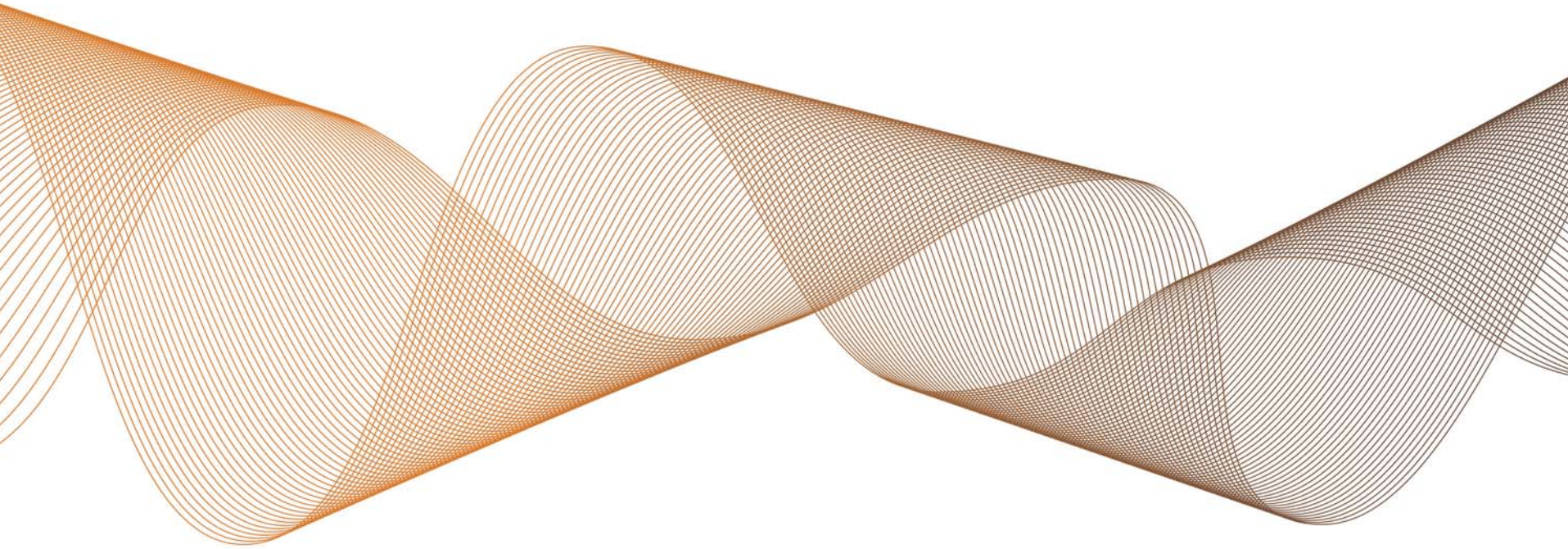


LFAS 101

Presentation to MAC
Meeting, October 2013



Presented by:
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Connecting people with electricity



Purpose

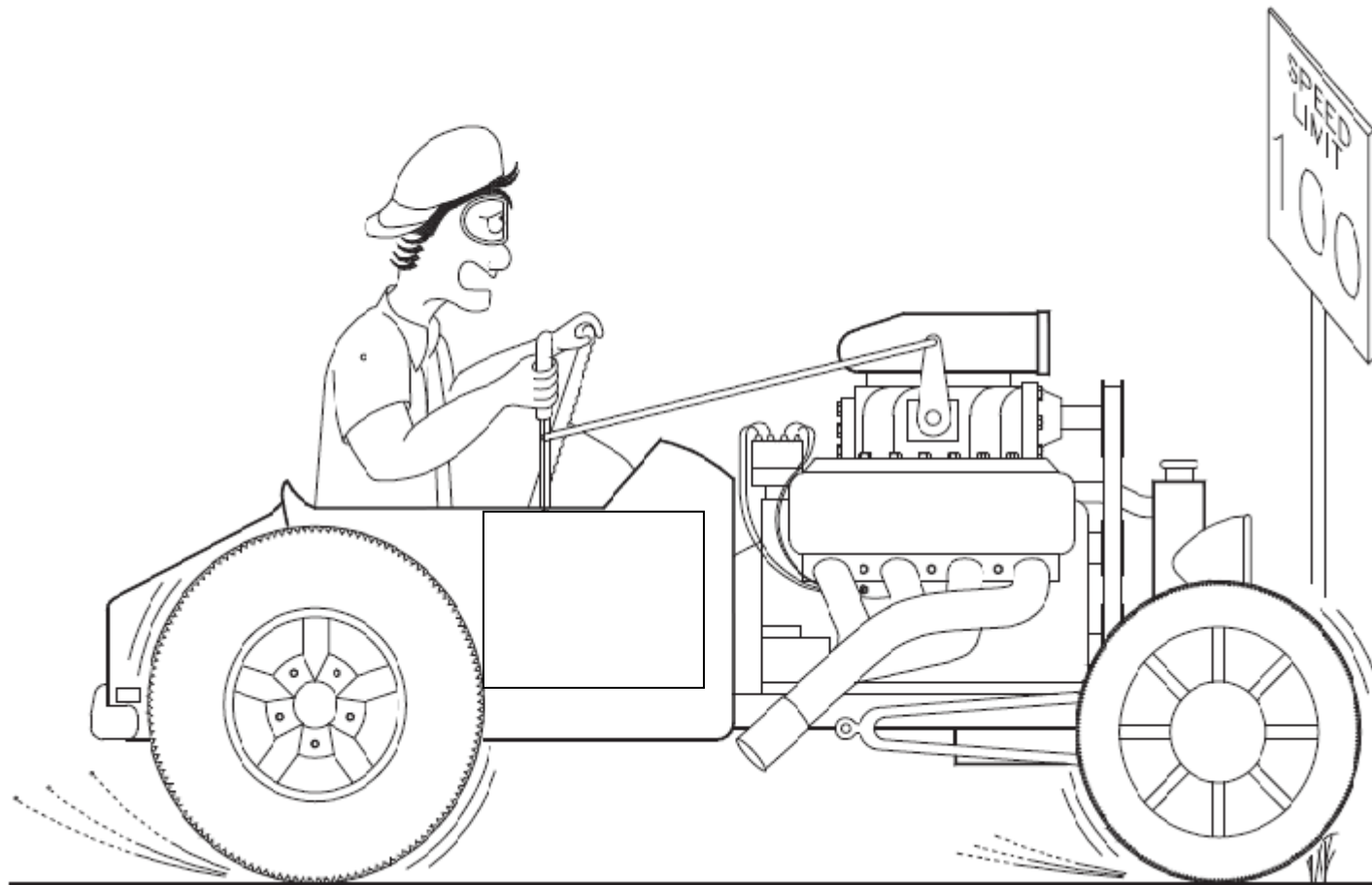
- Give MAC members a better understanding of:
 - Governor response
 - Load Following, Spinning Reserve and Load Rejection Reserve
-
- what is the role of each “service”;
 - how the services are differentiated from one another;
 - how the services operate and how they are controlled;
 - how the services interact with one another; and
 - how the services interact with normal “balancing”.

