At a tipping point.

Supercharging decarbonization with energy storage | White paper

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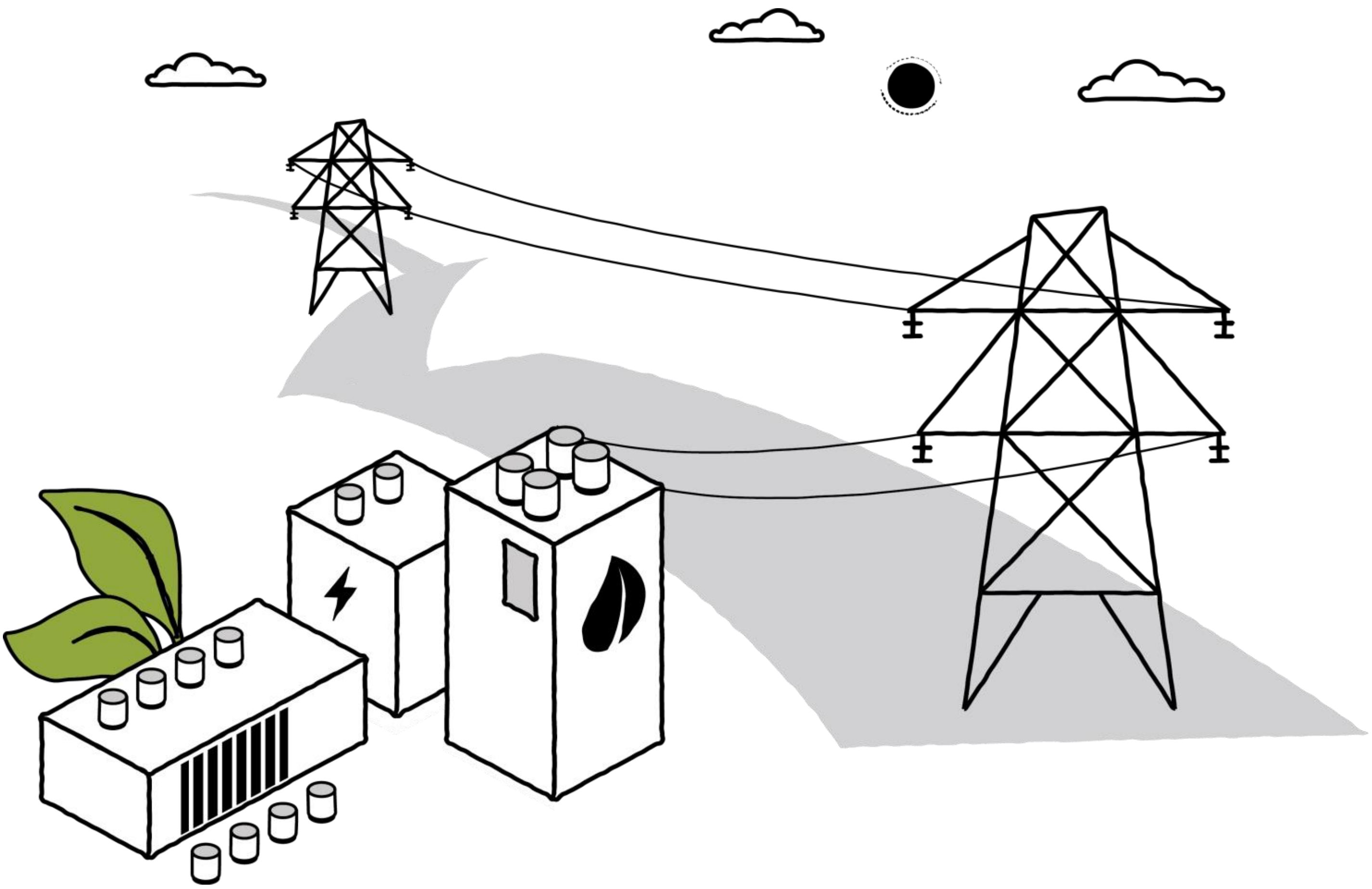


Energy storage has long been touted as one of the best solutions to smooth out the intermittency of renewable energy. That moment has finally arrived. As the sector further matures, we expect energy storage to become mainstream in the infrastructure investment universe.

