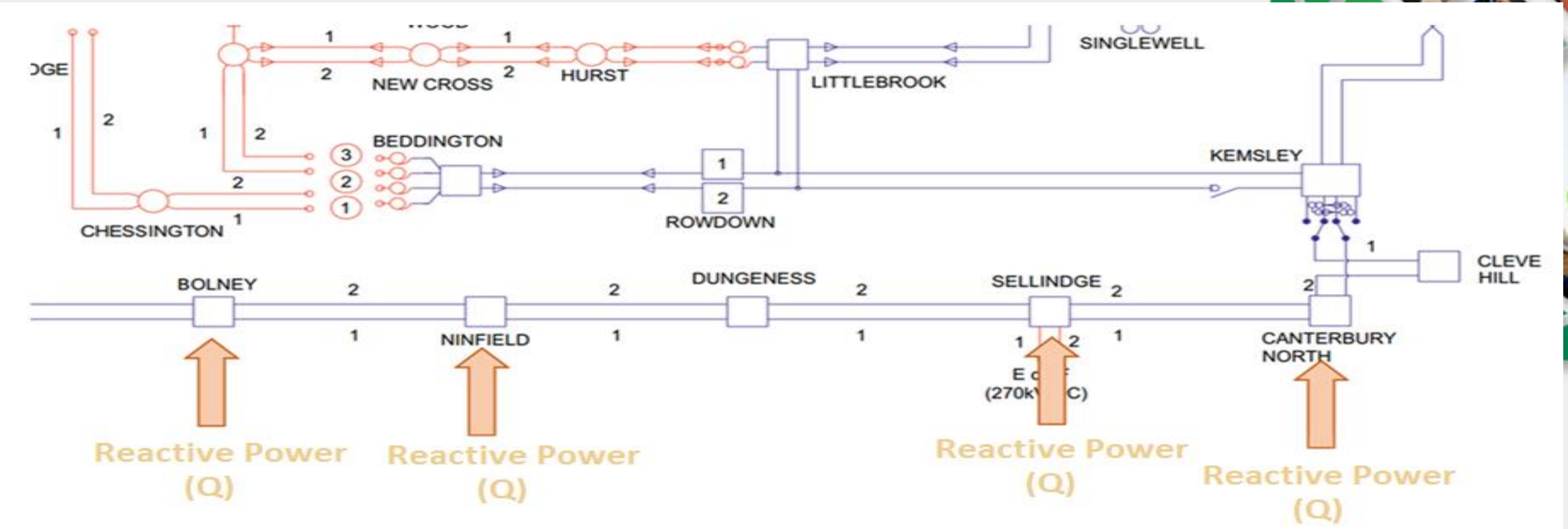
Why Power Potential?





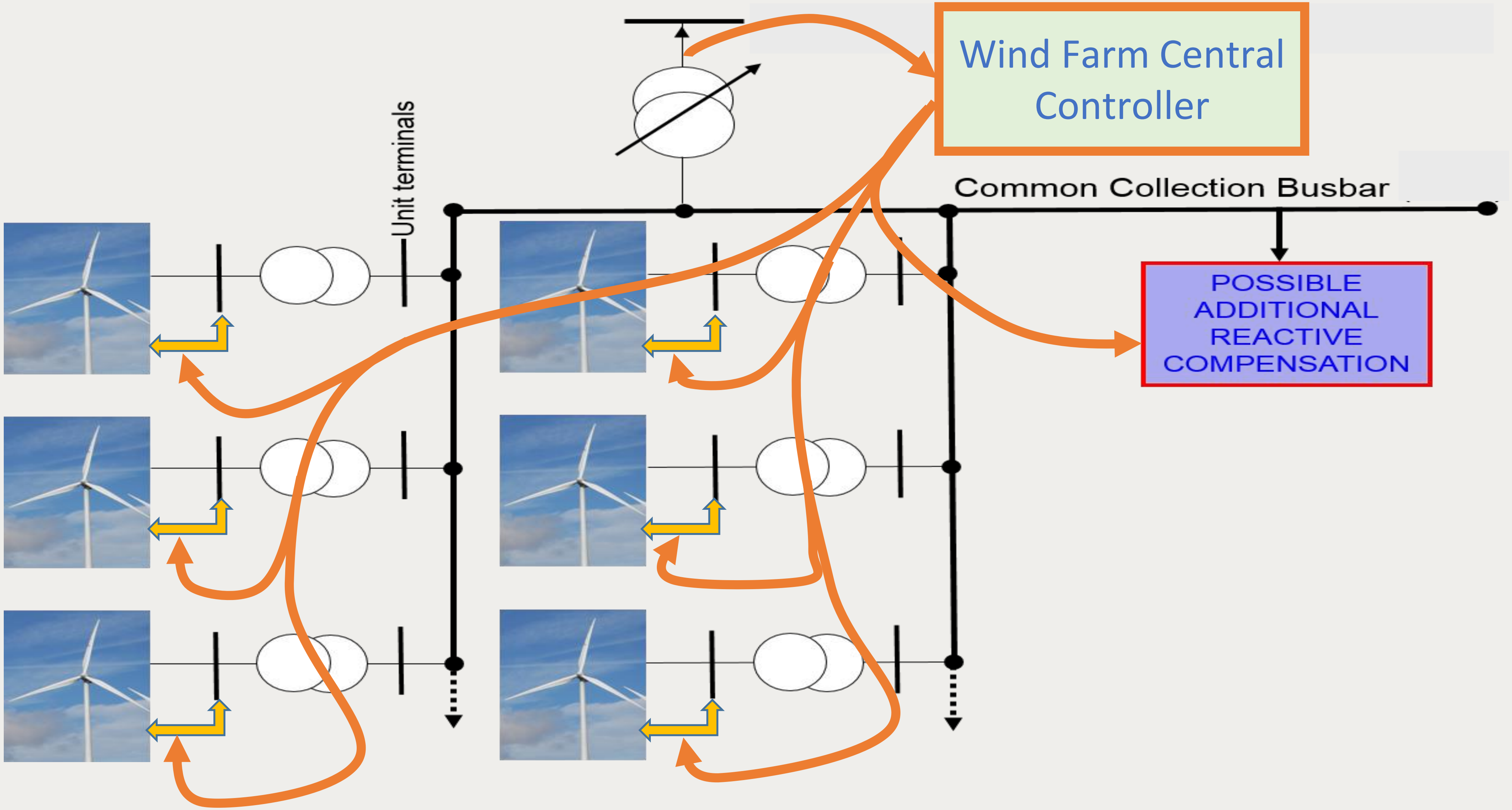


The How?



1. Technical solution
   - Dynamic voltage control from DER
   - Active Power Support for constraint management and system balancing
2. Commercial solution
   - Establishing new reactive power market from DER
   - Prove of the concept of the whole system approach
3. Business Change
   - Concept of transition from DNO to DSO

Copying an idea from offshore wind farms



Project timeline

Design
- Jan 17 – Dec 17

Build
- Jan 18 - Nov 18

Test
- Dec 19 – Apr 19

Trial
- May 19 – Dec 19

DER Trial Requirements

Trial recruitment

Testing of the solution

Commercial arrangements

Trial Participation

Demonstrating approach & establishing its commercial viability

Our principles are:

1. Market efficiency
   1. Level of stimulus to DER – promote participation
   2. Efficient allocation of budget & in line with project budget

   Examples:
   - Reward the DER that is most effective
   - Pay a fair price that reflects the need for investment to provide the service but does not place participants in a significantly beneficial position going forwards
2. Operational
   1. Maintain system security by not utilising trial volume to secure system
   2. Trials to follow operational profile requirements for reactive power
3. Continuous review of applicability to business as usual – to provide projections for future use

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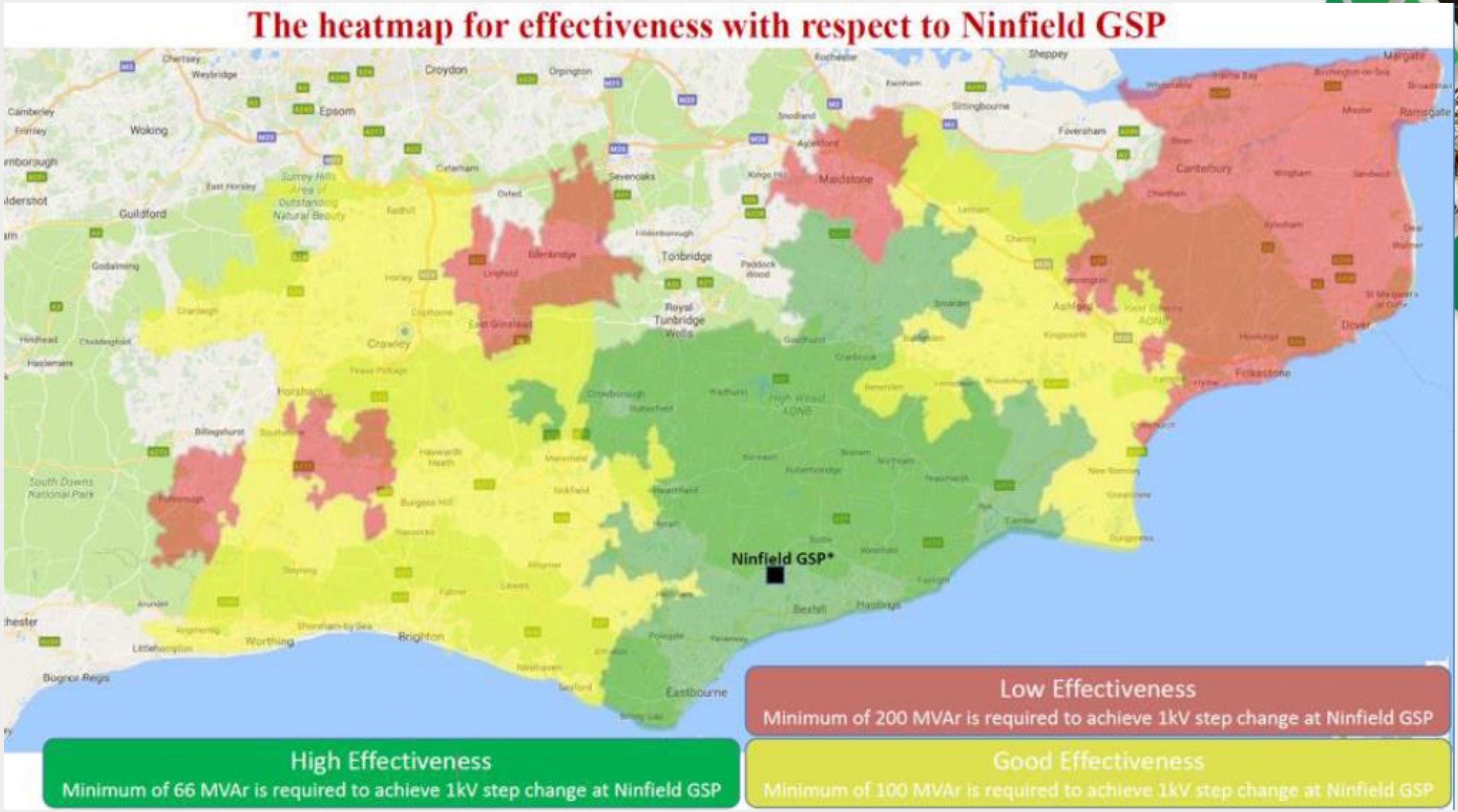
Reactive power heatmaps



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Overview of reactive power trials for 2019

Wave 1: technical trials	Wave 2: price discovery	Wave 3: Transition to Business As Usual
Objective: Demonstrate proof of concept	**Objective: Establish the commercial viability of this approach**	**Objective: Prepare DER for a transition to current business as usual operations**
DER will receive a *fixed participation payment*, in line with the number of hours they are available for during wave 1.	DER will compete with each other in day ahead auctions.	DER will compete with each other and the mandatory market in day ahead auctions.

