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Voltage Management

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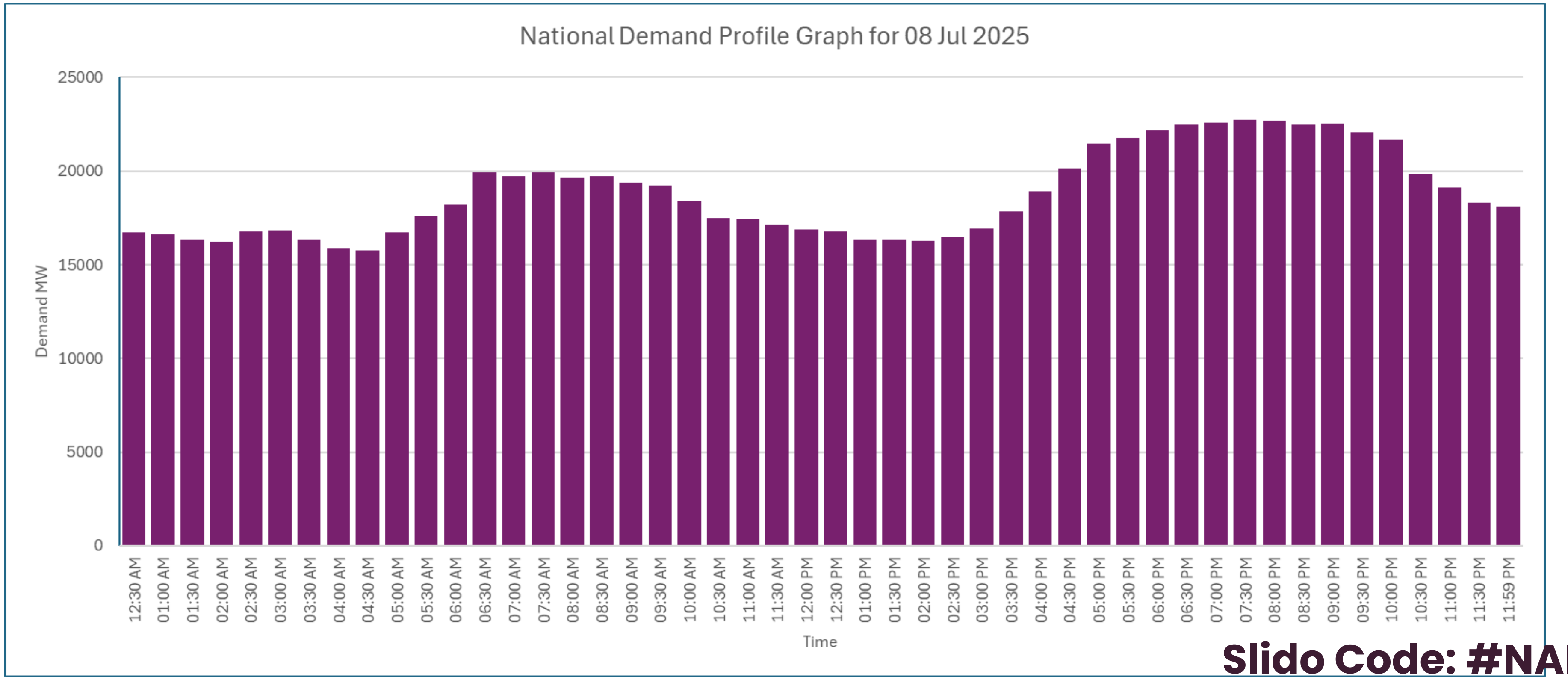
Typical day

- High voltages occur during minimum power flow conditions, (i.e typically overnight, but also during sunny mid-day)
- Reduced generation and lightly loaded circuits increase system voltage sensitivity (system gain).



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Cause of high voltages

Changes have been seen in demand and generation over the last 15 years that have an influence on system voltages making voltage management more challenging.

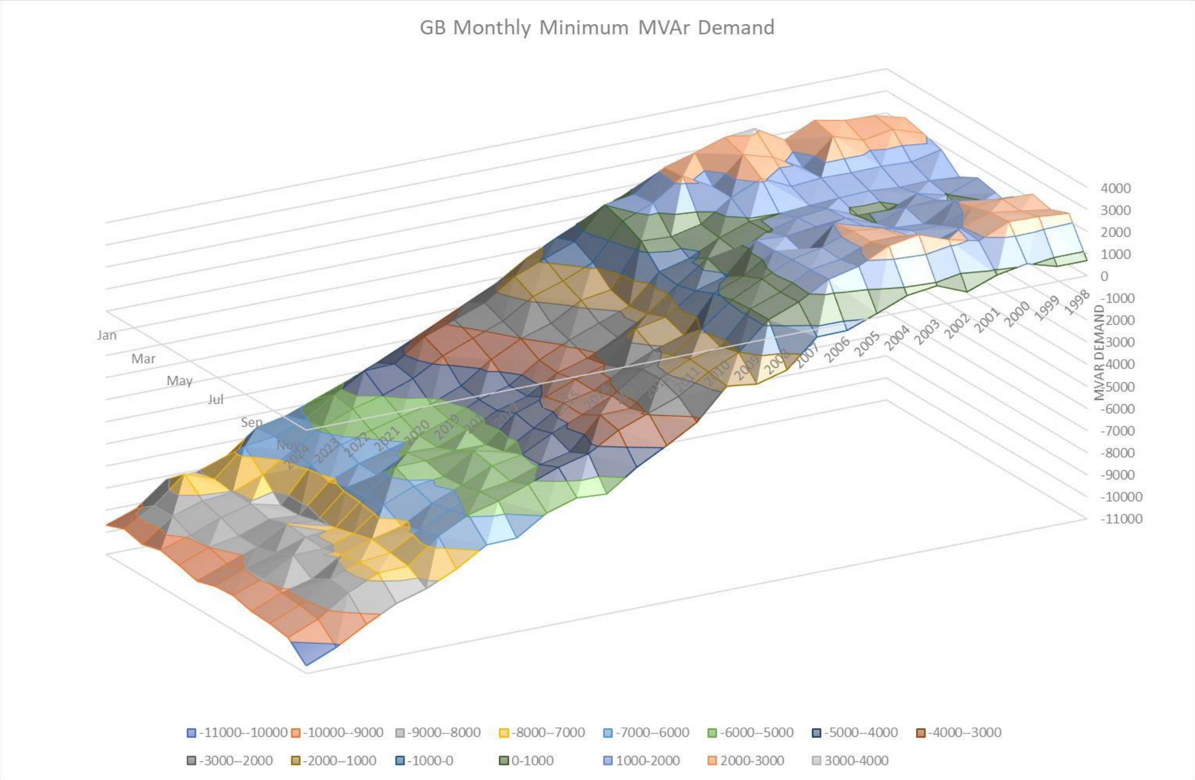
Demand:

