Rapid Frequency Response

BSSG/CBSG– 04/09/2013

Graham Stein & Tom Derry

Frequency Response Technical Sub-group (TSG) Background

- The TSG was an industry Working Group tasked with
  - quantifying future frequency response requirements given
    - the change in the largest secured infeed loss criteria
    - the changing system background and its impact on system inertia
    - Customers and manufacturers are represented, as are Commercial, ENI and Network Operations
- The TSG reported to the ‘Frequency Response Working Group (FRWG)’
  - FRWG was constituted under both the Balancing Services Standing Group (a CUSC Standing Group) and the Grid Code Review Panel
  - The TSG was formed to look at the technical issues of frequency response to help the FRWG focus on commercial issues
- The TSG conclusions and recommendations were included with the Frequency Response Workgroup Report (submitted to GCRP January 2013)

TSG Focus

- The TSG focussed on
  - ‘synthetic inertia’
  - calculating the amount of frequency response that will be required
- It needed to do this because
  - the expected displacement of synchronous generation with asynchronous sources (wind and HVDC) reduces system inertia
  - frequency therefore falls or rises more quickly (in comparative terms)
  - where this coincides with generators ramping to deliver frequency response, the requirement for response grows in line with the assumed ramp rate

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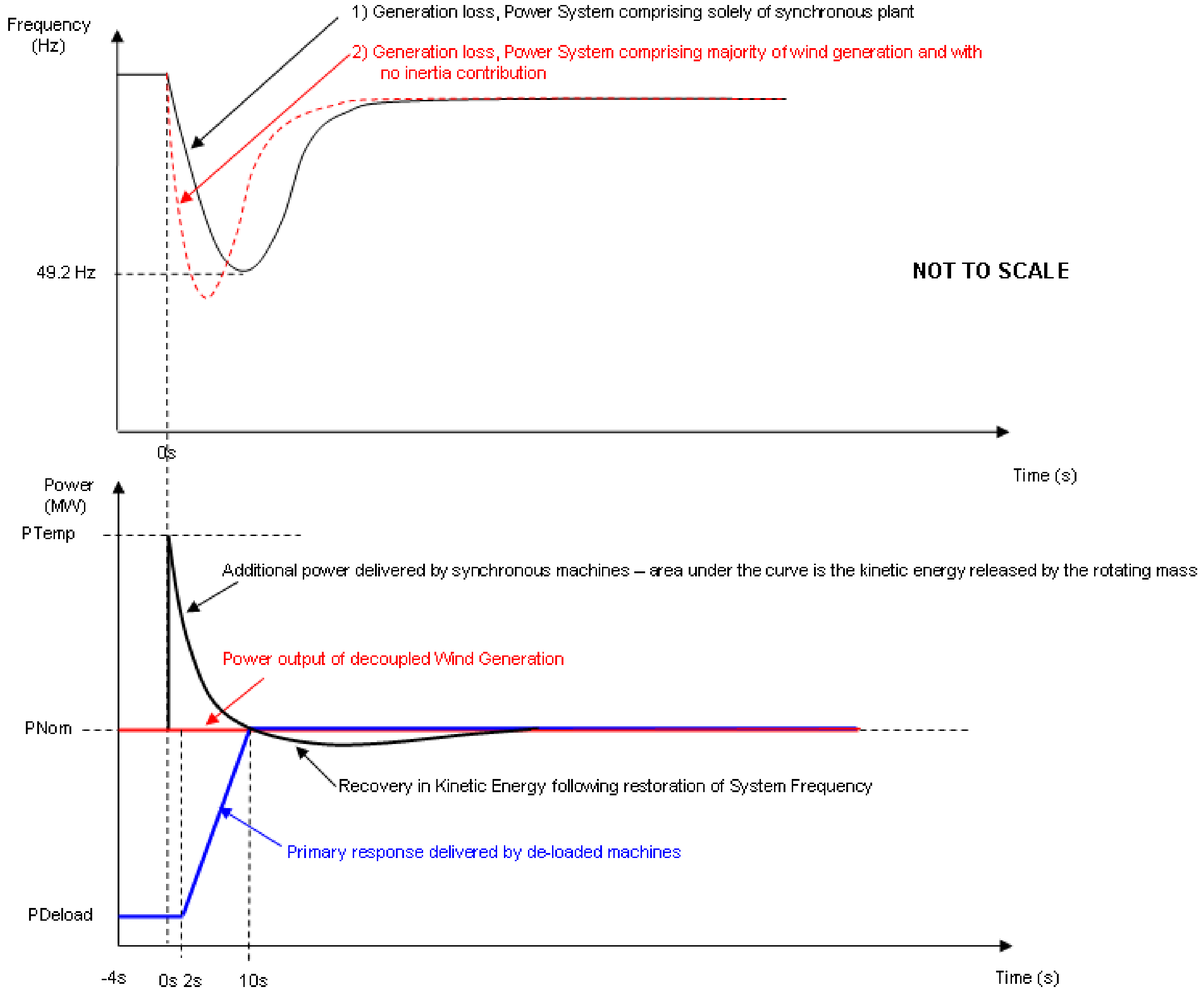
TSG Focus



