

## European Solar and Energy Storage Solutions

# Denmark seasonal storage



## Overview

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Seasonal thermal energy storage (STES), also known as inter-seasonal thermal energy storage, is the storage of heat or cold for periods of up to several months. The thermal energy can be collected whenever it is available and be used whenever needed, such as in the opposing season. For example, heat from solar.

There are several types of STES technology, covering a range of applications from single small buildings to community district heating networks. Generally, efficiency increases and the specific construction cost.

The Energy Conservation through Energy Storage (ECES) Programme has held triennial global energy conferences since 1981. The conferences originally focused exclusively on STES, but now that those technologies are mature.

A number of homes and small apartment buildings have demonstrated combining a large internal water tank for heat storage with roof-mounted solar-thermal collectors. Storage temperatures of 90 °C (194 °F) are sufficient to supply both domestic hot water and space.

Annualized geo-solar (AGS) enables in even cold, foggy north temperate areas. It uses the ground under or around a as to heat and cool the building. After a designed, conductive thermal lag of 6 months the heat is.

Small passively heated buildings typically use the soil adjoining the building as a low-temperature seasonal heat store that in the annual cycle reaches a maximum temperature similar to average annual air temperature, with the temperature drawn down for heating in.

STES is also used extensively for the heating of greenhouses. ATEs is the kind of storage commonly in use for this application. In summer, the greenhouse is cooled with ground water, pumped from the “cold well” in the aquifer. The water is heated in the process.

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Does Denmark need seasonal pit heat storage?

Denmark has had a steep – but successful – learning curve with regard to the cost and efficiency of seasonal pit heat storage, which is used to store sunlight in summer for heating purposes in winter.

How many large scale thermal storages have been built in Denmark?

Since the 80ties large scale thermal storages have been developed and tested in the Danish energy system. From 2011 five full scale pit heat water storages and one pilot borehole storage have been built.

How much does a pit storage system cost in Denmark?

Denmark's first big (10,000 m<sup>3</sup>) pit storage demonstration system, built in Marstal, came to 67 EUR/m<sup>3</sup>. This made it nearly three times as expensive as today's biggest seasonal storage, which was put up in Vojens and cost only 24 EUR/m<sup>3</sup>.

What is the thermal capacity of a Danish heat network?

Danish heat networks with CHP typically operate with a large amount of non-seasonal thermal storage in the form of steel water tanks. In 2013, this was estimated to have a thermal capacity of 50 GWh , while in 2018, seasonal storage capacity (almost entirely PTES) was estimated to be 14 GWh.

Why is the Dronninglund seasonal storage system better than the Marstal system?

During the webinar, Nielsen gave three reasons why the efficiency of the Dronninglund seasonal storage is significantly better than that of the Marstal system: The Dronninglund seasonal storage is connected to the district heating grid via a heat pump. This makes for lower storage temperatures throughout the year, which reduces heat losses.

How does pit heat storage work in Denmark?

“In Denmark, we have a wealth of experience in pit heat storage construction, which is fairly simple,” Nielsen said. “You dig a hole in the ground and put soil around the edges. Then, you add a watertight liner at the bottom of the pit, fill the pit with water and put an insulating and floating cover on top.”

## Denmark seasonal storage

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### Thermal Energy Storage for District Heating

Seasonal thermal energy storage is used primarily for large-scale solar collectors that generate more heat during the summer than is immediately needed. These storages are typically large pits lined with water and covered with a floating ...

### Seasonal storage through Power-to-X --the key to a ...

When we phase out fossil fuels, we will in Denmark need a terawatt-hour-sized energy storage solution to get through the winter. The capacity of terawatt hours (TWh) equals millions of car batteries, so it's not ...



### Seasonal Energy Storage Technology Review

The total generation of variable renewable energy including solar, wind, and hydropower often tends to peak in the spring. These low-carbon energy sources also tend to abate during the fall and winter months. To accommodate the use of this variable energy throughout the year the grid may benefit from economically viable seasonal energy storage to shift energy from one ...

### A Comprehensive Review on

## Enhancing Seasonal Energy Storage ...

The global energy transition requires efficient seasonal energy storage systems (SESSs) to manage fluctuations in renewable energy supply and demand. This review focuses on advancements in SESSs, particularly their integration into solar district heating systems, highlighting their role in reducing greenhouse gas emissions and enhancing energy efficiency.

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## Thermal Energy Storage for District Heating

This aligns with Denmark's goal of achieving a 70% reduction in CO2 emissions by 2030. Furthermore, TES supports the integration of surplus heat from industries and data centers into district heating networks, further enhancing environmental sustainability. Seasonal thermal energy storage is used primarily for large-scale

## Thermal Energy Storage for District Heating

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## Seasonal thermal energy storage as a complementary ...

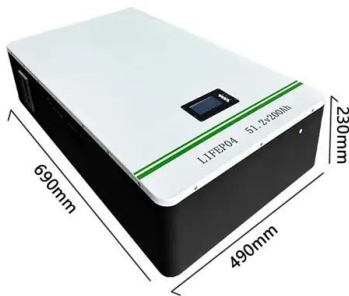
Seasonal thermal energy storage (STES) has potential to act as an enabling technology in the transition to sustainable and low carbon energy



systems. It is a relatively mature technology, providing a reliable and large-scale solution to seasonal variations in energy supply and demand where it has been deployed at scale.

