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“The fundamental interconnectedness of all things”

Rob Westmancoat
Senior Strategy Analyst

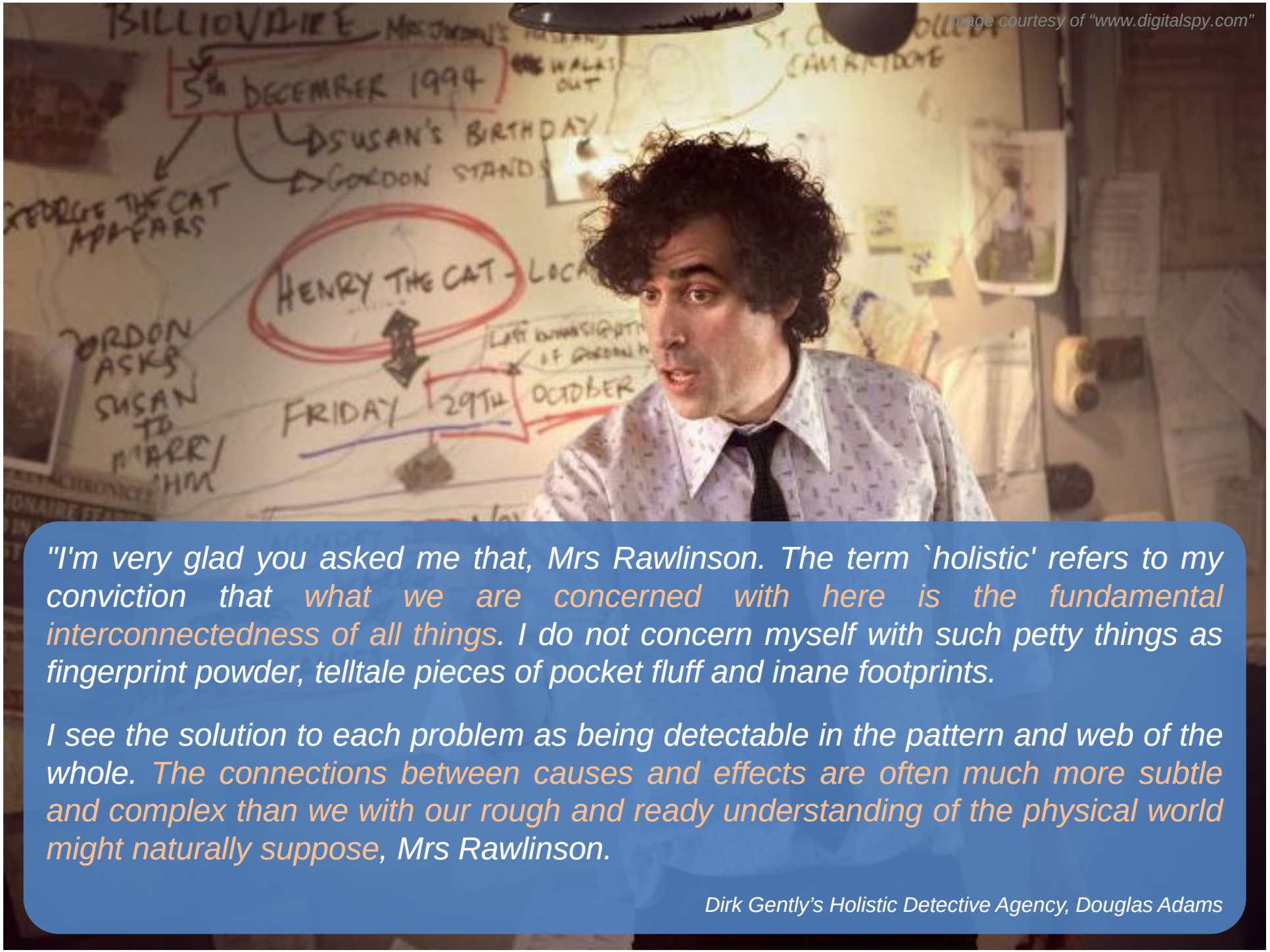

Image courtesy of "www.digitalspy.com"

"I'm very glad you asked me that, Mrs Rawlinson. The term `holistic' refers to my conviction that what we are concerned with here is the fundamental interconnectedness of all things. I do not concern myself with such petty things as fingerprint powder, telltale pieces of pocket fluff and inane footprints.

I see the solution to each problem as being detectable in the pattern and web of the whole. The connections between causes and effects are often much more subtle and complex than we with our rough and ready understanding of the physical world might naturally suppose, Mrs Rawlinson.

Dirk Gently's Holistic Detective Agency, Douglas Adams

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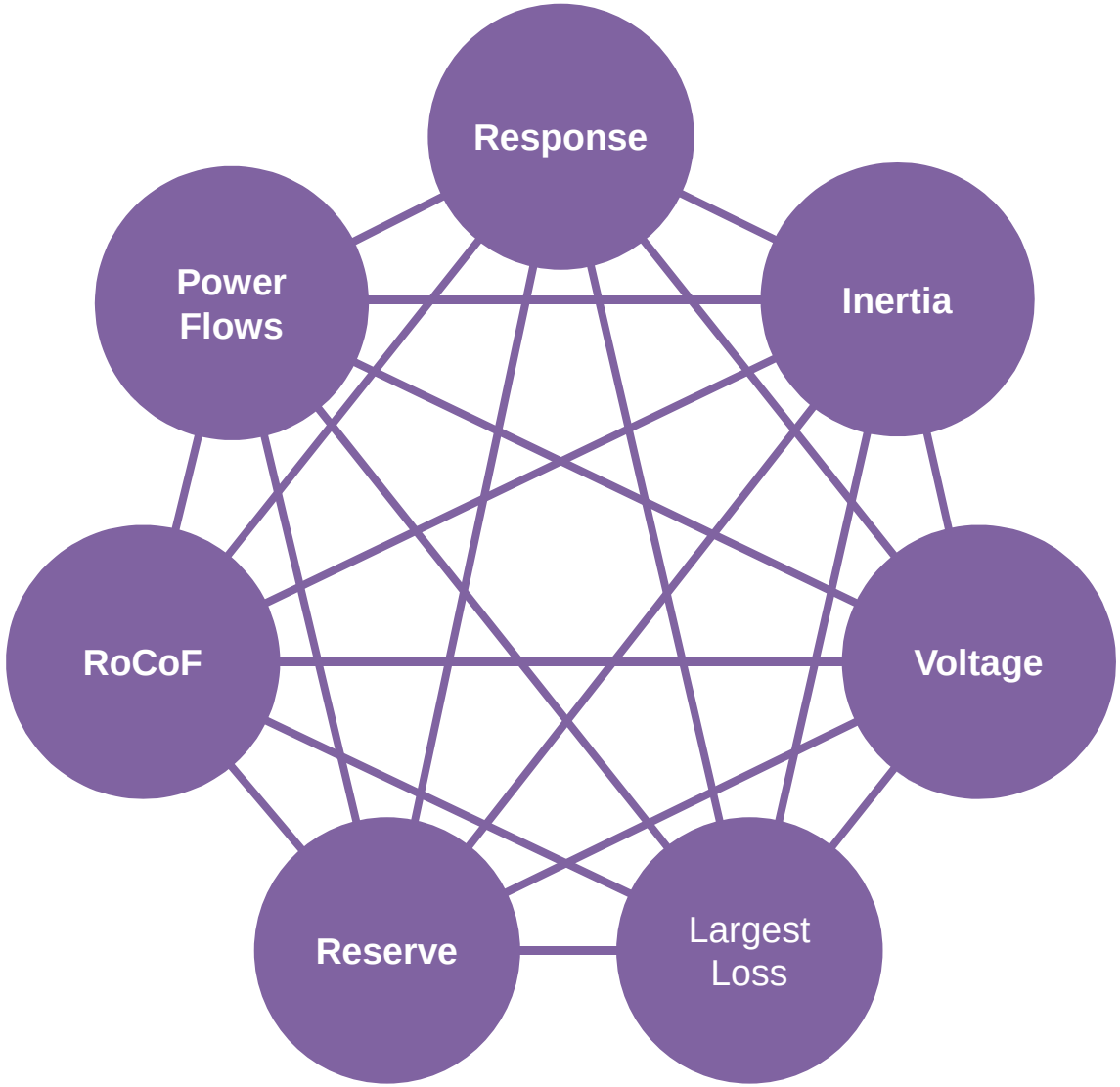
“The fundamental interconnectedness of all things”



- At low inertia and low demand, the interaction of different components becomes particularly important
- Can no longer consider different areas in isolation
- New tools to study and assess, and greater volume of actions to manage

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System Operation: “Rules of the Game”

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System Operation: key drivers

Frequency:
50.0Hz
+/-0.5Hz

Voltage:
+/- 10%
of nominal

Overloads:
No unacceptable
overloads

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System Operation: Operational Security Standards

For the following faults...

- A single circuit cable or overhead line
- A double circuit overhead line
- A busbar or mesh corner
- A supergrid transformer
- A reactive compensator
- The most onerous single system infeed

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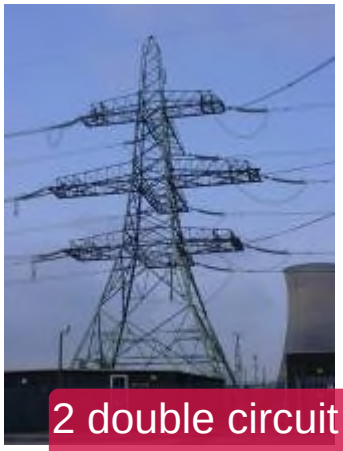
System Operation: Operational Security Standards

… there shall not be:

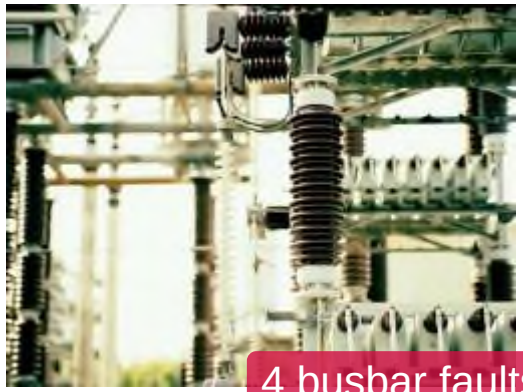
- A loss of supply
- A permanent change in frequency below 49.5 Hz or above 50.5 Hz
- Unacceptable overloading of transmission apparatus
- Unacceptable high or low voltage conditions
- System Instability