Historically, transmission demand was heavily inductive that in the last 10-15 years has reduced significantly and become largely capacitive

Distribution networks now often export reactive power to the transmission system, especially overnight.

Generation Mix:

Change from large conventional synchronous plants to less flexible or embedded generation within distribution networks.



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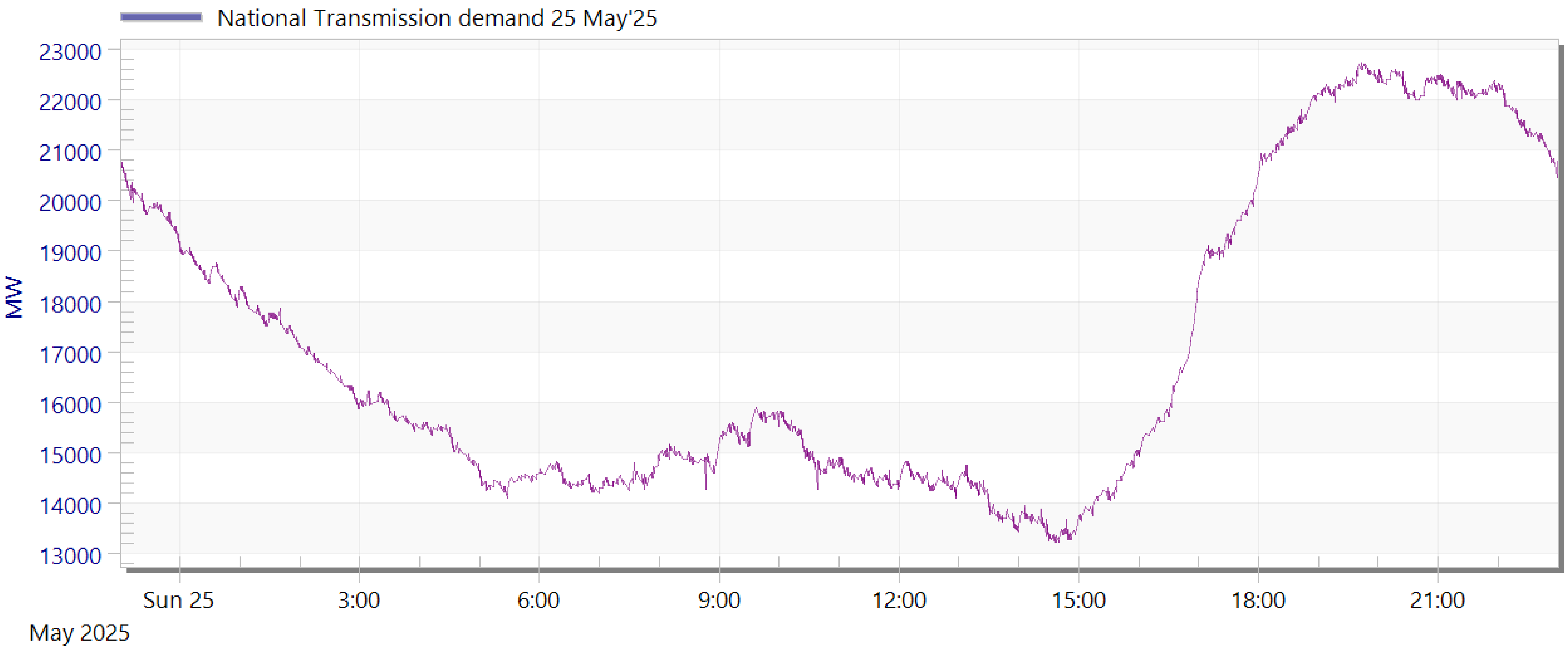
Overnight and High PV days 25th May