### Denmark: Dronninglund Inaugurates 26 MWth ...

Regarding the complete solution, it has been my impression that the combination of high-performance flat plate collectors and seasonal storage is maturing now, based on past experiences. Arcon has just signed a contract ...



### Seasonal pit heat storage: Cost benchmark of 30 EUR/m<sup>3</sup>

Seasonal heat storage is a very cost-effective way to make use of surplus electric power generated by wind farms in Denmark. "Wind energy has already contributed up to 40 % to electricity generation in a year and we want to combine this rich intermittent energy source with seasonal storage via heat pumps," Nielsen said.

### Seasonal pit heat storage: Cost benchmark of 30 EUR/m<sup>3</sup>

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## Seasonal pit heat storage: Cost benchmark of 30 EUR/m3

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## The Promise of Seasonal Storage

It stores energy during one seasonal condition (summer or winter) and discharges the stored energy in the other seasonal condition, depending on the load demand. Seasonal storage is, therefore, closely related to seasonal variations in temperature, wind speed and solar irradiation as these mainly determine the need for heat- and cooling demand



## Seasonal storage through Power-to-X --the key to a robust ...

When we phase out fossil fuels, we will in Denmark need a terawatt-hour-sized energy storage solution to get through the winter. The capacity of terawatt hours (TWh) equals millions

of car batteries, so it's not something we can solve using standard batteries.



## Monitoring results and performance of seasonal heat

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seasonal heat storage Thomas Schmidt Steinbeis Research Institute for Solar and Sustainable Thermal Energy Systems Meitnerstr. 8 Pit thermal energy storage in Dronninglund, Denmark 63 000 Pit thermal energy storage Solar heat central 37 600 Solar collectors Solar collectors Seasonal storage Heat pump CHP Boiler



## Large Scale Heat Storages for Solar District Heating

Denmark is the international frontrunner on large scale application of renewable energy systems. In the last four years, more and more Danish district plants have been equipped with large heat storages in the form of water pits with the aim to increase flexibility and stability of the energy system. 1st International Conference on Seasonal

## Development of Seasonal Storage in Denmark: Status of Storage ...

T1 - Development of Seasonal Storage in Denmark. T2 - 8th International Conference on Thermal Energy Storage. AU - Heller, Alfred. PY - 2000. Y1 - 2000. N2 - National survey on seasonal (thermal, large-scale) storage activities in Denmark. A storage programme under the Danish Energy Agency.



## Dronninglund water pit thermal energy storage dataset

The storage is used for seasonal and short-term heat storage of solar heat generated by a 37,573 m<sup>2</sup> solar collector field and supplies heat directly to the district heating grid or is used during



## seasonal heat storage in Denmark

seasonal heat storage, water pit, borehole heat storage; Fingerprint. Denmark Earth and Planetary Sciences 100%. Heat Storage Earth and Planetary Sciences 100%. Borehole Earth and Planetary Sciences 50%. Experience Earth and Planetary Sciences 50%. View full fingerprint



## Seasonal heat storage

Since the first project with pond thermal storage in Ottrupgård, PlanEnergi has been a leading consultant in large seasonal thermal storage, including 75,000 m<sup>3</sup> pond thermal storage in Marstal, 19,000 m<sup>3</sup> borehole storage in Brædstrup, 60,000 m<sup>3</sup> pond thermal storage in Dronninglund as well as the establishment of a pond thermal storage of 1.5 2.0 million m<sup>3</sup> in ...



## Seasonal pit heat storage: Cost benchmark of 30 EUR/m<sup>3</sup>

Denmark has had a successful learning curve regarding to the cost and efficiency of seasonal pit heat storage, which is used to store sunlight in summer for heating purposes in winter. Take Sunstore 3, for example, a 60,000 m<sup>3</sup> pit heat storage system built at a cost of 38 EUR/m<sup>3</sup> of storage capacity in the town of Dronninglund in 2014: It has



## Seasonal thermal energy storage: A techno-economic literature review

Seasonal thermal energy storage (STES) holds great promise for storing summer heat for winter use. It allows renewable resources to meet the seasonal heat demand without resorting to fossil-based back up. Besides, the studies conducted in Copenhagen, Denmark [32], and Marseille, France [33, 34], have indicated that when a TTES is built in a

## Seasonal thermal energy storage

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## A TOTAL ENERGY DESIGN FOR 92 HOUSES WITH COMBINED USE ...



Diagram of the central solar heating plant with seasonal storage in Herlev, Denmark. Solar heat is supplied from the solar collectors to the seasonal storage, depending on the delivered temperature. The solar collectors are manufactured by the Danish firm Scancon. Heat from the seasonal storage can be used directly, but when the storage

## Large Thermal Energy Storage at Marstal District Heating

GEO (Danish Geotechnical Institute), Denmark M. V. Jensen PlanEnergi, Denmark possible by seasonal thermal energy storage large enough to preserve the solar energy produced during summertime until winter. For this purpose a 75,000 m<sup>3</sup> pit thermal energy storage has been established. The pit measures 88 meters by 113 meters at the top and has



## Large-scale solar district heating plants in Danish smart thermal ...

Seasonal heat storage units normally have 4 types of designs: tank storage, water pit storage, borehole storage and aquifer thermal energy storage, as shown in Fig. 13. Denmark is the leading country for water pit storage for district heating in the world [74]. Table 1 lists all the seasonal heat storage project in Denmark.

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