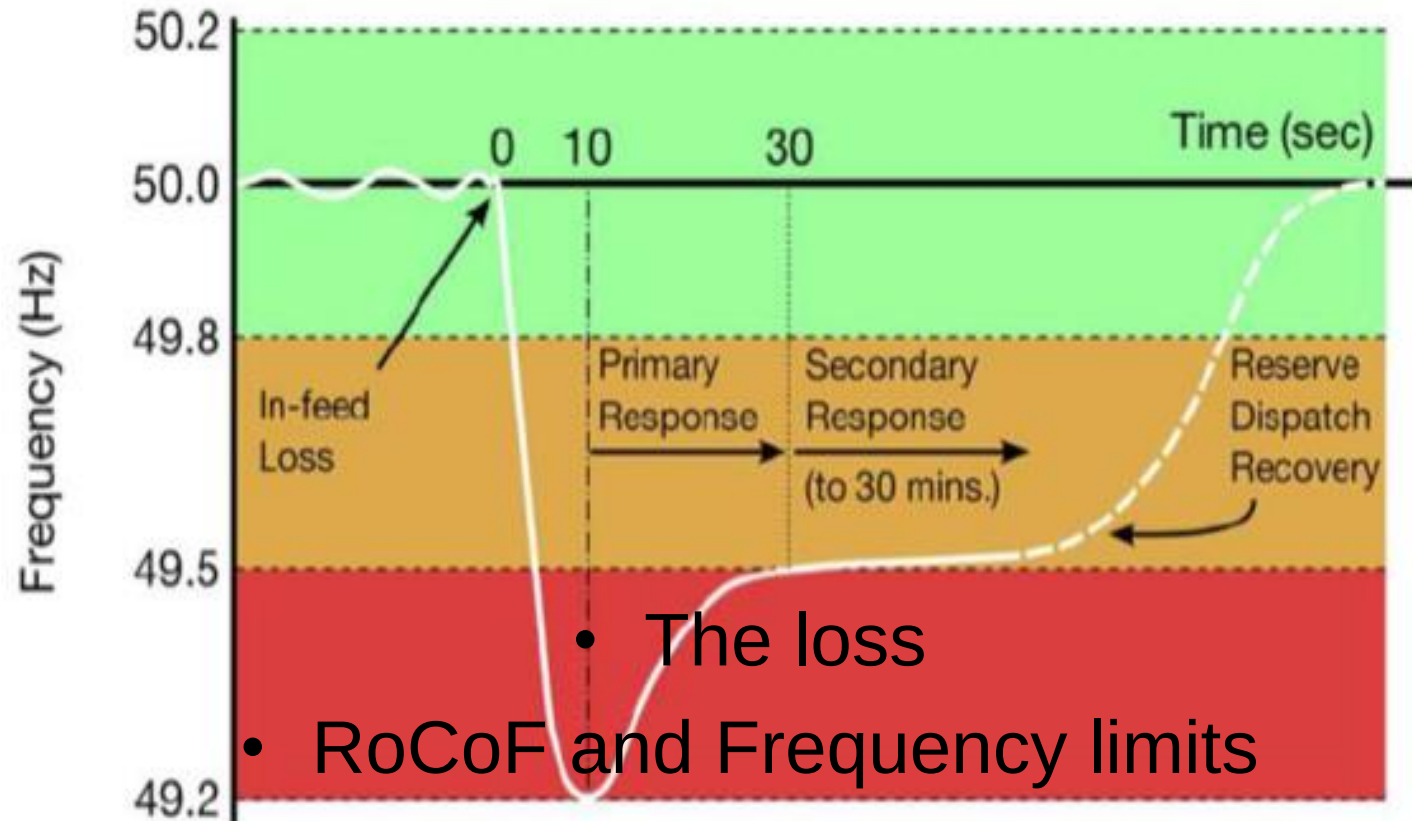


Frequency Containment in GB with August 9th Case Study

Marcel Nedd and Callum MacIver

Frequency Management in GB



- The loss
- RoCoF and Frequency limits
- The amount and speed of energy responses

Image Source: Ashton et al. (2015) <https://tinyurl.com/62q26m4>

Losses and Conditions

Frequency Conditions

Normal Loss	1 GW for ± 0.5 Hz
Infrequent Loss	1.32 GW avoid deviation outside 49.5 Hz – 50.5 Hz for more than 60s.

