# Pit Thermal Energy Storage (PTES) overview presentation

## Introduction to PTES and TTES technologies

Geoffroy Gauthier, PlanEnergi

Financial support from:

EUDP

UTES symposium, February 28th, 2024, Offenburg, DE

PlanEnergi

# Content

1. PlanEnergi, company presentation
2. TES development in Denmark
3. TTES and PTES technologies
4. Economics and potential of LTES for District Heating

# PlanEnergi, company presentation

Renewable energy consultancy at PlanEnergi

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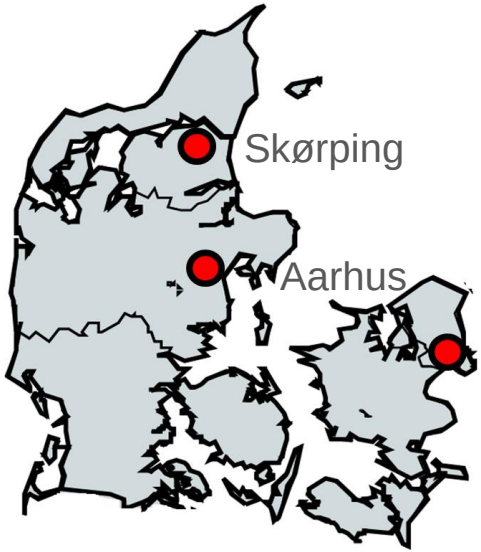
# PlanEnergi is a renewable energy consultancy with 3 offices dispatched over Denmark




# PlanEnergi's expertise

- District Heating Networks
- Solar heat & storage
- Heat pumps
- Energy planning
- Biomass
- Biogas
- Solar PV and wind energy