Synthetic Inertia

- Synchronous machines inject (and withdraw) active power in proportion to the rate of change of system frequency
- a synthetic inertia control has been postulated by a number of wind turbine manufacturers
  - implemented on generators operating at maximum output (for the available wind resource) and hence minimises curtailment
  - different approaches were discussed
    - continuous 'df/dt' control
      - **pro**: adaptive
      - **con**: noise amplifying, introducing delay and complexity to the control
    - one shot
      - **pro**: simple and predictable
      - **con**: non-adaptive
  - All approaches present risks for wind during the 'recovery period'
    - possible that active power output would reduce by up to 30% after the initial power injection
  - Manufacturers suggested that delivering synthetic inertia and conventional frequency response from the same machines was not possible
    - This could mean that not enough capacity was available to meet conventional frequency response requirements
- **The group concluded that it could not recommend prioritising development of synthetic inertia due to the unresolved technical questions**

Primary Response Requirements

- The amount of Primary Response required to contain a frequency deviation changes as system inertia changes
- The TSG therefore considered different generation and demand scenarios
- Generation was based on Gone Green on 2020
  - Low, Average and High wind situations were assessed
- Simulations were performed at 5GW intervals from 20GW to 55GW
  - Assumptions were **not** ‘worst case’

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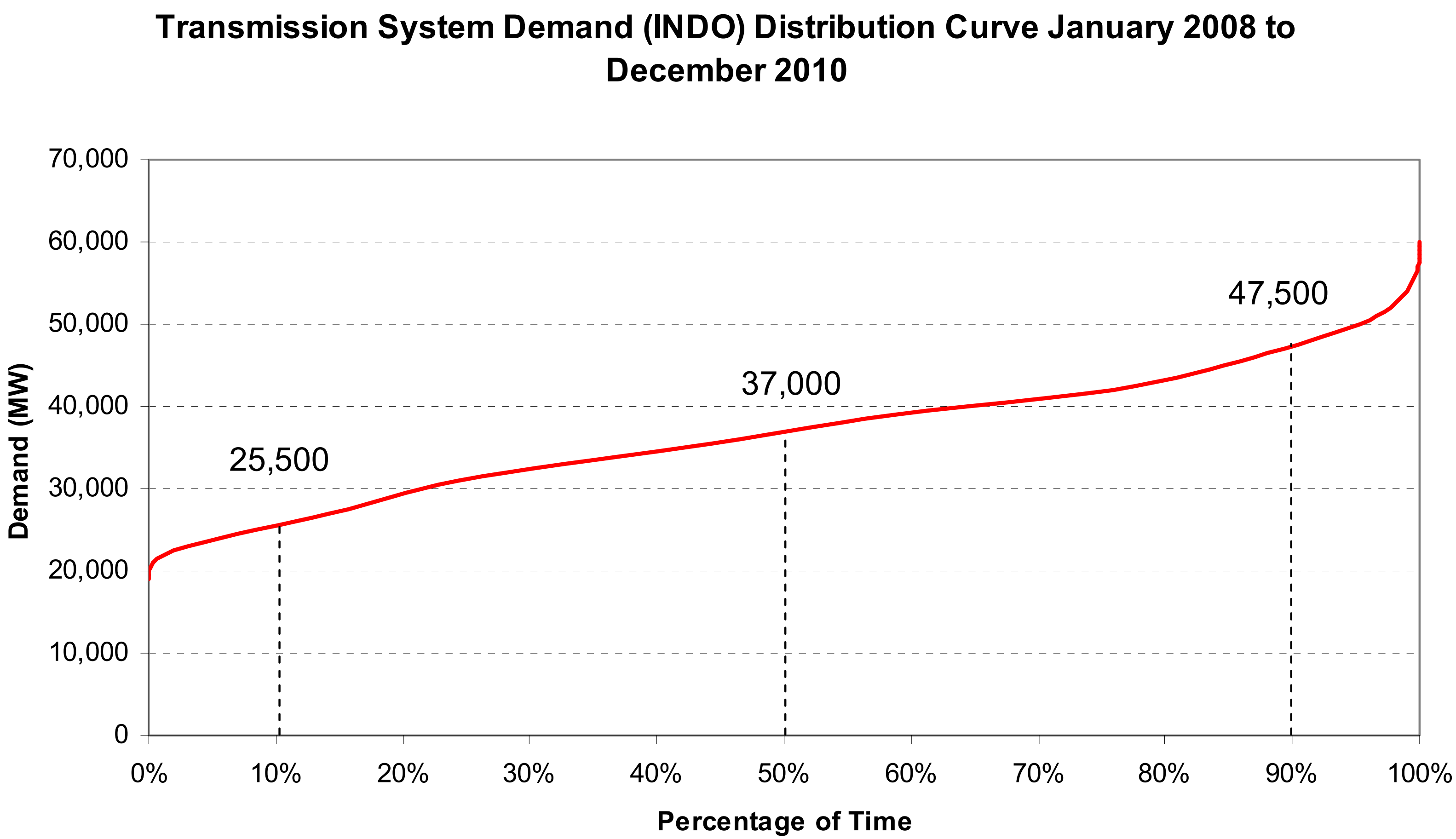
Primary Response Requirements



