Implications of Renewable Generation on the Power System Performance in Great Britain

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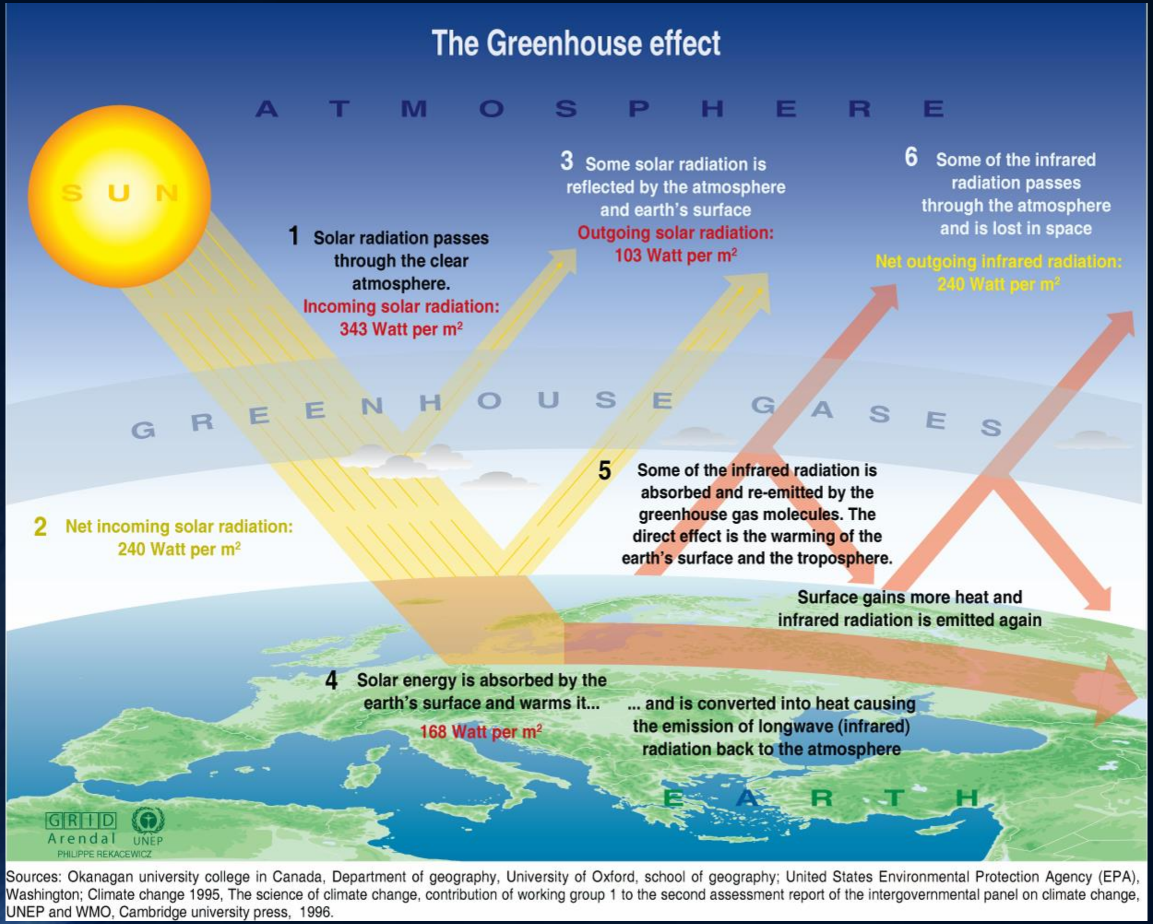
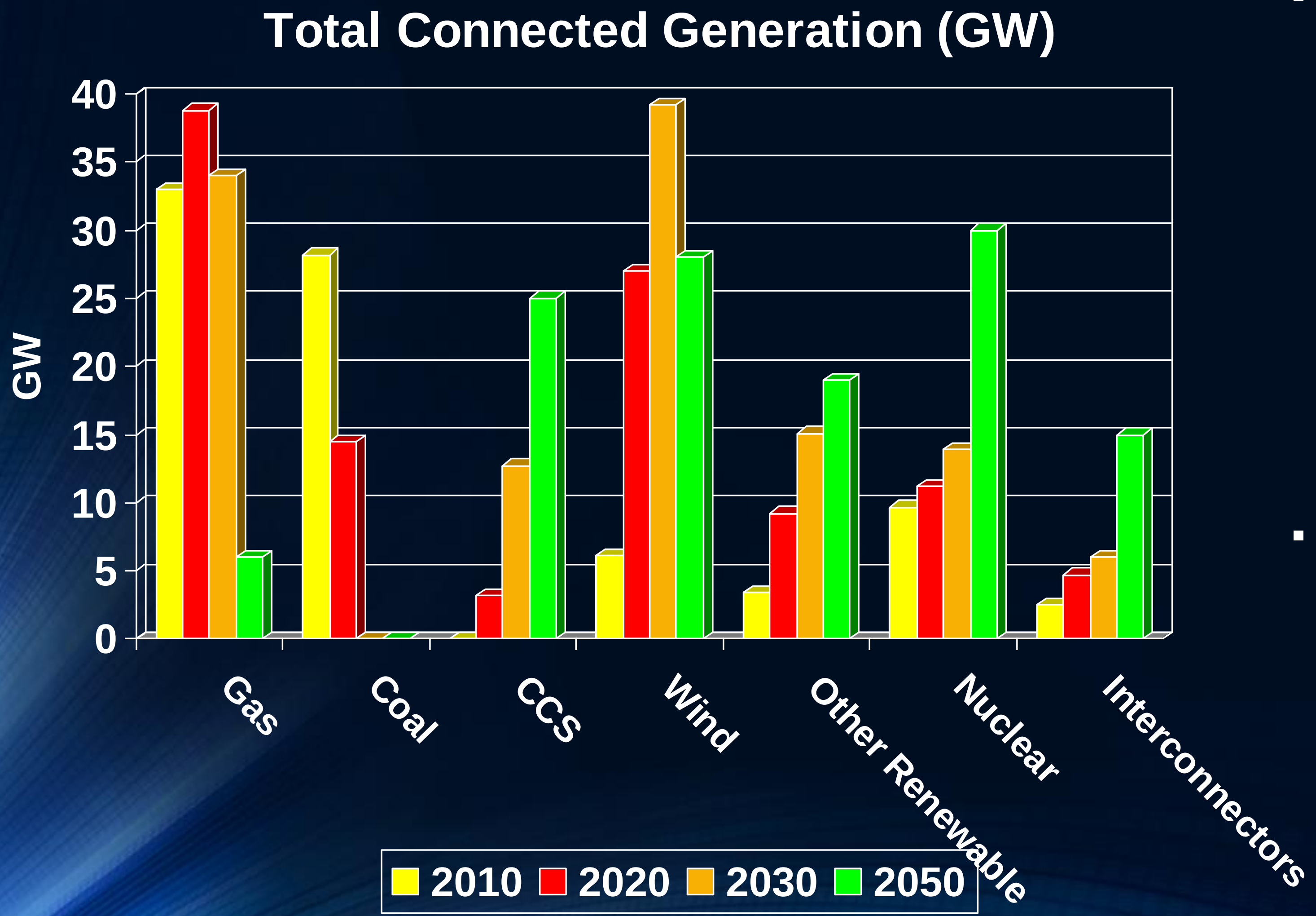
Presentation Overview

