ENERGY

Dimensioning of Control Reserves in Southern Region States

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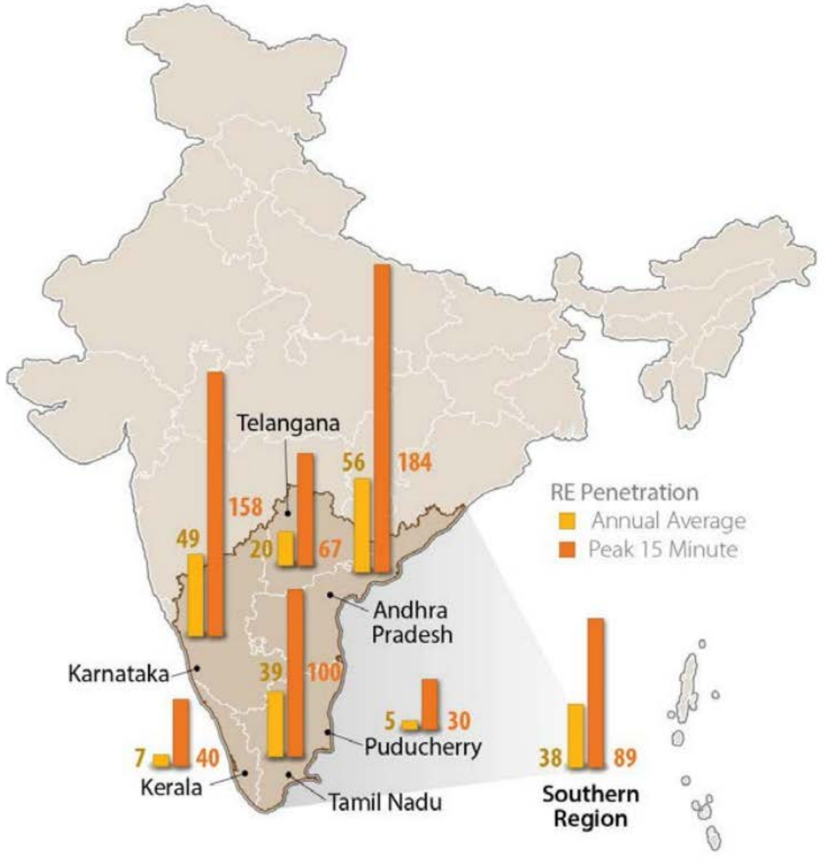
Contents

Background

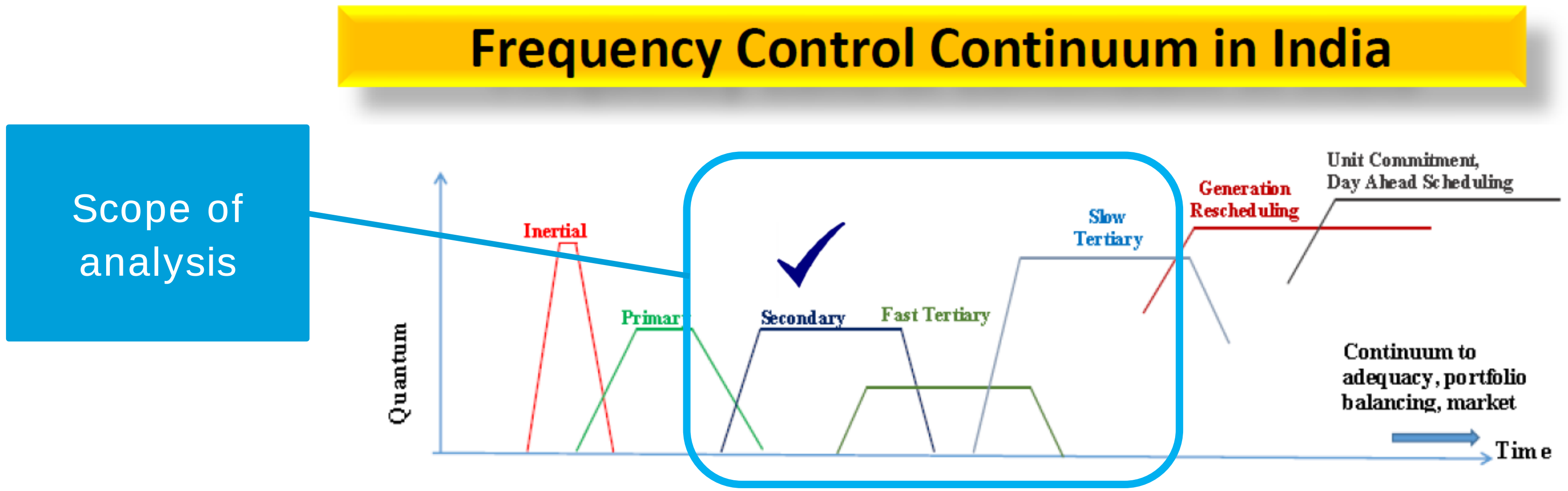
- In recent years, India has been implementing secondary frequency control, based on automatic general control (AGC) with tie-line bias control in each of the five regional power systems
- India has set herself a target of growing large-scale renewable energy to 175 GW by 2022, incl. 100 GW from solar energy and 60 GW from wind energy.
- About 70 GW of wind and solar energy shall be deployed in the Southern region of India
- Integrating 70 GW of variable sources (vRE) may create significant challenges to the system and may require additional reserves to be held available