Accelerating decarbonization with energy storage

Renewable energy from wind and solar may be clean and cheap, but they are also intermittent and unpredictable. Traditionally, thermal generation such as coal, gas or nuclear are used to offset the limitations of renewables, especially during hours that are not windy or sunny. However, energy storage has finally become an economic and sustainable alternative to thermal generation. Project costs have fallen by almost 80% in the past decade, while regulatory support continues to increase. Energy storage has reached an inflection point, with US capacity tripling in 2021[1]. Simply put, the energy transition cannot happen without energy storage.

For over a decade, the energy industry has long touted energy storage as the holy grail[2] of renewable energy, as it can offset the intermittency of wind and solar power generation by charging during sunny or windy hours, and discharging after the sun sets or after the wind stops blowing.

This has finally become a reality, as energy storage costs have fallen almost 80% in the past decade, according to the National Renewable Energy Laboratory (NREL), helped by significant technological improvements, massive R&D spending, and growing economies-of-scale that came with the popularization of electric vehicles.

The installed capacity of energy storage projects in the US tripled to 6GW in 2021, and will surpass 10GW in 2022[1]. The US energy storage industry has reached its tipping point, and investments from institutional investors will only accelerate as the asset class matures.

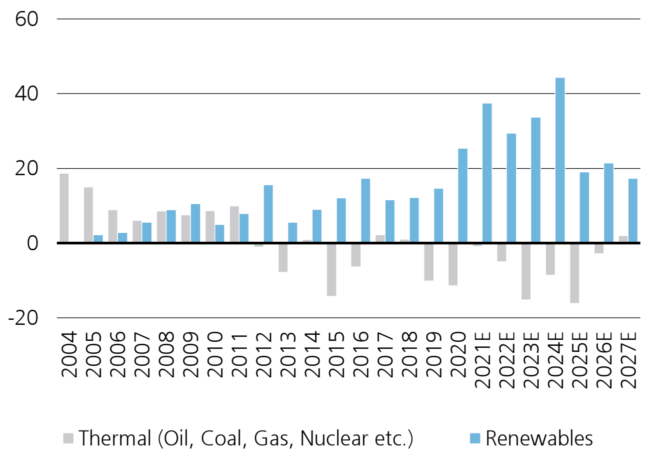
In this paper, we highlight how energy storage can help support a decarbonizing grid, summarize the changes that enabled this industry to grow, and most importantly, how projects can generate revenues.

Rising renewable penetration is a challenge for the grid
Before the recent blackouts in California and Texas, the electricity grid was often an afterthought for most people. What many do not understand is that the grid is actually a very delicate system, where supply and demand must be perfectly matched at all times, while voltage and frequency must remain stable within narrow limits.

Renewable energy such as wind and solar are economically highly competitive. However, their electricity production is limited by the unpredictability of weather patterns. Therefore, renewables alone cannot provide the 24/7 stability that a grid requires.

Across the country, renewable energy targets are becoming more ambitious. This means wind and solar farms are also being built at the expense of thermal power plants that use coal, gas, or nuclear fuels. Based on EIA data, we estimate that the US renewables capacity will increase by 160GW between 2021 and 2025, while thermal capacity will decrease by over 45GW (see Figure 1).

Figure 1: Intermittent renewable energy is replacing thermal power generation (net change in capacity, GW)



Source: EIA, August 2021

Not only are new thermal power stations not being built, but they are also actually being aggressively shut down. For example, in 2021, New York retired the last unit of the Indian Point nuclear power station 14 years ahead of schedule[3]. Similarly, in 2019, General Electric decided to decommission a gas-fired power station in California that still had 20 years of useful life[4].

A large nuclear power facility generates the same amount of electricity as 25 large-scale wind farms[5], provides much more reliability 24/7, and is not affected by weather. Therefore, the loss of a single thermal power station is as big of a challenge for the grid as the addition of large amounts of renewables, when it comes to balancing supply and demand.

Energy storage can replace thermal power, although not enough is being built

This is where energy storage comes in. By charging when there is an oversupply of renewable electricity (e.g. overnight in Texas when it is windy, or midday in California when it is sunny), and discharging during high demand hours, energy storage can essentially provide the reliability that was traditionally offered by thermal power generation.

With the acceleration of new energy storage projects in 2021, it is clear that we are at the inflection point. Based on data from EIA, storage capacity tripled in 2021 to 6GW, and will surpass 10GW in 2022. However, we are not building them fast enough.

