Hybridization of Existing Wind/Solar PV Plants

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Agenda

- Need for development of Wind-Solar Hybrids
- Development of framework for Wind-Solar Hybrids
- Key challenges and potential intervention measures
- Implementation strategy
- MNRE Draft RE Hybrid Policy: Key Suggestions
- Way Forward
Need for Development of Wind-Solar Hybrids

**Improved Land Usage**
- Combined land requirement for wind and solar to be lower than norm of 2.5 Ha/MW

**Shared Evacuation Infrastructure**
- Optimal planning and better utilization of upstream evacuation facilities
  - Excess gen. capacity of ~ 30 to 40 percent at Pooling S/S
  - ROW optimization

**Shared Operations**
- Benefits of shared operations and
- Shared infrastructure (roads, manpower, security, metering)

**Consistent Power Generation**
- Wind and Solar Generation to complement with improved profile
  - Better management of variability
Design considerations for Shared Evacuation Infra.
Evacuation Planning Criteria

• MNRE Draft Wind-Solar Hybrid Policy, (June 2016)
  • The hybrid power injected into the grid will not be more than the transmission capacity/grid connectivity allowed/sanctioned for existing wind/solar project. This will ensure that no augmentation of transmission capacity is required. (ref. MNRE draft Hybrid Policy Clause 5.2 (i))

• CEA (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations, 2010, outline conditions for design of Substation Capacity and Transmission Lines

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Voltage (kV)</th>
<th>Line Loading Capacity (MW)</th>
<th>Sub-station Capacity (MVA) as per CEA Technical Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>400</td>
<td>450</td>
<td>1500 MVA</td>
</tr>
<tr>
<td>2</td>
<td>220</td>
<td>250</td>
<td>500 MVA</td>
</tr>
<tr>
<td>3</td>
<td>132</td>
<td>90</td>
<td>150 MVA</td>
</tr>
<tr>
<td>4</td>
<td>66</td>
<td>27</td>
<td>75 MVA</td>
</tr>
</tbody>
</table>
CEA Transmission Planning Manual for Wind/Solar
Ampacity based Line Loading and Capacity of Substations

CEA’s Transmission Planning Criteria (Manual, 2013)

- CEA has published Manual for Transmission Planning Criteria, 2013 which outlines special dispensation and additional criteria for Wind and Solar Projects.
- The capacity factor for the purpose of maximum injection to plan the evacuation system, both for immediate connectivity with the ISTS/Intra-STS and for onward transmission requirement, may be taken as under:

<table>
<thead>
<tr>
<th>Voltage level/Aggregation level</th>
<th>132kV / Individual wind/solar farm</th>
<th>220kV</th>
<th>400kV</th>
<th>State (as a whole)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity Factor (%)</td>
<td>80 %</td>
<td>75 %</td>
<td>70 %</td>
<td>60 %</td>
</tr>
</tbody>
</table>

- The ‘N-1’ criteria may not be applied to the immediate connectivity of wind/solar farms with the ISTS/Intra-STS grid i.e. the line connecting the farm to the grid and the step-up transformers at the grid station.
- As the generation of energy at a wind farm is possible only with the prevalence of wind, the thermal line loading limit of the lines connecting the wind machine(s)/farm to the nearest grid point may be assessed considering 12 km/hour wind speed.

- Additional Wind & Solar Generation capacity at Existing Grid S/S can be absorbed without significant augmentation requirement.
India is bestowed with vast renewable (wind-solar) potential.

No utility scale hybrid project (wind-solar) has been implemented across the country.

