Holistic View of Power System Services

Aligning Incentives across Relevant Grid Services

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EPICS

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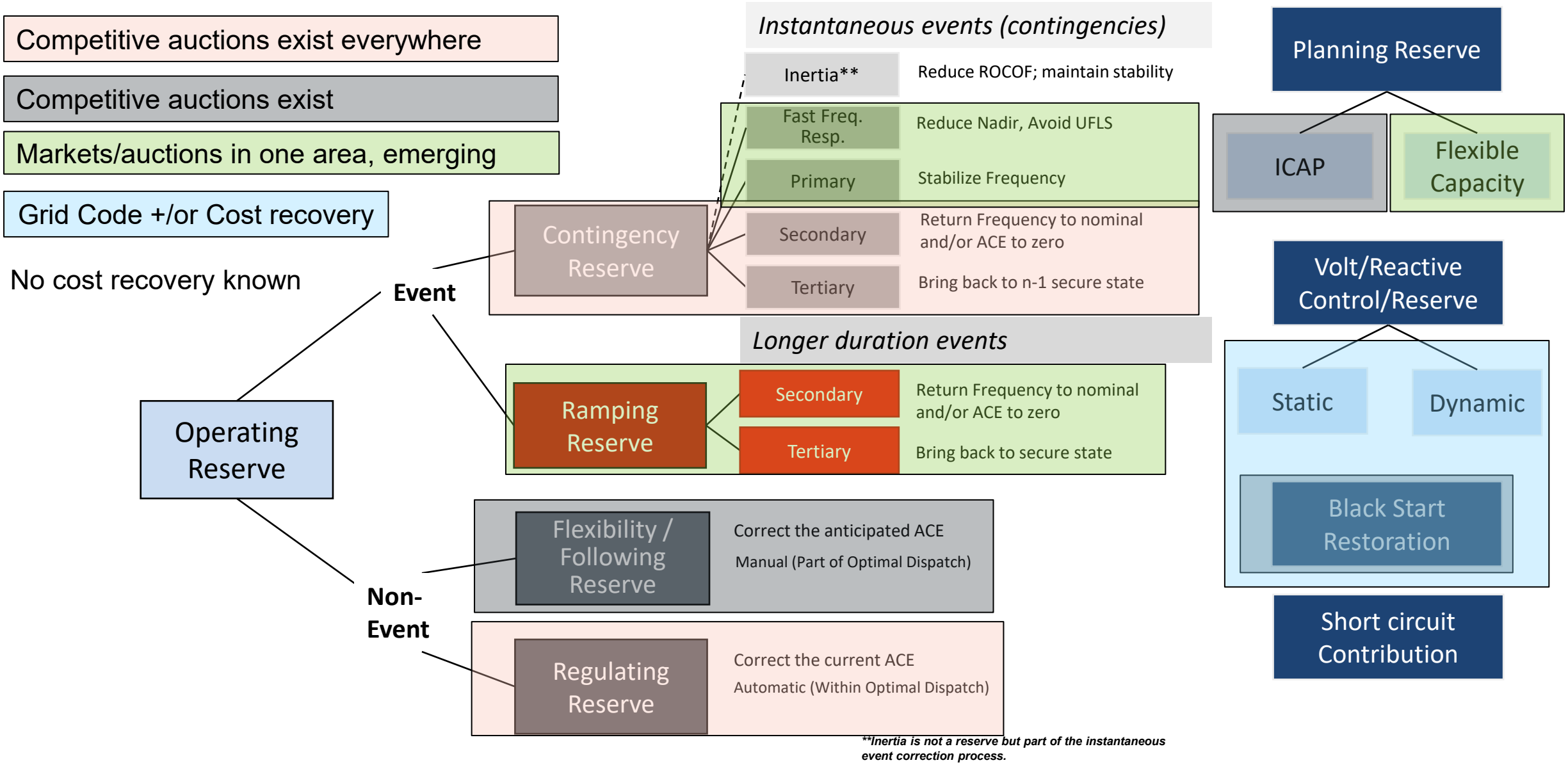
Ancillary Services (Bulk Power System)



Adapted from Ela et al., *An Enhanced Dynamic Reserve Method for Balancing Areas,* EPRI, Palo Alto, CA: 2017. 3002010941.

