The Enhanced Frequency Control Capability (EFCC) Network Innovation Competition Project

CIGRE Presentation

13th February 2019

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Contents

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Project background and overview

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Collaboration with the industry and academia

Responsible for the development of the monitoring and control system

Provide a response from their solar PV plants and their storage facilities (NIA DESERT)

Progressing with customers from industrial and commercial sectors for demand side response trials

Providing a view of large-scale thermal generation response by implementing revised frequency control logic

Results validation and sharing the learnings from the project

Demonstrating how wind farms can provide fast frequency response

How can EFCC assist with operability challenges for frequency containment?

Reduction in system inertia is making system frequency more volatile

- System inertia is the aggregated inertia of all rotating machines that are coupled to the system
- Frequency is more volatile when system inertia is low

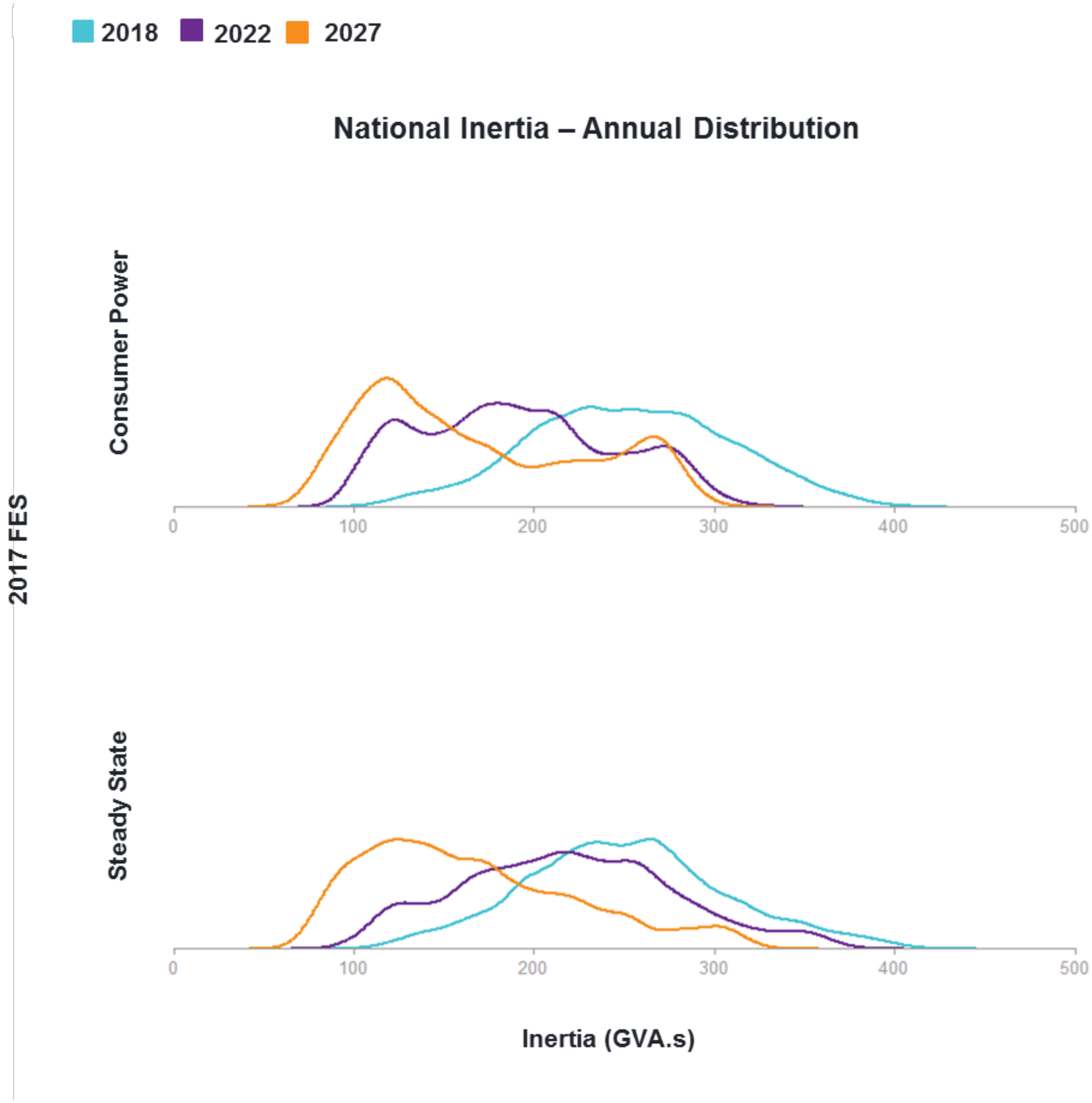
Rate of Change of Frequency (RoCoF) is increasing, faster response capability is required

- RoCoF depends on the total amount of energy stored in the rotating masses which are synchronised to the system
- Reducing system inertia requires faster delivery of response

Regional vs National Frequency: frequency differs across the system immediately after an event

- Requires proportional response to the estimates size of the frequency event

Falling system inertia results in faster Rate of Change of Frequency (RoCoF)