RoCoF Settings

Settings should be 1 Hz/s with 500ms window

Some are permitted 0.5 Hz/s with 500 ms window

RoCoF limit currently 0.125 Hz/s

Energy Responses

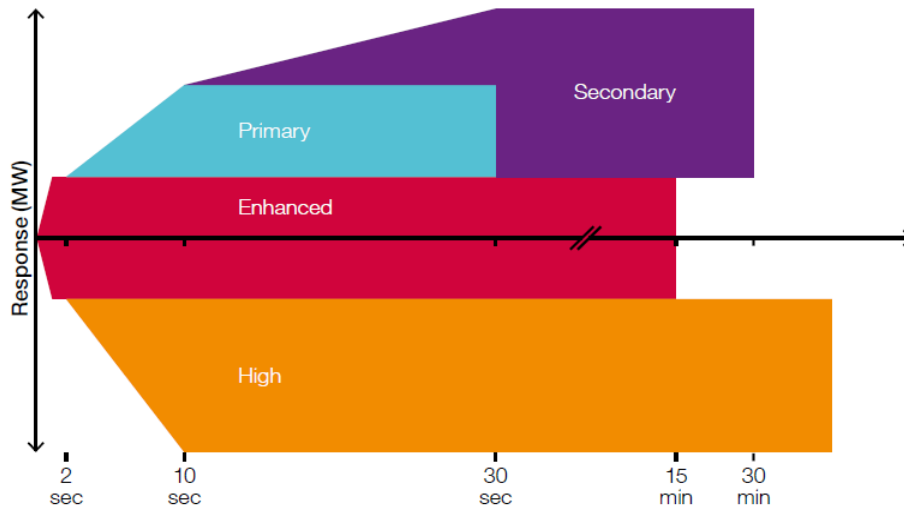
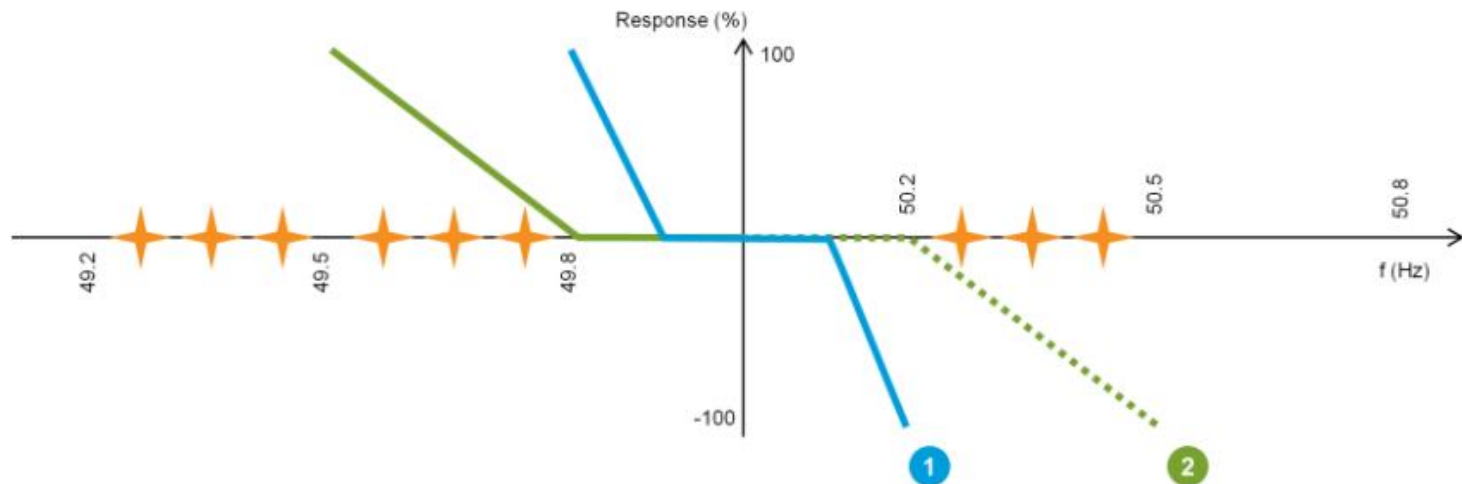


Image Source: SOF 2016 <https://tinyurl.com/y3fadel5>

- Dispatchable:
 - Primary
 - Secondary
 - High
 - Enhanced
- Inherent:
 - Inertia
 - Demand sensitivity

ESO's New Services



	LF Range Hz (-ve dev.)	HF Range Hz (+ve dev.)	Max Lag s	Max Ramp s	Duration
1 Dynamic Balancing (Pre-fault)	0.1 – 0.2		0.5	0.5	TBC
2 Dynamic Containment (Post-fault)	0.2 – 0.5	0.2 – 0.5	0.5	0.5	20 minutes
★ Static Containment (Post-fault)	Various	Various	1	N/A	30 minutes

- ★ 1 Planned service procurement starts late 2018
- 2 Planned service procurement 2019 +

Image Source: ESO – Faster Acting Response Webinar <https://tinyurl.com/ybnla3fw>

