Coverage

- Background
- Regulatory Framework for Grid Integration
- Discussion, Issues & Recommendations
  - Planning Stage
  - Construction Stage
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  - Institutional Stage
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- Summary of Recommendations
Background

✓ Current level of Wind Penetration
✓ Implication for Utilities
✓ New RE Targets
Current level of Wind Penetration: India

- Increasing penetration of wind energy - Share of WEGs as Percentage of installed generation capacity Gujarat, Tamilnadu and Rajasthan is 18%, 40.5% and 26% respectively.
- During windy season, percentage share of Demand met constitutes ~ 20-25% (35% in TN).
- With integrated regional Grid operations, intermittency or variability of wind generation needs to be viewed from National perspective.

High level of Wind Penetration (Energy Consumption) in States

- Tamil Nadu (~37%)
- Rajasthan (~26%)
- Karnataka (~25%)
- Gujarat (~22%)
- Maharashtra (~12%)

Source: NLDC-POSOCO
Implication for Transmission & Distribution Utilities

• Current network planning, design, operation and maintenance practices still based on conventional power capacities.
  ✓ Need to have long term planning horizon.

• Generator connection process need modification to take into account large number of generators.
  ✓ Need to develop new codes and standards for RE connection

• Shall expose Discoms to imbalance risks
  ✓ Adequate metering and communication facilities are required to ensure grid stability and efficient market operation.
New RE Targets

- Govt of India has exponentially increased its RE targets to 175 GW by 2022.
  - 100 GW – Solar; 60 GW – Wind; 10 GW – Biomass; 5 GW - Hydro
- **Wind Vision:** 200 GW by 2030 seems a logical extension of these targets.
- Such extraordinary capacity addition of variable and intermittent generation would pose unprecedented challenges to the Grid.
- The Grid related issues may be differentiated into: Planning; Construction; Operational and Institutional
Regulatory Framework for Grid Integration

- EA 2003
- CERC Grid Connectivity Regulations, 2009
- CEA Standard of connectivity (amendment) Regulations, 2013
- Indian Electricity Grid Code, 2010
Framework for Grid Integration of RE

Aspects of Tx system development

Planning

Construction

Operation

Entities

CEA, CTU and STU

CTU, STU

CERC, RLDC, SLDC

Governing Framework

National Electricity Plan, IEGC

CEA Regulations and Standards

IEGC and State Grid Code

Functions

- Long term & short term System Planning
- Investment plan

- Construction of Transmission lines
- Substations
- Protection
- Technical standards

- Scheduling
- Despatch
- Balancing & Control
- Metering
Framework for Grid Integration of RE sources

Electricity Act 2003

- Central Electricity Authority to prepare National Electricity plan (NEP) in accordance with the National Electricity Policy once in five years (Section 3)
  - NEP includes transmission plan for five years
  - NEP for 12th plan also provides insights on Integration of Renewable Energy (RE) Sources generation in National Grid.
  - NEP for 12th plan deals with need for adequate transmission, Forecasting & scheduling, Energy Accounting, Load-Generation Balance, Energy storage & Registry for RES

- Transmission Utility at the Central as well as State level, to be a Government company with responsibility for planned and coordinated development of transmission network. (Sections 38 & 39)

- Responsibility on State Electricity Regulatory Commission for promoting cogeneration and generation of electricity from renewable sources of energy by providing suitable measures for connectivity with the grid. (Section 86)
Framework for Grid Integration of RE sources

**Amendment: CERC Grid Connectivity Regulations ‘09**

- **7th September, 2010 (Second Amendment)**
  - RE Projects- Threshold capacity for connecting to inter-State grid reduced to 50 MW
  - Capacity less than 50 MW - can collectively aggregate 50 MW and above for connectivity

- **26th March, 2013 (Third Amendment)**
  - 5 MW to 50 MW - Renewable Capacity
  - Developed by a generating company in its existing generating station
  - Connectivity to the existing connection point with ISTS through the electrical system of the generating station
Framework for Grid Integration of RE sources

CEA (Technical Standards for Connectivity to the Grid) Amendment Regulations, 2013

- CEA has issued amendment to connectivity standards specifying the technical requirements from wind generators to be synchronized with the grid.

