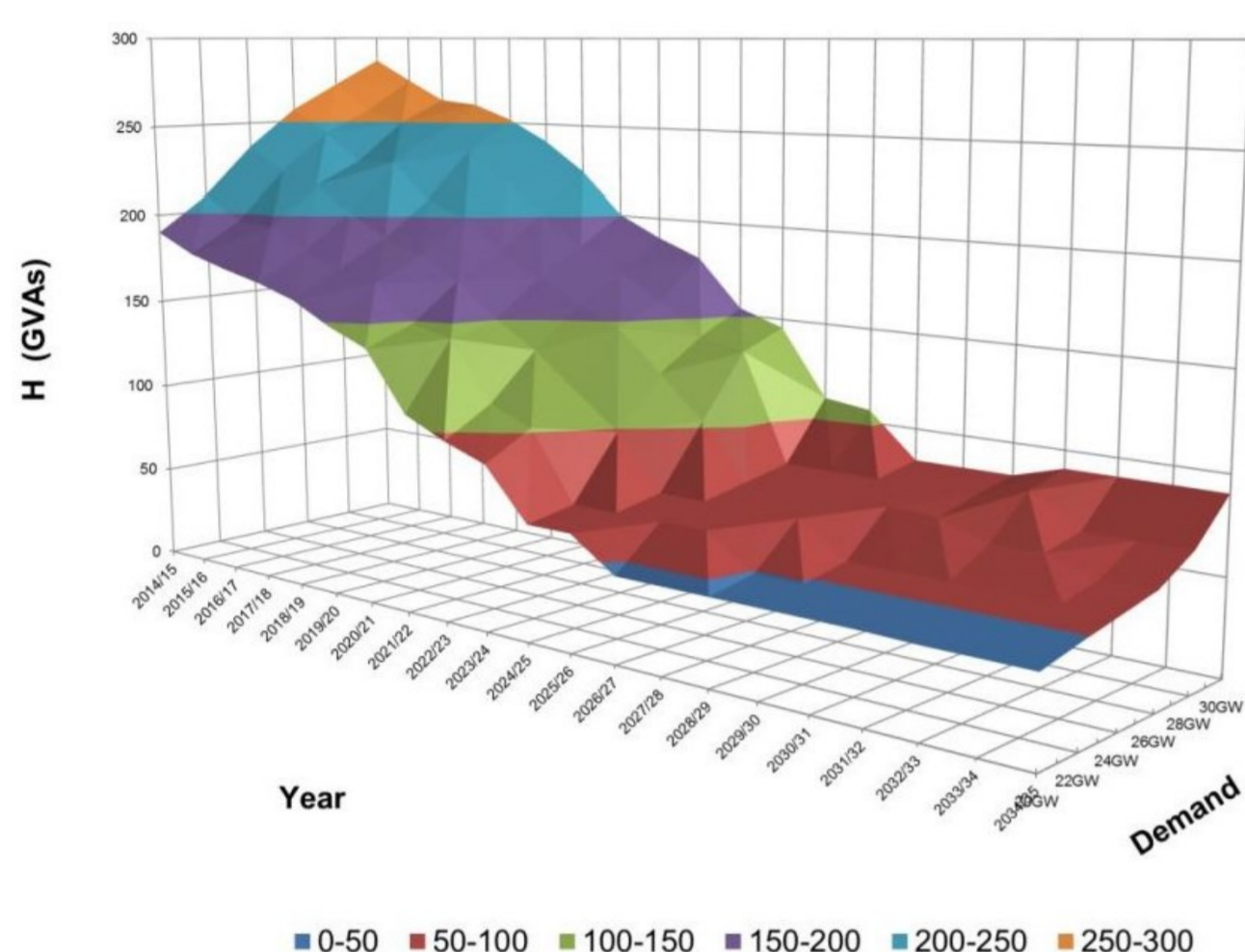


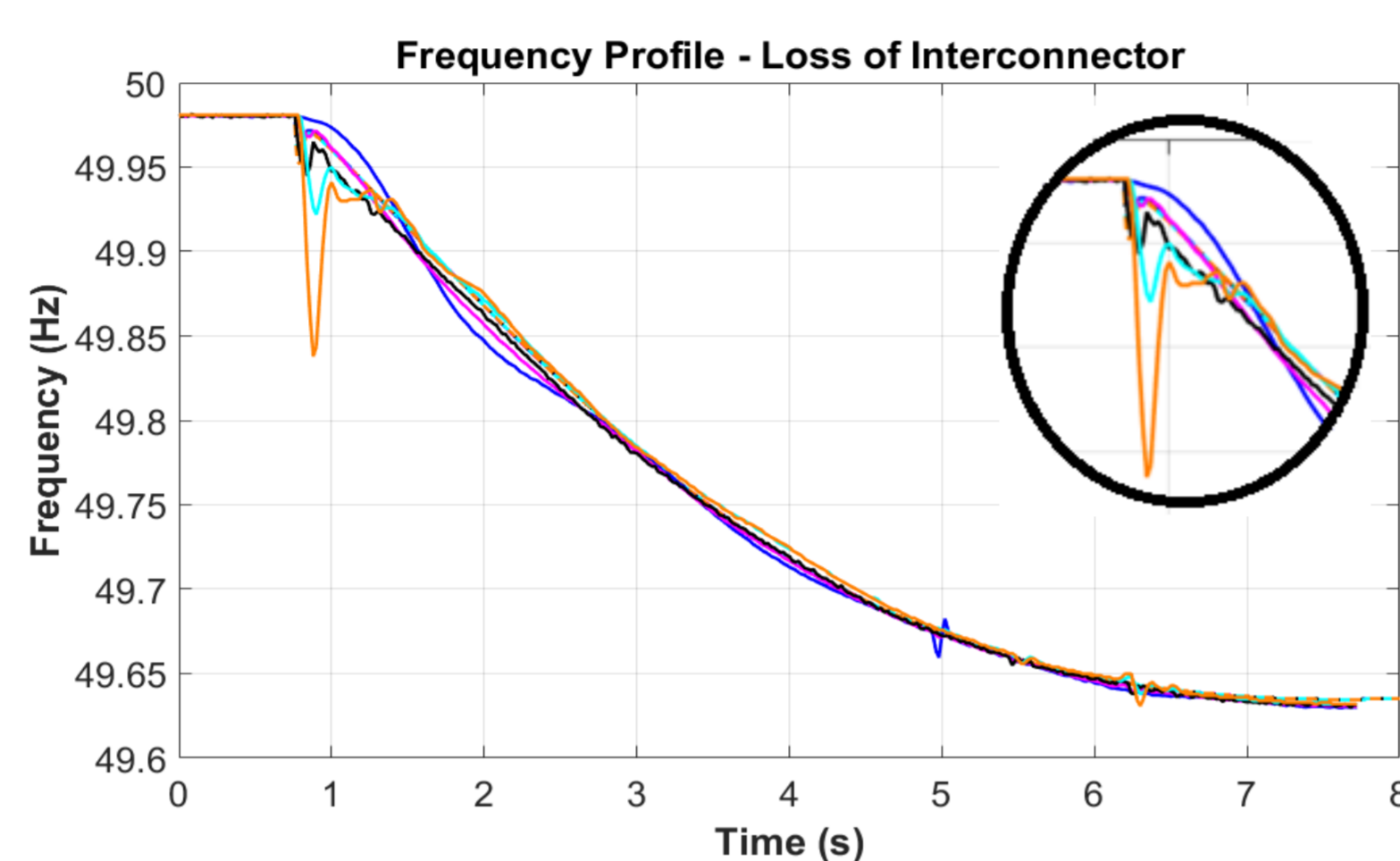
Introduction

EFCC aims at developing and demonstrating a wide area monitoring and control scheme that is capable of deploying fast and coordinated frequency response using a variety of resources such as PV, energy storage, wind farms, demand side resources (DSR), and CCGTs. The successful implementation of this project is expected to enable faster response than existing schemes and lead to **savings of £150m-£200m per annum by 2020**.

Challenges and motivation



Decrease in system inertia (Gone Green scenario at 70% wind output)