- Background to the change of generation mix
- Power system challenges
- Transmission licence obligations
- Development of frequency control services since industry privatisation
- Background to the RoCoF risk
- Balancing services use of system costs
- Low frequency demand disconnection incidents
- Conclusion
- Way forward

Drivers for Renewable Obligations



Indicative Generation Mix Trend



- In 2018, wind provides 17.1% of the UK's electricity (9.1% from onshore wind and 8% from offshore wind, both new annual records). Overall, renewables generated a record 33.3%. Low carbon generation (renewables and nuclear) reached a record 52.8%. Nuclear provided 19.5%, with gas generating 39.4%, and coal generation dropped to a record annual low of 5%.
- In 2017, wind provided 14.8% of the UK's electricity

Power System Challenges -associated with Renewable Generation

- Reduction of system fault level

    - Protection co-ordination problems
    - Excessive voltage dip
    - Power quality concerns
    - LCC HVDC commutation failure

… *But today's presentation is focus on*

- Reduction of system inertia

    - Frequency control implications
    - Rate of change of frequency (RoCoF) risk

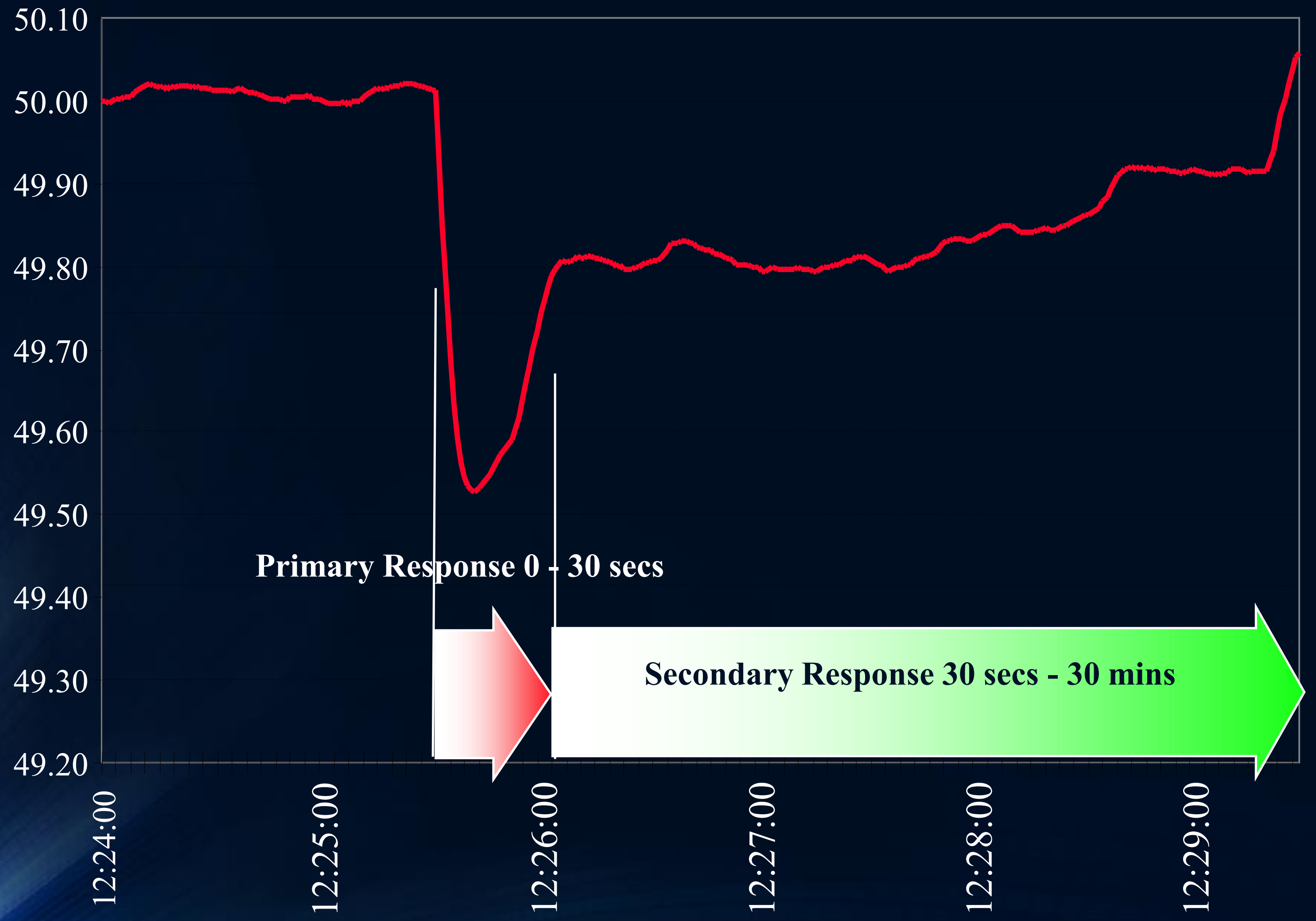
Transmission License Obligations

- Maintain standard of security and quality of supply
  - Manage constraints
  - Control system frequency and voltage performance
  - Maintain system stability
  - Limit harmonics and flickers disturbances
- Economic purchase obligations
  - Mandatory/commercial services
- System users/service provider commitment
  - Grid Code/CUSC compliance
  - Mandatory/Commercial Service Agreement

Frequency Control Background

- Frequency control requirements
  - Statutory limits +/- 0.5 Hz
  - Operational limits +/- 0.2 Hz (standard deviations 0.07 Hz)
- Cover instant generation loss was up to 1800MW
- Avoid low frequency demand disconnections (LFDD)
  - First setting at 48.8 Hz
  - If triggered - could be up to 9 stages and 60% load disconnection
- System needs reliable responsive and flexible plant

Typical Frequency Incidents



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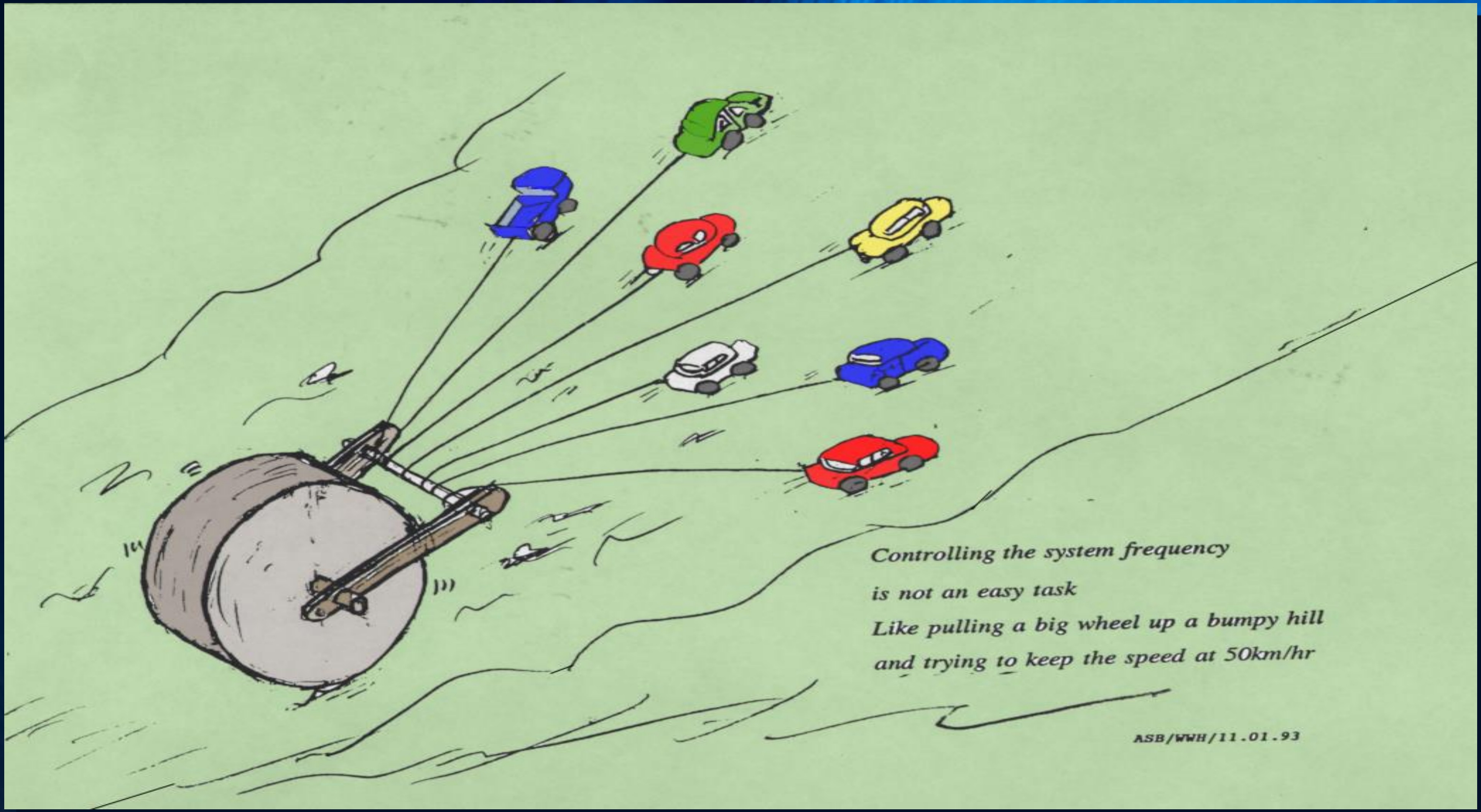
Frequency Control Analogy



