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Presentation on

Energy Transition: Opportunities and Challenges for Hydro Power Plants

by

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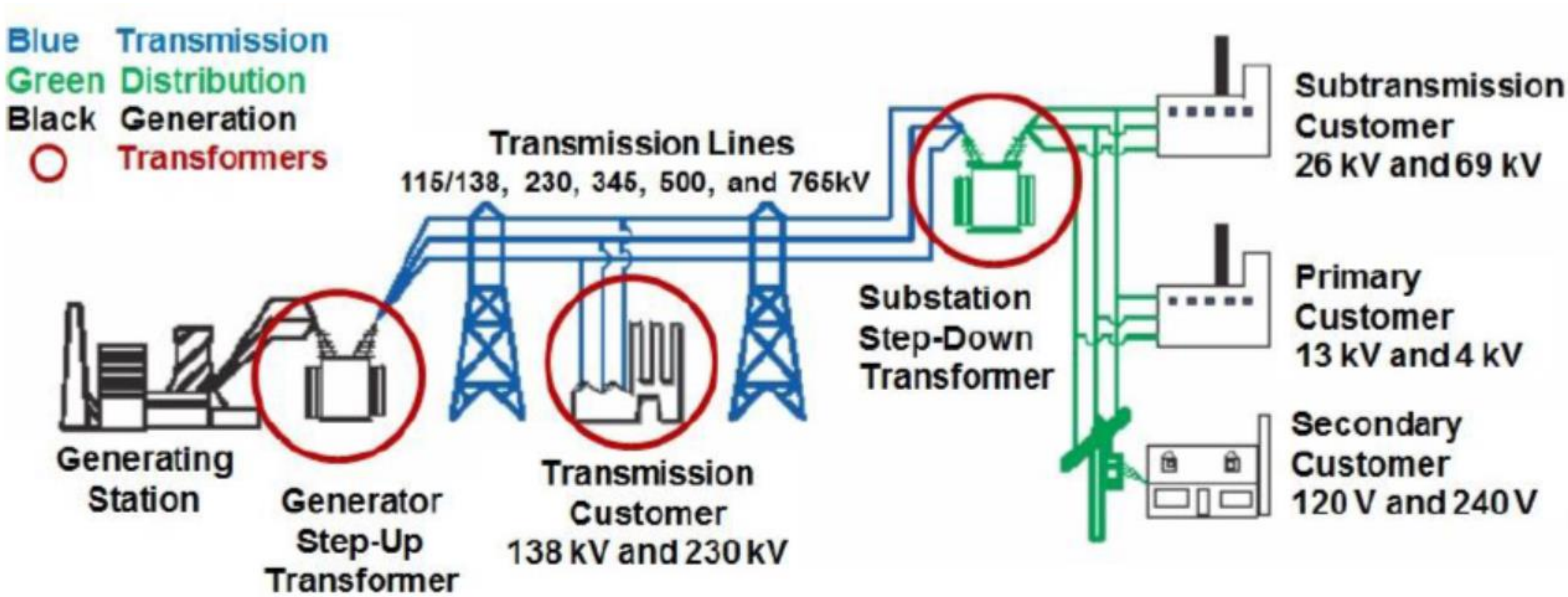
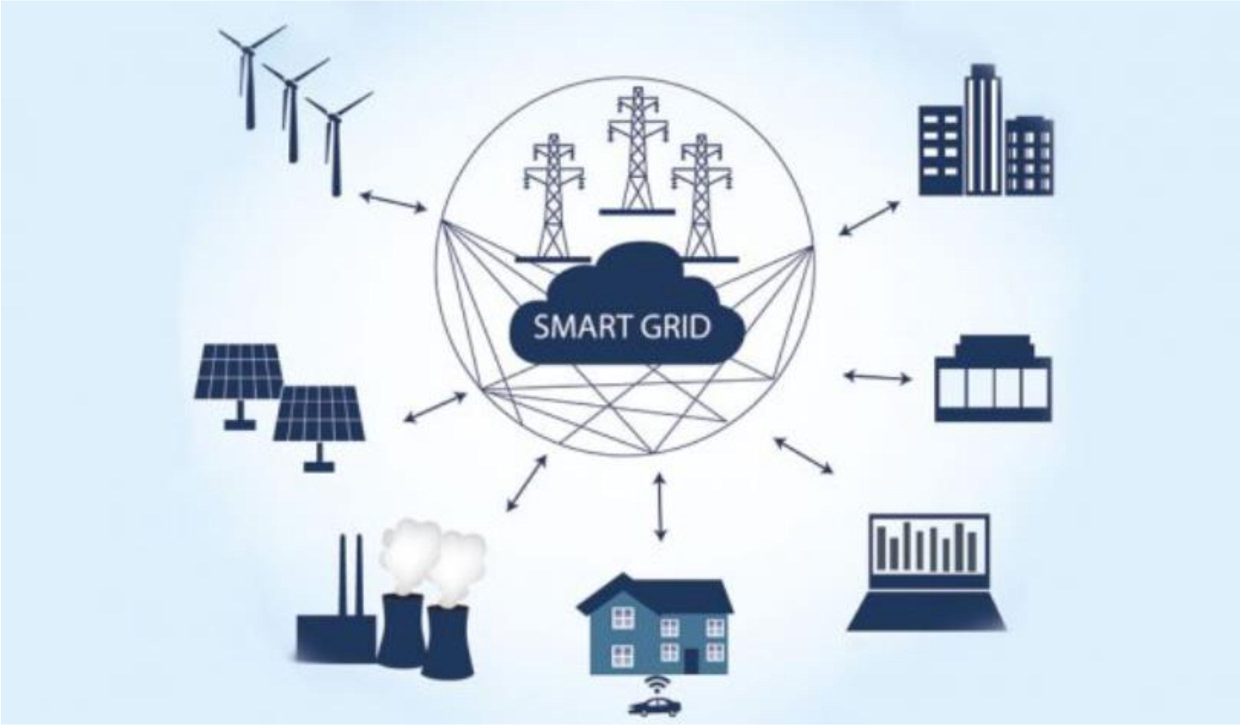
Conventional Power Systems



Source: US DOE

- **Key Features** – Centralized, Controllable Power Output, Natural Inertia, High Short-Circuit Current

Changing Power System



Source: https://www.project-sherpa.eu/smart-grids-and-ethics/

- **Key Features** – Decentralized, Uncertain/Variable Power Output, Less Natural Inertia, Low Short-Circuit Current

