Indian Wind Power

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Grid Management with Large Scale Renewable Energy in the Grid


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The Government of India has set a target of 175 GW renewable energy capacity additions, with 160 MW of capacity addition expected from solar and wind put together. In order to accomplish the target, the Government has initiated steps such as competitive bidding, resulting in large-scale capacity addition as well as significant decrease in the cost of electricity produced from renewable energy. Owing to these initiatives, India boasts 71.5 GW of grid connected renewable energy installed capacity (excluding large hydro power) as on July, 2018. Wind energy has been a flag bearer in the renewable energy sector having 34.4 GW capacity and thus comprising of around 50% of the total installed renewable energy capacity.

Source	Total Installed Capacity (MW)	Target for 2022 (MW)
Wind	34,402	60,000
Solar	23,115	100,000
Biomass	9,378	10,000
Waste to Power	138	
Small Hydro Power	4,493	5,000
Total	71,526	175,000

With the renewable energy sector in the country poised to achieve the target, it is imperative that necessary grid infrastructure facilities have to be in place to enable seamless integration of renewable energy. Further, managing the grid effectively with a never before level of proliferation of renewable energy, is the key.

The development of India's interstate green power corridor is a major policy initiative that is motivating the rapid deployment of renewable energy infrastructure. Since many states are falling short of meeting Renewable Power Obligation (RPO), the renewable energy surplus generation states like Tamil Nadu and Karnataka, are likely to be much in demand in the national market. In February, 2018, the Central Government extended the waiver of interstate transmission charges and losses for first 25 years of operation from date of projects commissioned till 2022, to facilitate more inter-state transactions.

In the recent times, the transition to an auction-determined tariff regime stimulated large-scale renewable energy addition year-over-year. In the coming years, the proliferation of renewable energy would significantly increase. The increasing share of renewable generations in the grid has impacted the traditional approach of load-generation balancing in the grid. The renewable sources with un-priced fuel such as wind and solar power are intermittent in nature that is their output depends on external conditions, such as sunshine or wind. In such circumstances, safety and security of the grid would be paramount and hence, cannot be compromised.

To address the grid management with more renewable energy capacity addition, the following issues are deliberated in the article:

- Grid Stability
- Managing Resource Variability & Intermittency
- Forecasting and Scheduling
- Impact on Conventional Generators

A. Grid Stability

Grid Stability becomes a major issue especially when there is high penetration of renewable energy. Majority of the existing renewable energy installations does not have capabilities to support the gird in the event of transients. For instance, most of the wind plants installed are not Fault Ride Through (FRT) capable, leading to collapse of the grid due to sudden loss of large chunk of renewable energy generation. The basic technical challenge comes from the variability of wind and solar power affecting the load generation balance and varying demand for reactive power, and has an impact on voltage stability. However, the burgeoning problem lies in the sudden loss of wind generation, which has a much more cascading effect as opposed to the gradual variability.

The non-availability of real time data of renewable energy generation to SLDCs is another important issue compounding the problem, particularly in renewable energy rich states. The real time data integration of renewable energy to SLDC's SCADA system is far below 100%. However, the availability of real time data has improved in some states such as Karnataka and Gujarat in the recent past. In order to ensure safe, secure and optimal operation of the overall grid, there is a need to improve coordination between conventional generators, renewable energy generators and State Load Despatch Centre (SLDC).

