Understanding Power Curtailment in California and Texas

BY ADITI SARKAR

Abstract

Renewable energy, viewed as a step towards a decarbonized future, comes with concerns about production variability. This article explores the issue of power curtailment in Texas and California, both major producers of wind and solar energy in the US. It examines the current situation and investigates potential solutions.

Aditi Sarkar earned her Ph.D. in Economics from the University of New Mexico in 2023, specializing in environmental and energy issues. Outside of her full-time role as a data scientist at a major bank, she continues to conduct independent research on energy topics.

Production of renewable energy, deemed as one of the solutions to mitigating global warming, has increased across different countries. France reported that more than 95% of power came from renewable energy (Chivers 2025). In the EU, solar power has overtaken coal for the first time (Clifton 2025). Solar energy now produces 11% of electricity in the EU and combined with other renewables such as wind, renewable energy provides 47% of electricity. Renewable energy can be divided into two categories:

- Variable renewable energy: these are the sources whose production cannot be controlled. Solar and wind fall in this category
- Controlled renewable energy: these sources can have controlled production. Hydroelectricity and geothermal power fall in this category.

Renewable energy also comes with its own set of problems. Its technology requires the mining of rare earth minerals for building capital which has its own environmental and geopolitical implications. Another problem is inadequate transmission of electricity, leading to congestion in the electrical system. Often times, congestion leads to negative pricing of power in the market, and a curtailment of power itself. This loss of viable electricity can amount to economic losses in the market; however, certain experts argue that the loss of electricity should not be seen as an unfavorable consequence but as a way to make the grid more flexible and cleaner (Oleson 2018).

This essay will focus on renewable energy power curtailment in two states of the US: California and Texas. Both these states have massive markets for solar, and wind and solar respectively. Both the states have reported increases in curtailment and are handling the situation in different ways.

Texas

The southern state of Texas is saddled between New Mexico to the west, Louisiana to the east, Oklahoma and Arkansas to the north and Mexico to the south. To the southeast, is the Gulf of Mexico. It is one of the leading energy producers in the US. It tops production of oil and gas in the country and due to its geographical terrain, it is the primary producer of wind, and solar energy. In 2023, it produced three-tenths of wind electricity in the US when the wind net summer generating capacity was 41000 MW. Furthermore, it is the country's second largest solar power generator after California. It produced almost 18500 MW in 2023 (EIA 2024).

Texas' electric grid is in a unique position. To avoid being regulated by the federal government in the early 20th century, the Texas grid, known as Electric Reliability Council of Texas (ERCOT), opted out of the national grid and has been operating independently since then. It covers 90% of the state now (McInerny 2021). Due to the presence of flat land where wind can blow uninterrupted and receive ample sunshine, excess wind and solar energy are produced at times. Since ERCOT is independent of the other grids, and the state's unequal demand and supply, they can cause renewable energy power curtailment. Another reason for curtailment is congestion in transmitting electricity. New transmission infrastructure is required to ease the congestion (EIA 2023).

In 2023, an increase in growth of wind and solar power in the state was reported with forecasts of a higher curtailment reaching 13% for wind and 19% for solar by the year 2035 (EIA 2023).

California

Located on the western coast, California boasts of a copious amount of sunshine, especially on the southern side. Mexico lies to the south, Arizona and Nevada to the east and Oregon to the north. To the west, is the vast Pacific Ocean. The state has been leading the country in running clean energy programs. And as such, it boasts of having the largest solar farms. In 2023, the state generated enough solar power that contributed 28% to electricity generation and in the beginning of 2024, it produced 36,500 MW, the most in the country (EIA 2024).

The Californian electric grid is managed by California Independent System Operator (CAISO). It covers 80% of the state and a small region of Nevada. Unlike ERCOT, CAISO is inter-connected with other states, so it is able to trade electricity with other states. It is part of the Western Energy Imbalance Market (WEIM) which aids in exporting excess electricity from California to nearby neighbors. Even then, it still faces renewable energy power curtailment. It was reported that wholesale electricity prices in southern California were negative for 23% percent of the time throughout the first six months of 2024. CAISO's negative prices are largely due to congestion and then oversupply of electricity. Rooftop solar panels generate more power than the grid can manage which led to a glut in solar power, thereby being curtailed (Shannon 2024).