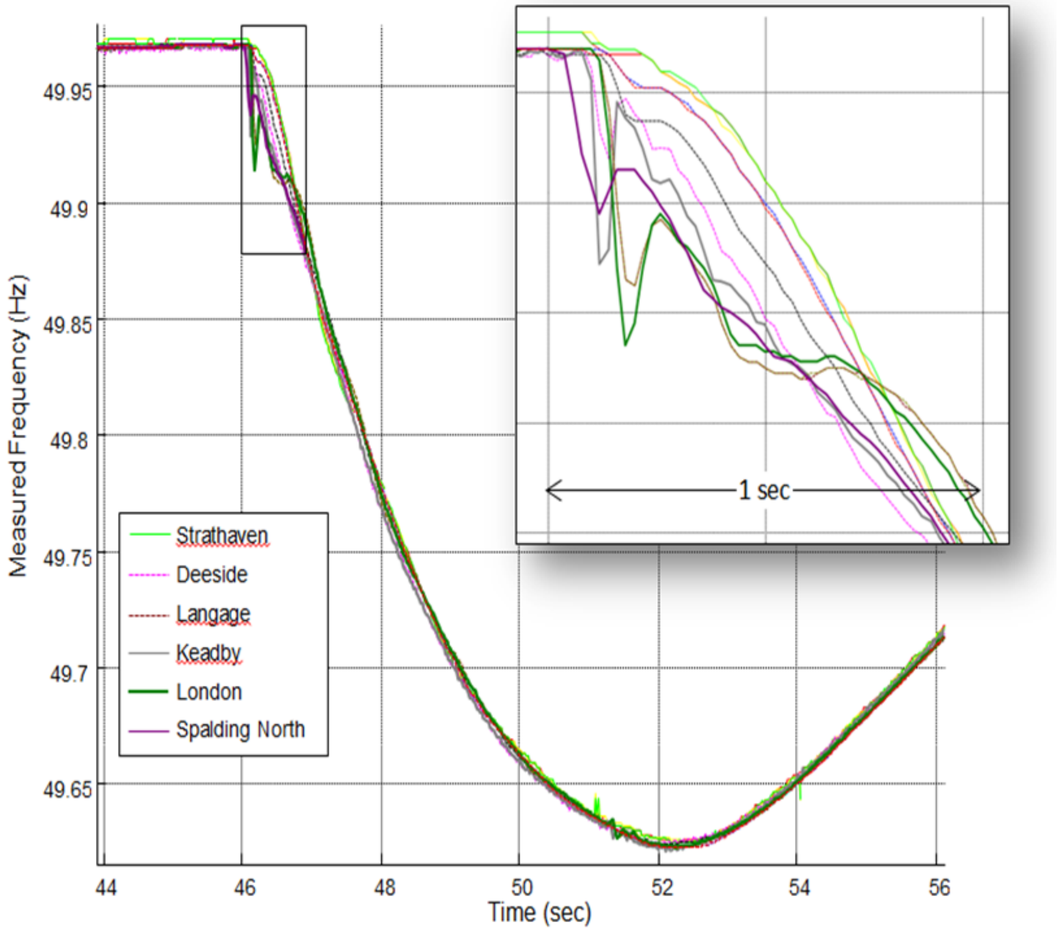


Operating with low system inertia: RoCoF relay changes and predicted reduction in synchronous generation resulting in reduced levels of system inertia *(unconstrained system)*

Frequency Containment: will become more challenging as RoCoF increases with the ability to respond faster required in the next 3-5 years

Regional vs National Frequency: when responding faster to an event (1-2 secs), system frequency differs across the network, requiring proportional response

with divergence & increased unpredictability in system frequency movement across the network



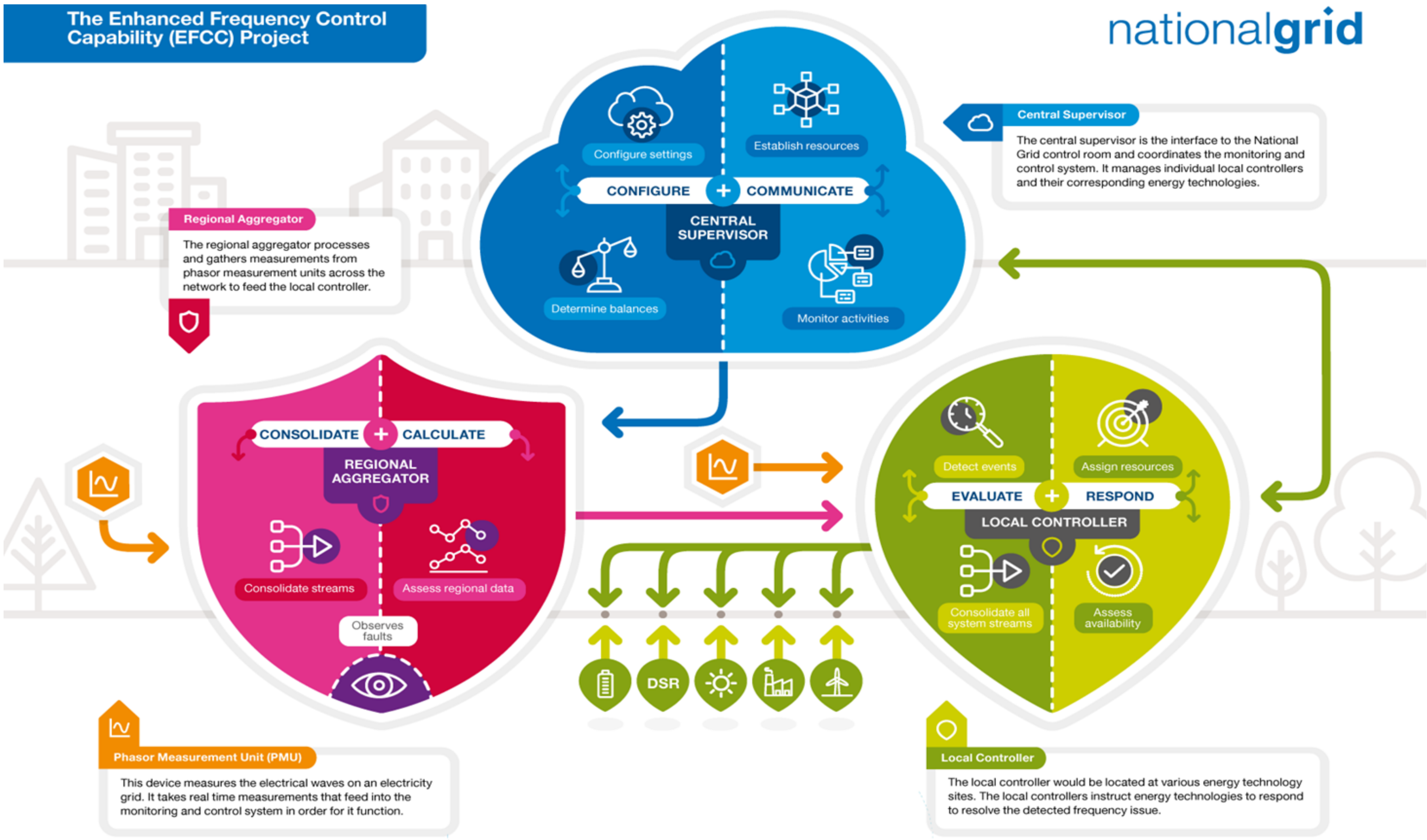
Event detection: ability to accurately identify events within faster timescales

Verification of Event: faster event detection requires accurate measurement

Faster Response: required to 'catch' frequency immediately after the event

Targeted and Proportional: accurate deployment required to avoid unintentional system consequences