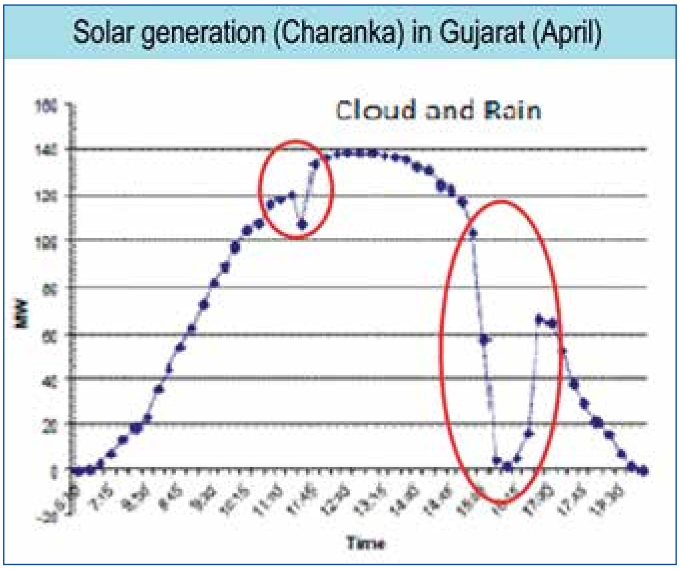


Figure 1: Solar Generation in Gujarat

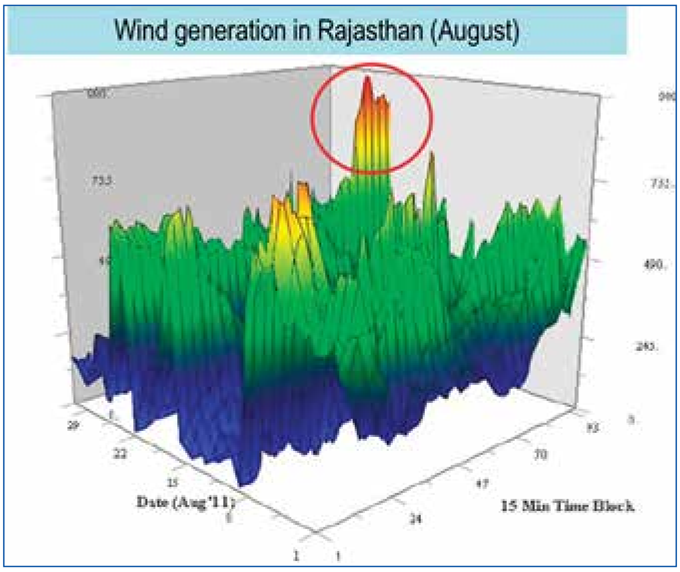


Figure 2: Wind generation in Rajasthan

B. Managing Resource Variability & Intermittency

Large scale renewable energy integration with grid has significant challenges which are both technical and economic in nature. The intermittent generation from renewable resources, due to seasonal weather fluctuations introduces uncertainty in the generation trend of days and months. System operators would find it difficult to balance the grid with sudden rise or fall of renewable energy in the grid.

The above graph scenarios show that sudden fall in solar generation due to clouds and rainfalls. There is no sufficient hydro/gas based power plants in the grid to balance the sudden downfall. Due to high penetration of wind (being seasonal), the thermal generators have limited ability to back down due to technical minimum generation. One approach to address the variability of renewable generation is capacity addition of conventional load following generating stations such as hydroelectric plants and gas based plants. As per Energy Storage Report published by CERC, the use of load following generating stations is not limited to variation of load, but its use is now extended to counter the variability of renewable generation. The higher penetration of renewable generation will require higher capacity of load following generating stations. The balancing through the conventional load following generating stations such as hydroelectric plant and gas based thermal plant would not be adequate. The renewable generation dominated states use coal based thermal generating stations to counter balance the variability of the renewable generation. However, regulating generation output of coal based thermal generation plants; to address the variability of renewable generation is not recommended based on number of considerations including uneconomical cost and challenges involved in practical implementation.

Managing the duck curve phenomenon with advent of large scale solar in the grid is perceived as another major challenge for grid stability. As per the duck curve phenomenon, ramp up rate increases significantly during the evening time of the day when contribution from Solar generation recedes, however demand pick up. The existing conventional generation sources are not sufficient to provide such high ramp rates in the grid. In this context, it is worthwhile to note that wind generation can be of rescue in such situations, whereby wind can provide sufficient support to the Grid. Wind generation peaks in the evening when solar generation recedes and thus reduces the duck curve impact (of high ramp up requirement) on the grid. This very feature establishes the need for promoting wind hand-in-hand with solar. The following graphs depict the wind generation profile that establishes the above argument.

