System Operability Framework

Post-assessment Results Webinar – 22nd/27th September 2016

Patrick Cassels and William Ramsay

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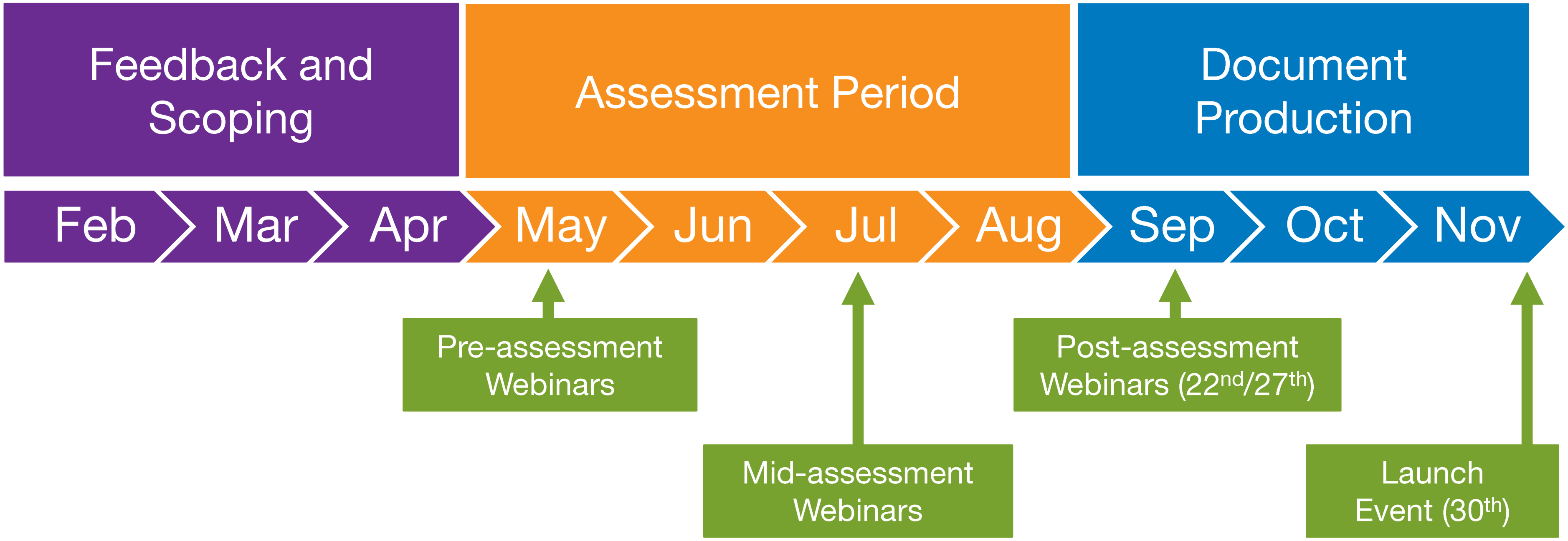
Progress Update



Introduction

System Balancing

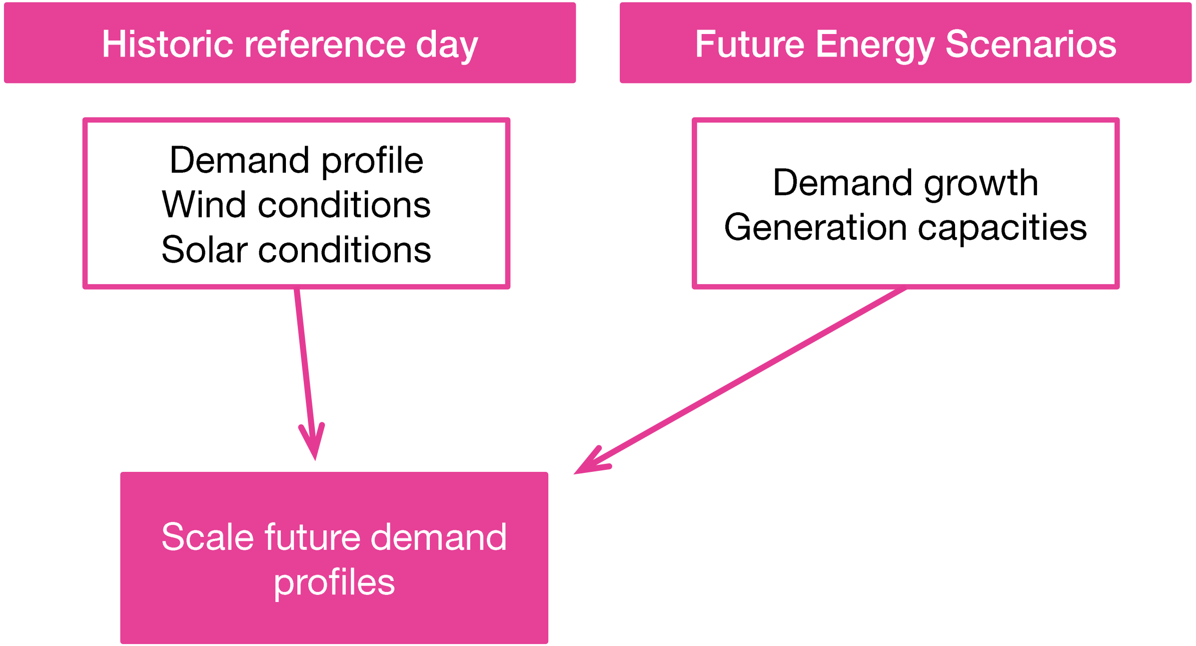
- Frequency Management
- Voltage Management
- Whole System Coordination

Normal Operation
Undisturbed system

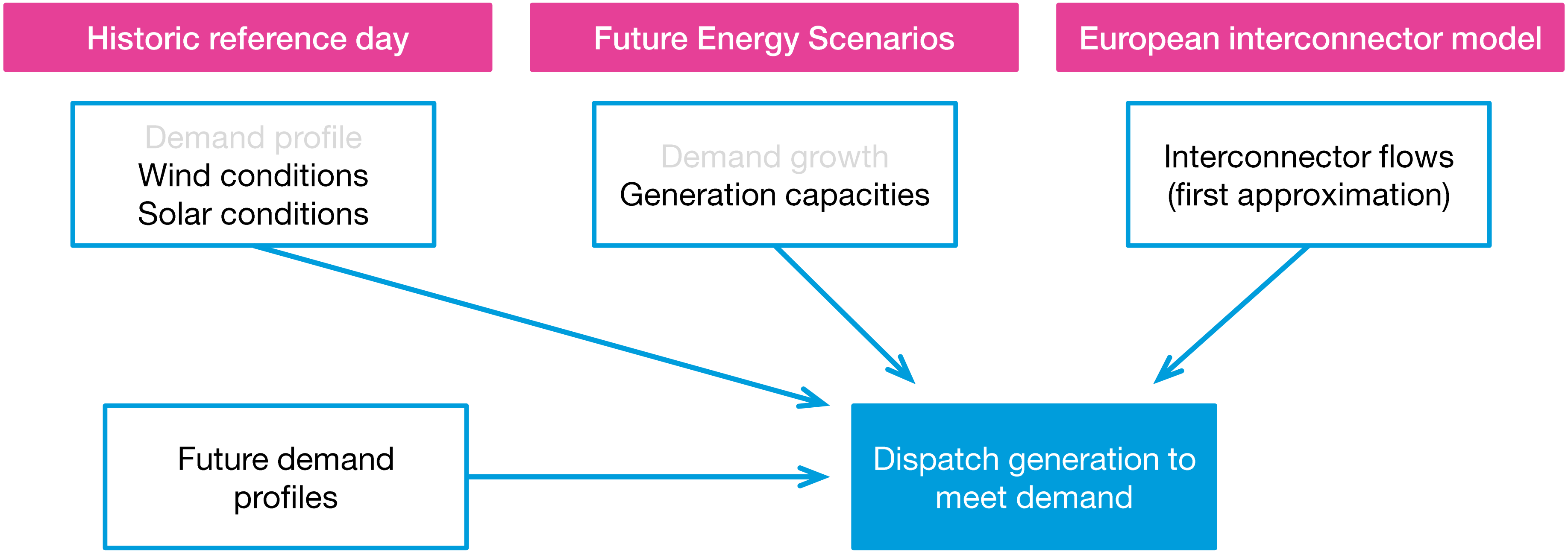
Post-event Operation
Disturbed system
(e.g. after a loss or fault)

- System Balancing is a new area which addresses within day balancing over the next 10 years
- It matches generation and demand within day to a half-hour resolution to provide a credible view of unit dispatch
- A number of sensitivities have been explored
- It enables us to answer three questions across our core operability topics:
  - What is the requirement?
  - How often it is required?
  - How does it change over time?

