Green Power - Renewable energy Integration in the Smart Grid

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Presentation Flow

Challenges to Indian Power Sector and Smart Grid

RE integration with Grid
   Commercial Issues and solutions
   Technical Issues and Solutions

RE and Smart Grid

Few RE smart Grid Pilots as Proof of Concepts

Conclusion
The Challenge

The link between electricity and economic growth remains unbroken so the challenge is much the same i.e. adequate supplies of reliable electricity at low cost. But:

• Economic expansion and population growth are driving electricity demand.
• An increasingly digital world has amplified the need for high-quality electricity.
• A global construction boom is underway, increasing competition for resources.
• Meanwhile, some potential game changers are developing
  - Smaller-scale generation
  - Renewable energy
  - Storage
  - Electric vehicles
  - Large pool of ICT professionals

Meanwhile, the long-term trend for the cost of electricity has turned up due to increasing fuel prices and a climate emergency demands more efficient use of natural resources.

Thus, business as usual is not a sustainable option.
Smart Grid-India Objective

**T & D Performance**
- Loss Reduction
- Peak Reduction
- Supply reliability improvement
- CAPEX and OPEX optimization

**RE Integration**
- Growth of RE, its Integration and Storage
- Rural Outreach
- Carbon reduction
- Network efficiency

**Customer Engagement**
- Customer choices and interactions available (tariff & services)
- Effectiveness of demand side management

A Balanced Scorecard covers the Supply Side and Demand Side
The push for renewable additions poses several challenges

- Although renewable resources will reduce carbon footprint, they present several challenges:
  - Unreliable/volatile: Wind tends to blow the hardest at night, when the demand for power is low. Sunshine can lose its intensity in seconds if eclipsed by a cloud, unreliable for steady power flow
  - Location: renewable generation is based on location of fuel supply, which might not be available in highly congested location
  - Transmission: getting renewable power to the “market”
  - Price Disparity: Renewable energy is often expensive over coal thermal resources

- Ultimately, policy must focus on the appropriate level of incentive and creating sustainable market based mechanisms to ensure reliability

**Wind Potential**  **Solar Potential**

Source: mnes.nic.in
Smart grids will maximize the potential of renewable generation, and can shift some power demand to off-peak hours

- The aging and outdated electrical grid will need major updates in order for renewable capacity to be fully utilized. A smart grid is an illustration of a possible modernization to the electricity grid.

Source: EPRI and Wall Street Journal
Issues and solutions related to connecting renewables

Commercial Challenges
**Commercial Challenges**

- The cost per Mega Watt for Renewable Energy is **HIGH** compared to Thermal Generation.

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**Table 1. Estimated Levelized Cost of New Generation Resources, 2016.**

<table>
<thead>
<tr>
<th>Plant Type</th>
<th>Capacity Factor (%)</th>
<th>U.S. Average Levelized Costs (2009 $/megawatt-hour) for Plants Entering Service in 2016</th>
<th>Total System Levelized Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional Coal</td>
<td>85</td>
<td>65.3 3.9 24.3 1.2</td>
<td>94.8</td>
</tr>
<tr>
<td>Advanced Coal</td>
<td>85</td>
<td>74.6 7.9 25.7 1.2</td>
<td>109.4</td>
</tr>
<tr>
<td>Advanced Coal with CCS</td>
<td>85</td>
<td>92.7 9.2 33.1 1.2</td>
<td>136.2</td>
</tr>
<tr>
<td>Natural Gas-fired</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conventional Combined Cycle</td>
<td>87</td>
<td>17.5 1.9 45.0 1.2</td>
<td>66.1</td>
</tr>
<tr>
<td>Advanced Combined Cycle</td>
<td>87</td>
<td>17.9 1.9 42.1 1.2</td>
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<tr>
<td>Advanced CC with CCS</td>
<td>87</td>
<td>34.6 3.9 49.8 1.2</td>
<td>89.3</td>
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<tr>
<td>Conventional Combustion Turbine</td>
<td>30</td>
<td>45.8 3.7 71.5 3.5</td>
<td>124.5</td>
</tr>
<tr>
<td>Advanced Combustion Turbine</td>
<td>30</td>
<td>31.6 5.5 62.9 3.5</td>
<td>103.5</td>
</tr>
<tr>
<td>Advanced Nuclear</td>
<td>90</td>
<td>90.1 11.1 11.7 1.0</td>
<td>113.9</td>
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<tr>
<td>Wind</td>
<td>34</td>
<td>83.9 9.6 0.0 3.5</td>
<td>97.0</td>
</tr>
<tr>
<td>Wind – Offshore</td>
<td>34</td>
<td>209.3 26.1 0.0 5.9</td>
<td>243.2</td>
</tr>
<tr>
<td>Solar PV^1</td>
<td>25</td>
<td>194.6 12.1 0.0 4.0</td>
<td>210.7</td>
</tr>
<tr>
<td>Solar Thermal</td>
<td>18</td>
<td>259.4 46.6 0.0 5.8</td>
<td>311.8</td>
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<tr>
<td>Geothermal</td>
<td>92</td>
<td>79.3 11.9 9.5 1.0</td>
<td>101.7</td>
</tr>
<tr>
<td>Biomass</td>
<td>83</td>
<td>55.3 13.7 42.3 1.3</td>
<td>112.5</td>
</tr>
<tr>
<td>Hydro</td>
<td>52</td>
<td>74.5 3.8 6.3 1.9</td>
<td>86.4</td>
</tr>
</tbody>
</table>