Questions

- What is the response window for each service?
- What drives the requirements for LFAS, how much is due to loads, unscheduled generators e.g. wind farms and scheduled generators, weather and time of day/season
- How does a generator actually provide LFAS; what characteristics does a generator require to be eligible to supply LFAS
- Are LFAS signals totally independent of the Balancing Market (and BMO DIs)?
- Are these signals recorded? What metrics are currently available? (An LFAS market needs to be measurable)
- What differentiation is there between providing governor automatic frequency response and paid LFAS?
- How does the LFAS system know when to send an LFAS signal
- why don't we rely on (paid/dedicated) LFAS response first before expecting unpaid units to response to frequency changes

What is a Governor?

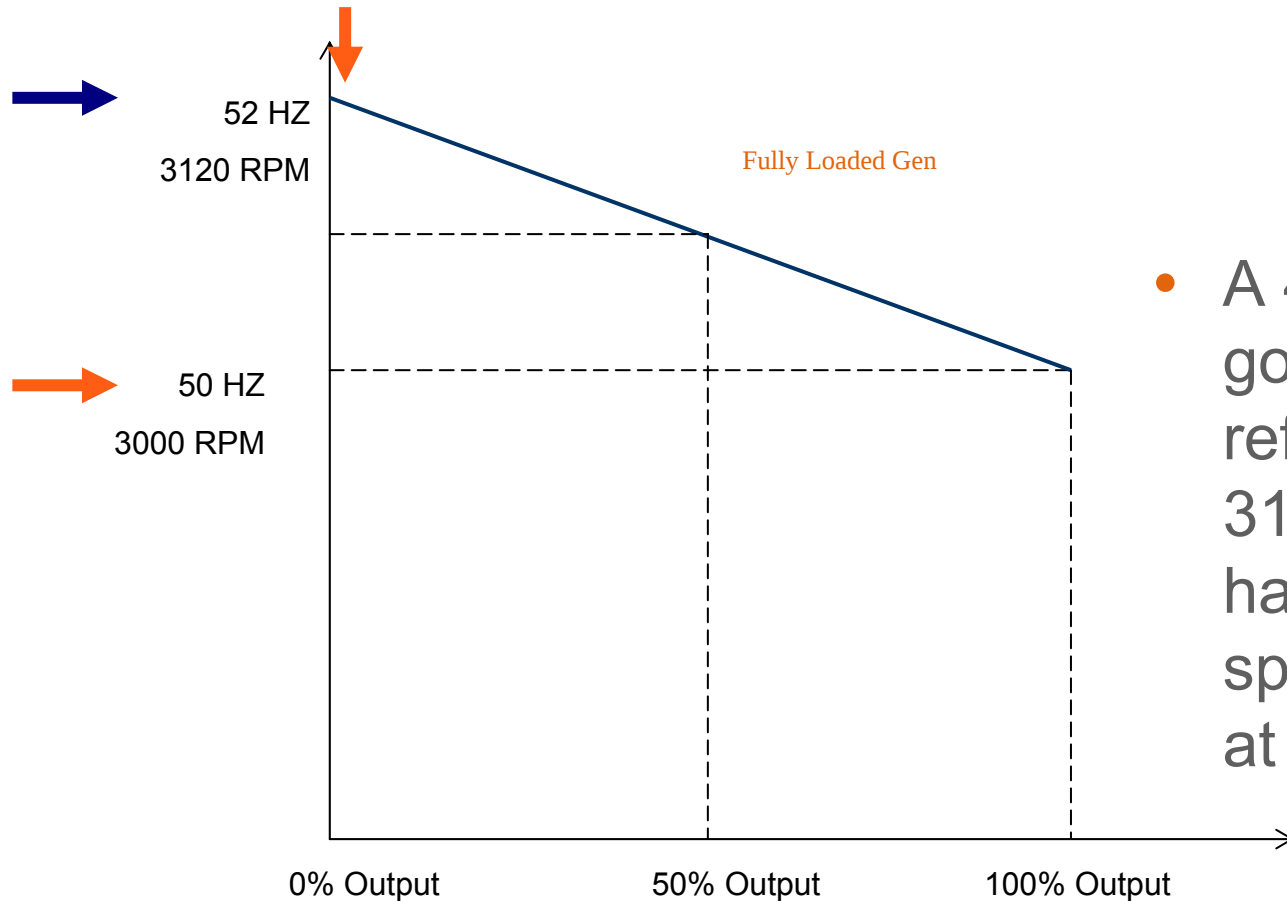
- ***Governor*** controls the speed or power output of an engine, turbine, or other source of power (***prime mover***).
- A governor senses the speed (or load) and controls the fuel (or steam) to maintain speed (or load) at a desired level.
- In all cases, ***a governor controls the energy source to a prime mover, to control its power***



What is Droop and why is used?

- Without speed control, generators slow down as load increases.
- Droop is the amount of speed (or frequency) change that is necessary to cause the main prime mover control mechanism to move from fully closed to fully open.
- Droop is a straight line function with certain speed reference for every fuel position.