Source: Introduction of secondary frequency control in Indian power system, POSOCO

Scope and objectives

- The paper focuses on:
  – Impact of growing share of vRE on secondary and tertiary reserve requirements
  – Reserves required for frequency control, i.e. secondary and tertiary control
  => excludes other operating reserves (primary)
  – Distribution of overall reserve requirements with Southern region at state and/or regional level, but as part of the overall architecture in India



Source: Introduction of secondary frequency control in Indian power system, POSOCO

Rationale for probabilistic reserve dimensioning

- Currently, CERC mandates that each region has to maintain secondary reserves corresponding to the largest unit size in the region and tertiary reserves should be maintained in a decentralized fashion by each state control area for at least 50% of the largest generating unit available in the state control area
- These measures do not reflect the stochastic impact of wind and solar power and will thus become inadequate in a future system with a high share of VRE
- Need for frequency control reserves is mainly driven by the following types of system imbalances:
  - Sudden disturbances (loss of generation, load or HVDC links)
  - Continuous, stochastic variations of load and/or generation
  - Forecast errors of load or generation (e.g. wind, solar or run-off-river hydro power)
  - Any deterministic deviations caused by market imperfections
    (Not considered below)

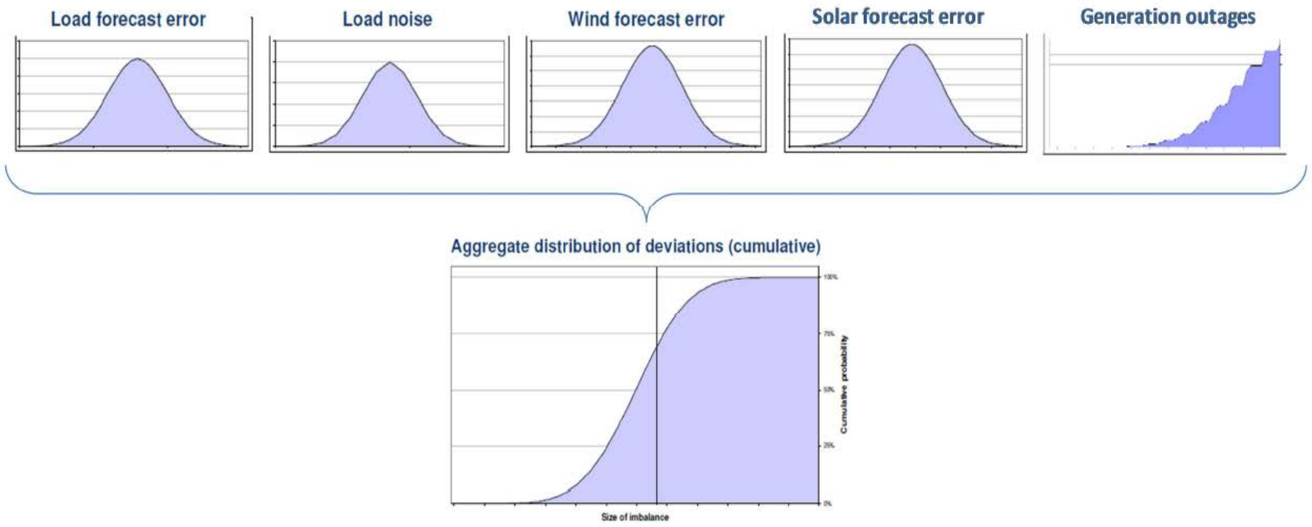
Methodology for probabilistic dimensioning