**Comprehensive Study for Development of Suitable Framework** for promotion of hybrid projects was necessary.

Study initiated by **PACE-D TA Program** to comprehensively cover technical, commercial and regulatory aspects of wind-solar hybrid development in **Karnataka & Rajasthan**:

- Identifying challenges for deployment of RE hybrids in the states.
- Formulating suitable regulatory intervention measures and policy framework necessary to address the challenges.
- Enabling framework for existing wind/solar power developers in the states to explore options for the development of Brownfield and Greenfield RE hybrid projects in the states.
Solar and Wind Resource: Potential Mapping for Karnataka

Mapping of Solar and Wind Resource Potential Suggests Ideal Location for Wind-Solar RE Hybrids: Chitradurga, Bagalkot, Gadag and Belgaum
Solar and Wind Resource: Potential Mapping for Rajasthan

Mapping of Solar and Wind Resource Potential Suggests Ideal Location for Wind-Solar RE Hybrids: Jaiselmer, Barmer, Jodhpur, Bikaner
Simulation of Energy Mix: Wind-Solar Generation

Sample Data for Wind Power Project:
- 3 Days for 3 Months
- June to August
- Time-Blocks

Sample Data for Solar Power Project:
- 3 Days for 3 Months (Same Sample Days)
- June to August
- Time Blocks

Boundary Conditions:
- Evacuation Capacity
- Minimizing Generation Curtailment

Wind Generation Profiling

Solar Generation Profiling

Extrapolation for 100 MW Wind Power Project

Simulation of Wind-Solar Generation at Pooling S/S

Extrapolation for Solar Power Plant Capacities (20/30/35/40/45 MW)
Simulation Results:
Wind-Solar Generation Scenario

Utilization of PE system up to 30 to 40 percent of existing wind capacity is possible without constraint.
## Avoided Cost of Evacuation Infrastructure

### Estimated Benefit for the Utilities

<table>
<thead>
<tr>
<th>No. of districts with predominant RE-hybrid potential in <strong>Karnataka</strong></th>
<th>Chitradurga, Bagalkot, Gadag and Belgaum</th>
<th>No. of districts with predominant RE hybrid potential in <strong>Rajasthan</strong></th>
<th>Jaisalmer, Barmer, Jodhpur and Bikaner</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Installed capacity of wind farms in each such districts</strong></td>
<td>Chitradurga</td>
<td>Bagalkot</td>
<td>Gadag</td>
</tr>
<tr>
<td></td>
<td>726 MW</td>
<td>~ 50 MW</td>
<td>716 MW</td>
</tr>
<tr>
<td><strong>Solar capacity that could be added to existing wind farms without PE infrastructure augmentation</strong></td>
<td>30 percent of 1,800 MW = 540 MW (considering additional 30 percent of existing wind installed capacity)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Avoided cost for KPTCL for setting up of evacuation infrastructure of 540 MW (including transmission substation and line cost for 400 kV or 220 kV level)</strong></td>
<td><strong>INR 540 Crore to INR 650 Crore</strong> (Considering expected per MW cost of INR 1 Cr to INR 1.2 Cr for PE infrastructure)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Installed capacity of wind farms in all Districts</strong></td>
<td><strong>Total</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Considering 30 percent of solar capacity that could be added to these wind farms without power evacuation infrastructure augmentation</strong></td>
<td><strong>3,355 MW</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>30 percent of 3,355 MW = ~ 1,000 MW</strong> (considering additional 30 percent of existing wind installed capacity)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Avoided cost for Rajasthan utility for setting up of evacuation infrastructure of 1,000 MW (including transmission s/s and line cost for 400 kV or 220 kV level)</strong></td>
<td><strong>INR 1,000 Crore to INR 1,200 Crore</strong> (Considering expected per MW cost of INR 1 Cr to INR 1.2 Cr for PE infrastructure)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Key Challenges in Wind-Solar Hybrids

Technical Challenges

- **Interconnection Point & Metering Point**
  - Different practices for wind & solar being followed in the state.
  - Clear demarcation of roles (STU/Developer)
- **Transmission and Evacuation Arrangement**
  - Planning Codes/Standards to recognize benefits of hybrid operations (30 to 40%)
- **Metering and Energy Accounting**
  - Need for modification of procedures for Joint Meter Reading and Loss apportionment
- **Forecasting and Scheduling Regime**
  - Rules for F&S and deviation settlement for wind and solar to aligned for hybrid options.