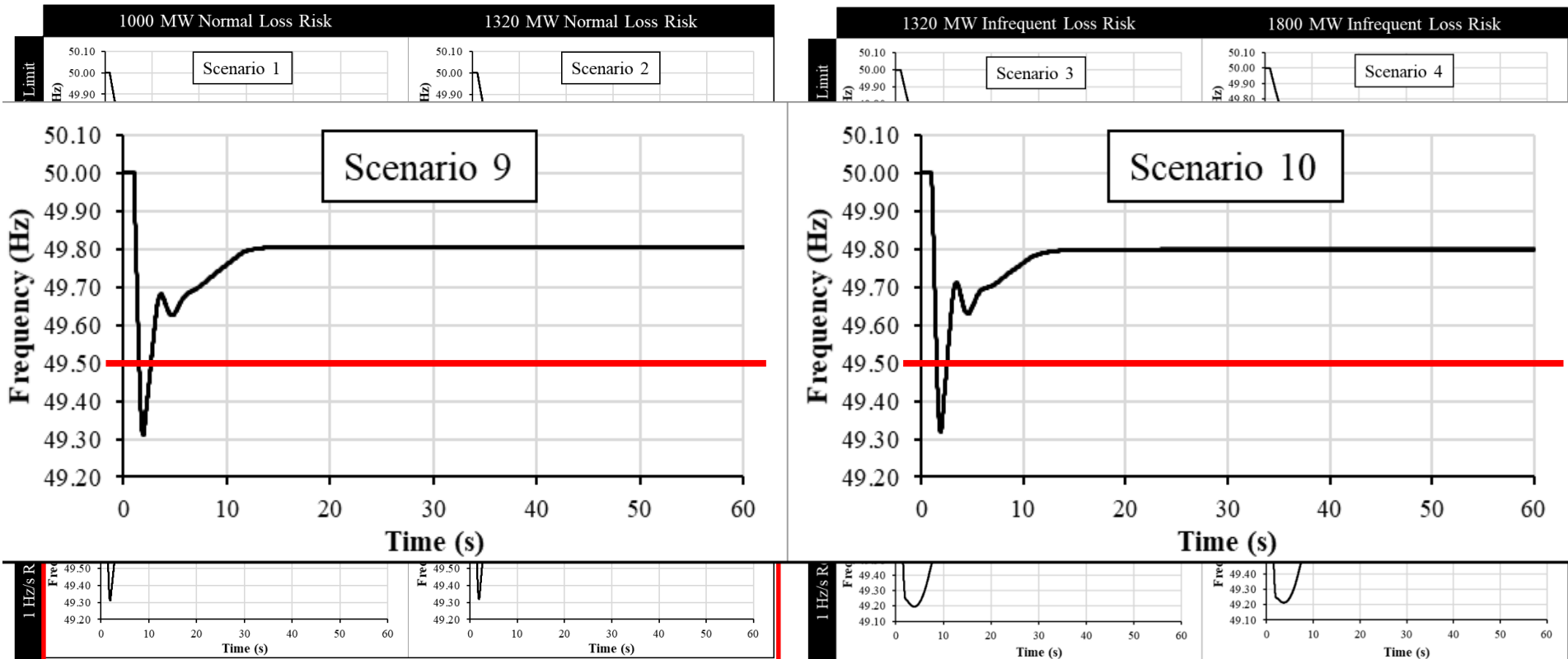
Test Scenarios

Scenario	RoCoF Limit (Hz/s)	Loss of Infeed (GW)	Inertia (GVAs)	Frequency Condition
1	0.125	1	200	Normal loss
2		1.32	264	Normal loss
3		1.32	264	Infrequent Loss
4		1.8	360	Infrequent Loss
5	0.5	1	50	Normal loss
6		1.32	66	Normal loss
7		1.32	66	Infrequent Loss
8		1.8	90	Infrequent Loss
9	1	1	25	Normal loss
10		1.32	33	Normal loss
11		1.32	33	Infrequent Loss
12		1.8	45	Infrequent Loss

$$H_{sys} = \left(\frac{\Delta P \times f_0}{2} \right) \div \left(\frac{df}{dt} \right)$$

Loss (points to ΔP)
 Nominal Frequency (points to f_0)
 Inertia (points to H_{sys})
 RoCoF (points to $\frac{df}{dt}$)