Alternately, other options for addressing the duck curve challenge includes Wind-Solar Hybrid, Energy storage, Pumped storage, Electric vehicles, Grid strengthening which needs to be explored. Out of these options, Wind Solar Hybrid has many advantages as Wind and Solar generation complement each other. Other benefits of the Wind Solar Hybrid projects include improved land usage, shared evacuation and shared operation infrastructure. In order to provide adequate policy and regulatory support for large scale deployment of such projects, the Government announced National Wind Solar Hybrid Policy. The following figure highlights the modulation in the generation profile that wind-solar hybrid solutions can offer. The graph on the left hand side shows independent generation profile of wind-solar Hybrid and the one at the right hand side shows the net-generation considering hybrid benefit.

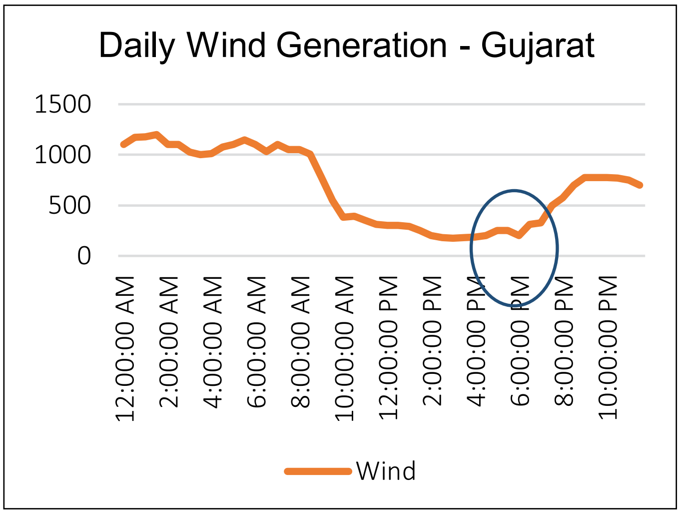


Figure 3: Daily Wind Generation – Gujarat

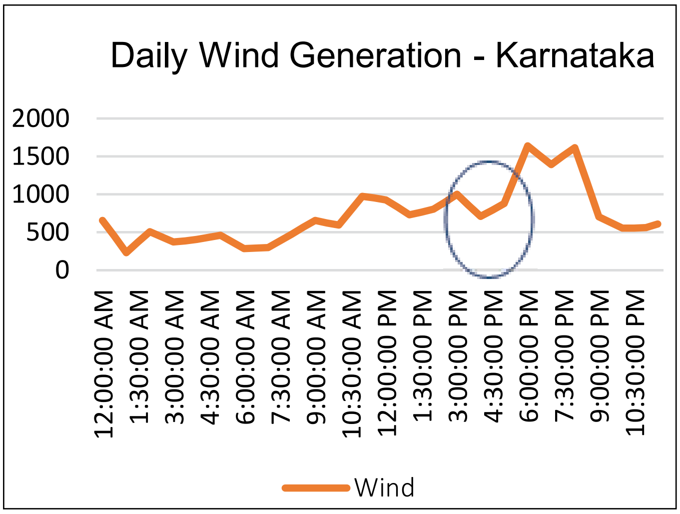


Figure 4: Daily Wind Generation – Karnataka

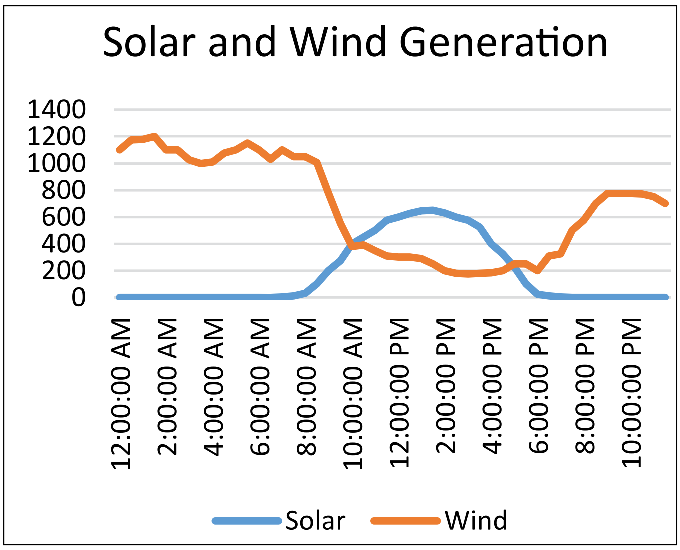


Figure 5: Solar and Wind Generation

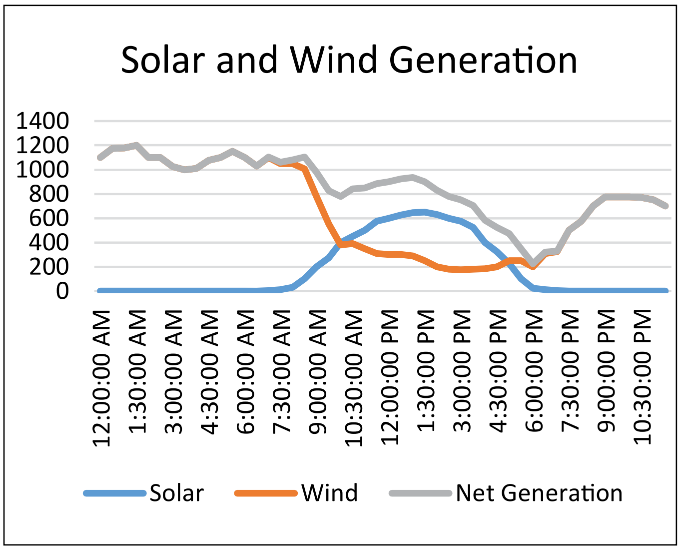


Figure 6: Hybrid Generation Profile

Fact Check

International study shows that variable renewables are not threat to grid reliability.

If the grid reliability in other countries are studied and compared to US, Denmark and Germany, which host some of the highest levels of non-hydro renewables in the world, have 10 times fewer minutes of outages each year. Germany and Denmark have two to four times the renewables of the USA. Still, the presence of very high amounts of renewable energy in European countries made possible with sophisticated grid management techniques does not itself make the grid less reliable.

(Source: Greentechmedia)

C. Forecasting and Scheduling