Commercial Challenges

- **Need for Flexibility of Off-take arrangements**
  - Multiple generators/owners with sale options (TPS/Captive/Sale to DISCOM/inter-state) needs to be enabled.
- **Tariff Treatment**
  - Generic hybrid RE Tariff is not necessary.
  - Composition of share of W:S for hybrid would depend upon site specific aspects.
- **Treatment Under RPO**
  - Need to separately track Solar/Non-Solar RPO
- **Clarity on Extending Fiscal/Financial Benefits under Wind Policy, Solar Policy and Investment Schemes to Hybrid RE**
  - Eligible Hybrid RE project(s)/Capacity, share of W:S
Technical Aspects:
Interconnection & Metering Point...1/2

- Clear demarcation of solar generation and wind power generation is important from the perspective of energy accounting, scheduling requirement and RPO compliance.
- Rules for interconnection, metering arrangement for RE hybrids need to address these requirements.
## Technical Aspects:
### Interconnection & Metering Point...2/2

<table>
<thead>
<tr>
<th>Existing Practice</th>
<th>Challenges</th>
<th>Recommendations for Hybrid</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Interconnection Point:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>➢ Presently grid substation to which the wind project is connected</td>
<td>➢ Existing framework not suitable for hybrid</td>
<td>➢ From perspective of RPO compliance <em>wind and solar need to be separately metered</em></td>
</tr>
<tr>
<td><strong>Metering Point:</strong></td>
<td>➢ Existing framework considers single metering point for entire wind farm</td>
<td>➢ Interconnection point to be defined as HV side of pooling substation</td>
</tr>
<tr>
<td>➢ Presently grid substation</td>
<td>➢ Single metering point cannot account for wind and solar generation separately for RPO</td>
<td>➢ Metering points to be defined as either feeder level or individual generator level (i.e., Level ‘1’ or ‘2’)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>➢ As a pre-condition, incoming feeders of pooling station to have all solar or all WTGs connected to it</td>
</tr>
</tbody>
</table>
Technical Aspects:
Energy & Loss Accounting

**Existing Practice**
- JMR conducted at grid substation
- Energy credit on account of individual generator arrived at based on JMR reading and WTG controller data
- Loss apportioning done among WTGs based on JMR reading and WTG controller data

**Challenges**
- Separate energy credit for solar generators is not possible with no separate feeder metering at pooling station
- Separate loss apportionment for solar generator is not possible

**Recommendations for Hybrid**
- JMR to be done at HV side as well as at incoming feeder level of the pooling substation
- Additional metering infrastructure to be in place at each incoming feeder level
- Energy accounting and loss apportionment to individual generator to be based on JMR reading at new metering point at pooling substation and the controller reading
Technical Aspects: Transmission & Evacuation

**Existing Practice**
- Entity for connectivity and planning - STU / Utility
- Responsibility of setting up evacuation facility up to grid S/S – by generator
- Cost of setting up evacuation facility up to grid S/S – by generator

**Challenges**
- Evacuation infrastructure in RE pockets to be strengthened
- Evacuation infrastructure planning - no specific consideration for RE evacuation
- No mechanism in place for sharing cost of evacuation with Utility

**Recommendations for Hybrid**
- **Brownfield project:**
  - Upstream evacuation infrastructure need not be upgraded – avoided cost for Utility
- **Greenfield project:**
  - Optimum capacity evacuation substation to be planned depending on wind-solar hybrid potential in the region
- Transmission infrastructure planning to strengthen grid at wind-solar pockets of state
- State level planning code to give priority for grid planning for RE hybrid
- SNA to assess and notify hybrid potential areas to STU to enable timely grid strengthening
Implementing Brownfield Wind Solar Hybrids

Addressing key challenges

Key Challenges

- Ownership of Existing Facilities (Turbines/Modules)
- Modifications to PPA
- Feasibility of evacuation infrastructure and sharing costs
- Exploring Re-powering opportunity
- Issue of land ownership

Brownfield Wind-Solar Hybrid

Need for encouraging suitable Business Model and devising overarching framework for RE Hybrid
## Suggestions for Overarching Wind-Solar Hybrid Framework