Major Challenges

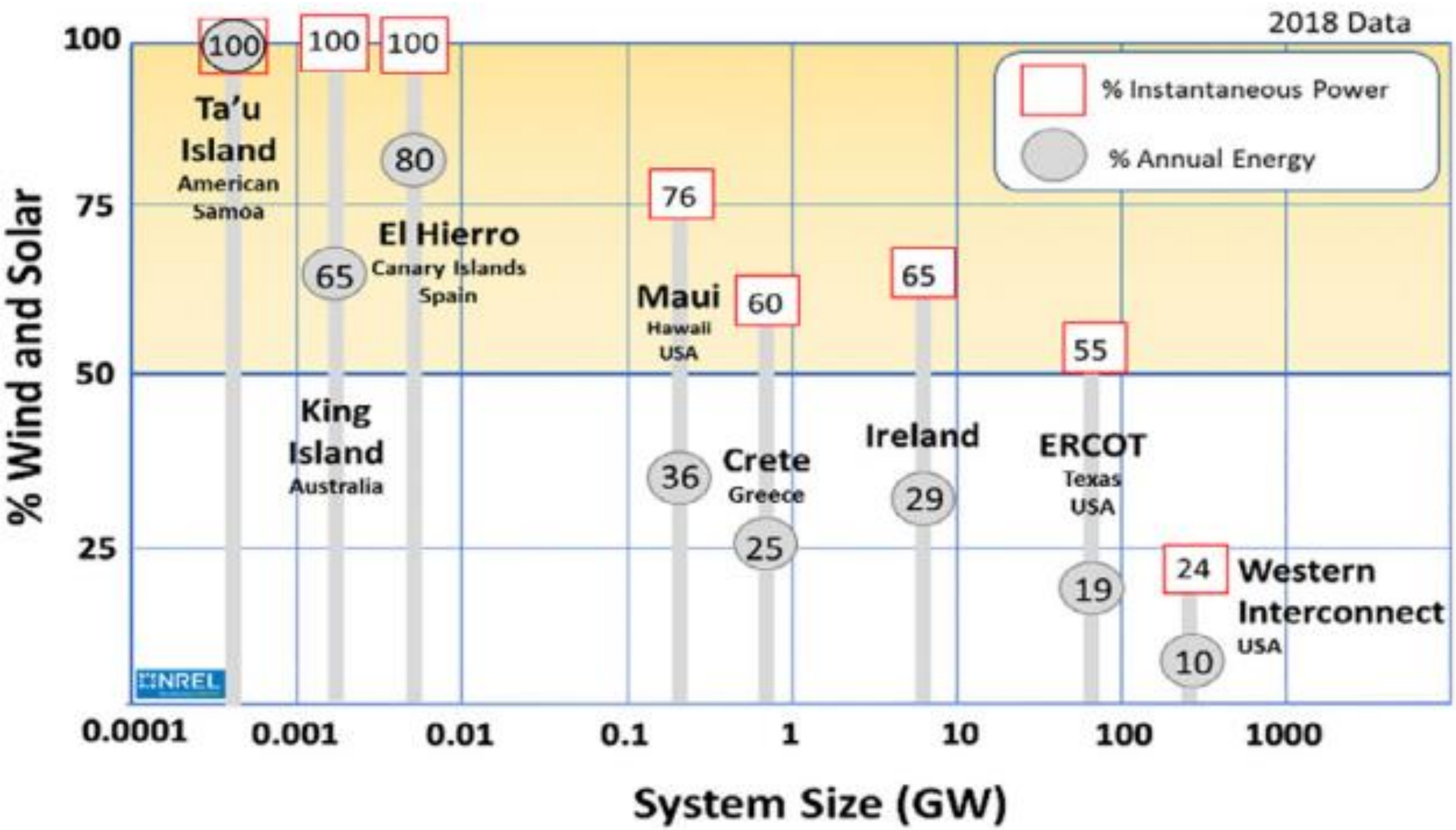
- **Variability and uncertainty of variable renewable energy (VRE) resources** (e.g., wind and solar PV)
  - How do I balance load and demand at all times?

- **Energy limited generation resources** (e.g., battery storage)
  - What happens if I cannot charge battery storage?

- **Inertia**
  - Frequency may change faster and drop lower than today

- **System strength**
  - Stability and relay protection concerns

Increasing Variable Renewable Generation



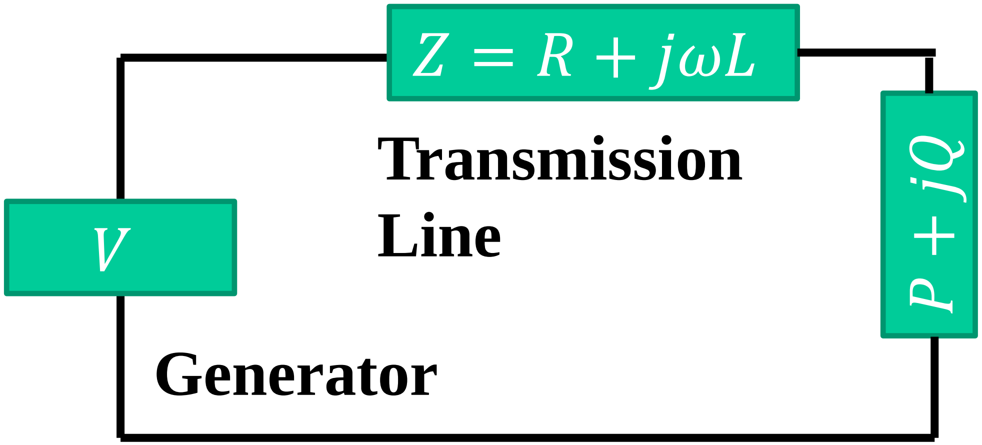
Source: BMS Hodge, **H. Jain**, et al., "*Addressing technical challenges in 100% variable inverter-based renewable energy power systems*", in WIREs Energy and Environment, 2020

