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Disruption in Motion

India Energy Transition Fuels Growth Path for Sustainable Development

Over the past few years, India has added huge electricity generation capacity, resulting in an impressive reduction in its energy and peak deficits to just 0.4% and 0.6% respectively by June 2019, even as electricity demand has grown 5-6% annually.

The country's electricity supply has historically been largely coal-dominated, with 194GW currently operational. However, in the last 2-3 years, the share of solar and wind generation, although still low, has been increasing rapidly.

India has set exceptionally ambitious renewable energy targets, including 175 gigawatts (GW) of renewables (RE) by 2022, and 275GW by 2027, with the aim of achieving 40% of electric power installed capacity from non-fossil fuels by 2030.

Such high-reaching targets have invariably encountered various headwinds and challenges in the past. In recent months, some of these challenges have been brought to the fore, including questions over grid capacity to incorporate such high-variable energy penetration so quickly. There is also the question of a likely under-utilization of coal-based capacities and the non-resolution of the pressing issue of stressed thermal power assets. The plant load factor (PLF) of coal-based plants has declined from 78.6% in 2007/08 to 62.5% in 2018/2019.[1]

The Central Electricity Authority (CEA) conducted a study to estimate the optimal generation capacity mix under various technology options, including the issues of intermittency associated with renewable energy sources and other constraints to meet the projected peak electricity demand and electrical energy requirement in the year 2029/30. The year 2029/30 was selected to allow 10-12 years for shifting from thermal based generation with renewable uptake complimented with energy storage technology.

The CEA report maps a target of 523GW of renewable energy capacity (including hydro) for India by 2030. This comprises 300GW solar, 140GW wind, 73GW hydro and 10GW biomass. The CEA model also forecasts that India will need 34GW/136GWh of battery energy storage systems (BESS) by 2030 to balance grid stability.

Demand Analysis

The optimal capacity generation mix is based on the demand projected by the country's 19th electric power survey (EPS), adjusted to include the contribution of rooftop solar (75 billion units (BU) for the year 2029/30). Under the survey, the

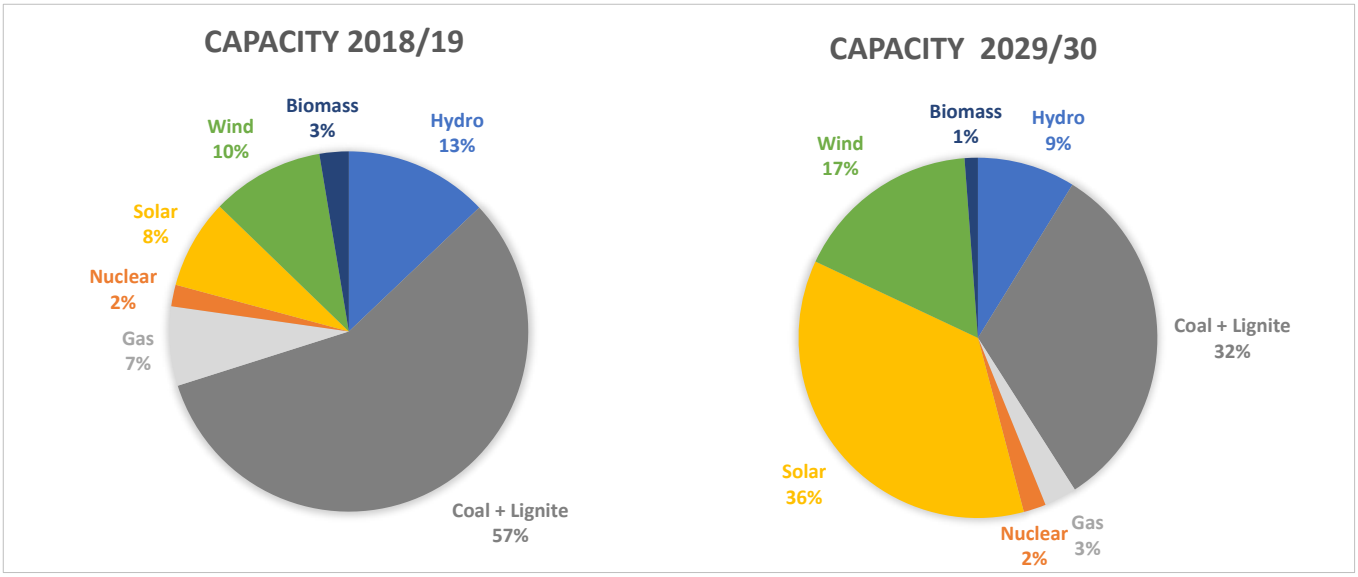
[1] Based on average of All India Thermal PLF from January to May 2019.