Frequency Control/ Wheel Pulling Analogy

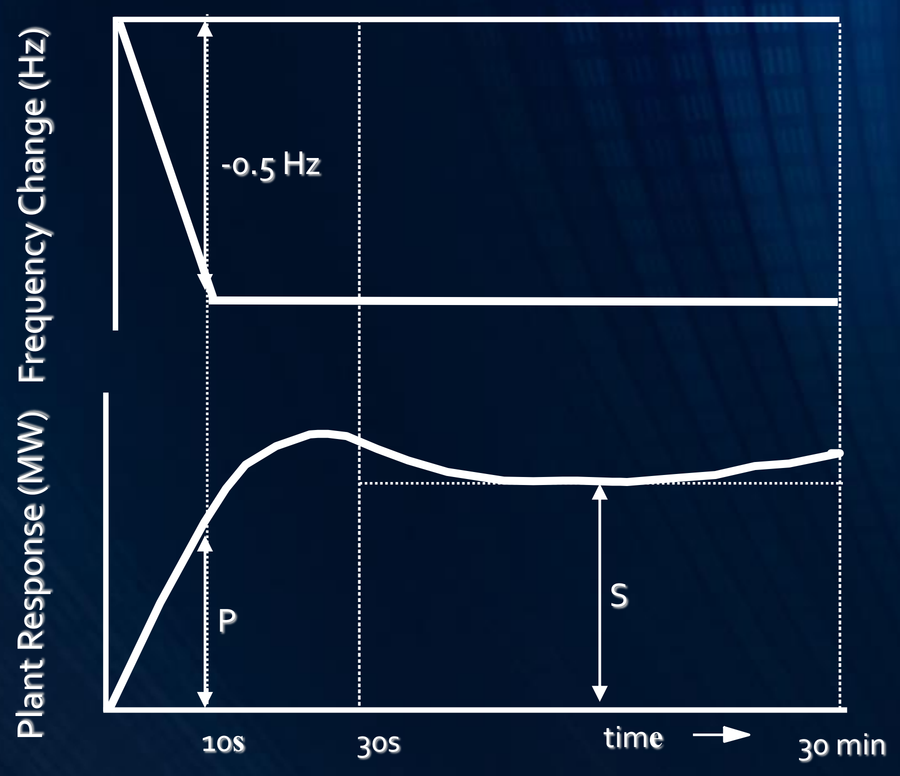
Generators	Vehicles
Frequency	Wheel speed
Demand level	Slope gradient
Load variations	Bumpy road
TV pickup	Big rock
Largest generation loss	Largest truck stalled
Blackout	Wheel run away

Improve Frequency Service Provision

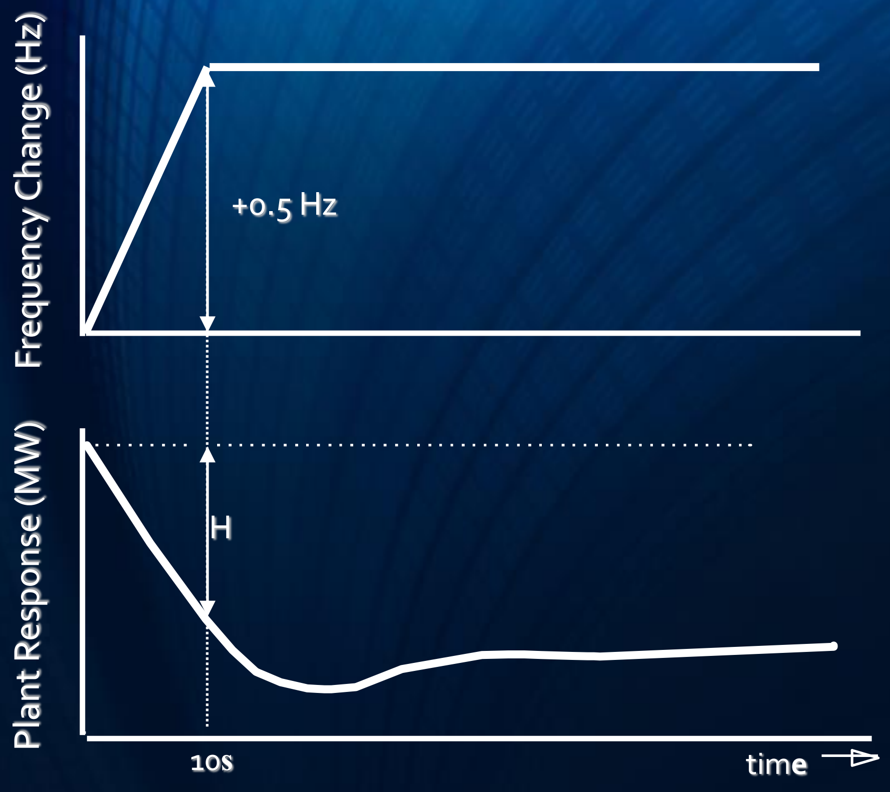
- Define frequency services
  - Primary, Secondary and High Frequency Response services
  - Enhanced frequency response and dynamic demand services introduced
- Establish transparent contract format and payment mechanism
- Validate response capability through modelling and testing
- On-line monitoring – gain confidence on service delivery
- Liaise with main plant suppliers and service providers to improve service performance