System Operation: faults



2 double circuit faults
105 single circuit faults

5 cable faults



4 busbar faults

2000 protection or Communication failures

10 transformer faults

21 circuit breaker faults

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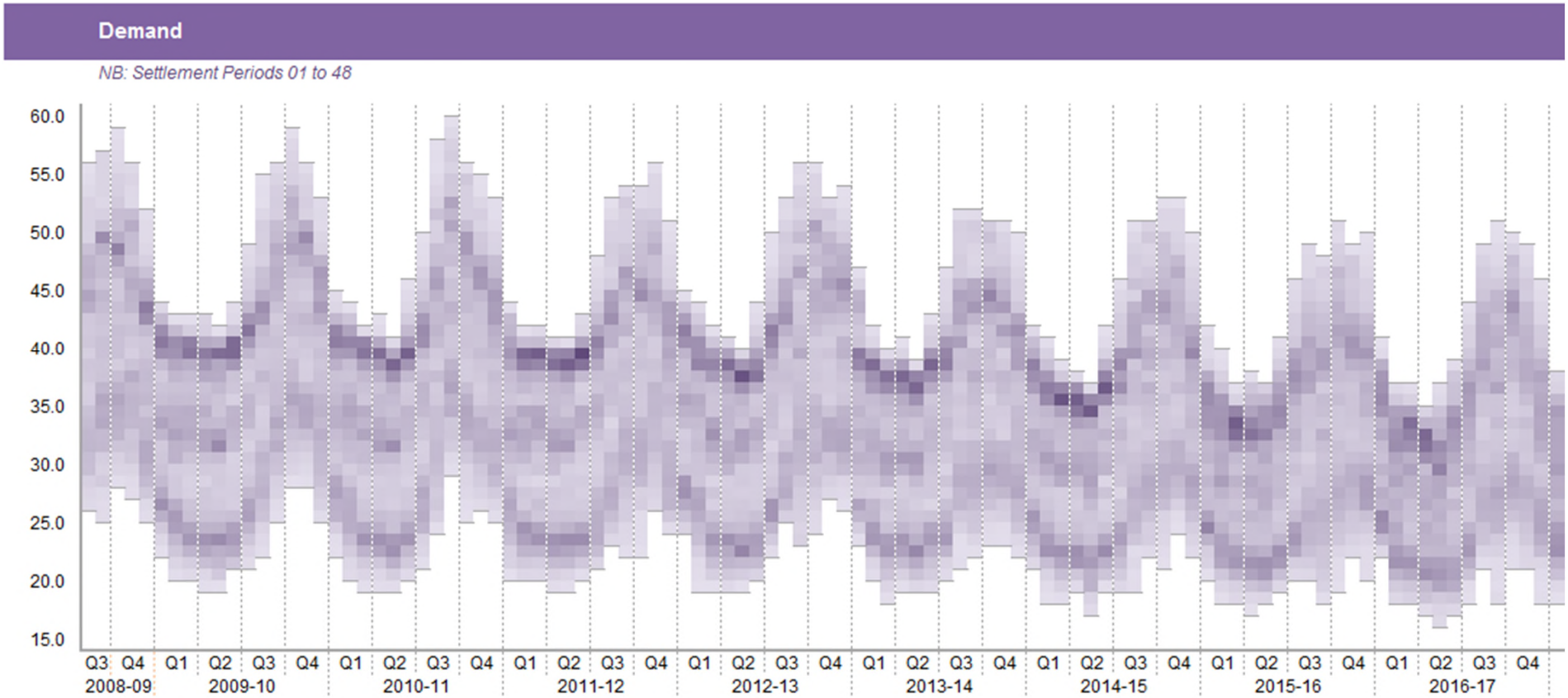
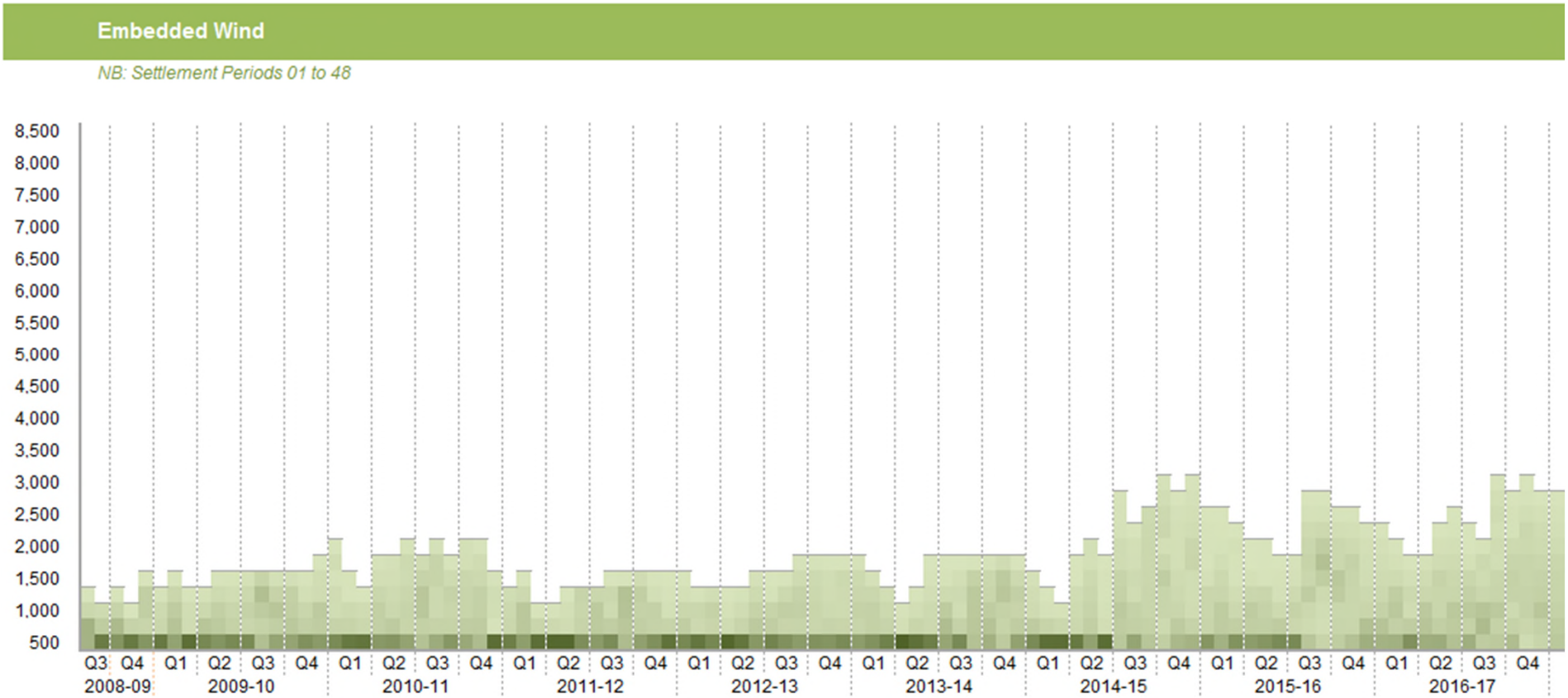
“The only thing that is Constant is Change”

Evolution of demand



Evolution of embedded wind



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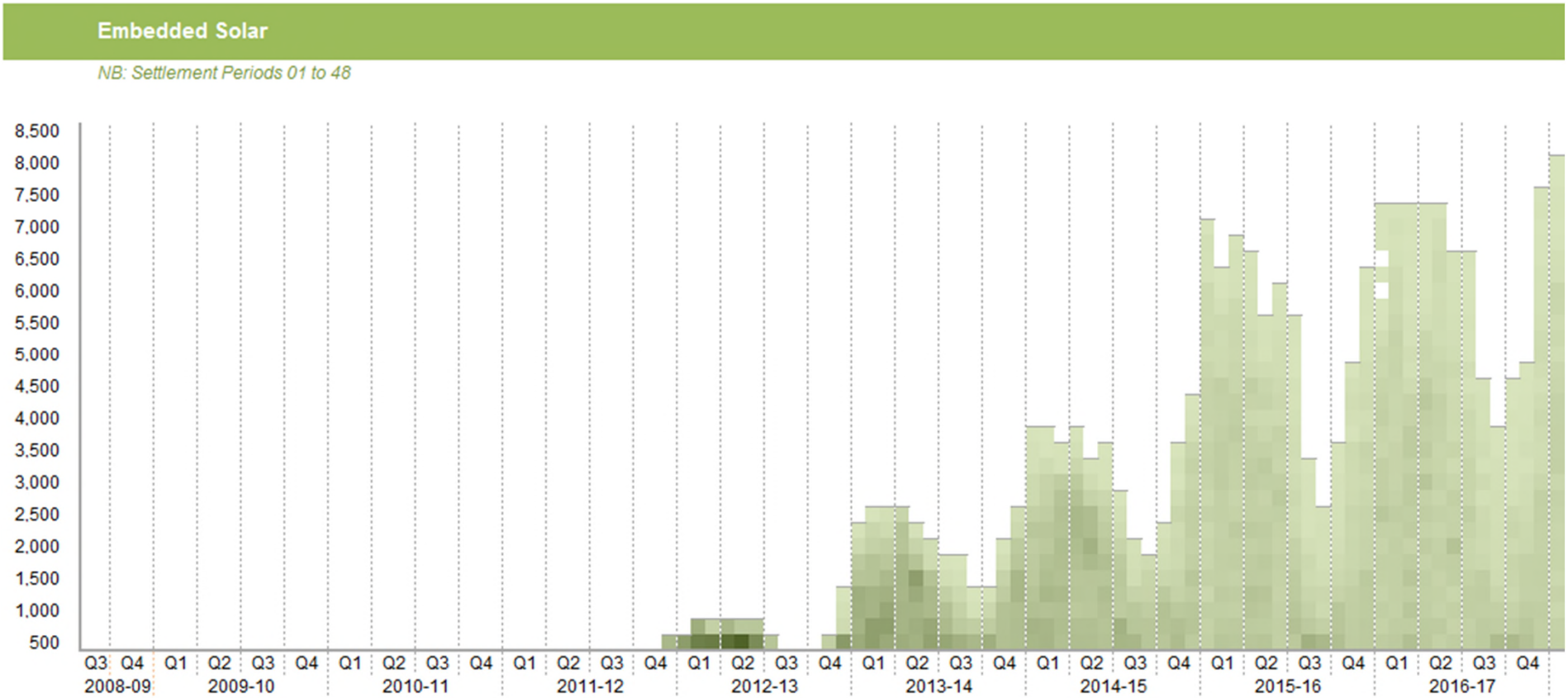
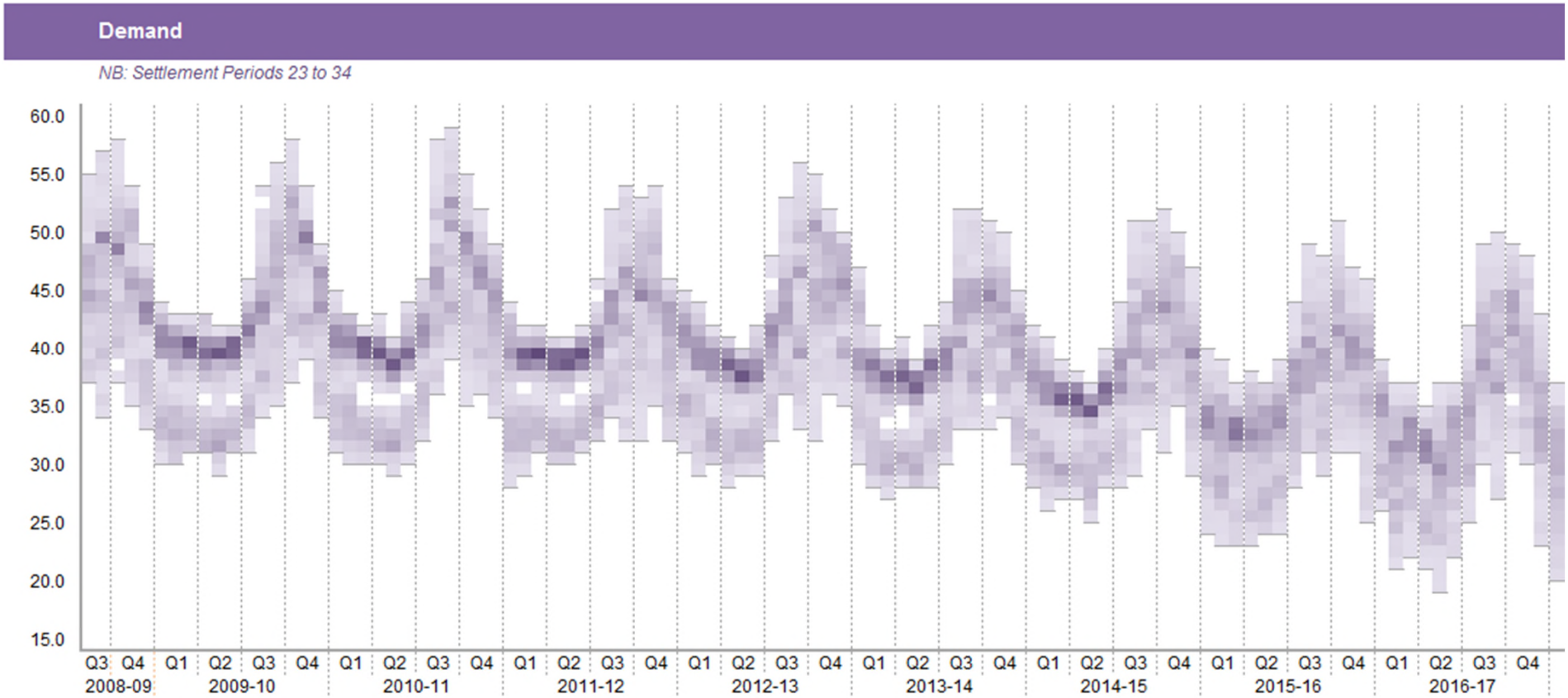
Evolution of embedded solar