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Summary of final payment models for trial

Reactive Service

Wave	Participation payment	Availability payment policy	Utilisation payment policy
1	Up to £45,000 per site, linked to availability	N/A	N/A
2	N/A	Driven by market bids	Driven by market bids
3	N/A	Assessed in line with other options available to the ESO	

Active Service

Wave	Participation payment	Availability payment policy	Utilisation payment policy
Competitive bidding	N/A	N/A	Driven by market bids

Dr Inma Martínez Sanz

Power Systems Engineer, National Grid ESO

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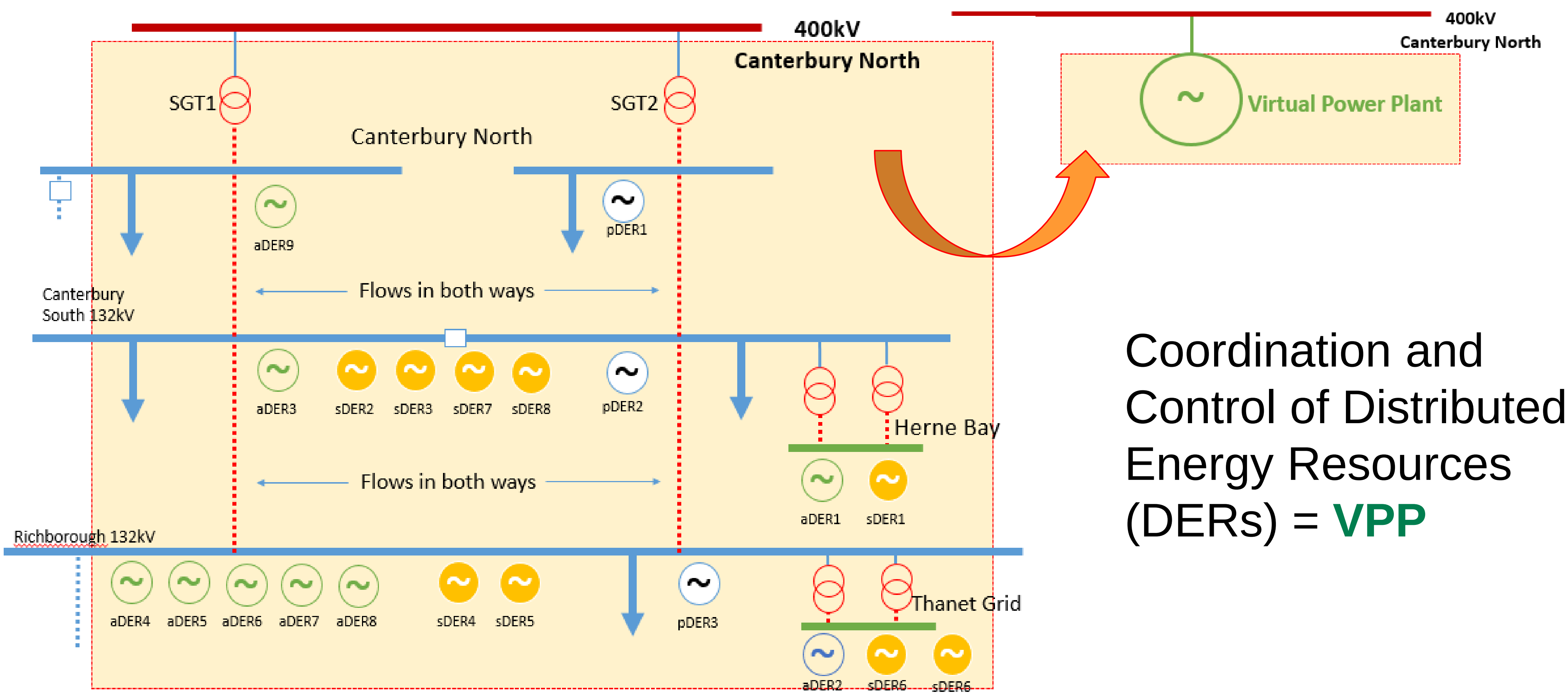
Background: concept Virtual Power Plant



Coordination and Control of Distributed Energy Resources (DERs) = **VPP**

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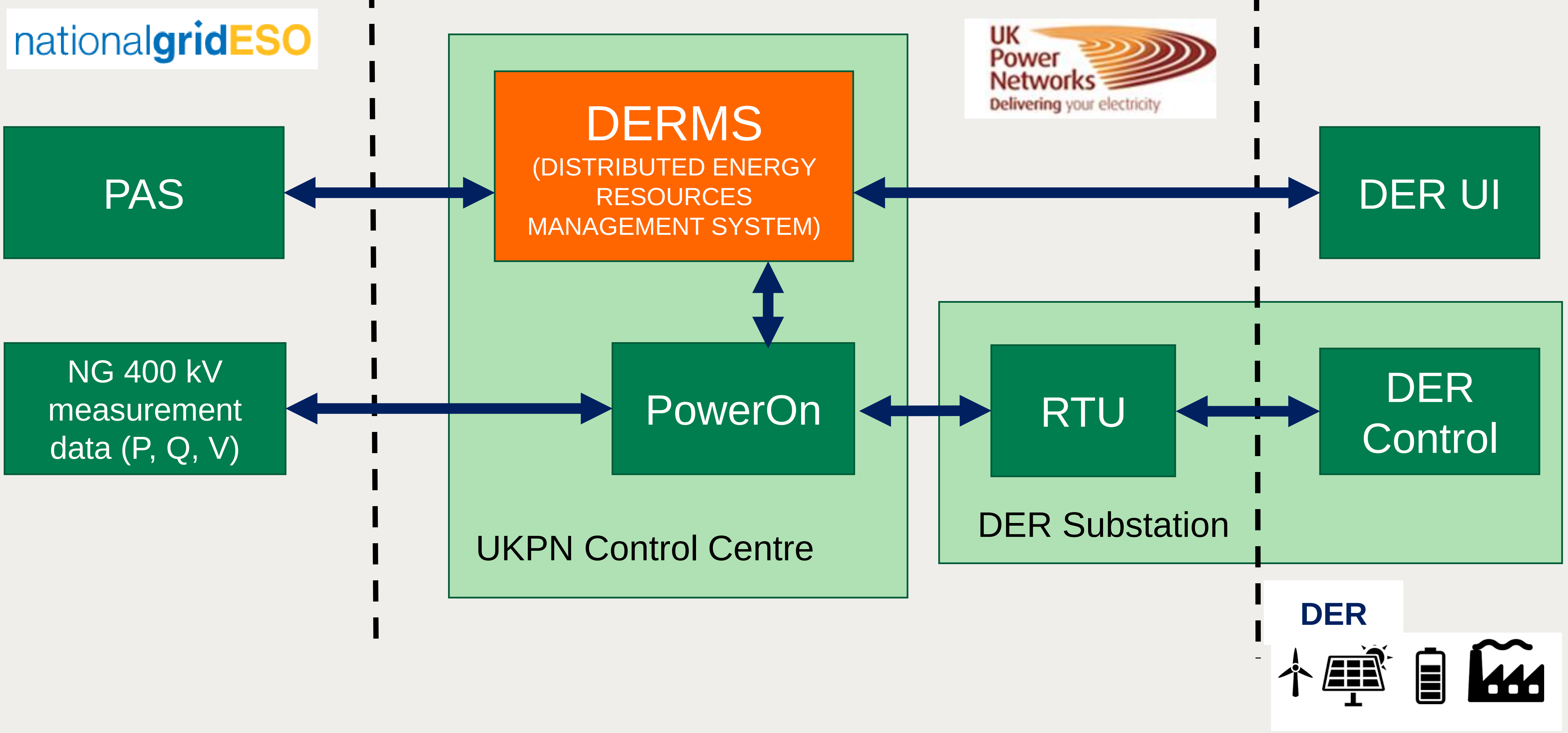
Power Potential technical solution overview



NGESO interface: PAS (Platform for Ancillary Services)

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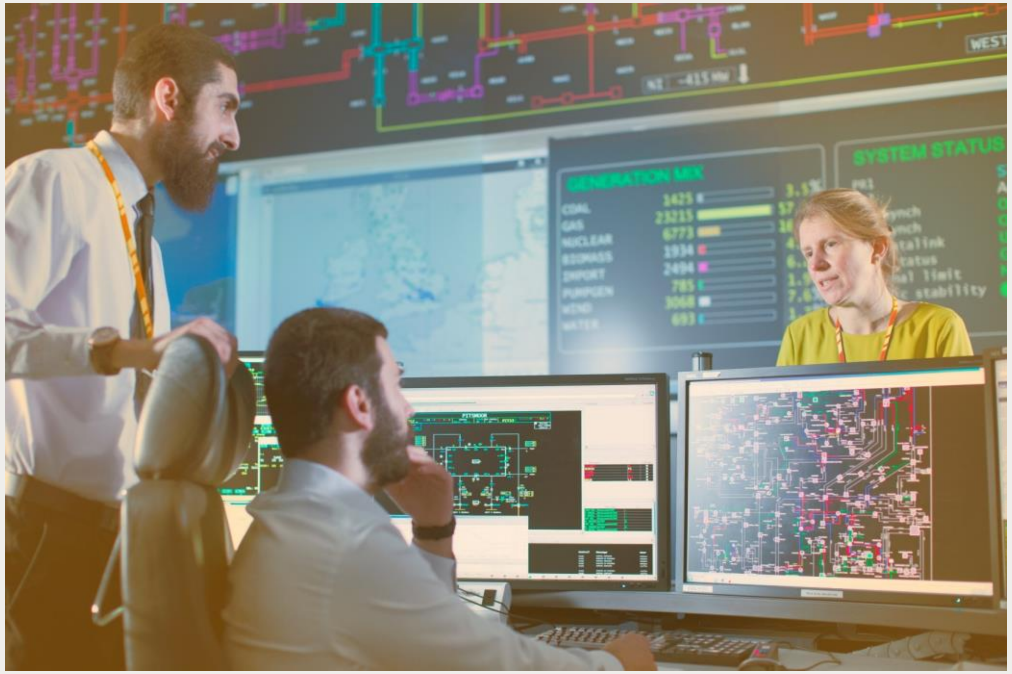
Day-ahead – DERMS Future Availability Mode

- Gate closure (14:00)
- Post-gate pre-nomination
- Nomination (17:00)

