Long-Term Planning for the Tamil Nadu Power System

Identifying least-cost pathways for Tamil Nadu's power sector transformation

Increased deployment of wind and solar raises new questions for power system planners regarding the future mix of generation technologies, optimal siting of generation capacity, trade-offs between generation and transmission investments, and system flexibility needs. The National Renewable Energy Laboratory (NREL) is working with Tamil Nadu Generation and Distribution Company (TANGEDCO) to answer the following questions:

- How much—and what type—of generation and transmission investments are needed to serve future demand at least cost?
- How can variable resources such as wind and solar be considered in the planning process?
- What are the key drivers (e.g., policies, technology costs, fuel constraints) for investments?

This analysis does not seek to identify a single optimal investment plan for Tamil Nadu's power sector. Instead, we use scenario analysis to identify a range of possible least-cost pathways for the state and the policy, regulatory, and technical drivers that could influence investment decisions.

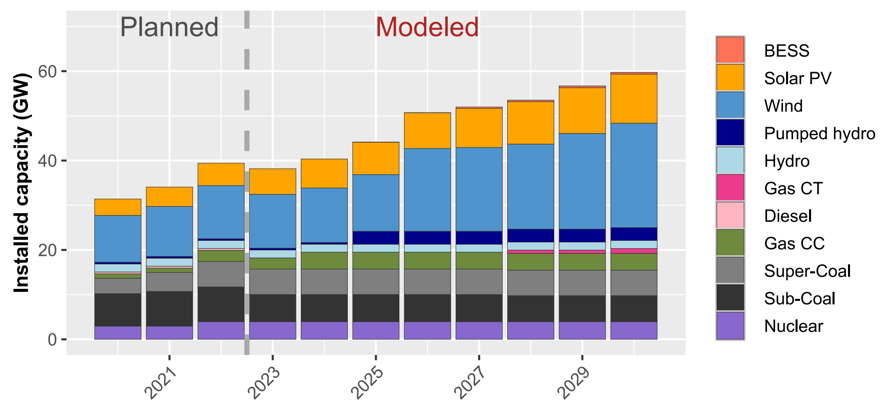

Figure 1. Evolution of Tamil Nadu capacity mix 2020–2030

Key Findings

Tamil Nadu's electricity supply is poised for significant changes.

State capacity targets and competitive technology costs could drive investments in wind and solar. Total wind and solar capacity increases from 10 GW in 2017 to 34 GW in 2030, accounting for over 50% of annual generation. By contrast, the share of coal in the capacity mix falls from 31% to 18% by 2030.

New generation sources may change patterns of transmission usage.

Investments in wind capacity could increase transmission utilization across key corridors. Power flows from the Tirunelveli region to northern regions increase significantly to transport excess wind generation from the southern part of the state to load centers in the north and west.

Wind plays a key role in meeting future electricity demand.

By 2030, more than 34% of electricity demand could be met by 23 GW of wind capacity. The share of wind in the generation mix varies seasonally, reaching over 63% in the summer and monsoon seasons (mid-May through mid-September) and falling to 20% in the winter (mid-November through mid-March).

Energy storage technologies help balance supply and demand during peak periods.

Investments in battery storage could begin after 2025, reaching 300 MW by 2030. Battery storage and pumped hydropower are used to time-shift excess generation from daytime hours to evening peak hours. Using storage technologies as a peaking resource avoids the need for new generation capacity to meet peak demand and improves the economics for solar photovoltaic (PV) that is unavailable to meet electricity demand in the evenings.

Renewable energy (RE) can play a role in meeting system adequacy requirements.

By 2030, Tamil Nadu could have adequate firm capacity to meet peak demand in every season plus a 15% planning reserve margin. Hourly simulations of RE generation and demand reveal that wind and solar (to a lesser extent) can contribute to the seasonal planning reserve margin. By 2030, 23 GW of wind capacity contribute 13 GW to the planning reserve margin during summer months (mid-May–mid-July).

Capacity additions are driven by coindicence of demand and RE generation rather than peak demand alone.

As investments in wind increase, the seasons with the highest peak demand are no longer capacity-constrained due to high wind availability. Instead, the lowest reserve margin is experienced during moderate demand months when the expected availability from wind generators is lower.

Investment in gas capacity is not limited by fuel availability.

Scenario tests of increased gas availability to the power sector have no significant impact on investments or system operations. This indicates the future of gas for electricity production is constrained by cost-competitiveness with other technologies rather than fuel availability.

Demand response reduces the need for investments in flexible resources.

Policy or regulatory measures to shift consumption during peak demand to other times of day could reduce the need for capacity investments. Scenario tests in which growth in peak demand decreases by 10% result in a 60% decrease in battery storage investments by 2030. Existing and planned pumped storage hydropower provides adequate flexibility. Shifting electricity demand to midday also reduces renewable curtailment by 62%, as demand is better-aligned with solar generation.

Conclusions

- Wind and battery storage are increasingly cost-competitive with other conventional generation technologies in Tamil Nadu. Investments in solar are still driven by policy targets.
- Failing to account for RE and storage in the planning reserve margin could result in an overbuilt system with stranded assets.
- In a future system with high penetrations of RE, the periods of highest system risk may not correspond to the periods of peak demand.
- Demand response programs could reduce the economic opportunities for battery storage to provide energy arbitrage, reduce RE curtailment, and contribute to the planning reserve margin. However, battery storage may still be economic for providing other services (e.g., voltage support, frequency regulation, backup power).

For more information:

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About the model:

The Regional Energy Deployment System (ReEDS) capacity expansion model was selected for this study for its rich assessment of technical, geographic, and operational aspects of RE deployment. More information on ReEDS can be found at: https://www.nrel.gov/analysis/reeds.

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