Evolution of demand: afternoon period



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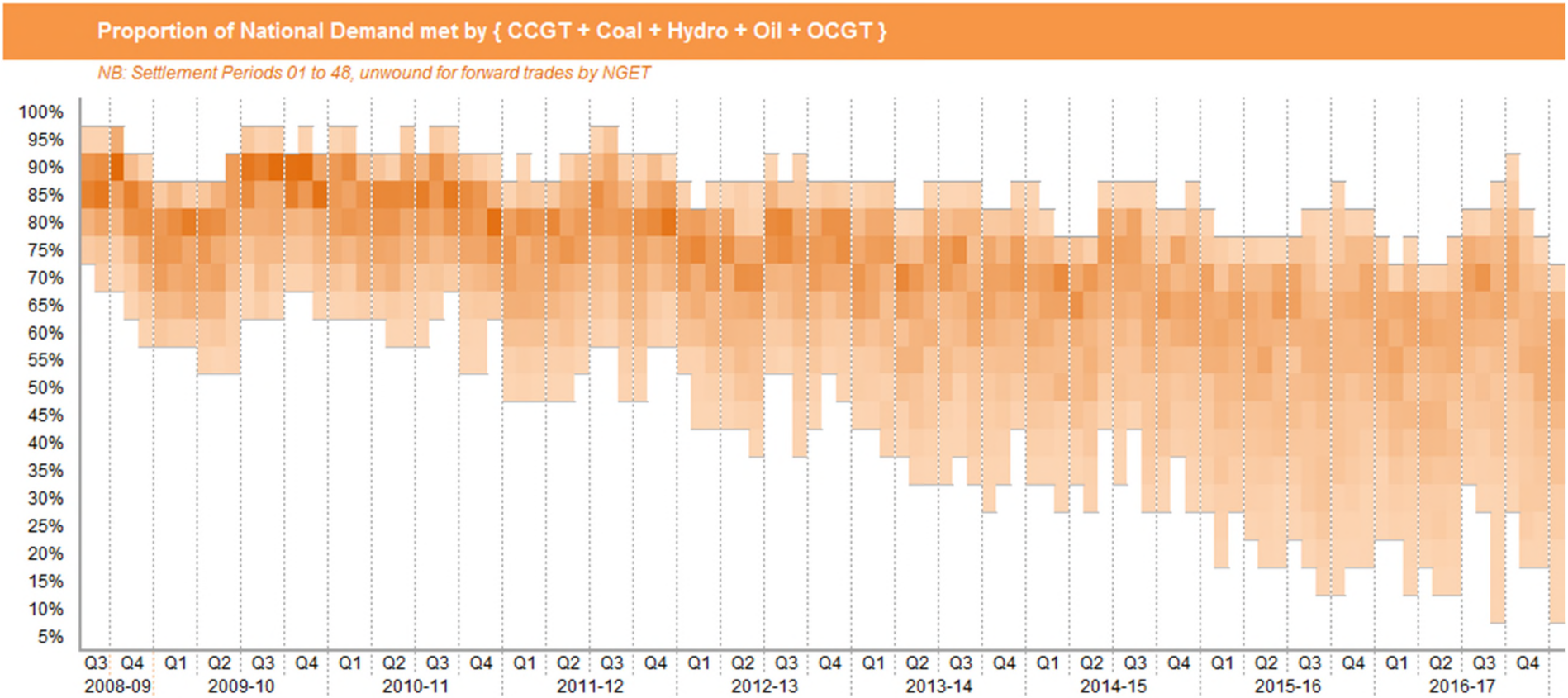
Evolution of the generation mix



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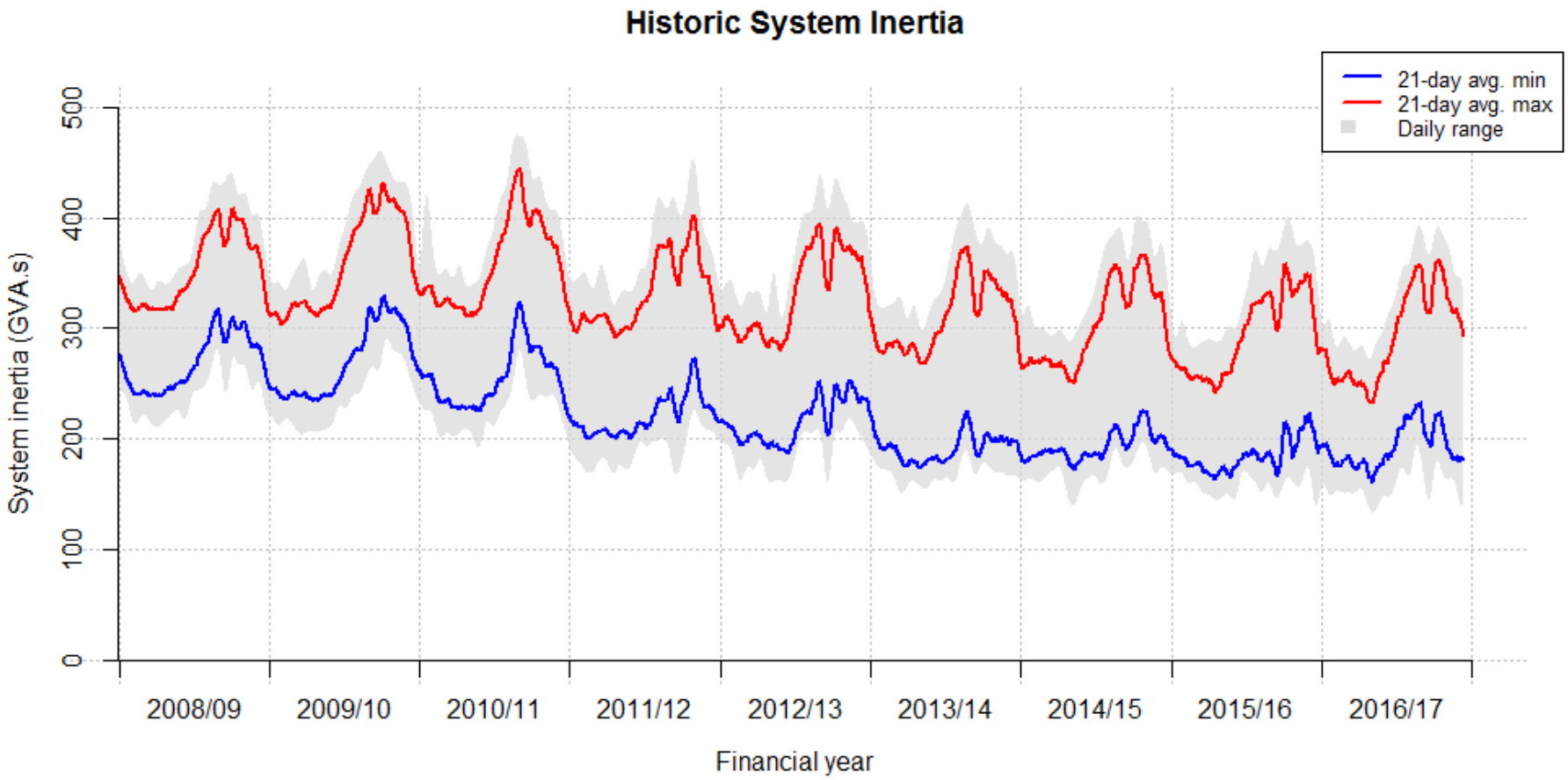
Evolution of system inertia