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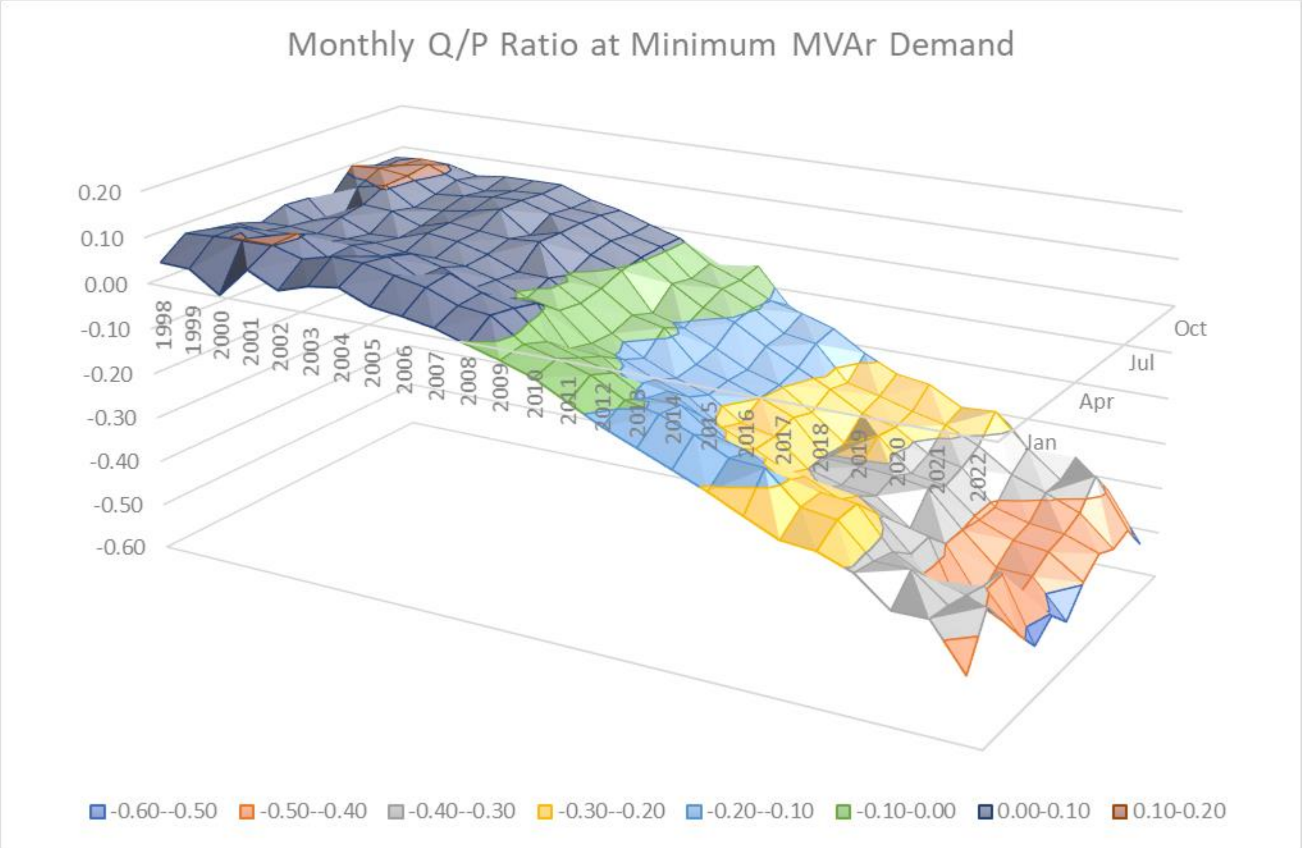
Demand Q/P ratios also exhibiting a decline

- This graph shows the ratio of reactive to real power demands at GSP level.
- Similarly, to the MVAr curve, there still appears to be a steady decline.



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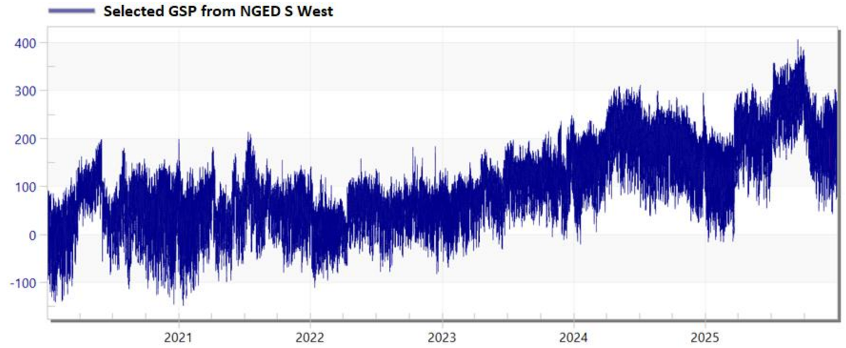
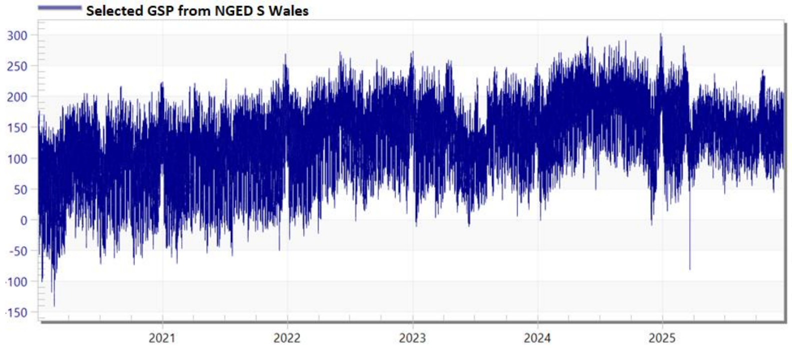
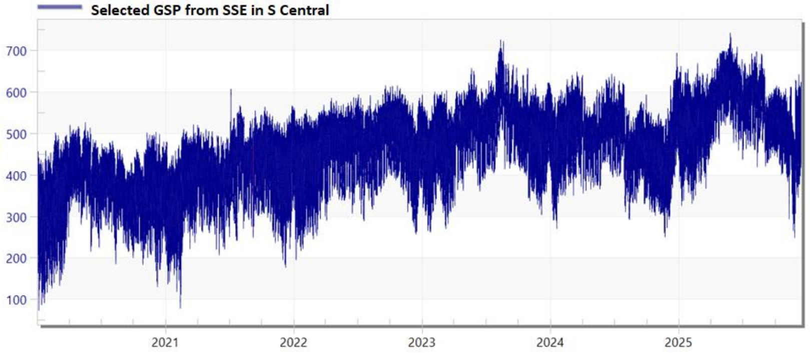
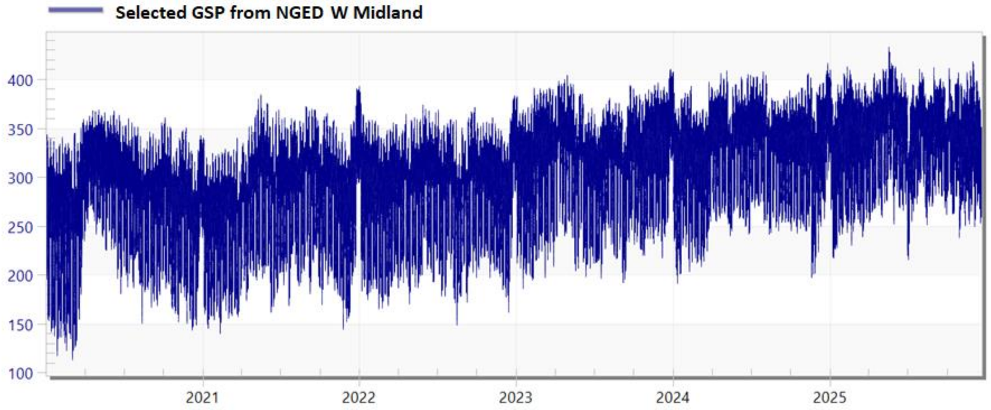
Cause of high voltages