The MCS detects and verifies frequency events, providing a targeted, proportional response



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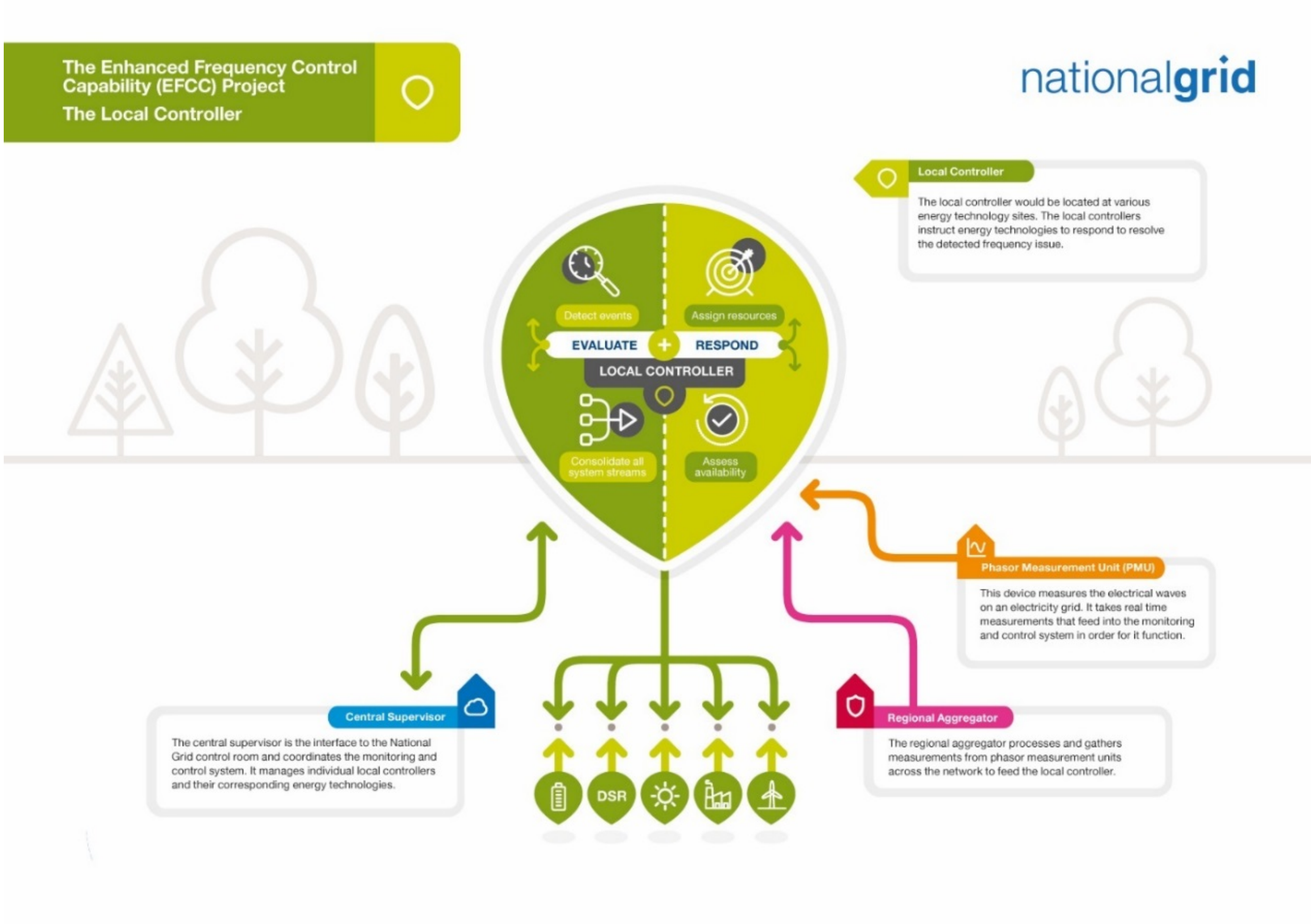

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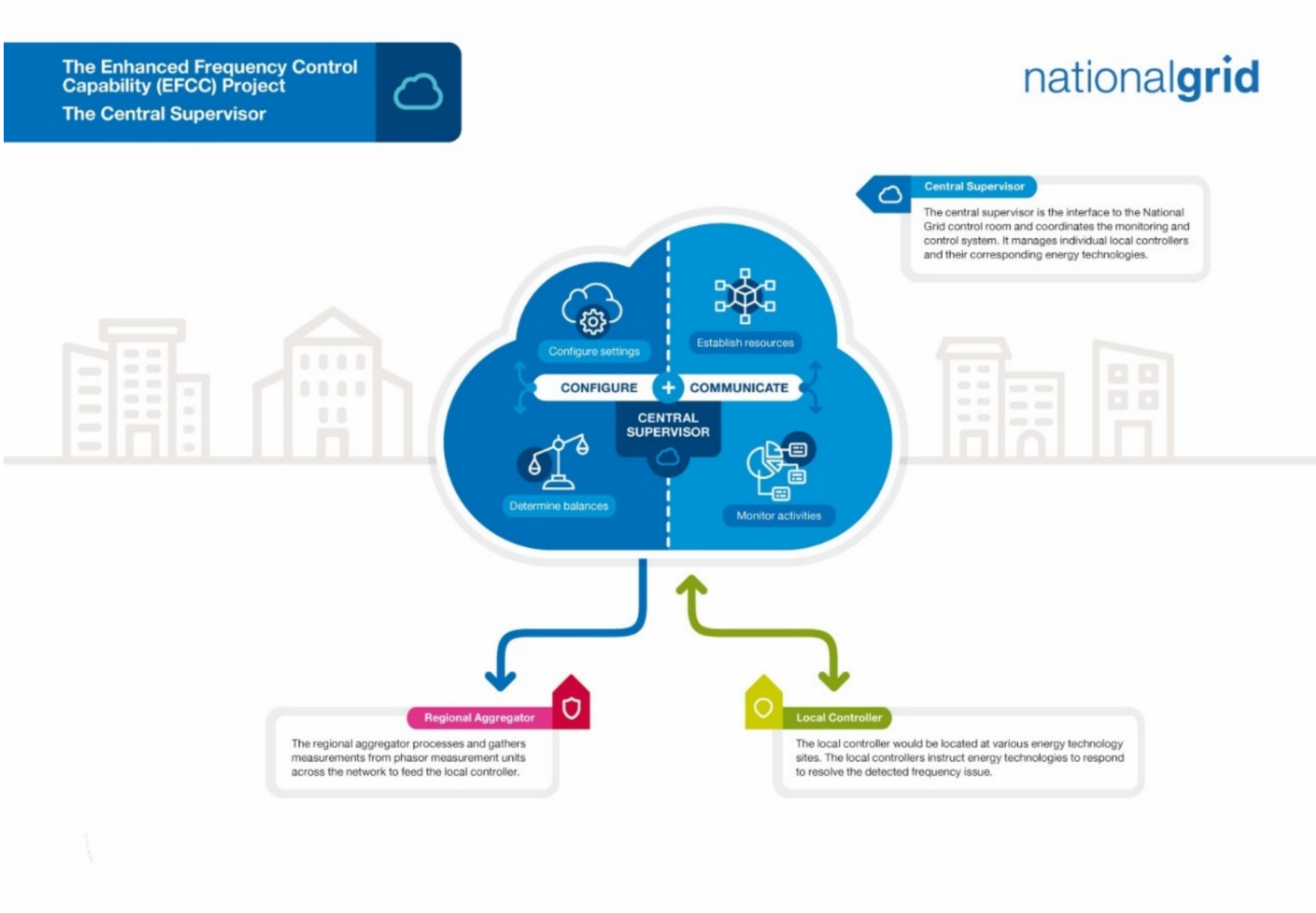