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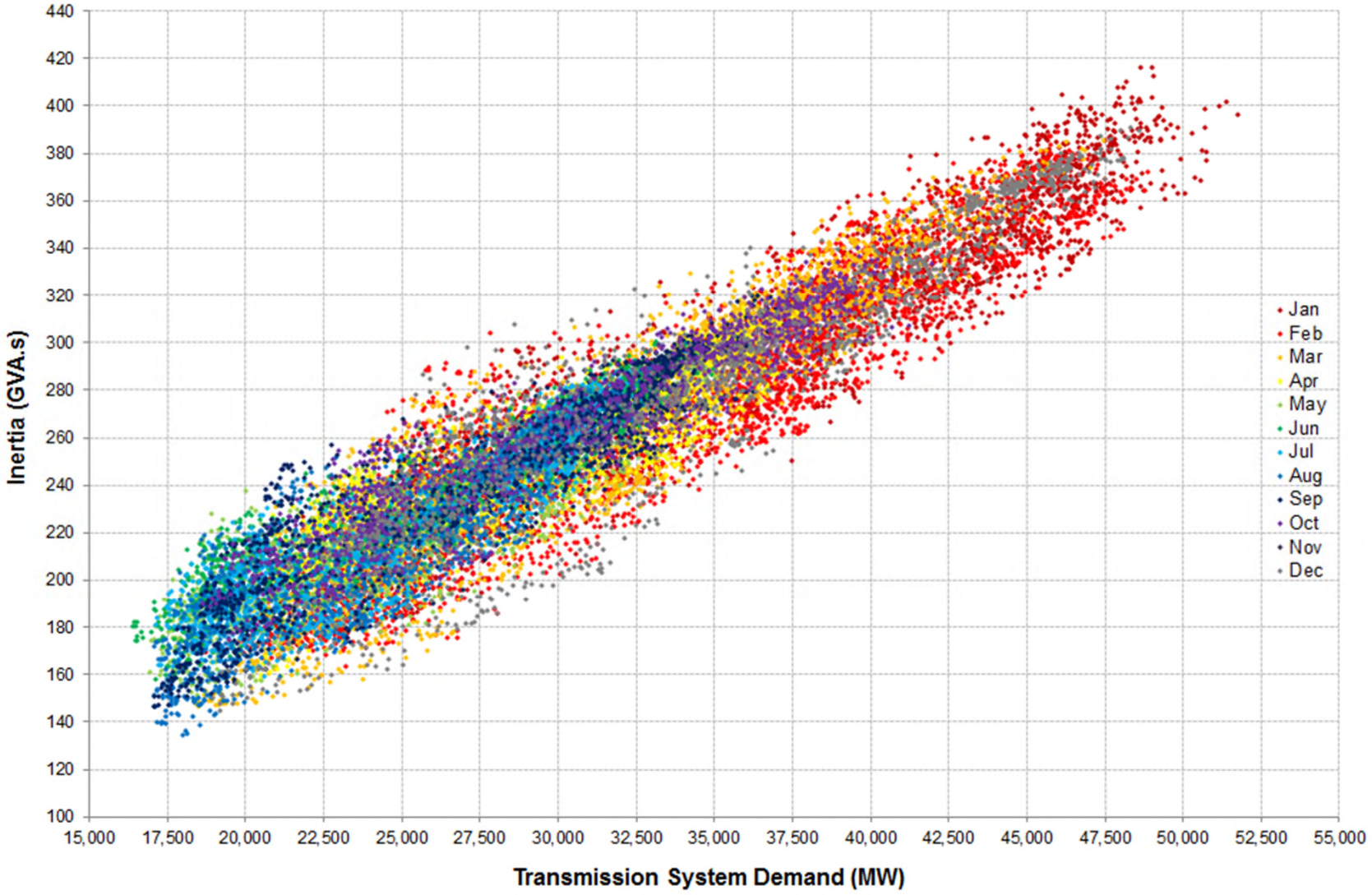
Inertia vs. Demand (2016)



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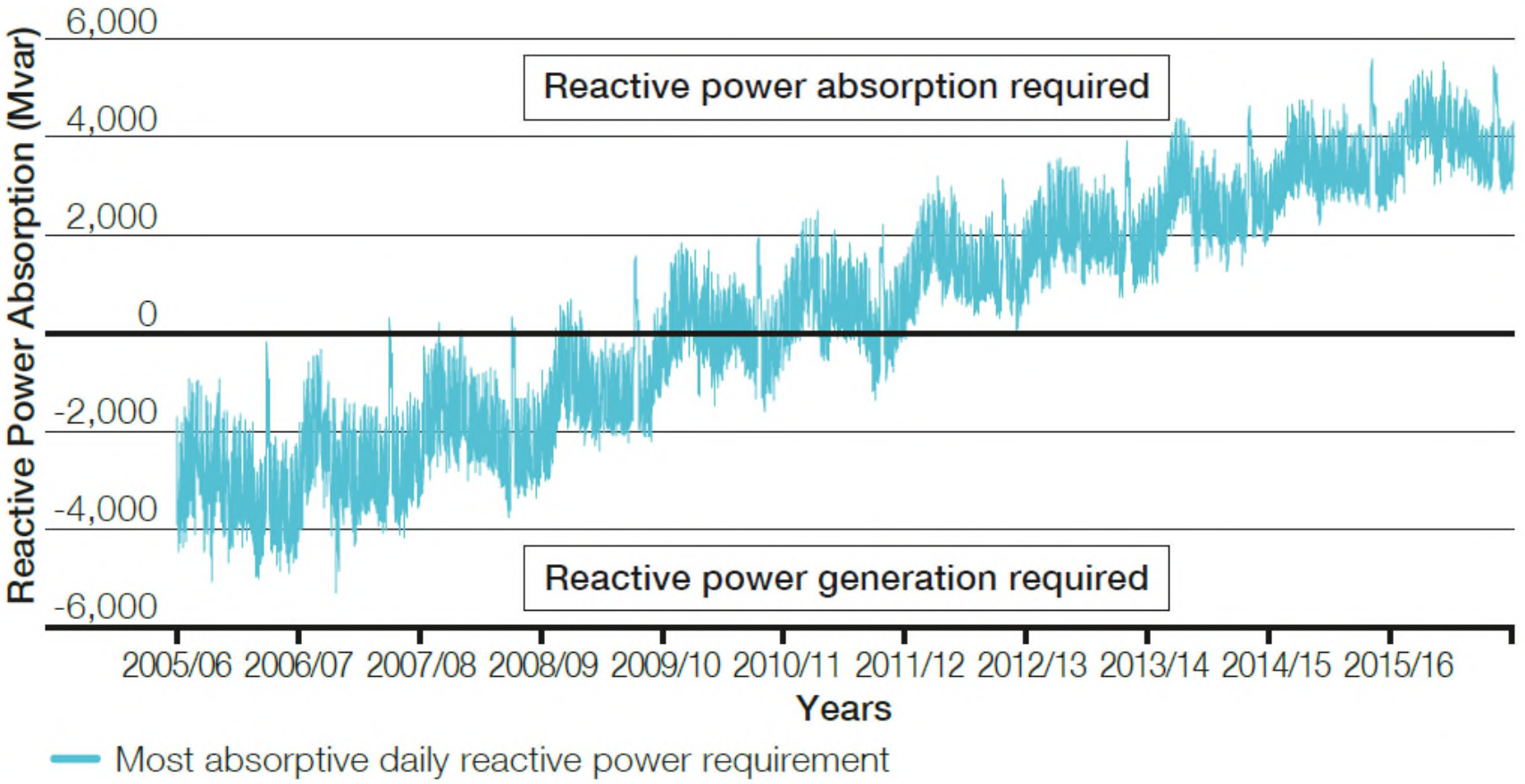
MVar demand



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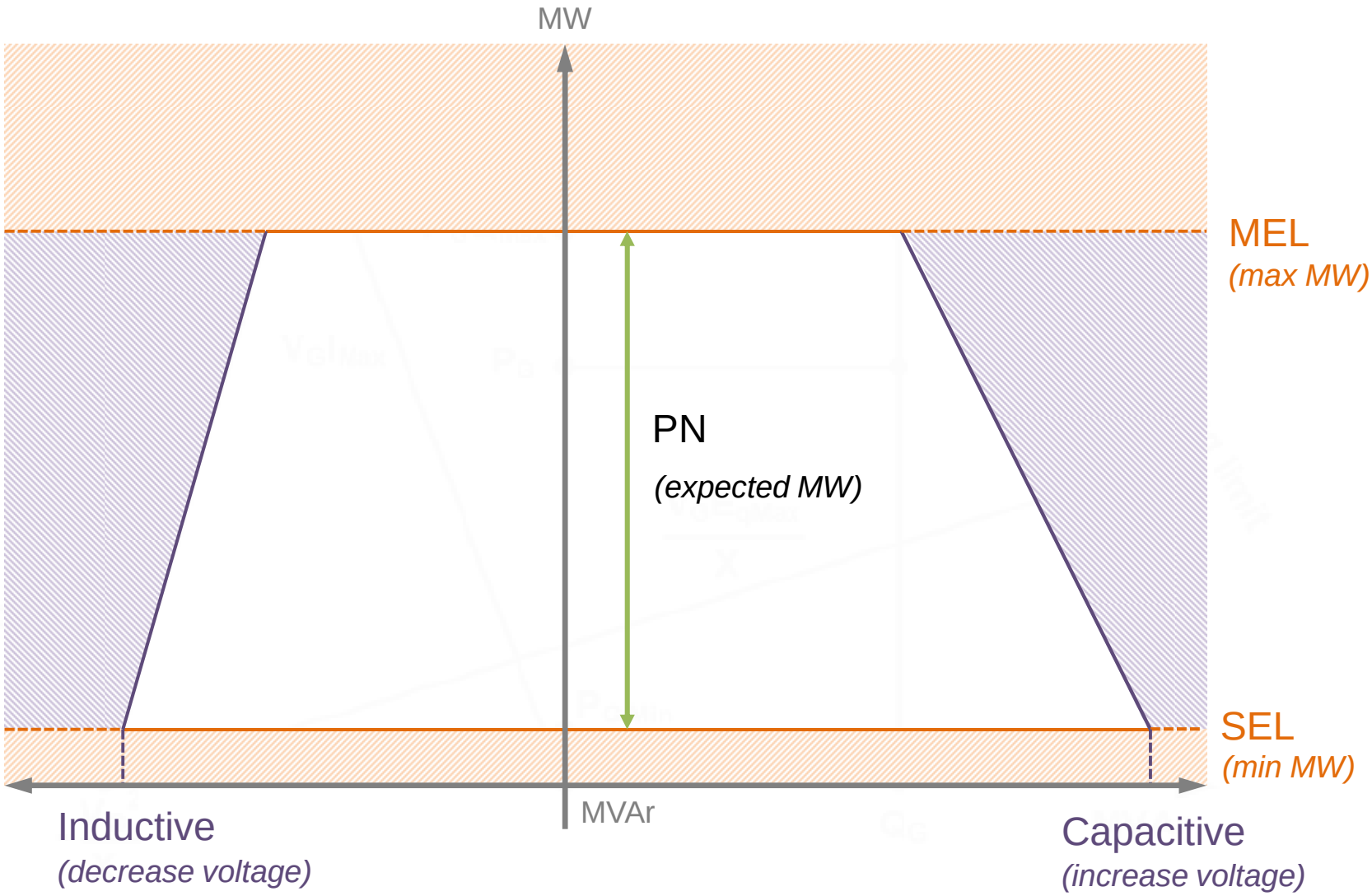
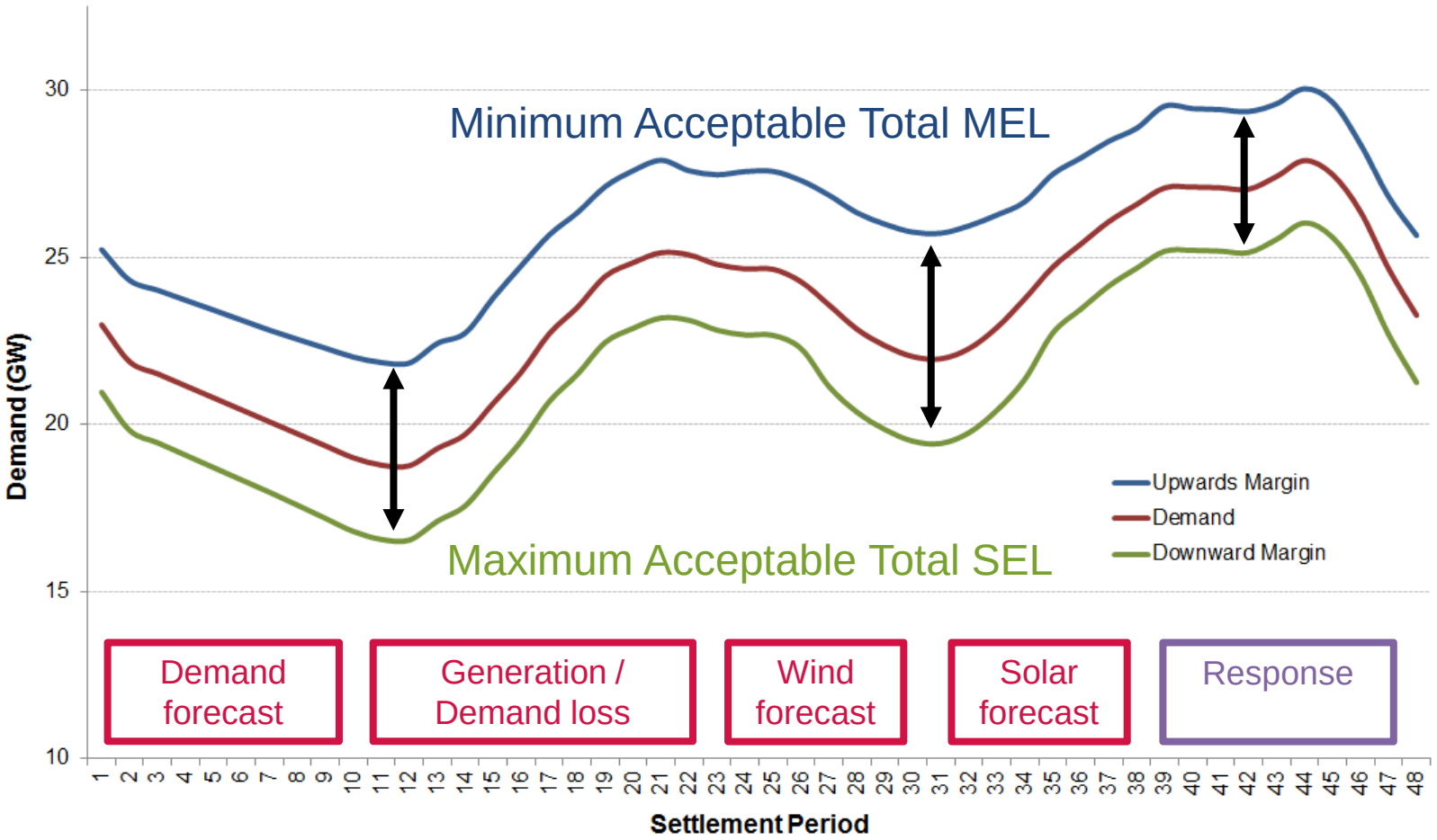
System Operation: “Tools of the Trade”