- **45 employees**
- **40 years experience with renewable heat**

Marstal district heating

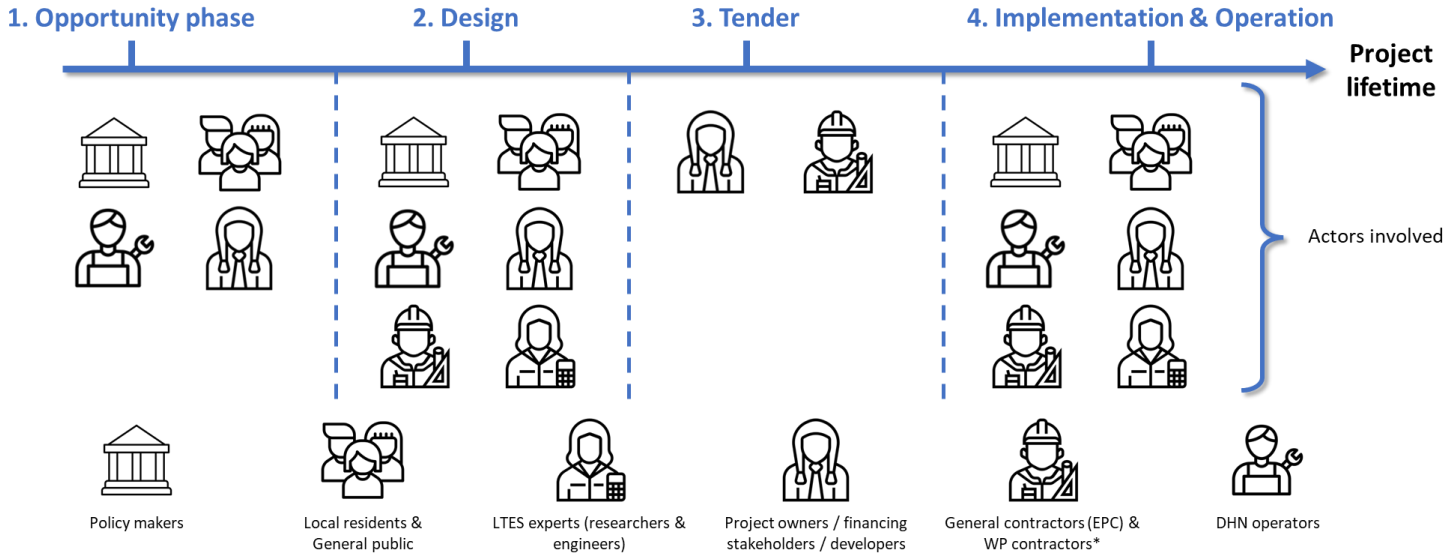
Brønderslev district heating

Thorsø - biogas plant

Broager district heating

Ulsted district heating

# PlanEnergi is a renewable energy consultancy

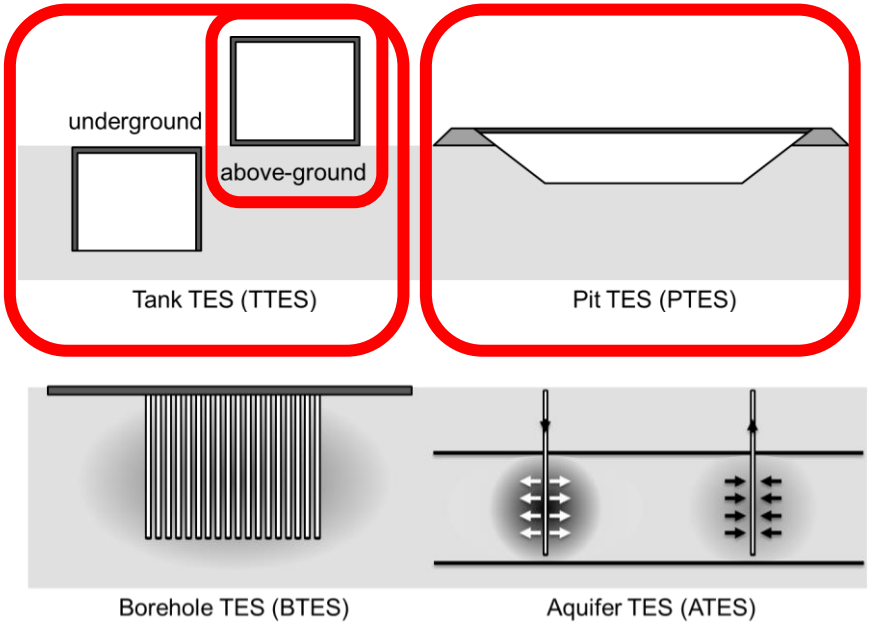



Extract from: IEA-ES Task 39 deliverables

# Thermal Energy Storage (TES) development in Denmark

From TTES to PTES

# In Denmark, mostly 2 TES technology variants




Sketch: Solites

# 1. Above-ground TTES* coupled to DH

TTES in Karup (Denmark) – 3'600 m³. Photo: Karup district heating

TTES in Detmold (Germany) – Stadtwerke Detmold, 1'850 m³

*A TTES is a large tank ("thermos"), usually cylindrical, filled with hot water
DH: District Heating

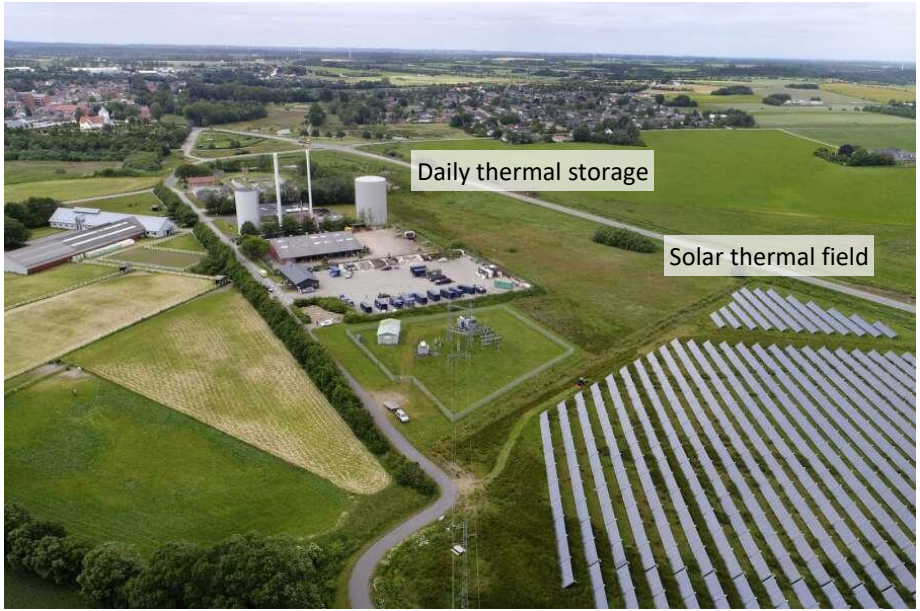
# 1. Above-ground TTES coupled to DH

TTES in DK are coupled to biomass boilers, waste incinerators & CHPs


**6.000 m³ TTES in Slagelse (SK Varme)**
**Source: Steeltank A/S**

# 1. Above-ground TTES coupled to DH

TTES in DK are also widely used for Solar District Heating




Aerial view of the SDH plant in Aulum (DK) https://www.herningfolkeblad.dk/artikel/52ba4119-a03e-4537-84ee-d3f06b95758d/