Primary, Secondary & High Frequency Benchmark Responses

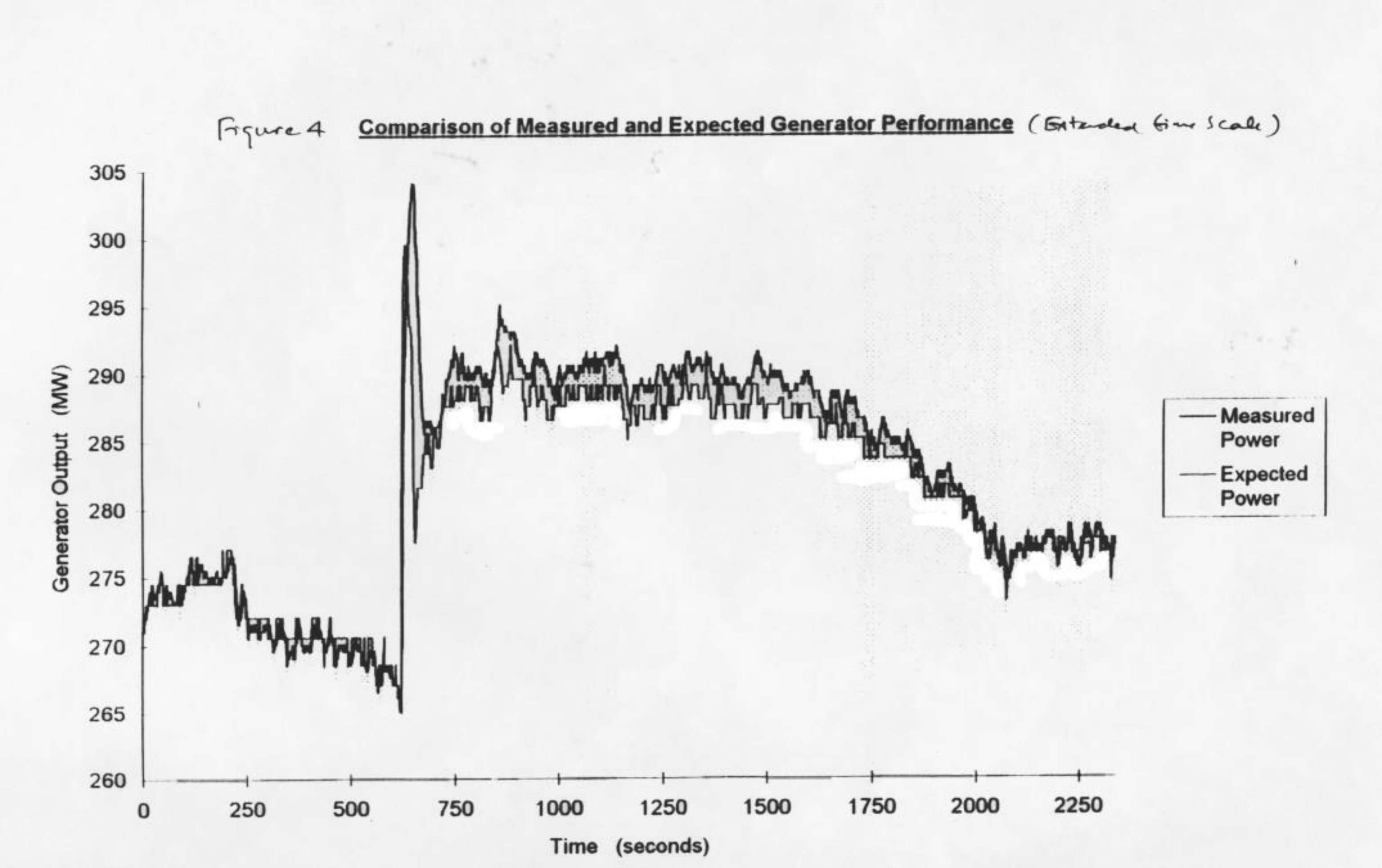
Frequency fall event



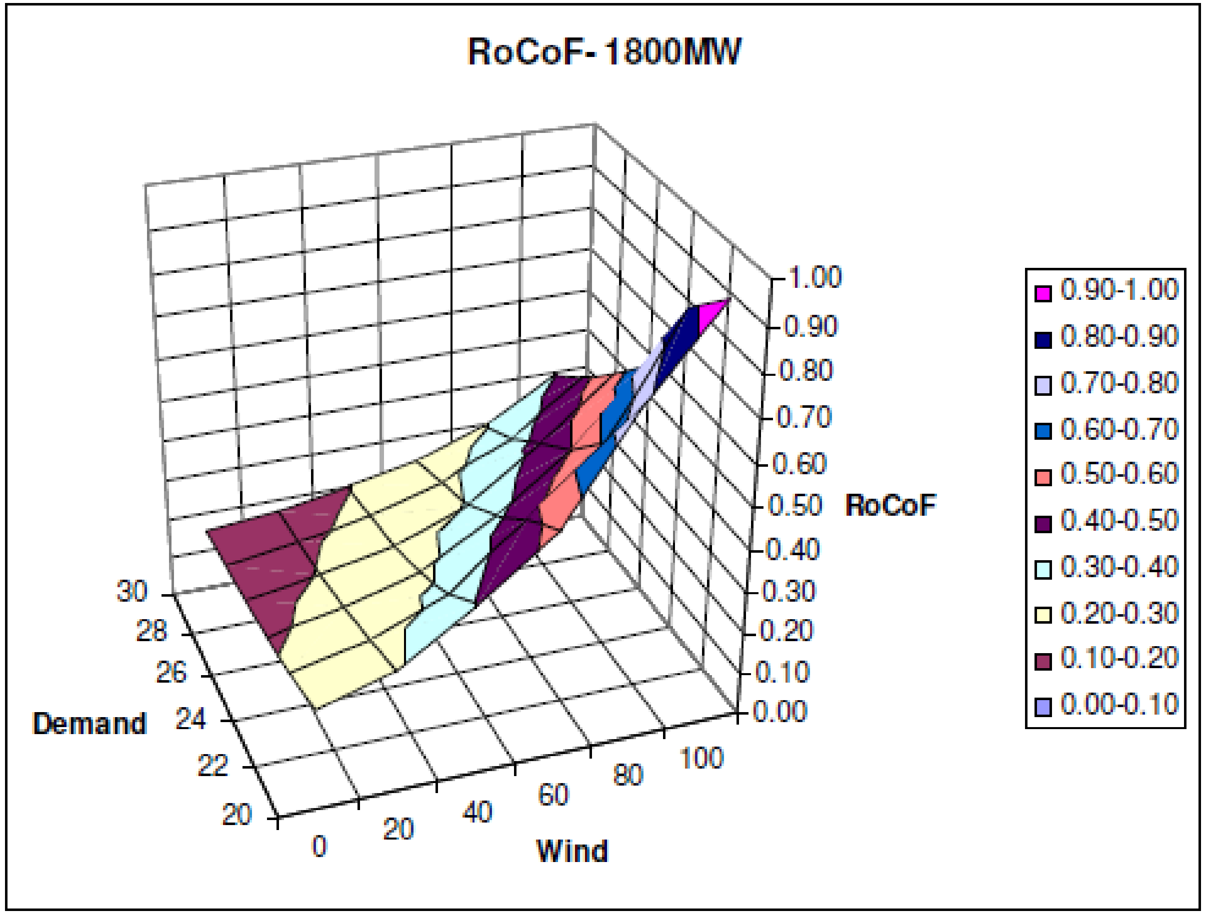
Frequency rise event



On-line Monitoring Example



Forecast of RoCoF up to 2020