Reliability Service Compensation

- Some reliability attributes are not currently incentivized:
- Sometimes auctions and market-based pricing for certain services may be impractical
- Grid codes and standards
- Prioritization of market design and software changes also key
  - It cost money to develop, discuss, test, implement, and administer new designs

Reasons why a market product may not be implemented	Example
Too complex to design (e.g., software complexity)	Volt/VAR support
Too specific to certain local areas (little to no competition)	Volt/VAR support
System inherently has more than sufficient amounts of the service	Synchronous Inertia
Costs for the service may be small, so cost of administrating market product may outweigh benefits	Black start (restoration) service
A specific resource requirement rather than a system-wide need	Low Voltage Ride Through

The examples are used for illustrative purposes only and the reason may not be necessarily true for each example in each region.

Complex Competitive Markets are not needed for every service!

Frequency Response Incentive Characteristics Checklist

Enough frequency responsive capacity to meet credible event

- NERC N-2

Frequency response sensitive enough to avoid UFLS

- Droop curve, head room, dead bands and operational mode

Frequency response triggered fast enough to avoid UFLS and fully deployed within reasonable time frame

- Different resources have unique non-linear responses

Sufficient inertial response, combined with fast frequency response

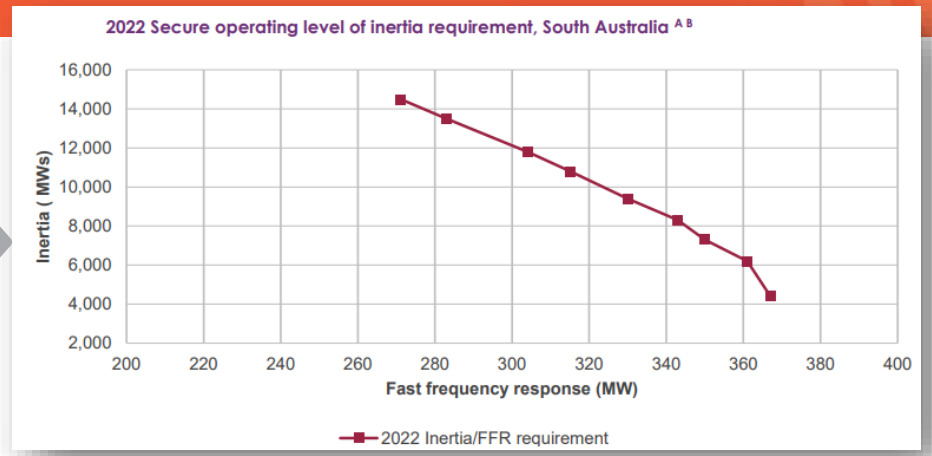
- These services are all connected with overall frequency response

Stable, non-oscillatory, no governor withdrawal

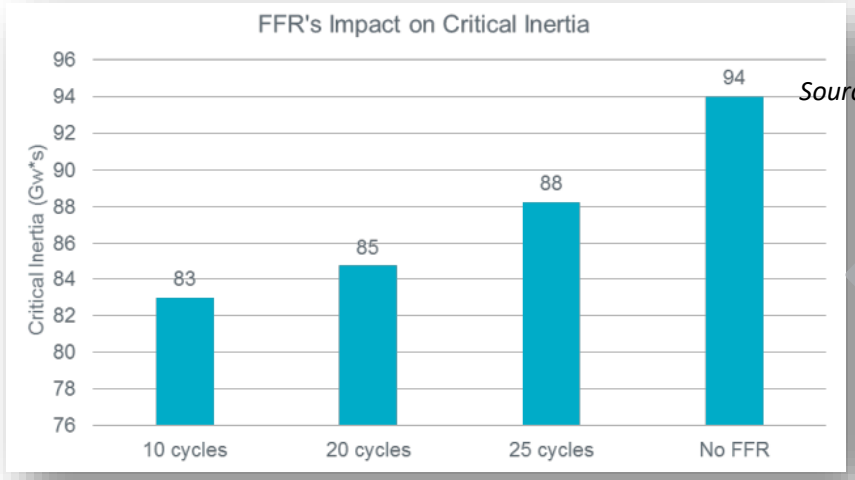
- Requirements to avoid poor frequency response incentives

Impact of IBR Fast Frequency Support on Min. Inertia Required

Increasing level of FFR reduces minimum level of inertia required[1]