# 1. Above-ground TTES coupled to DH

TTES in DK are also widely used for Solar District Heating

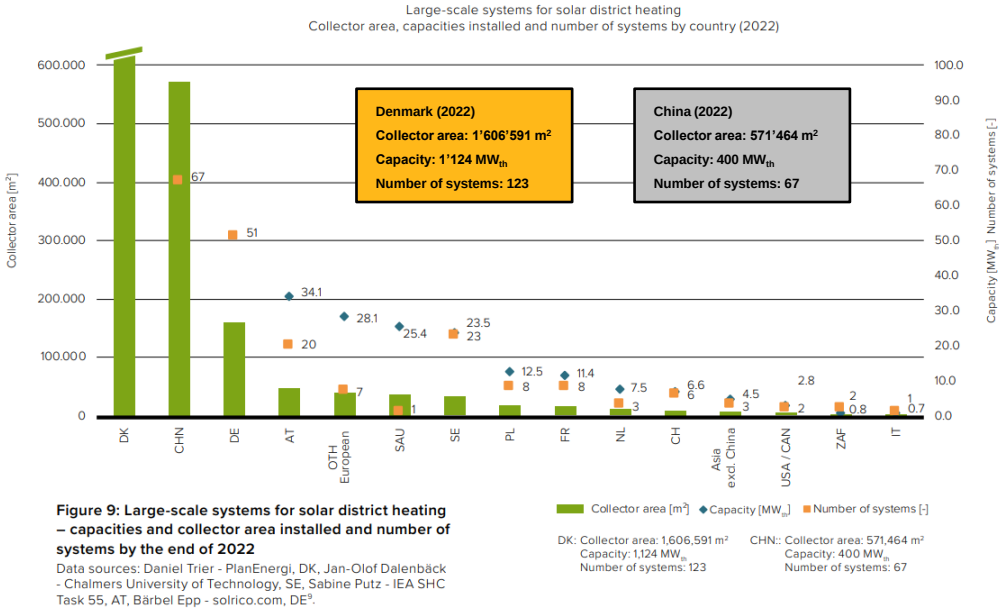


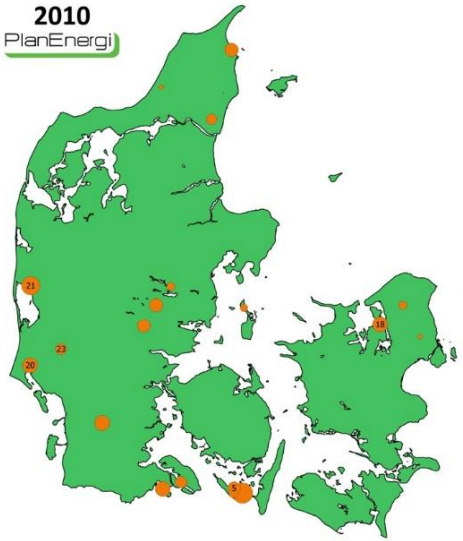

**Figure 9: Large-scale systems for solar district heating – capacities and collector area installed and number of systems by the end of 2022**

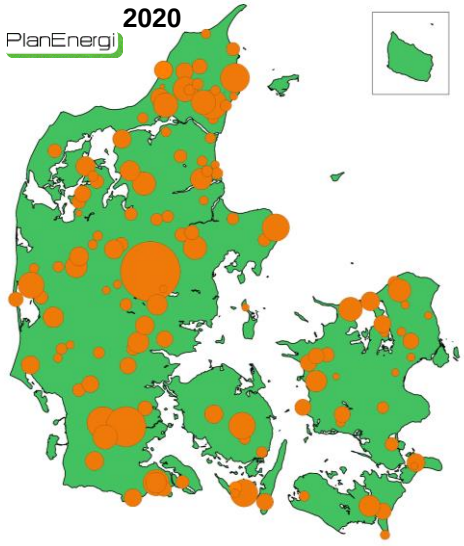
Data sources: Daniel Trier - PlanEnergi, DK, Jan-Olof Dalenbäck - Chalmers University of Technology, SE, Sabine Putz - IEA SHC Task 55, AT, Bärbel Epp - solrico.com, DE[3].