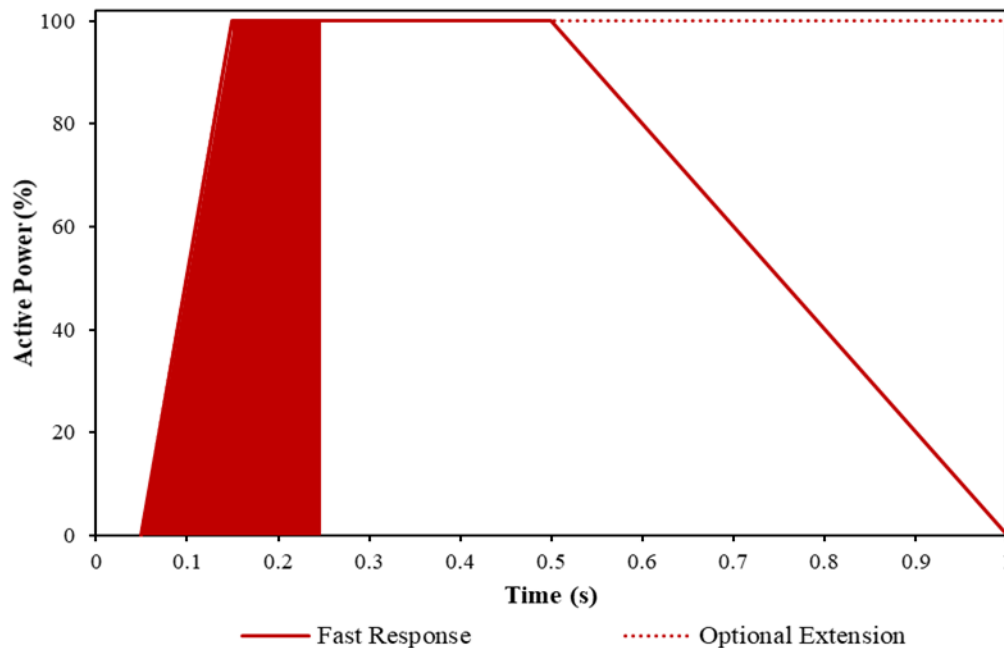
Results



Normal Loss Risks

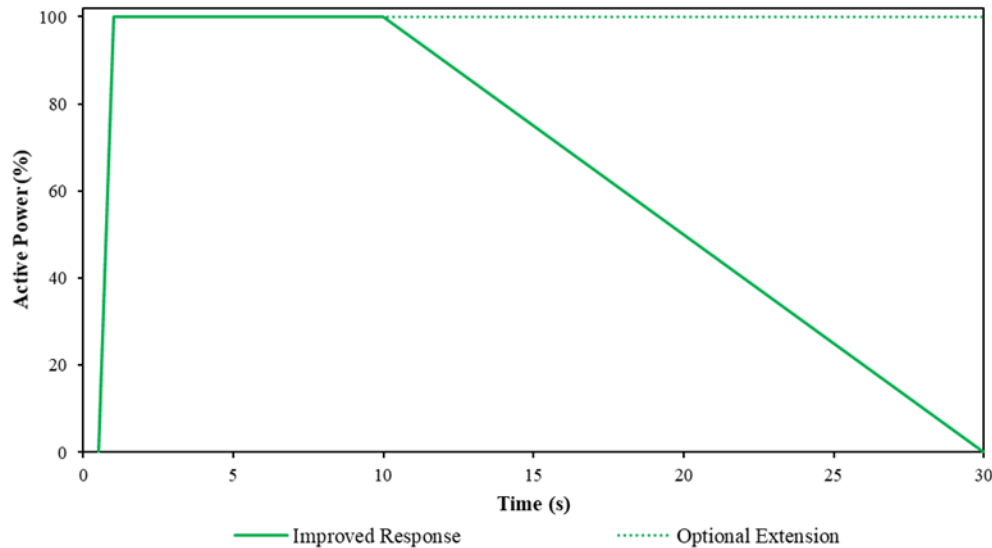
Infrequent Loss Risks

Fast Response Concept



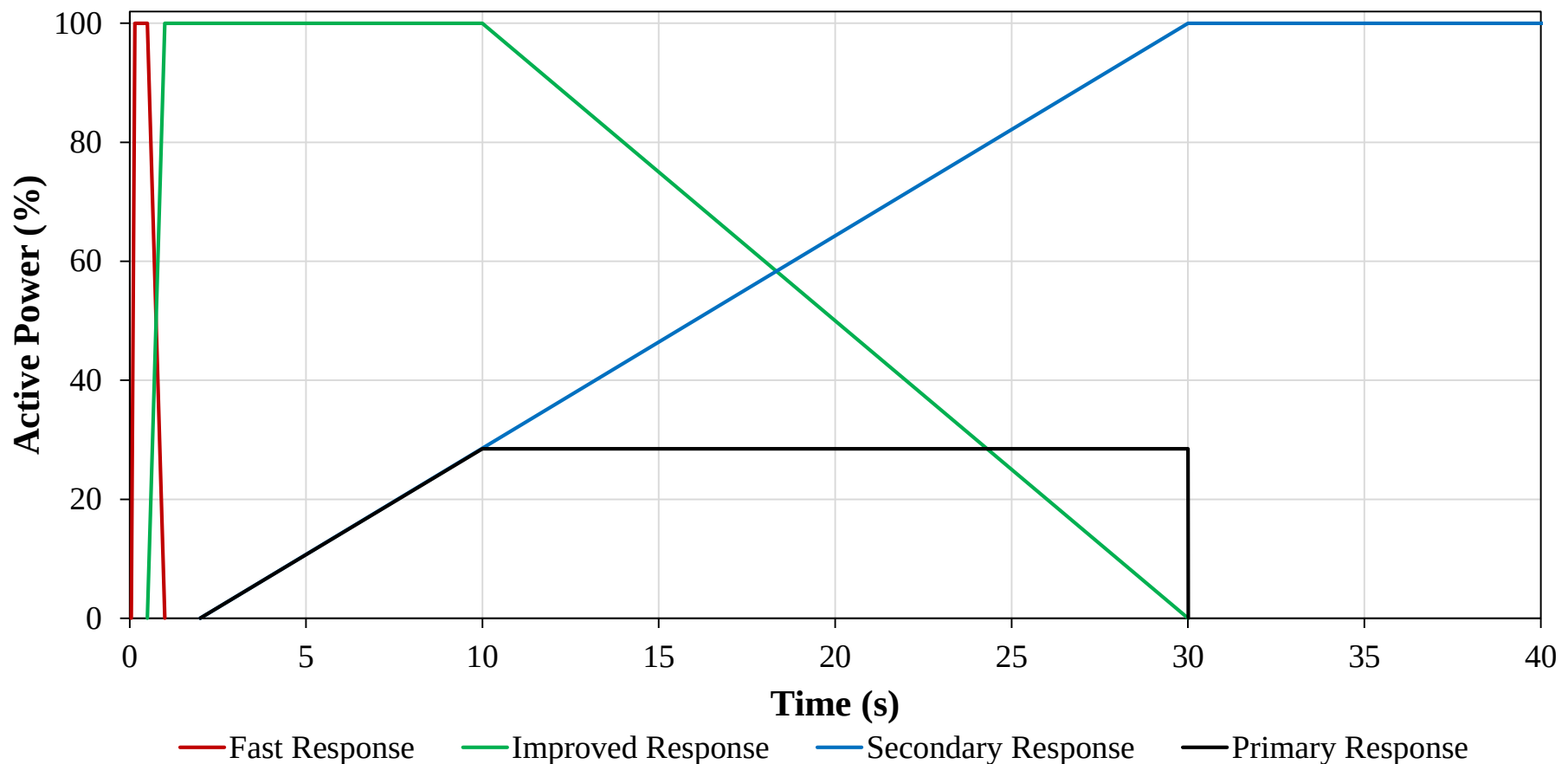
- Fully delivered within 250 ms and sustained until 500 ms after the event.
- Can be sustained beyond but if deactivated must do so over 500 ms (min) so that it is deactivated no sooner than 1 second after the event.
- 'Recovery period' not permitted within this timeline.

