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SOLAR & WIND POWER INTEGRATION IN INDIA: A CONCEPT OF BRIDGING THE ENERGY GAP

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Abstract

The high demand of energy in India makes it necessary to utilize the available renewable energy resources in India in an integration manner. In this way Government of India has set targets for renewable power installation capacity to 175 gigawatts GW) of generation capacity from wind, solar, biomass and small hydropower by 2022. In addition to this, the vision with India's Nationally Determined Contribution target of 40% renewable electricity capacity (including hydropower) by 2030 was set by GOI in 2015. To achieve these goals, Govt. of India has taken numerous initiatives like National Solar Mission; tariff based competitive bidding for wind & solar power plants, incentives given to renewable power generators and renewable power obligation for distribution utilities etc. This research outlay the steps & processes to achieve the solar & wind power integration to benefit the Indian Power sector & bridging the demand supply gap of energy requirements. Annual growth rates of over 30% in the last four years, with solar alone growing 82% in 2016.

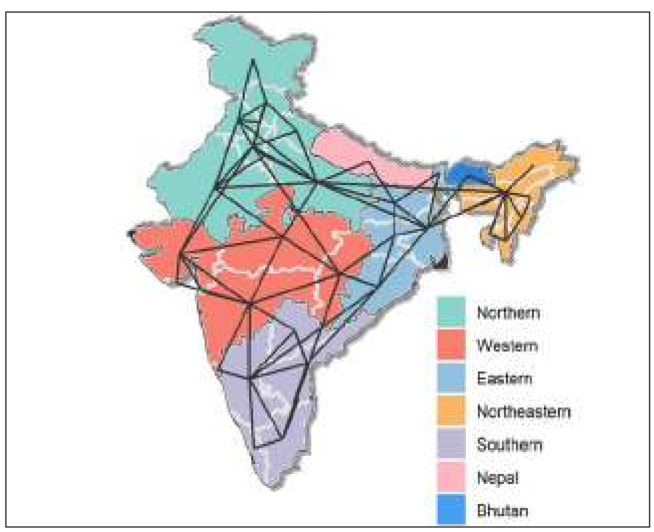
***Keywords*:** RE (Renewable Energy), CEA (Central Electricity Authority), CERC (Central Electricity Regulatory Commission), T&D (Transmission & Distribution), SLDC (State Load Dispatch Centre), STU (State Transmission Utility), BEE (Bureau of Energy Efficiency), TERI (The Energy and Resources Institute), PASA (Projected Assessment of the System Adequacy), ICT (Information & Communication Technology), MT(Mid Term), ST (Short Term), PLF (Plant Load Factor).

Introduction

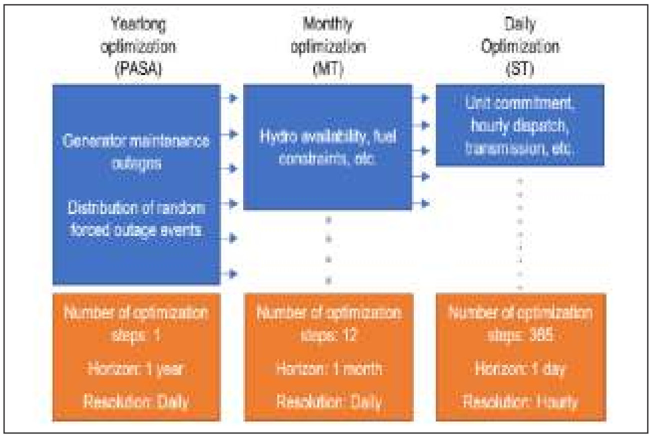
As per the research of IIT Patna in collaboration of TERI, India's energy demand will grow by more than 35% in year 2040. By the collective efforts of govt. agencies & private players, the annual growth rate of renewable power installation capacity has been increased over 30% in the last four years, with solar alone growing 82%. As a consequence of the targets and rapidly falling RE prices, the generation mix is changing, and the operations, planning, and regulations are similarly evolving. The CEA and the CERC recently form a number of regulations and policies aimed at improving the energy efficiency & making market reforms. With these significant changes to India's power system, this report is about the operational challenges for India's power grid by 2030