Source : https://www.iea-shc.org/Data/Sites/1/publications/Solar-Heat-Worldwide-2023.pdf

# 1. Above-ground TTES coupled to DH

SDH has grown significantly between 2010 and 2020


Source : www.planenergi.dk

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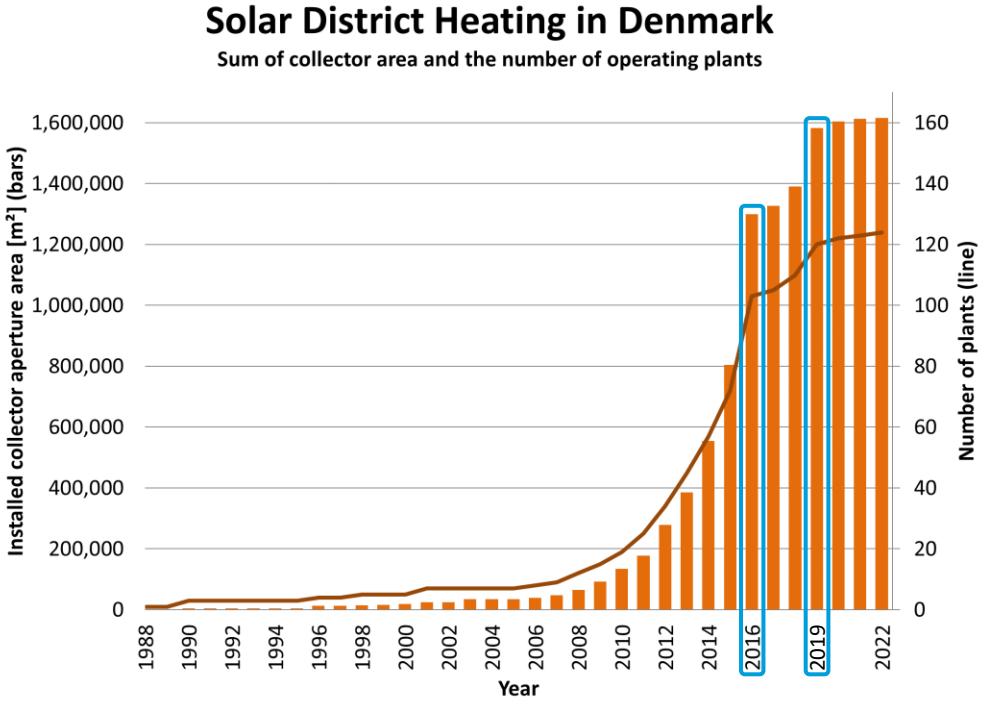
# 1. Above-ground TTES coupled to DH

SDH has grown significantly between 2010 and 2020



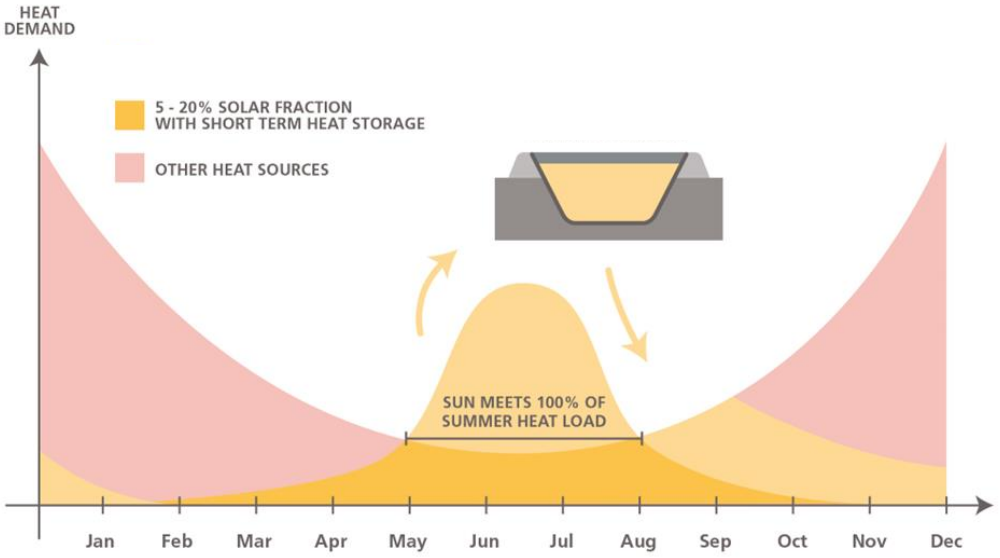

Source : PlanEnergi

# 2. Semi-underground PTES (with embankments)

75'000 m³ PTES in Marstal (DK)
Photo: Aalborg CSP

# 2. Semi-underground PTES (with embankments)

Seasonal PTES helped SDH cover more than 20% of DH demand

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# 2. Semi-underground PTES (with embankments)