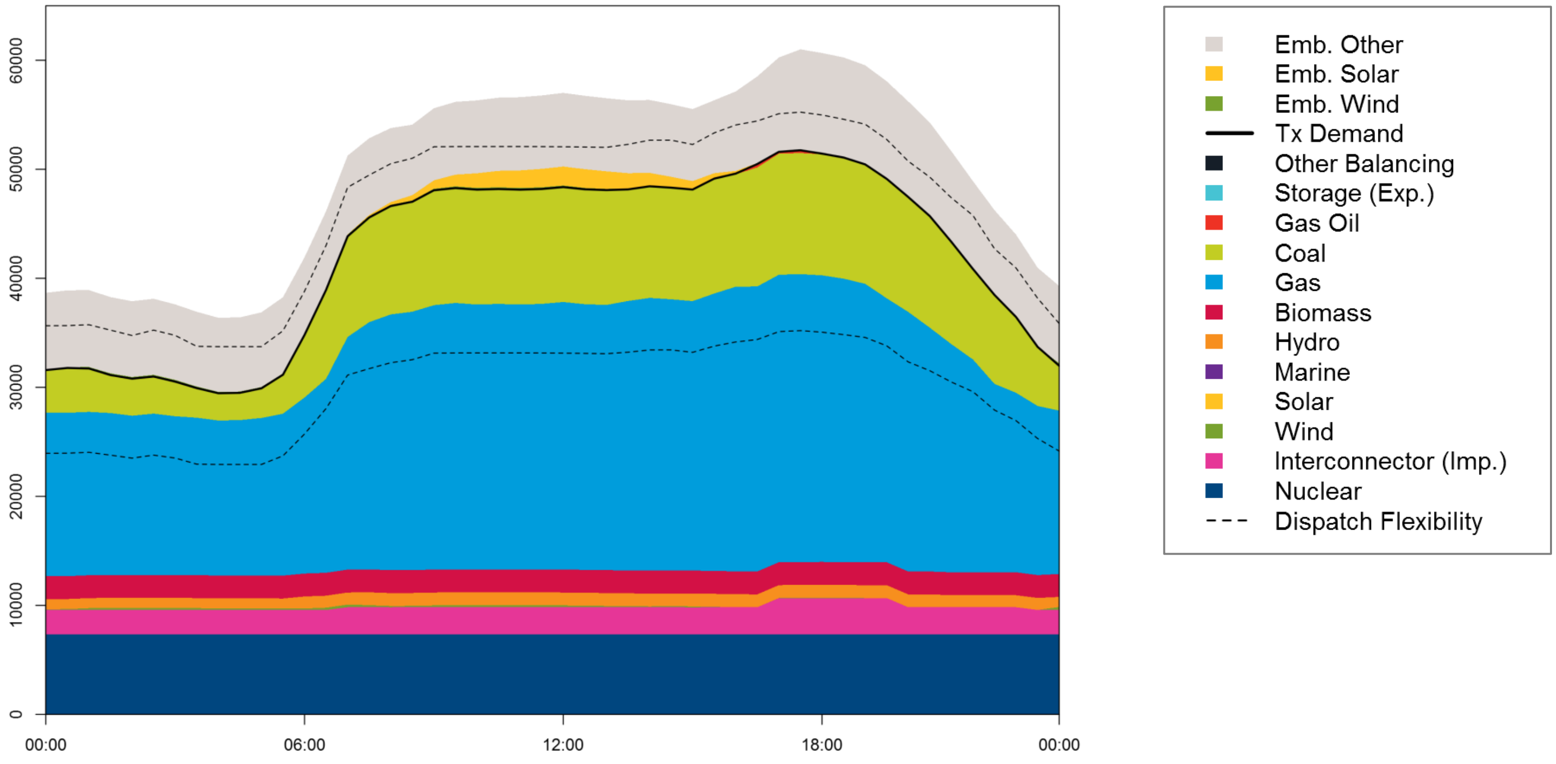
System Balancing Method



System Balancing Method



Winter Peak – No Progression



Winter Peak – No Progression

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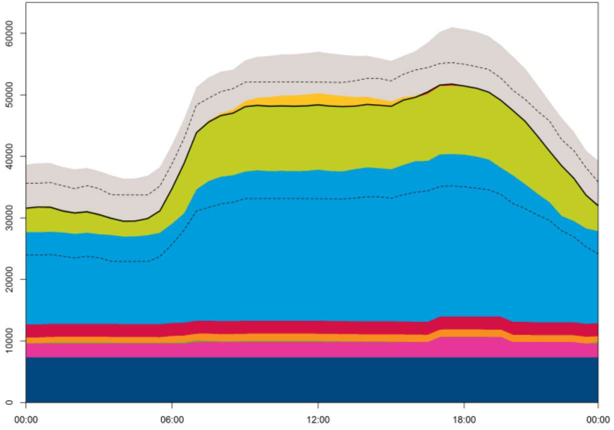
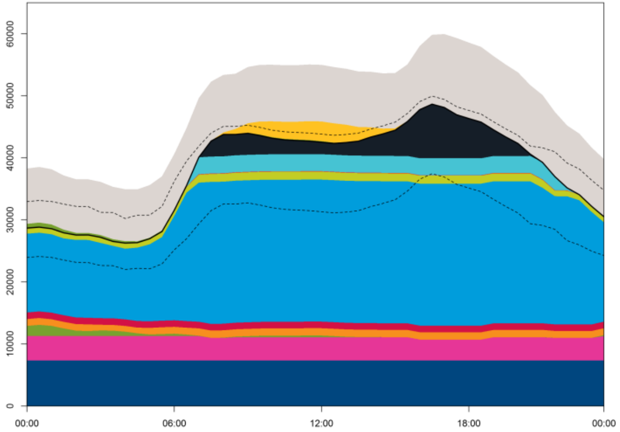
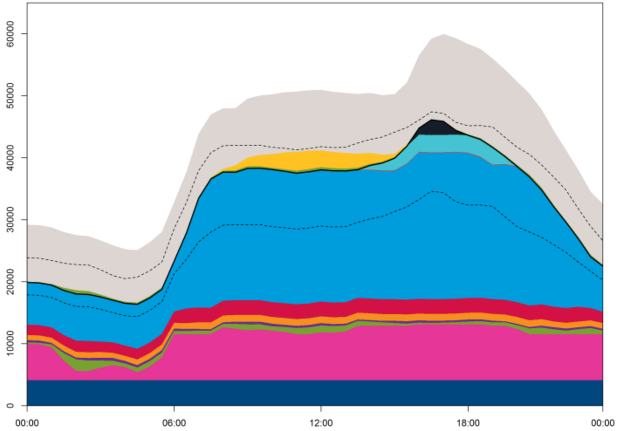
2016/17



2020/21

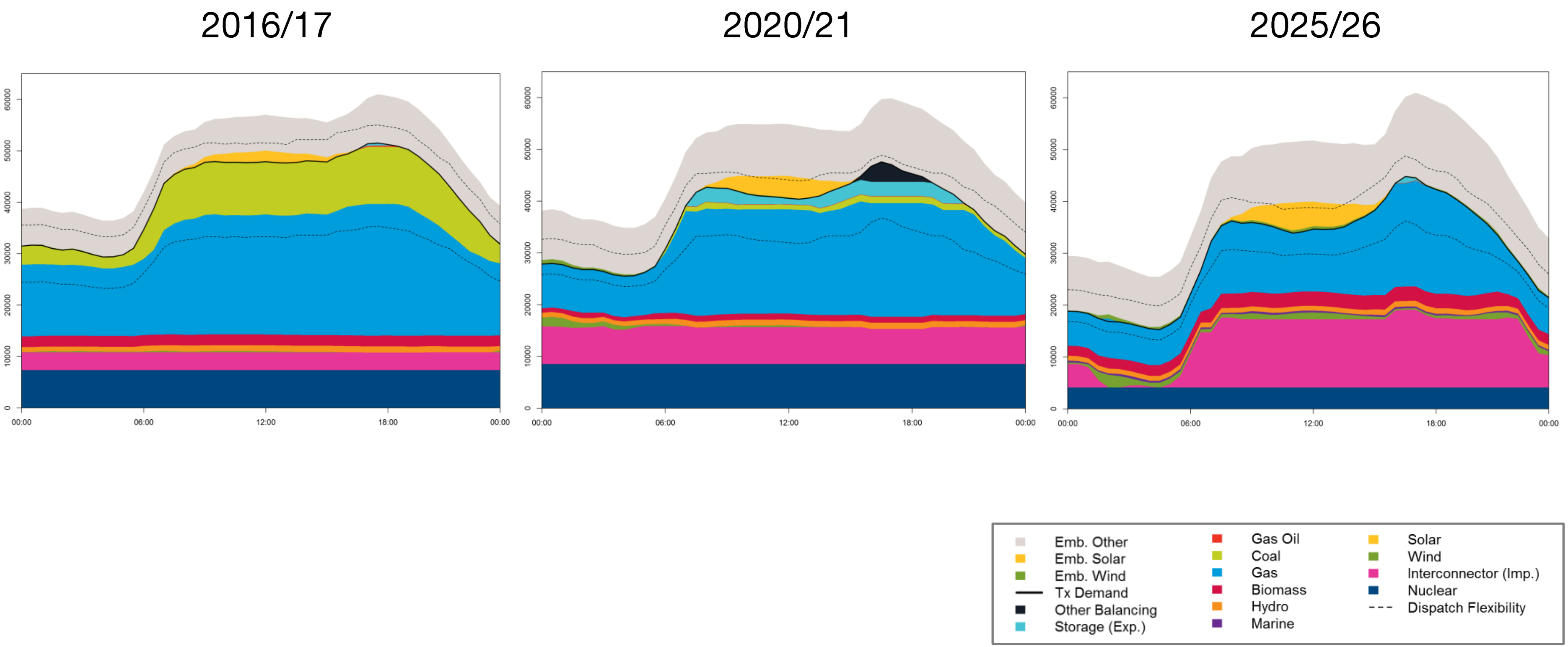


2025/26

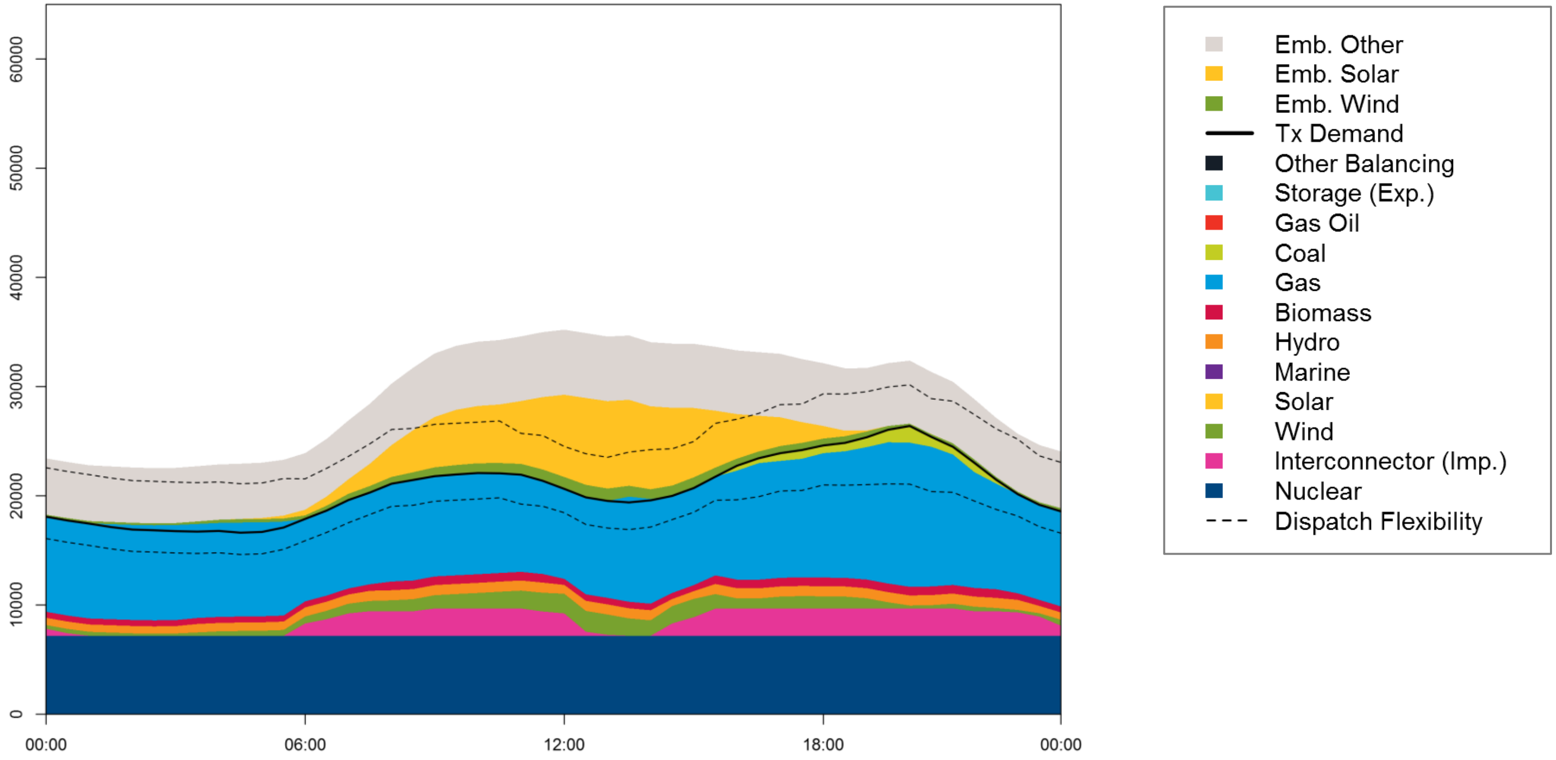


- Emb. Other
- Emb. Solar
- Emb. Wind
- Tx Demand
- Other Balancing
- Storage (Exp.)
- Gas Oil
- Coal
- Gas
- Biomass
- Hydro
- Marine
- Solar
- Wind
- Interconnector (Imp.)
- Nuclear
- Dispatch Flexibility