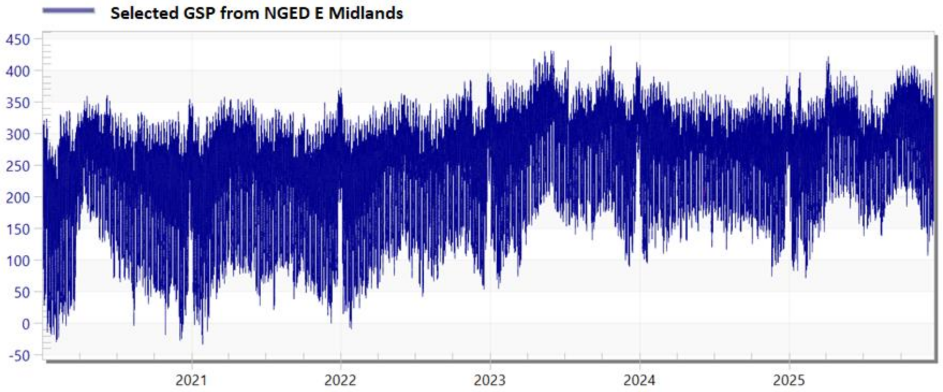
Over the years reactive power injection (LV to HV) from GSP increased as shown











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Why manage high voltages?

Need to maintain system voltages within limits set out in:

- Electricity Safety, Quality and Continuity Regulations
- Grid Code
- Security and Quality of Supply Standard
- /!\ SAFETY /!\ -the bottom line is the safe operation of the system
- Voltages in excess of equipment ratings can damage equipment and cause flashovers
- Management of other voltage constraints, such as voltage stability, are normally considered through other processes

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Deriving the Voltage Plan

Identify the Minimum Plant Requirement

Minimum plant is the minimum of BM plant required (with good MVAr range) to maintain voltage within standards at all times (pre-and post-fault).

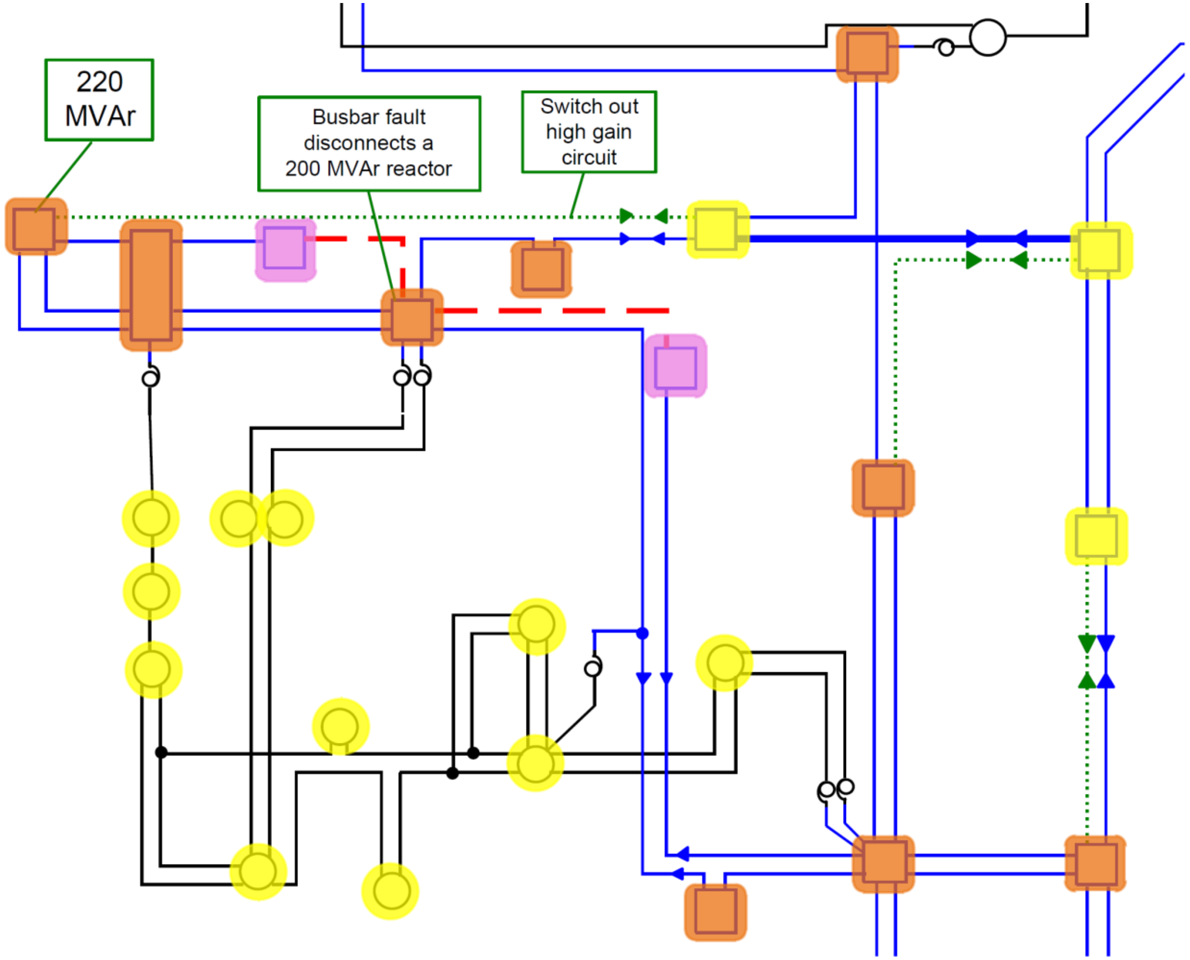
The definition of plan that is not operable is one where there is no action that can be taken to ensure all pre and post fault voltages are within standards. A plan may be considered in-operable if:

- The only BM plant that will resolve an issue is unavailable.
- There is no effective BM plant on an area to resolve the problem.
- More generation is required at SEL than the likely minimum demand.