Ancillary Services

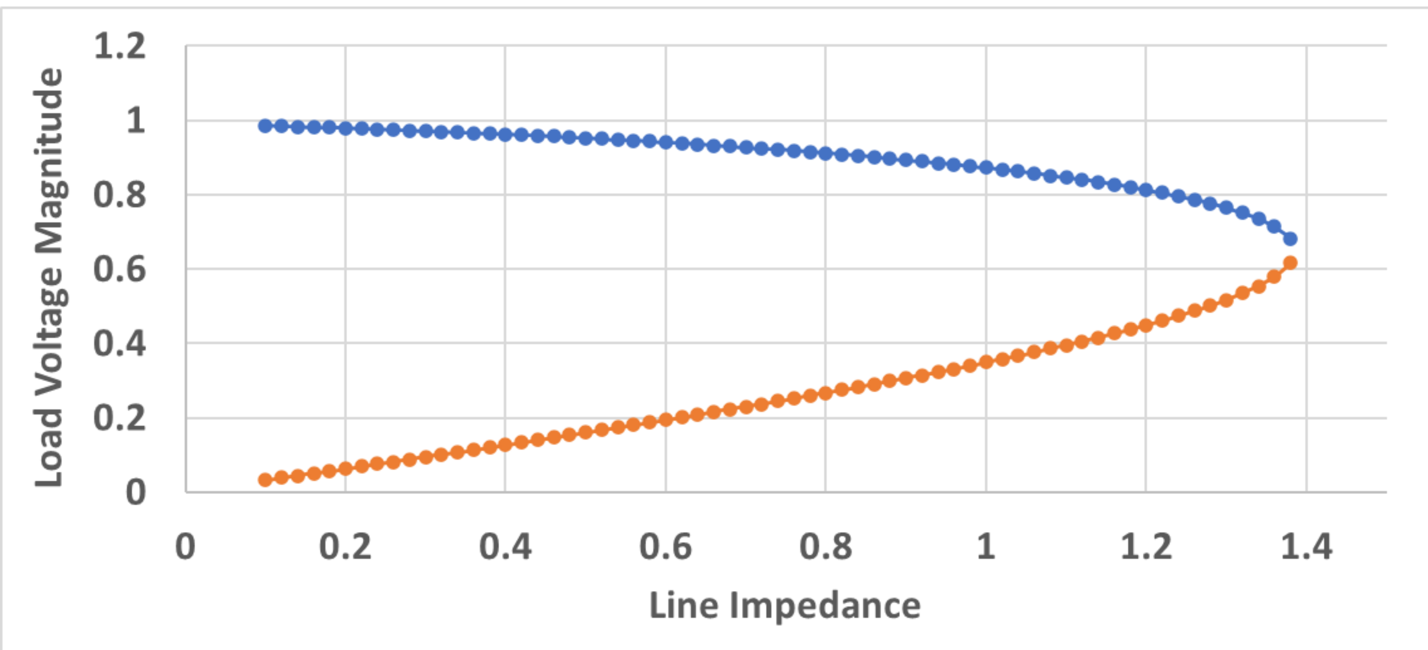
Indian Electricity Grid Code Regulations, 2010 (IEGC):

"*means in relation to power system (or grid) operation, the services necessary to support the power system (or grid) operation in maintaining power quality, reliability and security of the grid, e.g. active power support for load following, reactive power support, black start etc.;…*"

Need for Ancillary Services – Voltage Support Example



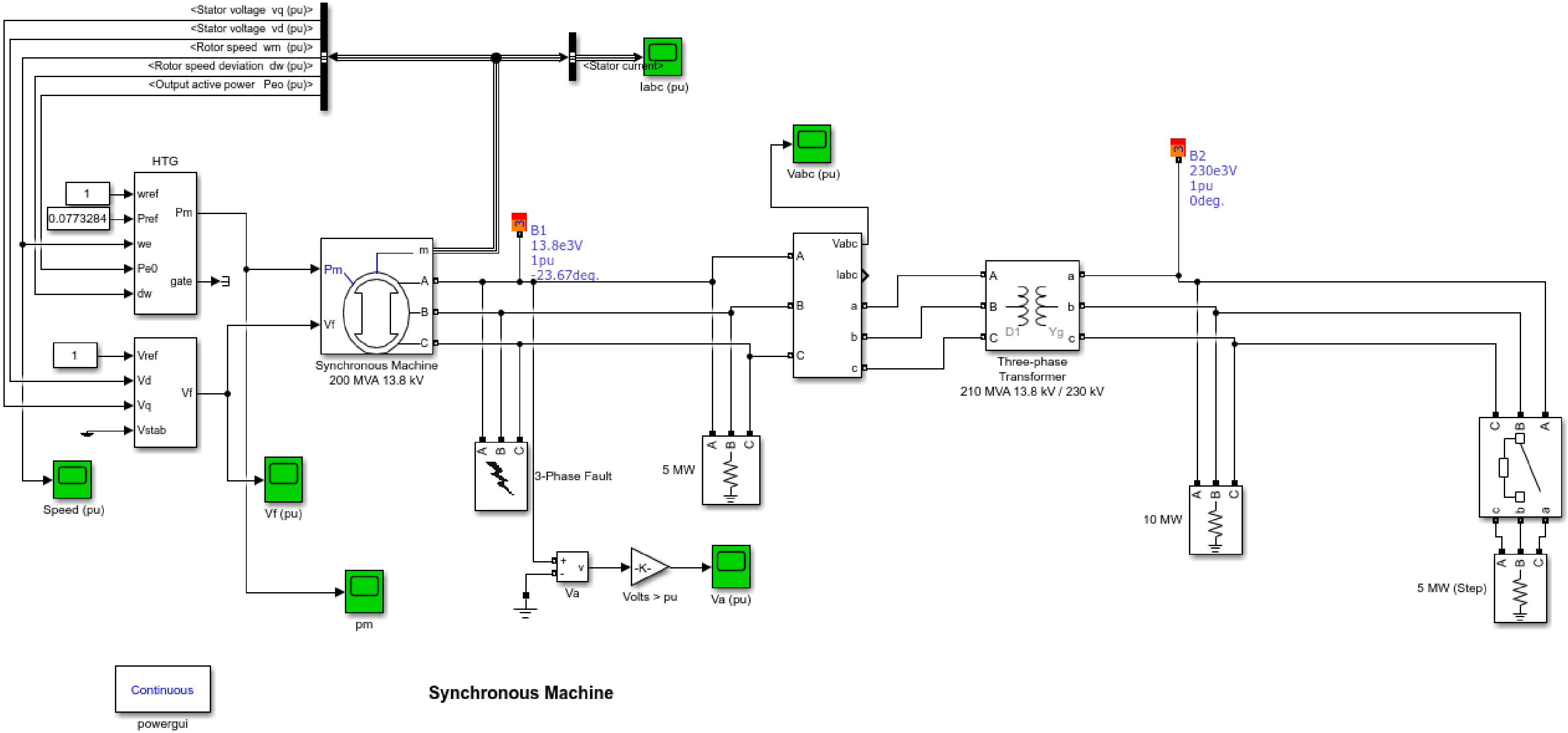
As Z increases [line(s) trip], current increases and voltage across load decreases