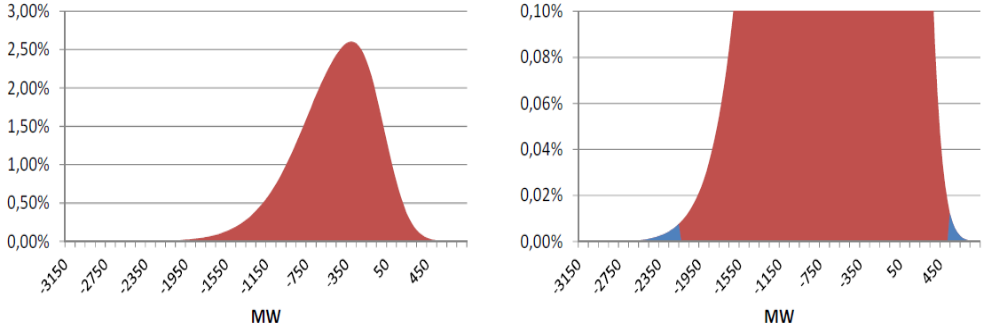
- Methodology used by several European TSOs (Germany, other Central European countries)
- Using convolution of probability distributions for different drivers of system deviations
- As indicated below, assumptions must be tailored to applicable time horizon (e.g. less uncertainty in predictions, outages… for ‘faster reserves’)

	Day-ahead	x hours ahead	15-minutes ahead
	Sufficient flexibility is maintained during production scheduling	Sufficient thermal capacity can be activated when needed	Deal with unforeseen events during real-time operation
	Unplanned generation outages (full day)	Unplanned generation outages (x hours)	Unplanned generation outages (15 min)
	Load forecast error (D-1)	• Load forecast error (h-x) • Load noise	Load noise
	RE forecast error (D-1)	RE forecast error (h-x)	RE variation (ramp rates)

Methodology for probabilistic dimensioning

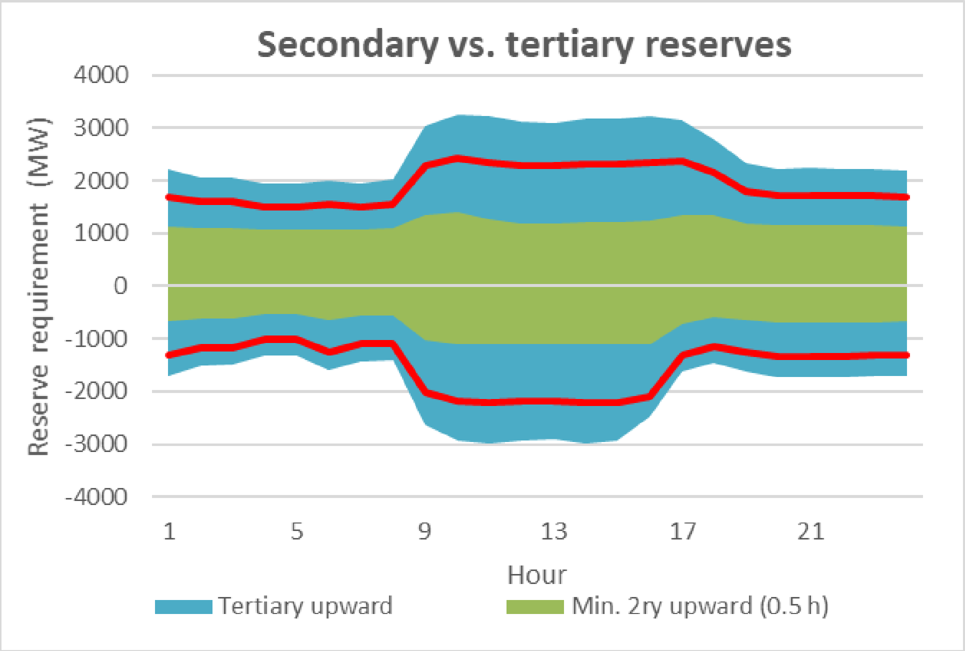
- Individual distributions are aggregated by convolution of individual probability functions
- Reserve requirements can then be determined based on:
  – Cumulative probability function (for all factors)
  – Defined confidence interval (accepted risk margin)
- Note: Aggregate distribution skewed towards deficits due to plant outages