Voltage Assessment

We have to consider voltages pre-fault (or N-state) and post-fault voltages, following secured events. General process is:

- Pre-fault: identify locations where additional reactive power absorption, or other actions, may be required to reduce voltages within limits
- Run contingency analysis to identify voltages outside limits post-fault
- Identify locations where additional reactive power absorption/other actions may be required to reduce post fault voltages within limits
- Repeat the above until all voltage issues are resolved and reactive requirement is optimised



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Voltage Assessment

The fundamental physics of AC power systems means that the effect of reactive power flows on system voltage and vice versa is localised.

Therefore voltage requirements are based on zonal requirement.

Requirement in zones is given by number of BMU required.

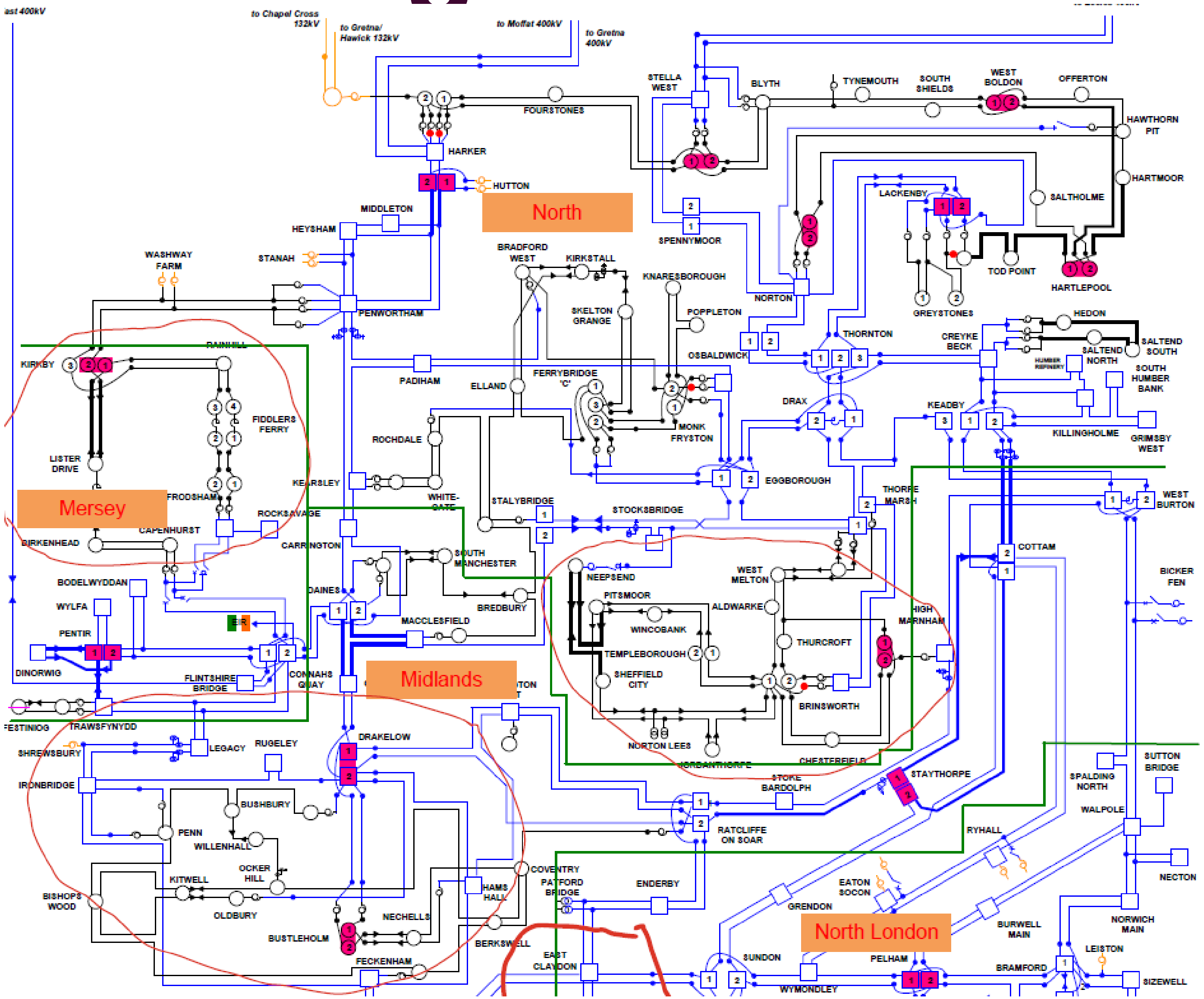
- This identifies where there is a need to access BMU with MSAs which can provide the required level of reactive compensation to supplement TO provided equipment.

Transmission outages can have an impact on the boundary of a zone where reactive power providers sit close to the boundary.

- If a circuit is taken on an outage which disconnects a provider from their usual zone, this can greatly reduce their effectiveness within that zone, yet increase their effectiveness in the neighbouring zone.

Significant changes in generation availability or running can also change the requirement in a zone, as there is interaction between adjacent zones.