- Wind Generators shall be capable of supplying dynamically varying reactive power support so as to maintain power factor within limits of 0.95 lagging to 0.95 leading.

- Wind Generating stations shall have fault ride through capability of not less than 300 milli-seconds so that grid is not destabilized due to sudden outage of renewable generation in the event of a grid disturbance.

Where, $V_t/V_n$ is the ratio of actual voltage to the nominal system voltage at the interconnection point.
Framework for Grid Integration of RE sources

**Framework**

- Indian Electricity Grid Code, 2010
- Issued by CERC, notified on 28 April, 2010

**Salient Features**

- Effective from 3rd May 2010
- As per IEGC Provisions, Scheduling was supposed to be mandatory for WEG w.e.f. 01-01-2011 to help increase variable component of grid power.
- Make wind and solar generators responsible for grid discipline.
- Will also facilitate Interstate transaction of Wind and Solar through Open Access Route.
- Applicable for all new wind/solar farms with collective capacity of 10 MW and above connected at connection point of 33 KV level and above, who are yet to sign a PPA with states or others
- Revision of Schedule by wind and solar power generating stations shall be effective from 6th time-block, the first being the time-block in which notice was given. There may be maximum of 8 revisions for each 3 hour time slot starting from 00:00 hours during the day.
### Framework for Grid Integration of RE sources

#### Implication
- The wind and solar generators shall be responsible for forecasting their generation up to an accuracy of 70%.
- If the actual generation is beyond ±30% of the schedule, wind/solar generators have to bear UI charges.
- Within ±30%, the State which purchase power from the wind generators shall bear the UI charges for this variation.
- However, the UI charges borne by the State/s due to the wind/Solar generation, shall be shared among all the States of the country in the ratio of their peak demands on a monthly basis, in the form of a regulatory charge known as the Renewable Regulatory charge for wind/solar energy.

#### Renewable Regulatory Fund
- The RRF shall be maintained and operated by the National Load Despatch Centre on the lines of UI Pool Account at the Regional level.
- Scheduling = 70% accuracy
- Max. Generation Allowed = 150% of the schedule in a time block, over generation will be paid @UI corresponding to 50-50.02Hz
- Variation allowed = ±30%
- For Intra State Transaction = Contracted Details & Rate should be informed to -> RPC/RLDC through respective SLDC
- For Inter States Transaction = Contracted Details & Rate should be informed to -> RLDC/NLDC through respective RPC.
Planning Stage

- Issues/Challenges
- Mitigation
Planning Stage:

Need for transmission plans focusing RE integration to Grid at State level and Central level

- Arranging for adequate transmission infrastructure for Grid Integration of Wind is the key for encouraging & ensuring capacity addition

- Off-late, RE has been given due focus while developing Inter-State transmission plans
  - Green Energy Corridors and Desert Power – Transmission plan of envisaged RE capacity – *Study carried out by PGCIL*
  - National level Perspective Transmission Plan for evacuation of power from Renewable Energy Sources – *By CEA*

- Due focus for RE integration yet to be given while Intra-State level transmission planning
  - Sub-transmission system strengthening at State level in few States are taking into consideration RE evacuation- TN, Guj, Raj, AP
Green Energy Corridor

- Study conducted by PGCIL
  - Total Rs. 42,000 Crore investment in transmission for 40 GW RE evacuation
  - Rs. 20,000 Crore for Intra-State TS strengthening
  - Rs. 22,000 Crore for Inter-State TS strengthening

Transmission system classified into:
- Connectivity transmission system
- Inter-State Transmission System
- Intra-State Strengthening

- Study Report submitted to MNRE/ CERC/ CEA/ Planning Commission/ MoP/ MoF
- Inputs from- MNRE, Forum of Regulators, State Nodal Agencies, State Transmission Utilities and CERC

- 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
CEA perspective transmission plan was prepared considering the Wind and Solar potential estimates in the States viz.