Winter Peak – Consumer Power

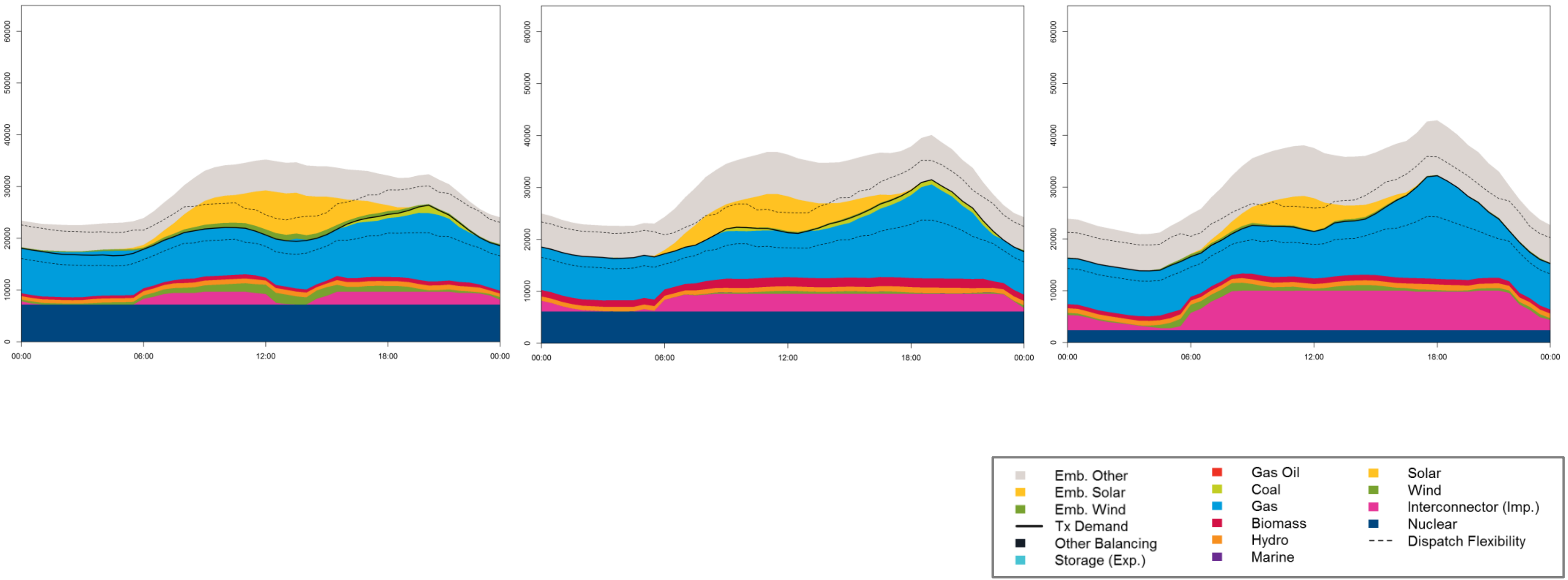


Summer Minimum – No Progression



Summer Minimum – No Progression

2016/17 2020/21 2025/26



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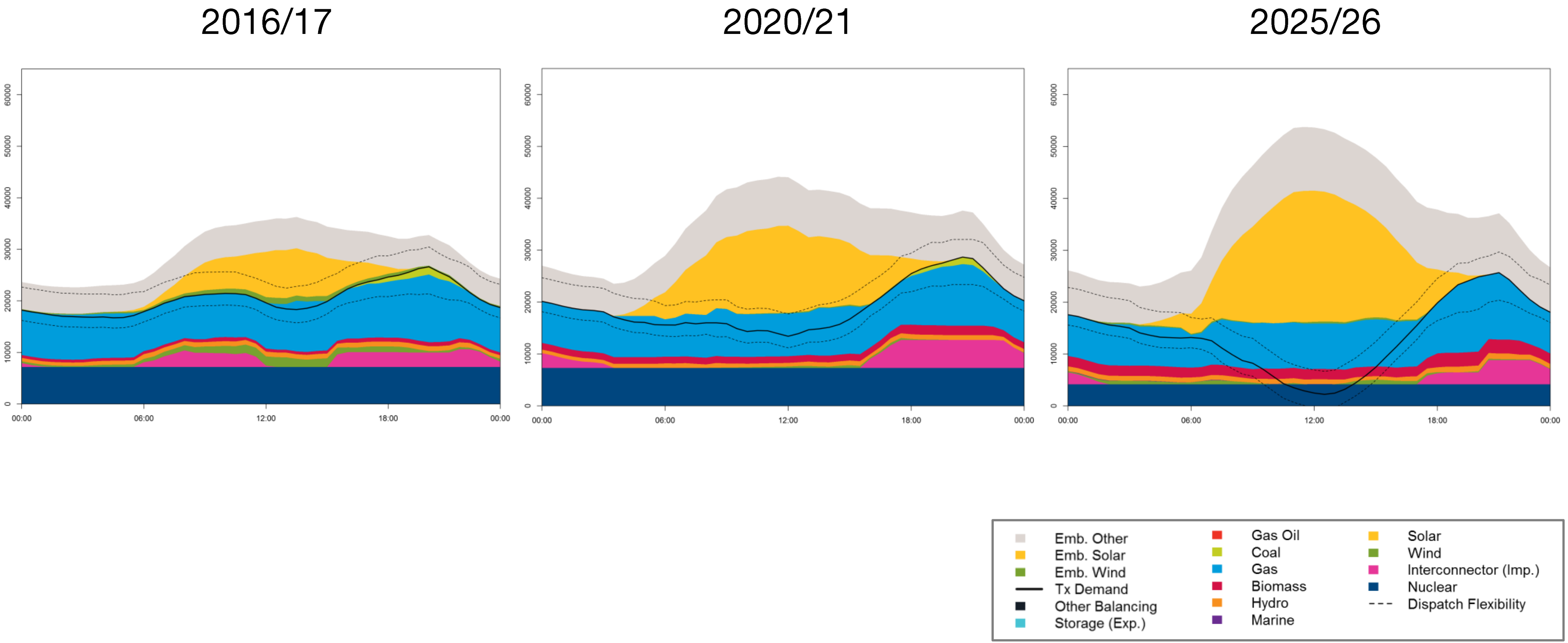
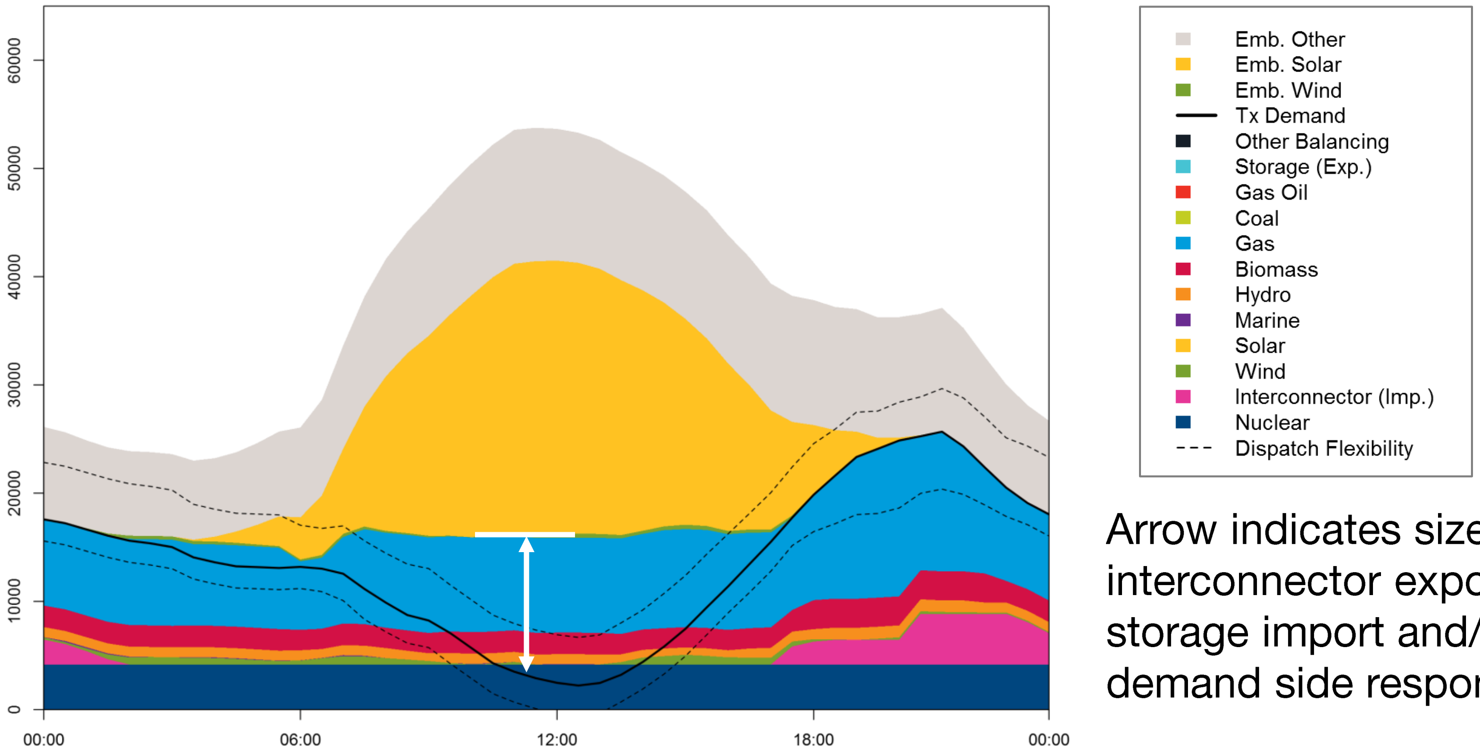
Summer Minimum – Consumer Power



Summer Minimum – Consumer Power



Arrow indicates size of interconnector export, storage import and/or demand side response

Effect of Reducing Proportion of Reserve from Transmission Units

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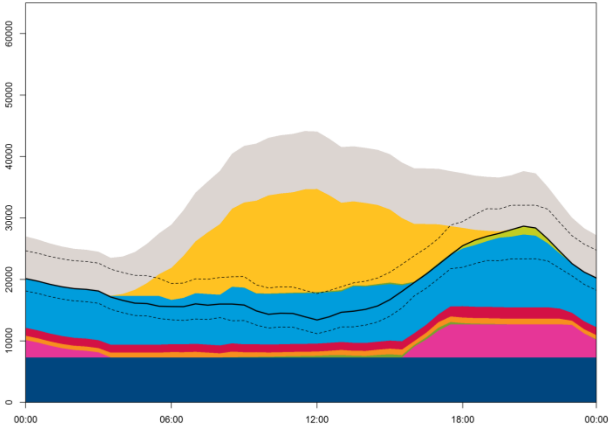
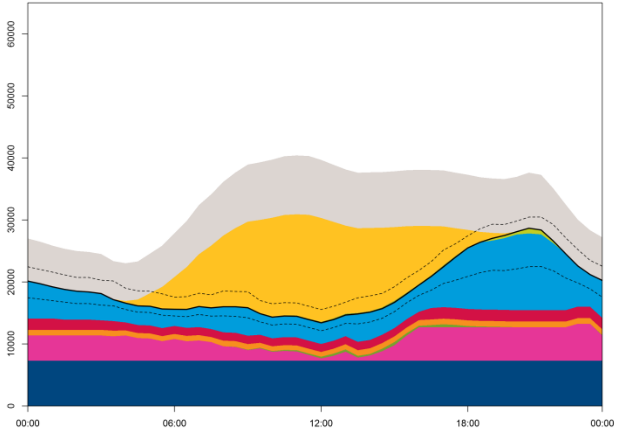
2020/21 Consumer Power – Summer Minimum