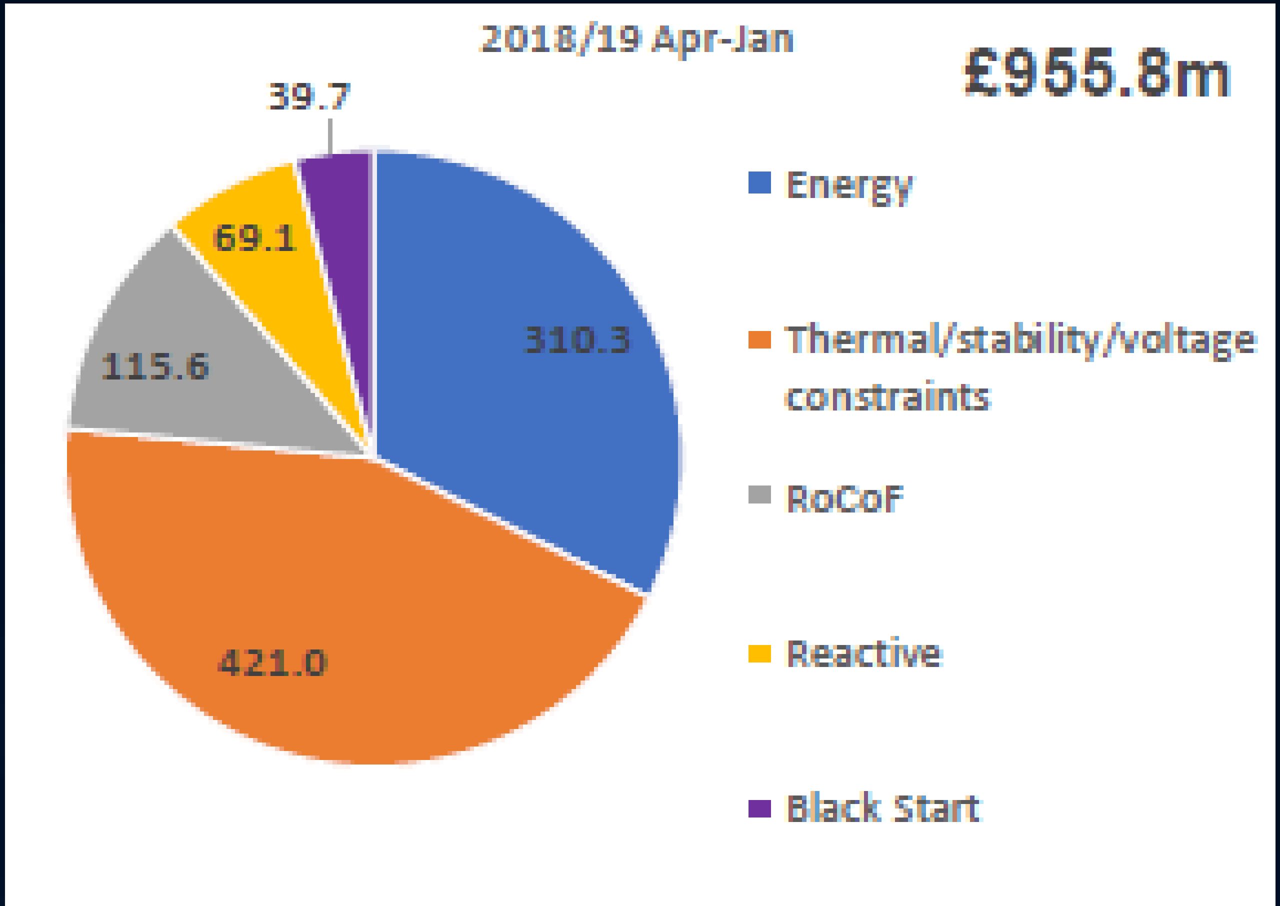


Predicted RoCoF (Hz/s)		
Demand (GW) / % Wind	20	30
0	0.24	0.15
50	0.48	0.21
100 (= 25GW)	0.97	0.39

GCRP WG

Traditional Roof protection setting of 0.125 Hz/s but changing to 1 Hz/ is in progress