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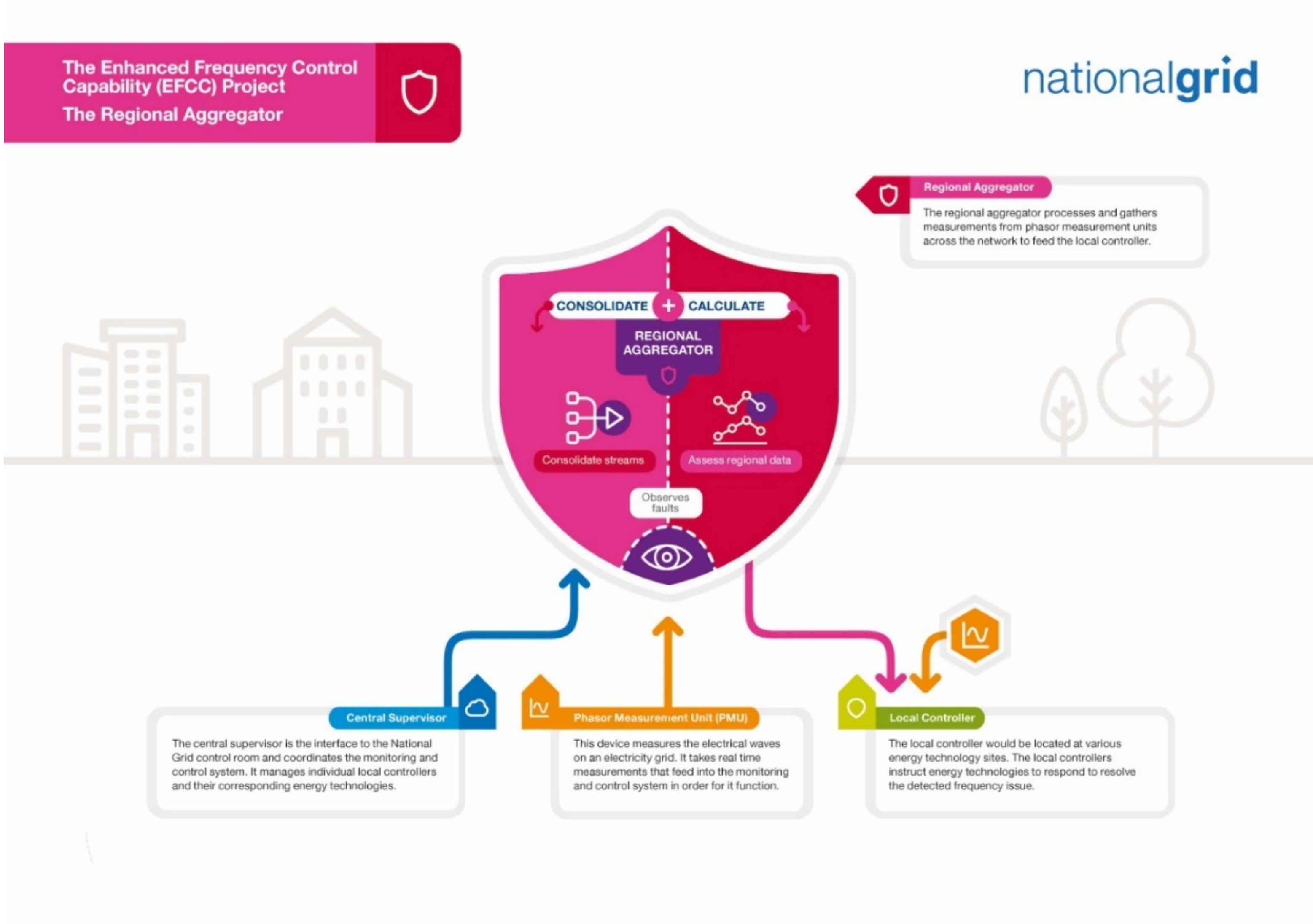
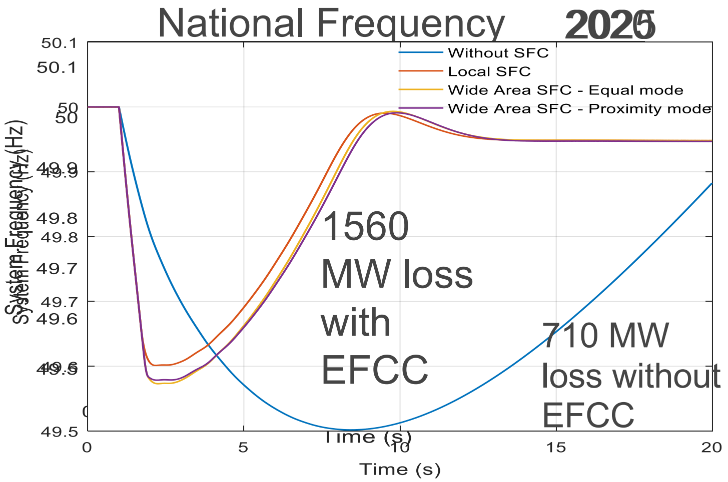
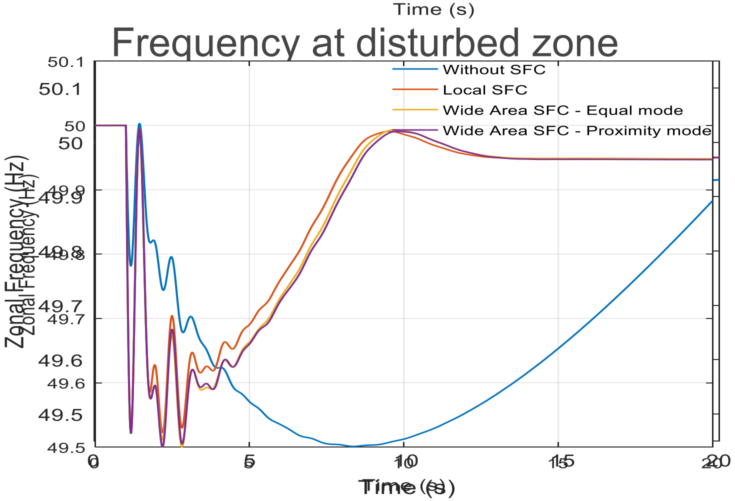