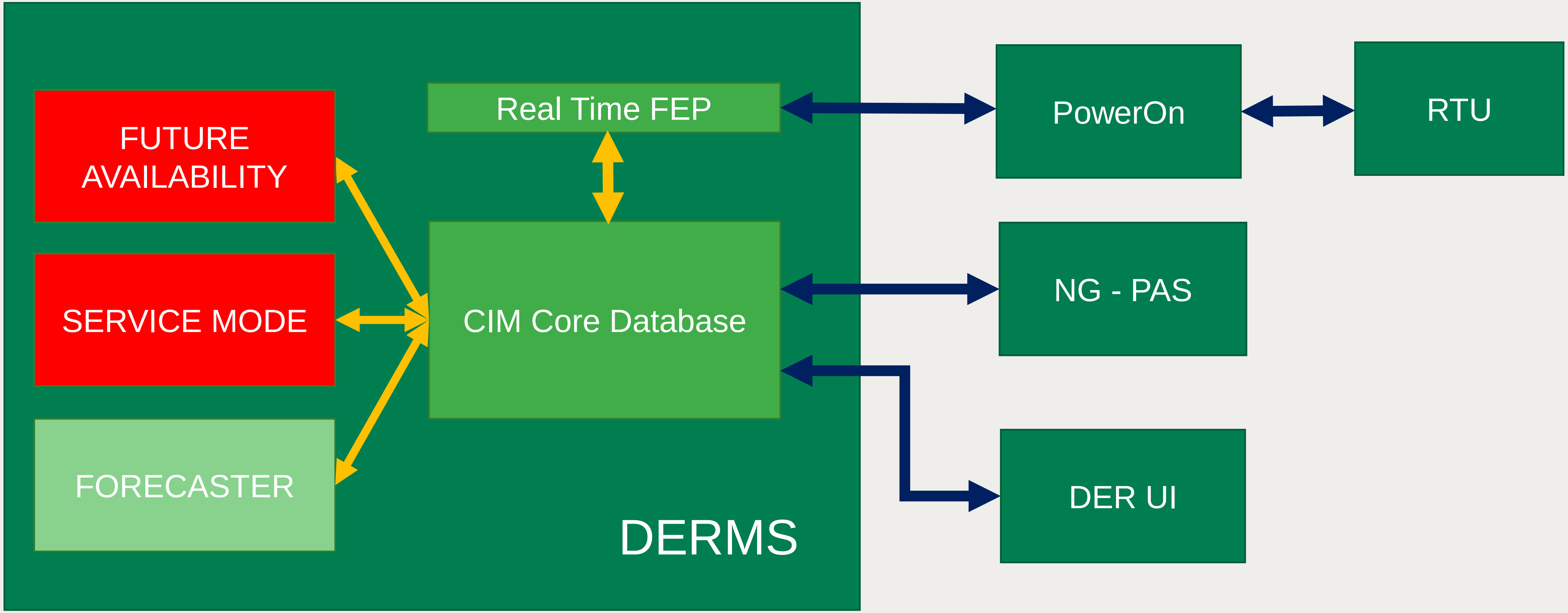
Delivery day – DERMS Service Mode

- Starts at 23:00
- Operational windows of 4 hours
- Service instructions



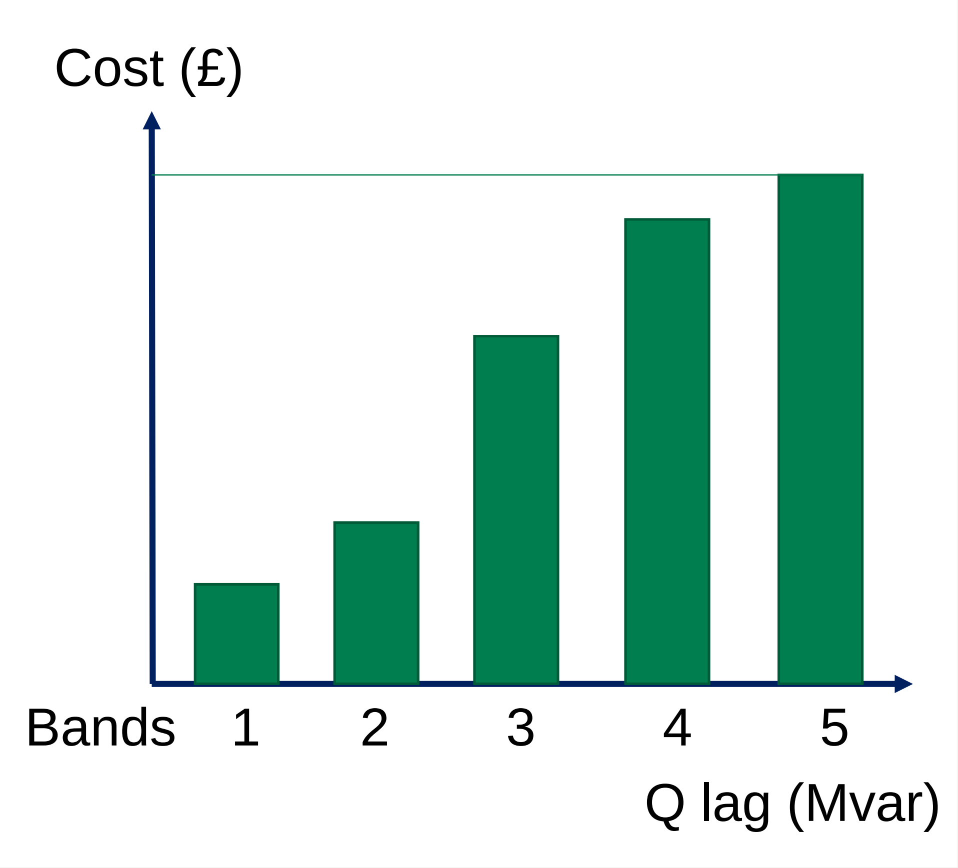
DERMS technical solution

Distributed Energy Resources Management System

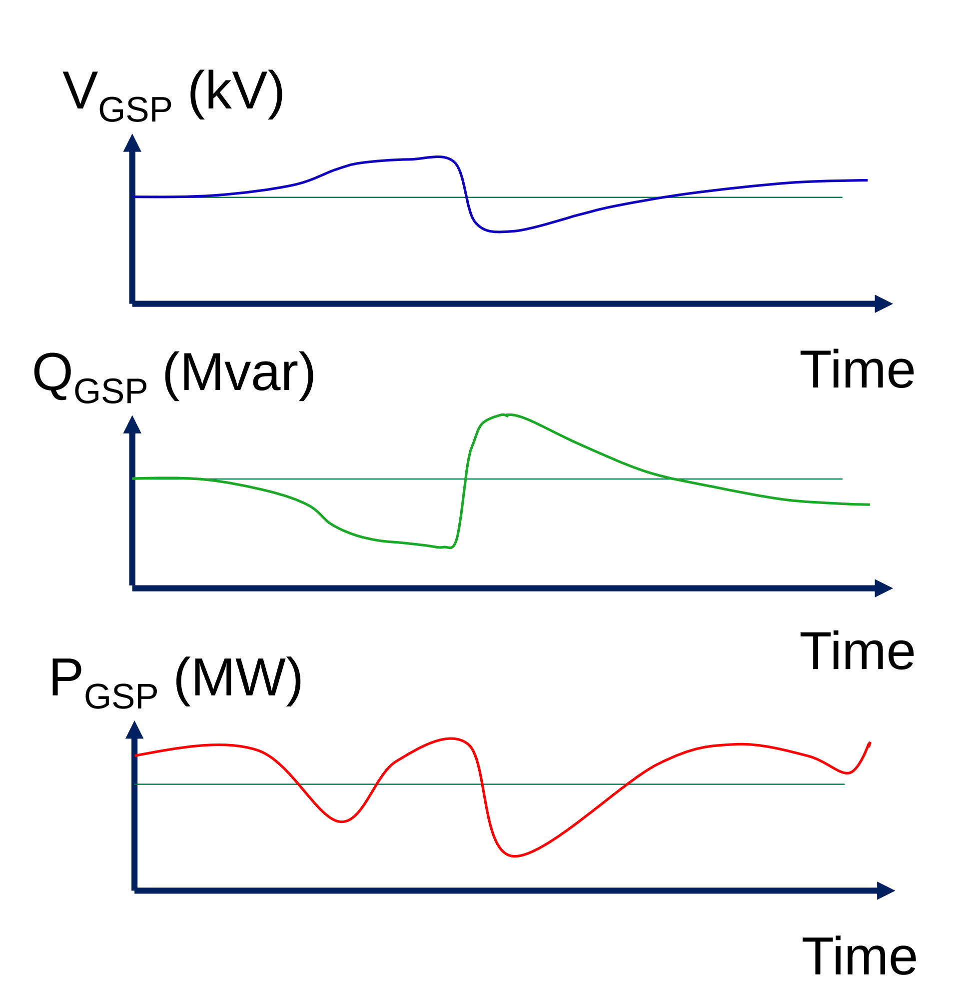


DERMS – Future Availability

- FA handles the commercial element of Power Potential.
- DERMS optimises the DER stack to indicate availability to provide GSP services.
- This is presented as **cost curves.**
- Both DER availability (£/Mvar/h) and utilisation (£/Mvarh) costs are considered.
- **Effectiveness** at GSP is included in the DER ranking.

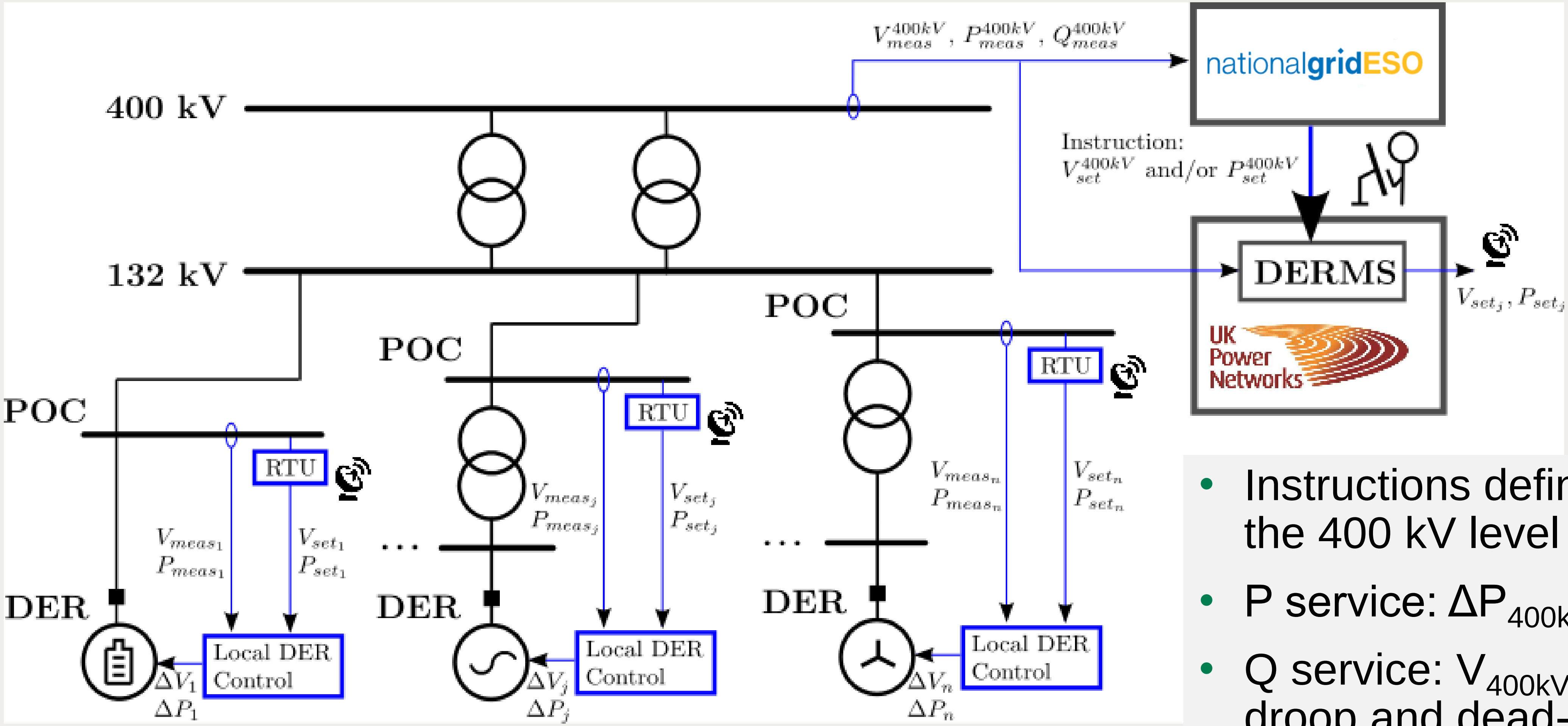


DERMS – Service Mode



- SM handles the dispatch element of Power Potential.
- Issues DER set-points to achieve GSP instructions
- Real-time control system responsible for delivering the commercial services.
- Capable of providing both services (Active Power and Reactive Power) simultaneously.