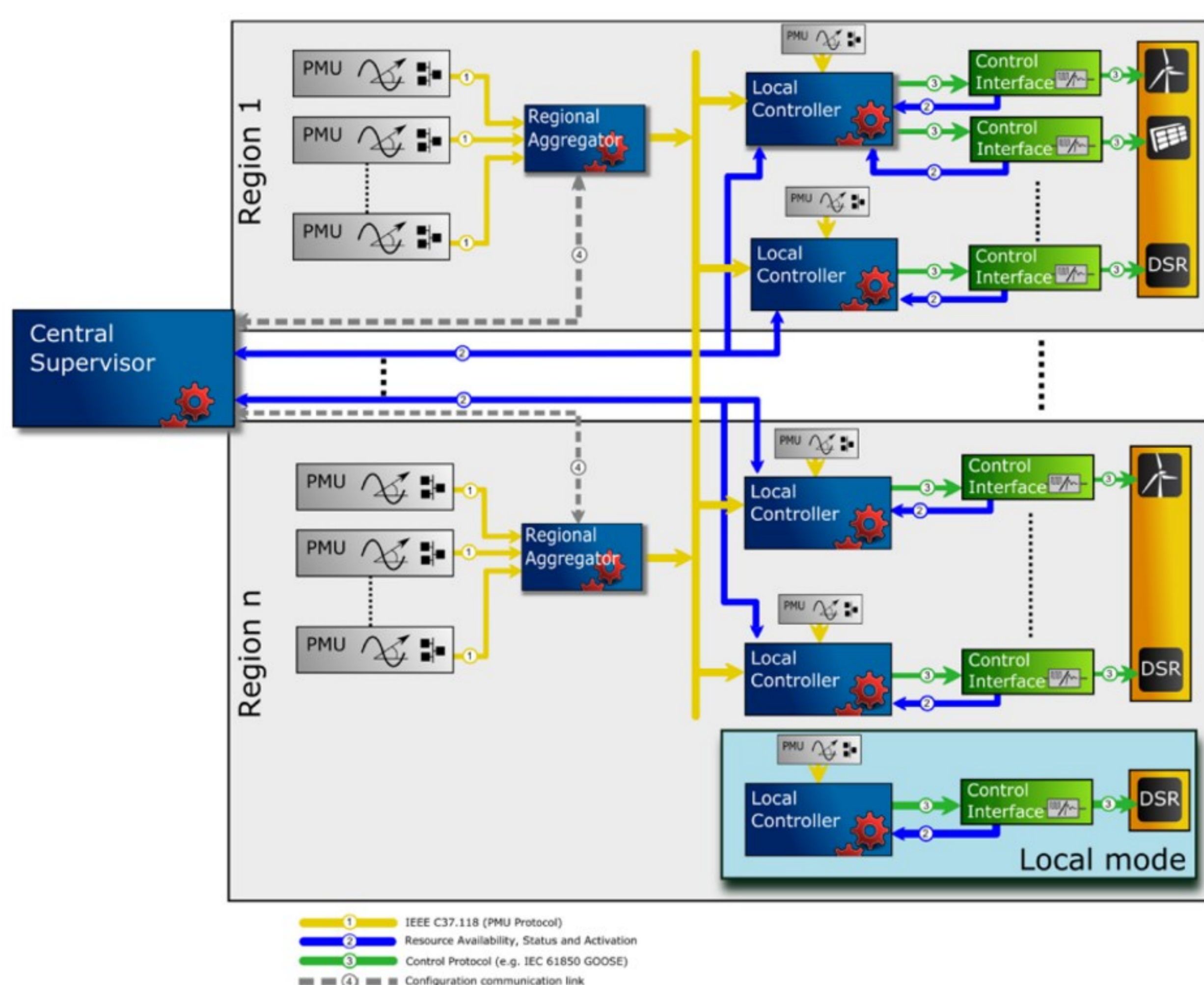


Regional variation in frequency during disturbances

The increase of renewable penetration level will reduce the system inertia, giving rise to the volume and speed of frequency response requirements. Under existing arrangements, such increased response requirements are anticipated to significantly increase the operational cost. Furthermore, during frequency disturbances, regional variation in frequency has been observed. This means that the location of the response also need to be considered in the current and future networks.