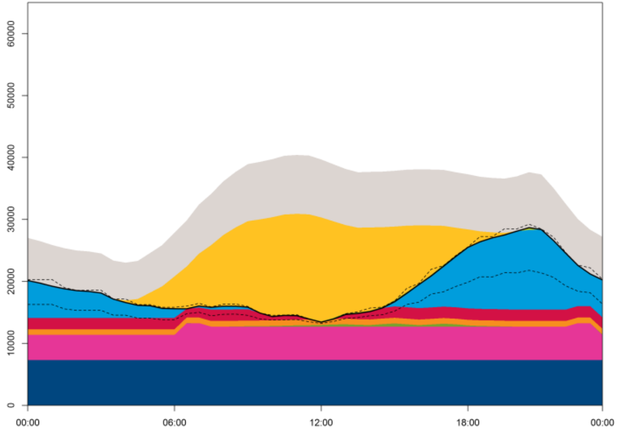
100% Reserve from Transmission

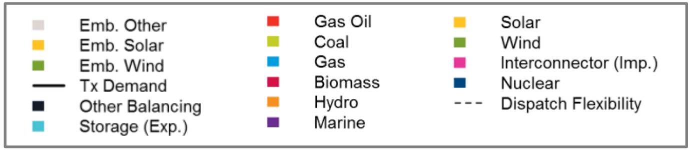


50% Reserve from Transmission

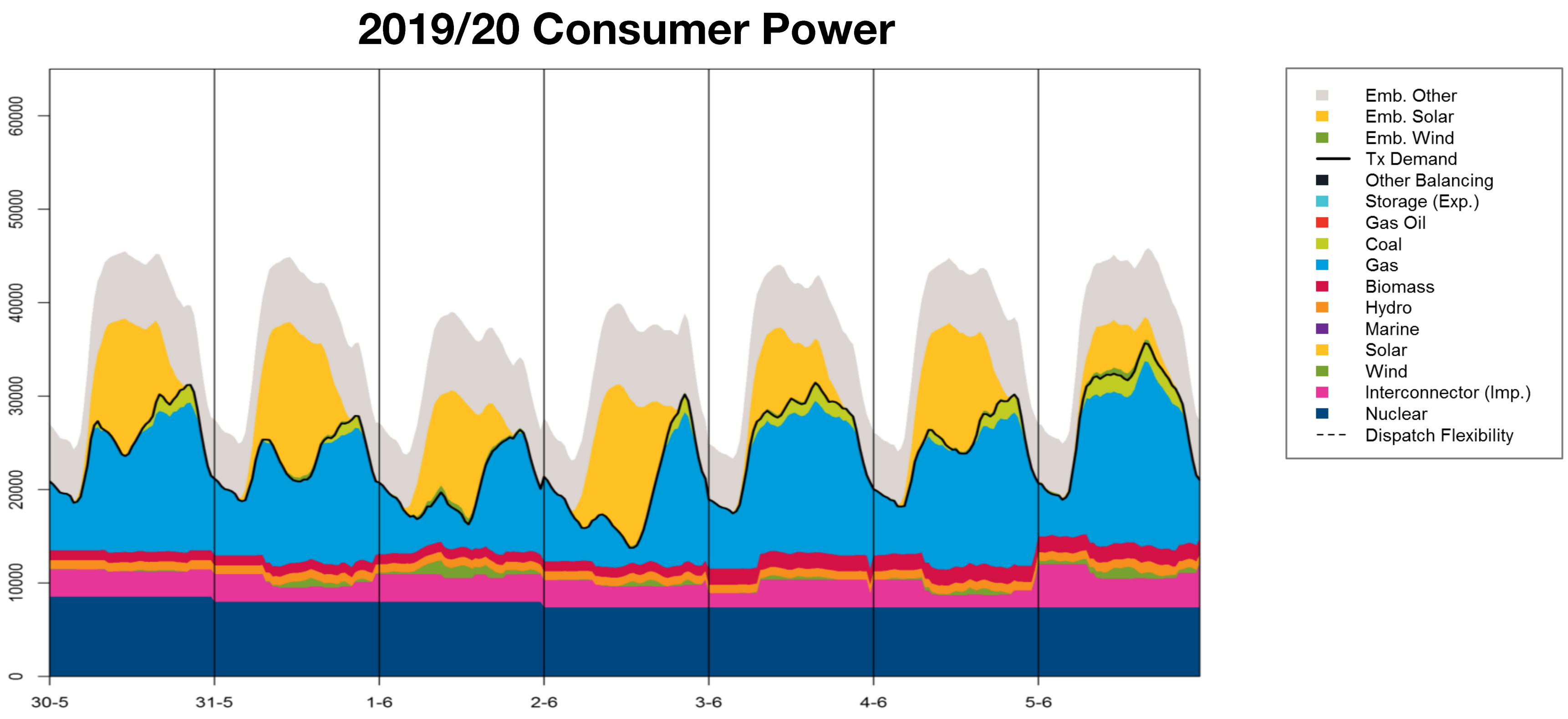


0% Reserve from Transmission





Effect of Embedded Solar Generation



Frequency Management

- Frequency Management
- Voltage Management
- Whole System Coordination

System Inertia (normal operation)
System inertia decreases as a result of reduced availability of synchronous plant. It is impacted by the number of synchronous machines

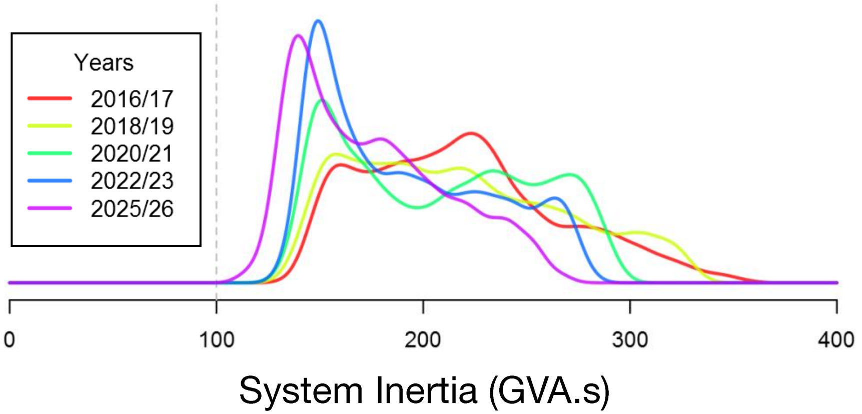
Rate of Change of Frequency (post-event)
RoCoF increases according to reductions in system inertia, demand changes and the size of the largest loss.

Containment (post-event)
Fast and controlled response is increasingly important as frequency deviation manifests more quickly following a system loss.

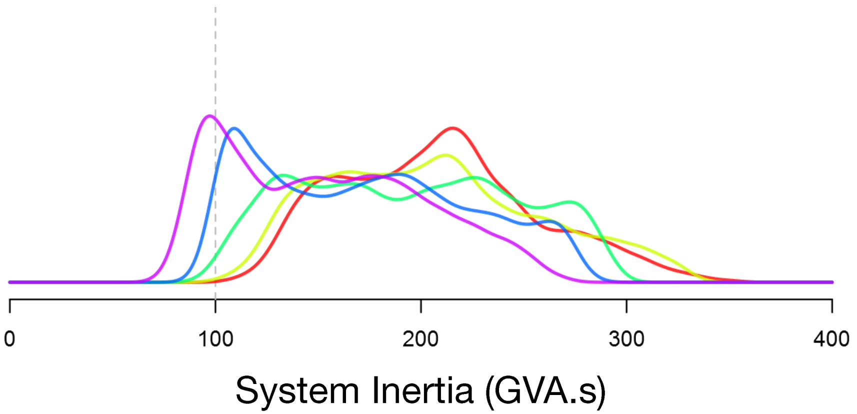
System Inertia – Slow Progression

Annual Distribution of System Inertia

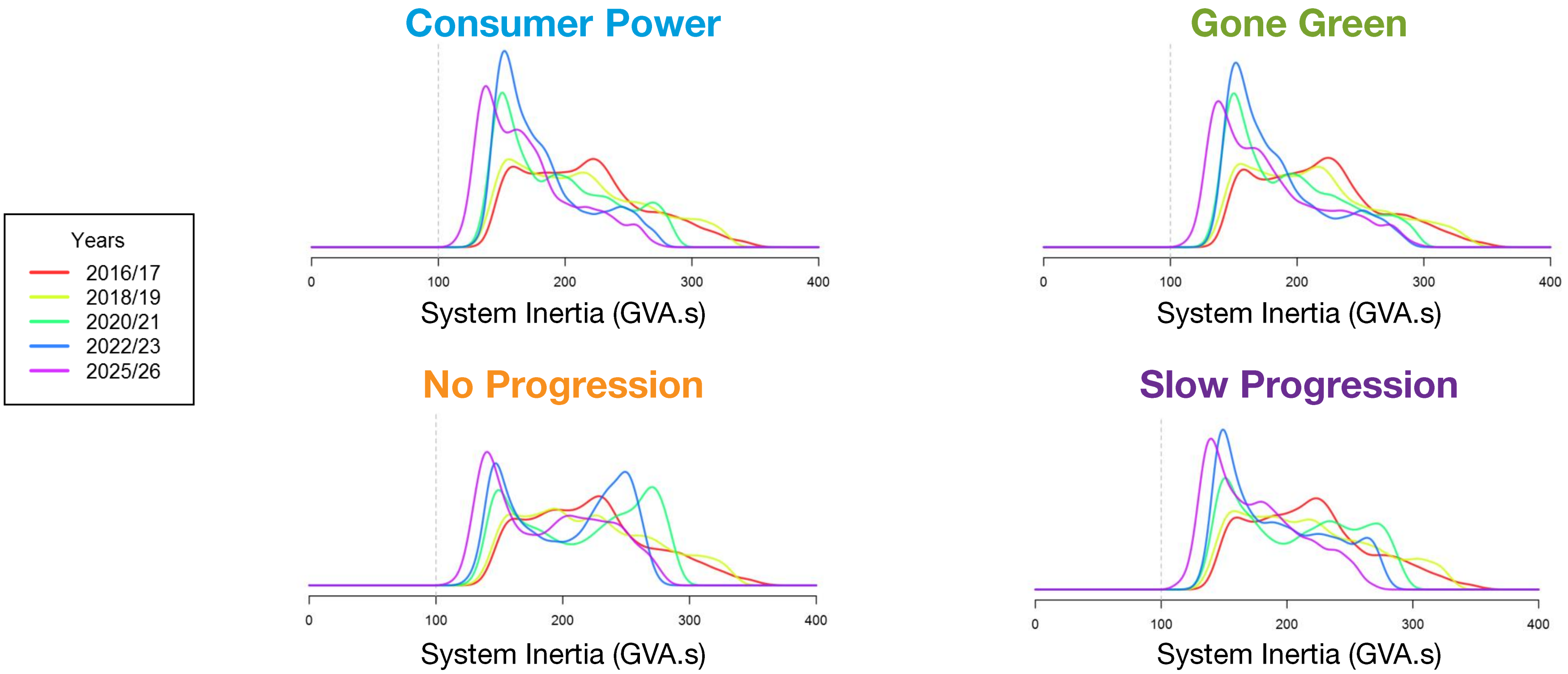
100% of Reserve from System Operator Dispatchable BMUs



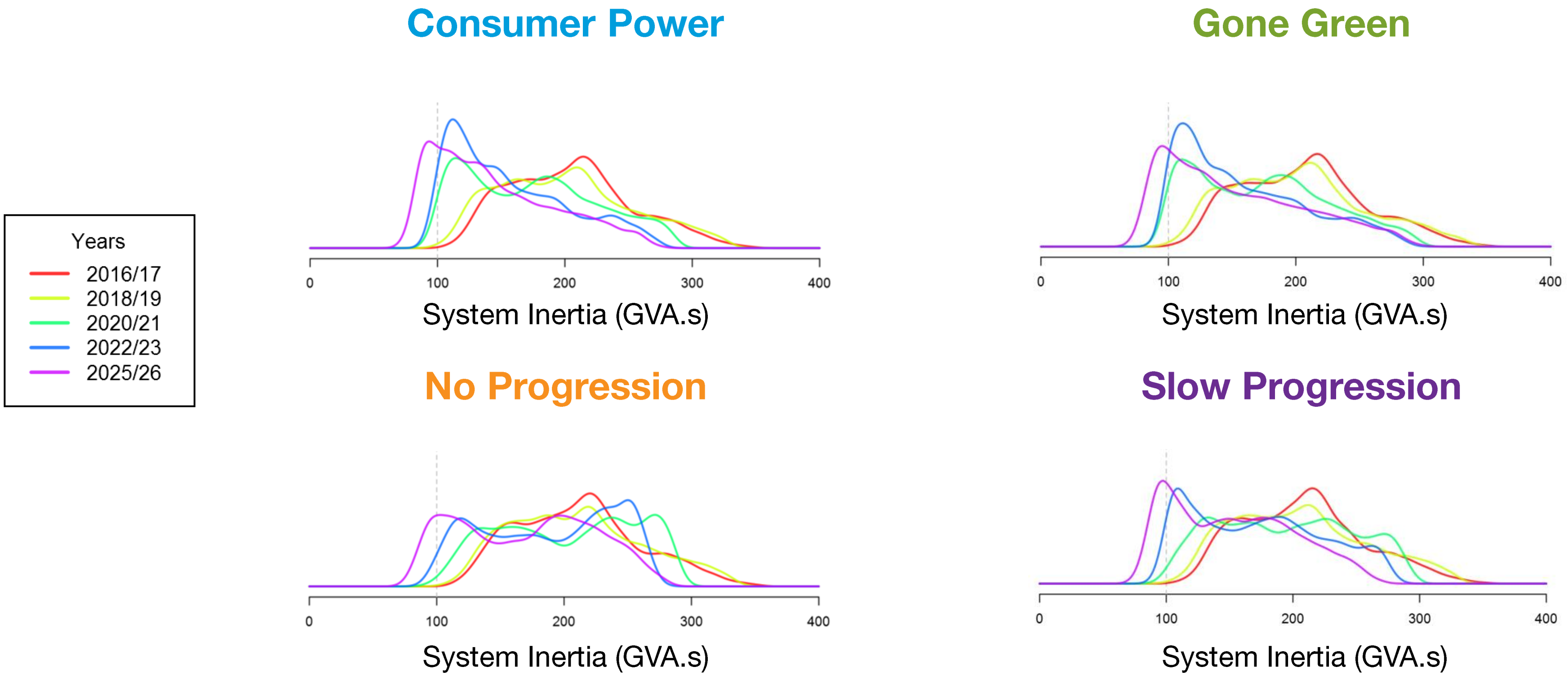
50% of Reserve from System Operator Dispatchable BMUs