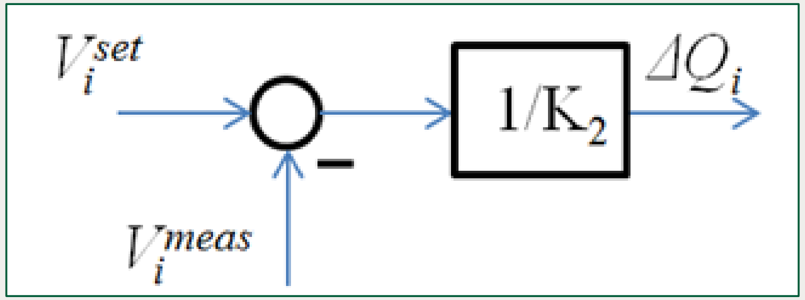
DERMS – Service Mode control overview



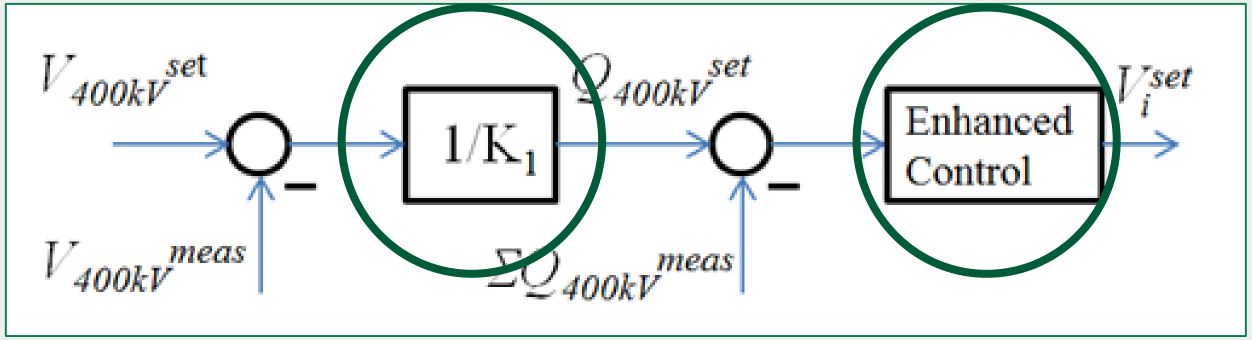
- Instructions defined at the 400 kV level (GSP)
- P service: ΔP_{400kV}^{set}.
- Q service: V_{400kV}^{set}, droop and dead-band.

DERMS – Service Mode control

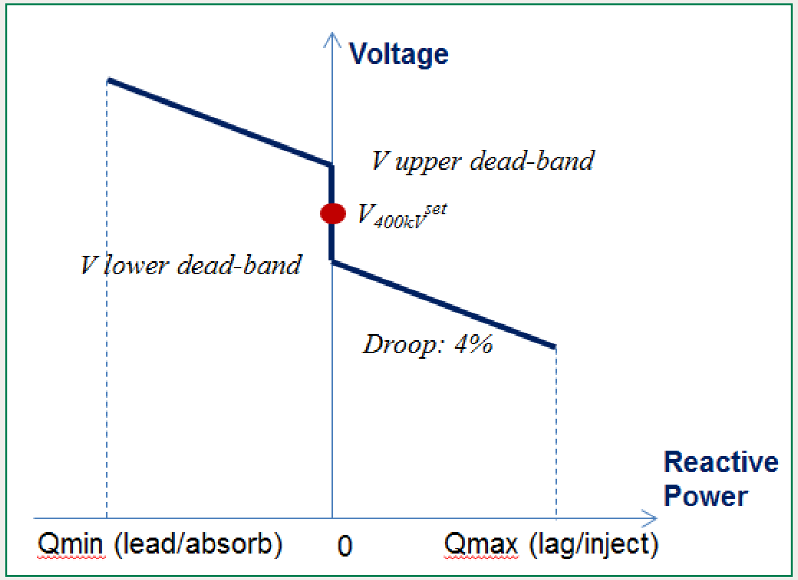
1. Local DER control



2. Supervisory DER control



GSP voltage droop characteristic

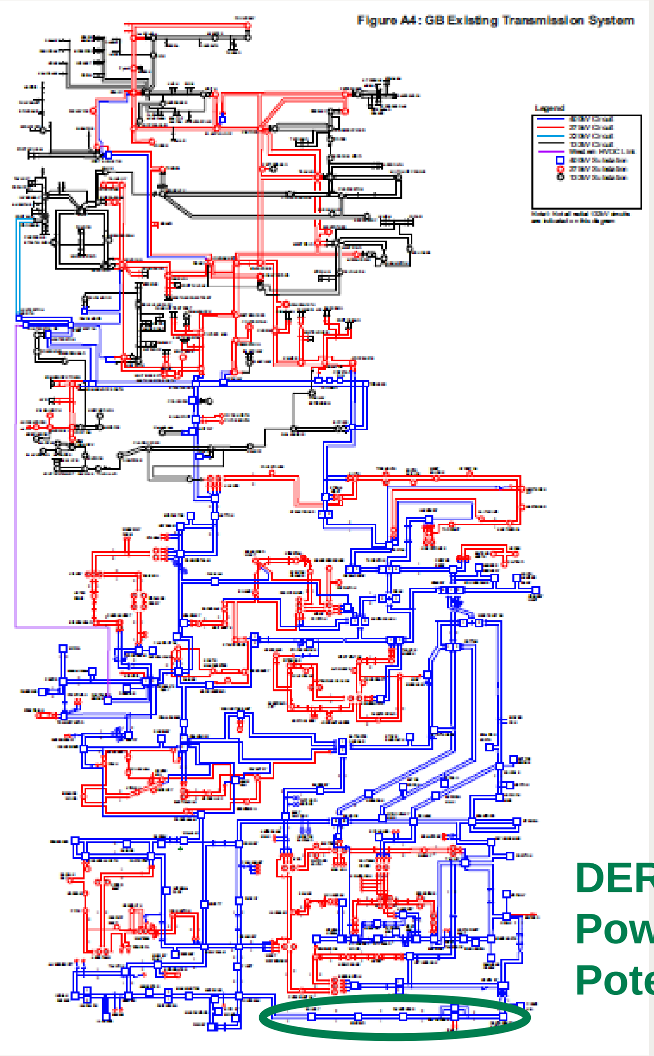


(Qmin, Qmax) are continuously updated according to grid conditions

Simulation results – modelling considerations

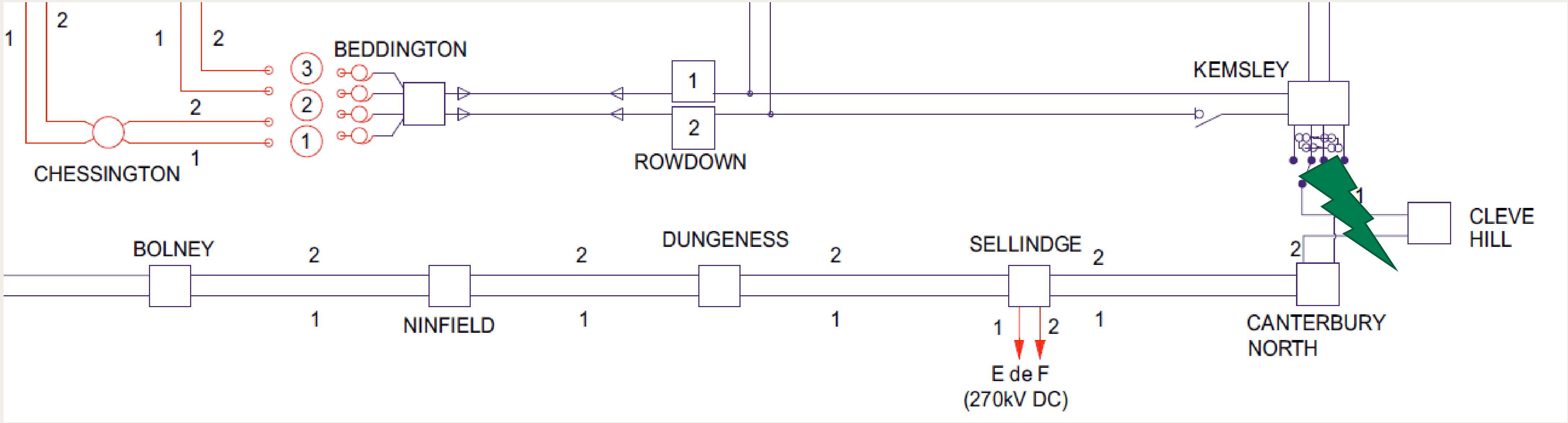
GSP	DER	Total MW
Bolney	8	92.15
Ninfield	6	108.13
Sellindge	4	32.50
Canterbury N.	9	274.95
Richborough	6	64.20

- Theoretical validation in full GB dynamic model (2025).
- System demand is 16.9 GW and south-east region exports power to London (approx. 4 GW, 1.6 GW from Bolney and 2.4 GW from Canterbury N.), interconnectors import 2.7 GW.
- DER controllers represented using generic models (PV and synchr. at 100%, wind 70%, no storage) – Q up to 0.95 p.f.