^1 Costs are expressed in terms of net AC power available to the grid for the installed capacity.

Commercial Solutions

– Renewable Obligations (ROs)
– Feed in Tariff (FIT)
– Renewable Energy Certificates (RECs)
– Net Metering
Cost Benefit Analysis May warrant a Broad Approach

- The Smart Grid’s transformational potential warrants inclusion of societal benefits and externalities. Smart grids could:
  - Reduce carbon emissions and improve public health
  - Create jobs, enhance agricultural security, stimulate economic growth and provide other benefits outside conventional projects.

Should we continue to ignore the cost of externalities as it is difficult to monitor?
But regulator wants to know the payback

- Societal benefits and externalities are important issues ...

- But many regulators want to know the impact of a Smart Grid program on rates ... NOW.

- Who will pay ... and how much ... are becoming pivotal issues
Issues and solutions related to connecting renewables
Technical Challenges

• Typical technical challenges associated with connecting renewable energy to the grid:
  – Intermittent Availability
    • Fluctuating Frequency
    • Stability issues due to the above
    • Damage to equipment due to the above
    • Difficult to forecast
Incorporating other complementary technologies, such as solar and battery storage, will help balance daily variability due to wind.

- **Solar plants** - generate during the day, when wind typically slows down.
- **Utility-scale batteries** - can store power for when wind declines, and are beginning to build interest.
- MV DC link
- Static Compensator
Renewables & Smart Grids
Renewables and Smart Grids

• Smart Grids offer a way to integrate and utilise renewable energy more effectively.

• Renewable energy will therefore be a driving factor for the evolution towards smart grids.
Micro-Grids:

Optimising Renewable Energy

- Located in buildings, factories, villages, small towns, islanded grid systems.
- They allow for the integration of renewable energy systems.
- They usually contain energy storage.
- They normally have enough generation capacity to supply local loads.
- Ideal for sensitive installations or remote locations.
Micro-Grids

- **For customers,** Microgrids enhance local reliability, reduce emissions, improve power quality and lower the costs of energy.

- **For Utilities,** Microgrids can be controlled as aggregated loads or generators and can provide ancillary services.

RE Smart Grid Pilots as Proof of Concepts
## Distributed RE Generation

### Business Case

One of the most incorrigible problems in India’s power sector is the rural-urban divide. The low customer density in rural areas, and more so in remote rural areas, creates an inherent disincentive to expand the grid. And when the grid is extended, this phenomenon (coupled with low income levels) creates a disincentive for utilities to “extensify” electricity access to more people. The purpose of this task would be to identify low cost energy solutions that do not require grid access and promote them in rural areas. Applications could include existing technologies, e.g. solar water heating but also other limited techniques to provide high-impact access to electricity, e.g. community internet access for medical and educational purposes, to enable farmers to check commodity prices, etc. The concept would be to install an RE source (e.g. a solar panel) that would provide sufficient power to operate an inexpensive laptop and fund it by donor agencies or GOI program to increase education reach.