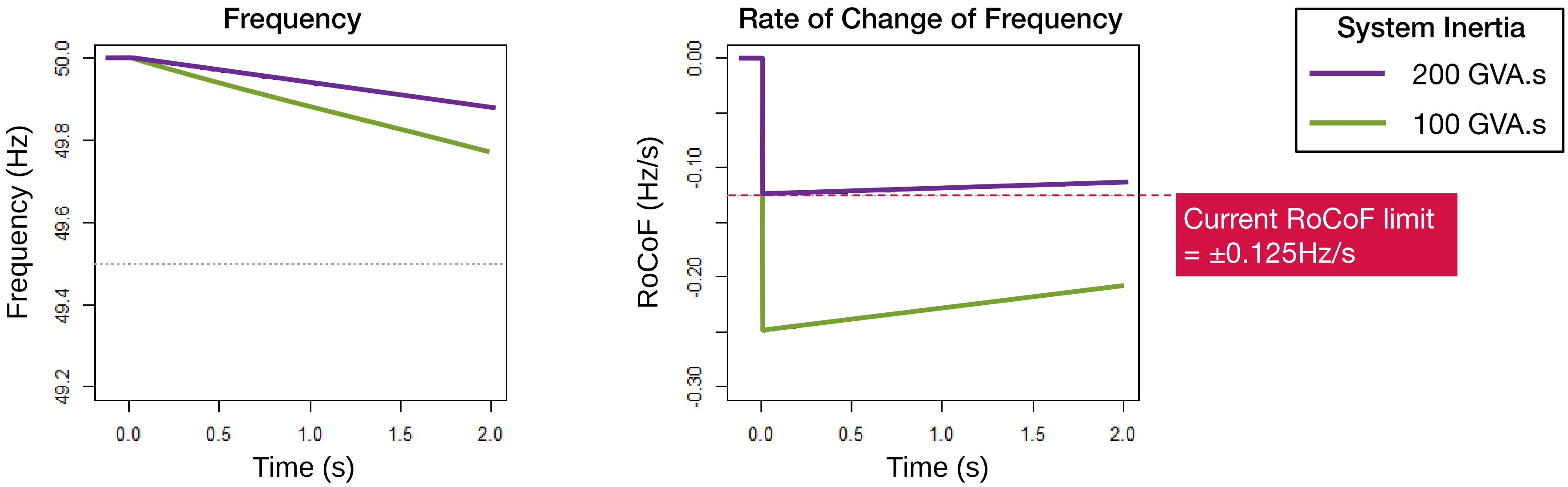
System inertia – 100% of reserve requirements obtained from transmission connected dispatchable generation



System inertia – 50% of reserve requirements obtained from transmission connected dispatchable generation

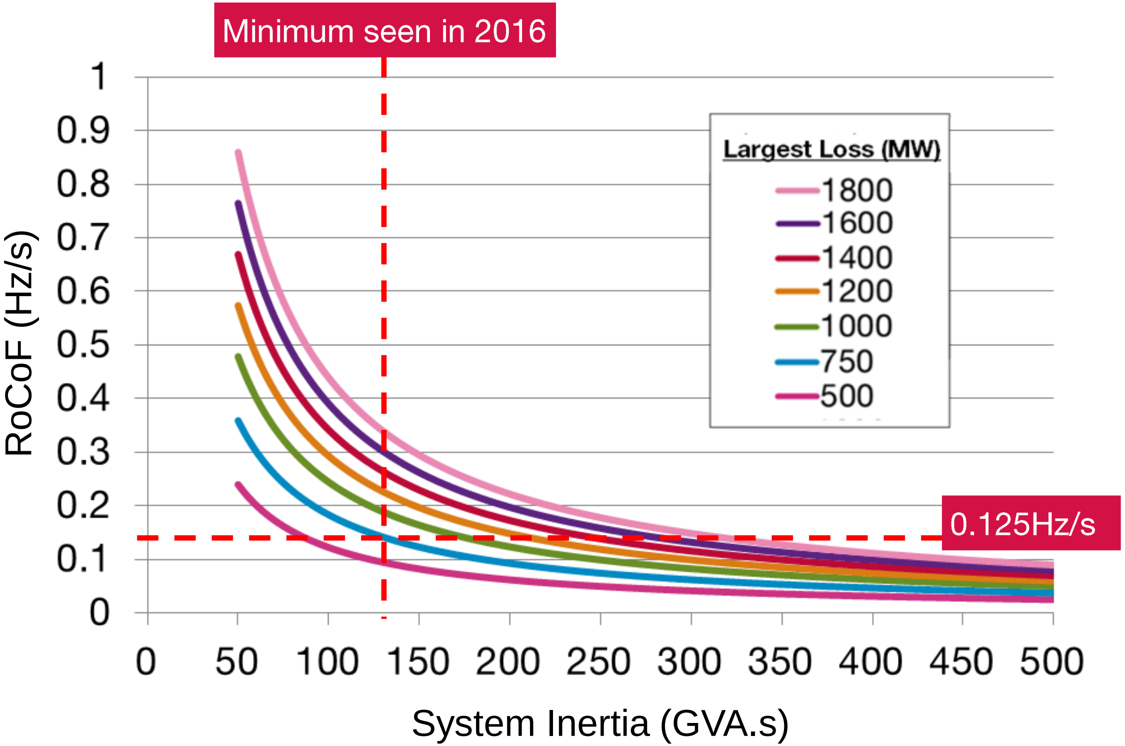


Rate of Change of Frequency (RoCoF)



- Simulations of a 1000MW generation loss
- Less system inertia results in a greater RoCoF
- RoCoF changes immediately, before any kind of frequency response can deliver, so has to be managed pre-fault, by increasing inertia or reducing the largest loss risk

RoCoF and Inertia Relationship



- This plot shows the relationship between system inertia, RoCoF and the largest loss risk on the system
- As system inertia decreases and the largest loss increases, the RoCoF risk increases
- The minimum inertia witnessed so far in 2016 was about 135GVA.s, limiting the largest loss to 680MW

RoCoF Risk – 100% of reserve requirements obtained from transmission connected dispatchable generation

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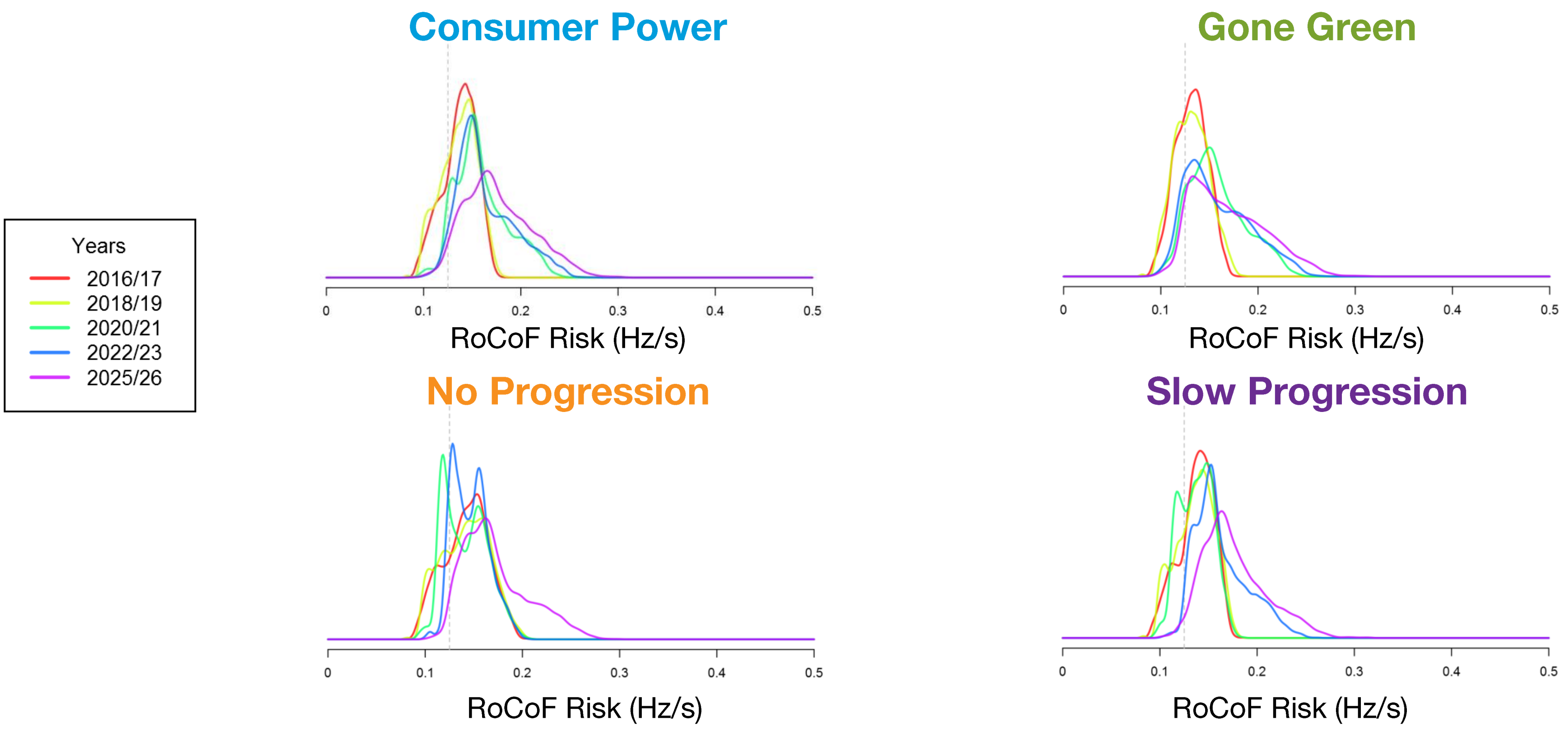
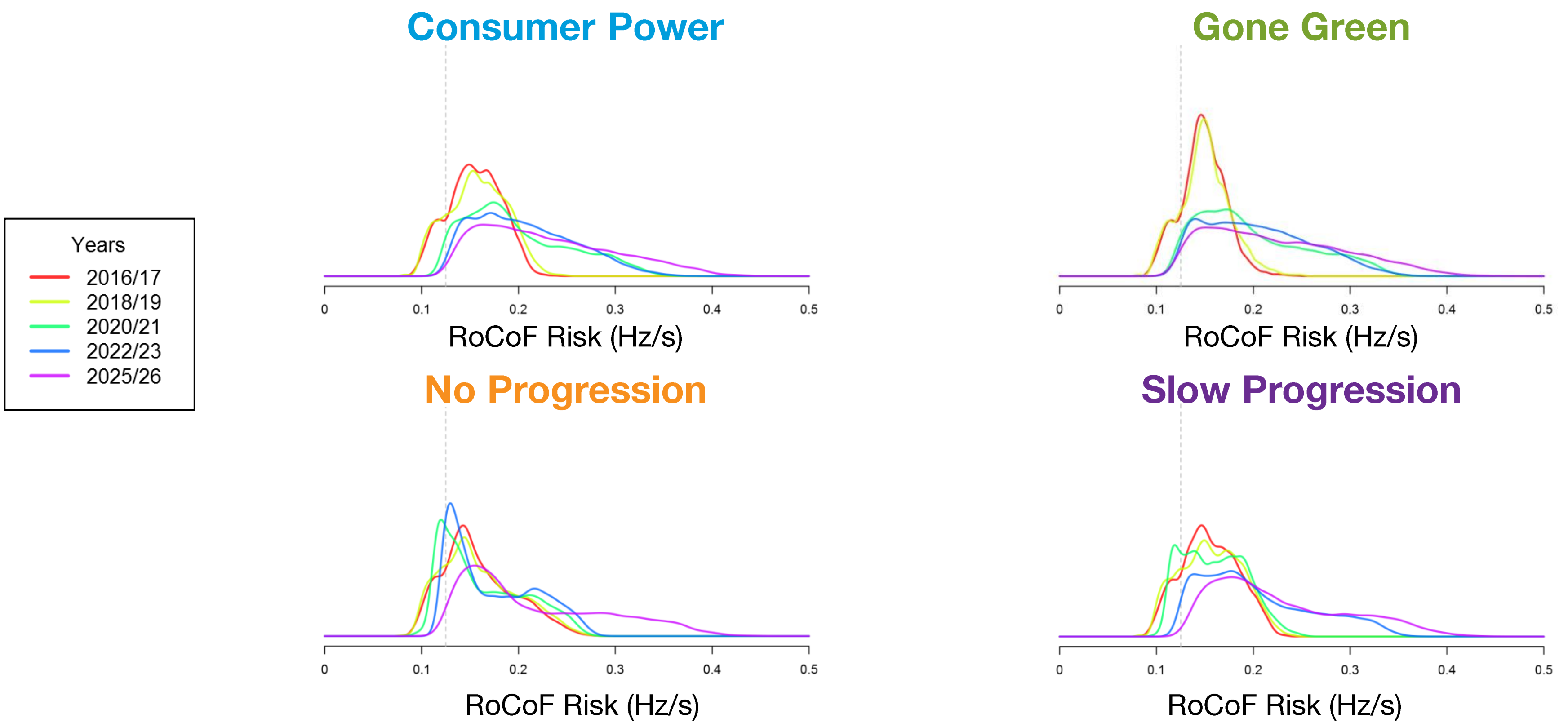
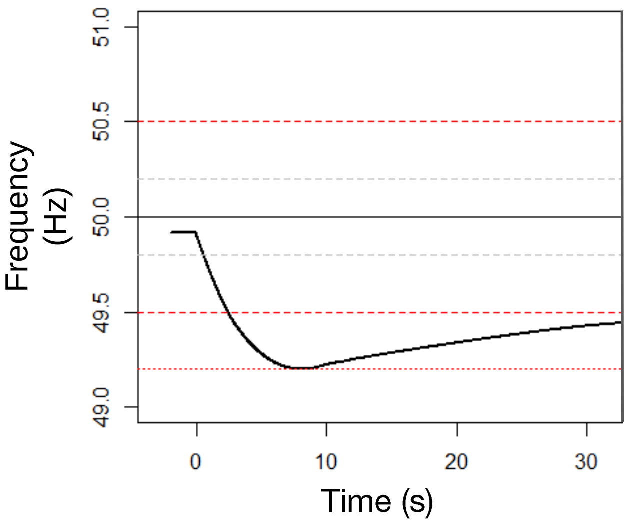
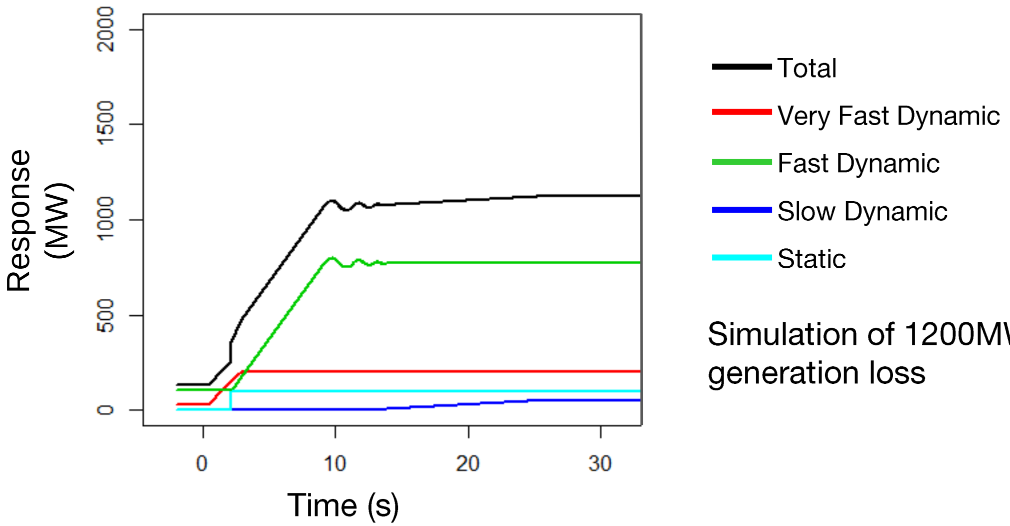