Simulation is able to show the value of EFCC Scheme against future events





- Key to EFCC optimisation is the deployment of sufficient resources to meet the event. The modelling approach is able to simulate this.
- Approach allows us to see regional and national frequency, identify how and to what extent regional resource is important and how best to combine EFCC with other forms of frequency response.

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The EFCC Scheme is a mechanism for managing system frequency in low inertia networks

by monitoring system frequency and regulating response to events, assisting with system stability

Detects | Verifies | Faster Acting | Proportional | Targeted

through the provision of rapid frequency response from a diverse range of technologies and their capabilities

Monitoring and Control System (MCS) + Faster Acting Response Providers =

Enhanced Frequency Control Capability Scheme

Testing results summary

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Monitoring and Control Scheme Testing

Component Testing

University of Manchester

- Frequency event caused by the system load increment/decrement in low system inertia conditions can be successfully detected
- Event detection and resource allocation modules respond within the designed time
- Wide-area based RoCoF calculation and loss of generation estimation are accurate.

Component Testing

University of Manchester

- Fault event can be successfully detected and event detection module is intentionally blocked for a defined period of time
- With fast coordinated response of the scheme, a moderate amount of fast service response can effectively counteract the frequency contingencies
- The scheme is efficient in scenarios with reduced system inertia

Communication Testing

University of Strathclyde

- Size of data buffering window directly determines MCS's capability to handle degraded communication performance
- Increasing buffering window can mitigate the risk of loosing packets, but can compromise the response speed
- Through the PNDC tests, the requirements for communication performance has been quantified
- MCS appears to be robust in degraded communication conditions.