Increase V or Reduce Load to increase load voltage

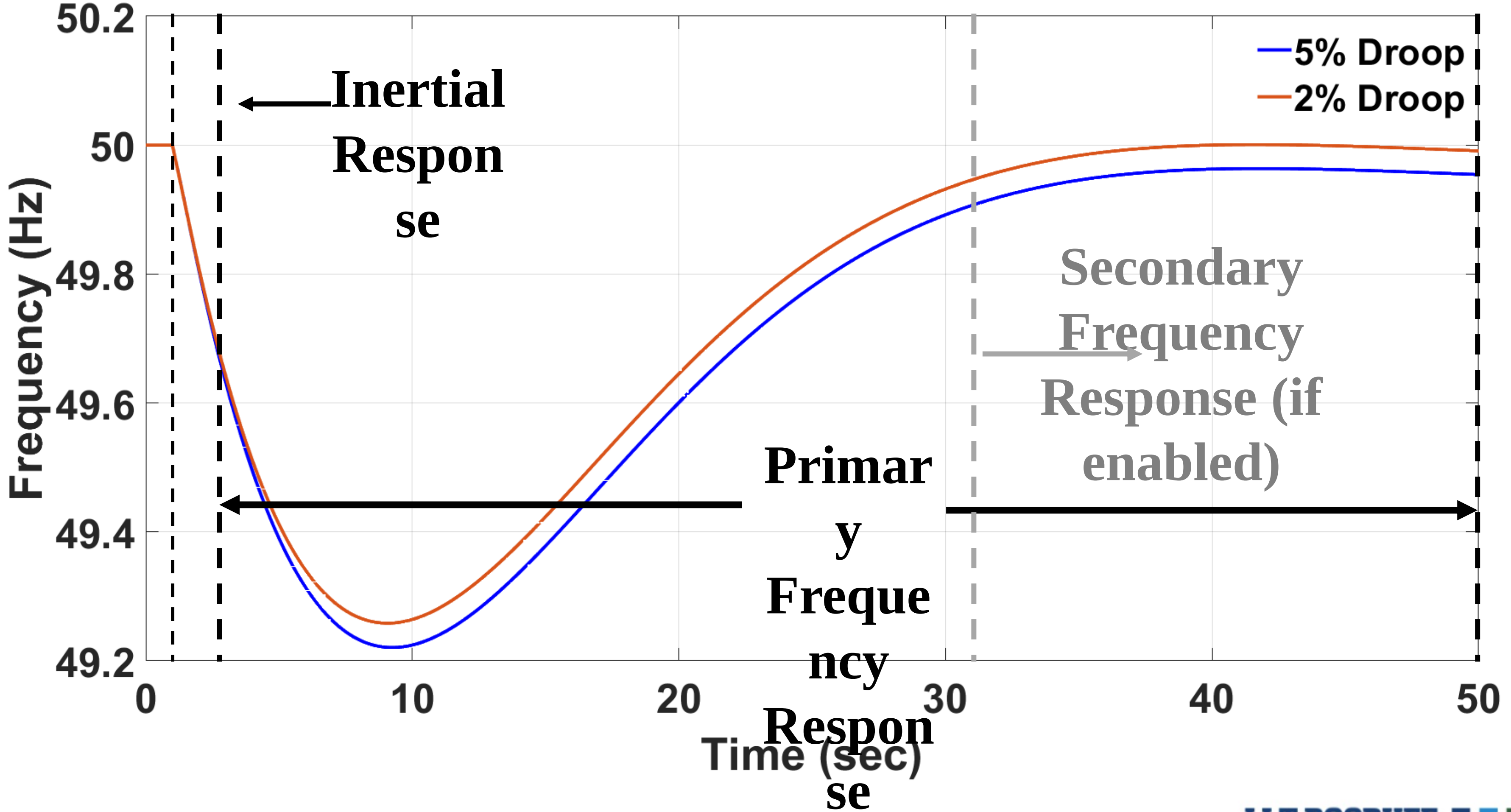
Need for Ancillary Services – Frequency Support Example

A simple system with one generator, its controllers and load



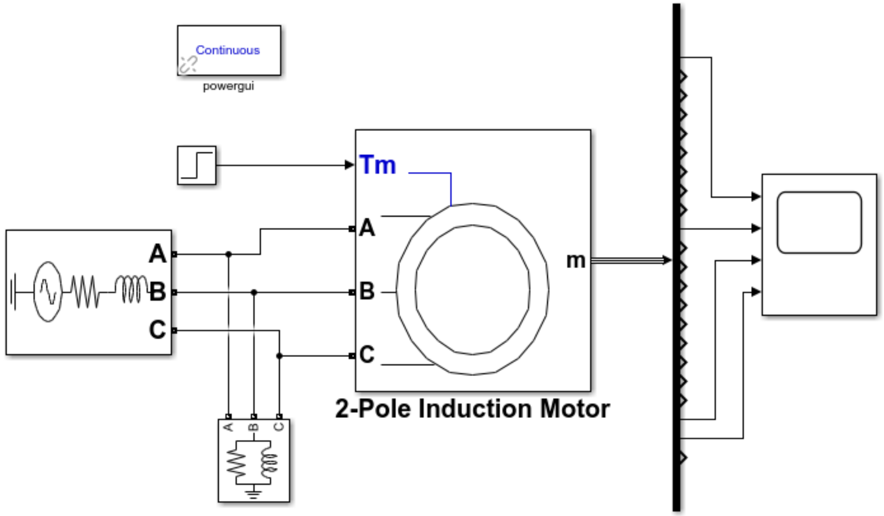
Need for Ancillary Services – Frequency Support Example

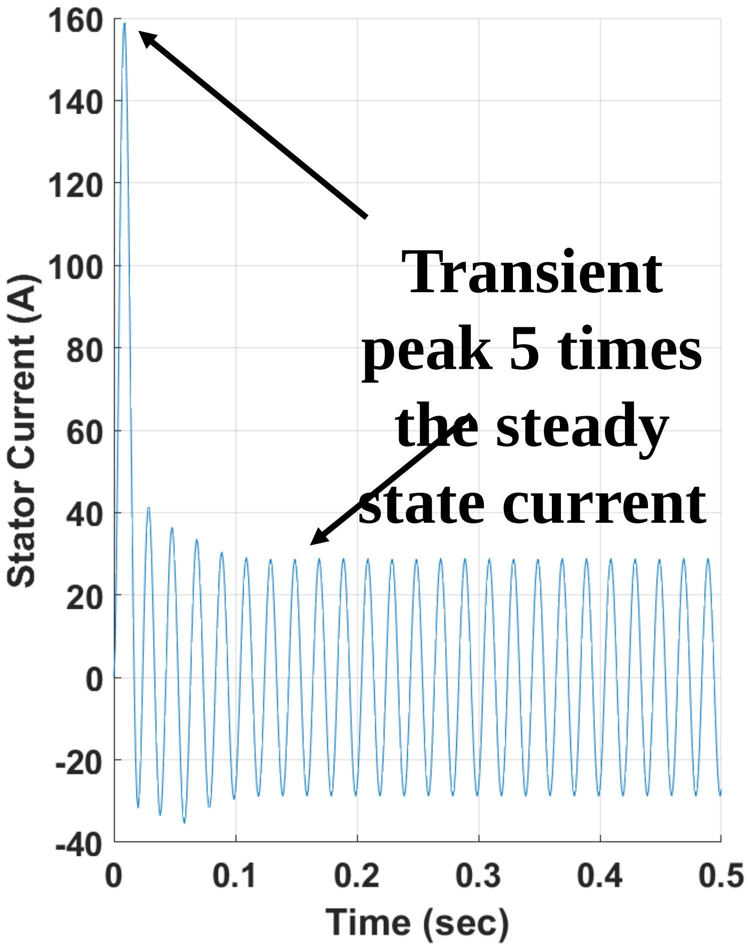
5 MW Step Change in Load



Need for Ancillary Services – Blackstart

Loads such as motors, unenergized transformers draw large transient current during Blackstart