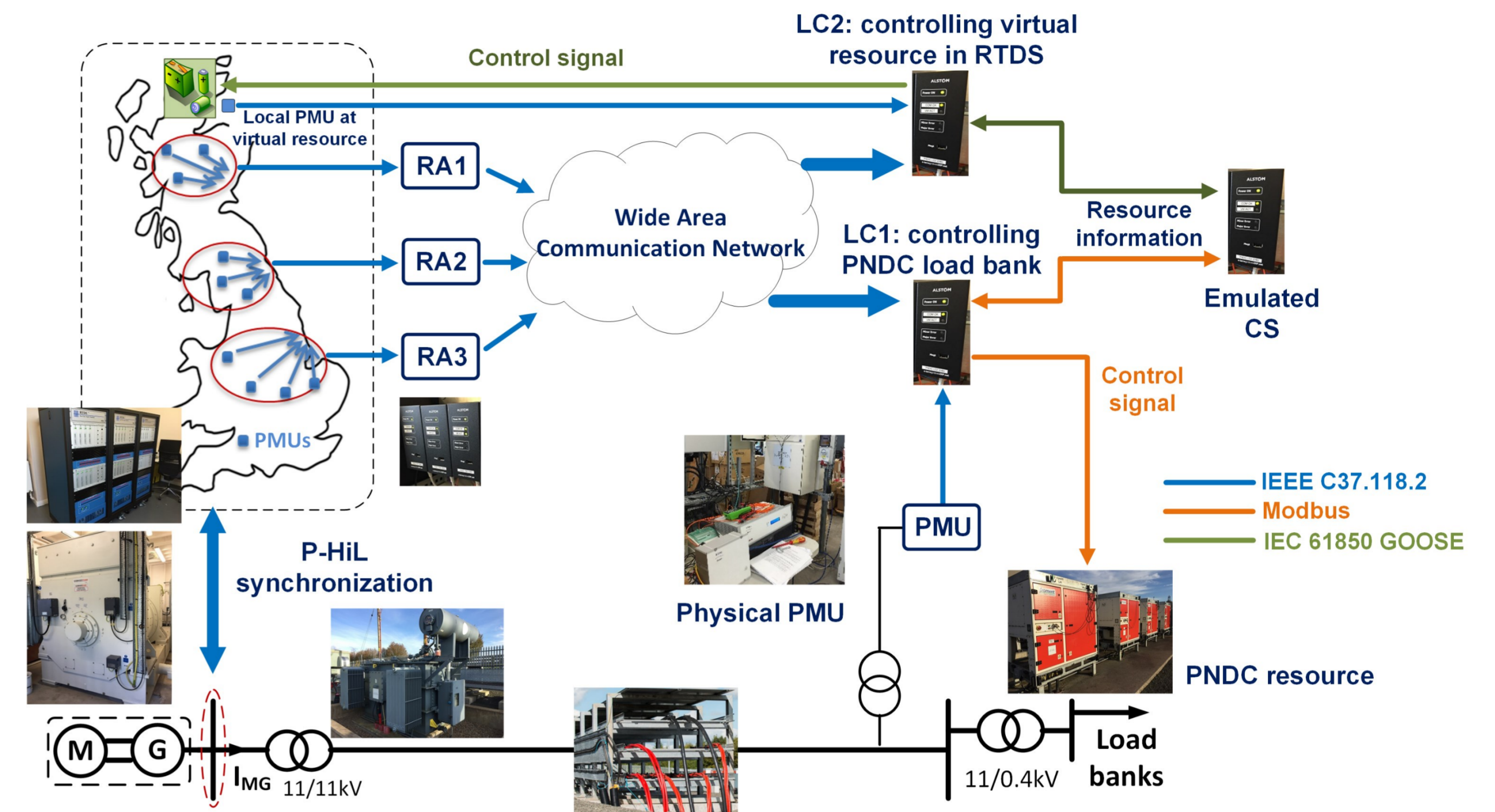
These issues present a strong need for a faster and coordinated frequency response scheme with disturbance and resource location taken into account.

The EFCC scheme



- EFCC scheme uses wide area PMU data for real time monitoring of the network. When a frequency disturbance occurs, the EFCC scheme detects the event, calculates the required response at regional levels and coordinates the resources in each region for optimised response.
- **Central Supervisor (CS):** receiving resource information from all service providers and periodically broadcasting the information to all LCs.
- **Regional Aggregators (RAs):** receiving PMU data, aggregating the data for the region and sending the data to all LCs in real time.
- **Local Controller (LC):** installed at service provider's site. Receiving real time measurement signals from RAs for event detection. When an event is detected, resource information received from CS will be used for calculate the local response required.