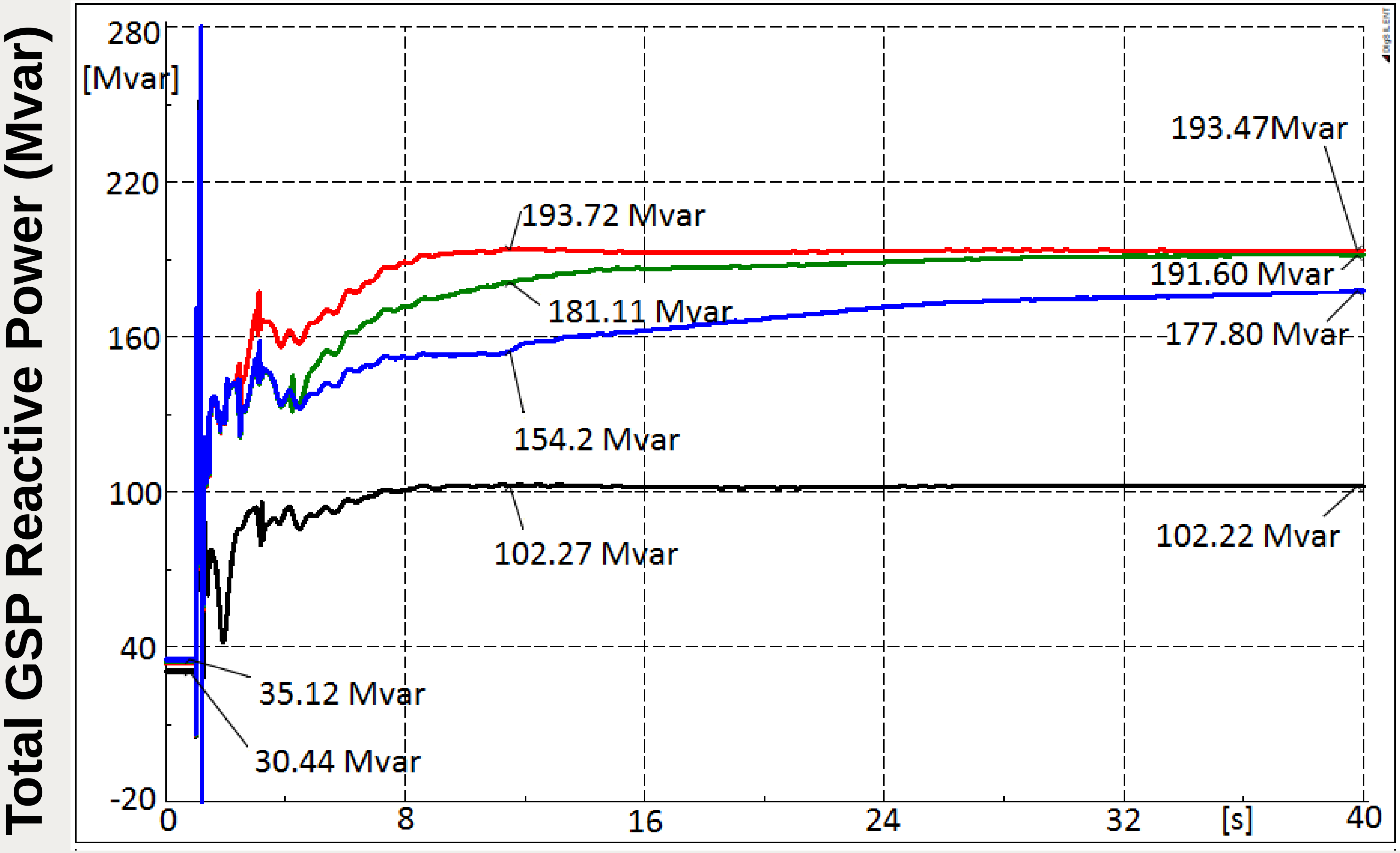
DER in Power Potential

Simulation results – modelling considerations



- Critical contingency leading to a low voltage scenario.
- Double circuit outage: Kemsley-Canterbury and Kemsley-Cleave Hill disconnected 140ms after a three-phase rigid fault.

Simulation results – response to a critical contingency



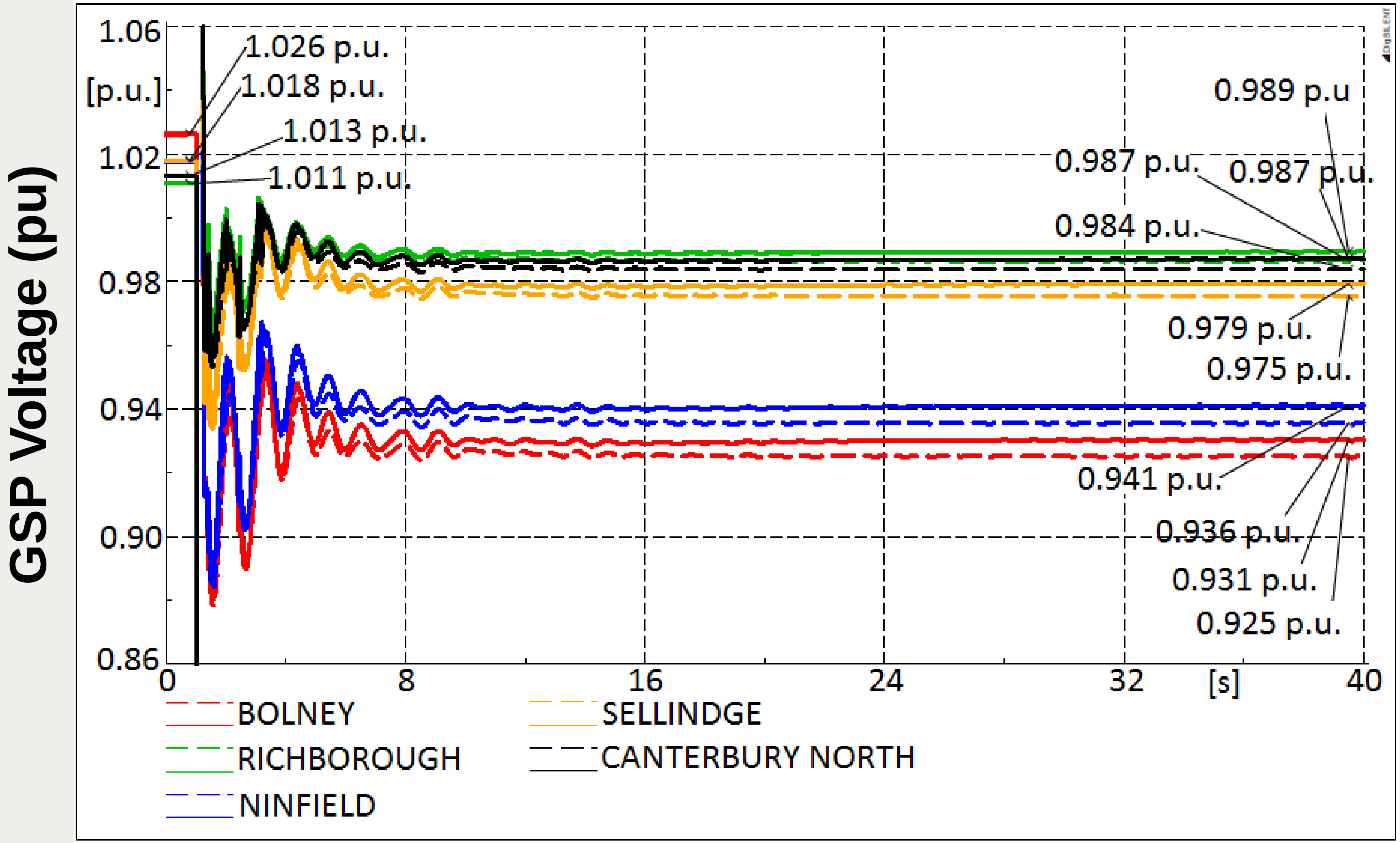
Without Power Potential

Power Potential (1 s delay)

Power Potential (3 s delay)

Power Potential (10 s delay)

Simulation results – response to a critical contingency



Bol.: without PP (- - -), with PP (——)

Ninf.: without PP (- - -), with PP (——)

Sell.: without PP (- - -), with PP (——)

Cant: without PP (- - -), with PP (——)

Rich: without PP (- - -), with PP (——)

Tatiana Ustinova

Power Potential Technical Coordination, UK Power Networks

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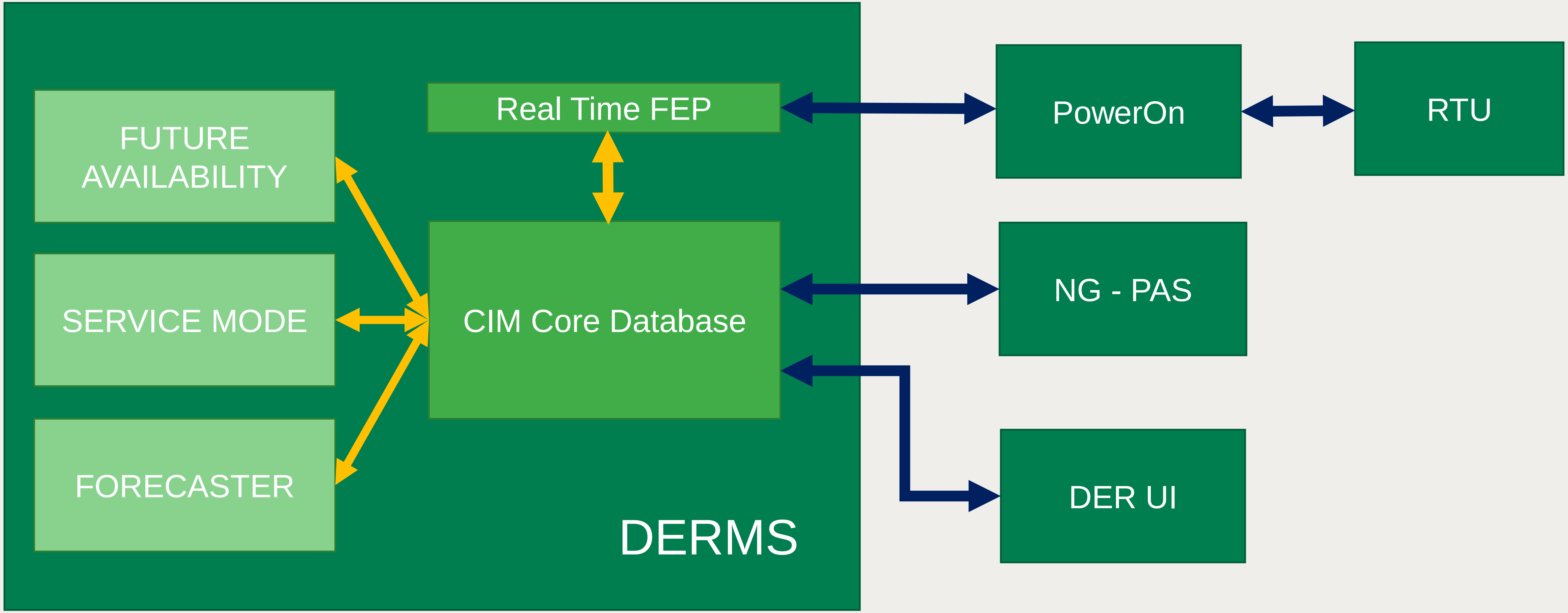
Power Potential functionality recap