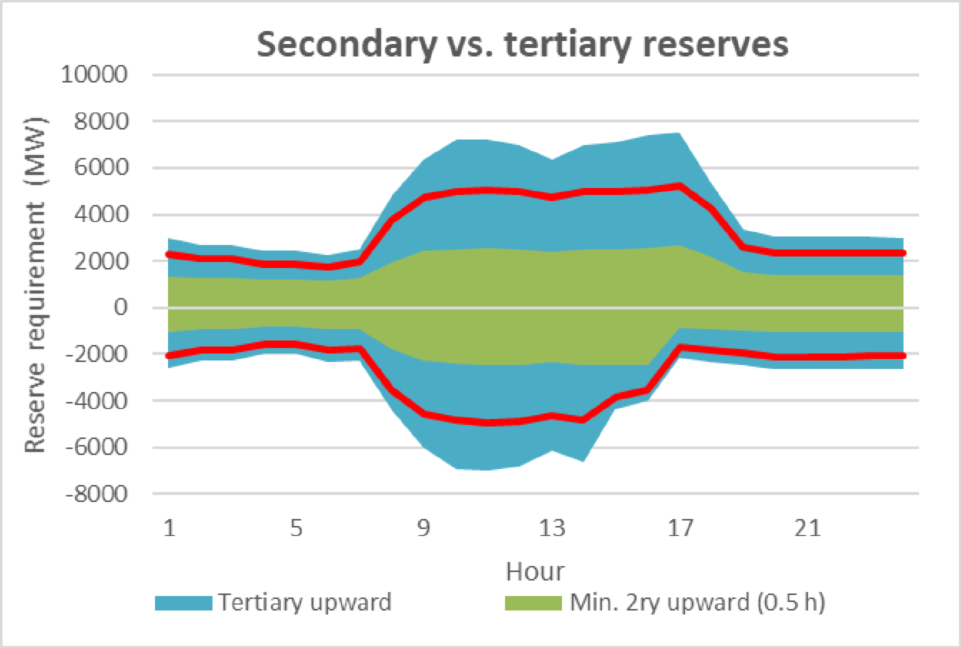
Reserve needs for the Southern Region

Reserve needs for 2018 (15GW Solar, 17GW Wind)