Improved Response Concept

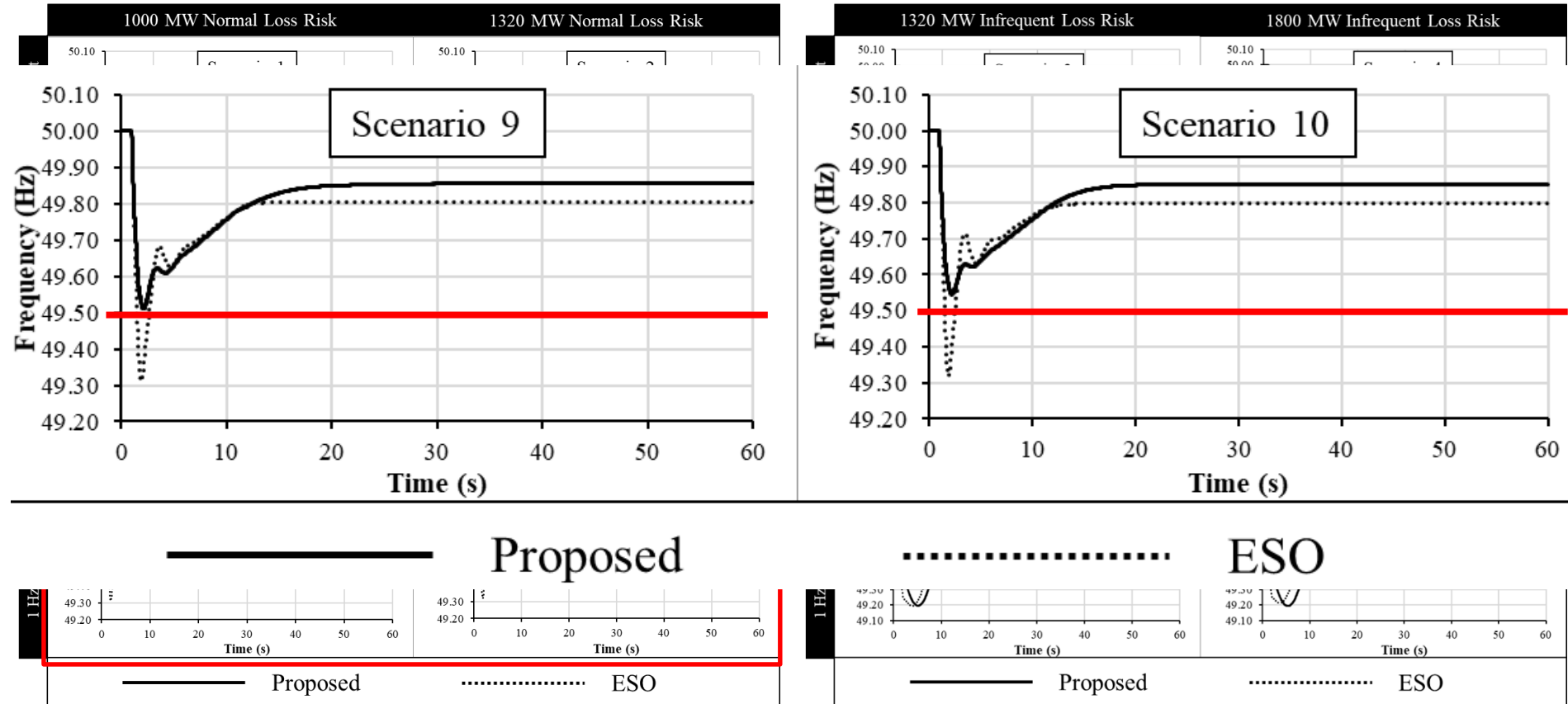


- Fully delivered response in 1 sec with a maximum delay of 500 ms.
- Sustained for a minimum of 10 seconds after the event.
- Can be sustained beyond but if deactivated must do so no sooner than 30 sec after the event.
- Recovery period is not permitted within this timeline.

Framework for Dynamic Frequency Response Services



Results



Normal Loss Risks

Infrequent Loss Risks

Future Work

- Further development and testing
- Recovery period
- Considering provider technologies

August 9th 2019 Event

- 4:52pm Friday 9th Aug: National Grid experienced its biggest frequency event since 2008