The practice of forecasting renewable energy generation and scheduling the same can be a potential and economical solution to tackle the issues posed by resource intermittency and will facilitate better balancing of the grid.

Most of the existing wind and solar generating stations are directly connected to the state grid and hence they fall under the operational control area of the respective SLDCs. The SLDCs/RLDCs are mandated by the Electricity Act to keep account of the electricity in the state/regional grid. Forum of Regulators (FOR) has published model state-level framework for Forecasting and Scheduling that outline a methodology of forecasting, scheduling and commercial settlement of intra-state renewable energy generators. However, implementation of such mechanism at state level would be quite challenging as the roles and responsibilities of the SLDC increases with the higher volume of generators; and more participants for off-take. With envisaged large scale integration of renewable energy in the state as well as interstate level, the number of players, energy transactions, market volume, complexity of pool administration would increase manifold. Further, different models are adopted in different states depending on applicability, which leads to practical difficulties in implementation of policies and regulations. The solution is to develop a forecasting and scheduling model that fits for all permutations and combinations for all participants.

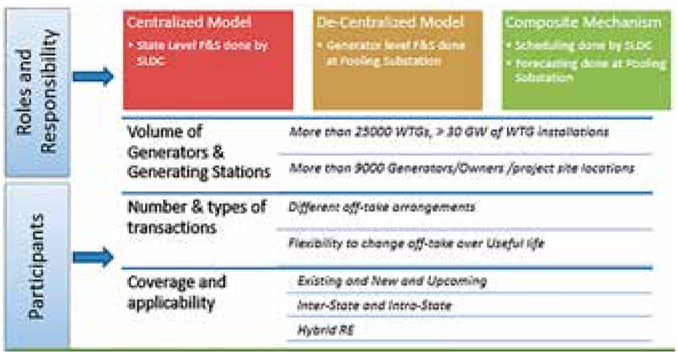


Figure 7: Premise for Establishing a Robust Forecasting and Scheduling Framework

As per present scheduling regulations, decentralized scheduling is adopted, which means that each wind farm submits its schedule to the system operator. It is observed that most countries prefer centralized or cluster-based scheduling with the concept of virtual power plants. The practices followed are:

➢ Centralized scheduling for committed wind farms through PPA: An independent body or system operator schedules and forecasts on behalf of all the wind farms.

