Issues and Challenges in Transmission stability and Grid Operation

- Frequency Stability
- Voltage Stability
- Transmission congestion
- Angular Stability

Frequency stability

CERC IEGC, 2010

- Mandates action by control areas to control inter-state

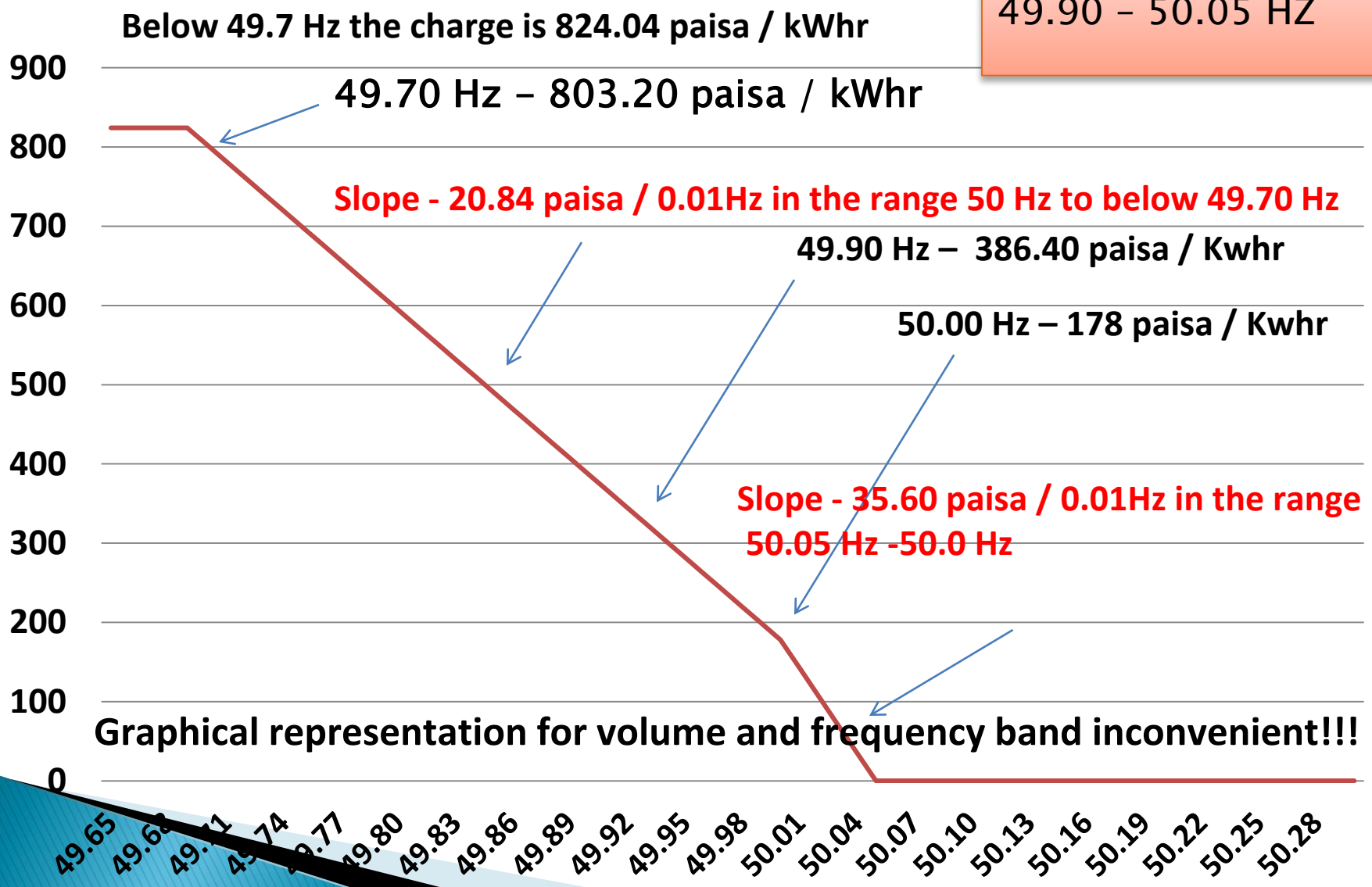
  inter changes
- States revise requisitions / procure power from market for handling deviations from schedule
- stipulates the imbalance handling and settlement mechanism

Permissible Deviation Volume Limits

Entity	Frequency – 50.10 Hz & above	Frequency - 49.7 Hz & above	Frequency - Below 49.7 Hz
Seller-Under Injection	Upto 12% of its schedule or 150 MW which ever is less		No under injection
Seller-Over Injection	No over injection	12% of its schedule or 150 MW which ever is less	
Buyer-Under Drawal	12% of its schedule or 150 MW which ever is less		
Buyer-Over drawal	12% of its schedule or 150 MW which ever is less		No Over drawal

Charge for Deviations w.e.f 17th February, 2014

IEGC Band:
49.90 – 50.05 HZ



RE – Grid integration issues : Impact

Commercial impact under Deviation Settlement Mechanism (DSM):

Impossible to restrict OD / UD within ±150 MW, when RE variation is more than 1500 MW in a day.