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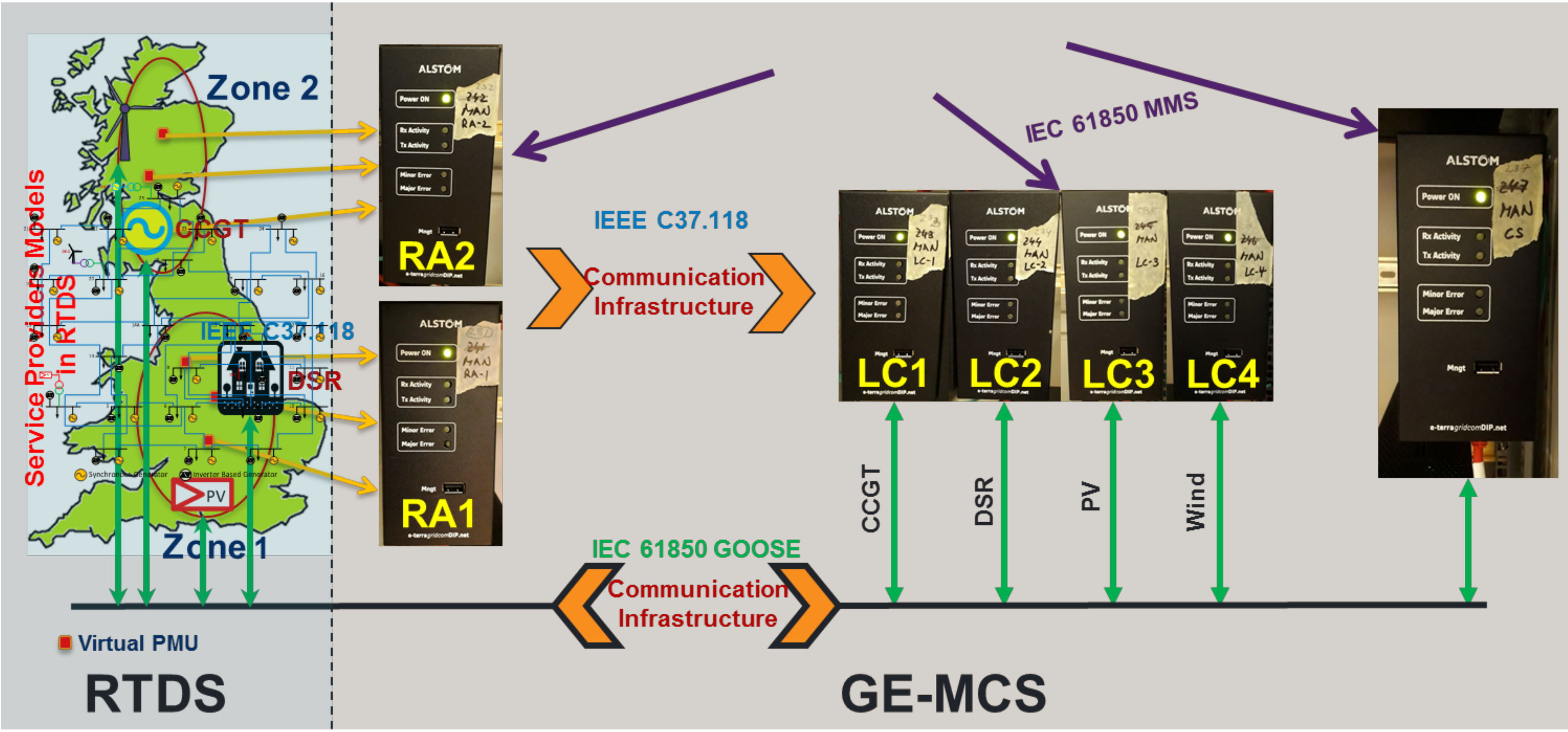
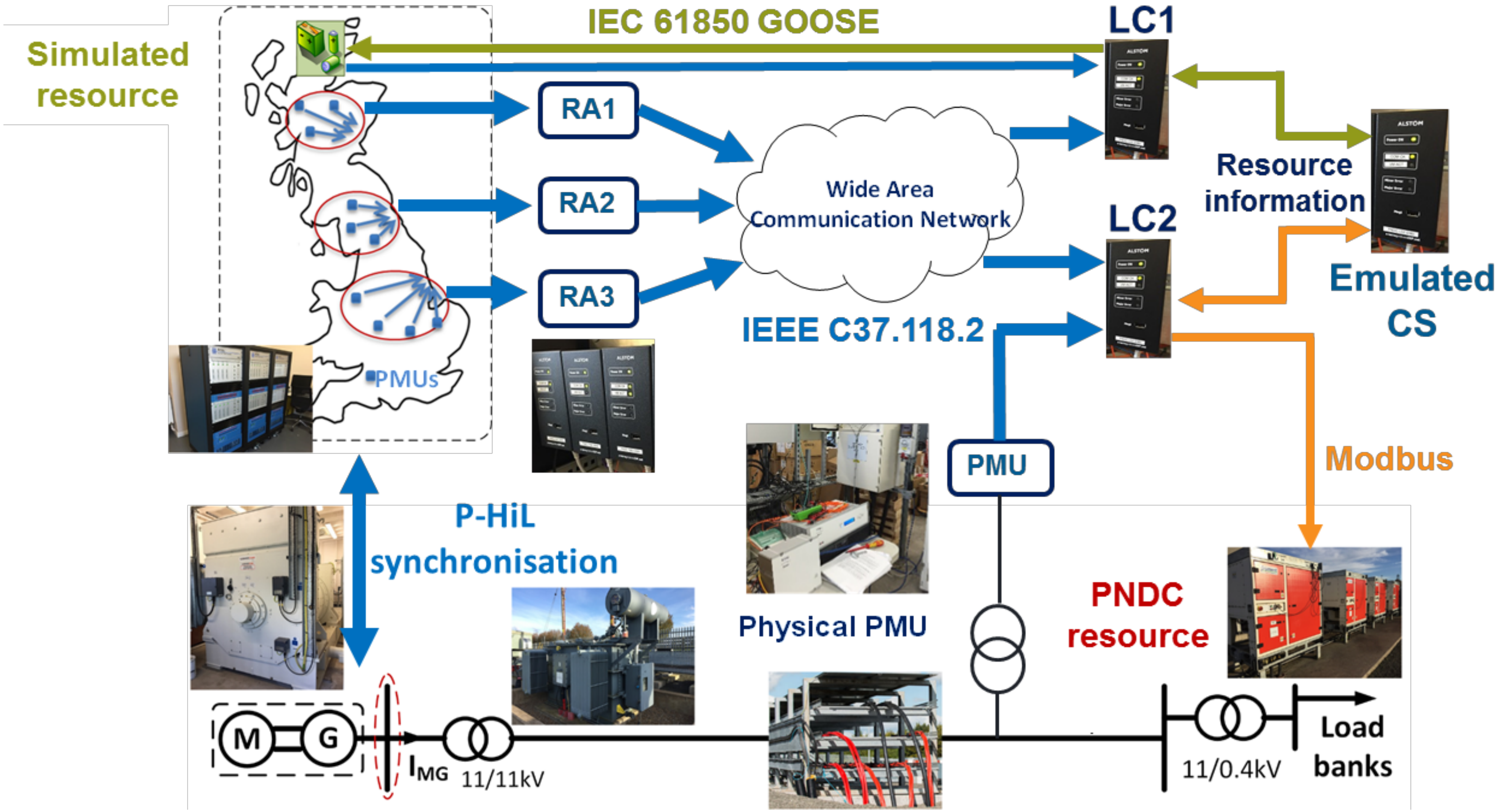
Real-time digital simulation of the impact of MCS



Physical simulation of the impact of MCS



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Field Trials Summary

DSR

Flexitricty

- Developed and tested three new demand response services – Static RoCoF, Spinning Inertia and Dynamic RoCoF.
- Demonstrated that both Static RoCoF and Dynamic RoCoF can both detect and respond to MCS signals for real events on the transmission network with appropriate setting of the control system. Delivery within the target 0.5 seconds is also achievable.

CCGT

Centrica/EPH

- Demonstrated that a CCGT can respond more quickly to rapidly falling network frequency by responding to RoCoF instead of deviation in frequency from a set point (normally 50.0 Hz).
- Determined that a new type of frequency response from large thermal plant is achievable and that a conventional primary response delivered at 10 seconds could be delivered approximately 3 seconds quicker and can be sustained for as long as dictated by network requirements.

Wind Inertial Response

Orsted, Siemens & UoS

- Wind has potential in enhancing frequency control however the second frequency dip needs to be considered.
- The second frequency drop can be significantly improved by
  - ramping down slowly the windfarm output after IR and careful selection of suitable capability of wind farms in providing IR
- The occurrence of the frequency second dip varies with profile data type/ratings/loading levels which will require close coordination with other resource
- Location on the network and activation time of the windfarm IR does not have a significant impact.