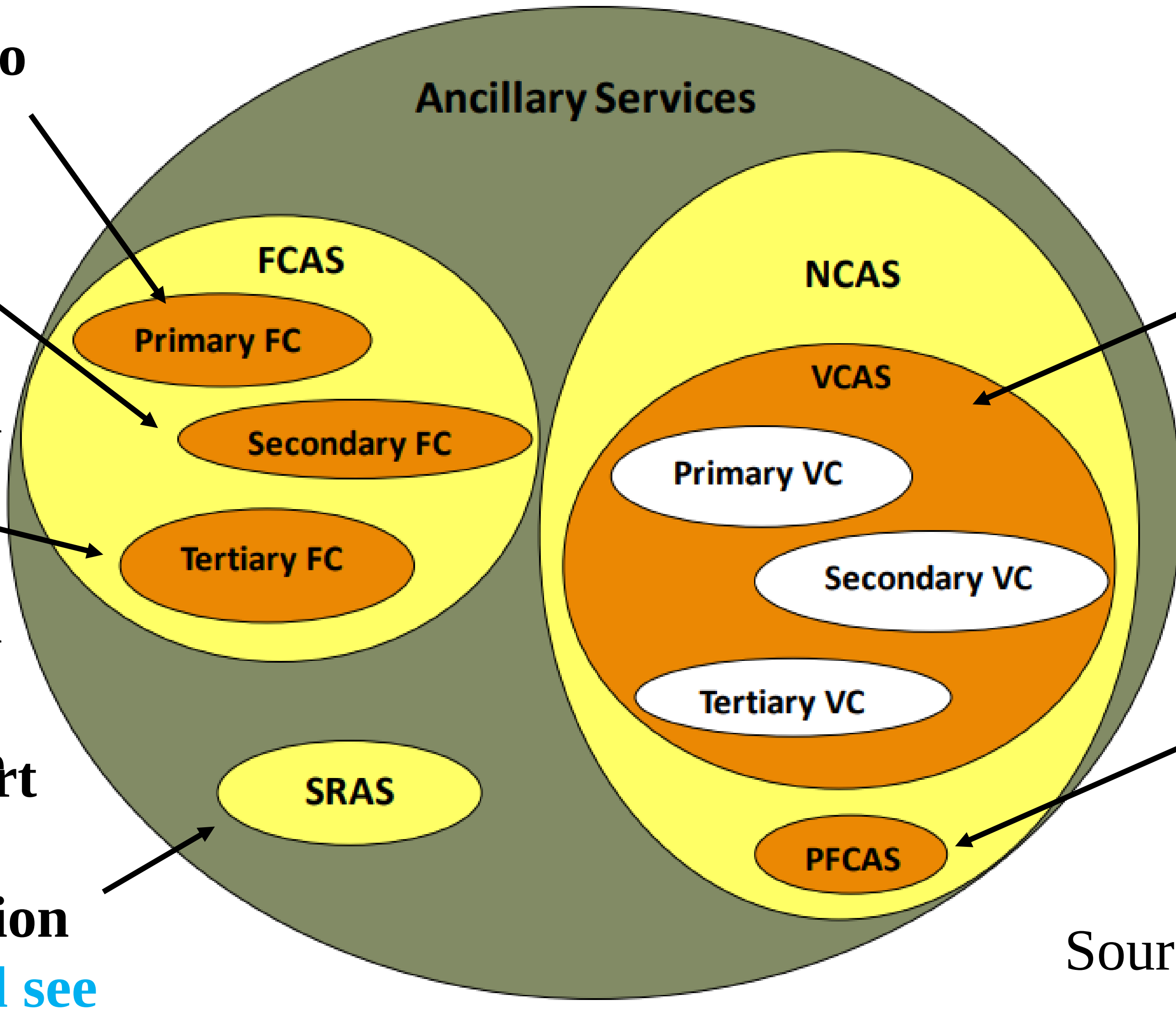


Types of Ancillary Services

Governor

AGC

Spinning and Non-Spinning Reserve



Blackstart and Restoration

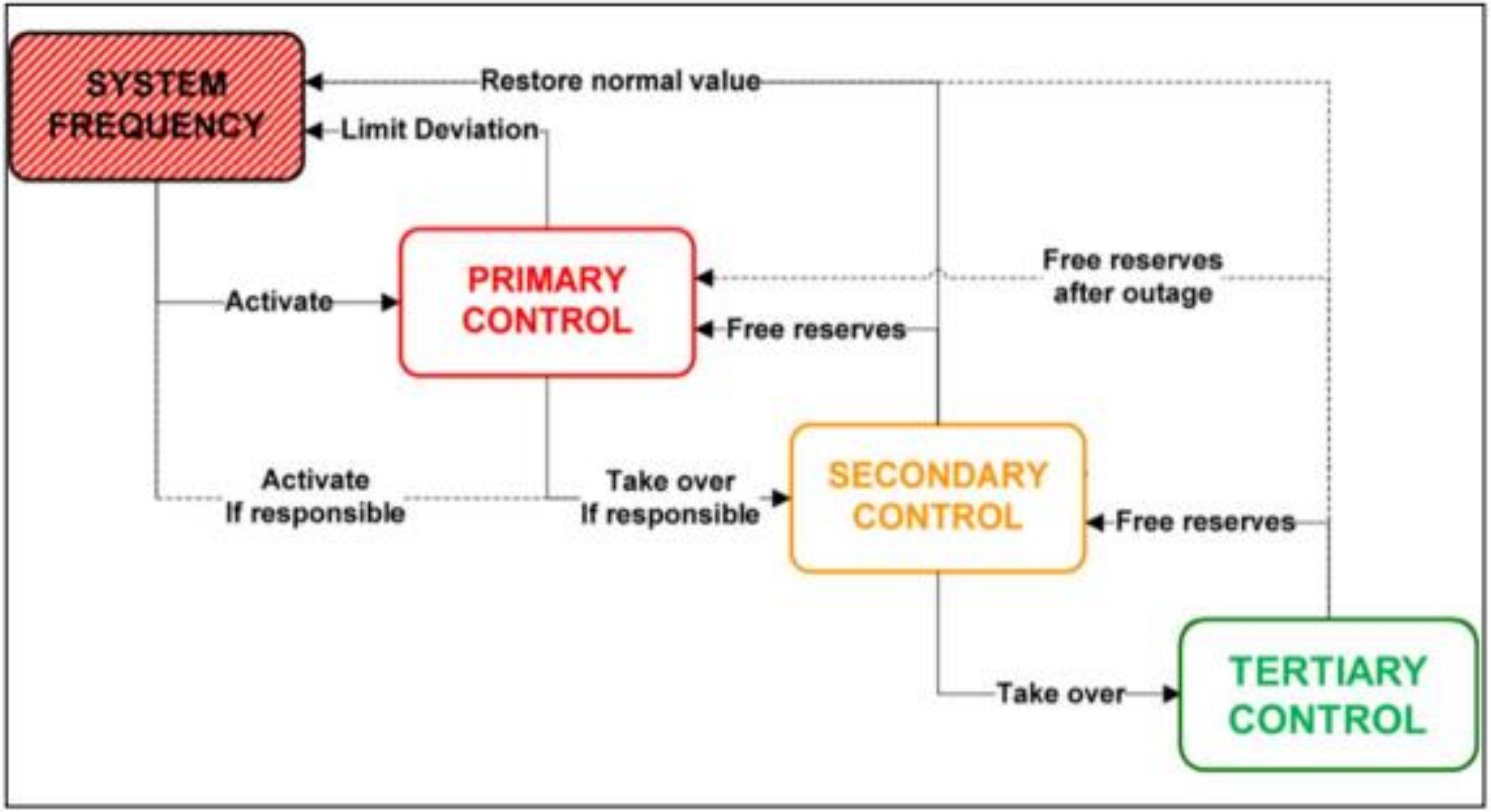
(We will see another

Voltage Control

Flow Control

Source: IIT Kanpu

Types of Ancillary Services (Frequency Control)



Source: CERC, India

Types of Ancillary Services (Voltage Control)

- **Primary**: Through local devices such as AVRs, SVCs
- **Secondary**: Through automatic central "dispatch" of reactive power
- **Tertiary**: Manual

Types of Ancillary Services (Voltage Control)

- In India, generators provide dynamic voltage support for stability but this is done manually as per requirement
- Provision for payment for static reactive power exchange from load serving entities at >33 kV
- Voltage control ancillary services are under consideration

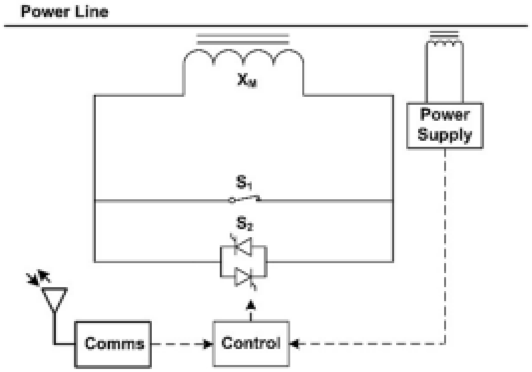
Source: Grid-India (formerly POSOCO)