peak load is considered unchanged with no peak contribution from rooftop solar. However, the load profile does not take into account the seasonal and hourly variation due to increased air conditioning (AC) load. As per IEA estimates, the share of AC in peak electricity load could reach 45% in 2050, up from 10% today, without strong policy intervention.[2]

Further, electricity demand is likely to increase at a higher rate due to faster adoption and manufacturing of electric vehicles (EVs) in India.

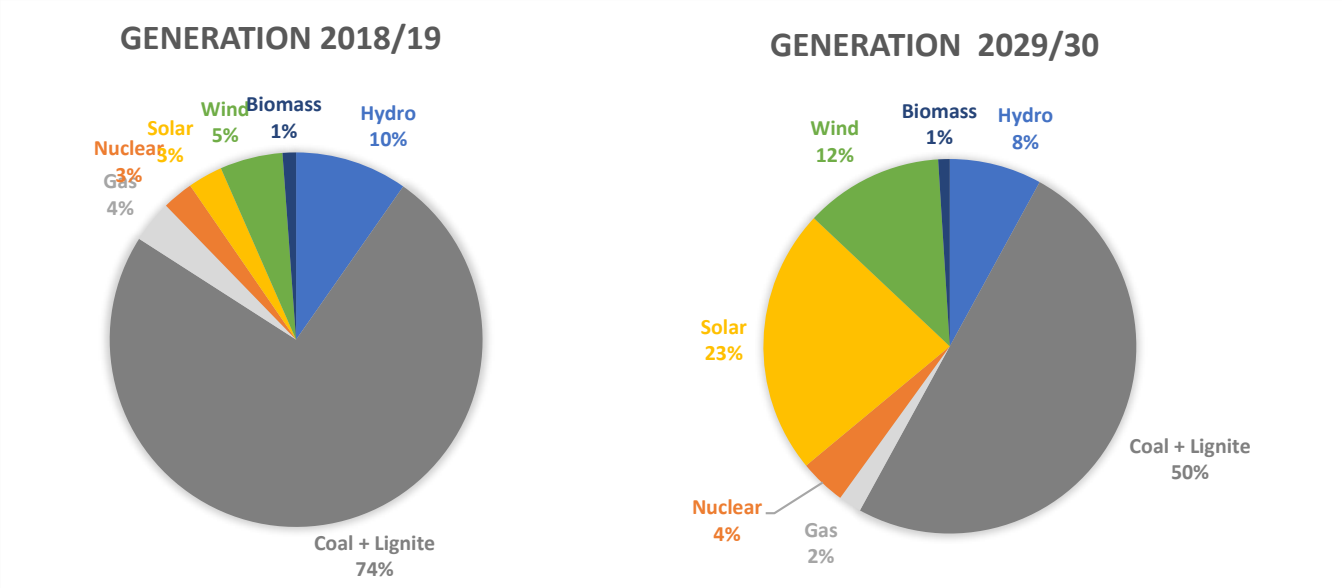
Capacity & Generation Analysis

Figure 1: Installed Capacity (MW) & Percentage Mix (%)



[2] IEEFA strongly endorses government plans to promote and enforce mandatory standards on the installation of energy-efficient 5/6 star-rated AC equipment.

Figure 2: Generation (BUs) & Percentage Mix (%)



Source: CEA Installed Capacity & Optimal Generation Mix Report.

The CEA's analysis projects moderate growth in coal capacity (from net end-of-life coal plant closures), while gas and biomass growth are expected to be negligible. The model projects a base thermal power capacity of 291GW by 2030, a clear expansion from the 225GW operating as of March 2019. But the bullish conclusion is that thermal capacity drops from a 64% share to just 35% of total installed capacity in only 11 years.

The growth in renewable energy installed capacity is anticipated to be tremendous, with its share increasing from 20% in 2018/19 to over 50% in 2029/30 (excluding hydro) of total installed capacity. If hydro capacity is included, renewable energy's share of total installed capacity increases from 33% in 2018/19 to 63% in 2029/30.