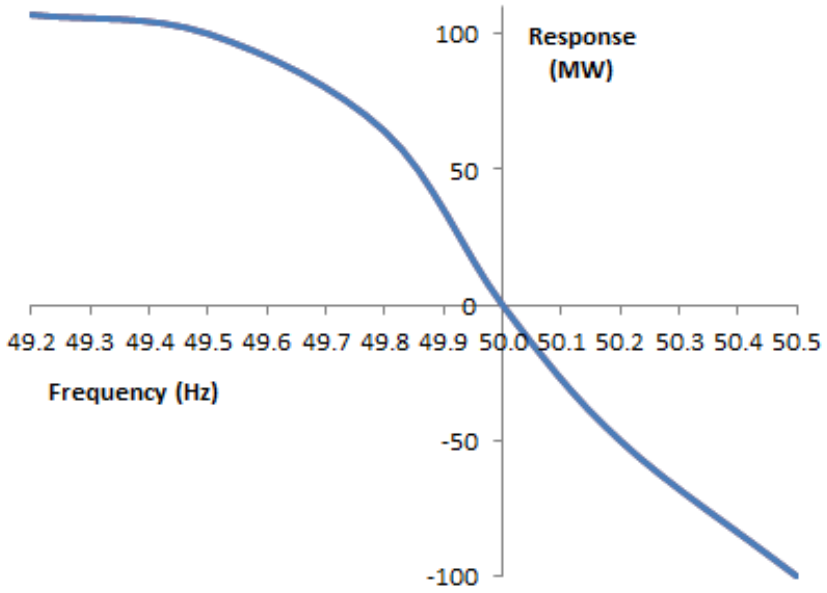
Generation: important notes



Managing the NETS: Reserve

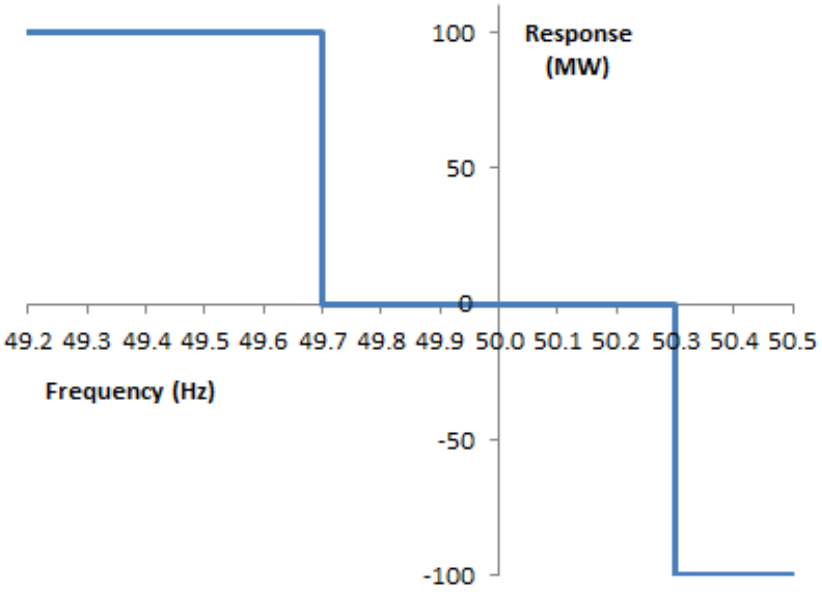


Managing the NETS: Response

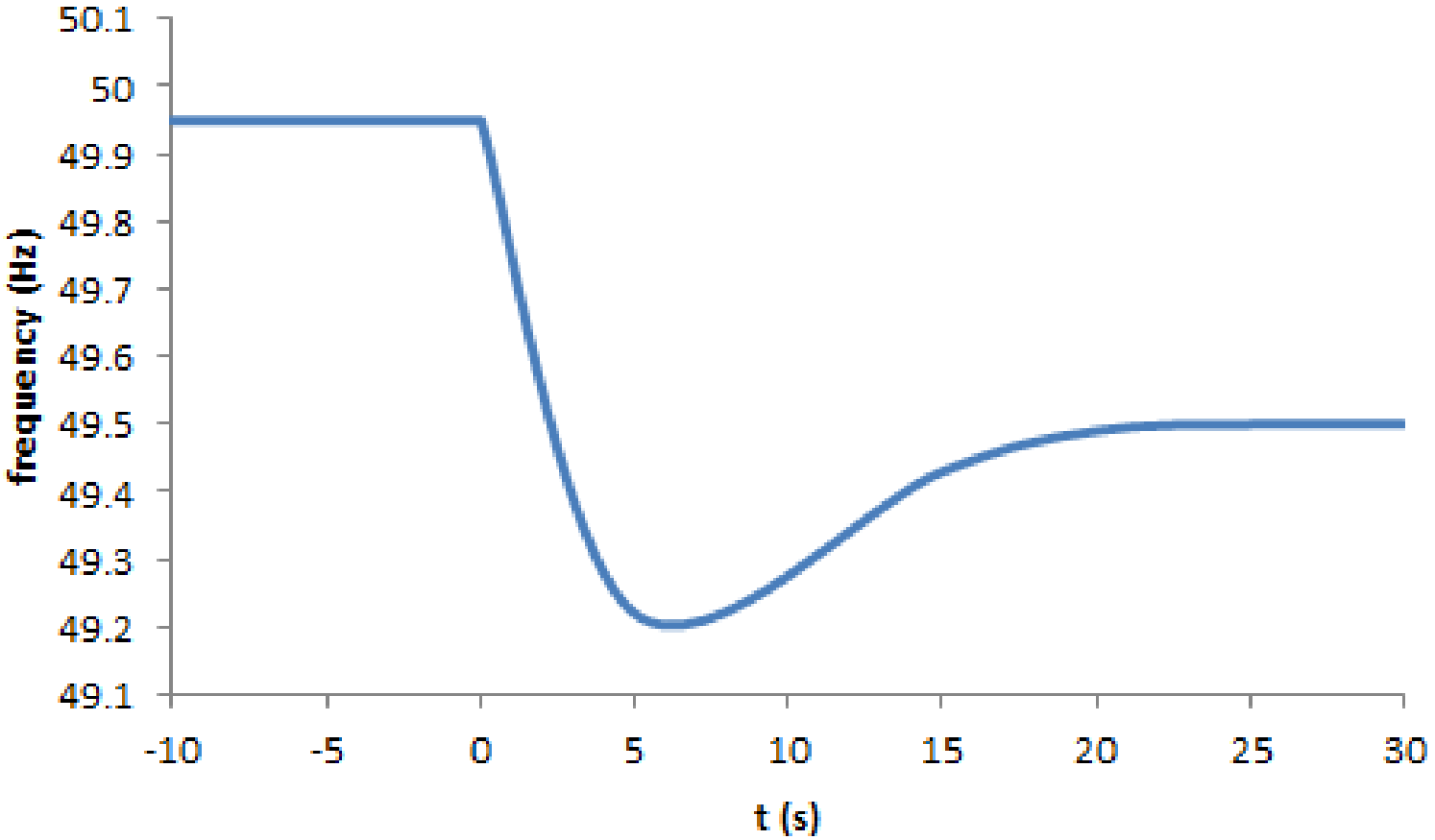


Dynamic

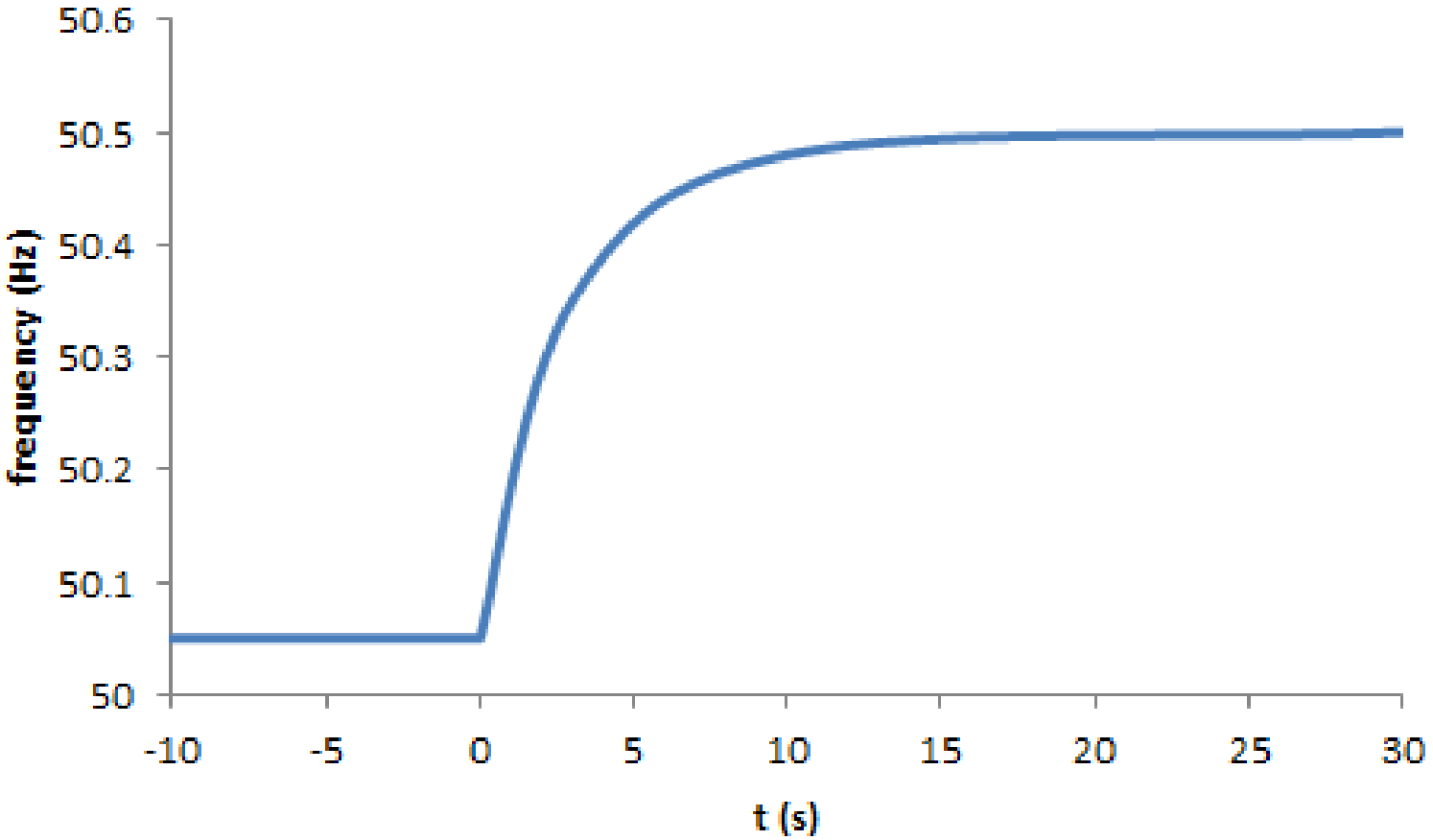