Field Trials Summary

Solar PV Belectric

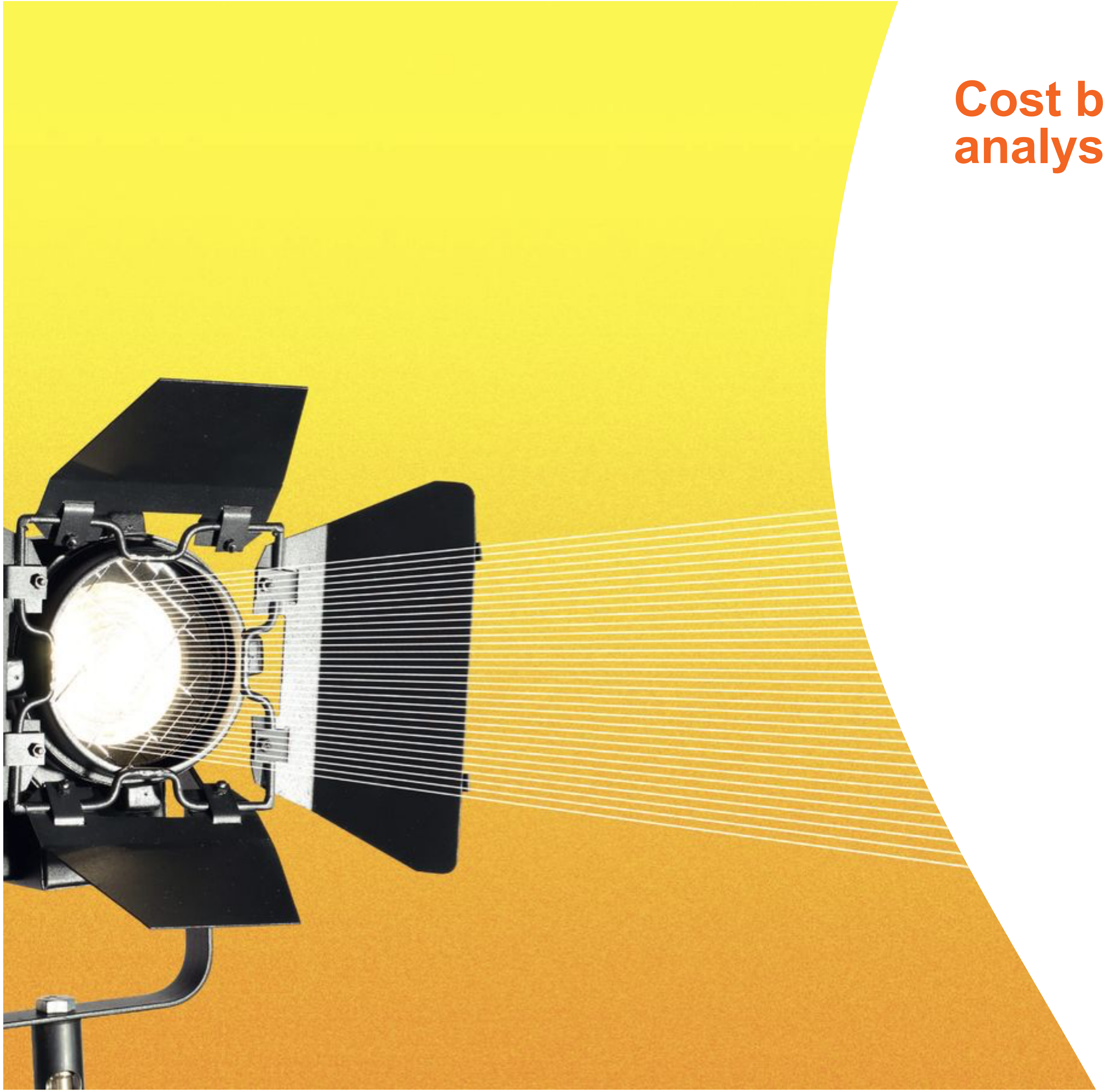
- Demonstrated that the provision of +/-frequency response services from central inverter based solar PV plant is possible.
- Limitations include curtailment for the provision of positive frequency response, day/night availability, asymmetric response time of inverters, flat ramp rates and the volatility of available power.
- Communications topology inside PV solar farms were never meant to be fast - good network design with fast switches and bridges necessary.

Solar PV Belectric

- Retrofitting a PV power plant network to provide frequency response is possible.
- Solar PV with solar forecast and curtailment algorithms can provide a significant contribution to network protection by limiting large RoCoFs in low inertia networks.

Solar PV & Battery Hybrid - Belectric

- Solar PV and Battery hybrid systems can be integrated into the EFCC scheme
- Creating additional value, faster overall response and increase the overall system availability.
- Battery systems can support large scale solar PV systems in the provision of system services, where the battery may provide the fast reaction part of the response and the night time availability.



Cost benefit analysis

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What are the system benefit of faster frequency response when using the MCS?

Ability to run the electricity system with increasing volumes of non-synchronous generation

Managing the system to faster RoCoF which has regional variation

The MCS is a delivery mechanism for managing faster frequency response

Utilising full capability from resource providers, coordinating the output to meet the response profile

What is the system value of faster frequency response coupled with MCS?

The ability to access and coordinate within quicker timeframes

Project learning

Learning Points

Reduction in system inertia makes the frequency more volatile

Faster coordinated frequency response through the MCS

Testing of MCS concept completed

Communication and business system impacts assessment completed

Learning Points

Faster frequency response is possible from a range of technologies

Faster frequency response coupled with MCS is beneficial

Increasing understanding of resource capabilities e.g. wind inertial response, faster droops, PV contributions

Ability to simulate system frequency disturbances and model how the EFCC Scheme and other response services would operate