Areas with voltage issues - North



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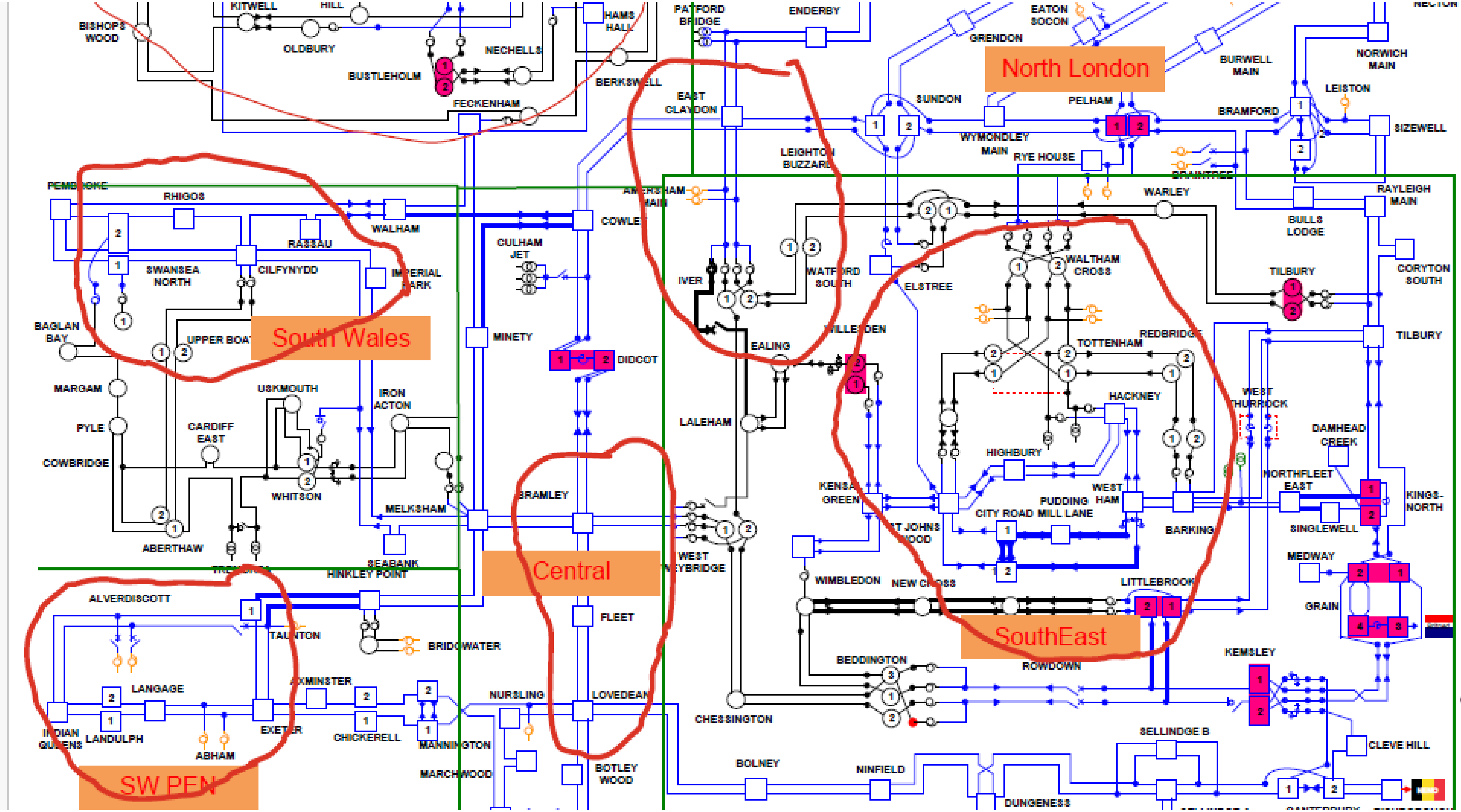
South East and South West



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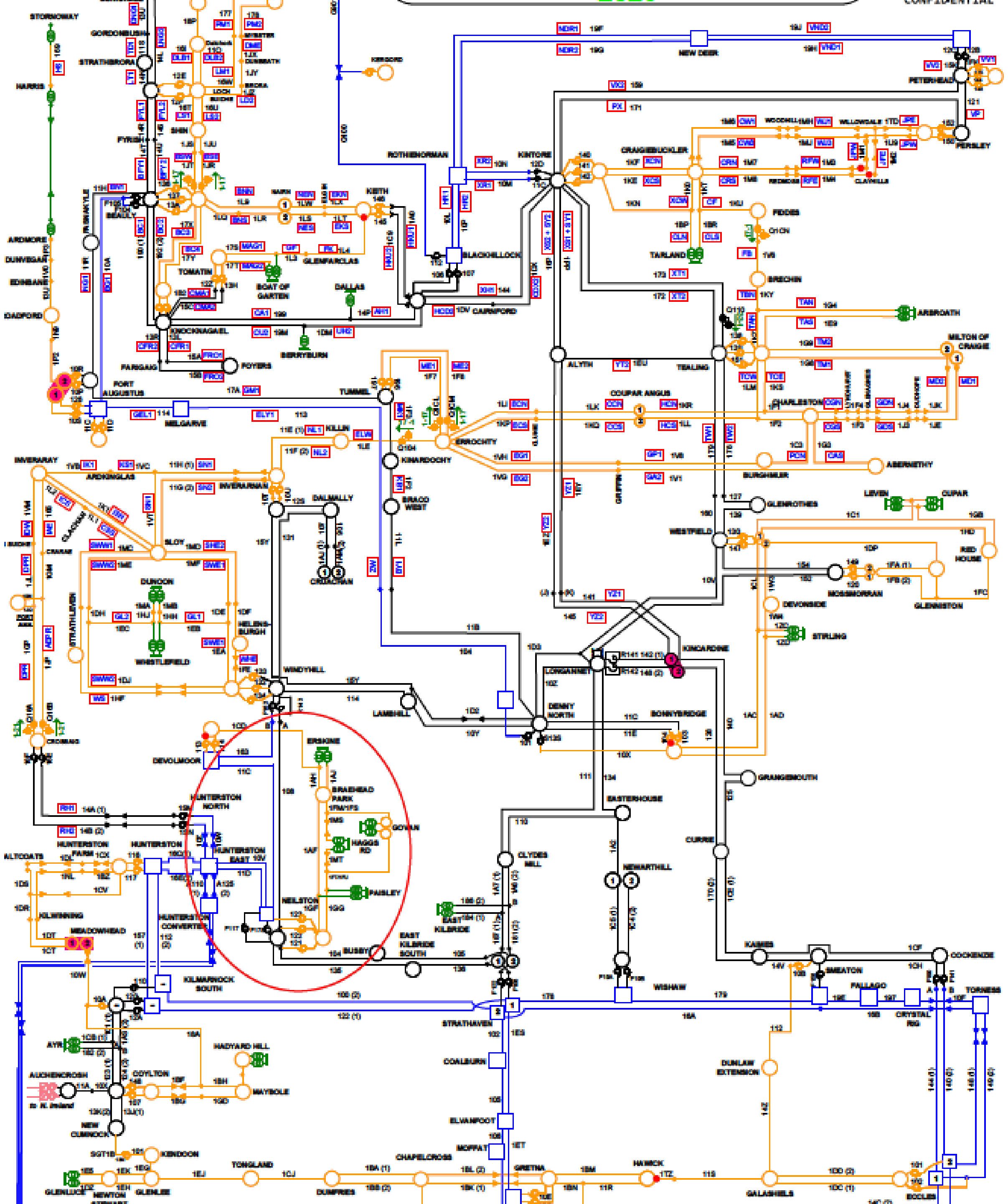
Scotland