- Tamil Nadu,
- Andhra Pradesh,
- Karnataka,
- Maharashtra,
- Gujarat and
- Rajasthan

- 165 GW of wind and 35GW of Solar capacity considered
- To transfer power from surplus states to deficit States
Transmission Plan: Challenges

- The biggest impediment as being perceived by the wind power developers is the inadequate power evacuation arrangement for RE based power
- Though State level Transmission Utility/distribution licensee being primarily responsible for evacuation of power from generators, the emphasis on proper planning for enhancement of the transmission network with a perspective of increasing renewable energy capacity addition, has been lacking
- State Grid Codes currently focus only on evacuation of conventional generators
- Huge level of investment requirement (As per Green Energy Corridor Report)
- Financial Status of STUs
- Availability of Right of Ways and land
- Adequate number of competent and quality suppliers of goods and erection contractors
- *Long term planning to be done in view of large untapped wind potential in the country, which is envisaged to be exploited in the coming years*
Transmission Plan: Mitigation

- Make renewable energy evacuation a high-transmission priority
- State transmission utilities should prepare a comprehensive 5-year transmission plan with appropriate consideration of the renewable generation projects based on load flow studies and location of generation projects.
- Apart from network planning, Transmission system plan needs to address other issues such as telecommunication, visibility at system operator (Load Despatch centre) level and reactive power planning etc.
- State Grid Codes to be amended to include provisions of RE focused transmission plan.
- Utilization of NCEF, issuance of green bonds by IREDA like agencies
- Dedicated funding should be allocated as part of existing programs, such as the government’s RGGVY or new green funds
- Close interaction between MNRE with concerned State Departments, Regulatory Authorities and Agencies to periodically address issues.
- Integrated Gx-Tx planning is required;
- Concepts like capacity value of wind, and availability of complementing resources need to be included in Gx/Tx planning.
Construction Stage

✓ Issues/Challenges
✓ Recommendation
Construction/Connectivity Stage:
**Wind Evacuation Issues**

- Wind farms with large capacities require interconnection with transmission infrastructure.
- Transmission utilities however, typically tend not to give priority to renewable evacuation infrastructure.
- Resource constraints make transmission utilities to prioritise their investment focus on evacuation of conventional power.

- **Existing Wind projects are backed-down despite sufficient resource availability**

The key issues to be addressed are:
- How should requirements of grid connectivity and evacuation infrastructure for Wind energy sources be addressed?
- What are the alternatives for attracting investments in creation of evacuation infrastructure for Wind energy sources?
- What is the role of STU in developing evacuation infrastructure for renewable energy projects? Definition of interconnection point and responsibility of construction of evacuation infrastructure beyond pooling substation?
Construction/Connectivity Stage: Wind Evacuation Issues

- Wind farms with large capacities require interconnection with transmission infrastructure.
- Vide CEA (Technical Standards for Connectivity to the Grid) Amendment Regulations, 2013, except few standards of fault ride through and PF, many connectivity/construction standards are unaddressed.
- In the absence of RE specific connectivity standards and construction standards, the Utilities tend to impose conditions as applicable and relevant for conventional power on renewable energy generators.
- This makes the connectivity & construction of evacuation infrastructure for wind energy project even more cumbersome & cost inefficient.
- For example, the conditions of double circuit lines, twin tower redundancy requirements, Surge Impedance Loading (SIL) requirements, insistence on use of particular type of conductor, restriction on capacity (MW) of evacuation on particular line even though loading shall be within technical limits of operation etc, are few constraining factors to make efficient evacuation arrangement for wind energy projects.
Some of the international practices and standards in respect of connection of wind power to the grid are as following:

- Scottish guidance note and the Ireland ESBNG include requirements regarding maximum active power change during start up, shutdown and wind speed change in order to avoid impacts on system frequency.
- ESBNG regulations of Ireland, require wind farms to include primary frequency control capabilities of 3-5%.
- DEFU of Denmark, VDEW of Germany and AMP of Sweden define the maximum permissible voltage increase from a wind turbine at the point of common connection PCC, which is 1% for DEFU, 2% for VDEW and 2.5 % for AMP.
- E.ON regulations recommend equipping the wind farm with a tap-changing grid transformer to be able to vary the transformer ratio.
Construction/Connectivity Stage: Recommendations

- With increasing penetration of wind energy into Grid, there is an urgent need to define “Connectivity and construction standards for RE Projects” that would take into consideration specific requirement of wind sector:
  - Active power control,
  - Frequency control,
  - Voltage control,
  - Tap changer,
  - Wind farm protection,
  - Modelling and communication requirements
  - etc,

- Central Electricity Authority should immediately initiate the process for formulation of such standard
Operation Stage

- Issues/Challenges
- Recommendations
Wind Power Plant Operation: 
**Key Issues**

- Key intrinsic characteristics of wind generation
  - **Variability** is the known natural variation in RE generation
  - **Predictability/Uncertainty** refers to the lack of accurate knowledge about the future RE generation
  - RE plants providing lesser grid support during system disturbances than the conventional in terms of MVAR/active Power regulation
  - Most of the wind plants are not FRT capable, may lead to collapse of large chunk of RE generation at a time in grid fault situations

- Some of the intrinsic characteristics of the Indian Grid which act as a challenge for accommodating more wind power to the system are:
  - Wide variation in grid frequency in comparison to International standards
  - Voltage fluctuation
  - Variable loading of transmission network
  - No transmission margin
Wind Power Plant Operation: Recommendations

Integration of RE Sources: Commercial /Balancing Mechanism

- Suitable market design to handle reserves for power balancing
- Flexible Generators
- Ancillary Market
- Multiple Iterations in Power Exchanges

Integration of RE Sources: Encouraging Wind Energy Forecasting

- System Operator to foresee what is expected to happen a few hours ahead
- Able to take appropriate measures.
- Nature of forecasting to be adopted in Indian context: Centralized Vs Decentralized remains an issue
- Forecasting accuracy need to be studied in Indian context– right kind of deviation tolerance to be set so that mechanism support the grid operation & at the same time commercially acceptable
- Results of mock exercises carried till date could be considered for reviewing tolerance level for deviation
Wind Power Plant Operation: Recommendations

Integration of RE Sources: Need for REMC

- Renewable Energy Management Centre (REMC) recommended by Working Group on Power for 12th Five Year Plan & Power Grid through its report “Green Energy Corridor”

- Functionality of REMC:
  - Forecasting of RE generation in jurisdiction area on day-ahead, hour ahead, week-ahead, month-ahead basis
  - Real time tracking of generation from RE sources and its geo-spatial visualization
  - Close coordination with respective LDC for RE generation and control for smooth grid operation
  - Single source information repository and coordination point for RE Penetration
  - On-line Dynamic security Assessment tool like Dynamic performance, Harmonic performance
Wind Power Plant Operation: Recommendations

Integration of RE Sources: Spinning Reserve

• National Electricity Policy mandated 5% spinning reserve by the year 2012

• Perceived Generation Shortage:
  • No Spinning Reserve
  • Preserving some of the available power generation units for spinning reserve considered as equivalent to loss of generation in power deficient scenario – Need for a change in outlook
  • Sudden generation outage / unforeseen higher demand
    ✓ States tend to deviate from schedule or resort to load curtailment

• In order to avoid such deviation from schedule, maintaining spinning reserve of at least 5% is a must
Institutional Stage

