# USING HEAT STORAGE FOR RENEWABLE INTEGRATION

**Featured Companies**

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## Executive Summary

*Thermal storage is a hot topic. From a niche area primarily focused on enabling concentrated solar power (CSP) to become dispatchable and thus compete with PV, storing heat has now grown into an ambitious enterprise aiming to solve one of the thorniest problems in renewable energy.*

The key challenge facing low-cost wind and solar is its intermittency. And while batteries may be able to bridge relatively minor energy shortfalls of up to a few hours, from a cost and resource perspective they are not suited to bulk storage at gigawatt-hour scales. Heat storage is, though. Thanks to the advances made by the CSP industry, heat storage can now be considered a relatively mature technology. It has proven capacity to act as a reliable source of bulk, low-cost energy storage and can be deployed in a range of settings.

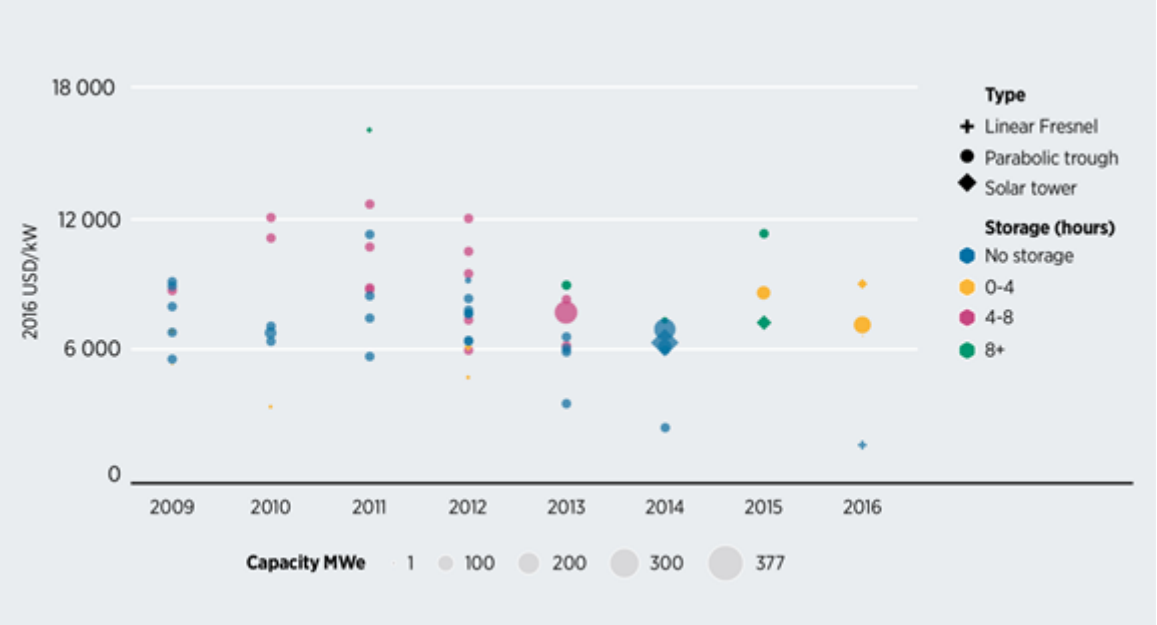
Because of this, there is increasing interest in deploying heat storage not just alongside CSP but also as a standalone asset, for example to store energy derived from excess wind or solar power. Against this backdrop, the CSP Madrid international solar conference and exhibition, on November 19 and 20, 2019, will be placing special emphasis on thermal energy storage opportunities. This white paper aims to serve as a primer on this rapidly developing sector.

**The evolution of thermal storage**

Technologies for storing heat have long been a feature of many western societies, with the Netherlands for example including aquifer thermal energy storage in thousands of houses. Such applications have mostly focused on storing heat for use in heating, though. Attempts to use heat storage for electricity production were instigated most prominently by the development of the CSP industry in the 2000s.

The Solar Two CSP plant, commissioned in the Mojave Desert in 1995, was the first to feature a molten salt store, allowing for up to three hours' operation after sundown.[1] Similar technology was deployed at the Gemasolar plant in Spain, in 2011, allowing the plant to deliver electricity around the clock by 2013.[2] Thermal storage has subsequently become almost essential to allow CSP to compete in renewable energy markets.