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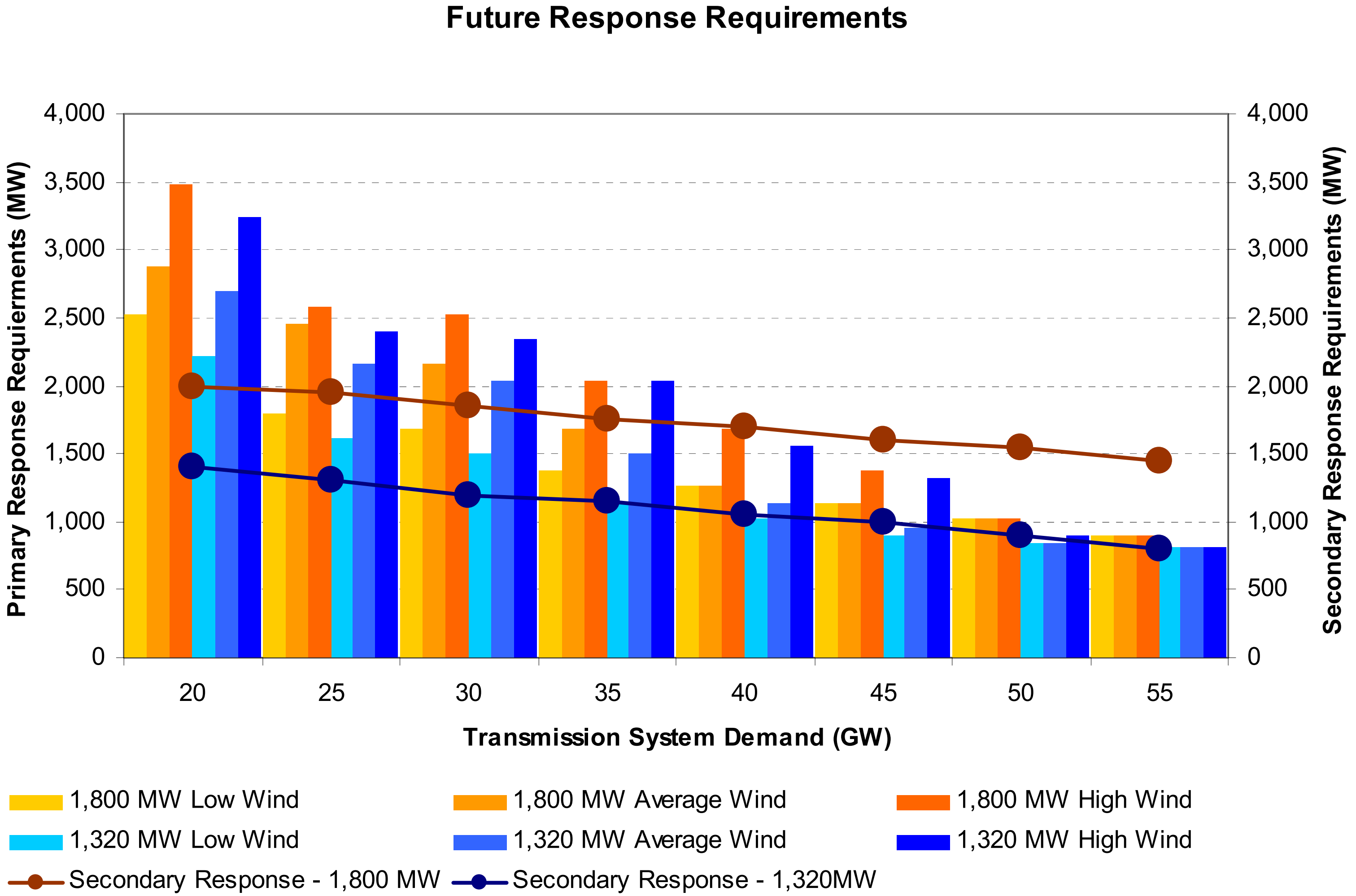
Primary Response Requirements



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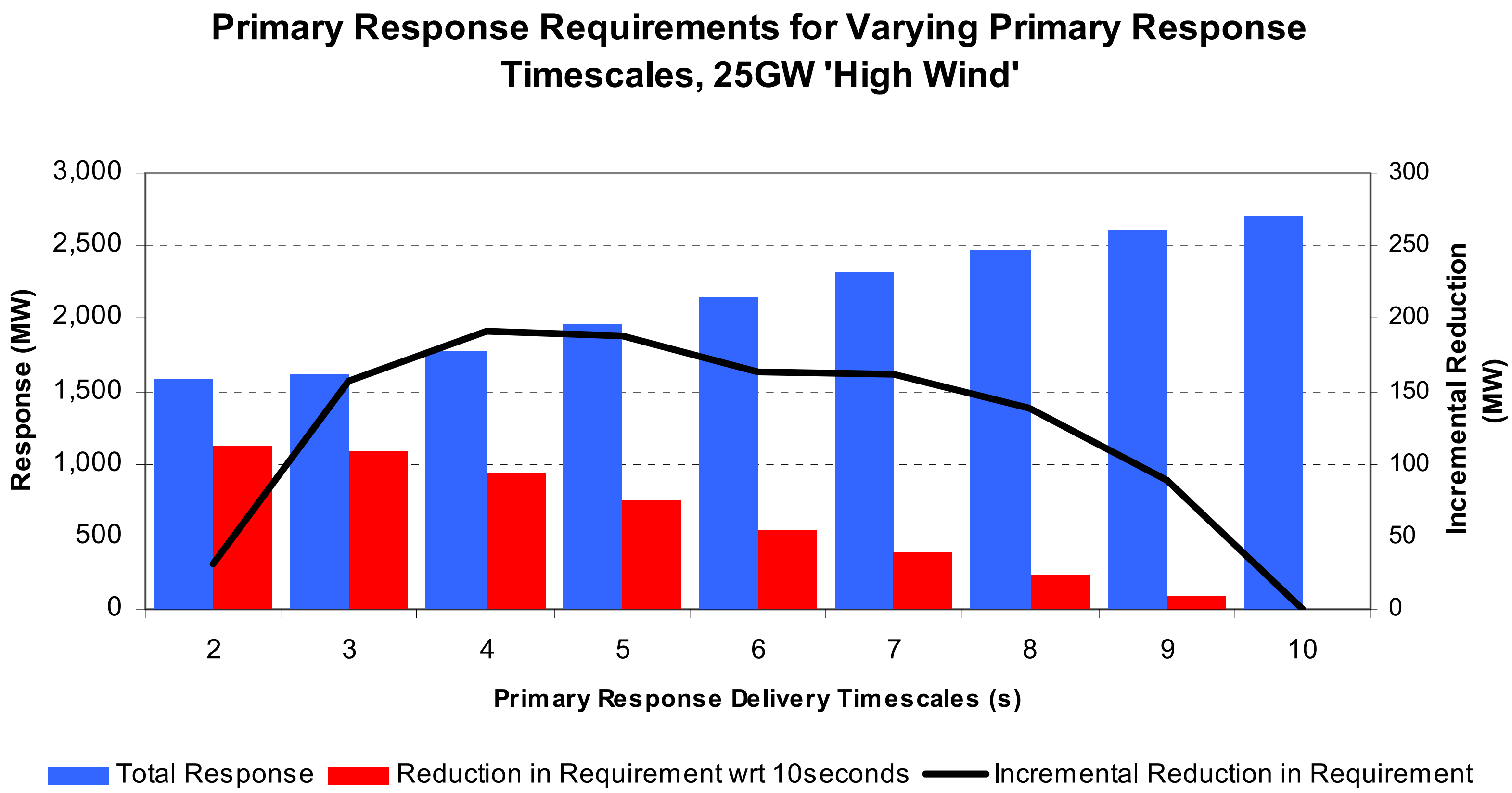
Primary Response Requirements