- Institutional Set up: Enabling Forecasting & Scheduling
- Recommendation
Institutional Set up: Enabling Forecasting & Scheduling

- **Regional level/Central level**
  - **SLDC**
  - **Forecasting**
  - **Scheduling**
  - **Other State pool participants & generation schedule**

- **States 1 to n**
  - **Consolidated Forecast & schedule at State level**

- **SREMC-1**
  - **CA-1**
  - **Wind Farm-1, 2..n**
  - **Forecasting**
  - **Scheduling**
  - **Other State pool participants & generation schedule**

- **SREMC-n**
  - **CA-n**
  - **Wind Farm-1, 2..n**
  - **Forecasting**
  - **Scheduling**
  - **Other State pool participants & generation schedule**

- **NLDC/RLDC**
  - **Schedule & Point of deviation measurement**
  - **Point of Forecasting & Penalty/Incentive distribution**
Institutional Set up:
Recommendation

• Features of Proposed Mechanism
  ✓ Within 30% deviation from schedule socialized among pool participants
  ✓ Deviation > 30% to be borne by Generators
  ✓ However, point of measurement of deviation shall be at SREMC level and not at Pooling station level.
  ✓ This practice reduces the absolute quantum of deviation to a large extent.
  ✓ Deviation penalty / incentive collection/disbursement to individual WTG to be done by CA (Coordinating Agency)

*Proposed mechanism shall lessen the impact of deviations on the WTGs compared to the present RRF mechanism*
International Experiences
### International Experience: Managing Large Scale Grid Integration

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<td>Twice a day*</td>
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<td>Grid Balancing Provision</td>
<td>Generation Control. Also Provides flexibility of 30%</td>
<td>Mechanisms include bringing variations to generation, linkage to international market and use of spinning reserves</td>
<td>Strong Interconnection to international market</td>
<td>Use of spinning reserve and linkage to International market</td>
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<td>Yes*</td>
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*As on year 2007

**Penetration level indicated in Energy Terms
MNRE: Draft Wind Policy, Feb 2015 (for comments) Objectives for Transmission

- Target to achieve 60 GW (cumulative) by 2022
- Policy aims to work with CTU and STUs on following aspects of transmission infrastructure:
  - Transmission planning at Central and State level may include wind potential and targets
  - To enable interstate off-take, high capacity corridors will be built under the Green Corridors projects
  - Open Access for wind needs to be prioritized and simplified by the States
  - Efforts to be made to bring uniformity in connectivity and metering standards across the states.
  - Efforts will be made to introduce Wide Area Management (WAMS) and other Smart Grid technologies for transmission management (along with associated analytics).
MNRE: Draft Wind Policy, Feb 2015 (for comments) Grid Integration

- **Forecasting and Scheduling:** Compliance to CERC guidelines must be ensured by obligated entities

- **Balancing Resources:**
  - Facilitating creation of large balancing areas and broad-basing the balancing responsibilities
  - Ancillary Services resources to be made available to the System Operators for real time management of the system, through contracts and eventually through a structured and well performing Ancillary Services Market
  - Carrying out Integrated Resource Planning

- **Storage Technologies:** To popularise energy storage technologies for better integration of wind energy projects into grid

- **Power Evacuation:** Curtailment exceeding 1% of the annual operational time, beyond which, State Govts may consider compensating the generator on ‘deemed generation’ basis
Summary of Recommendations

- Increased Private participation in Transmission Infrastructure Development
- Access to sufficient funds for RE evacuation - *Utilization by STU/Private*
- Grid Planning to be aligned for RE
  - CEA level planning body to take care RE
  - STUs to prepare comprehensive plans
  - Stage Grid codes to be amended
- Solar-Wind Hybrid and its benefits to be exploited through suitable policy
- RRF mechanism to be reviewed to reduce ambiguity and to reduce commercial risk level of WTGs
THANK YOU

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