Modeling Grid Operations in India

India's National Grid is a synchronous interconnection of all Indian states and UTs. A large portion of the management and operation of the grid is handled by the state-level in the form of STUs, SLDCs, and state generation companies. Therefore, this production cost model is built around the state-level distinctions with unique demand profiles for each state and UT, as well as transmission representation between state networks. This spatial granularity allows for insights into the state-level challenges and solutions in balancing supply and demand. Regional balancing, a key factor in maintaining reliability and coordination among India's states, is also considered through the representation of region-to-region transmission constraints in addition to state-to-state transmission. The below shown figure is for illustrates the transmission representation in the model, in which each solid line represents a unique transmission corridor in the simulation.



The suggested model is solved through a series of optimization steps, which reduce the longer constraints into manageable steps as shown below:



Capacity additions at the unit level to accurately represent National Energy Plan projections and also reflect the geographic distribution of generation capacity projected for 2030. RE is represented in the model with high spatial and temporal granularity, using the same resource data (wind speed, solar irradiance, etc.) from GTG, but with site selection performed by TERI to reach the 275 GW capacity target. Wind resource availability has spatial granularity of 3x3 km2, and solar 10x10 km2.

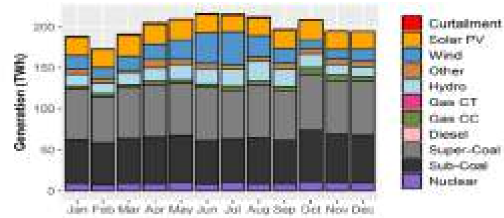
Conventional installed capacity of conventional resources is shown below:

	Diesel	GT-Gas	Hydro	Nuclear	Coal	Total
CEA values as of March 2018 (source: data provided by CEA) **plus NEP additions 2017-2027** (Chapter 5) (CEA, 2018)	701.6	25,635.5	80,354.7	16,980.0	278,388.6	402,060.4
NEP retirements 2017-2027 (Chapter 5) (CEA, 2018)		177.0			51,798.0	51,975.0
Final installed capacity for 2030*	701.6	25,518.5	80,354.7	16,980.0	226,740.6	350,295.4

* Discrepancies exist between the CEA installed capacity projections for 2027 and our final installed capacity. This is due to slight differences in plant-wise capacity that we inherited from the GTG database (based on direct input from POSOCO and other stakeholders).

Expected Power Generation in India

Annual generation from India in the 2030 model year would be appx. 2400 TWh, with appx. 60% generated by coal, appx. 25% generation from wind and solar and hydro 9%. Energy generation from wind and solar would be appx. 550 TWh in the 2030 model year, with relatively large variations between months. October has the lowest variable renewable generation month with 33.4 TWh, with the highest being July with 60.0 Twh



*Source: TERI report

The above figure shows the expected power generation pattern of 2030.

Demand & Supply balance

The ability of the generators to reach full output during peak periods, combined with the total installed capacity, indicates that there should be an adequate supply of generation. However, unserved energy occurs because available capacity is not present due to thermal and gas generators being turned off for outage. Maintenance outages are distributed throughout the year to maximize capacity reserves, resulting in a somewhat optimal distribution of maintenance events that avoid outages during peak load times. However, the state-centric structure of our model is also considered in the scheduling of outages, which convolutes the planning for peak load periods. Each state seeks to reduce the outages of its fleet during the individual state peak demand.

Conclusion

This report analyzed the base scenario, in which penetration of wind & solar power generation would reach upto 25% to total installed capacity. Added to these PLFs of coal plants, which is also one of concern should rise to 70% (as from current level i.e. 60%), giving better signals for revenue sufficiency. With curtailment of RE at 2.3% without any major changes to current or planned system operations, the trajectory of system plans is, from an operations perspective, not substantially different from what might be expected in 2022. This research also offers of the possible outcome of increased transmission capacity. Operational cost savings and increased system efficiency are the principal outcomes of increasing interstate and inter-region connection capacity. Most of the cost benefit and reduction in RE curtailment of increased transmission is realized when the intra-region transmission system is expanded. This research establishes a baseline scenario roughly in line with India's electricity system planners for India's 2030 electricity system. Future work also involves a broader set of analysis with different scenarios for capacity of both generation and transmission.

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