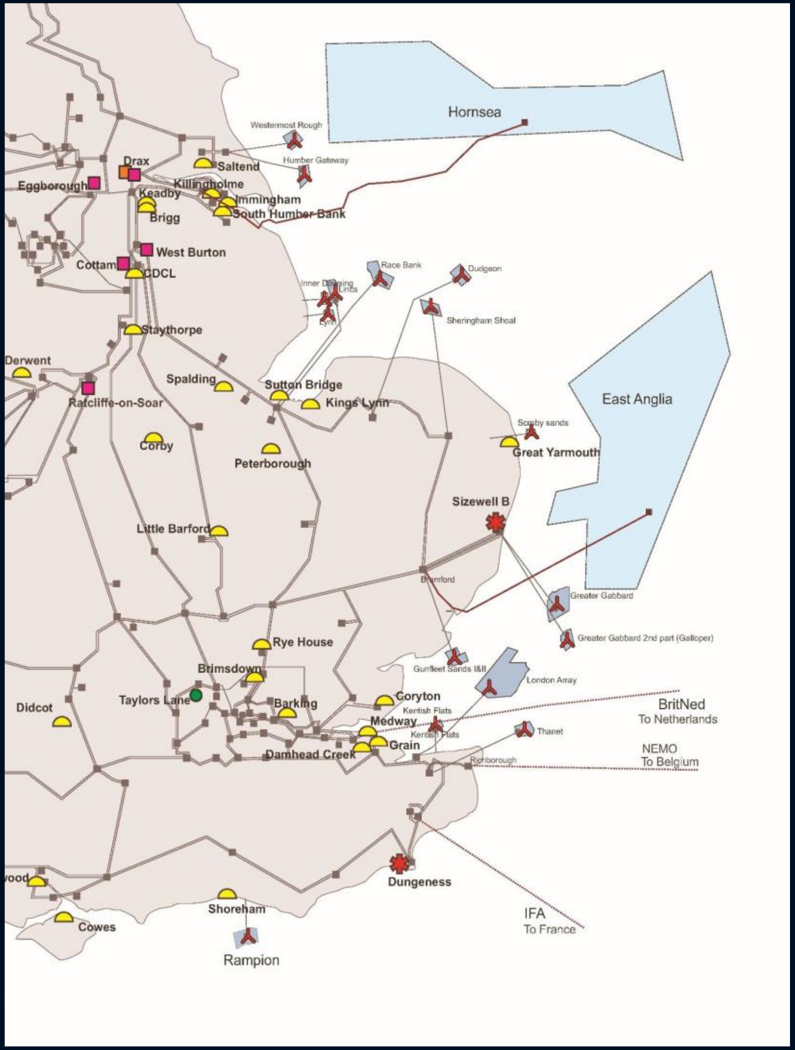
Balancing Services Use of System Costs



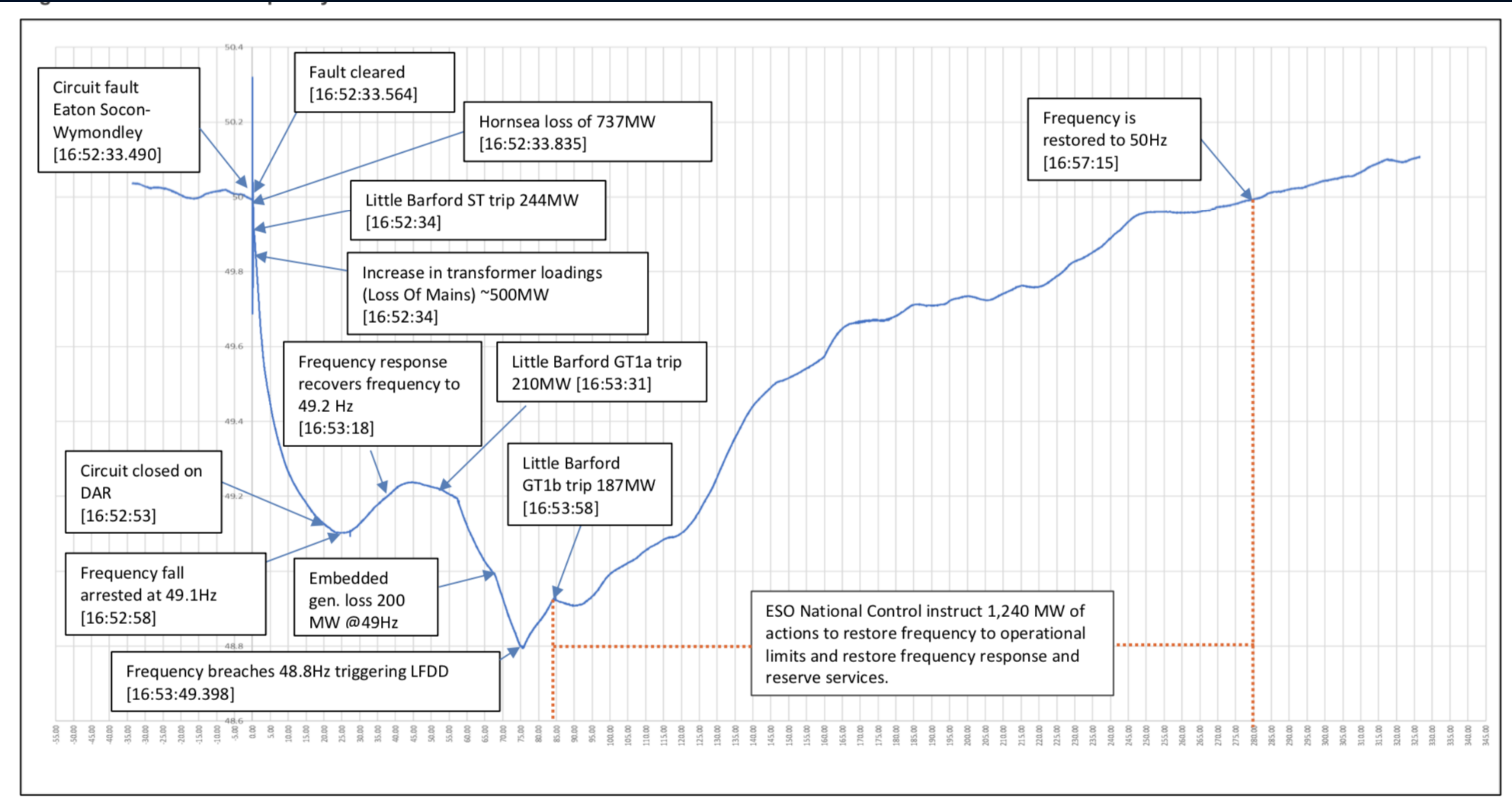
Annual cost of energy balancing, response, reserve and RoCoF could be up to £500m