Droop Curve



- A 4% droop governor with reference speed of 3120 rpm at no load has a reference speed of 3000 rpm at full load

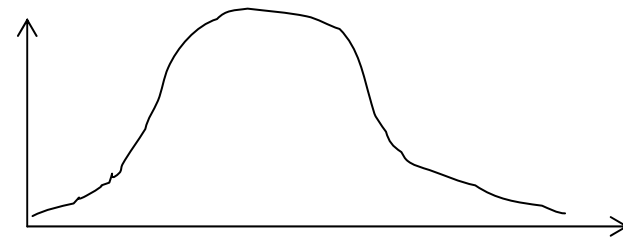
- $\% \text{Droop} = (\text{No load speed} - \text{Full Load Speed}) / \text{Full load speed}$

Example

- (Scenario 1) A (240 MW) Gas Turbine synchronised
 - Frequency fell from 50 Hz to 48 Hz,
 - Increase load from 0 MW to full load 240 MW
- (Scenario 2) the GT output is 80 MW
 - Frequency dropped 1 Hz or 2% from 50 Hz to 49 Hz
 - increase load by 50% of its capacity (i.e. by 120 MW) to a load of 200 MW
- The load change in MW is relative to the frequency change and the maximum capacity of the generator (240 MW).

Q: What happens with F?

Example - Continued



- For this GT (240 MW) a change in frequency of -0.2 Hz causes a load change of 10% (24 MW)
- SWIS frequency deviations ± 0.05 Hz ($\pm 0.1\%$) or less, resulting in -6 MW to +6 MW ($\pm 2.5\%$ of maximum capacity).
- Deadband of 0.05 Hz (i.e. ± 0.025 Hz) = load change of 3 MW. If system frequency deviates past that point then a 4% governor droop response is required.
- The response is within 6 sec, maintained for 10 sec.

Using Droop to Share Loads

- Same droop setting = sharing load proportionally
- Load change = Frequency Change = change in frequency setting for each generator = System frequency stabilises with new load

Automatic Generation Control

- Sustained change in frequency needed for sustained change in generator output. Thus, governors alone cannot restore frequency to the pre-disturbed level.
- This is accomplished by the speed adjustment input made by the dispatch center, AGC system.
- AGC is to maintain frequency by matching generators' output to fluctuating demand
- This action restores system frequency by making generators follow the load, ie Load Following.

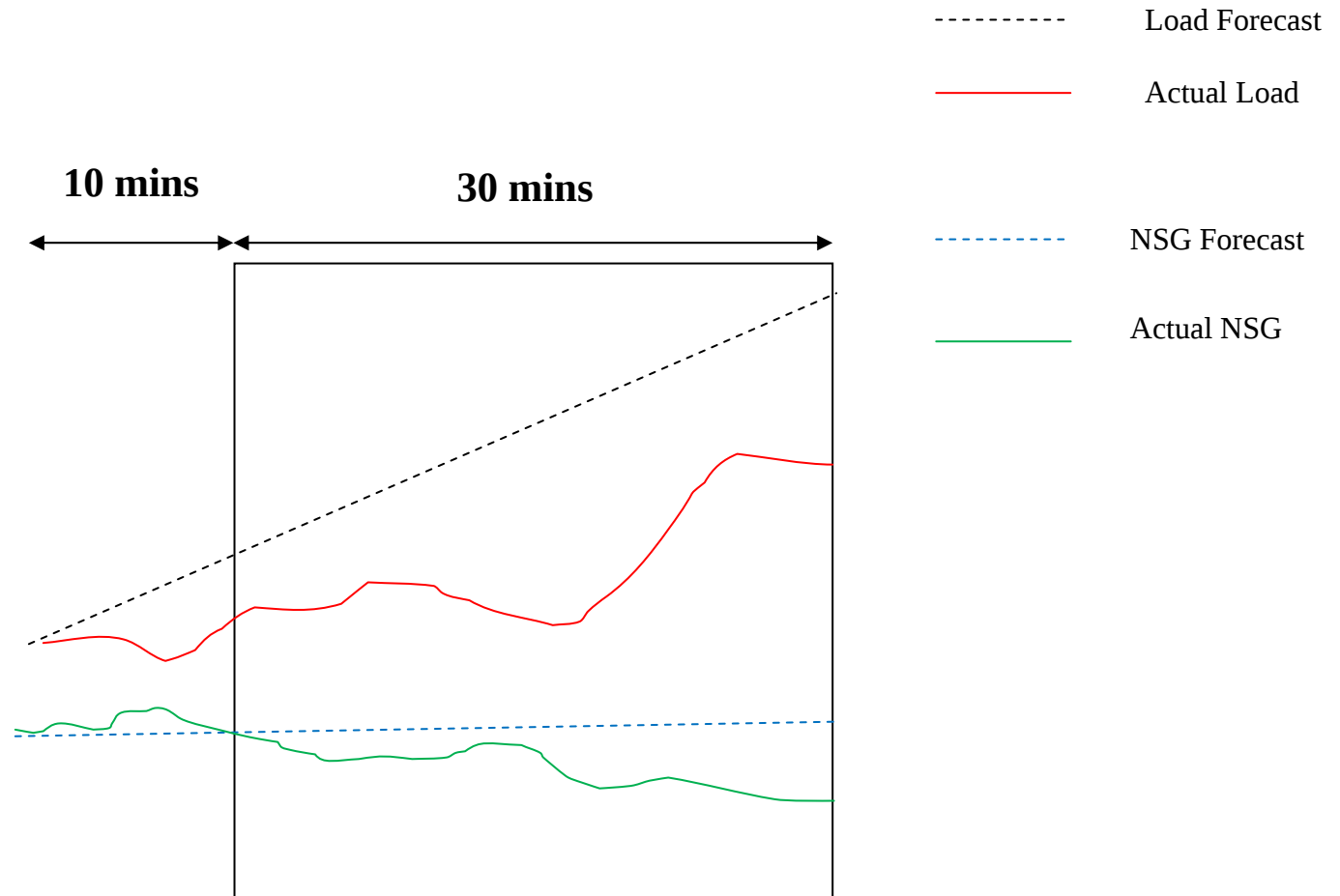
Load Following Definition

- Load Following is the service of frequently matching total system generation to total system load, so as to correct frequency variations.
- Continuously done (every 4 seconds) by the AGC.
- Load Following is different from Droop Control, as it is a secondary control initiated remotely from Control Centre.