Source: AEMO, Australian Energy Market Operator

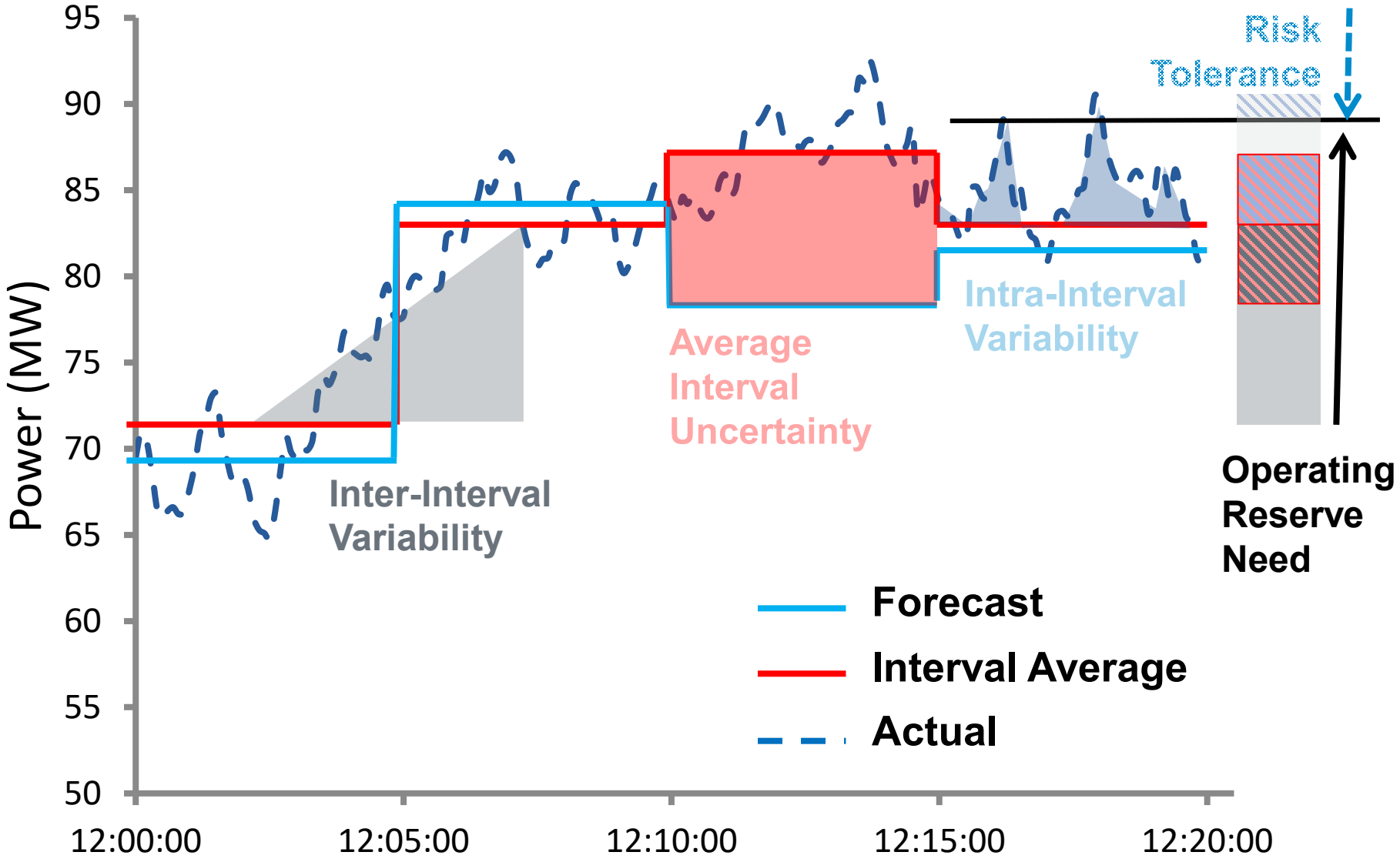


Source: ERCOT

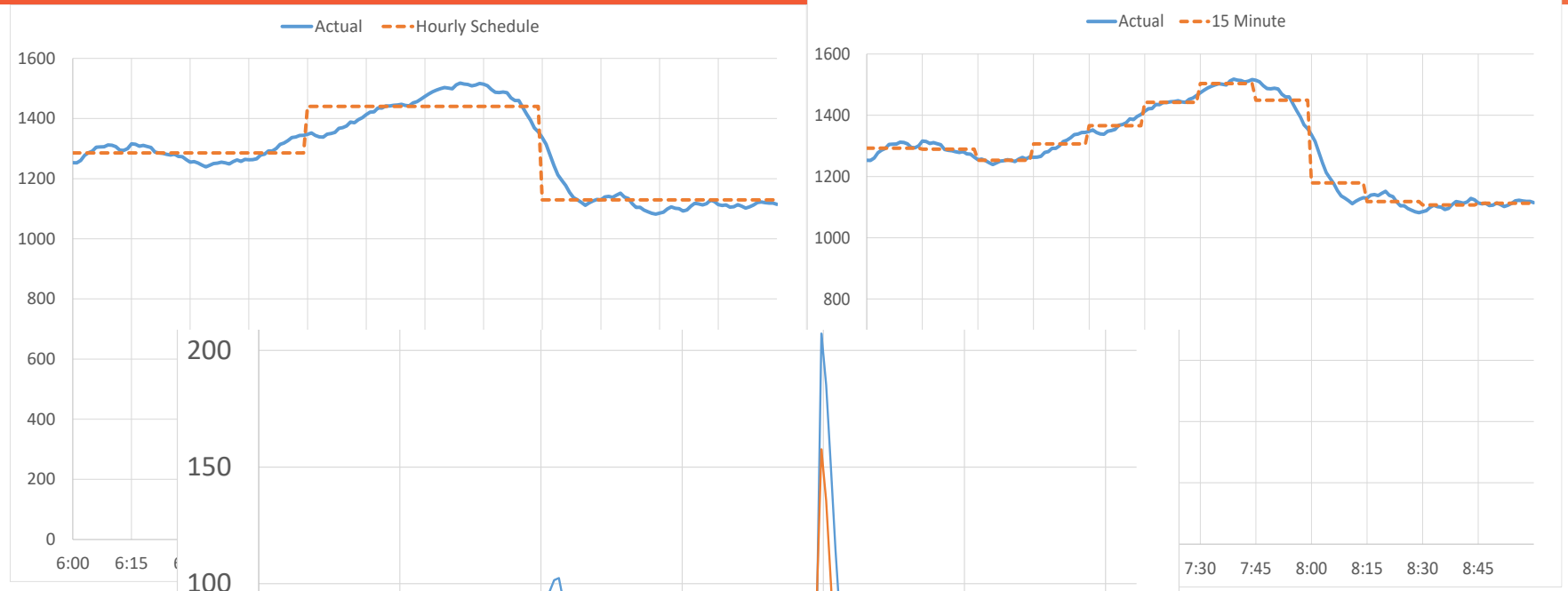
Decreasing FFR response time reduces minimum level of inertia required[2]

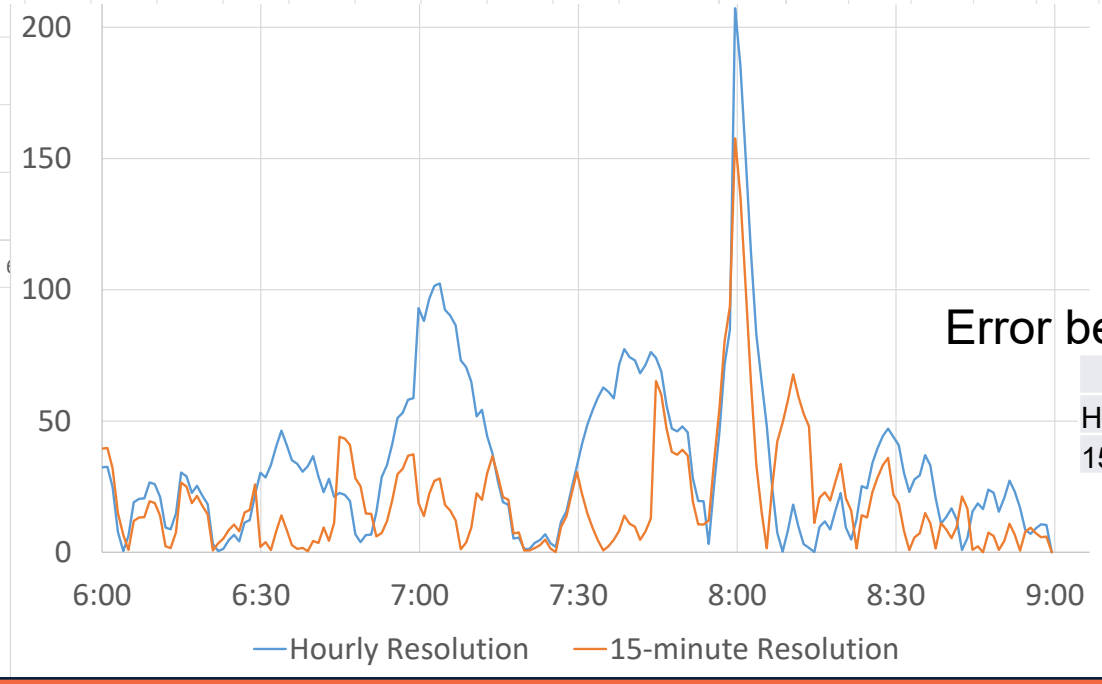
[1] AEMO, "2022 Inertia Report," 01 December 2022. [Online].
[2] ERCOT, "Inertia: Basic Concepts and Impacts on the ERCOT Grid," 04 April 2018. [Online].
- EPRI, "Declining Inertia in the Grid: Importance, Impacts, and Solutions," Webcast, Aug. 24, 2023.
- Slide Credit: Ham Zhang, EPRI

Quantity of Reserve Services depends on how you operate the system, not just the conditions and characteristics!