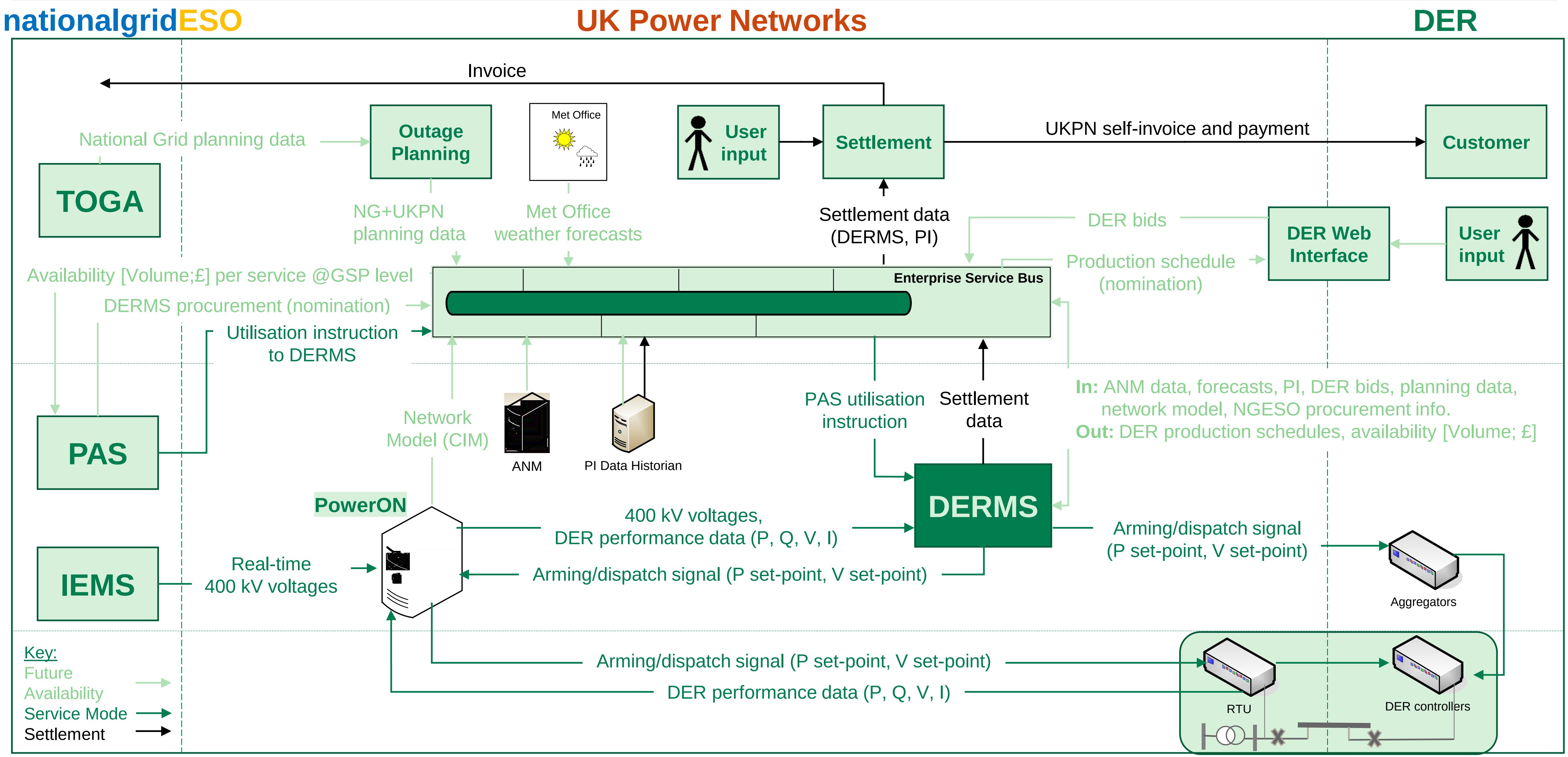
	Future Availability	Service Mode	Settlement
Objectives	DER bid for service(s) DERMS predicts available P and Q volumes NGESO procures service for the next day	NGESO dispatches DERMS DERMS dispatches DER DERMS controls DER, monitors DER performance and distribution network	Estimate DER performance (volume and cost) Invoice NGESO Pay DER
Time horizon	Day ahead	Delivery day (real time)	Once a month

DERMS technical solution

Distributed Energy Resources Management System



Power Potential IT Architecture: Existing interfaces & systems



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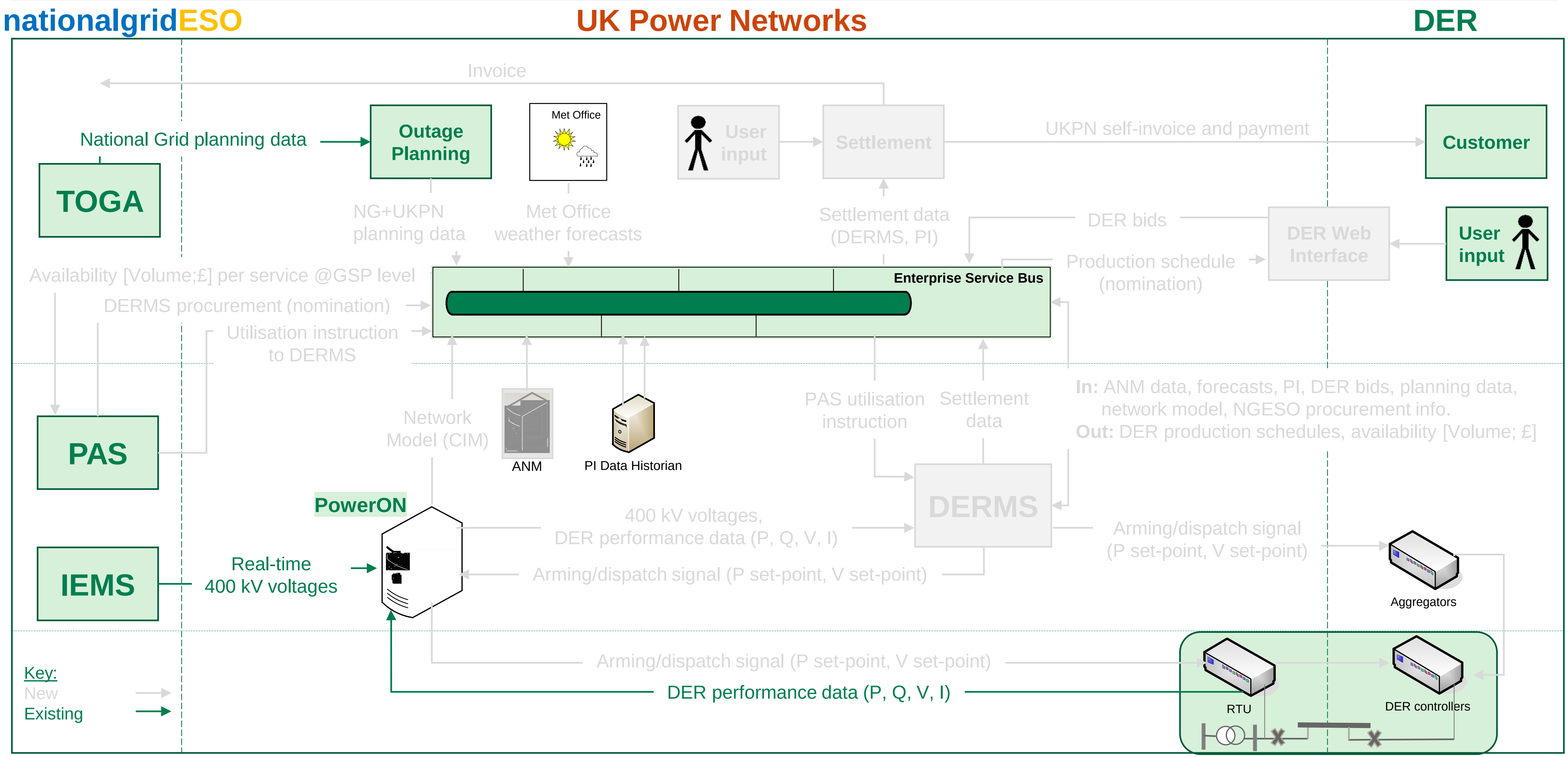
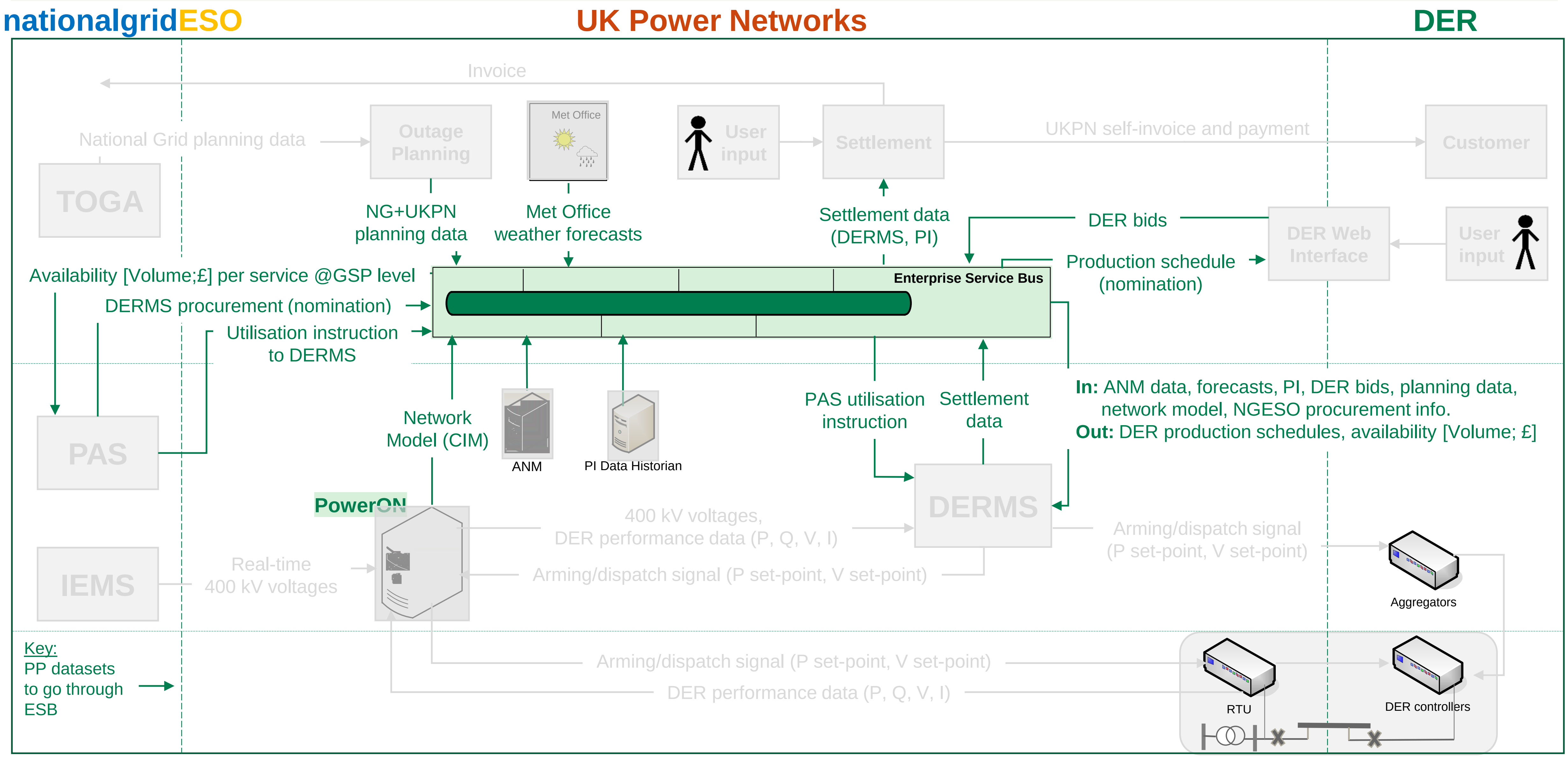
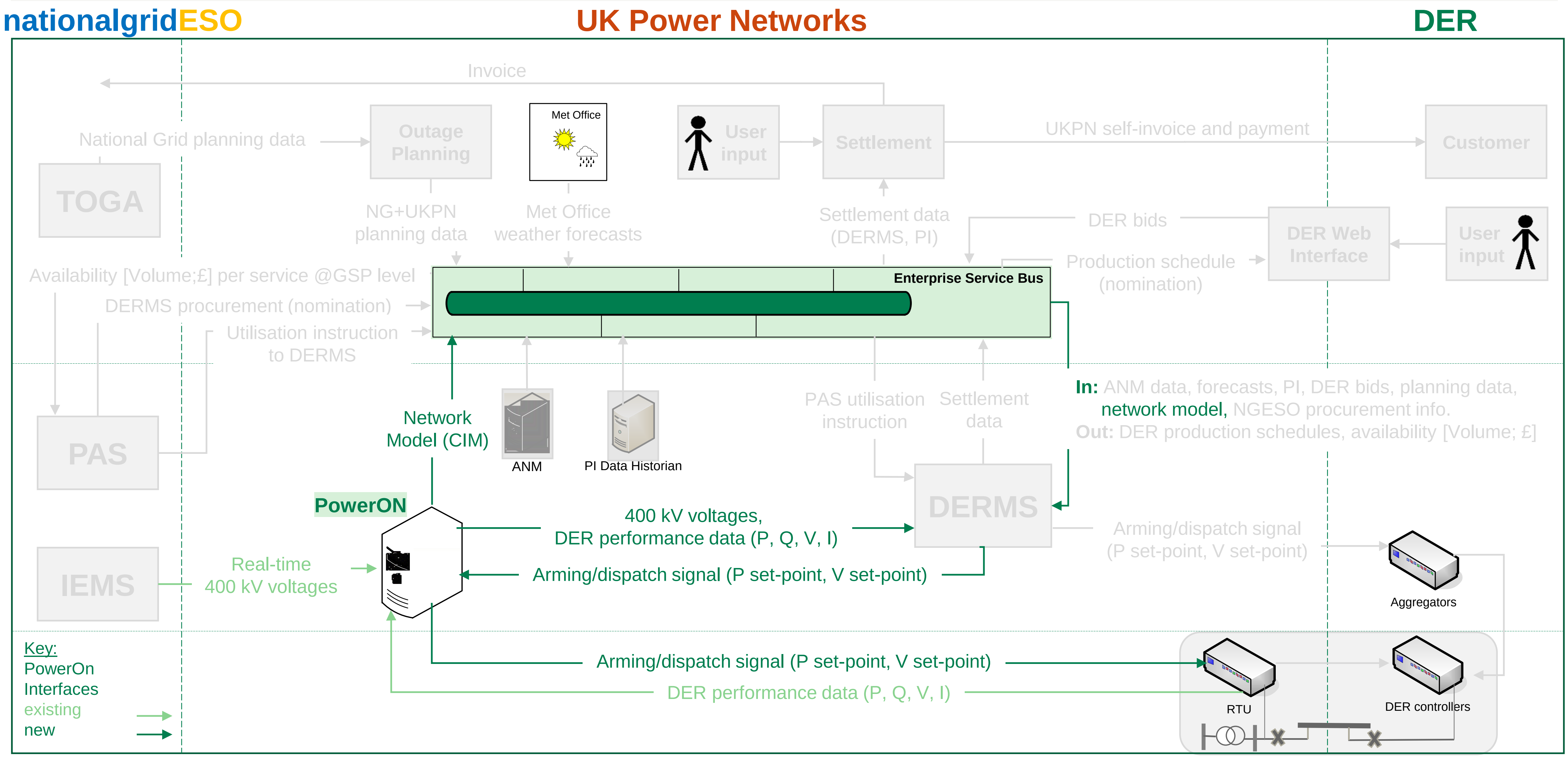