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How do we manage voltage in real-time?

To manage voltage effectively, voltage profile is suppressed after evening peak demand and following process are applied:

- Switching out shunt capacitors and switching in shunt reactors
- Switching out Voltage Control Circuits (sometimes leaving these out even during daytime if system condition permits)
- Adjusting targets on all available SVCs, STACOMs & sync comps on NETS including onshore TO/OFTO and I/C
- Carry out simultaneous tap operation across GB which provides maximum benefit
- Run additional BM plant if required
- Tap stagger on supergrid transformer as a last option

During summer period voltage control is very challenging, and voltage profile is kept low during daytime as well to arrest the gain

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Why the Voltage Task Force?

Purpose:

Address urgent voltage management risks and prevent breaches of SQSS standards.

Approach:

Form a cross-functional NESO task force for short, medium, and long-term solutions.

- Higher voltages from low demand, embedded generation, changing flows.
- Recent issues: Two reportable high voltage events in 2025
- High number of voltage events observed in 2025, increasing.
- Immediate and medium-term actions required.
- Task Force established to coordinate solutions across NESO, DNOs, TOs, and market.
- Significant generation synchronisation cost impact

What's driving the challenge?

KEY DRIVERS	IMPACT
Lower transmission demand	Higher voltage levels on lightly loaded lines
High embedded generation and cabling	Increased MVAr transfer from distribution to transmission
Delayed network development	Limited compensation equipment availability
Planned generator outages	Reduced reactive support during critical periods
Unavailability of reactive assets	Restricted ability to manage voltage locally

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Task Force Scope & Focus Areas

Transmission	Distribution	Modelling	Internal Processes
• Reactive equipment prioritisation • Optimise network topology • Generator availability • Voltage control circuits • Automated sequential switching	• Enable DSO-level reactive management • Cable switching • Voltage set points • DER power factor • Improve DER visibility	• Align with real-time • Re-baseline models • Introduce reasonable-worst-case adjustments • Integrate AI/ML for demand forecasting	• Strengthen analysis • Track delivery • Identify study gaps • Enhance emergency guidance

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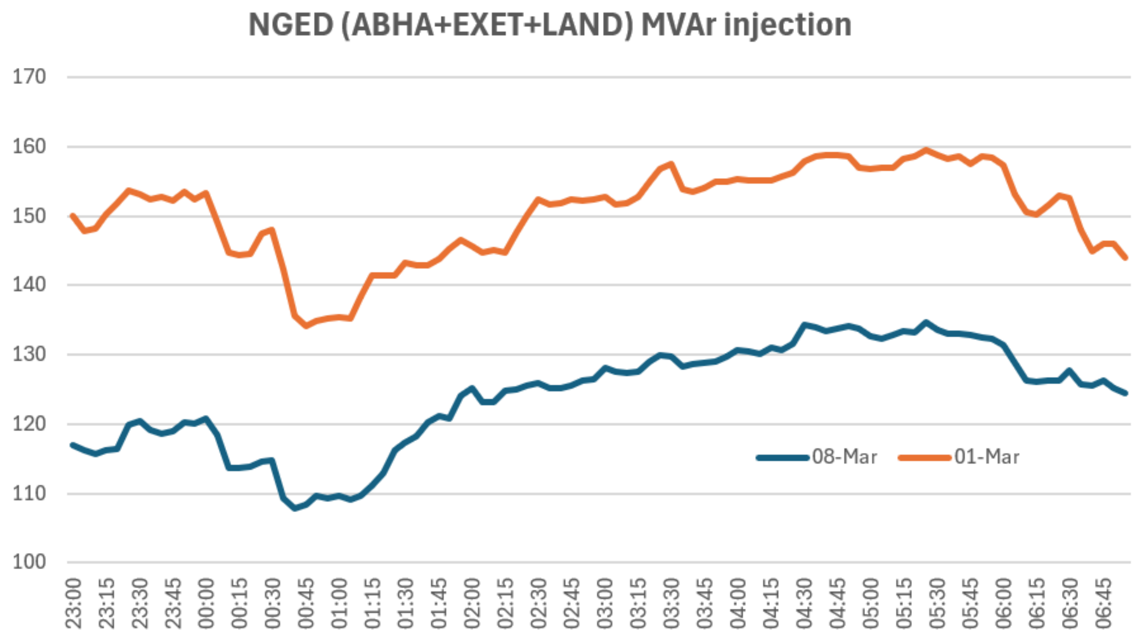
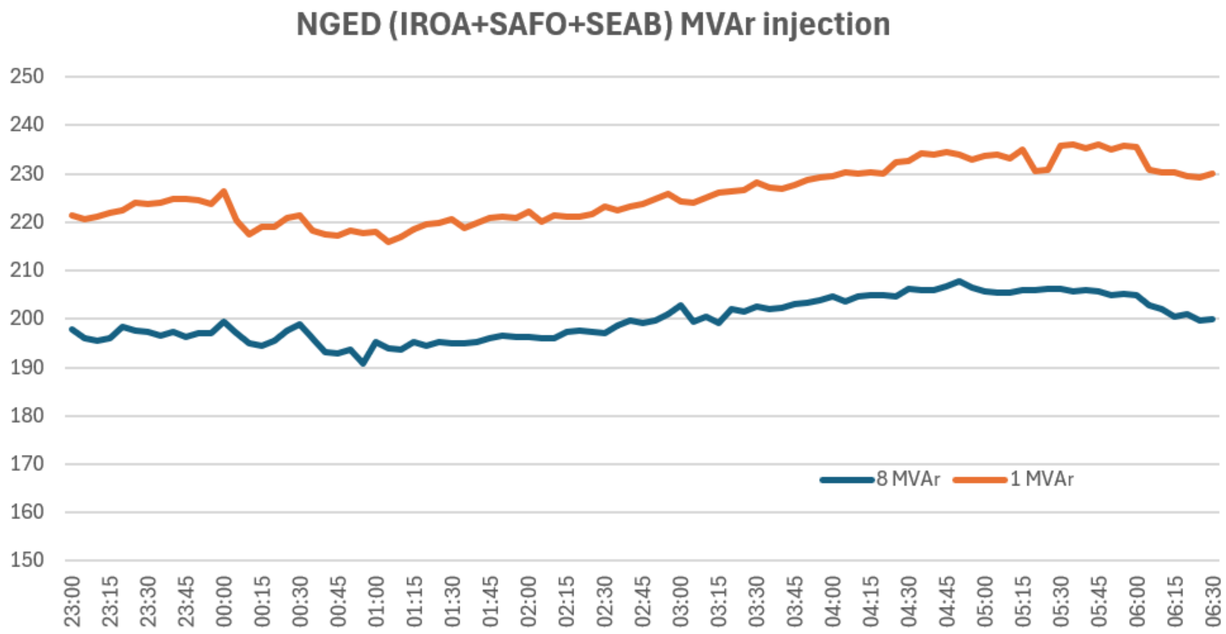
RIOT1 with NGED S West