RoCoF Risk – 50% of reserve requirements obtained from transmission connected dispatchable generation



Frequency Containment





Simulation of 1200MW generation loss

- Investigation into the balance of different types of response
- Balance of response time (lag) and delivery time (ramp)
- Balance of static and dynamic response

Voltage Management

Frequency Management

Voltage Management

Whole System Coordination

Voltage Profiles (normal operation)
Need for additional compensation across all areas to manage steady-state regional voltage profiles

Short Circuit Level (during fault)
Decreasing fault levels drive requirements for new protection solutions and fast fault current injection

Static/Dynamic Compensation (post-event)
Additional sources of dynamic voltage control are required to support post-event voltage recovery

Voltage Management Regions

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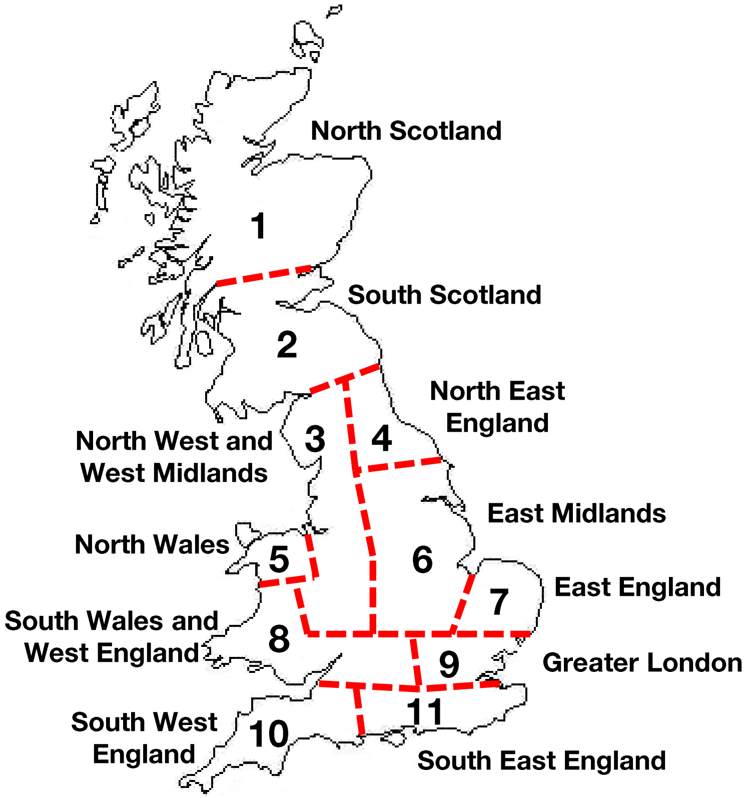
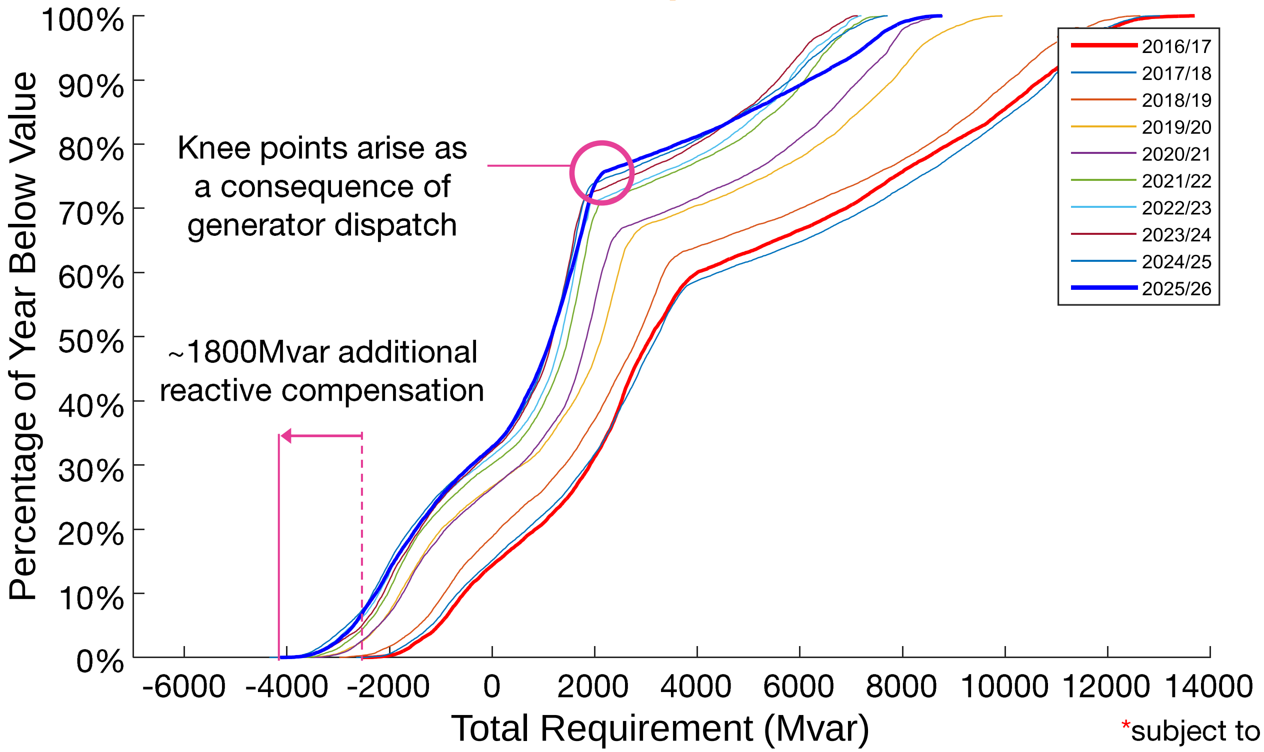


- The voltage management zones in SOF 2016 are consistent with the Short Circuit Level zones which were studied in SOF 2015
- These regions have been selected on the basis of strongly interlinked regions of the network
- This year, assessments have been performed based on known relationships between regional network characteristics and generation dispatch sensitivities
- By applying the System Balancing data to this information, we have been able to characterise the regional variation and relative requirements

Voltage Profile – East Midlands

No Progression



*subject to review prior to 30th November

Voltage Profile – South East

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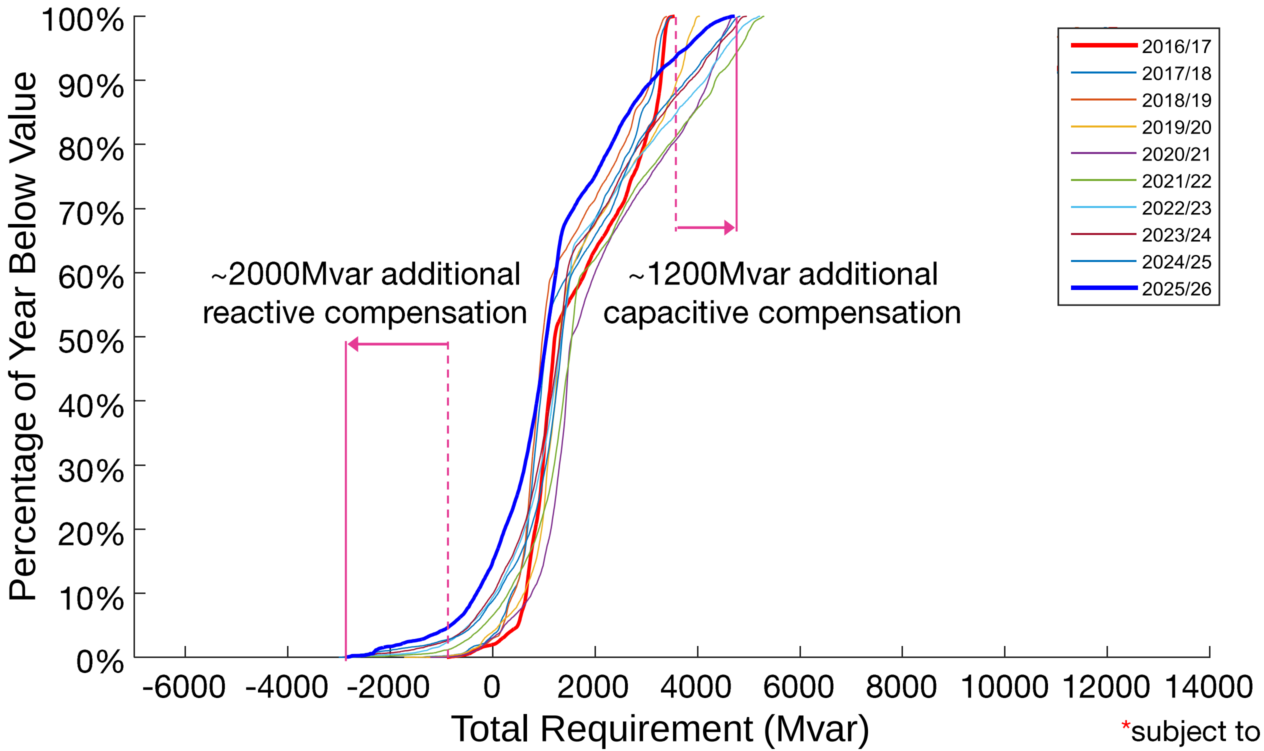