Critically, the CEA model also forecasts that India will need 34GW/136GWh of battery energy storage systems (BESS) by 2030 to balance the grid reliability and stability needs of 440GW of variable renewable energy capacity, supported by 73GW of hydro and 10GW biomass. At expected rates of technology change and the cost deflation in batteries, this ambitious forecast could well prove entirely prescient. However, as overall electricity demand is set to double, IEEFA would recommend that India concurrently invest in: significantly expanded pumped hydro storage, greater national and international grid connectivity, as well as gas peakers and demand-response management technologies in pursuit of an all-of-the-above strategy to best manage risks associated with this transformation.

Under the CEA projections, the share of generation from coal and lignite-based capacity is reduced to 50% in 2029/30 from 75% in 2018/19. While this estimate is entirely necessary from an air, water and carbon emissions/pollution perspective as well as economically sound, it also represents an unprecedented rate of market share loss for coal-fired power generation. The share of generation from variable

renewable energy sources would increase from 9.6% to 35% during the same period (44% including hydro and biomass).

Scenario Analysis

The model looked at short-term generation dispatch projections on an hourly basis to assess the adequacy of various capacities to meet the demand in 2029/30 at every time of day at the lowest possible cost.

Table 1: Impact on RE Curtailment on Critical Days

S.No.	Scenario	Month	Coal Capacity PLF	Wind CUF	Solar CUF	RE Curtailment
1	Maximum variation in demand	January				0%
2	RE Generation Minimum	February	71.8%	16.1%	10.5%	0%
3	Solar Generation Maximum	March			28.0%	16.8%
4	RE Generation Maximum (wind & hydro)	July		69.8%		17.2%
5	Solar Generation Minimum	August			14.25%	0.9%
6	Maximum variation in net demand	October				17.6%
7	Peak Demand	October	55.0%	10.0%	20.7%	4.5%
8	Energy Demand Minimum	December				6.0%

The study considered a minimum technical load of coal-based power plants of 55% (as estimated by the Central Electricity Regulatory Commission). The analysis was conducted for critical days as highlighted in Table 1. Renewable energy (RE) curtailment varies between 0 - 17%.

The study further noted that by reducing the technical minimum load of coal-based plants or by increasing the battery energy storage system size, curtailment of RE can be minimised to commercially acceptable levels. However, this will necessitate significant financial investment in technological upgrades to facilitate faster ramping up of power plant construction, system planning and integration. With every 5% reduction in minimum technical load of coal-based capacity, reduction of approximately 3% in the RE curtailment can be achieved. However, the impact may vary from day to day depending on the coal-based capacity and available RE generation.

Conclusion

India dominates the list of countries with the most polluted cities on earth. According to World Bank estimates, air pollution costs India the equivalent of 8.5%

of GDP. India is also facing extreme and growing water shortages in major urban areas. As has been found in various studies, the power sector contributes to and is significantly affected by water stress.

Transitioning to clean energy can help the country achieve its twin objectives of strong economic growth and sustainability. RE will further aid in reducing air pollution and water stress, as well as helping mitigate India's chronic over-reliance on fossil fuel imports, that lead to inflation and erosion in the value of the Rupee.

IEEFA notes that the momentum to build more RE capacity should not only be facilitated at the central level planning, but also integrated and co-ordinated with state governments. India clearly is making huge strides, with 13GW of solar projects being tendered in the month of June 2019 alone.

Gujarat is a front runner, with the state announcing its plans to increase power generation capacity from renewable sources to 30GW in the next three years. However, in order to build energy security and incorporate an ever-increasing share of zero-pollution and deflationary renewable energy, quality interstate grid transmission expansion needs to be heavily prioritised at the state and central level. This is a critical pre-requisite for India to fulfil its renewable energy ambitions.

IEEFA notes that for large-scale integration of RE generation sources, it will be critical to introduce grid-scale energy storage technologies. In light of technological advancement, the cost of battery energy storage systems has been decreasing at a fast pace, down 30% in 2018 alone. India needs to invest considerable technical and financial resources to expand energy storage capacity, that will enable the power system to integrate more renewable energy for a more sustainable future.

About IEEFA

The Institute for Energy Economics and Financial Analysis conducts research and analyses on financial and economic issues related to energy and the environment. The Institute's mission is to accelerate the transition to a diverse, sustainable and profitable energy. www.ieefa.org

About the Author

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Vibhuti Garg is an IEEFA energy economist who undertakes research promoting sustainable development through influencing policy intervention on energy pricing, subsidy reforms and deployment of clean energy.