August 9th 2019 Event

The
Guardian

UK energy watchdog demands
major power cut

NEWS



INDEPENDENT

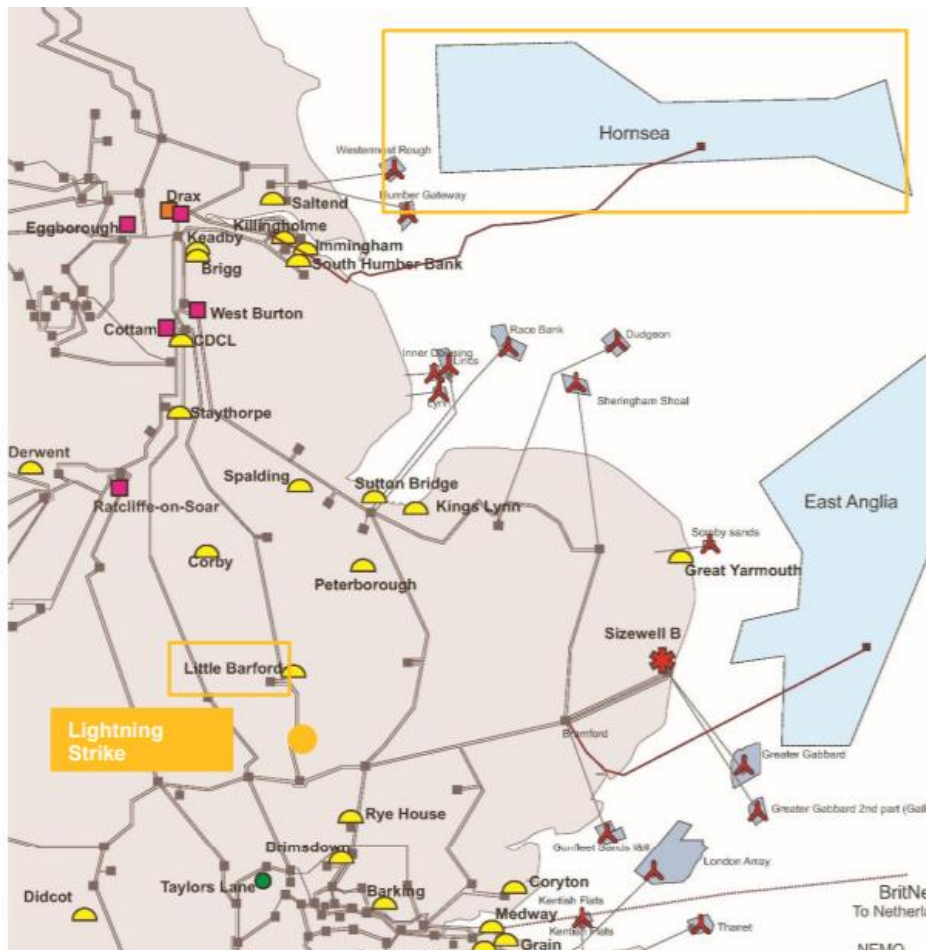
failure

National Grid blames lightning strike for
blackout

UK Government
investigation into
power cut

August 9th 2019 Event

What happened?



Lightening strike causes circuit outage which triggers loss of:

- Little Barford gas power station
 - 644MW in 3 stages
- Hornsea offshore wind farm
 - 737MW instantaneous
- Distributed Generation
 - Loss of Mains protection ~500MW

Known loss of ~1.9GW in stages over the course of around 80s

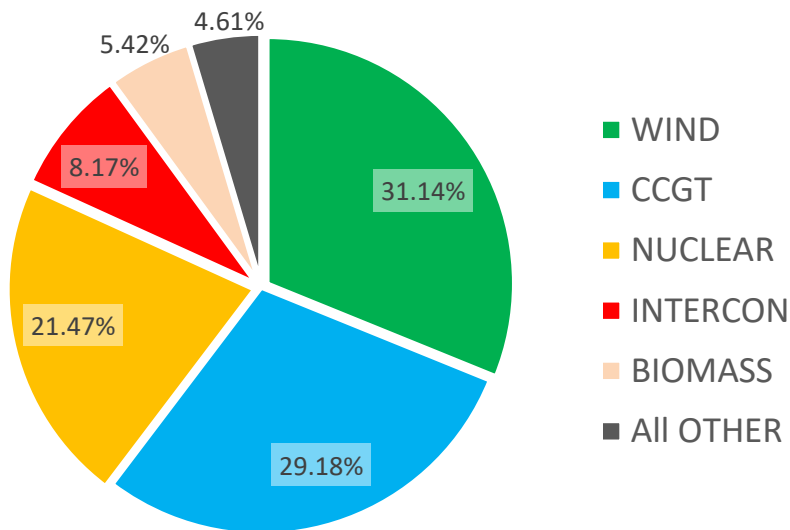
Only the DG element “expected” according to National Grid