Now PTES is also used as a **weekly** storage for DH in Denmark

| Country | Project | Size | Heat capacity | Year commissioned |
|---|---|---|---|---|
| DK | DTU | 500 $m^3$ | | 1983 |
| DK | Ottrupgaard | 1'500 $m^3$ | 43.5 MWh | 1995 |
| DK | Marstal Sunstore 2 | 10'000 $m^3$ | 638 MWh | 2003 |
| DK | Marstal Sunstore 4 | 75'000 $m^3$ | 6'960 MWh | 2012 |
| DK | Dronninglund | 60'000 $m^3$ | 5'500 MWh | 2013 |
| DK | Gram | 122'000 $m^3$ | 11'300 MWh | 2014 |
| DK | Vojens | 203'000 $m^3$ | 18'800 MWh | 2015 |
| DK | Toftlund | 85'000 $m^3$ | 6'500 MWh | 2017 |
| CN | Tibet | 15'000 $m^3$ | 1'000 MWh | 2018 |
| **DK** | **Høje-Taastrup** | 70'000 $m^3$ | 3'300 MWh | 2023 |

# Tank and Pit Thermal Energy Storage technologies

TTES and PTES are relatively low-tech structures

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# A TTES is a giant thermos, built in 5 main steps

1. **Build the foundation of the tank**

2. **Build the roof of the tank*, then build from top to bottom, one level at a time**

3. **Build diffusors at each corresponding level while building up the tank**

4. **Install insulation around and on top of the tank once the tank is built up**

* It is possible to do it the other way around, from bottom to top, with the roof last

# A TTES is a giant thermos, built in 5 main steps

**5. Install cladding around the insulation to protect it from wind & rain, and decorate the tank**

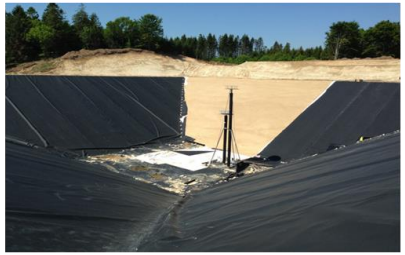

5'600 $m^3$ TTES from Alperia Ecoplus, in Bolzano (IT)


Picture from a project of F.W. Rørteknik of a 4'500 $m^3$ TTES in Chile
See: https://www.fw.dk/references/4500-m3-heat-storage-tank-chile/ for more information

# A PTES is a giant pit filled with hot water

1. **Excavate a pit in the ground and put excavated soil around the edges.**

2. **Add a watertight liner at the bottom and sides of the pit.**



3. **Fill the pit with water.**

4. **Add an insulating floating cover on the top.**

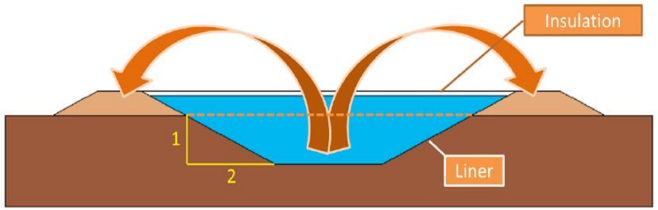
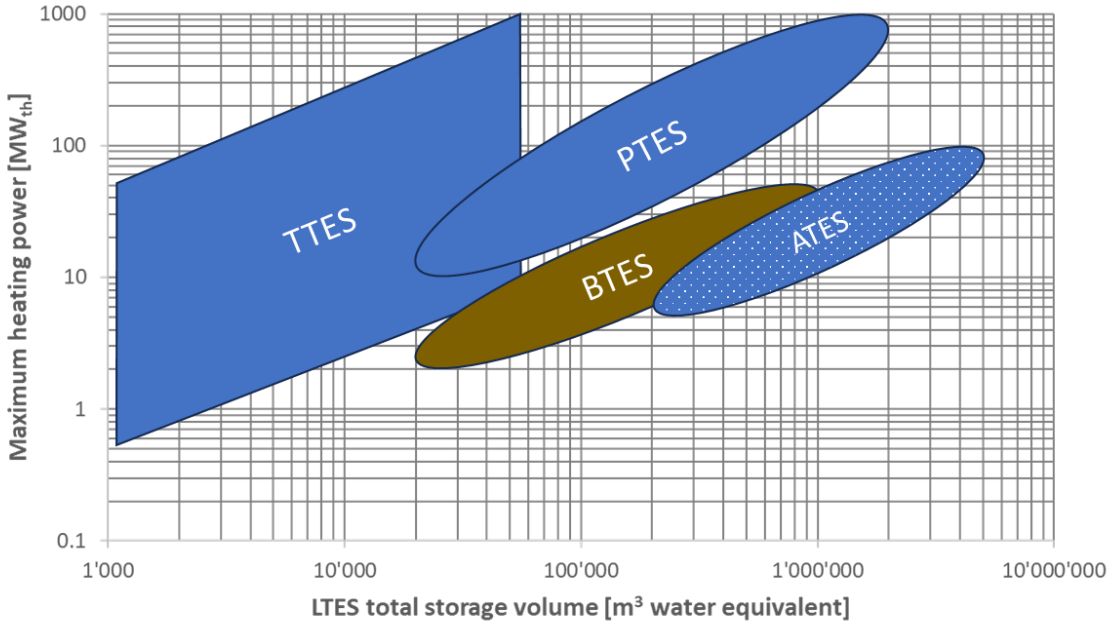