System Restart Ancillary Service (SRAS)

- Provided solely by synchronous generators-based power plants
- Ability to self-start, handle large transients, sustain rated power for several hours are some key requirements
- Global efforts to use renewable generation resources for blackstart and system restoration
- As per the Indian Electricity Grid Code (IEGC), stations capable of providing blackstart support must demonstrate their capability once in every six months through conduct of mock drills or under intimation from system operators

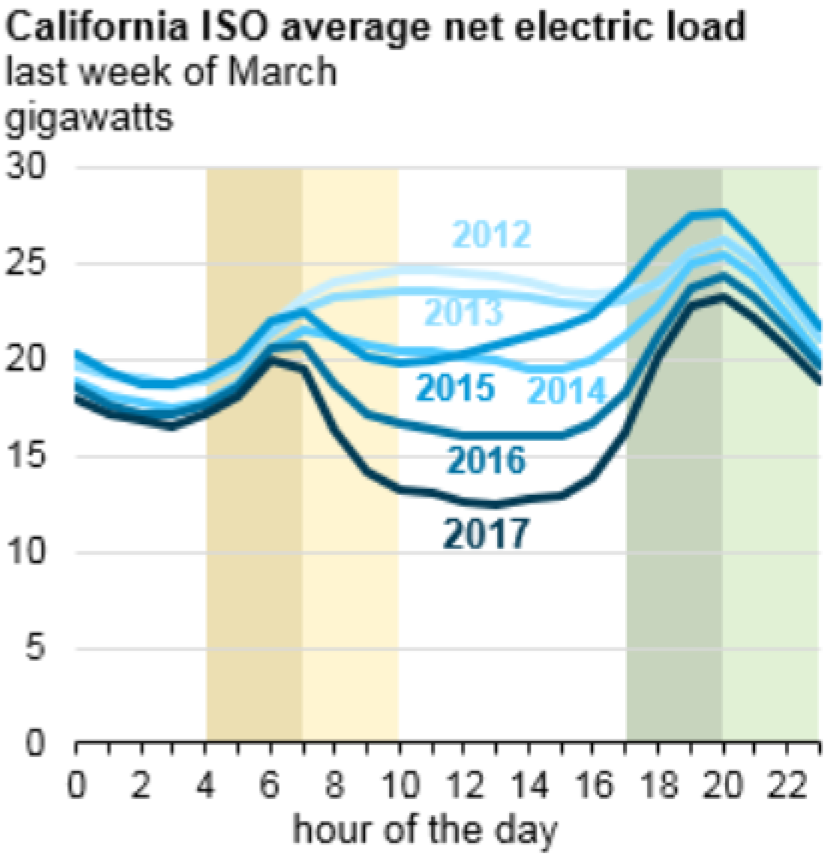
Power Flow Control Ancillary Service (PFCAS)

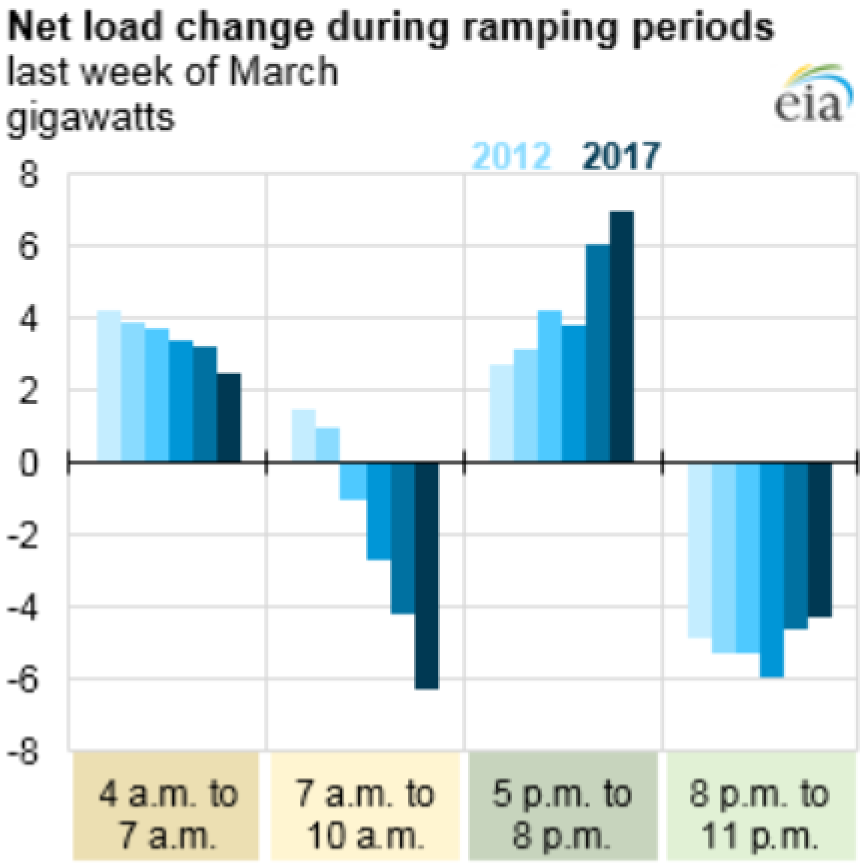
- Used to improve Available Transfer Capability (ATC) and/or relieving real time constraints
- Power electronics-based devices can provide flow control
- Distributed series reactors are a recent technology to enable flow control