Sources of Load Following Demand

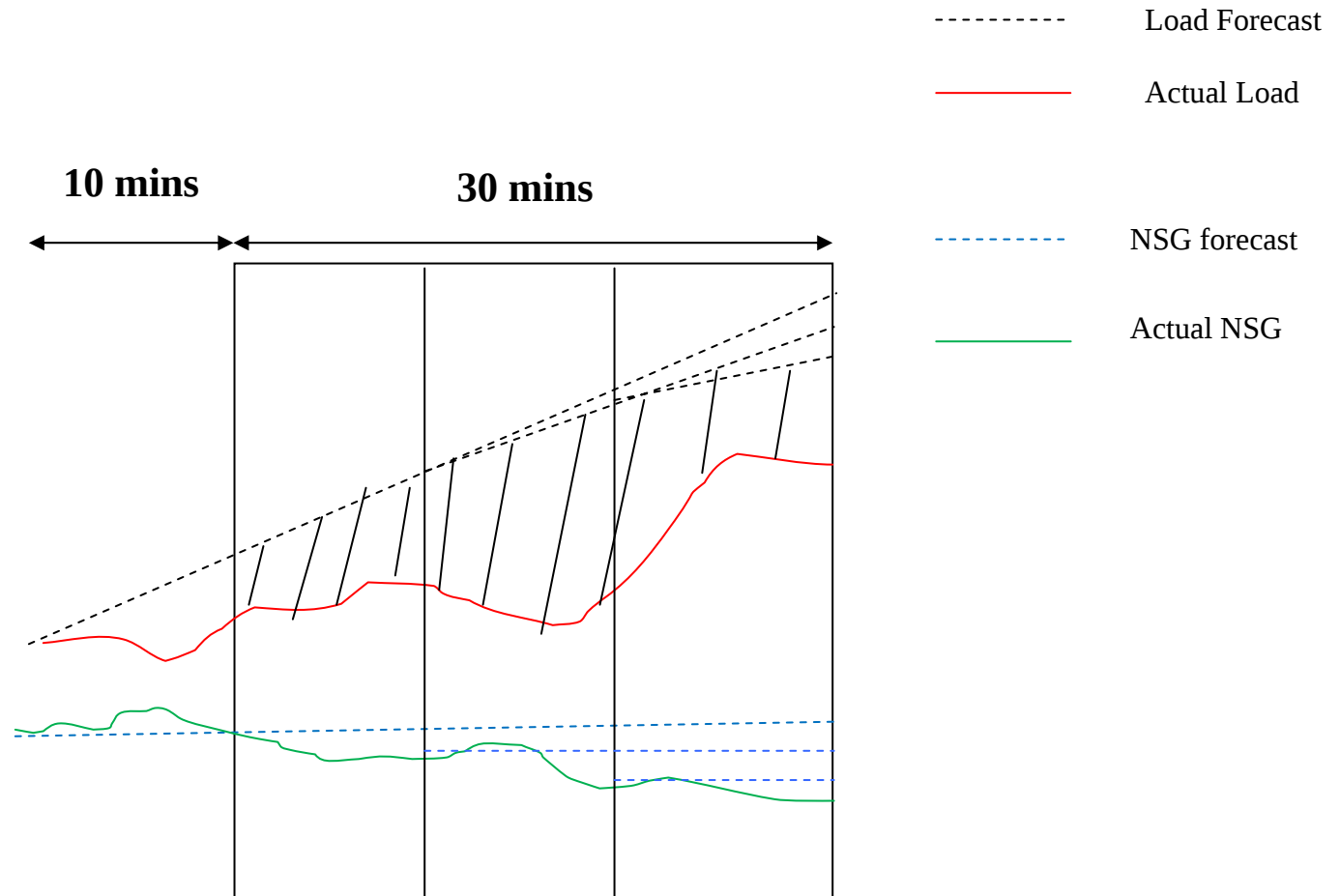
- Load Forecast error and variability
- Non Scheduled Generation variability
- Scheduled Generators variability from Dispatch Instruction
- Generator dispatch ramp rate requirement