*Figure 2. Principle sketch of a pit heat storage cross section.*

Source : IEA-SHC Task 55

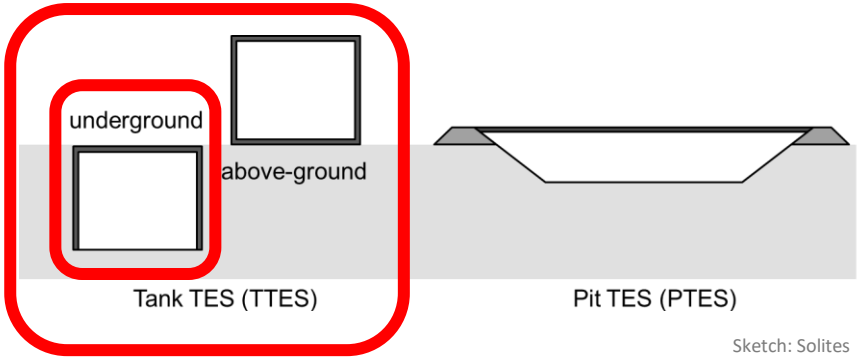
PTES in Dronninglund, main implementation steps

# LTES technologies overview




Extract from: IEA-ES Task 39 deliverables

# Another variant of TTES is underground




Sketch: Solites

The following slides have been presented by **Ruud van den Bosch*** at the online webinar on TTES, organized by IF Technology and TKI Urban Energy on December 14th, 2024
https://topsectorenergie.nl/nl/kennisbank/webinarreeks-warmteopslag/

* Project developer at GroeneWarmte

# 1. (dis)Advantages

**Advantages compared to above ground:**

- **Smaller visual impact after construction**
- **Possibility to make larger volumes (>50,000m$^3$)**
- **Smaller losses due to soil temperature and less convection (wind)**
- **Double use of space**

**Disadvantages:**

- **Cost can be higher (depending on project and scale)**
- **Feasibility depending on local soil conditions / situation**
- **Can be challenging due to rocky soil and ground water level**
- **Longer construction time, higher impact during construction**
- **Unpresurised and <100°C**

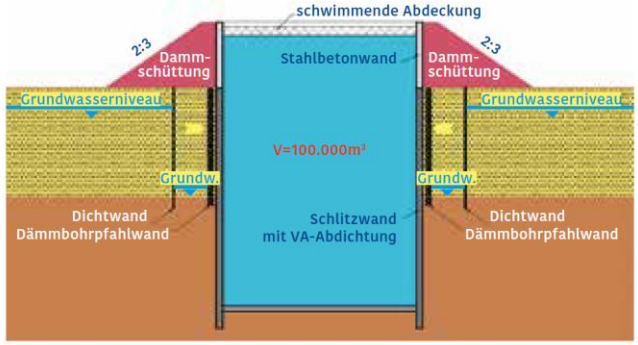
Following up on general TTES (dis)advantages in presentation PlanEnergi 14-12-2023

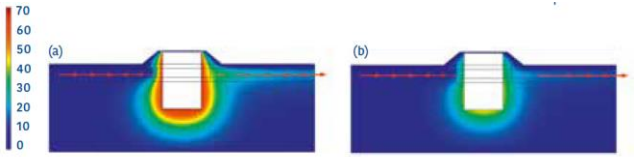
GroeneWarmte

# 2. Two example initiatives

ecovat

gigaTES




Main difference:
Insulation attached to inside of Diaphagm-wall (Ecovat)
Insulation inside borepile wall (GigaTES)