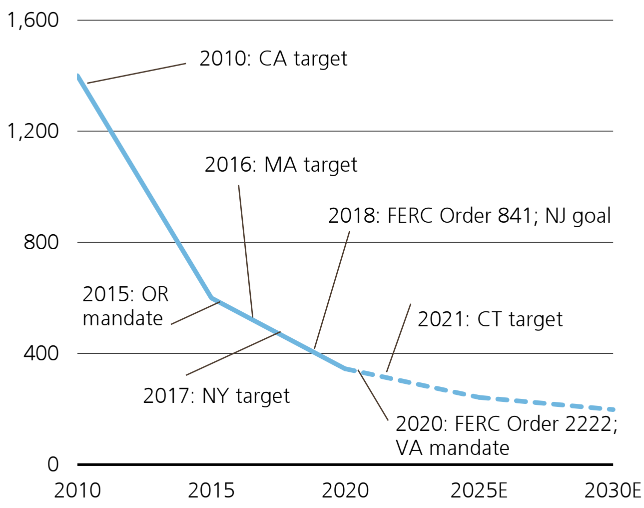
A recent a Wall Street Journal article[6] highlighted California's difficulty in replacing its rapidly retiring nuclear and gas plants. Although the state has ordered utilities to purchase significant amounts of renewables and energy storage as an offset, the California Energy Commission and the grid operator have "expressed concern that the purchases may not be enough to prevent electricity shortages in coming summers."

Cost declines, regulatory support, and extreme weather push energy storage to its tipping point

So, the big question is – *why now?*

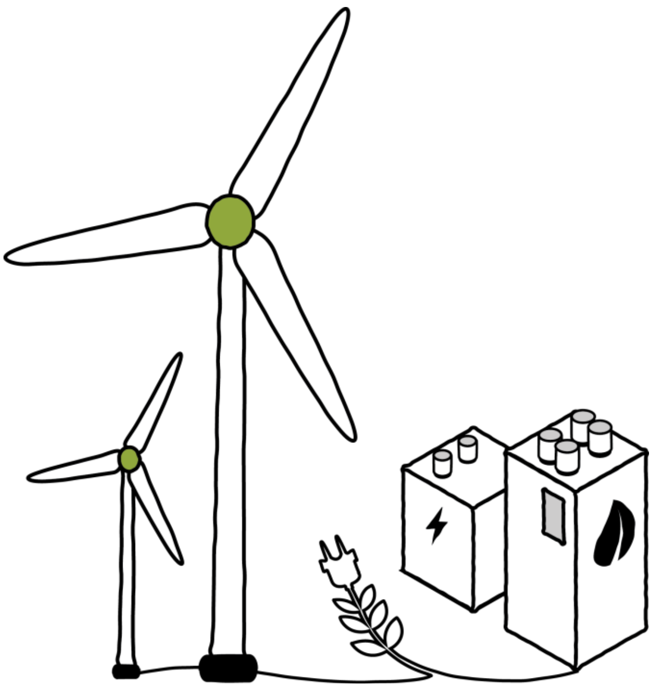
We believe that the main driver is the 80% decline in project costs this past decade (see Figure 2). Due to the rising popularity of electric vehicles, the automobile industry has essentially subsidized the maturation and the de-risking of battery technologies used by storage projects. But cost is only one part of the story.

Figure 2: Energy storage – rapid cost declines and increasing regulatory support (energy storage project cost, USD/KWh)



Source: NREL; Media reports; Energy Storage Association; UBS analysis, October 2021

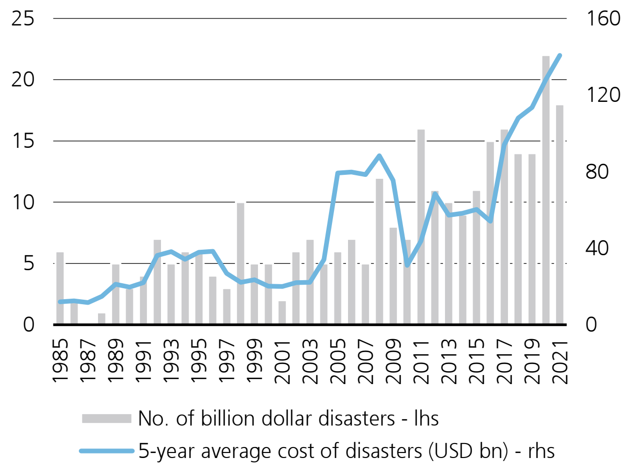
The government has recently provided significant regulatory support. For example, the Federal Energy Regulatory Commission (FERC) issued Order 841 in 2018 that opened up significant revenue opportunities for storage projects in wholesale electricity markets. In addition, states such as California, Massachusetts and New York have also set more aggressive energy storage targets.