- The data recorded for OD and UD more than ± 150 MW for wind generation variation as high as 1500 MW in a day.

Date	Wind variation between Maximum & Minimum wind injection in a day	No. of blocks when deviation beyond ± 150 MW
01-04-2015	1579	60
11-04-2015	1661	66
23-06-2015	1749	59
16-04-2015	481	29
25-05-2015	646	44
18-06-2015	498	44

- Evident that deviation is comparatively lesser when wind variation band is limited (maximum and minimum in a day).
- Data recorded proves direct relation of wind variation with OD / UD deviation.

Forecasting and Scheduling

Forecasting

- Global at LDC level for grid security, balancing
- Local at solar/wind farm level for scheduling and commercial treatment

Scheduling in CERC RE Framework

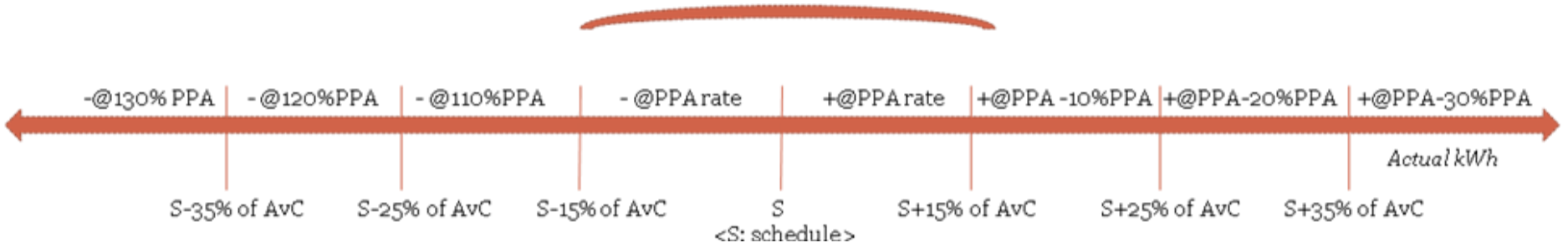
- Wind/solar generators at the inter-state level whose scheduling is done by the RLDCs
- To be paid as per scheduled generation
- Maximum of 16 revisions for each fixed 1.5 hour time slot
- Transact through long /medium/short-term trades.
- Transmission charges (POC charges) and losses applicable
  - Only for Wind at present
  - Exemption to Solar projects commissioned till Jun-2017

Scheduling Enables Electricity Market Access to Renewables

Imbalance Handling and Settlement

- **Salient Features of CERC RE Framework**
  - Deviation charges of RE generators delinked from frequency
  - More opportunities to revise the schedule
  - Commercial liability known upfront
  - Centralized as well as De-centralized forecasting
  - No additional charges, surcharges etc.
  - RECs to ensure physical energy balance

Deviation Settlement Framework for Regional Entities



- Error definition: [(Actual generation – Scheduled generation)/Available Capacity] x 100
- Payment as per schedule @PPA Rate
- Deviation Settlement within tolerance band (+/- 15%):
  - Receipt from/payment to pool @PPA rate (i.e. in effect, payment as per actuals)
- Beyond 15%, a gradient band for deviation charges is proposed as follows:

Abs Error (% of AvC)	*Deviation Charge*
15%-25%	10% of PPA rate
25%-35%	20% of PPA rate
>35%	30% of PPA rate

- 16 revisions allowed, one for every one-and-half-hour block, effective from 4th time-block.

Must Run Status

- IEGC Regulation 5.2 (u): Special requirements for Solar/ wind generators

"System operator (SLDC/ RLDC) shall make all efforts to evacuate the available solar and wind power and treat as a must-run station. However, System operator may instruct the solar /wind generator to back down generation on consideration of grid security or safety of any equipment or personnel is endangered and Solar/ wind generator shall comply with the same."

Backing down of wind generation in Tamil Nadu during wind season

RE – Grid integration issues :
Impact On conventional generation

[1] inefficient / Uneconomical operation – Technical minimum operation

[2] Frequent back down / ramp up to honor "Must Run" status –

Higher Heat rates and emission from fossil fuel generators

Consequences of frequent back downs and shut downs

[3] Backing down of cheaper generation – to restrict OD / UD within 150 MW, to honor "Must Run" status, cheaper generation is backed down

Impact on conventional generation

- All components of the power plant are highly stressed by the new kind of operation
- With increasing low-load operation high amounts of coal remain at the coal storage over a longer period with the risk of self ignition
- The combustion system must be able to offer high flame stability also at low load without support fuel
- Decreasing HP and IP temperatures accompanied by too high gradients can lead to stresses of the casings
- The entire flue gas pass is affected
  - Very low flue gas velocity due to low-load operation
  - longer retention time of flue gas in stack
  - Reverse flow in the inlet area of the scrubber
  - Increasing slagging at the duct walls

All sources of flexibility are needed!