Furthermore, there is insufficient transmission lines to supply the excess electricity causing congestion. With California poised to generate 100% carbon-free electricity by 2045, the problem of power curtailment will grow.

Restriction in renewable energy power generation bears economic costs. Curtailed power means not only missed income for the supplier but also mismanagement or misallocation of resources. In the next section, possible solutions are discussed.

Solutions

Electric Energy Storage

A common solution for renewable energy curtailment is building electric energy storage. It is a set of technologies that can store electricity for later use. There are two types of electric energy storage systems (NREL 2015; CAISO 2023):

i. The first type operates rapidly where the stored electricity has to be discharged within seconds or minutes. This type of service is known as operating reserves and is used for managing unplanned contingencies such as loss of generation or demand exceeding the forecast. It can provide power for 15 minutes to 1 hour. Examples include flywheels and certain battery technologies.
ii. The second type of storage can store electricity for a longer period of time in which power can be discharged continuously over a duration of time. It can be used as both operative reserves and firm system capacity. Examples include high energy batteries, and pumped hydro-storage.

Battery storage for EV charging

Jordan is known for its adoption of renewable energy amongst the Middle Eastern countries. Wind energy is the largest source of renewable energy in the country. To reduce curtailment of wind power, the country charges lithium-ion batteries to charge electric vehicles (EV) in turn. Alkhalidi et al. (2022) show that this method reduced curtailment by storing them in lithium- ion batteries for charging EVs later on.

This is a possible solution to avoid curtailment of power in California and Texas. Both the states have high EV consumption. Using excess power to charge batteries for EV consumption is an efficient strategy of power management. EV use will increase more in the future and further charging stations will be required across the country. It will be worthwhile to study the possibility of having strips of land made for charging EVs where batteries can be stored and connected to cars. Expansion in charging stations will incentivize a greater number of people to adopt EVs which will be beneficial for the environment.

Alternative pricing contract

The usual electricity contracts are long-term with an electricity buyer, also known as the 'offtaker', and the generator. The length of the contract gives the generators a relatively definite and lasting revenue stream. In the event of curtailment, the offtaker may or may not have to pay for the curtailed power depending on the contract. This presents a risk factor that the industry stakeholders are aiming to resolve by exploring alternative contracts.

Fixed payment contract: it shifts the curtailment risk from generators to offtakers by including fixed payments in the contract in adjunct to or replacing volumetric payments. This way the marginal effect of curtailment is reduced.

Time-of-delivery (TOD) contract: The rate in this contract is based on the delivery time of the output. When there is high demand, the rate will be higher and with a lower demand and a higher chance of curtailment, the rate will be lower. This way both the generator and offtaker will incur less losses due to curtailment owing to lower prices.

These two contracts are based on solar energy, but the concept can be expanded to other variable renewable energy (VRE) as well (Shaugnessy et al. 2021).

Increased Transmission

Transmission of electricity and ramped up demand of electricity due to data centers and burgeoning expansion of VRE have not grown at the same pace. To add to the pain, the renewable energy power plants are located at a distance from places with high demand as opposed to fossil fuel power plants. This means long-distance transmission lines are required, which calls for an upgrade in transmission lines. This will also help with the reduction in curtailment of VRE.

Furthermore, extreme weather events have made it clear that the regional power markets should be more integrated, which will require advanced transmission systems (Mercer 2024).

Demand Response

Curtailment cannot be reduced without the aid of consumers because they play a major role in the market. There are two mechanisms through which demand response can be used:

i. Price-based demand response programs where the price of electricity varies over time and influences the consumption of electricity during various parts of the day.
ii. Incentive or event-based demand response programs where they provide financial compensation to consumers who allow the program administrators to directly control electronic equipment so that they can manage electricity consumption.

Given the solutions mentioned above, how have the states of Texas and California responded to this growing problem? What programs have they implemented to reduce the problem? The next two paragraphs will answer the question.