		System Demand (GW)							
		20	25	30	35	40	45	50	55
Primary Response Requirement									
Low Wind	1,800 MW	2,520	1,800	1,680	1,380	1,260	1,140	1,020	900
	1,320 MW	2,220	1,620	1,500	1,140	1,020	900	840	810
Average Wind	1,800 MW	2,880	2,460	2,160	1,680	1,260	1,140	1,020	900
	1,320 MW	2,700	2,160	2,040	1,500	1,140	960	840	810
High Wind	1,800 MW	3,480	2,580	2,520	2,040	1,680	1,380	1,020	900
	1,320 MW	3,240	2,400	2,340	2,040	1,560	1,320	900	810
Secondary Response Requirement									
	1,800 MW	2000	1950	1850	1750	1700	1600	1550	1450
	1,320 MW	1400	1300	1200	1150	1050	1000	900	800

Rapid Frequency Response

- Speeding up the delivery of primary response gave significant benefits
  - Necessary to achieve compliance in some cases
- Reduction in requirements of up to 1,100MW
- Only necessary when asynchrounous plant is providing response
- Applicable to LF triggered demand
- Much simpler than “synthetic inertia options

Rapid Frequency Response



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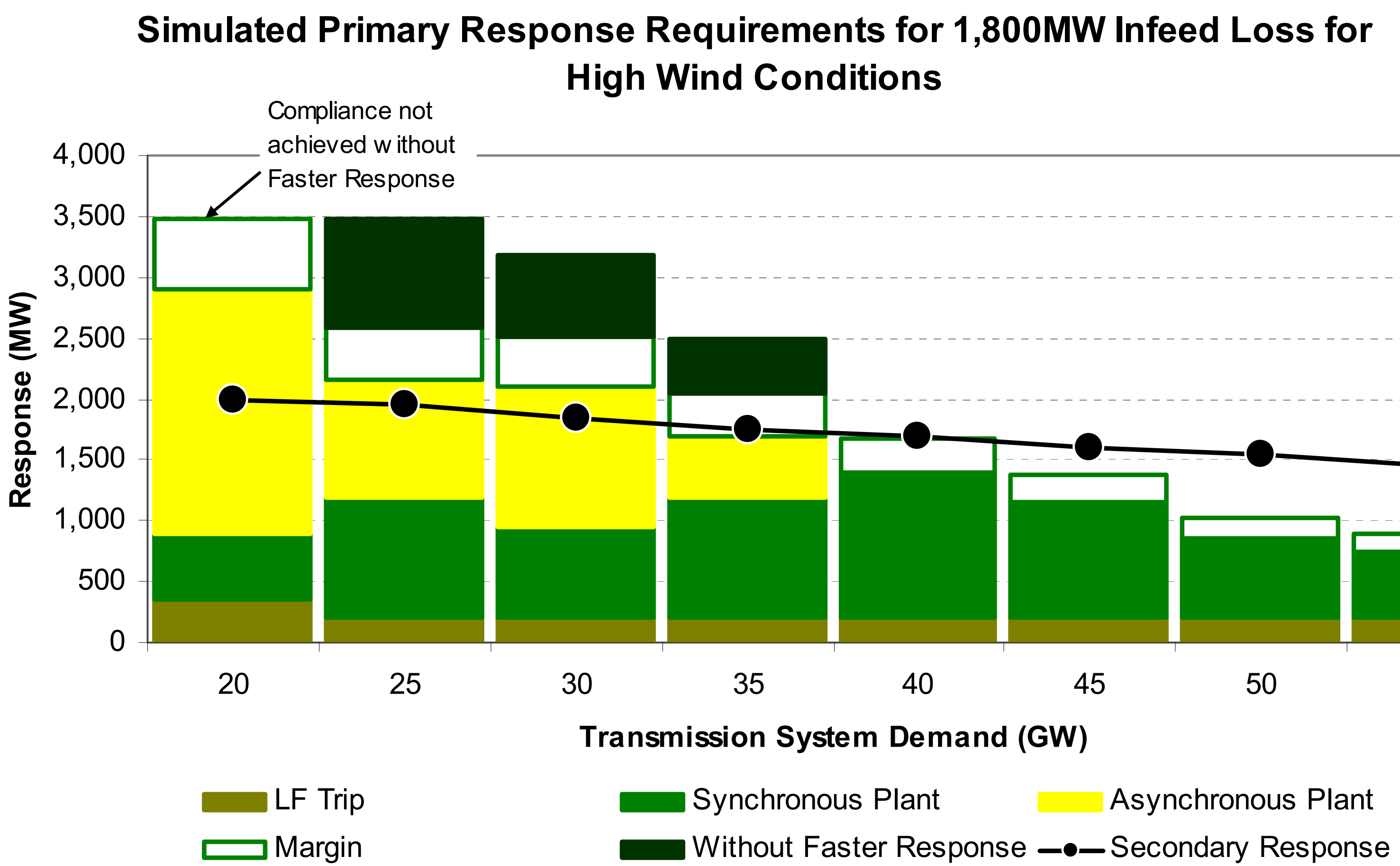
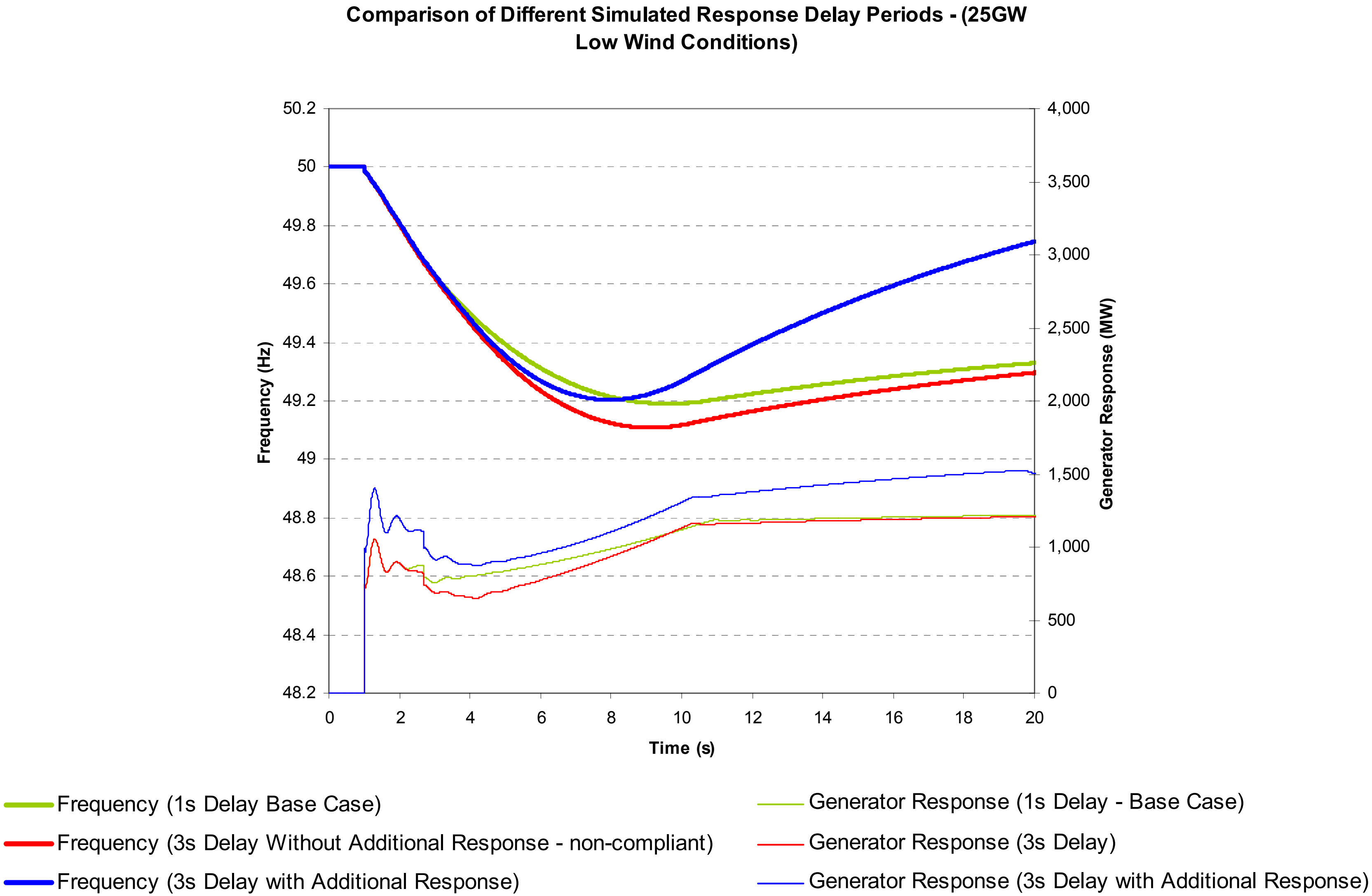
Rapid Frequency Response