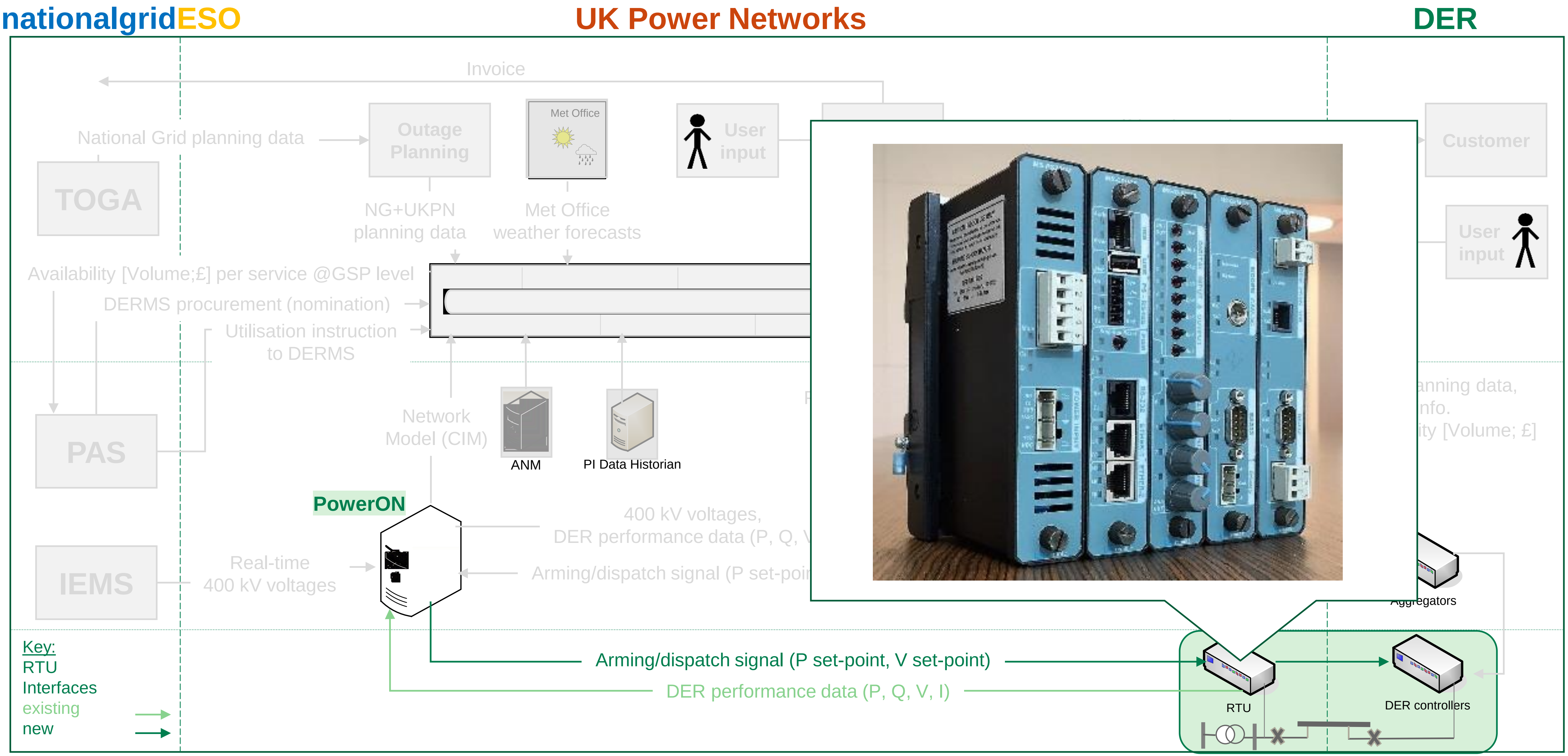
Key Integration Activities: Enterprise Service Bus (ESB)



Key Integration Activities: PowerOn



Key Integration Activities: Remote Terminal Unit (RTU)



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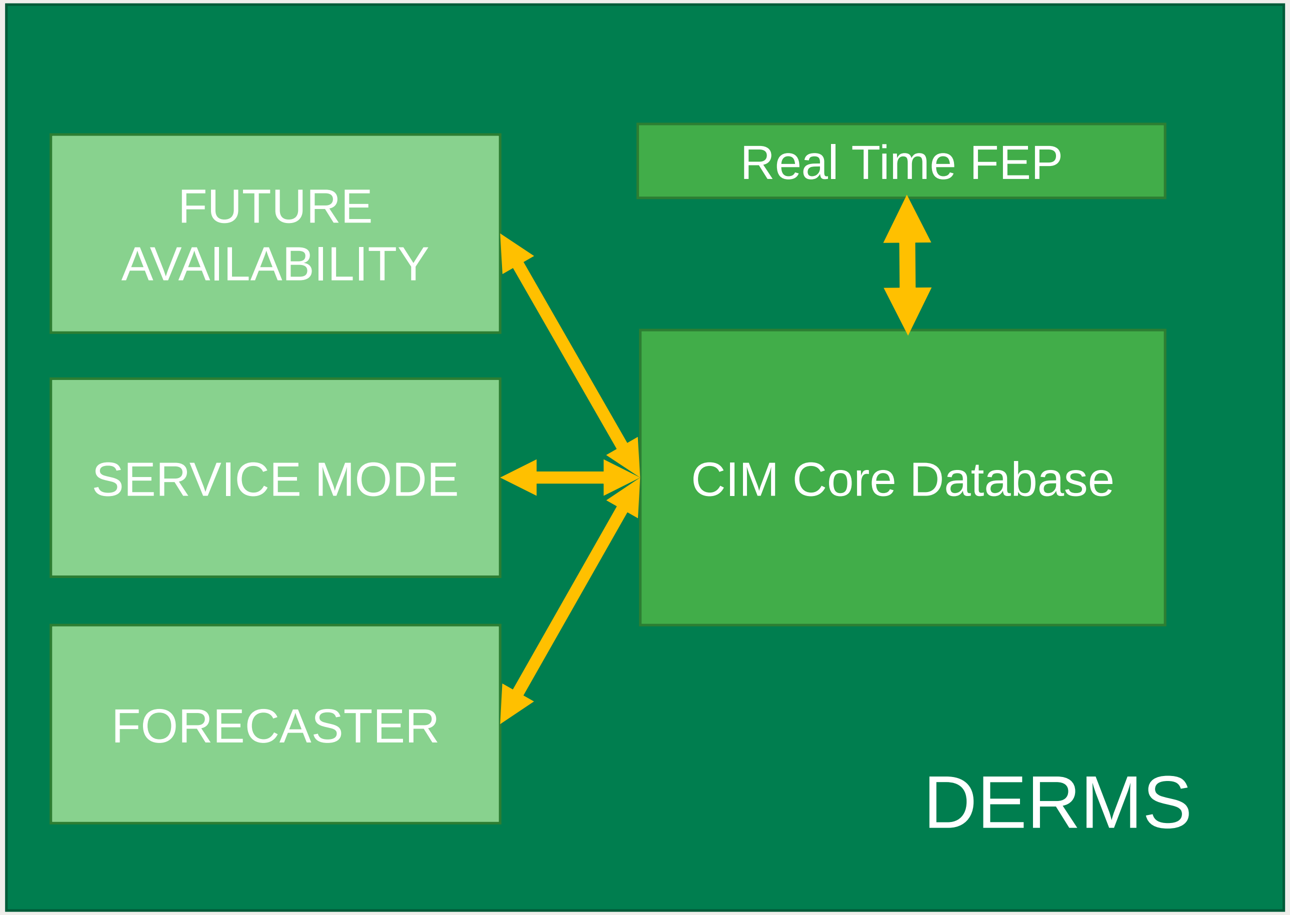
Testing Process: Developer’s internal testing