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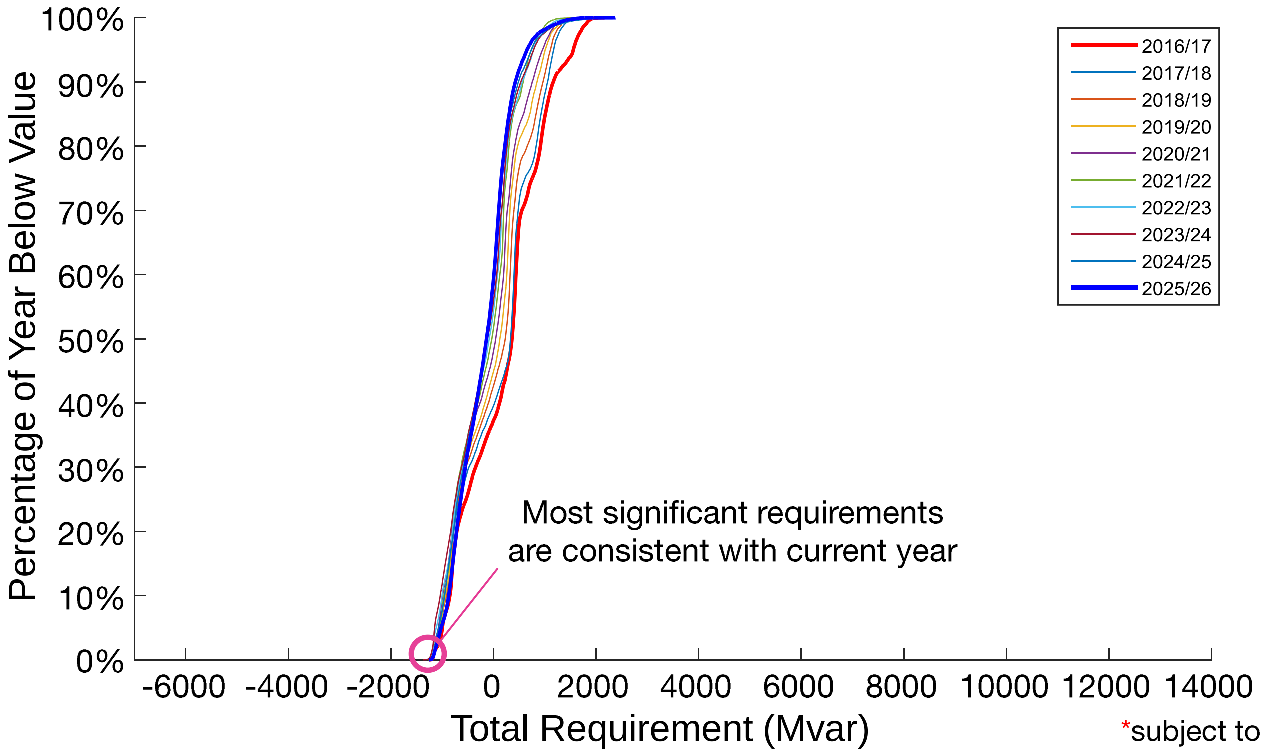
Voltage Profile – North Scotland

Gone Green



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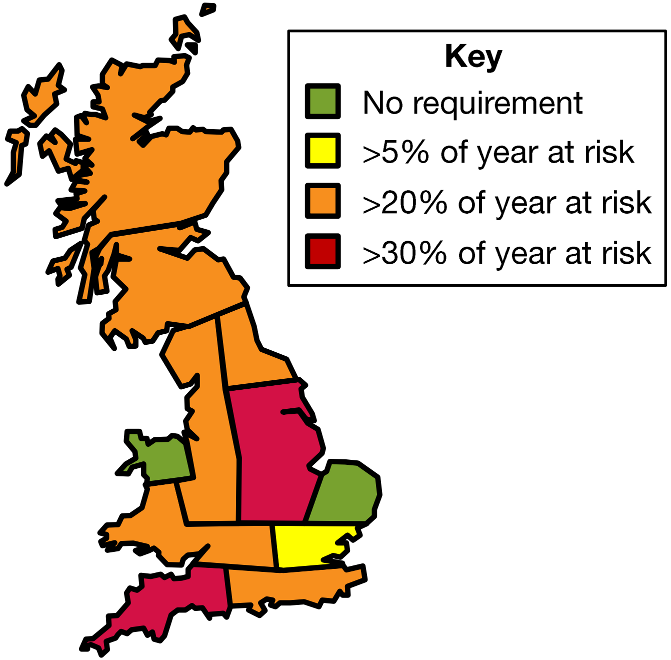
Short Circuit Level

2025 – Consumer Power Protection Risk Summary



- SCL, or fault level, is often used as an indication of regional 'system strength'. During a fault, generators which have an overload capability and are local to the fault will inject a fault current

- Short Circuit Levels (SCL) decline significantly over the next 10 years, particularly in regions where large plant is closing or availability could be limited in future years

- An impact of reduced SCL is a reduction in the ability of existing network protection approaches to function at periods of low system strength

- From 2020 onwards, in most regions, this begins to trigger a requirement for new approaches.

*subject to review prior to 30th November

Regional SCL – West Midlands

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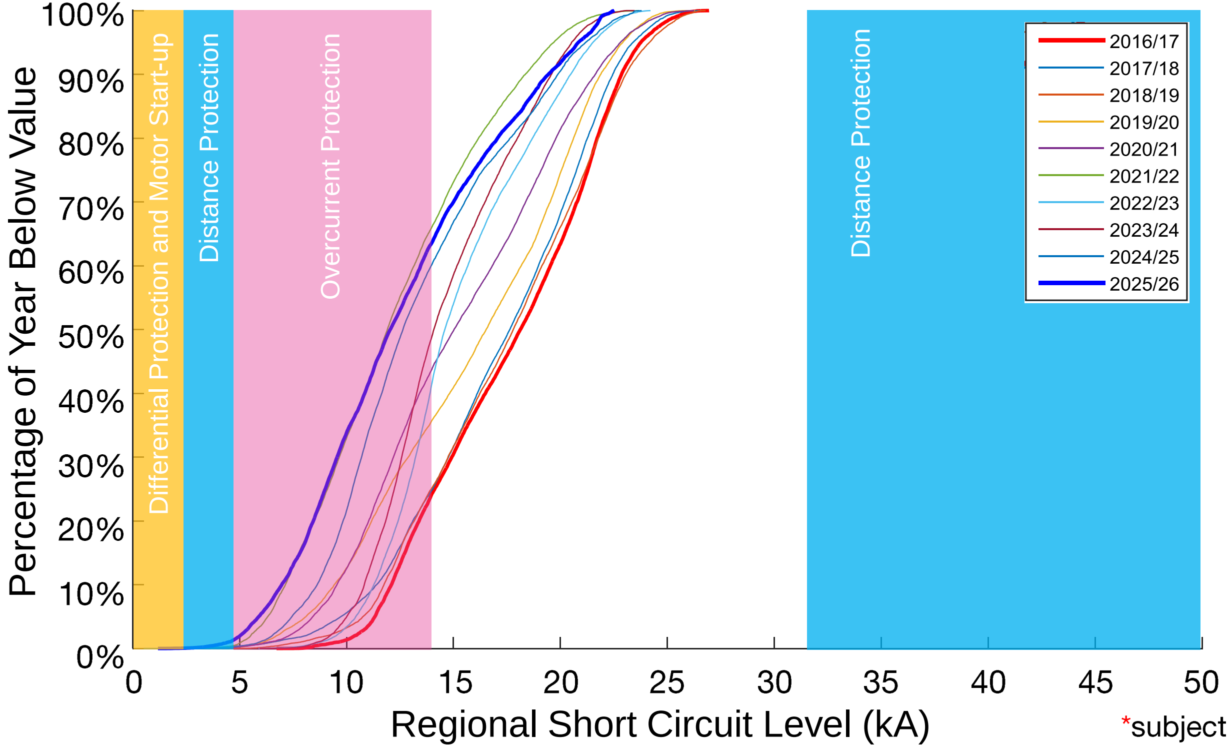
Gone Green



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Regional SCL – South East

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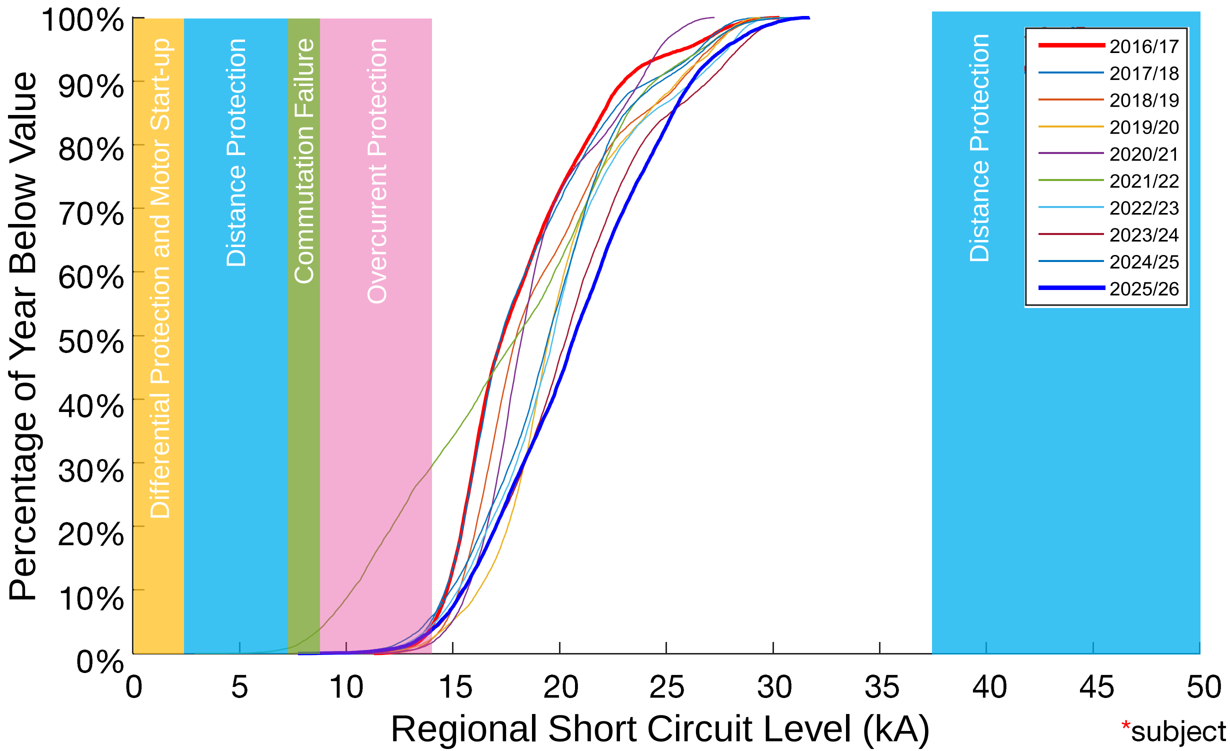

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Static Compensation – East Midlands

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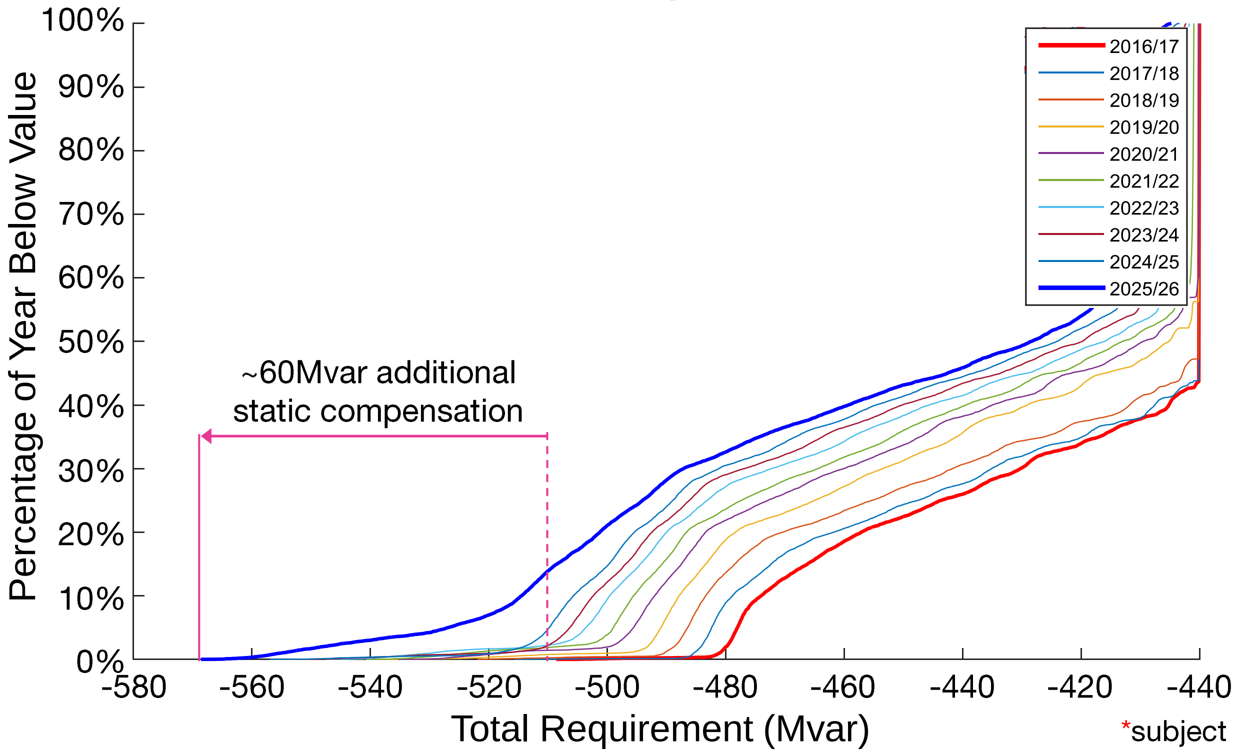
No Progression