Delays and Ramp Rates

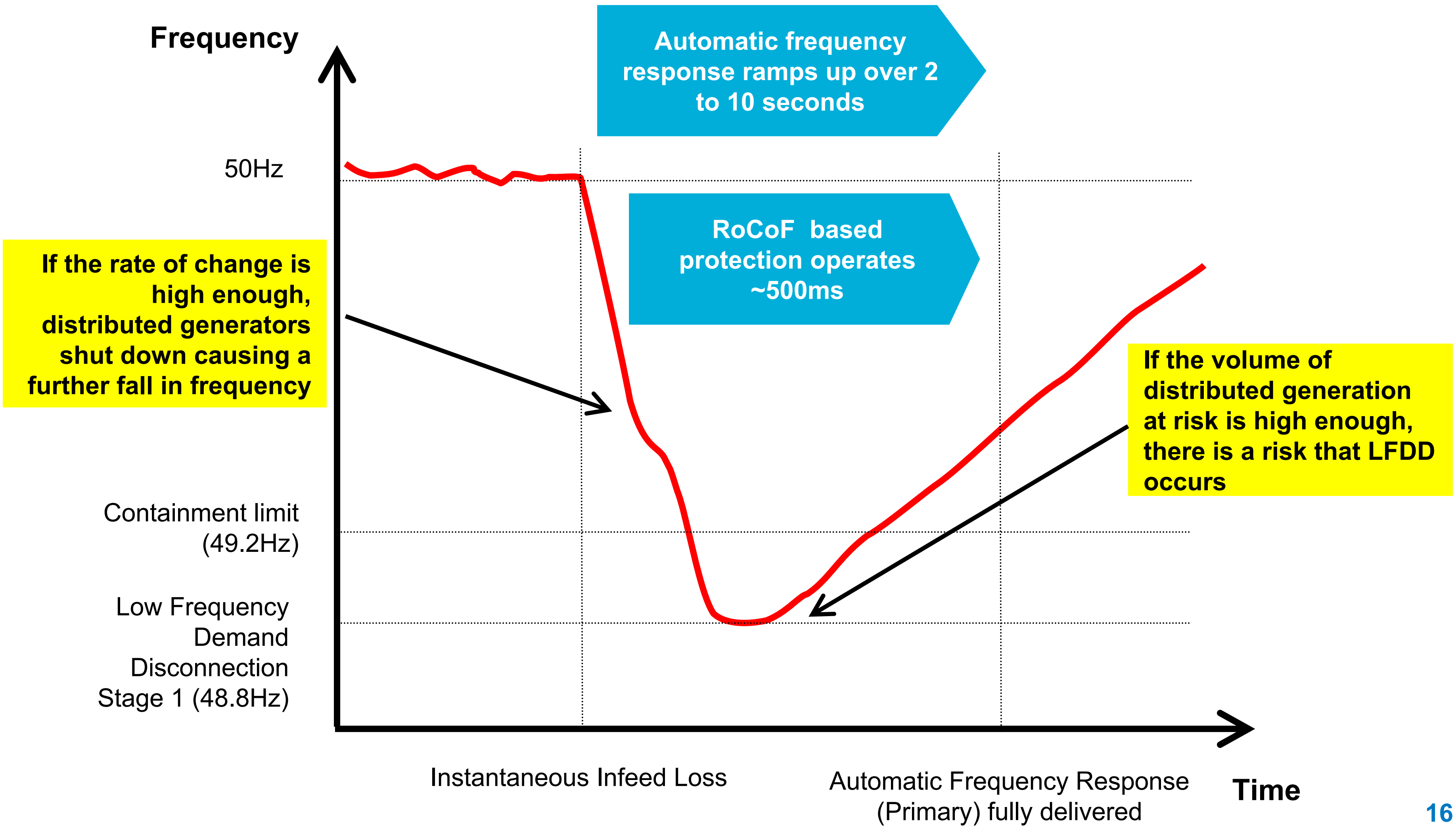
- Base case simulations assumed a 1 second delay in response delivery
- Changing this has a significant effect
  - 500MW in the case illustrated here
- Report includes a recommendation to firm up delay and ramp rate requirements for response