August 9th 2019 Event

System Conditions

Demand: ~29GW

Generation Mix



System Inertia: ~200GVAs

System Frequency Response

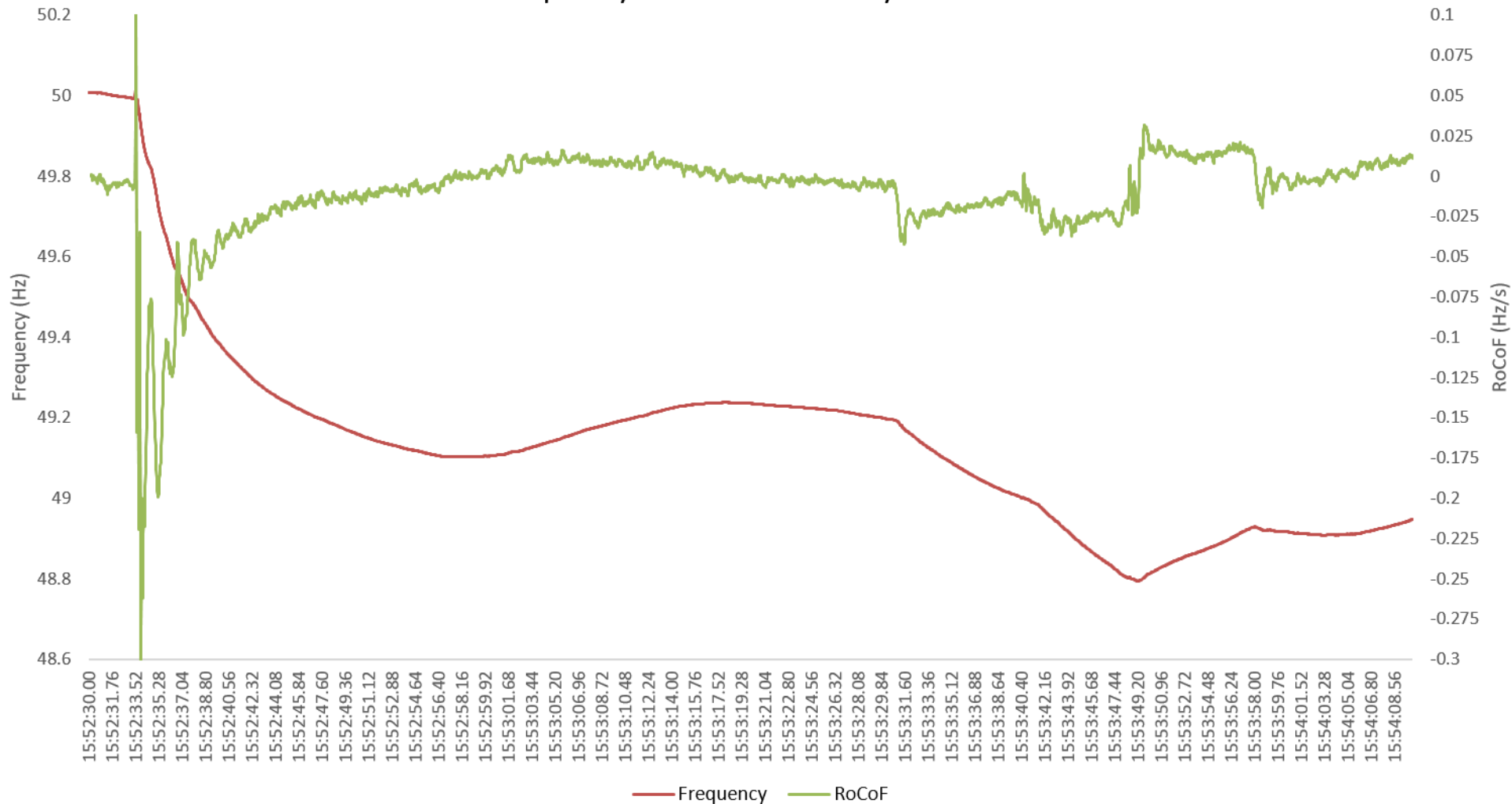
Securing to 1000MW loss risk

Response Provision	Available (MW)	Delivered (MW)
Enhanced	227	165
Primary [secondary] Dynamic	564 [+31]	497
Static 49.7Hz (30s)	285	198
Static 49.6Hz (1s)	231	230
Total	1338	1090
Demand Response	2.4%/Hz	