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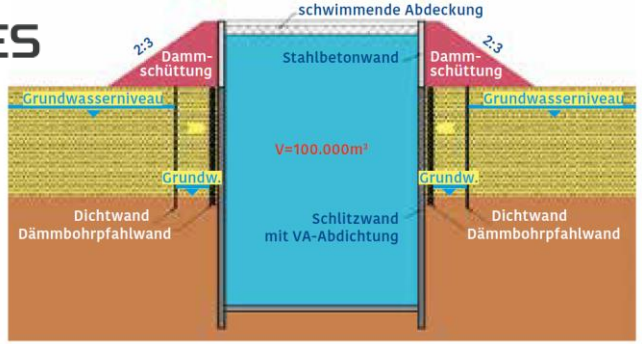
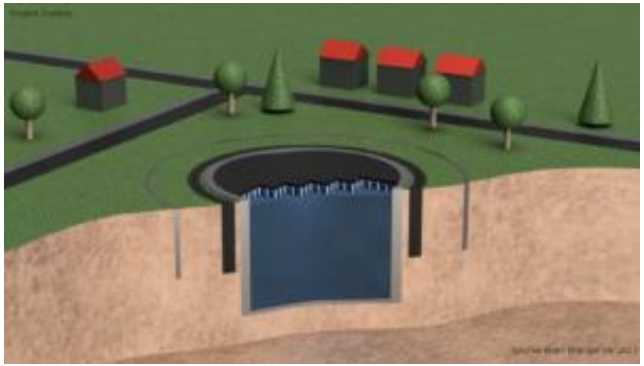
# 3. Gigates (Scale-up)

- Vienna
- Project from 2018-22. Follow-up project: Scale-up
- 100,000 $m^3$
- Floating roof
- Insulation: option with foamglass gravel inside borepile wall
- Currently evaluating different options
- Goal is demo in 2 years

gigaTES



www.gigates.at/index.php/de/

https://positionen.wienenergie.at/blog/gastbeitrag-scaleup/

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# 4. Ecovat

ecovat

- Development since 2013, Demo in 2017
- 10,000-100,000 $m^3$
- Supporting roof
- Insulation: attached to precast modules which are installed on the inside of the Diaphragm wall

www.ecovat.eu/bouw-ecovat-beeld/

# Economics and potential of LTES for District Heating

LTES is key element of the future energy system

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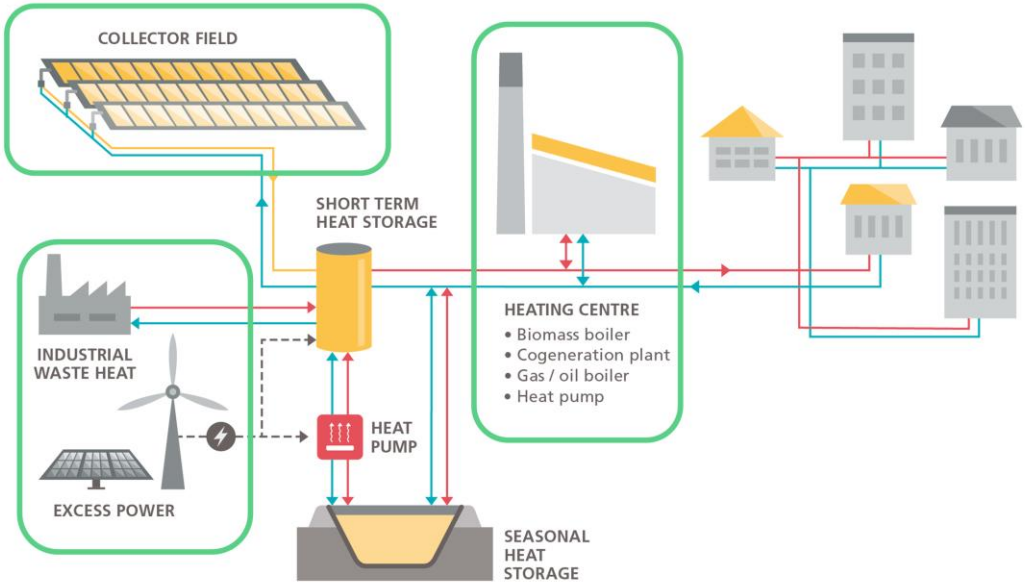
# Why focus on LTES (for District Heating)?