Interconnections

Though we have a wide NEW + S grid, congestion at inter-connectors can affect reliability. Also, with more RE, system inertia will come down.

Energy storage

- Pumped Hydro
- Battery

- Limited
- Not yet grid-scale

Flexible generation

- Hydro . Must tap potential. But, not all-season, all-state. Irrigation-dependent
-

Demand response

Futuristic. Limited potential right now

Need for Flexibility

- **CERC IEGC (4th Amendment) (Draft)**
  - Proposed Technical Minimum - 55%
  - Proposed station heat rate degradation to be considered for the purpose of compensation
- **Balancing mechanisms**
  - – Need for flexible generation, Pumped storage plants,
  - – Spinning reserves, Frequency Regulation
  - – Reduction in system inertia – need for synthetic inertia
- **Flexible Market Mechanisms**
  - - Supply Side : Increased granularity, More frequent market
  - - Demand Side : More / New products, Compliance Monitoring
  - - Ancillary services (Regulation has come in august 2015)
- **Flexible transmission-**
  - – Robust transmission at Inter State as well as Intra State Level
- **Energy Storage Systems**

Commercial mechanism

- Market mechanisms could further help large scale integration of renewable sources of energy:
  - **Suitable market design to handle reserves for power balancing**
  - **Flexible Generators**
  - **Ancillary Market**
  - **whole day markets-through PXs**
- Renewable Energy Certificate (REC) Mechanism
- Renewable purchase Obligation(RPO) – promotes the market mechanisms

Amendments to Electricity ACT 2003

Proposed amendments:

- RPO target to be increased to 10.5% by 2022
- Introduction of Renewable Generation obligation
- Penalties for non compliance of RPO and RGO

Amendment to tariff policy

- Proposed amendments are
- Pass through of RPO and RGO costs in tariff
- Implementation of RGO on a cost plus basis
- Waiver of interstate transmission costs

Voltage Stability

- Fluctuating wind and solar generation causes variation in reactive power exchange of the wind and solar generators with the grid, and, therefore, the fluctuations of voltage in the grid.
- Mitigation measures of the effects of the multiple start-ups include provision of dynamic reactive power compensation i.e. SVC (Static VAR compensators)/ STATCOM (Static Synchronous Compensator).
- Most of the advanced energy storage systems can also provide reactive power support without need for consuming active energy.
- Locational requirement for reactive power could help in determining appropriate location for deploying energy storage systems that can provide multiple value propositions to the grid.

Transmission congestion

- Flexible AC Transmission System (FACTS) devices like phase shifting transformers should be installed to shift power from heavily loaded lines to lightly loaded lines in parallel paths.
- Strategically placed energy storage devices can also help in relieving transmission congestion by time shifting the flow of energy across constrained paths
- Alternately, In order to harness the huge potential of RES in specific States, high capacity Inter-State and Inter-Regional corridors transmission corridors could be constructed linking high concentration renewable generation areas to balancing generation already located elsewhere in the grid.

Green Energy Corridors Part I

GREEN ENERGY CORRIDORS
Transmission Plan for Envisaged Renewable Capacity

₹ 42,000 crore investment in transmission for 40 GW

- Planning of intra-State/inter-State Transmission requirements
- Provide Mechanism to address Wind/Solar generation uncertainty
  - Forecasting of generation
  - Provision of flexible generations, reserves
  - Demand side Management
  - Energy Storage
  - Policy and Regulatory Framework

- Study Report on Green Energy Corridors
  - Submitted to MNRE/ CERC/ CEA/ Planning Commission/ MoP/ MoF
  - Inputs from- MNRE, Forum of Regulators, State Nodal Agencies, State Transmission Utilities and CERC
  - Transmission System classified into:
    - Connectivity Transmission System
    - Intra-State Strengthening
    - Inter-State Transmission System

Intra-State TS Strengthening: ₹ 20,000 crore

Inter-State TS Strengthening: ₹ 22,000 crore

includes

- Other associated works like Energy Storage, Real Time Monitoring System etc.
- Establishment of Renewable Energy Management Center

Source: PGCIL Green Corridors Presentation

Green Energy Corridors Part II

- It gives the transmission plan for integration of ultra Mega solar plants
- Out of total 22,000 MW Ultra Mega Solar Power capacities envisaged in 12 states, about 17,600 MW capacity is proposed to be evacuated on Inter-state and balance 4500 MW by State Transmission utilities over Intra state network.
- Part-A covers the integration plan of ultra-mega solar power parks on ISTS.
- Transmission system strengthening within state for absorption of power within state which shall be identified by respective STUs

Angular Stability

- Various type of FACTS devices, which would need to change dynamically, to change the power system parameters in accordance with changing topology of intermittent generation from renewable energy sources, may need to be installed.
- System Operator should be aided in this by Phasor Measurement Units (PMUs) installed at critical points in the grid, for visibility in the grid w.r.t. real-time angular difference.

Thanks