California's curtailment is mostly caused by congestion of power. It uses the WEIM to export power to a neigh-

boring grid. In 2022, more than 10% of curtailment was avoided. It has 45 transmission projects in development which will aid in reducing congestion. Further, it is advocating for the development of battery storage, that can quickly adapt to sudden changes in demand and supply. In 2024, when there was a glut in solar energy due to high generation from the rooftop panels, the state responded by limiting incentives for solar panel use (Osaka 2024).

Texas is witnessing growth in power generation and consumption owing to the development of artificial intelligence, data centers, industrial electrification, hydrogen and electric vehicles. To manage the demand and supply, ERCOT is planning a suite of operations including faster generation interconnection without further examination of curtailment issues. Further, they are working on evaluating both demand response and energy efficiency opportunities- key to reducing curtailment. They are working on improving and accelerating the building of transmission facilities and infrastructure which is notorious for taking several years to be completed.

The operator is also exploring ways to use generation hubs to identify locations of new power plants. This can be a solution to the needs of future load growth. Additionally, it is planning on operating its system at a higher voltage which can hopefully support longer-term growth forecasts with lower cost. It is also adapting distributed energy sources to improve visibility in distribution resources (Walton, 2024).

The US is a vast nation, and it needs a concerted effort and a combination of different solutions as mentioned above to avoid curtailment of renewable power. The increase in transmission wires remains a top priority. And meanwhile, we can have consumers keep batteries at home and charge them when there is a glut of electricity and then use these batteries during peak hours. This can assuage the situation to a certain extent. Texas and California, being the most prolific in supply of VRE, can lead the way in avoiding curtailment for the rest of the country.

References

1. Alkhalidi, Ammar, Khalid Alqarra, Mohammad Ali Abdelkareem, A.G. Olabi. “Renewable energy curtailment practices in Jordan and proposed solutions”. *International Journal of Thermofluids*, Volume *16*, 2022, 100196. https://doi.org/10.1016/j.ijft.2022.100196.

2. “As Texas wind and solar capacity increase, energy curtailments are also likely to rise”. U.S. EIA, July 13, 2023.

3. “California State Profile and Energy Estimates”. U.S. EIA, May 16, 2024. https://www.eia.gov/state/analysis.php?sid=CA

4. Chivers, Tom. “France’s electricity generation is nearly fossil fuel-free”. Semafor, Jan. 22, 2025.

5. Clifton, Mizy. “Solar overtakes coal for the first time in EU”. Semafor, Jan. 22, 2025

6. “Maintaining operating reserves”. CAISO 2023.

7. McInerny, Claire. “Why Is Texas On Its Own Electric Grid?” KUT News, July 22, 2021.

8. Mercer, Emily. “National Transmission Analysis Maps Next Chapter of US Grid Evolution”. NREL Oct. 3, 2024, https://www.nrel.gov/news/features/2024/national-transmission-planning-study.html

9. O’Shaughnessy, Eric, Jesse Cruce, Kaifeng Xu. “Rethinking solar PV contracts in a world of increasing curtailment risk”. *Energy Economics*, Volume *98*, 2021, 105264, https://doi.org/10.1016/j.eneco.2021.105264.

10. Oleson, Devonie. “Reframing Curtailment: Why Too Much of a Good Thing Is Still a Good Thing”. NREL, July 18, 2018, https://www.nrel.gov/news/program/2022/reframing-curtailment.html

11. Osaka, Shannon. “Rooftop solar panels are flooding California’s grid. That’s a problem.” Washington Post, April 22, 2024.

12. “Solar and wind power curtailments are rising in California”. EIA, Oct. 30, 2023.

13. “Texas State Profile and Energy Estimates”. U.S. EIA, July 18, 2024. https://www.eia.gov/state/analysis.php?sid=TX#129

14. “The Role Of Storage And Demand Response”. NREL 2015.

15. Walton, Robert. “ERCOT launches new planning efforts as 2030 load growth projections soar 40 GW in a year”. Utility Dive, April 24, 2024. https://www.utilitydive.com/news/ercot-transmission-planning-2030-load-growth-projections/714104/