➢ Individual wind farms who participate in the market: The wind farms participate in the open electricity markets through bidding process and settlement takes place according to the market rules. Here, scheduling & forecasting is the responsibility of the wind farm owners.

There are advantages and disadvantages of both centralized and decentralized approaches. For power system operation and security, the centralized mechanism is preferred.

The, Composite Model (Scheduling done by SLDC and Forecasting done at Pooling Substation) combines the advantage of all models and safeguards generators against individual forecast risk. Hence, a solution that fits for all permutations and combinations for all participants has to be developed.

D. Impact on Conventional Generators

The higher penetration of renewable energy also has an adverse impact on conventional generators (such as coal and gas power plants). In order to accommodate renewable energy, coal and gas power plants need to be backed down. Under the flagship PACE-D (The US-India joint partnership) programme, a Committee published a report on "Greening the Grid (GTG)" which suggests various pros and cons of addition of 100 GW solar and 60 GW wind in the National grid. The following figure depicts the impact as highlighted in the said report.

(Source: GTG Report)

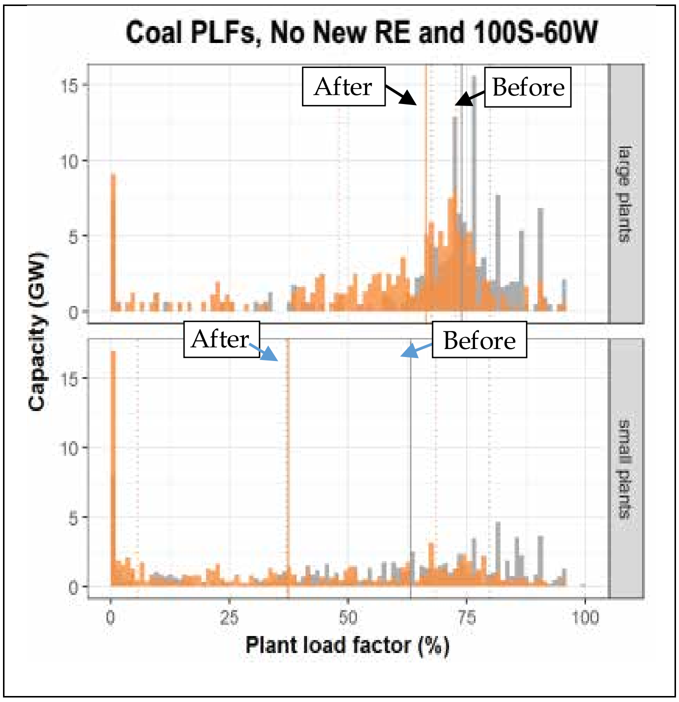
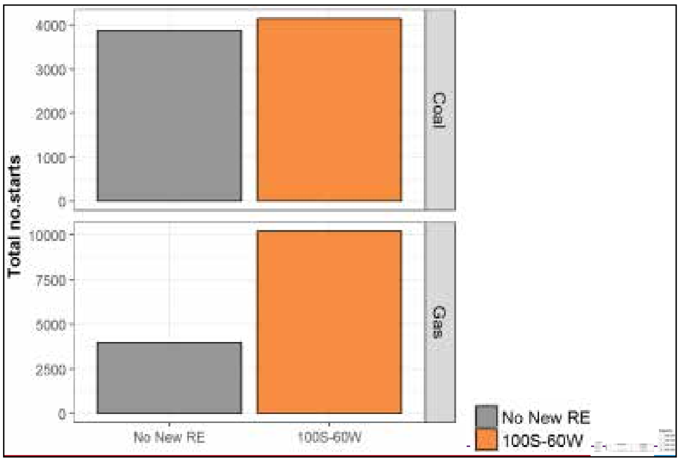