### Project Developers
- Site Identification
- Feasibility Study

#### Site Identification
- Wind resource assessment
- Solar resource assessment
- Assessment Hybrid options for Site
- Topography study and shadow analysis
- Access and infrastructure

#### Feasibility Study
- Detailed Design options & configuration
- Options study for Solar PV technology
- Share of (W:S) Hybrid and Energy yield estimation
- Power Evacuation – options study

### SNAs
- Implementation Plan

#### Implementation Plan
- Develop State level Hybrid RE Programs (phase-wise or brownfield/greenfield)
- Milestone linked incentives for SNA
- Utility Benefit Sharing Model
- Devise strategy for selection of Implementation Partner

### Govt/SERCs
- Policy & Regulatory Intervention

#### Policy & Regulatory Intervention
- State Policies to recognize Hybrid RE for land allotment, fiscal & financial benefits
- Modification to Metering Code
- RPO/FIT regulations
- Amendments to Utility processes on Tx Planning, JMR and Energy Accounting

### Utility/SNA
- Selection of Implementation Partner

#### Selection of Implementation Partner
- Utility/SNA Bidding process
- Implementation Agreement with SNA/Utility
- EPC & O&M contracts for Hybrid RE Park
- Model Off-take Agreements
Hybrid (Wind-Solar) Policy - Goal and Scope

- Ambitious target of 10 GW Hybrid has been proposed.
- However, suitable Business Models need to be devised to encourage planning, development, investment and operationalization of RE Hybrid schemes.
- Multiple stakeholders would be involved at each stage – Utility, Developer, Generators, Off-takers: Concerns of all stakeholders need to be addressed.
- Policy need to address all scenarios of Hybrid RE - covering multiple owners, separate owners for wind/solar, multiple off-takers, brownfield/greenfield within RE Hybrid project scheme.
Wind-Solar Hybrid Systems: Eligibility and Scope

• Definition of Hybrid RE and Eligibility conditions need to be clearly defined.

• Optimisation of the benefit of Hybridisation from Utility perspective for Power Evacuation is the key.

• Promoting co-located Hybrid RE systems at level of Pooling S/S would maximise benefit of aggregation and Hybridisation rather than Turbine/Module level.

• Technology for Hybrid, (AC/DC integration) etc. may be left for market to decide. Standards for DC meters would be challenge.

• For Brownfield Hybrid RE, Balance Useful Life should be important determinant.
Draft MNRE RE Hybrid Policy:
Key Suggestions...3/4

Hybridization of Existing Wind-Solar PV Plants: (Brownfield)

• For RE Hybrid, Transmission Capacity should be linked to ‘Ampacity based Thermal Line Loading’ as per CEA planning criteria for wind/solar.

• Existing condition would actually limit Hybrid RE capacity.

• Our studies in Karnataka and Rajasthan suggests the hybridization (upto 30%-40%) is feasible within existing PE capacity.

• Policy should encourage different off-take arrangements with multiple owners for RE Hybrid project scheme.
Draft MNRE RE Hybrid Policy: Key Suggestions...4/4

New Wind-Solar Hybrid Plants: (Greenfield)

• Need for separate determination of ‘Hybrid RE’ Tariff at this stage does not arise.

• Separate off-take arrangement with independent Tariff arrangement(s) for Wind/Solar within Hybrid RE project scheme can co-exist and need to be encouraged.

• The Policy should encourage different off-take arrangements with Multiple Owners for Hybrid RE project scheme.

• Incentive Scheme and/or Grant to Utility and Project Developers to devise Hybrid RE schemes may be put in place.
Way forward

• Model Policy Guidelines for Wind-Solar Hybrid Project Development for:
  • Existing (Brownfield) Wind-Solar Hybrid Projects
  • New (Greenfield) Wind-Solar Hybrid Projects

• Model Regulatory Framework for Wind-Solar Hybrid
  • Modifications for Grid Connectivity, Metering Code and Planning Code.

• Development of Pilot Wind-Solar Hybrid Scheme:
  • Devising Implementation plan in consultation with SNA/State Utility
  • Development of Standard Documentation for Wind-Solar Hybrid projects
Thank You

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