Static



Managing the NETS: Response



Managing the NETS: Response



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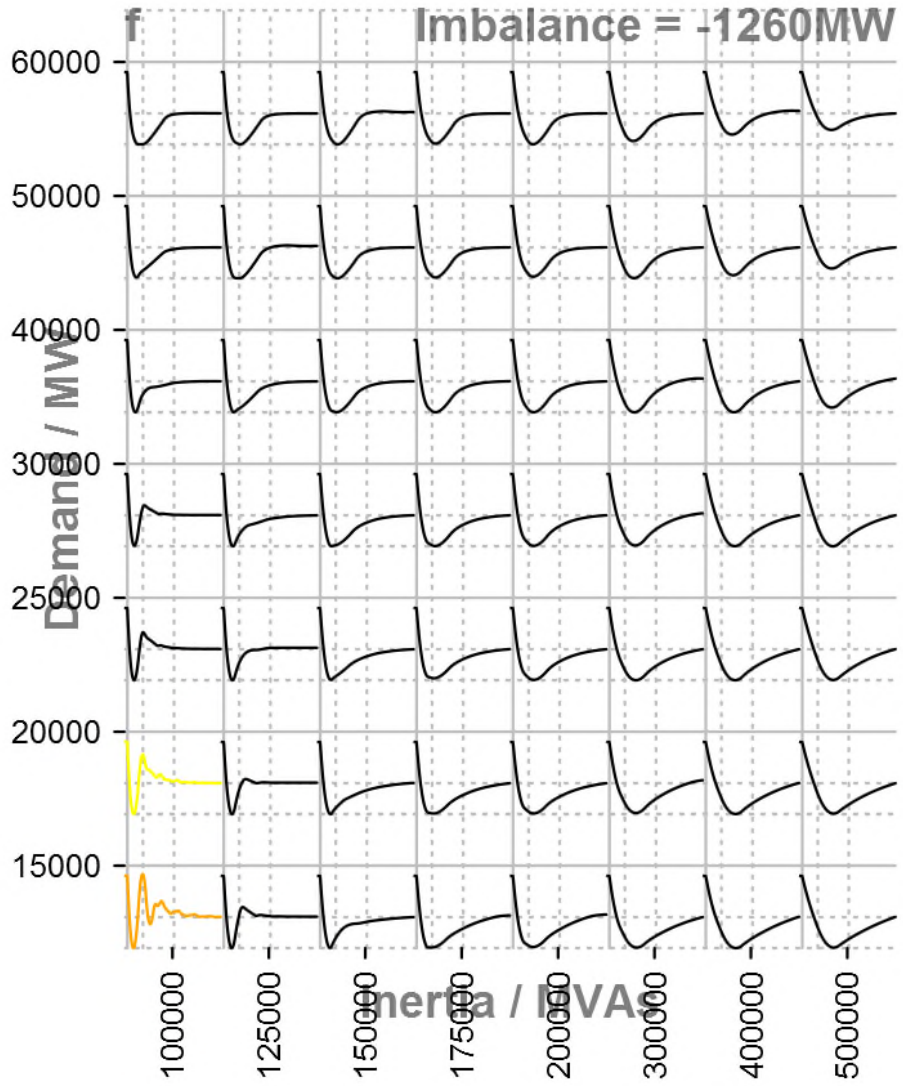
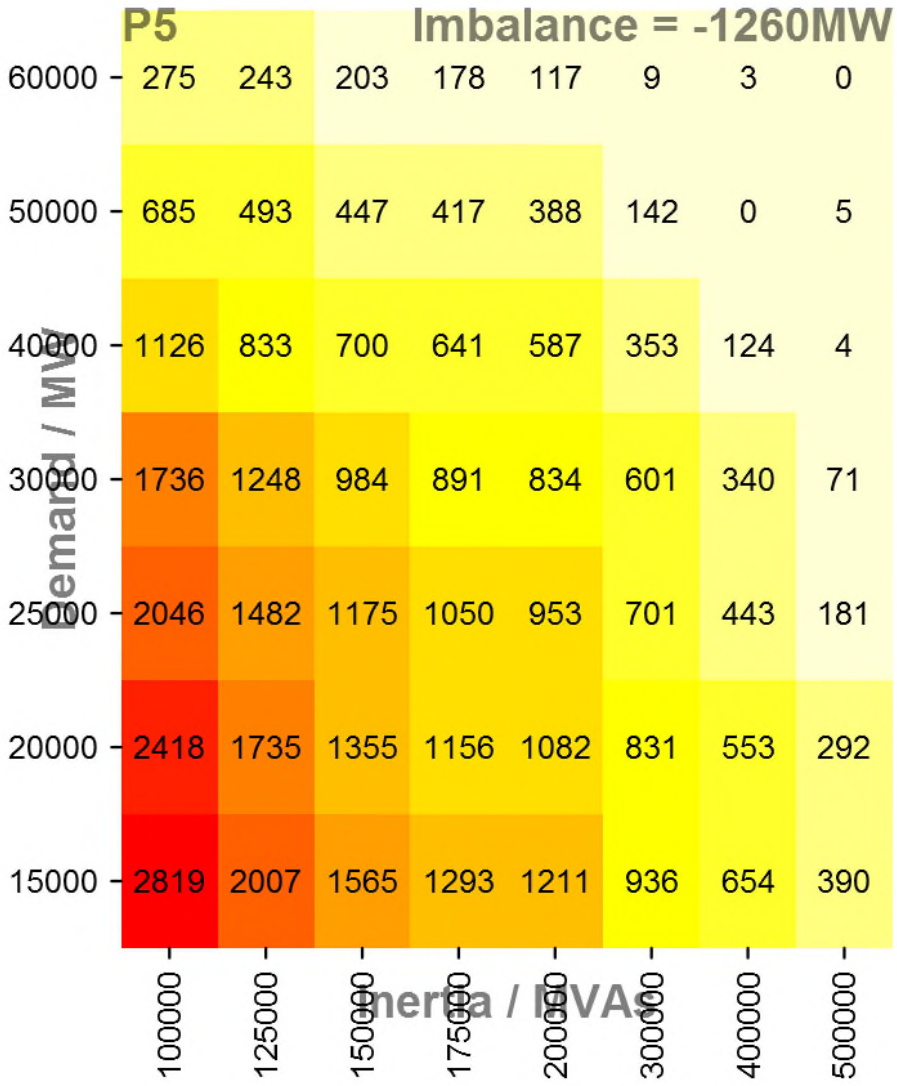
Managing the NETS: Inertia