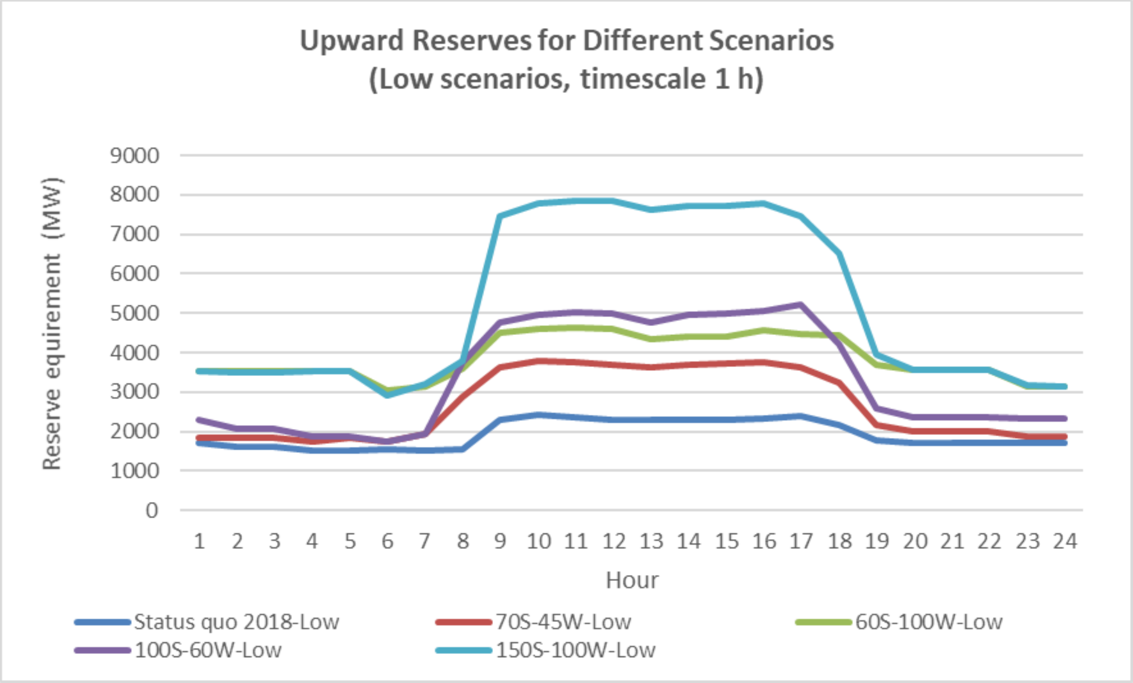
- Overall reserve needs remain in a range of up to ±2,000 MW during night hours, they increase to ±2,500 during daytime
- The increase of reserve needs thus mainly reflects the risk of solar forecast errors

Reserve needs for 2022 (42GW Solar, 28GW Wind)



- Reserve requirements are significantly impacted by the rapid growth of VRE in the Southern region
- The wide range of required reserves during the day furthermore highlight the benefits of dynamic reserve dimensioning