Finally, recent extreme weather events have highlighted the fragility of the electricity network and the volatility of the power markets. The record wildfires in California and once-in-a-century winter freeze in Texas may not be one-off events, as the number of costly natural disasters in the US have been increasing rapidly over the past decade (see Figure 3). Grid resiliency has now become a hot topic.

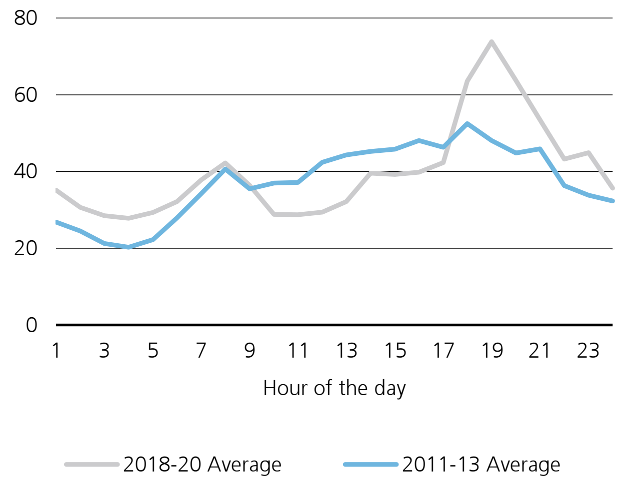
However, wholesale electricity prices can move 50-100% over the course of several hours during a typical day. On an average day between 2018 and 2020 in California, electricity prices increased from USD 30-70 per MWh between noon and 7pm (see Figure 4).

Figure 3: Rising number of billion-dollar natural disasters in the US (CPI-adjusted)



Source: National Oceanic and Atmospheric Administration, October 2021

Figure 4: Renewable energy increases intraday electricity price volatility (electricity price, USD/MWh)



Source: CAISO; UBS estimates, October 2021

Energy storage is an economic way of enhancing the reliability of our grid without costly investments in new transmission lines. For example, during extreme weather events, a local grid can draw power from a nearby energy storage project, rather than importing power from a remote generation resource.

The combination of battery cost declines, regulatory support and extreme weather events have increased the attractiveness of energy storage projects in recent years, which has led the industry to the current inflection point.

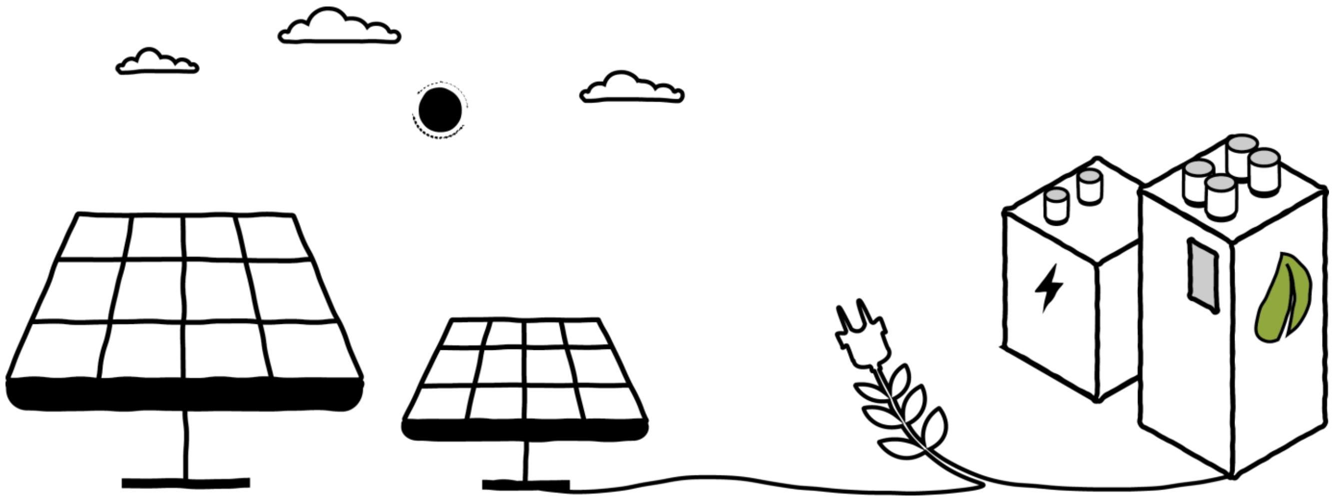
How does energy storage make money? Buying *low* and selling *high*

Electricity price dynamics are very different from those of other commodities. For example, a 5-10% percent daily price change in oil or gas is considered significant.