System Incident 9 Aug 2019 – overview

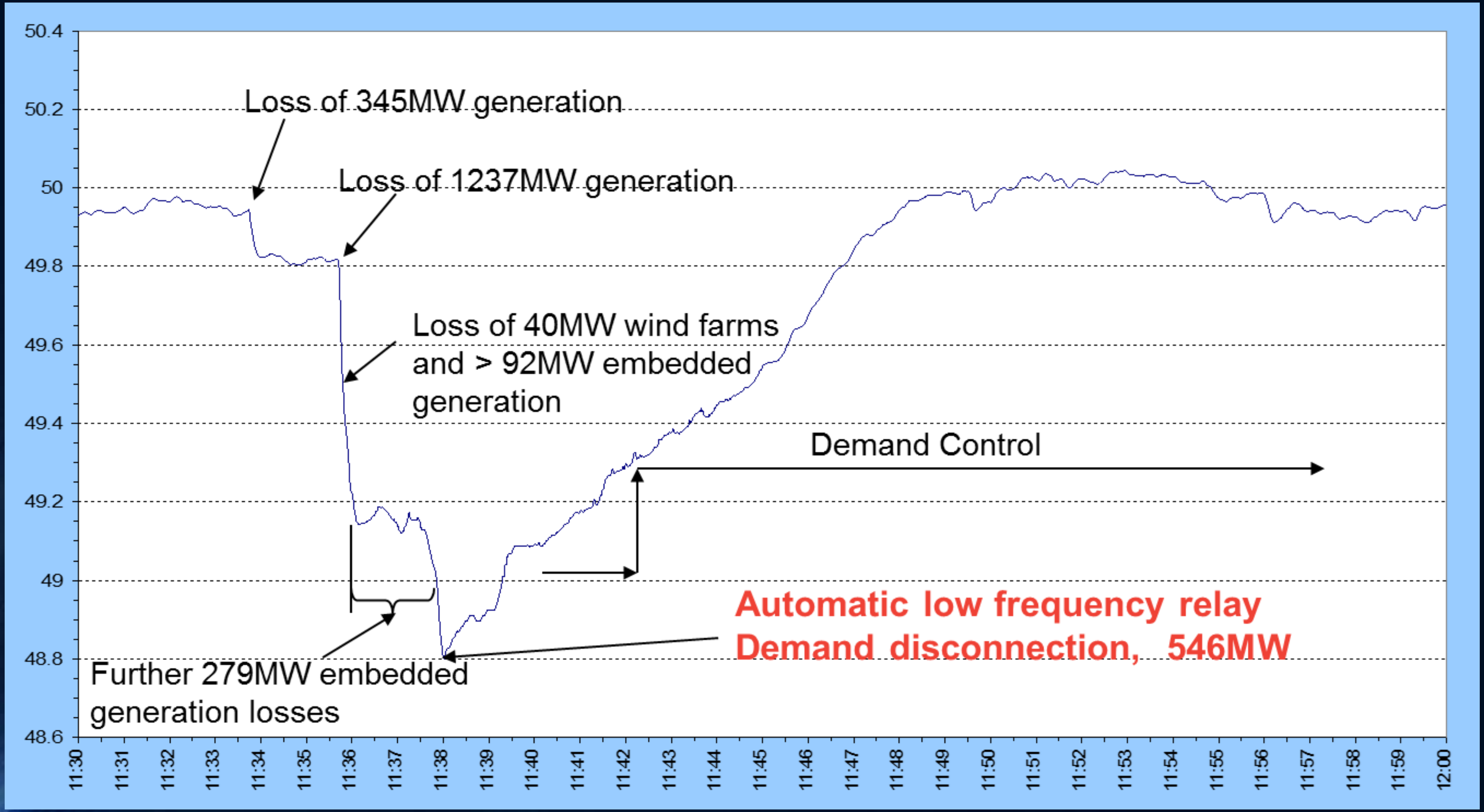
- Loss Hornsea 737MW
- Little Barford ST tripped 244MW
- Embedded gen LoM tripped ~500MW
- Frequency fall captured at 49.1 Hz in 25s
- But, Little Barford GT tripped 210MW
- Embedded gen tripped at 49 Hz~200MW
- Freq felt again to 48.8 Hz causing LFDD
- Disconnected 930 MW to restore system



System Incident 9 Aug 2019 – sequence of events



Low Frequency Automatic Demand Disconnection Incident - 27th May 2008



Conclusion

- The recent frequency incident has raised the public awareness of the importance of a secured power supply system.
- Significant collaborative effort has been made since privatisation between the industry led by National Grid to develop and improve frequency response services through benchmarking, testing and monitoring means.
- The services have therefore been reliable and well defined and I believe the two events discussed here are the only two LFDD incidents within the past 30 years.
- However, the continuous change in system dynamics arising from renewable generation will require more join-up thinking and collaborative effort between the electricity supply utilities, wind farm stakeholder communities and academic researchers to resolve these issues.

Way Forward

- The Transmission System Operator will continue to maintain a safe, secure, sustainable and efficient electricity system.
- This is achieved by the effective management of system balancing and operability through encouragement of new innovative service products and competitive market (eg enhanced frequency service from battery energy storage systems, dynamic demand, etc).
- For frequency control management, the erosion of system inertia is one of the main challenges.
- The RoCoF risk could be reduced by the acceleration of the setting change programme. In a longer term, the LoM protection should be replaced by a more reliable and stable alternative or if possible removed.
- For effective frequency containment, the wind farm communities/ academic researchers are invited to address the issue and provide effective solutions .