Developer’s internal testing

Objective	DERMS components work separately & together
Who involved	ZIV Automation

TESTING: Developer's internal testing



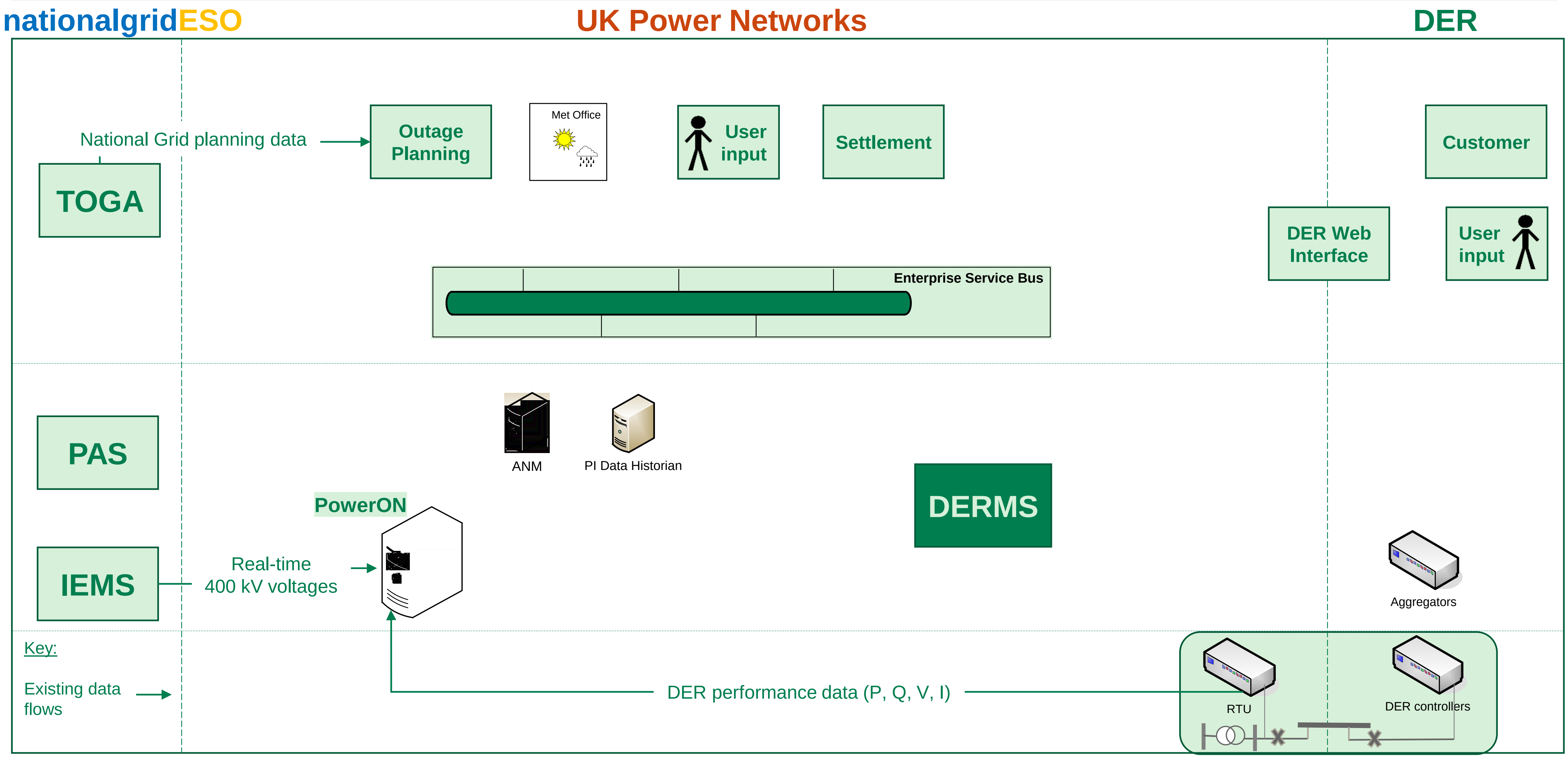
Testing Process: Factory Acceptance Testing (FAT)

	Developer’s internal testing	FAT
Objective	DERMS components work separately & together	DERMS satisfies functional requirements
Who involved	ZIV Automation	NG & UKPN project teams

Testing Process: Site Acceptance Testing (SAT)

	Developer's internal testing	Factory Acceptance Testing (FAT)	**SAT**
Objective	DERMS components work separately & together	DERMS satisfies functional requirements	DERMS installed correctly
Who involved	ZIV Automation	NG & UKPN project teams	UKPN IT team

TESTING: Site Acceptance Testing (SAT)

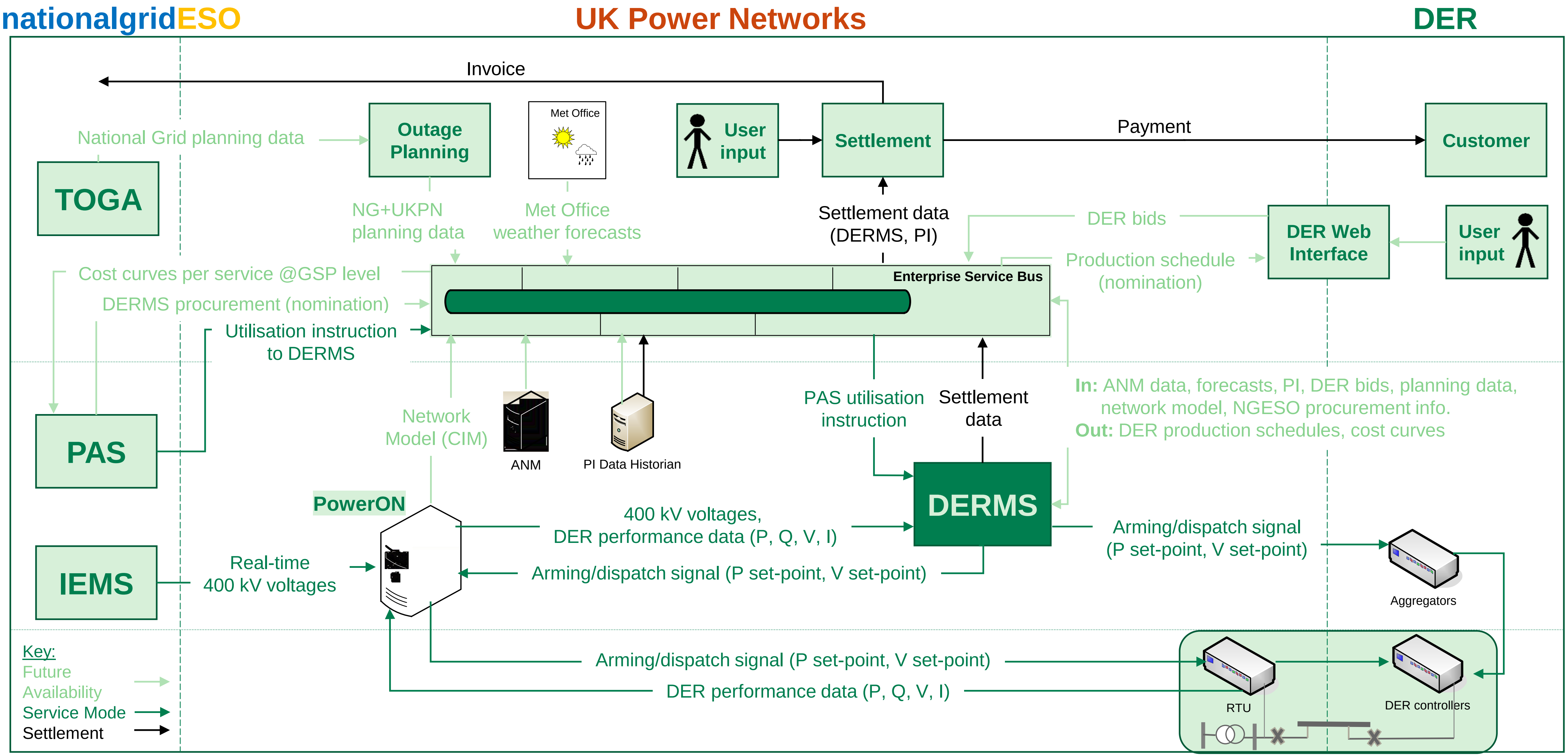


Testing Process: System Integration Testing (SIT)

Developer's internal testing	Factory Acceptance Testing (FAT)	Site Acceptance Testing (SAT)	SIT

Objective	DERMS components work separately & together	DERMS satisfies functional requirements	DERMS installed correctly	Interfaces are designed & working correctly
Who involved	ZIV Automation	NG & UKPN project teams	UKPN IT team	NG & UKPN IT teams

TESTING: System Integration Testing (SIT)



Testing Process: User Acceptance Testing (UAT)

Developer's internal testing → Factory Acceptance Testing (FAT) → Site Acceptance Testing (SAT) → System Integration Testing (SIT) → **UAT**

	Developer's internal testing	FAT	SAT	SIT	UAT
Objective	DERMS components work separately & together	DERMS satisfies functional requirements	DERMS installed correctly	Interfaces are designed & working correctly	PP solution satisfies requirements
Who involved	ZIV Automation	NG & UKPN project teams	UKPN IT team	NG & UKPN IT teams	NG & UKPN project teams, DER

Testing Process: Operational Acceptance Test (OAT)

	Developer's internal testing	Factory Acceptance Testing (FAT)	Site Acceptance Testing (SAT)	System Integration Testing (SIT)	User Acceptance Testing (UAT)	OAT + NFT	
Objective	DERMS components work separately & together	DERMS satisfies functional requirements	DERMS installed correctly	Interfaces are designed & working correctly	PP solution satisfies requirements	Sign-off by NG & UKPN control engineers	PP solution performance, security, reliability
Who involved	ZIV Automation	NG & UKPN project teams	UKPN IT team	NG & UKPN IT teams	NG & UKPN project teams, DER	NG & UKPN business stakeholders	NG & UKPN IT teams

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DER journey to the trials

DER

Hardware and software upgrade

DER + UKPN


Framework Agreement


Connection Agreement

DER commissioning tests

Commissioning certificate

UKPN

RTU logic upgrade

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Lessons learned so far & observations

- Collaboration between two network companies with different philosophies and cultures is crucial.
- Keeping the lights on remains a priority.
- Need to prove both technical and market based solution.
- Exploring the needs of potential trial participants is a key to success.
- Cyber security, confidentiality and access to data are challenges to overcome.

Thank you for listening!

Any questions?

Biljana Stojkovska – Dr.Biljana.Stojkovska@nationalgrid.com
National Grid ESO

Inma Martínez – Inma.Martinez@nationalgrid.com
National Grid ESO

Tatiana Ustinova – Tatiana.Ustinova@ukpowernetworks.co.uk
UK Power Networks

General queries: box.PowerPotential1@nationalgrid.com

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