Delays and Ramp Rates



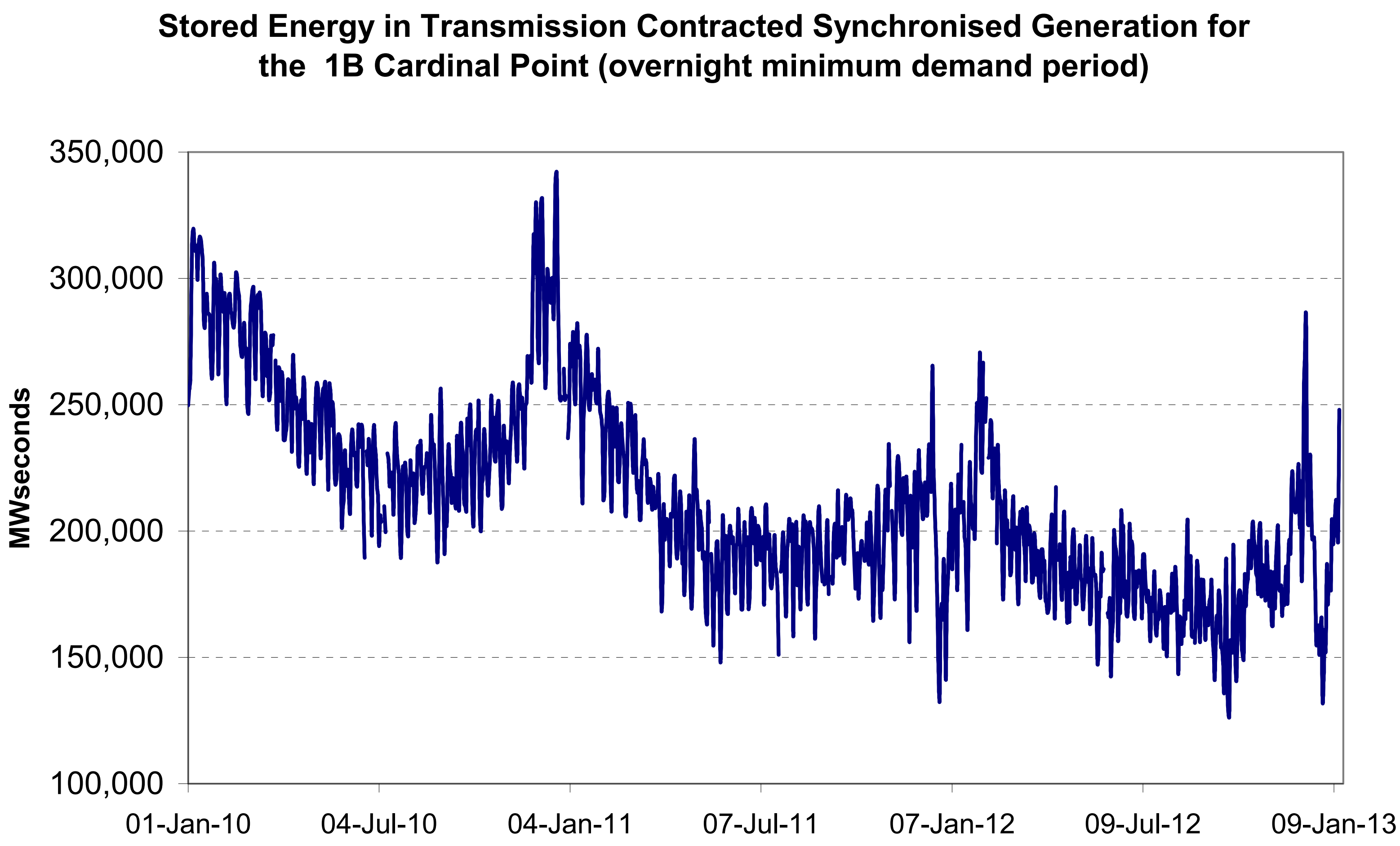
Rate of Change of Frequency

Background



Frequency
50Hz
Automatic frequency response ramps up over 2 to 10 seconds
RoCoF based protection operates ~500ms
If the rate of change is high enough, distributed generators shut down causing a further fall in frequency
If the volume of distributed generation at risk is high enough, there is a risk that LFDD occurs
Containment limit (49.2Hz)
Low Frequency Demand Disconnection Stage 1 (48.8Hz)
Instantaneous Infeed Loss
Automatic Frequency Response (Primary) fully delivered
Time

System Requirement



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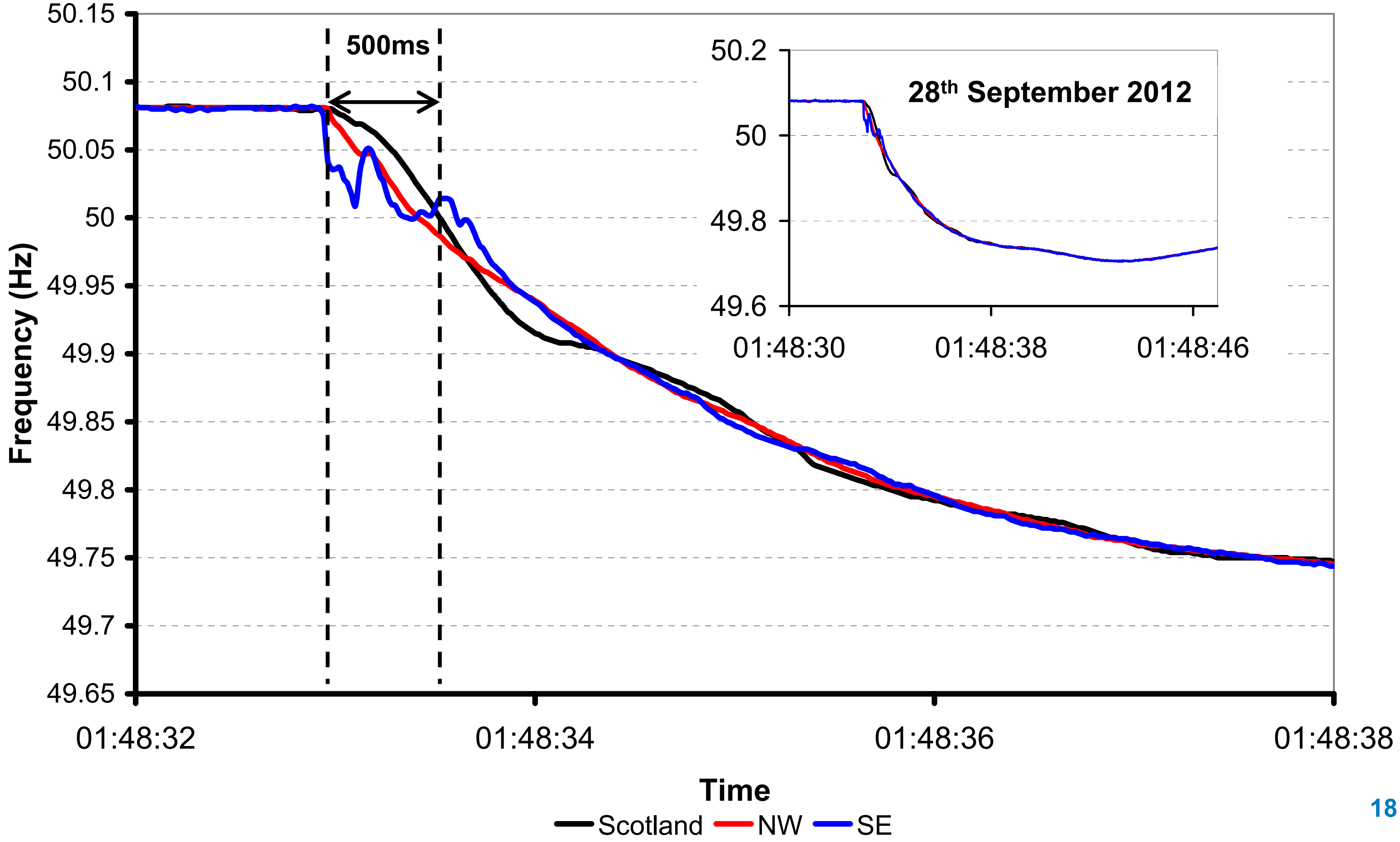
System Requirement