Some days, the intraday price spread can be up to several hundred dollars. This happens because during the sunniest hours around noon, prices collapse as there is too much solar generation in California. Prices can even fall to zero or negative, which basically means that the grid is paying people to consume electricity because of oversupply.

But as solar generation falls while the sun sets in the early evening, people are also returning home from work and turning on their air conditioning and appliances. Consequently, electricity prices begin to spike with rising demand.

Energy storage can come in and charge during the low price hours, and discharge later in the day when prices increase, earning an arbitrage revenue spread. If renewable penetration continues to increase, opportunities for arbitrage will continue to rise as intraday price spreads widen further.



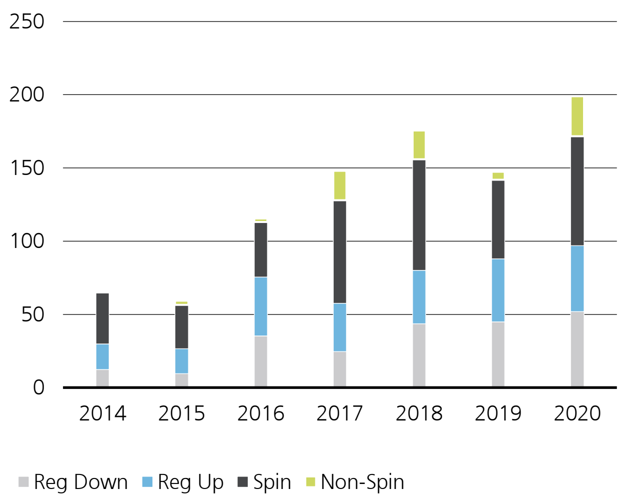
Ancillary services – generating revenues by stabilizing the grid

Price arbitrage is just one revenue stream. Another important revenue source is called *ancillary services*. Essentially, the grid operator pays energy storage projects to help support the grid's resiliency and reliability.

One important ancillary service is called *frequency regulation*, where a storage project helps the grid maintain a 60 hertz frequency. The importance of frequency regulation became apparent during the recent Texas winter storm, when the grid's frequency dipped from 60 to 59.4 hertz for several minutes[7], forcing the grid operator to partially shut down the network to avoid a larger catastrophe.

Other grid services include spinning or non-spinning reserves (short-term backup capacity), voltage regulation (maintaining grid voltage), black start (quick start backup generation), and similar grid resiliency related products. With the increasing penetration of intermittent renewable energy, grid operators are purchasing significantly more ancillary services than before to ensure reliability (see Figure 5).

Figure 5: Demand for ancillary services have increased with rising renewable penetration (ancillary services costs, USD/million)



Source: CAISO, October 2021

Energy storage soon to be a mainstream investment choice

Although energy storage is a relatively new asset class, it is already displaying attractive investment characteristics for different types of investors. It provides an essential service, has high barriers-to-entry and upfront costs, high margins and long asset life.

This is important because once markets and investors become more comfortable with this asset class, valuations will rise as the assets are deemed more de-risked.

This is what we have seen across wind and solar projects in the last 10-20 years. Energy storage will likely mature even faster, given the precedence set over other renewables.

Figure 6: Attractive investment characteristics of energy storage

Provides an essential service	Currently the most feasible solution to offset the intermittency of renewable energy
High upfront capital cost	Most capex is spent upfront, with minimal maintenance capex
Long asset life	20-year asset life with periodic augmentation to maintain battery capacity[8]
Rapid industry growth	We are still in the early innings of the energy storage investment cycle
High EBITDA margins	~70-80% EBITDA margins due to low operation and maintenance costs[9]
Barriers to entry	Like renewables, energy storage projects require significant technical and market expertise, to fully optimize financial performance of projects
Long-term contracts	Long-term *resource adequacy* contracts available depending on market

To be fair, just like wind and solar power, current energy storage technologies also have some limitations. For example, lithium-ion batteries, which is the dominant storage technology right now, can typically only discharge for four hours maximum.