LTES can store renewable heat and other renewable energies & are a key enabler for sector coupling and energy independency

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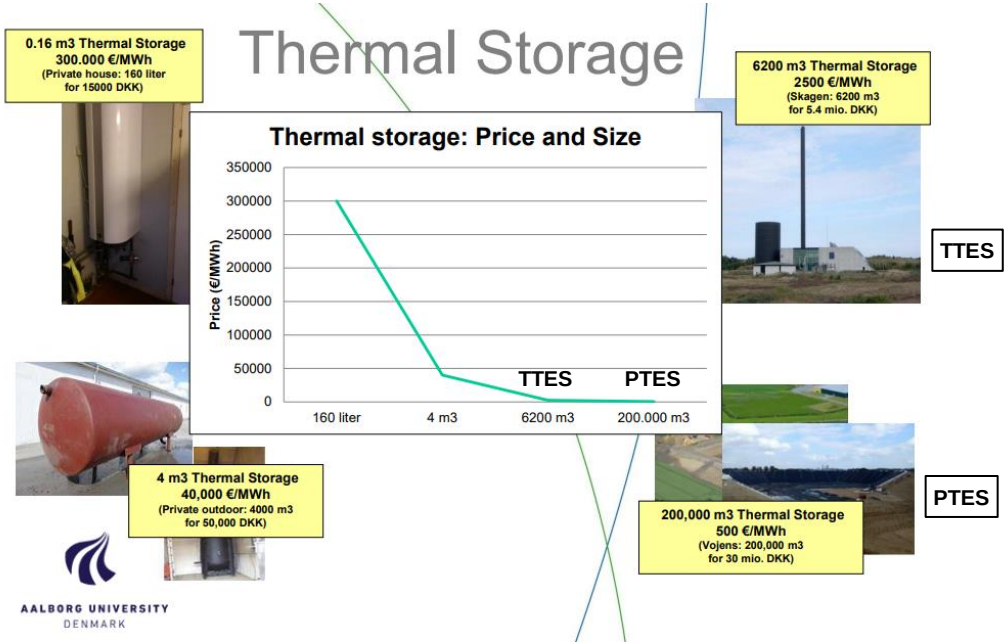
# Why focus on LTES (for District Heating)?

LTES is **inexpensive** to store at large scale: from 4€/kWh to less than 1€/kWh

(Pumped Hydro Storage: 175€/kWh)




Source: The Status of 4th Generation District Heating: Research and Results. Presentation by Henrik Lund made at the 4th International Conference on Smart Energy Systems and 4thGeneration District Heating, 13-14 November 2018 in Aalborg, Denmark.

# Why focus on LTES (for District Heating)?

LTES make DH **cost** and **energy-efficient**

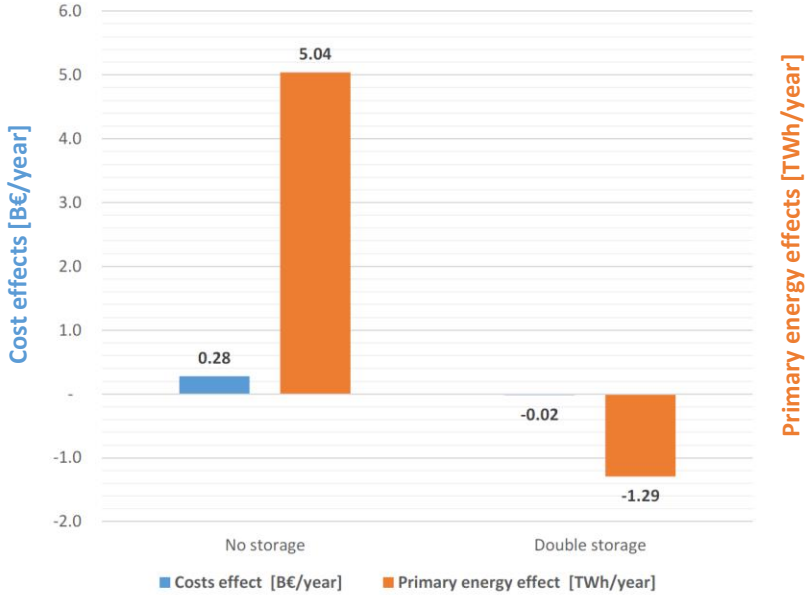



Figure 6: Results for the changes in total costs and primary energy supply in scenario 1a (DH storage) by removing and doubling the DH storage, compared to the reference scenario.

Extract from the Final Report of IEA-ES Task 35

# Thank you for listening

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https://iea-es.org/

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