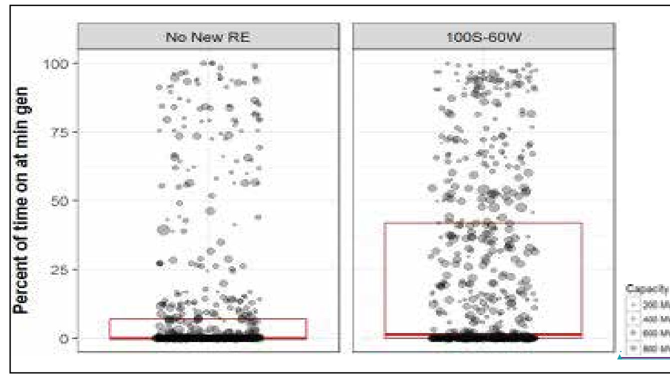
Figure 8: Impact on Coal PLFs & no. of starts under No New Renewable Energy and 100S 60W scenarios

In 100S-60W (100 GW solar and 60 GW wind scenario), the average coal Plant Load Factor (PLF) would drastically fall down as compared to no new renewable energy capacity addition scenario. The same results are applicable to gas based power plants as well. The report states that gas power plants would have to face more start-ups and spend more time at minimum generation. The graph depicts the total number of start-ups for coal (top) and gas (bottom).



(Source: GTG Report)

Figure 9: Impact on number of starts under No New Renewable Energy and 100S 60W scenarios



(Source: GTG Report)

Figure 10: Impact on Online Status at Minimum Generation of Coal Plants

The report further states that the percentage of time, the coal power plants spends online at minimum generation (minimum stable level), also increases under the 100S-60W scenario as compared to no renewable energy capacity addition scenario.

As can be seen from similar studies, large scale renewable energy integration is envisaged to have impact on conventional generators, however through appropriate compensation for such generators coupled with grid management regulations could bring in win-win situation for the stakeholders involved.

Conclusion

Addressing grid management issues upfront, is the key for increasing acceptability of more and more renewable energy in the grid. Sustainable efforts has to be put while adopting green energy and the countries resources has to be optimally utilised while evaluating the production costs on a continual basis. In the long-run, bearing in mind the interest of developers, institutions, Regulatory Commissions, utilities, funding agencies and other stakeholders in power sector, a coherent approach has to be followed to tackle the issues discussed and an energy plan could enable to handle more green power penetration.

Snippets on Wind Power

European Investment Bank, SBI Expand Cooperation in Wind Energy Financing

The European Investment Bank and State Bank of India have agreed to cooperate on financing renewable energy and providing new support for wind energy projects across India by expanding the ongoing financing initiative in the field of onshore wind projects. With this collaboration, the promoters of wind projects in India will benefit from long-term low cost financing under the dedicated EUR 600 million renewable energy financing programme that is already supporting large-scale solar investment across the country. EIB has also approved a new line of credit to Yes Bank to boost private investment in clean energy projects.

Floating Wind Farm in Portugal

A consortium led by Portugal's EDP Renewables (EDPR) will invest 125 million euros ($144 million) over three years in a 25 MW floating offshore wind farm in the Atlantic about 20 km off the coast of Viana de Castelo in northern Portugal. The project, Europe's second floating wind farm, involves anchoring three turbines on semi-submersible platforms at water depths of up to 100 meters with each turbine of 8.4 MW capacity. The European Investment Bank (EIB) is providing 60 million Euros of the funding for the new wind farm. Offshore floating wind farms are an attractive alternative energy source because they open up areas of deep ocean to harness energy, unlike fixed offshore wind turbines that need to be installed in shallower coastal waters.

Source: REUTERS, 20 October 2018

Country's Tallest Hybrid Concrete Tubular Wind Turbine Generator Commissioned by Suzlon

Suzlon has commissioned the first prototype of country's tallest hybrid concrete tubular Wind Turbine Generator. The 140 metre tall tower in Tiruneveli district is a combination of concrete base and foundation, supporting a tubular steel tower and avoids exponential increase in weight and costs of steel tubular towers. The S120 rotor incorporates fourth generation rotor aerodynamics and enhanced pitch control systems to reduce overall loads.

Source: PTI, Chennai, October 3, 2018