



3. Outlook – The Energy Transition and the Electric Grid

APERC Workshop

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Outline

Recent electric grid-related events

The electric grid as an integrated system

Estimating total system costs

Key takeaways



Japan: Tight supply-demand balance in TEPCO area in March 2022

- After an early March earthquake near Fukushima, some thermal power stations were shut down.
- Later in the month, demand increased due to cold weather and at the same time the output of solar power plants declined due to clouds.
- In recent years, the supply-demand balance has frequently been tight in the Tokyo Electric Power Company (TEPCO) area due to a declining share of dispatchable generation capacity.



Solar PV output for everyday of March

Supply-demand balance around March 22 in TEPCO area





USA: ERCOT load exceeded dispatchable capacity for over 1,000 hours in 2023



 The Electric Reliability Council of Texas (ERCOT) system now lacks sufficient dispatchable generation capacity to serve as a backstop for intermittent power sources.

Source: Hartley et.al. Rice University's Baker Institute for Public Policy. ERCOT and the Future of Electric Reliability in Texas (2024).

USA: ERCOT declared an EEA2 on September 6, 2023

- The Texas grid narrowly avoided blackouts in the evening of September 6, 2023, as cooling demand from extreme heat combined with thermal outages and low solar and wind output forced the state's grid operator into emergency operating conditions.
- The ERCOT declared an Energy Emergency Alert 2 around 7:30 p.m. local time, allowing it to bring all available generation online, utilize reserve power, and call on demand response.
- The extreme heat led to a new ERCOT peak demand record for September of 82,705 MW. The previous September peak demand occurred in 2022 (72,370 MW).
- ERCOT CEO also said: "High demand, lower wind generation, and the declining solar generation during sunset led to lower operating reserves on the grid and eventually contributed to lower frequency, which precipitated the emergency level 2 declaration."

ERCOT: The Electric Reliability Council of Texas

Source: https://www.utilitydive.com/news/ercot-declares-emergency-conditions-extreme-heat-texas-blackouts/692963/



The electric grid is an integrated system



Cost of wind and solar power have dropped dramatically



Weighted average LCOE for solar PV energy (2021 USD/kWh)

- The levelized cost of energy (LCOE) for offshore and onshore wind turbines decreased by 8% and ٠ 10% per year from 2010 to 2021.
- The LCOE for solar PV electricity dropped by 88% from 0.417 USD/kWh in 2010 to 0.048 ٠ USD/kWh in 2021.



As solar generation grows, the duck's belly drops

CAISO lowest net load day each spring (March-May, 2015-2023), gigawatts



Source: Energy Information Agency, California Independent System Operator



As the share of wind and solar energy increases, electricity storage requirements rise exponentially





Storage modeling challenge

- Grid-scale vs distributed storage
- What is the size of a grid-scale storage?
- Battery Electric Vehicles (BEVs)
- Short- and long-term storage
- In mid- to long-term models, we can operate hours, not minutes and seconds



Source: Handbook on Battery Energy Storage System, 2018

Load profiles and supply technologies vary widely among economies

- Differences in geography, resource availability, existing grid systems, demand, etc.
- Economies are under different stages of development in tackling the energy transition.

Total system costs vs Plant-level costs

Source: Nuclear Energy and Renewables: System Effects in Low-Carbon Electricity Systems

- Focusing only on the plant-level costs of reducing carbon emissions underestimates the total system costs required to implement the energy transition.
- The 9th edition of the Outlook will include results from our efforts to estimate total system costs.

Total system costs can be usefully divided into categories

Total System Costs

| Categor | 'Y |
|---------|----|
|---------|----|

Generation facilities – capital, operating and maintenance costs

Load profile – accommodate supply variability (vRE) and additional load shapes (electrification, EVs)

Energy storage – 4-hour, week-long, seasonal

Grid services – AGC, VAR balance, inertia, synchronous condensers, resilience to N-1 events

Grid expansion – additional investments and operating costs in transmission and distribution infrastructure

Included in the model?

Estimating total system costs (Illustrative)

Key Takeaways

- Recent events highlight the challenges of maintaining grid reliability during the energy transition.
- The grid is an integrated system; changes in one segment can affect many other segments.
- Solutions should be based on economy specific circumstances.
- Estimating the total system costs of proposed technology and policy changes is difficult but important.
- In order to be helpful to APEC policymakers, in the 9th edition of the Outlook we plan to provide estimates of the total system costs for each economy based on its current power sector decarbonization targets or roadmaps.

Thank you.

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