Project next steps

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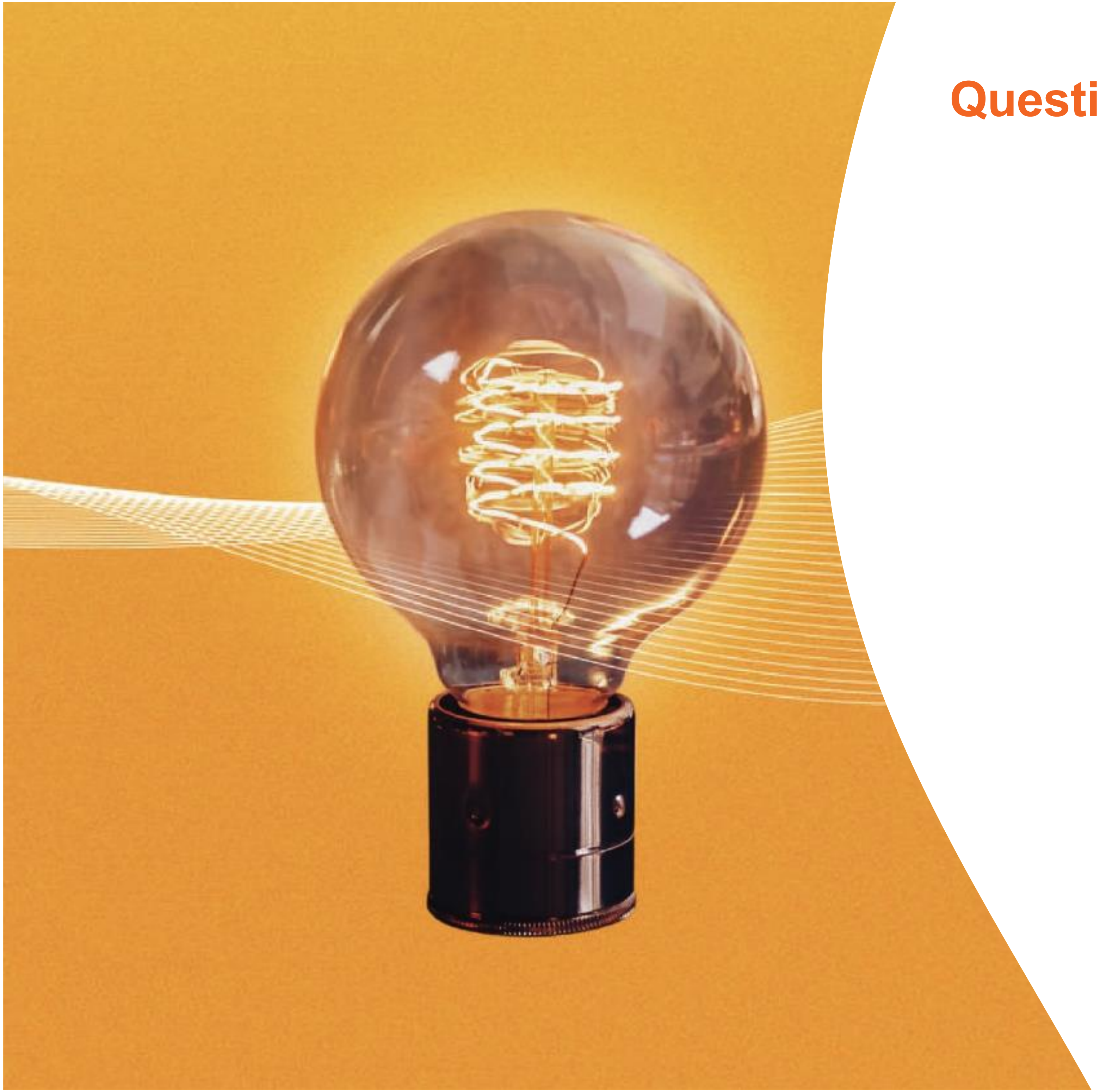
Next Steps

Publication of Closing Down Report

Finalisation of cost benefit analysis including sensitivities

Installation of MCS on the system – testing communications network

Continue to share findings and learnings with the industry



Questions

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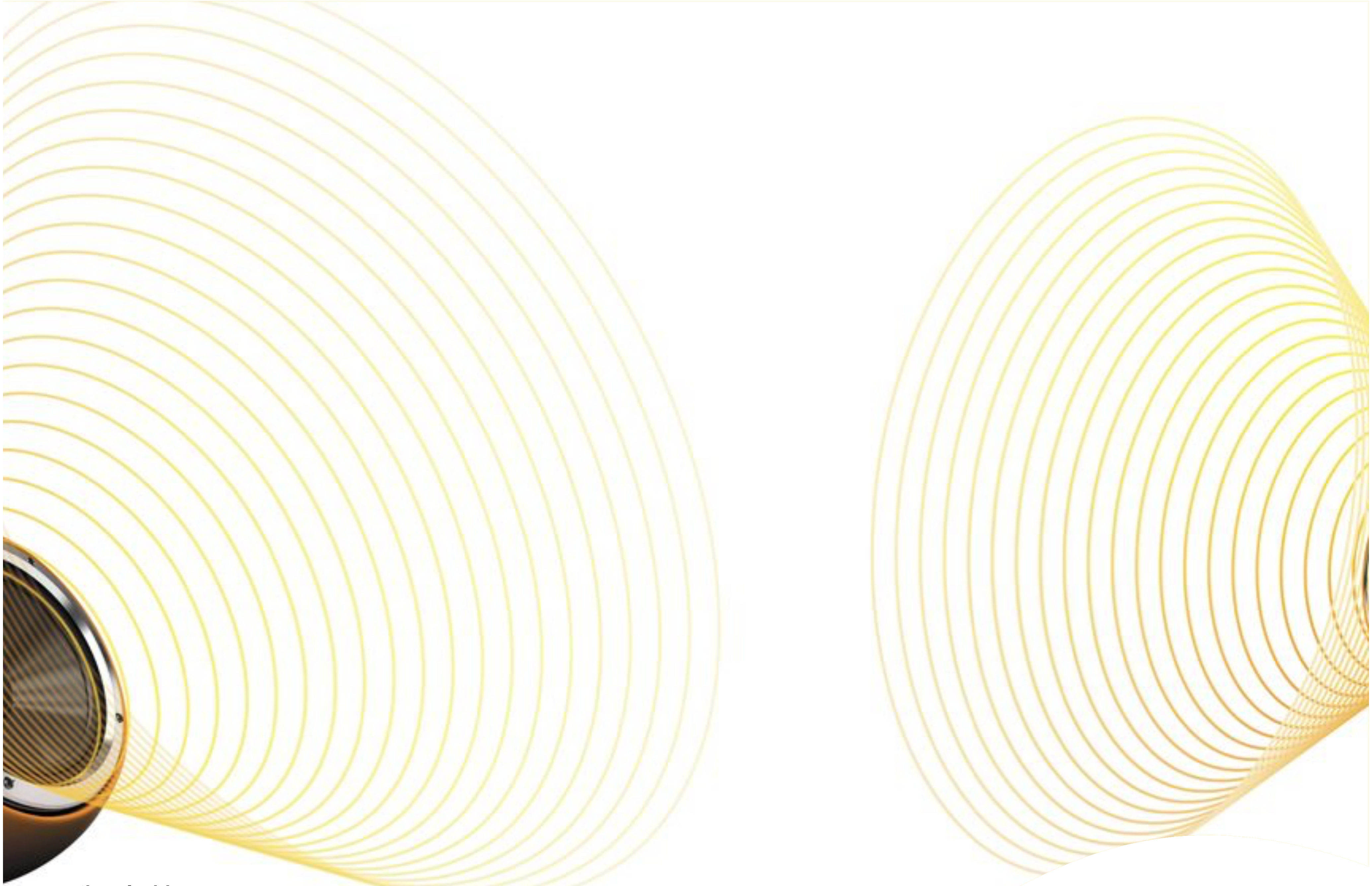

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