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System Requirement

Predicted Average System RoCoF (Hz/s)

Year	Demand	1320 MW loss		1800 MW loss	
		100ms	500ms	100ms	500ms
2014	20 GW	-0.24	-0.24	-0.34	-0.33
	35 GW	-0.13	-0.13	-0.18	-0.17
2016	20 GW	-0.25	-0.24	-0.35	-0.34
	35 GW	-0.13	-0.13	-0.19	-0.18
2018	20 GW	-0.30	-0.29	-0.43	-0.42
	35 GW	-0.16	-0.16	-0.23	-0.22
2020	20 GW	-0.36	-0.35	-0.50	-0.49
	35 GW	-0.19	-0.19	-0.27	-0.26

Table 1: Predicted Average System RoCoF (High Wind Conditions)

Year	Demand	1320 MW loss		1800 MW loss	
		100ms	500ms	100ms	500ms
2014	20 GW	-0.26	-0.26	-0.36	-0.36
	35 GW	-0.14	-0.13	-0.19	-0.18
2016	20 GW	-0.27	-0.27	-0.38	-0.37
	35 GW	-0.14	-0.14	-0.20	-0.19
2018	20 GW	-0.33	-0.32	-0.47	-0.45
	35 GW	-0.17	-0.17	-0.24	-0.24
2020	20 GW	-0.42	-0.40	-0.57	-0.56
	35 GW	-0.21	-0.20	-0.29	-0.28

Table 2: Predicted Average System RoCoF (High Wind, High Imports)

Frequency Changes Workgroup Recommendations

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- Phase 1
  - Change RoCoF settings on LOM protection for existing and new distributed generators within stations of registered capacity of ≥ 5MW to $1Hzs^{-1}$ measured over half a second
  - Completion of information gathering for distributed generation at stations of registered capacity of 5MW and larger
  - Implementation of protection setting changes within 18 months
  - Conduct site specific safety risk assessment for impacted generators (i.e. ≥ 5MW) prior to implementation of a protection setting change
- Phase 2
  - Develop RoCoF proposals for all distributed generation of < 5MW in capacity and a RoCoF withstand capability.

Summary of Current Position for Rapid Frequency Response

- Connections to the networks mean infeed risks of > 1,320MW are likely after 2015
- Relaxation of the current RoCoF constraint is expected after 2015
- Therefore, the requirement for Rapid Frequency Response grows from 2015 onwards
  - Implementation of any obligated requirement will take time
    - No plans for retrospective changes
    - Contingent on industry consultation
  - Parallel development of commercial service to
    - Bridge any shortfall
    - Provide a route to market for providers not captured by a new obligation

Code Changes

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Overview

- Commercial Rapid Frequency Response
  - No Code Changes
  - Fits within existing commercial arrangements
  - New Firm Frequency Response product
  - Developed alongside but independent of Mandatory Rapid Frequency Response

- Mandatory Rapid Frequency Response
  - Grid Code Changes
    - Industry Consultation
  - CUSC Changes
    - Industry Consultation
  - Inclusion within Electricity Balancing System (EBS)
  - Implementation ~ 2015/16
  - All subject to Authority approval

Principle

Keep it simple

- Primary Response
- Secondary Response
- High Frequency Response

No new definitions

Existing definitions have a new reference to Grid Code CC Appendix 3

Grid Code CC Appendix 3

- Split frequency response requirements based on delivery time
  - 10 second (CC.A.3.Y)
    - All existing generators and requirements are maintained
  - 5 second (CC.A.3.X)
    - New Onshore and Offshore Power Park Modules, and DC Converters

Grid Code Changes

- Glossary & Definitions
  - Primary Response, Secondary Response and High Frequency Response
- Connection Conditions
  - CC.6.3.7 (Control Arrangements)
  - CC.A.3 (Minimum FR Response Requirement Profiles)
- Operating Code 5 - Testing & Monitoring
  - OC5.A.2.8 (Synchronous Plant)
  - OC5.A.3.6 (Power Park Modules)
  - OC5.A.4.5 (DC Converters)
- Data Registration Code
  - Schedule 4 (Large Power Station Droop and Response Data)
- Balancing Code 3
  - BC3.7 (DC Converter Stations)

CUSC Changes

- Schedule 2 Exhibit 4 (Mandatory Services Agreement)
  - Appendix 1, Section B – Tables amended to allow indication of which form of Primary and High Response is being delivered (i.e. Grid Code CC.A.3.X or CC.A.3.Y)
  - Appendix 3, Further Definitions – Formula symbol definitions to be amended to reflect different delivery times