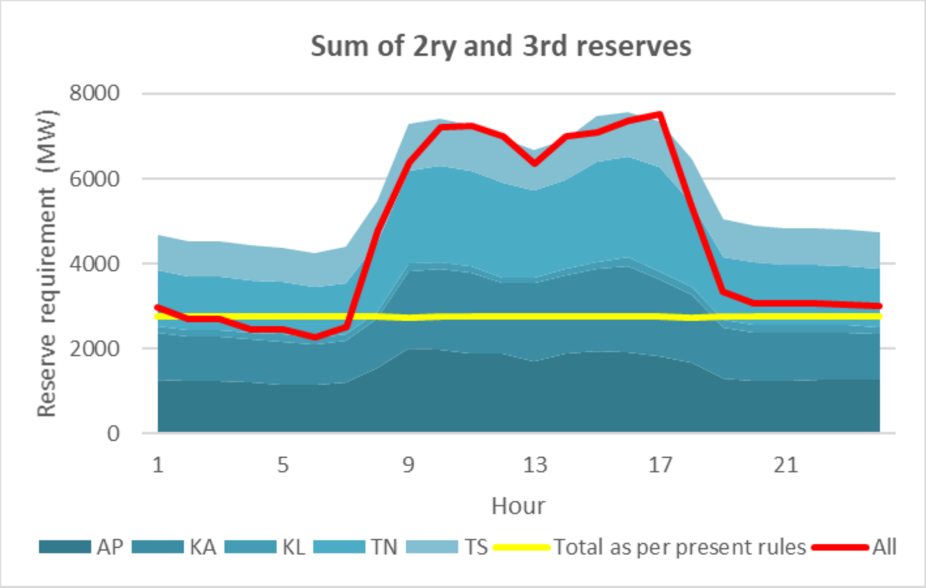
Impact of VRE on reserve needs



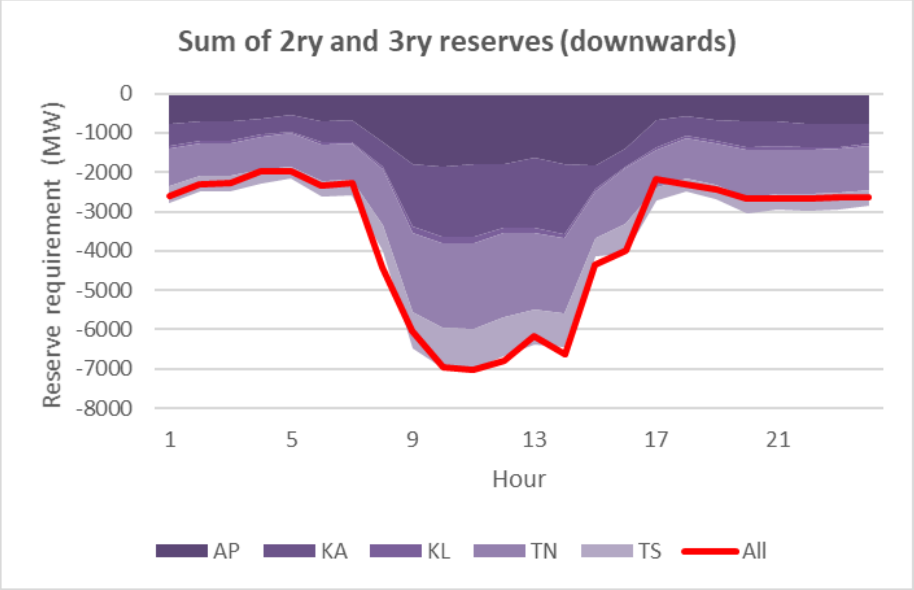
- Chart shows reserve requirements for 2018 and four future scenarios, with between 50 GW and more than 100 GW of VRE in the Southern region
- Compared to today, VRE may lead to up a four-fold increase of future reserve needs

Benefits of Regional Reserve Sharing

State-wise vs. Regional (2022): Upward



State-wise vs. Regional (2022): Downward



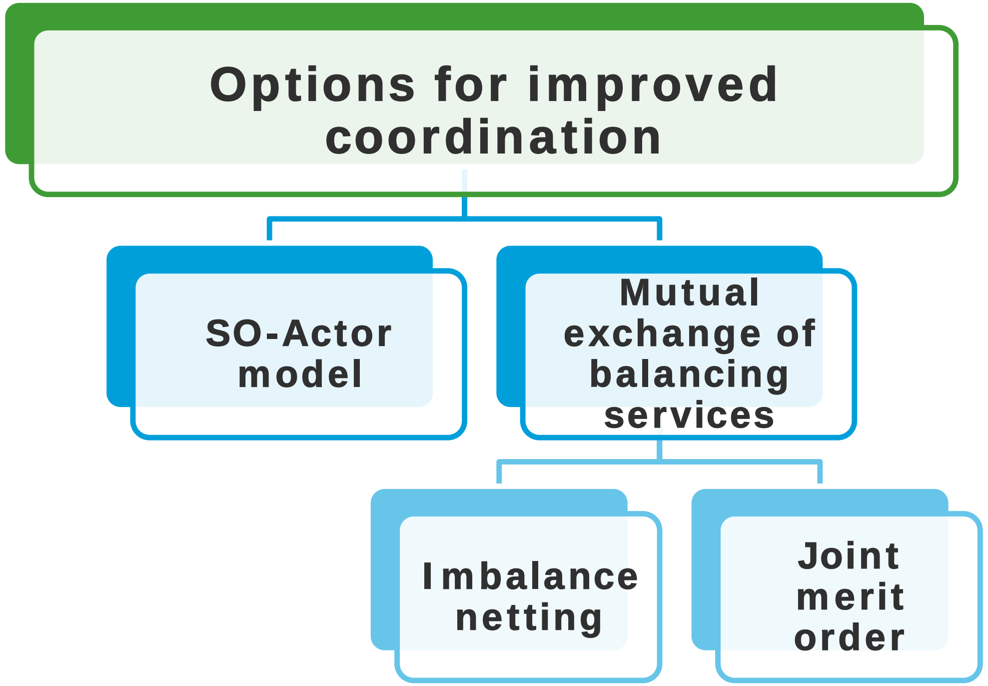
- Sum of state-wise reserve requirements larger than under regional dimensioning during night hours, but broadly equivalent during day hours and for downward regulation
- Regional needs for upward regulation comparable to volumes to be maintained under current rules during night hours, whereas the latter fail to account for additional risks during day hours
- For downward regulation, the volumes calculated by us are consistently larger than current requirements, which are limited to 1,000 MW of secondary reserves.