Dispatch per Balancing Merit Order

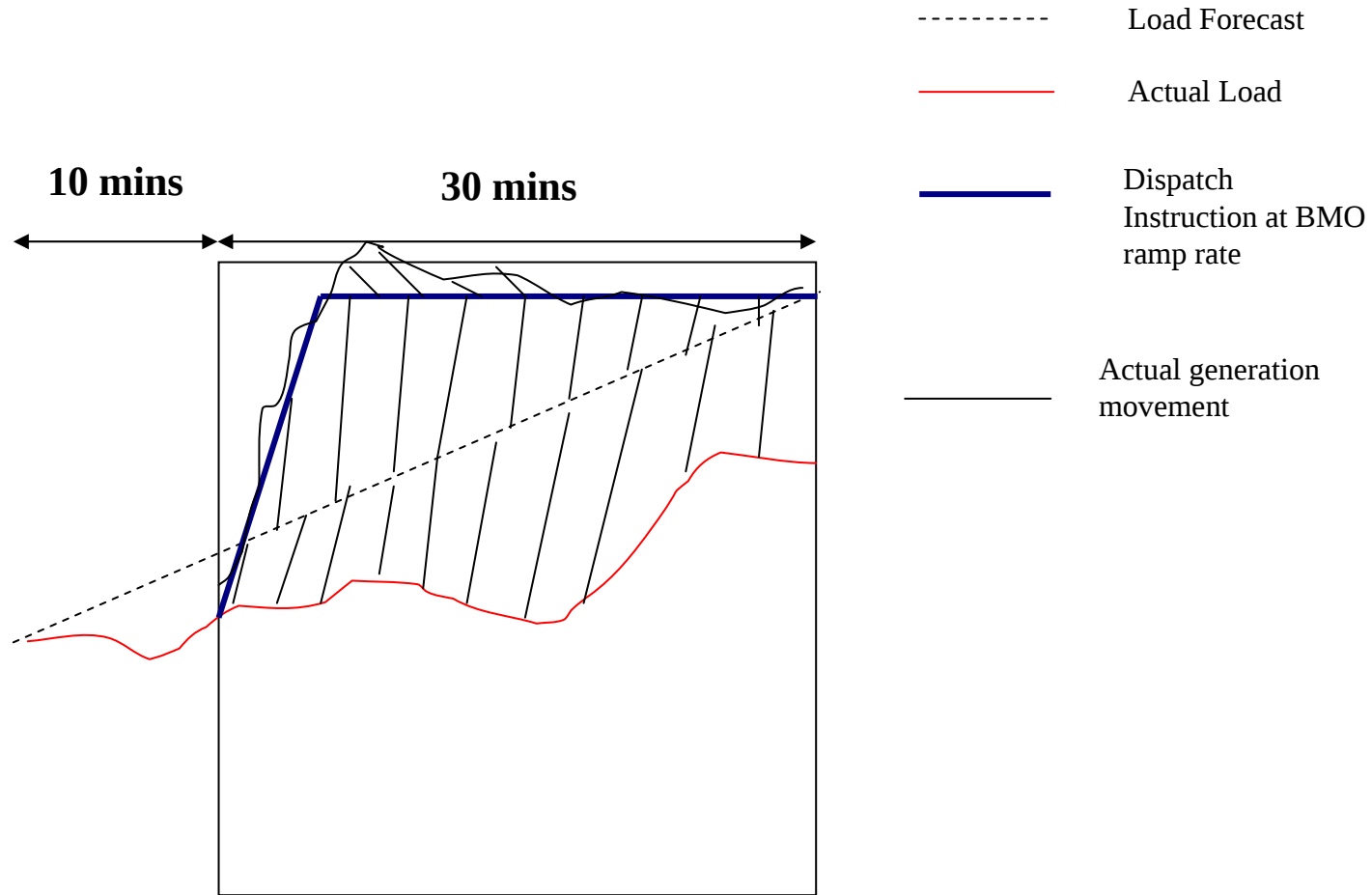


Differences between estimates and actuals = Ancillary Services

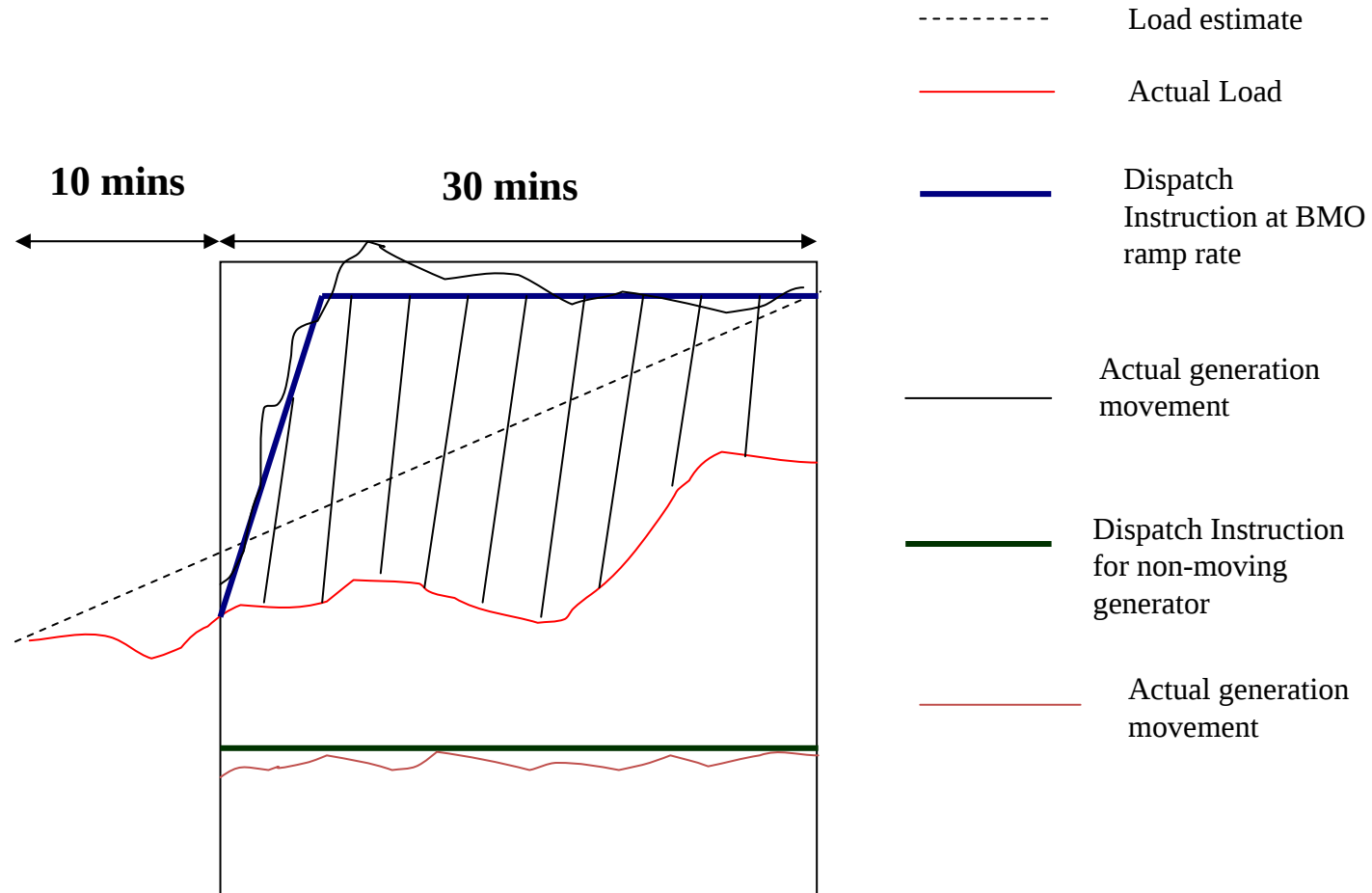
Inter-interval Dispatch



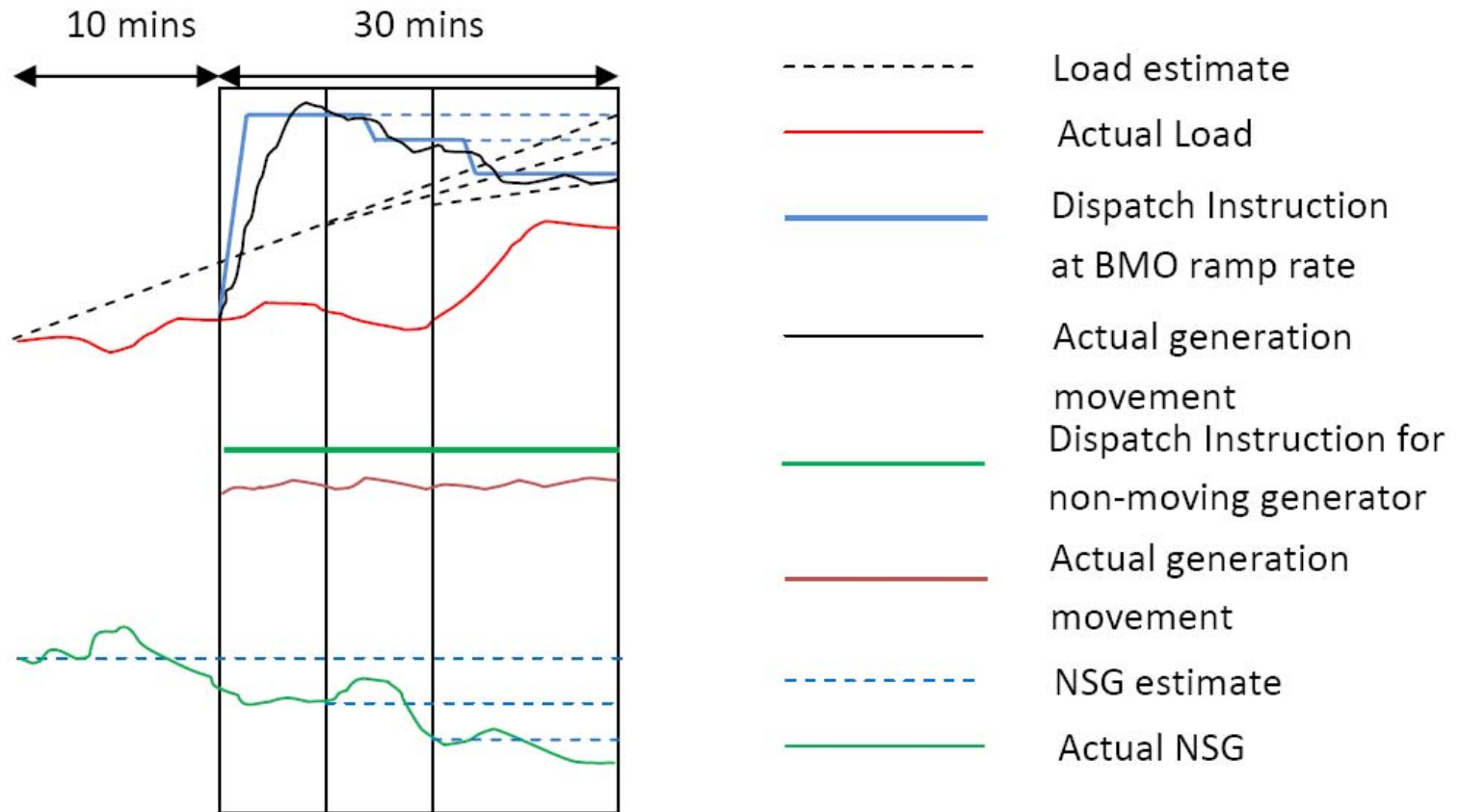
Ramp-rate Requirement



Generators' Movements



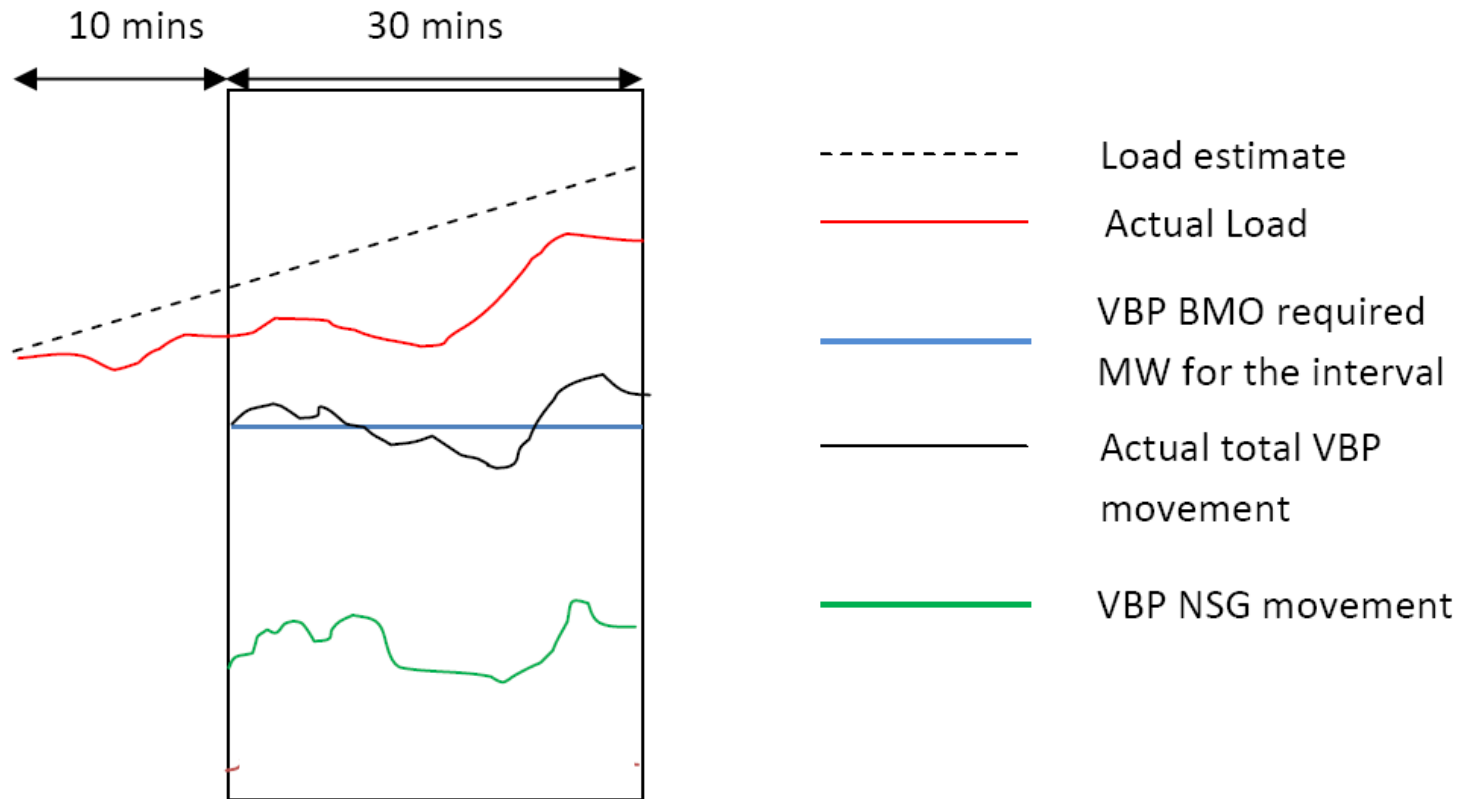
Putting it All Together



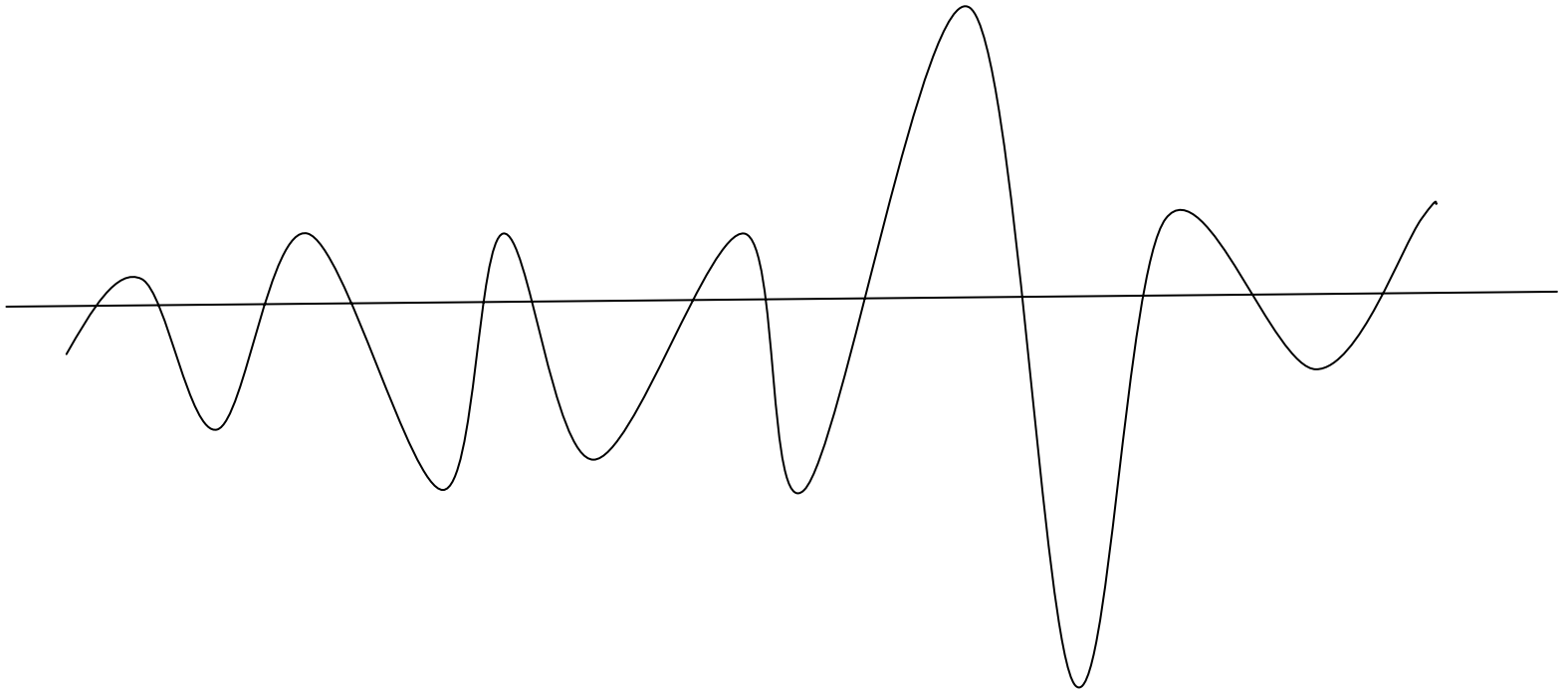
LF covers for all of these variability

Verve Portfolio Dispatch

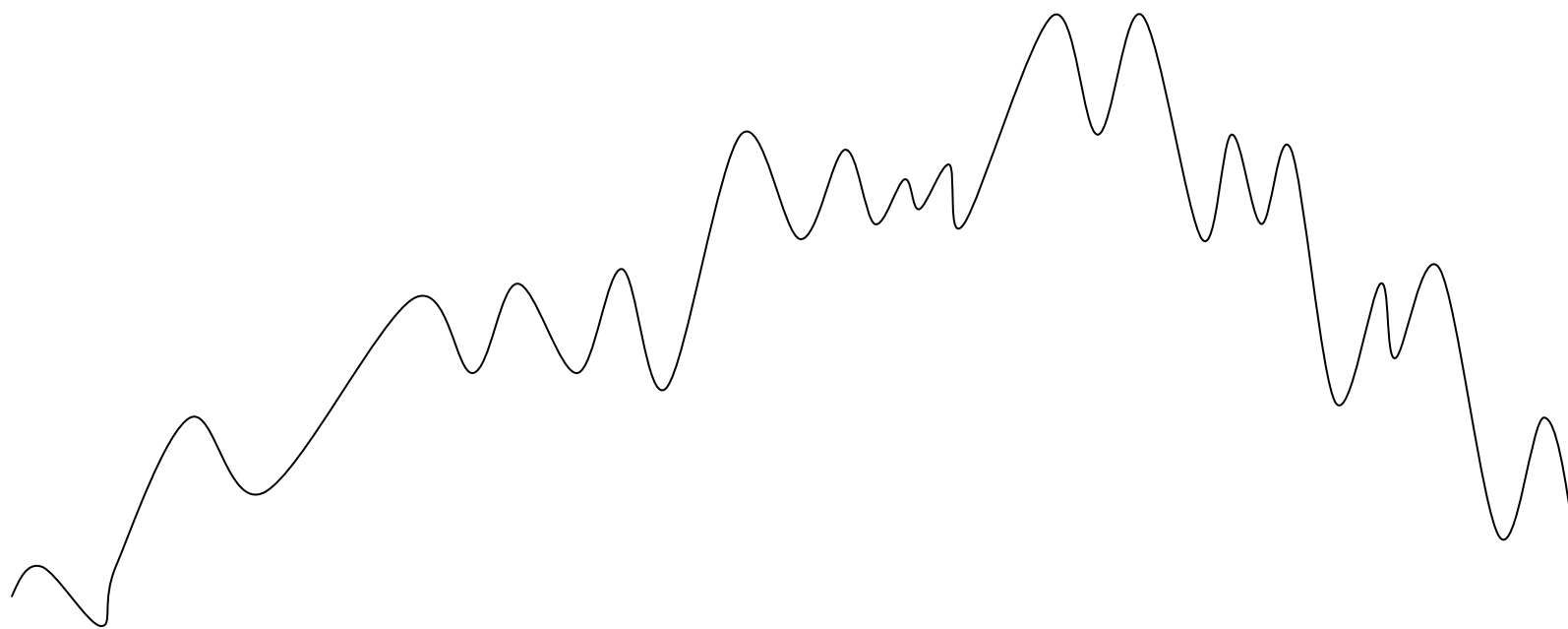
- Hybrid in Day-ahead STEM
- Hybrid in CBLF market



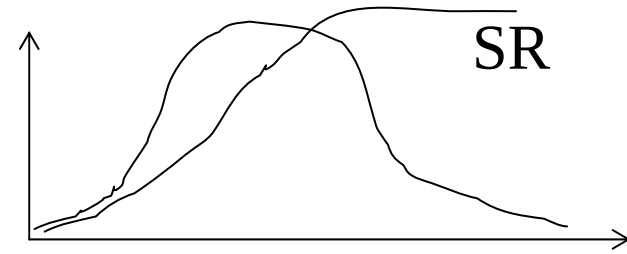
IPP LF Movement Around a Set-point



Verve Balancing Portfolio



Spinning Reserve (SR)



- Capacity held to retard frequency drops following a failure of generating unit/s and supply the shortfall of electricity to avoid load shedding
- Must be sufficient to cover the greater of: 70% of the total output of the biggest generator; and the maximum load ramp expected over a period of 15 minutes;