Reactive Injection Operability Trial

On 8th March, NESO together with NGED S West carried out a Reactive-power Injection Operability Trial. During this trial, selected circuits on LV transmission system were switched out for overnight, resulting in lower injection from the selected GSP group:





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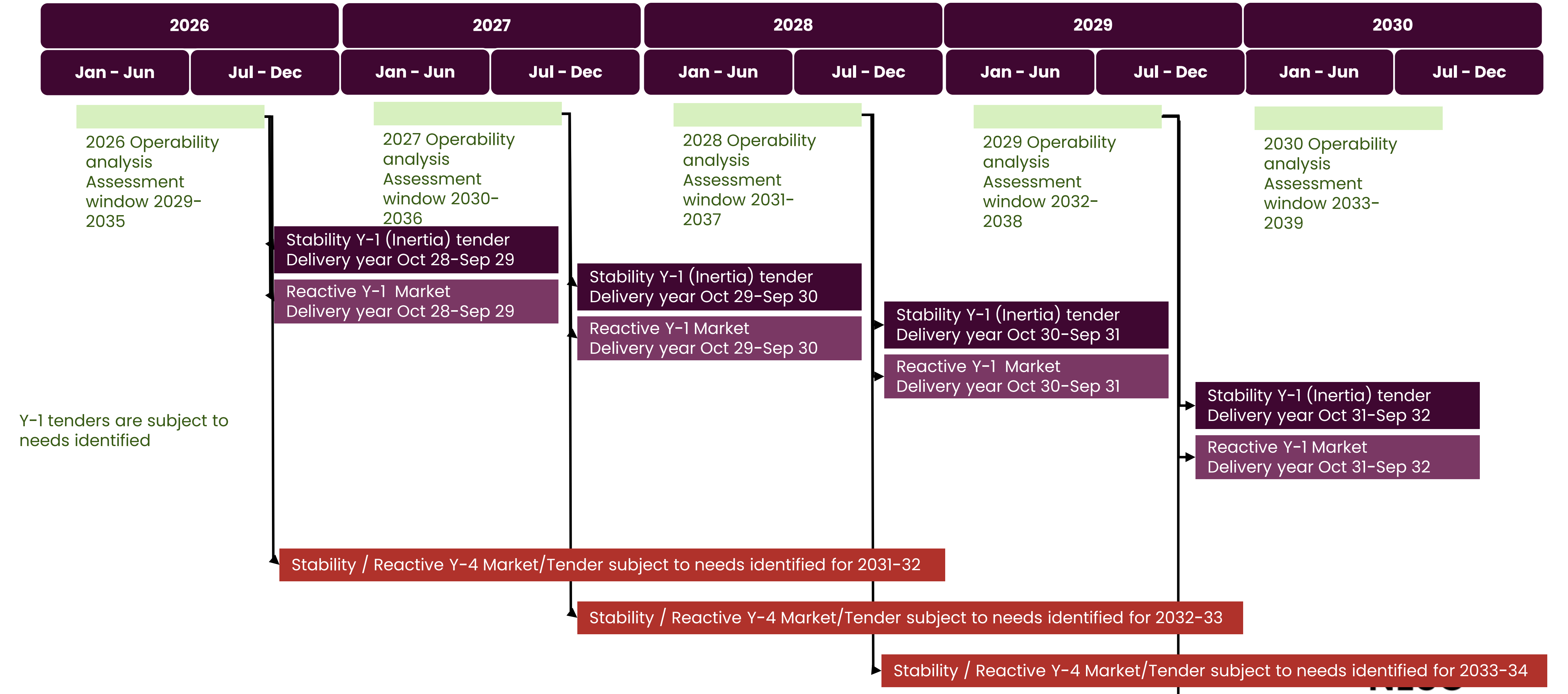
Long Term Operability Needs Process



Operability analysis = An annual process assessing voltage and stability (inertia and min SCL) needs for 3-10 yr period.

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What was the intended function of each Reactive Power Market?

Each market has its own discrete purpose:

	Long-term market	Mid-term market	Short-term market
Purpose	**BUILD** CAPACITY	**UNLOCK** CAPACITY	**OPTIMISE** CAPACITY

For more detail on our reactive power markets, please see our website.

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