In 2016, for example, almost 90% of 50 MW-plus plants being built or entering operation were equipped with storage, with an average of almost eight hours.[3] By that point, leading developers such as Abengoa had already for some time considered decoupling thermal storage from CSP plants and using standalone molten salt systems as a replacement for gas peakers.[4]




CSP installed costs by project size, collector type and amount of storage, 2009-2016. Source: International Renewable Energy Agency. [5]

While this particular application has failed to catch on, interest in standalone thermal storage has continued to grow, buoyed by a growing need to cost-effectively store increasing amounts of renewable energy production. The value of heat-storing media for energy storage is underscored by the fact that the thermal stores connected to CSP plants far outweigh global battery capacity, according to 2017 data from the International Renewable Energy Agency.[6]

## Market overview

As of 2018, there was approximately 17.6 GWh of thermal storage capacity in operation around the world, almost all connected to CSP plants.[7] This capacity is likely to increase significantly in the coming years as China embraces CSP. In June 2019, for example, China Daily reported that China's first molten CSP plant had reached full capacity.[8] The first of 20 plants planned for the country[9], the 100 MW Dunhuang plant has 1.2 GWh of energy storage.[10]

To date, almost all heat storage capacity has in the form of molten salt, typically made up of 60% sodium nitrate and 40% potassium nitrate. This has excellent thermal properties and production and pricing of the salts is relatively stable owing to their widespread use in the fertilizer industry.

SQM, the top molten salt provider to the CSP industry, has on its own a production capacity of 1.5 million tons of sodium nitrate and potassium nitrate a year[11], so raw materials should not be an impediment to the scalability of heat storage. At the same time, though, there is extensive research into alternative storage media that might reduce the levelized cost of energy by using a cheaper substrate or allowing for higher temperatures and thus greater efficiency.

These are increasingly the focus for standalone heat storage technology developers such as those outlined below.

### 1414 Degrees

Based in Adelaide, Australia, 1414 Degrees has developed a molten silicon thermal energy storage system that it claims can store 500 kWh of energy within a 70-centimeter cube.[12] The company began commercial installation of its systems in 2019 and in August announced a feasibility study into whether 10 MWh of storage could be used to help an Australian brewer increase its use of renewable energy.[13]

### Malta

Perhaps the highest-profile heat storage contender to date is Malta, a company that started out inside Alphabet's X moonshot incubator and last year was spun out with $26m in backing from Breakthrough Energy Ventures. Concord New Energy and Alfa Laval.[16] Malta's technology combines heat and cold storage to deliver higher efficiencies than can be achieved with hot media alone.[17]

### EnergyNest

EnergyNest of Norway has been working for several years on the development of a thermal energy storage technology that uses specially formulated concrete, called HEATCRETE, as the heat sink.[14] In August 2019, the company published the results of tests on two 500 kWh storage systems, carried out at the Masdar Institute Solar Platform, which showed the material was capable of operating at up to 380°C over a period of more than 20 months.[15]

### Siemens Gamesa

In 2014, the renewable energy technology developer Siemens Gamesa carried out tests on a 5 MWh heat storage system based on volcanic rocks heated to up to 600°C. The company claims the technology could work at gigawatt-hour scale and is looking to commission a 50 MW plant in 2020.[20]

### RWE Power

In March 2019, RWE Power, Aachen University and the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt or DLR) announced plans to replace a boiler from an old coal plant with a molten salt thermal storage tank.[18] Engineering proposals were expected to take 12 to 18 months and construction another year and a half, meaning the pilot plant could be up and running within three years.[19]

## Outlook and conclusions

In August 2019, the analyst firm Wood Mackenzie warned that current rates of energy system decarbonization were too slow to meet Paris Agreement goals, putting the world on course for 3°C warming.[21] The inference is that renewable energy integration must increase to a scale where battery storage is no longer practical or economical because of constraints on raw materials such as cobalt.

Heat storage not only provides a cost-effective alternative but is also a technology that is increasingly tried and tested. Find out more about its potential at the CSP Madrid international solar conference and exhibition, on November 19 and 20, 2019.

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