Seasonal Storage for Solar District Heating

Experiences from Denmark

PlanEnergi
- Consultant Engineers
- 40 employees
- 35 years with renewable heating
  - biomass, biogas, solar heat, heat pumps, district heating, ...

Jan Erik Nielsen
Seasonal Storage for Solar District Heating

IEA SHC Solar Academy Task 55, March 2019

Wind turbine
Photo voltaic field
Solar collector field
Heat pump
Large multi-functional heat storage
City
CHP plant
Industry waste heat
Geothermal plant
Boiler plant

Sector coupling with multifunctional heat storage
Seasonal Storage for Solar District Heating

Real heat prices solarheatdata.eu

Specific investment versus construction year

Heat price versus size of collector field

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Design of the water pit storage

The soil excavated from the bottom part of the storage is used as embankments around the upper part of the storage.
Marstal: 33 000 m² & 75 000 m³ pit heat storage

- 4.0 MW wood chip boiler (willow)
- 750 kW_electrical ORC
- 75,000 m³ pit heat storage
- 1.5 MW heat pump using CO₂ as refrigerant
Marstal | Energy flow diagrams 2016

- Solar fraction: 35 %
- RE fraction: 100 %
- Storage efficiency: 66 %
- T-min: 20 °C
- T-max: 82 °C
Dronninglund: 37 500 m² & 60 000 m³ pit heat storage

- 2,1 MW absorption heat pump
- Gas engine
- Bio oil boilers
Dronninglund | Energy flow diagrams 2016

- Solar fraction: 40%
- Storage efficiency: 91%
- T-min: 12°C
- T-max: 87°C

Storage losses < 10%!
Gram: 41 000 m²; 110 000 m³ water pit storage

Vojens: 71 500 m² & 200 000 m³ pit heat storage

http://www.gram-fjernvarme.dk/

http://www.vojensfjernvarme.dk/
Costs of pit heat storages

> 100 000 m³ → costs approx. 30 €/m³:

![Graph showing estimated project costs for PTES](image)

Project cost for PTES... (PlanEnergi)
Design of the borehole storage

A large volume of earth is heated/cooled by a matrix of regularly spaced vertical u-tubes.

Braedstrup
Seasonal Storage for Solar District Heating

Braedstrup: 18 600 m² & borehole heat storage (demo size)

- Gas CHP engine
- Heat pump
- Boilers
Braedstrup | Energy flow diagram 2014

Solar fraction: 22 %

Demo size only

Storage efficiency: 49 %
T-min: 10 °C
T-max: 56 °C
BTES cost

Limited cost data is available for the implementation of borehole thermal energy storages. The figure shows the specific cost for installed and conceptual BTES. It is clear that the specific cost drops significantly as the size increases.

Heat capacity of soil is significantly lower than for water (factor around 4)