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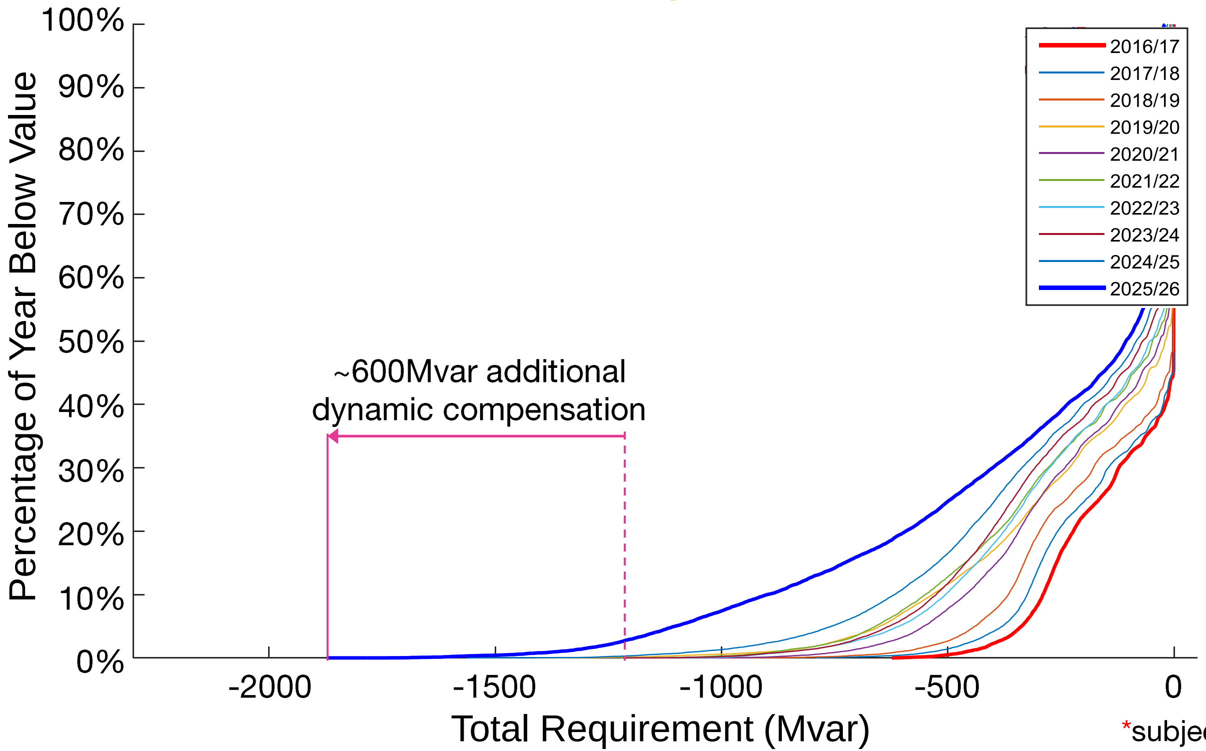
Dynamic Compensation – East Midlands

No Progression



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Whole System Coordination

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- Frequency Management
- Voltage Management
- Whole System Coordination

Visibility and Control
Diminishing generation and demand visibility will drive uncertainty and requirements in other areas unless existing thresholds are reassessed

Distribution System Case Studies
Assessment of potential for distributed generation to provide voltage support and ANM to countermand SO instructions.

Contingency Control Actions
Assessment of future requirements for coordinated whole system contingency control capability

Visibility and Control

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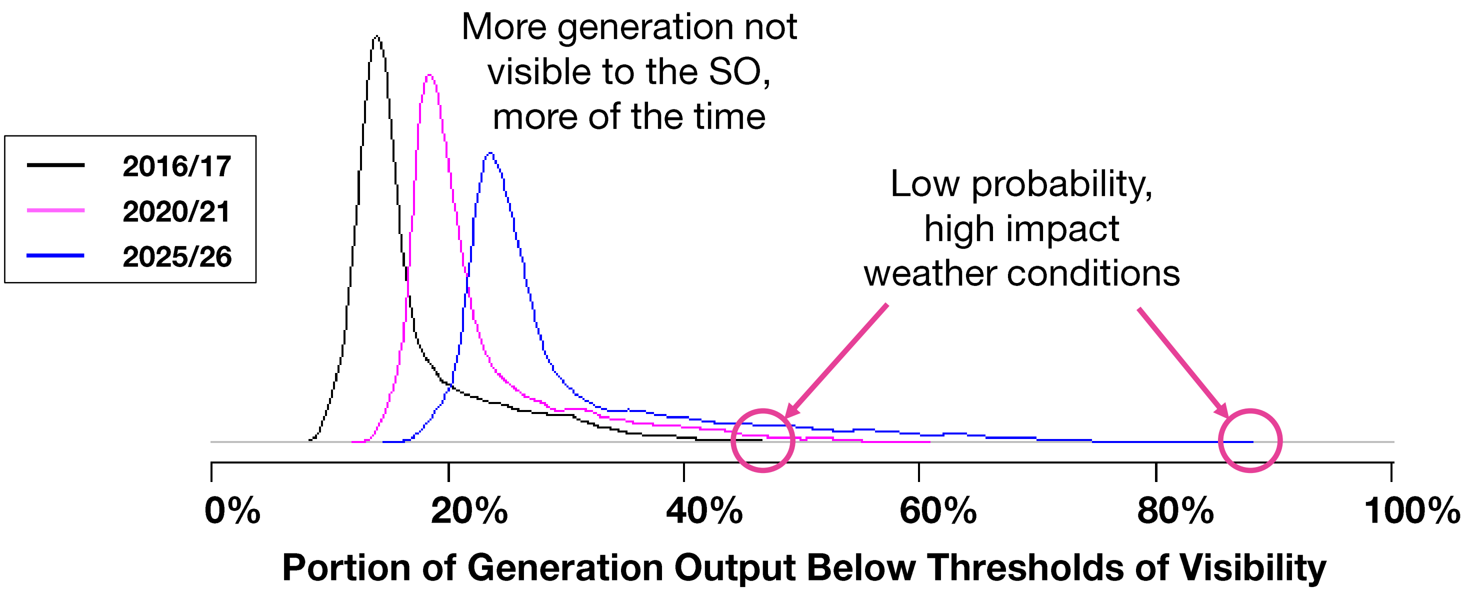
Total Generation Output



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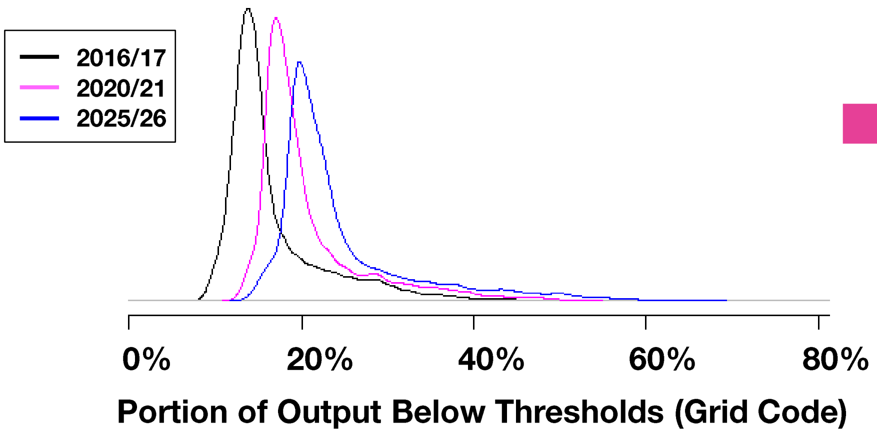
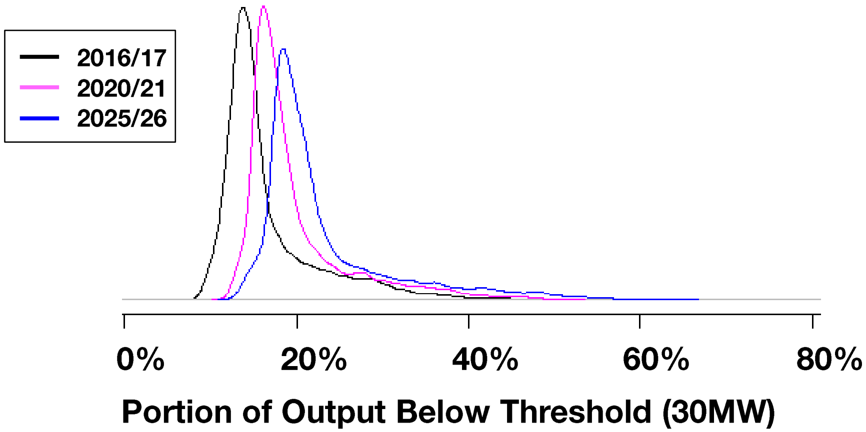
Thresholds of Visibility

Slow Progression

Grid Code Visibility Thresholds



30MW Visibility Threshold



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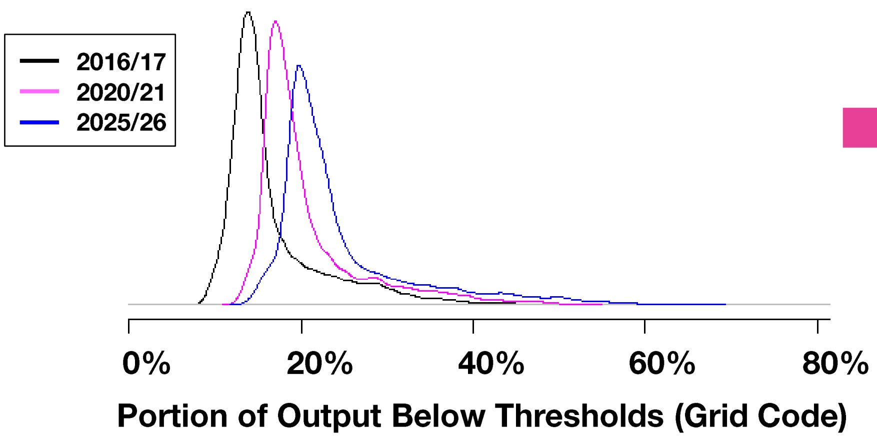
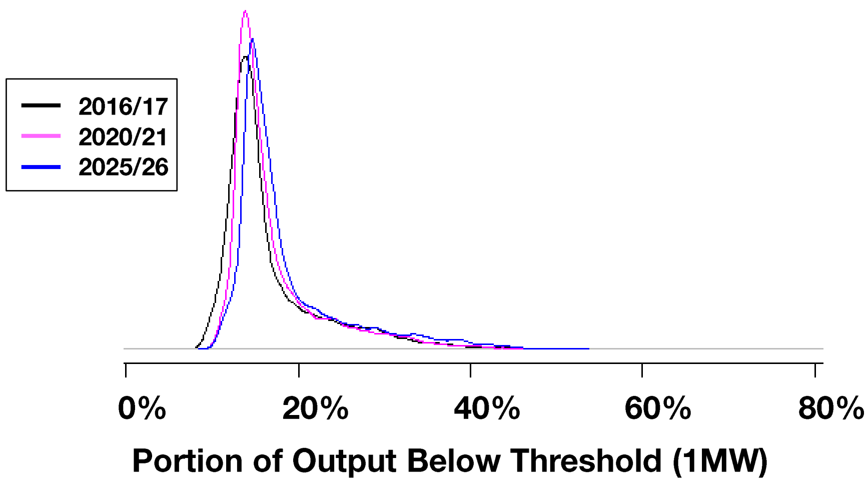
Thresholds of Visibility

Slow Progression

Grid Code Visibility Thresholds



1MW Visibility Threshold



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Continuing the Conversation

Thank you for listening. Please take a moment to submit questions via chat for the live Q&A.

The launch event for the SOF takes place on November 30th at National Grid House, Warwick. Registration will be available from Wednesday 28th October.

All material relating to SOF 2016 is made available at:
www.nationalgrid.com/sof

Contact us via email: sof@nationalgrid.com