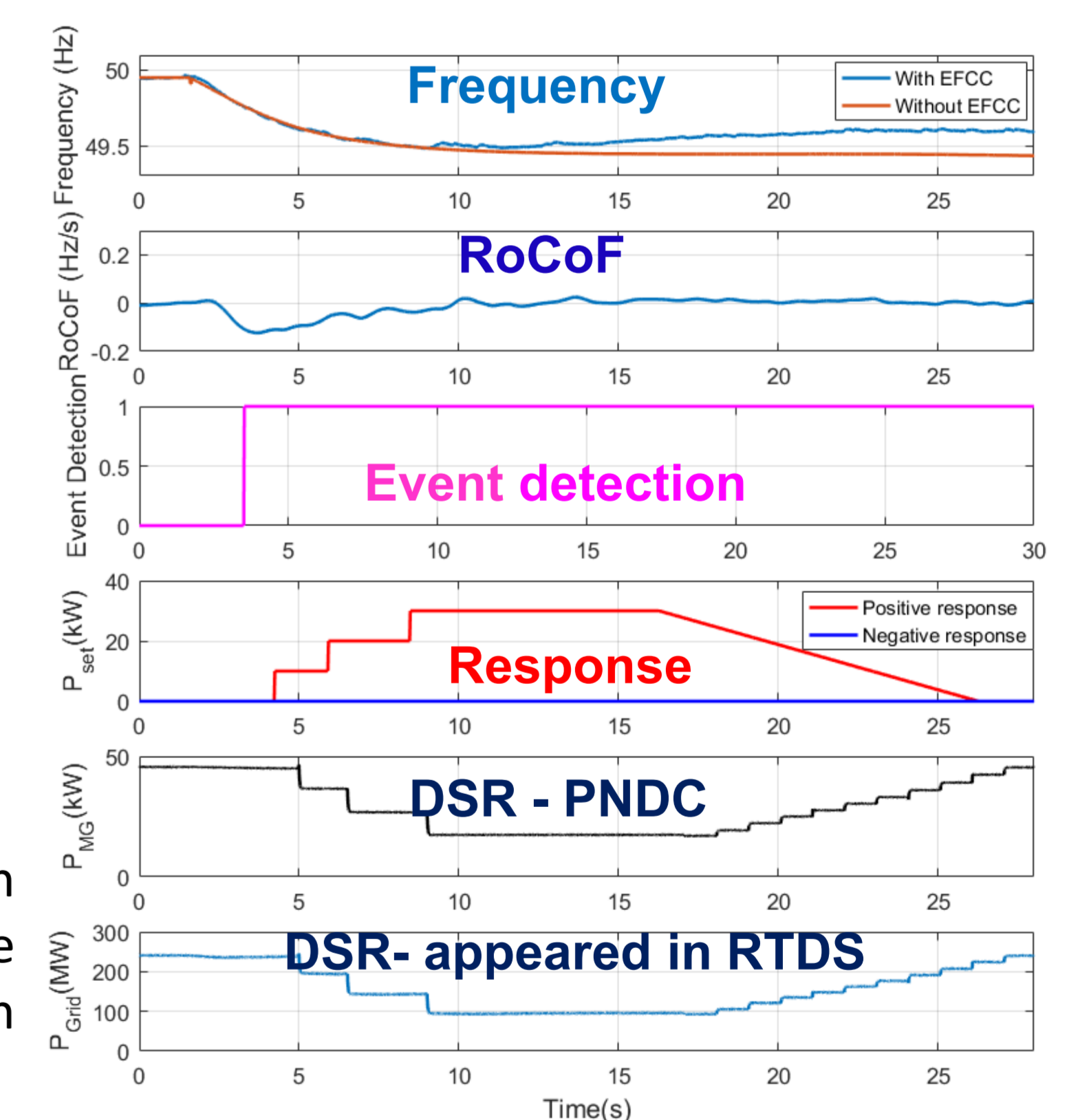
Validation of the EFCC scheme



- A flexible and realistic testbed has been established for comprehensive validation of the EFCC scheme's performance
- The testbed uses Power-Hardware-in-the-Loop (P-HiL) to couple a reduced GB transmission network in RTDS with the 11 kV physical network in the Power Network Demonstrator Centre (PNDC) at Strathclyde through a MW scale Motor-Generator set.
- Three RAs receive and process PMU measurement from RTDS model and send data to Two LCs
- One LC controls the physical load bank at PNDC and one LC controls a resource modeled in RTDS
- An emulated CS is used to feed resource information to two LCs.
- Frequency and non-frequency events are triggered where both dependability and reliability of the EFCC scheme are assessed.
- Communication latency and jitter at the involved communication links will be introduced to investigate the impact of the communication issues to the EFCC scheme.

Initial test results

- The figure shows initial results from LC2 when it is tested under its local mode, i.e. when wide area communication links are lost.
- Under-frequency event is triggered as a disturbance.
- LC2 successfully detects the events and deploys 30 kW response from physical load reduction, equivalent to 120 MW in the simulated RTDS network.
- The first plot shows the improvement in frequency restoration during a severe frequency disturbance with EFCC. In this case, only one single resource is being controlled and the wide-area monitoring signals are lost. The results shows the EFCC is still capable of providing a level of support to frequency restoration even under such poor network visibility conditions.



Conclusions and future work

- The EFCC project aims at deploying fast and coordinated frequency response to address the challenges from reduced system inertia
- A flexible and realistic testbed has been established for end to end test of the scheme
- The test activities are still going and initial results have demonstrated the effectiveness of the EFCC scheme to restore frequency even with the wide area communication links are lost
- Future work will continue the test of the system with all communication links enabled and introduce different levels of latency and jitter to these links to investigate how these factors will affect the performance of the EFCC scheme