### Implementation Approach

<table>
<thead>
<tr>
<th>Implementation Approach</th>
<th>Key Challenges &amp; Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Create Micro Grid</td>
<td>• Involvement of local community?</td>
</tr>
<tr>
<td>• Use 90% capital subsidy from GOI in RGGVY scheme</td>
<td>• Sustainability of model</td>
</tr>
<tr>
<td>• Support of nearby Industrial house</td>
<td>• Roll out on larger scale after successful pilots</td>
</tr>
<tr>
<td>• Develop an economic model, evaluate costs and benefits and assess funding options</td>
<td>• Connectivity with main Grid</td>
</tr>
<tr>
<td>• Plan demonstration pilots for several different regions, e.g. those with good solar potential, good wind, etc.</td>
<td></td>
</tr>
</tbody>
</table>

### Benefits

- Basic source of electricity for rural villages, esp. remote villages
- Enhanced access to basic health care knowledge
- Remote learning capability (e.g. farming techniques, health care, etc.)
- Enhancing Socio-economic life
- Education of children
- TV use entertainment
- Open rural markets for many electronic/electrical gadgets
- Generates employment

### Costs

- The initial capital cost could be significant
- Installation and O&M costs are unknown
- Sustain ability cost and its funding

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www.maritimesecurityafrica.com
# Micro grid for a House or a Community

## Business Case

80 thousands villages are un electrified. About 30% of the country’s electricity consumption is in rural India with almost no return to utility. Govt of India has committed to provide electricity to all by 2012 and is proving 90% subsidy for rural electrification. There is a demand supply gap of about 11% and it is likely that even revised generation targets of 11th five year plan will meet. In rural areas abundance of untapped RE sources. A self contained grid for an house or a community can be created with a provision to feed in and taken in grid supply if available. Otherwise a dc grid with storage capacity can be created. This will help in increasing availability of power supply in urban areas. The availability of electricity in rural areas will improve the scio-economic life of the rural masses tremendously.

<table>
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<th>Implementation Approach</th>
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</tr>
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<tr>
<td>• Study of RE potential on community/village basis</td>
<td>• Capacity building to operate, maintain and use.</td>
</tr>
<tr>
<td>• Develop DC appliances for use.</td>
<td>• Development of DC appliances</td>
</tr>
<tr>
<td>• Capacity building to operate, maintain and use.</td>
<td>• Safety</td>
</tr>
<tr>
<td>• Develop an economic model, evaluate costs and benefits, and assess funding options</td>
<td>• Uncertainty with availability of RE sources.</td>
</tr>
<tr>
<td>• Plan demonstration pilots for several regions with different RE.</td>
<td>• A robust technology model as a proof of concept.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Increase availability of power supply in urban and rural areas.</td>
<td>• The initial capital cost could be significant</td>
</tr>
<tr>
<td>• Improved socio-economic life in rural India</td>
<td>• Capacity building and safety</td>
</tr>
<tr>
<td>• Employment generation in rural India.</td>
<td>• High developmental cost</td>
</tr>
<tr>
<td>• Efficient use of resources.</td>
<td></td>
</tr>
</tbody>
</table>
Globally renewable generation will continue to expand, and changes will ultimately be required to accommodate it. Smart Grid provides ready answer.

A diverse and flexible generation fleet, transparent price signals, and transmission upgrades will all be required to incorporate wind while maintaining a reliable and stable grid.

- Spatially diverse transmission system to balance local variations
- Smarter grids to adapt to variability
- Advanced grid technologies

- Adequate capacity and ancillary services market
- Fast time signals to adjust generation on time
- Locational signals to guide dispatch and incent transmission and generation builds

- Sufficient peaking capacity will be required
- Complementary generation such as solar and battery storage
The secret to survival is to embrace change and to adapt
For further details pl. feel free to contact TetraTech ES India Limited Gurgaon India

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Thank you