Resources for supply of AGC and tertiary reserves

- Results indicate that it may be difficult to supply the required volumes of reserves from conventional generation only
- Increasing reserve provision may require higher loading of conventional plants, thereby leading to need for (additional) curtailment of VRE
- Alternatively, reserves also be supplied by VRE:
  - Easily possible for downward regulation
  - Technically possible but economically costly in case of upward regulation
- May need to consider asymmetrical AGC, i.e. with separate bands for upwards and downwards regulation

Enhanced Cooperation and Management of Reserves and Real-Time Balancing

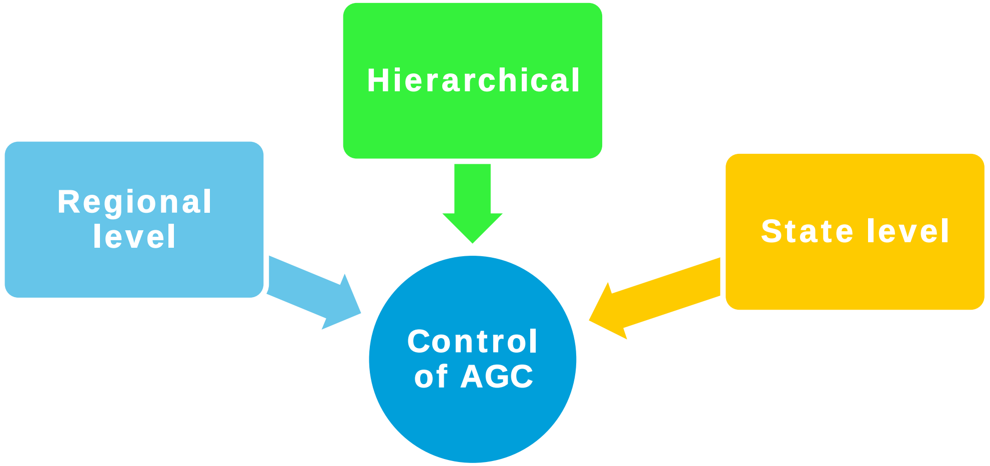
To cope with increasing reserve requirements, India should aim at enhanced mechanisms for coordinated / shared use of reserves across multiple states and/or regions



In addition, it will be important to ensure a coordinated use of available resources for AGC within each region

DRIVERS AND SOURCES OF OF FREQUENCY CONTROL

Level	Driver			Source
	Load	VRE	Generation	
State	✓	✓	✓	✓
Region		(✓)	✓	✓



Conclusions

- Increasing penetration of VRE will likely lead to increasing reserve requirements
- Calculations show clear benefits for joint reserve dimensioning and sharing
- Forecast accuracy will become major driver of future reserve needs
- Reserve volumes depend on desired safety margin, definition between different reserve products and interaction with (intraday) wholesale market
- Dynamic dimensioning helps to greatly reduce average reserve needs
- Supplying reserves exclusively by conventional plants likely to become very difficult and/or costly in the future

Thank you very much for your attention!

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