Source: NEETRAC, Georgia Tech

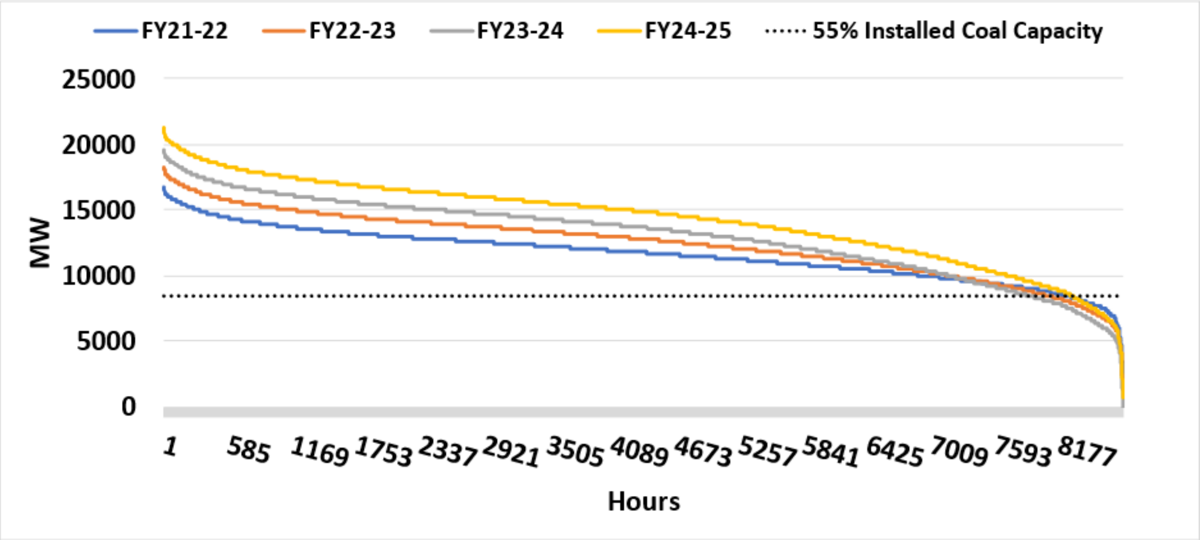
How Renewable Energy Impacts Need for Ancillary Services – CAISO Ramps (2012-17)

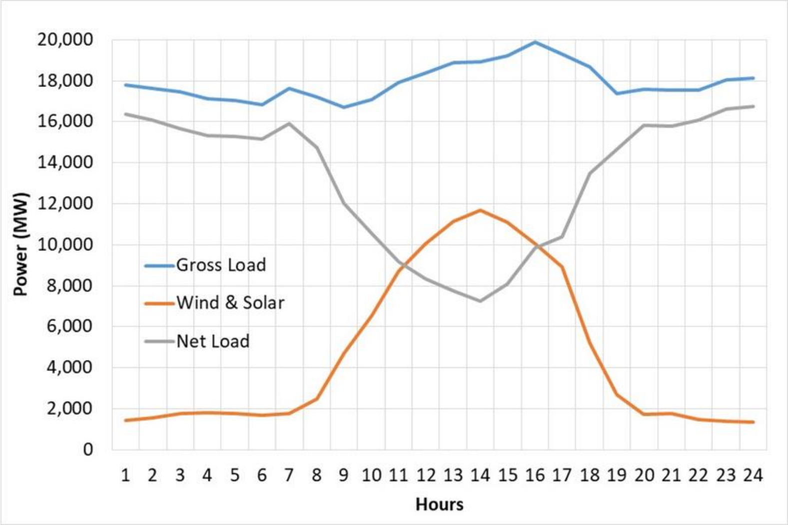




Source: EIA, USA

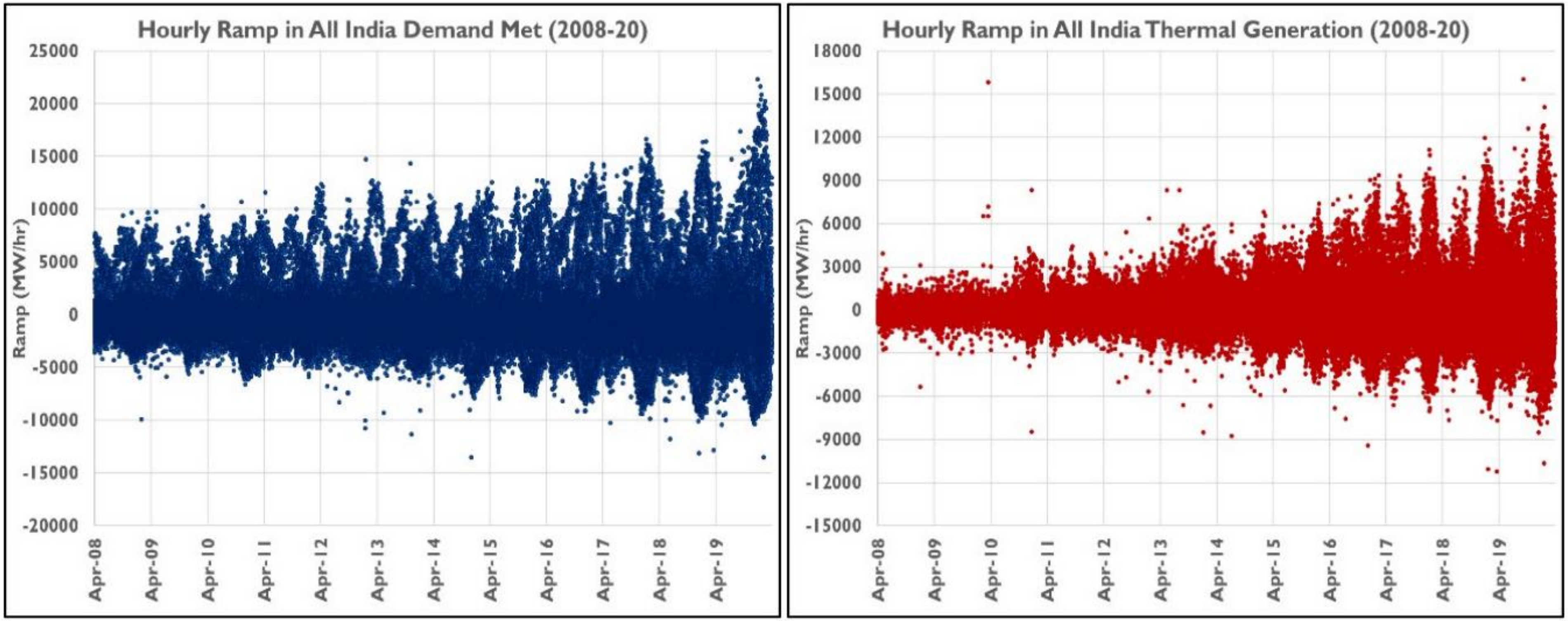
How Renewable Energy Impacts Need for Ancillary Services – An Indian State