Explicit vs. implicit – Intra-Interval variability





Error between Schedule and Actual

	stdev	Max	Min	MAE	95th %ile
Hourly	46.7	207.2	-102.4	33.9	77.2
15-min	30.0	157.6	-93.6	20.0	49.7

Once the TSO decides to move to 15-minute Scheduling granularity, its reserve requirements go down

Timescales can have impact on incentives

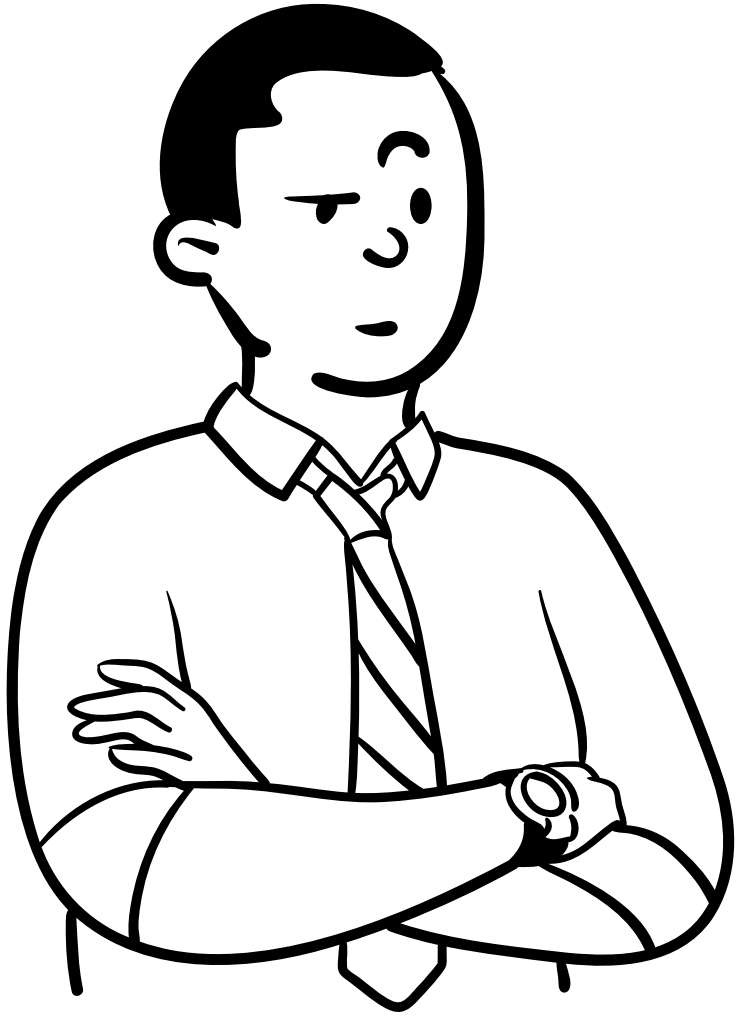
	SCED at 5-minute intervals	SCED at 1-minute intervals
Regulation Reserve	Regulation reserve at 1% load	No regulation reserve
σ_{ACE} (MW)	4.46	3.04
Cost ($)	$742,920	$742,351
Total Revenue ($)	$218,980	$211,274

Improved reliability, same costs, but **less profit**. Missing money?

FESTIV Model:
Ela, O'Malley, "Studying the variability and uncertainty of variable generation at multiple timescales," IEEEE Trans. Power Syst., 2012
118-bus modified IEEE system, Perfect forecasts in all time frames, hourly day-ahead SCUC, 30-min real-time SCUC, 20% wind penetration, 6-second AGC, 24 hour simulation.

Open Question: Thinking Holistically on Services

- If the system has:
  - **Fast Frequency Control** Service and Incentives
  - **Traditional Primary Frequency Control** Service and Incentives
  - **Spinning and Non-spinning Reserve** for contingencies (10-minutes to 30-minutes)
  - **Ramp Products** (5-15 minute horizon)
  - Day-ahead **Uncertainty** Capacity in case Day-ahead forecast errors result
  - Resources able to **follow** five-minute dispatch
  - **Incentives** for being **flexible** in the energy market
- Do we really need:
  - Regulation control service and incentives?



THANK YOU

For correspondence, questions, and future ideas, contact Erik Ela

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NERC ENTSO-E/UK Reserve Products Comparison