Load Rejection Reserve (LRR)

- Capacity held by a scheduled generator or Dispatchable load, in response to sudden loss of load, to
 - Reduce output rapidly
 - Increase consumption rapidly
 - sufficient to keep over-frequency below 51 Hz for all load rejection events.

How these different services
work together and what is the
purpose for each?

LFAS Up and Down

- **High frequency ($< 50.2\text{Hz}$)**
 - generation is dispatched at a high ramp rate
 - large upwards movements of NSG
 - sudden load drops, etc.
- **Load Following Ancillary Services Down ↓**
- **Low Frequency ($> 49.8\text{Hz}$)**
 - generation is dispatched at a low ramp rate
 - large downwards movements of NSG
 - sudden load increases, etc.
- **Load Following Ancillary Services Up ↑**

Load Rejection & Spinning Reserve

- High frequency ($> 50.2\text{Hz}$)
 - large loss of load
- **Load Rejection Ancillary Service**
(supported by LFAS Down)
- Low Frequency ($< 49.8\text{Hz}$)
 - large loss of generation
- **Spinning Reserve Ancillary Service**
(supported by LFAS Up)

Boundaries

Frequency

< 49.8 Hz

49.8 - 50Hz

50 - 50.2Hz

> 50.2 Hz

Main
Ancillary
Service

Spinning
Reserve

LF Up

LF Down

Load
Rejection

Supported
by

LF Up
Gov. Droop

Gov. Droop

Gov. Droop

LF Down
Gov. Droop

Common Name	Primary Control Governor Droop Control	Secondary Control Automatic Generation Control
Function-Generic	Holds the system together as load changes and un-commanded generation excursions occur	Shifts generation between units to achieve security & economic objectives. Restores frequency to rated value.
Function-Technical	Provides the correct amount of mechanical input to turbines to match the electrical output of the corresponding generators	Creates set-points for the units to achieve scheduled values established by the market.
Control Input	Frequency/rotational speed of the turbine	Frequency/Remotely from the Control Centre
Control Time Constant	Fast - Momentary	Slower - 4 seconds
Style of Control	Local within the units. Controller has no direct control over governor response.	Centralized from the control centre
Performance Optimization	Having more governors minimizes the magnitude of frequency deviations	Having more units on AGC minimizes the duration of frequency deviations
Key Parameters	Steady state speed characteristic (droop), governor dead-band,	Base power schedule, deployments of balancing energy, AGC dead-band, frequency range.
Market Characteristics	No market – Technical Rule requirement	Bids and settlement through the Ancillary Service Market.
Disturbance Timeline	Initial governor response is over completely by the time units start receiving secondary control signals	Kicks in every 4 secs to ensure smooth , rapid and sustained frequency recovery.