Source: HRED, IITR

Higher Ramping Requirement in India

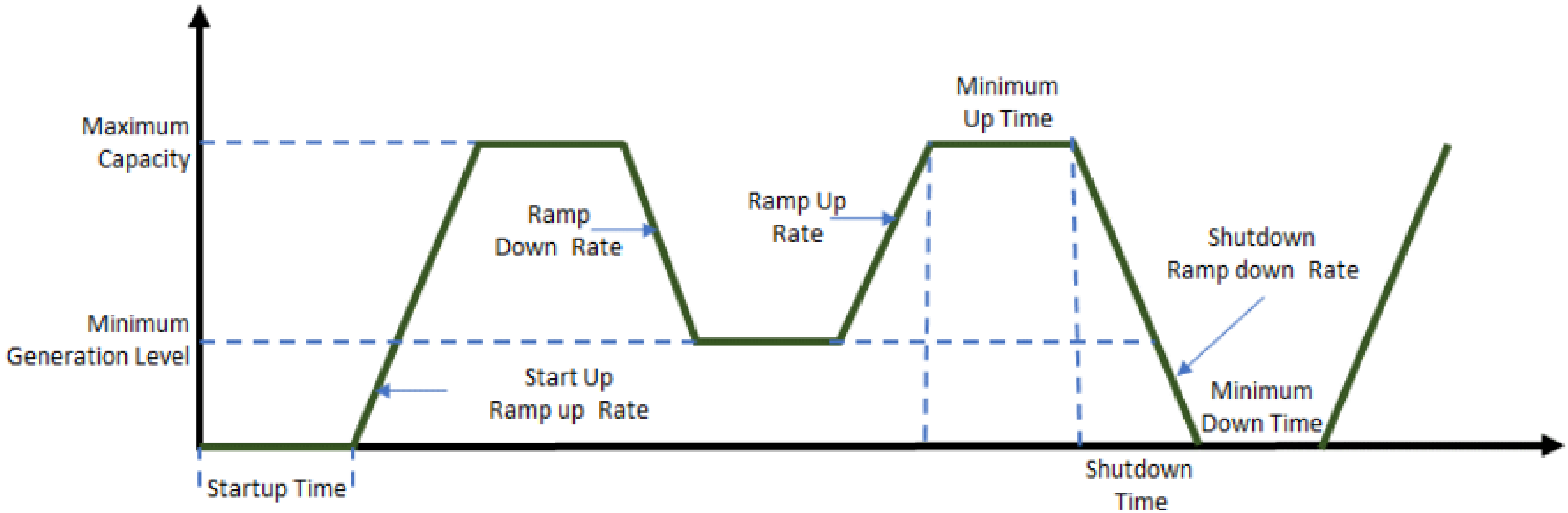


Hourly ramp rates of demand and thermal generation in India from 2008–2020

Source: Grid-India

Flexibility is Key…Increased Importance of Ancillary Services

Flexibility Attributes of Generators



Hydro generators, Pump Hydro Storage, Gas turbines, Battery Storage, and Virtual Power Plants score high on flexibility attributes

Source: NREL, USA

Need for long duration energy storage

- VRE drought events, longer than 8 hours, are already happening
- The magnitude / impact is likely to increase in future due to extreme weather
- Resources adequacy measures will need to evolve from current standards to ensure enough capacity to meet energy needs over a period of time instead of capacity needed to meet peak demand

HYDROPOWER – OPPORTUNITIES

1. High Potential for new hydro development and PSP very large
2. Storage can contribute to large-scale water management needed due to climate-change
3. Regardless of size can be an opportunity for local, national and regional development when social and environmental impacts are dealt with properly – new tools exists to increase environmental and sustainability performance
4. Very important to Play a key role in power systems due to its flexibility and reliability
5. Support the other renewable by providing the backup that intermittent/variable technologies mass-storage for electricity
6. Rivers have been supporting the man kind for their needs.
7. Water use and environment appears to be in conflict even though both are made for each other

Socio-Economic Benefits

- Benefits not only to the locals but also to the whole chain of the activities
- Local development through project investment in Local Economy (contactors, labour, material, transportation, hotels, residences, local business etc)
- Increased employment, wages and incomes for households
- Helps in arresting migration from remote hilly/rural areas
- Local area development through LADA
- Hydro Tourism
- Better electricity supply in terms availability and voltage profile
- All sustainable

CHALLENGES IN THE HYDROPOWER DEVELOPMENT

- Delays in environmental and forest clearances
- Land acquisition issues
- Rehabilitation and resettlement issue
- Local law and order issues
- Large capital outlay
- Financial constraints
- Tariff related

Challenges

- Media management
- Legal affairs management
- Public participation and awareness
- Climate Change affecting the other Extreme Events
  - Glacial lake outburst flow (GLOF)
  - Cloud bursting – extreme quantity of precipitation more than 100 mm per hour – Capable of creating severe flood Flash flood
  - Landslides

RESTRUCTURING OF FINANCES

- Free power to state – deferment for 12 years may reduce the tariff around Rs. 0.30-0.40 per kWh
- Waiver of inter-state transmission charges
  - ✓ Available @100% for new projects that are awarded and where PPA is signed by 30.06.2025.
- Debt equity ratio: changing from 70:30 to 80:20 may reduce tariff around Rs. 0.40 per kWh
- Tax incentives – GST, Income Tax
- Viability Gap Funding

VIABILITY GAP FUNDING

- VGF or grant means one-time grant or deferred, provided with the objective of making a project commercially viable. It may be upto 20% of the project cost.
- The financial support under VGF shall be in the form of capital grant and operational grant for completion of the project and first five years after the commercial operation date (CoD).
- It applies if the contract is awarded to a private sector company, selected through open competitive bidding. The company is responsible for financing, construction, maintenance and operation of the project during the concession period.
- Capital grant VGF shall be disbursed after the company has subscribed and expended the equity contribution required and will be released in proportion to debt disbursements by the financial institution.
- Operational grant shall be disbursed annually

Thank You