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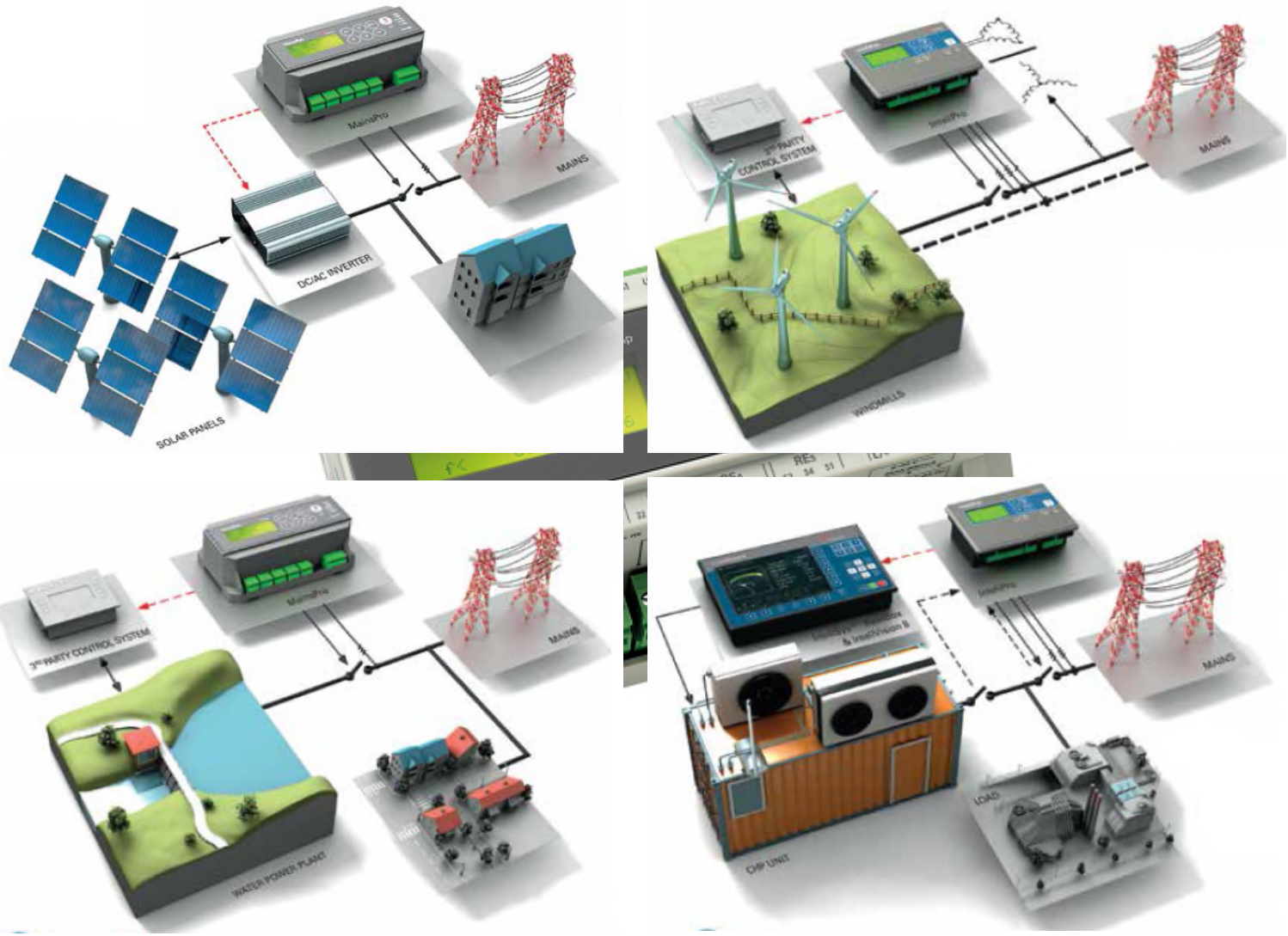
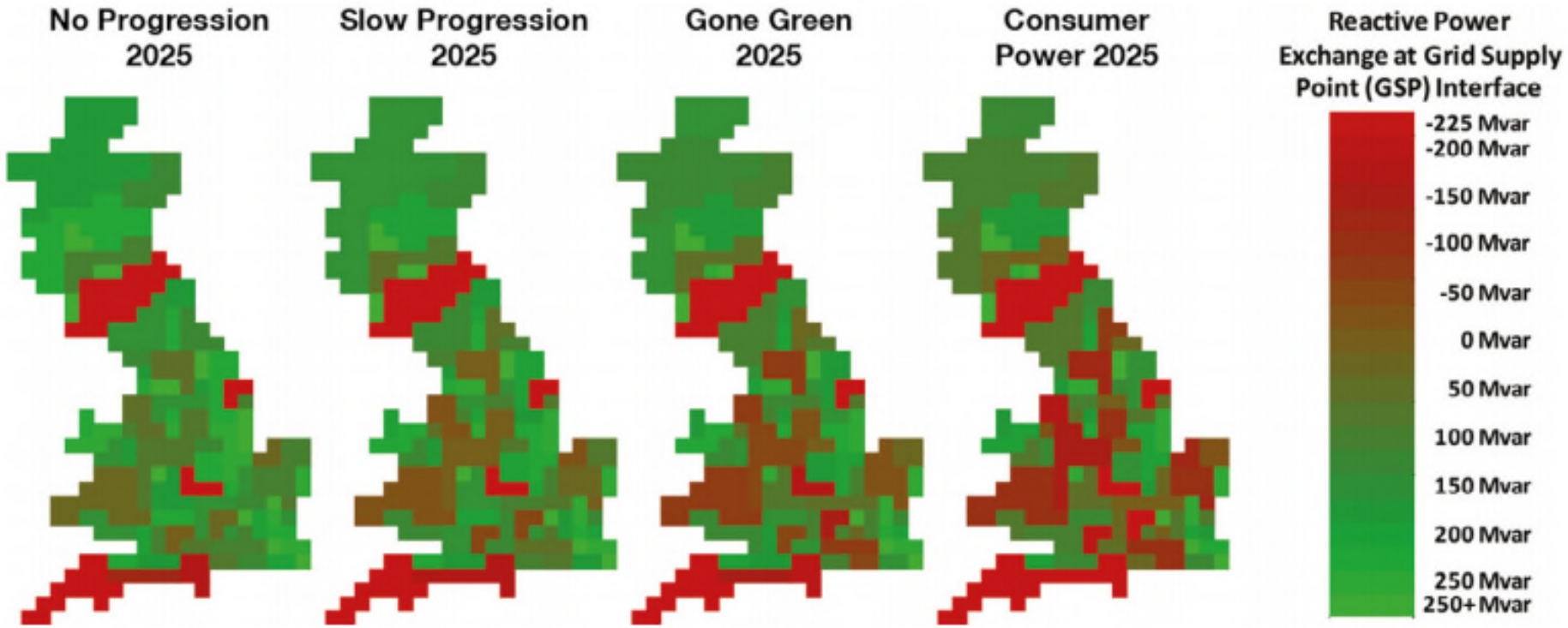
Managing the NETS: RoCoF



Managing the NETS: Voltage



Projected Reactive Power Exchange Geographically in 2025
System Operability Framework (2015)

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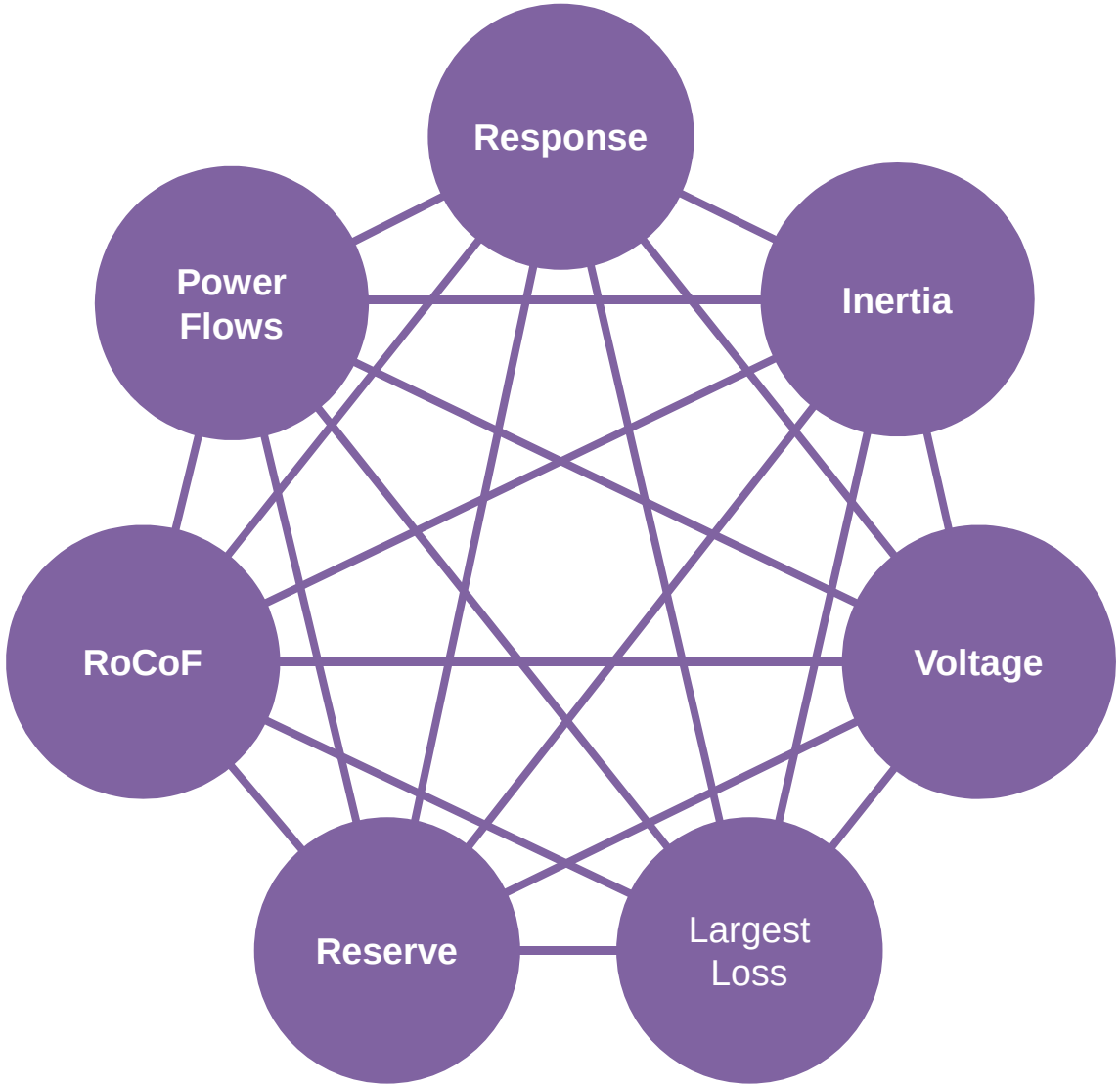
“The fundamental interconnectedness of all things”



- At low inertia and low demand, the interaction of different components becomes particularly important
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System Operation: The “Operational Trilemma”

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Cost of operating the Transmission System

~£1bn p.a.