System Reserve: ~4GW

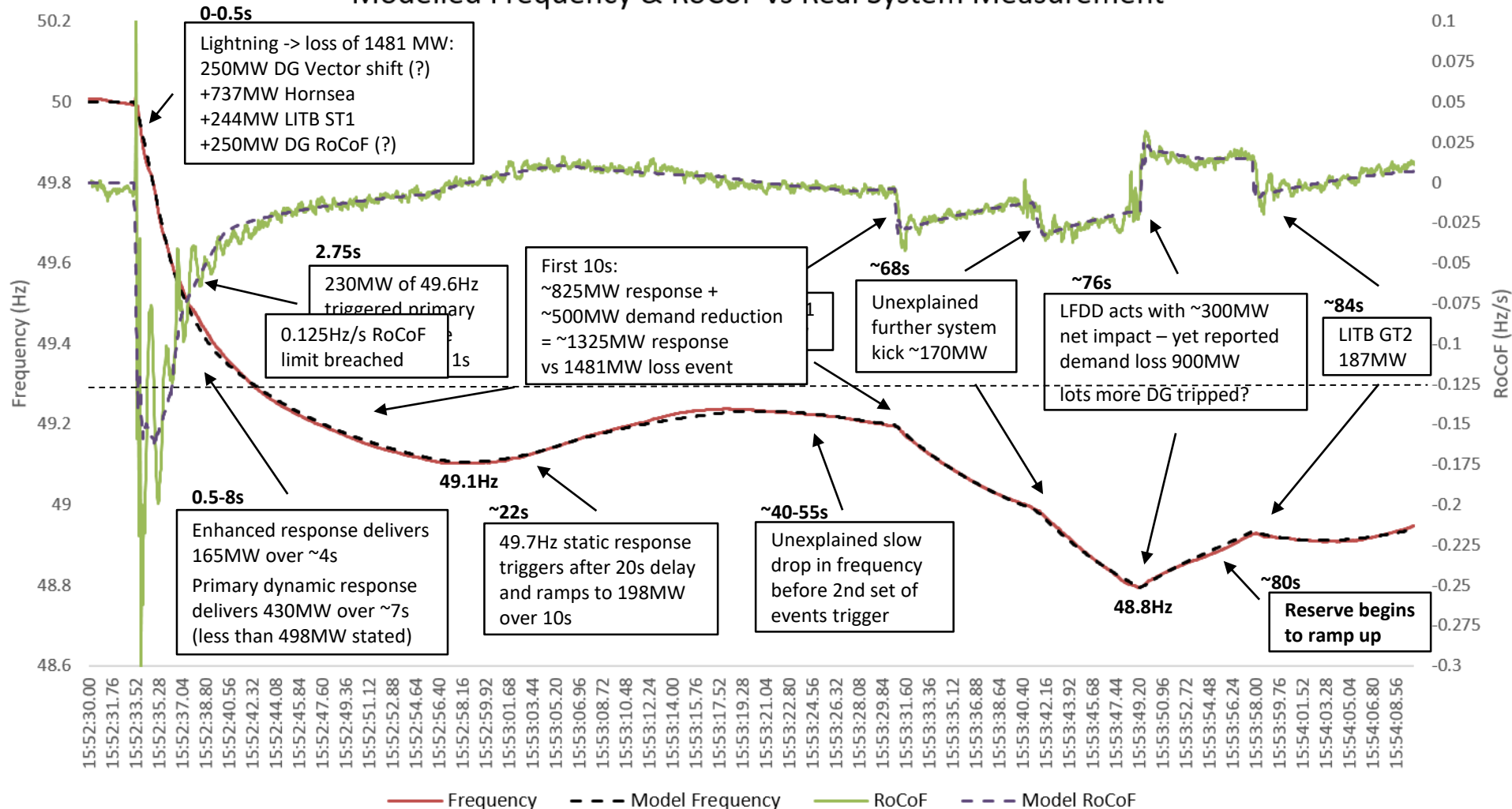
August 9th 2019 Event

Modelled Frequency & RoCoF vs Real System Measurement

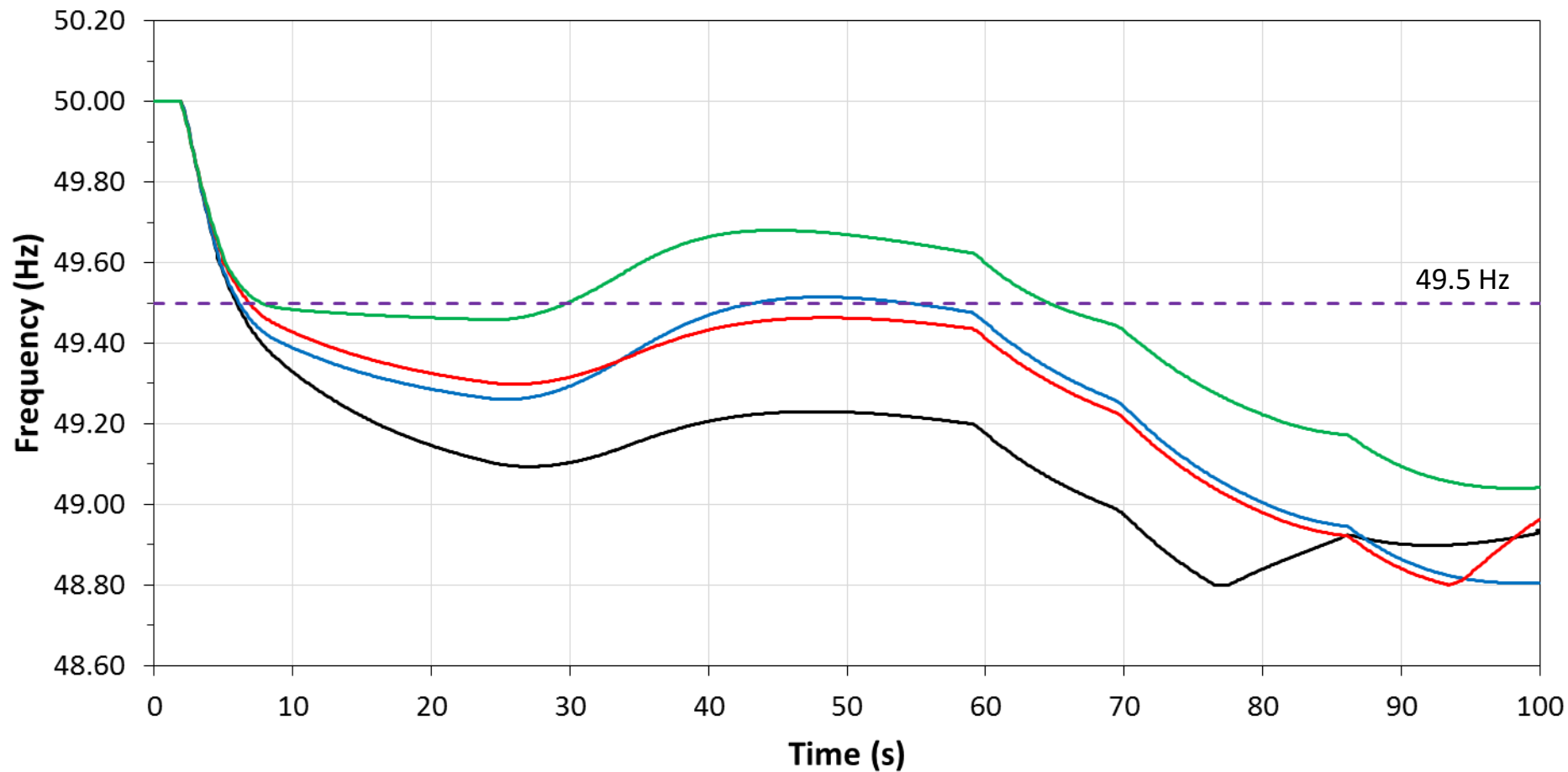


August 9th 2019 Event

Modelled Frequency & RoCoF vs Real System Measurement



August 9th 2019 Event



— Original Event - Most Response Delivered — Original Event - All Response Delivered
— Secured Event - Most Response Delivered — Secured Event - All Response Delivered

Q&A Session – Starter Q's

- What went wrong at Hornsea?
 - Still in build phase & not fully commissioned – significant?
- What went wrong at Little Barford?
- Was the system operator compliant?
- Were response providers compliant?
- “accelerated” program to change LoM protection on DG by 2022
 - Is that accelerated enough? Almost 50000 units.
- Are we *really* confident that this is a 1 in 15 year event?
 - double circuit fault with further loss of DG?
- How much response should be held anyway?
- How much are consumers willing to pay?
- How resilient are public services to future disruptions?



University of **Strathclyde** **Glasgow**