In the future, the industry may find longer duration energy storage methods to complement existing shorter duration projects. However, lithium-ion batteries remain the most economically feasible and technologically mature storage solution, and just like wind and solar, they will remain important components of the future of clean energy infrastructure.

Investing – easier said than done

The business case for energy storage is clear. Economics, regulation and climate are all pointing towards an acceleration in adoption. However, investors interested in the sector face a steep learning curve, as investing in these projects is not straightforward. Below, we summarize what we believe are several key factors to be successful in the sector.

Embracing the unique revenue dynamics

Unlike most other infrastructure investments, energy storage thrives in volatile commodity price environments. Energy storage can generate arbitrage revenues whether prices are high or low (or even negative), as long as those large price swings remain. In addition, investors must understand other sources of income such as ancillary services or contracted revenues in order to optimize the revenue stack.

Technical expertise is a must

Not only does energy storage require an understanding of project development and engineering, it also requires expertise in commodity markets, trading and data analytics. Storage projects use advanced software and algorithms to optimize revenues. Thousands if not millions of decisions are made in real-time. For example, when to charge or discharge, which service to bid for, etc. The ability to use and refine these analytical tools is a significant competitive advantage.

Adapting quickly to market changes

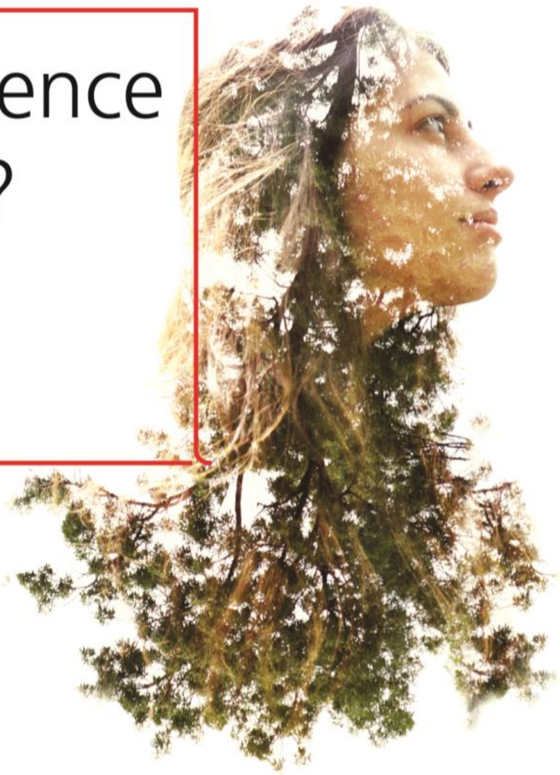
Market opportunities and risk appetite changes rapidly. For example, several years ago, Texas storage project economics were not yet attractive[10]. But now, it is one of the fastest growing markets due to volatile electricity prices. Also, most storage projects were unlevered several years ago. Now, 50%+ leverage is common, as banks have gotten more comfortable with these assets. Therefore, investors will need to adapt to rapid changes in the market.

Final thoughts

We are in the early innings of the energy storage investment cycle, but the industry will not stay in this phase for long. Energy storage already exhibits attractive economic returns and infrastructure-like characteristics.

We believe that energy storage will follow the path of the wind and solar industry, and rapidly become mainstream infrastructure investments as the sector continues to mature.

1 EIA; December 2021
2 The Challenge for Green Energy: How to Store Excess Electricity; Yale Environment 360; July 2009
3 New York's Indian Point nuclear plant to close; The Hill; January 2017
4 General Electric to scrap California power plant 20 years early; Reuters; June 2019
5 Assuming 90% capacity factor for a 2GW nuclear facility and 35% capacity factor for wind farms (200MW each)
6 California Scrambles to Find Electricity to Offset Plant Closures; Wall Street Journal; October 2021
7 The Texas Grid Came Close to an Even Bigger Disaster During February Freeze; Wall Street Journal; May 2021
8 In the energy storage industry, augmentation means installing new batteries to offset the degradation of older batteries in order maintain overall system capacity
9 UBS Asset Management, Real Estate & Private Markets (REPM); December 2021
10 Why Is the Texas Market So Tough for Energy Storage?; Greentech Media; November 2018



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