* size of each “pile of coins” for illustrative purposes only, and is not representative of actual charges

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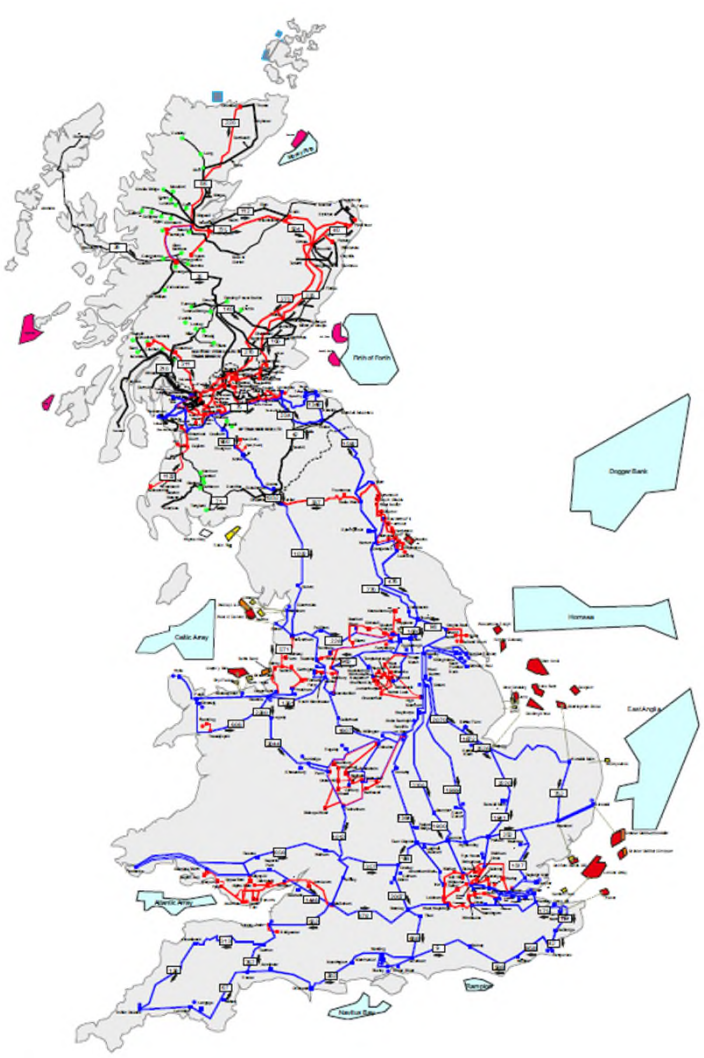
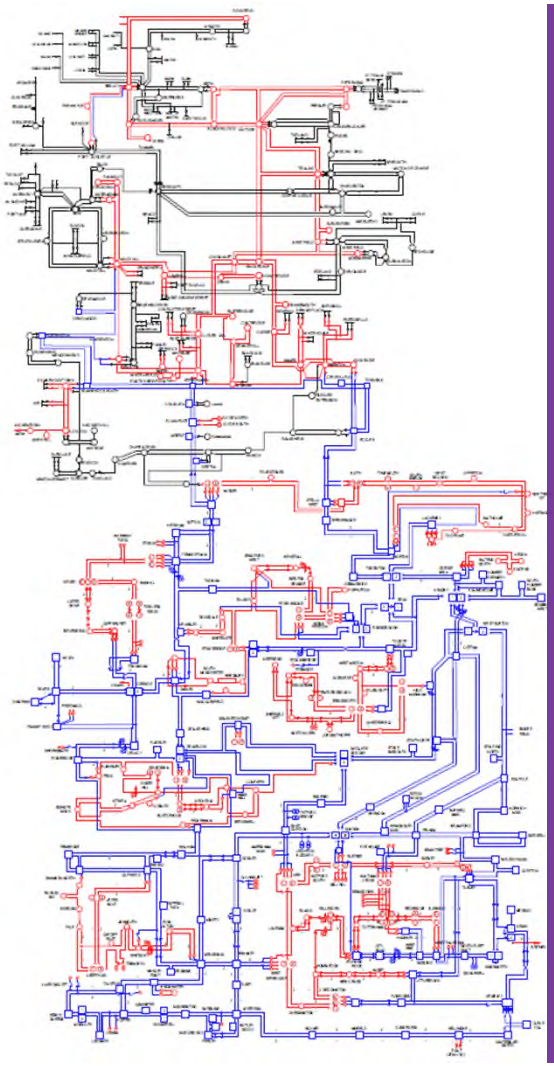
System access





400 / 275kV
Transmission voltages

22,300 km
Overhead Line

900 km
Underground Cables

1305
sites

190,000
sets of maintenance

~88,000
pylons

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System access

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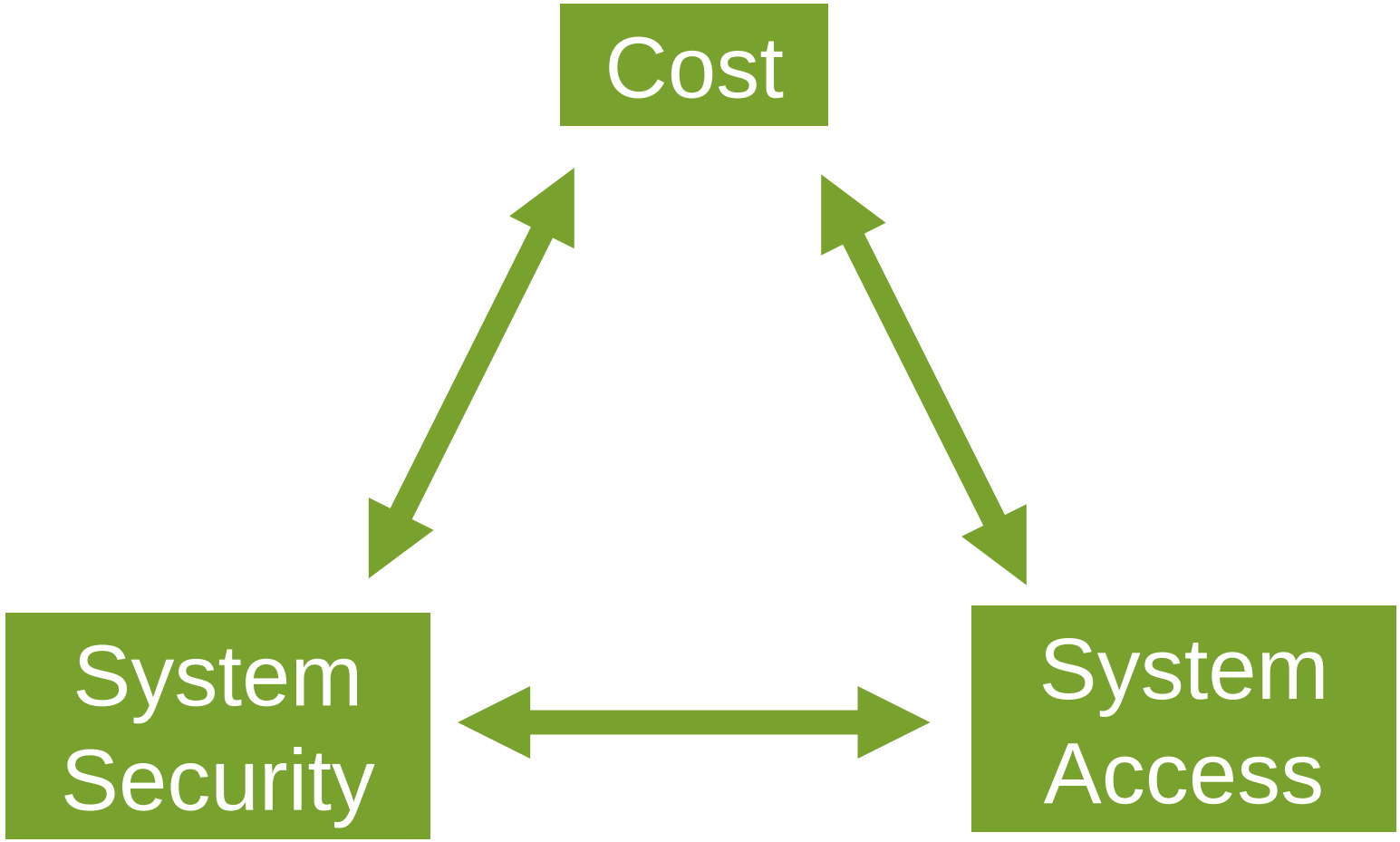
The “Operational Trilemma”



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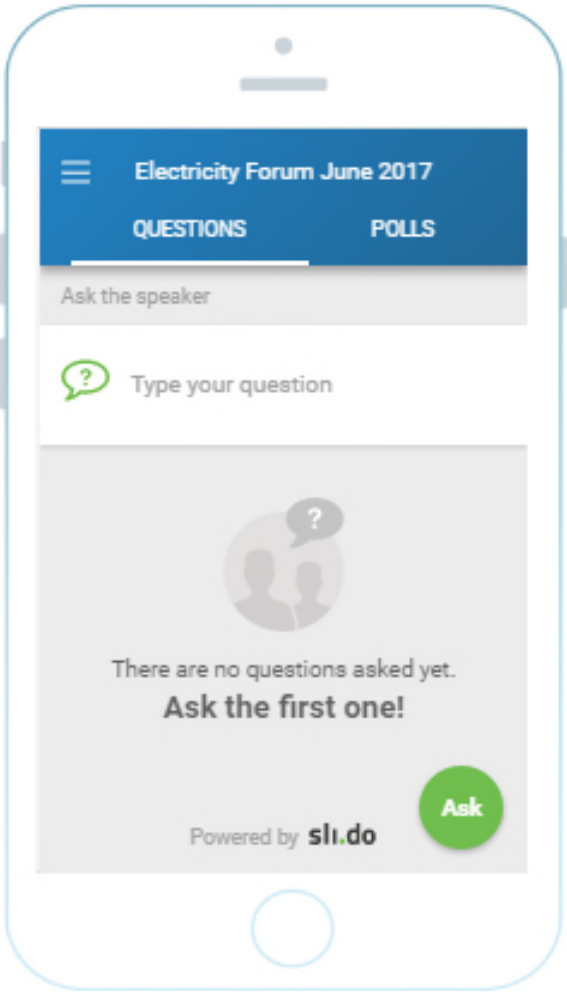
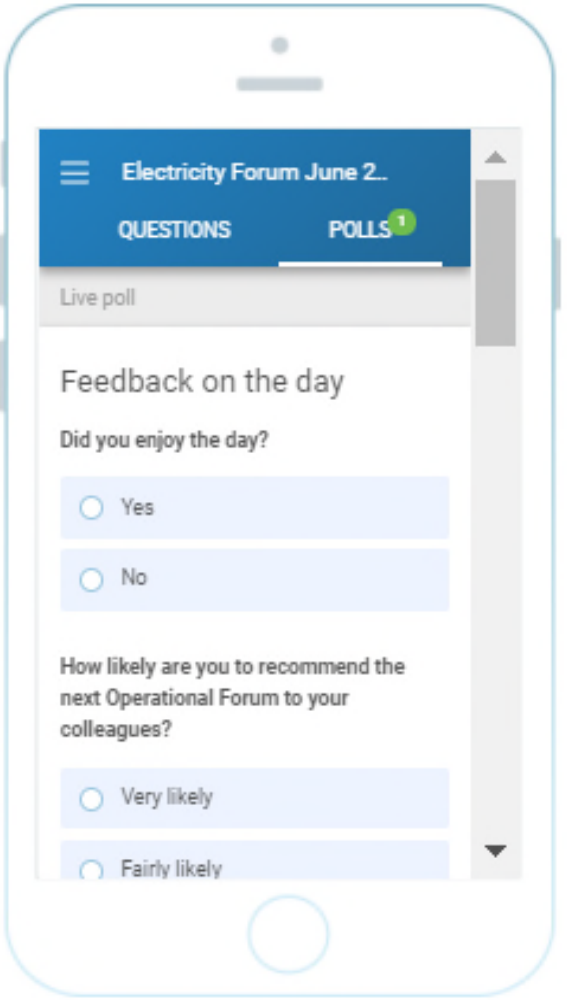


Q&A

Please provide feedback via www.sli.do

#C021



box.futureofbalancingservices@nationalgrid.com