Effective Geosynthetics Solution for Pit Thermal Energy Storage

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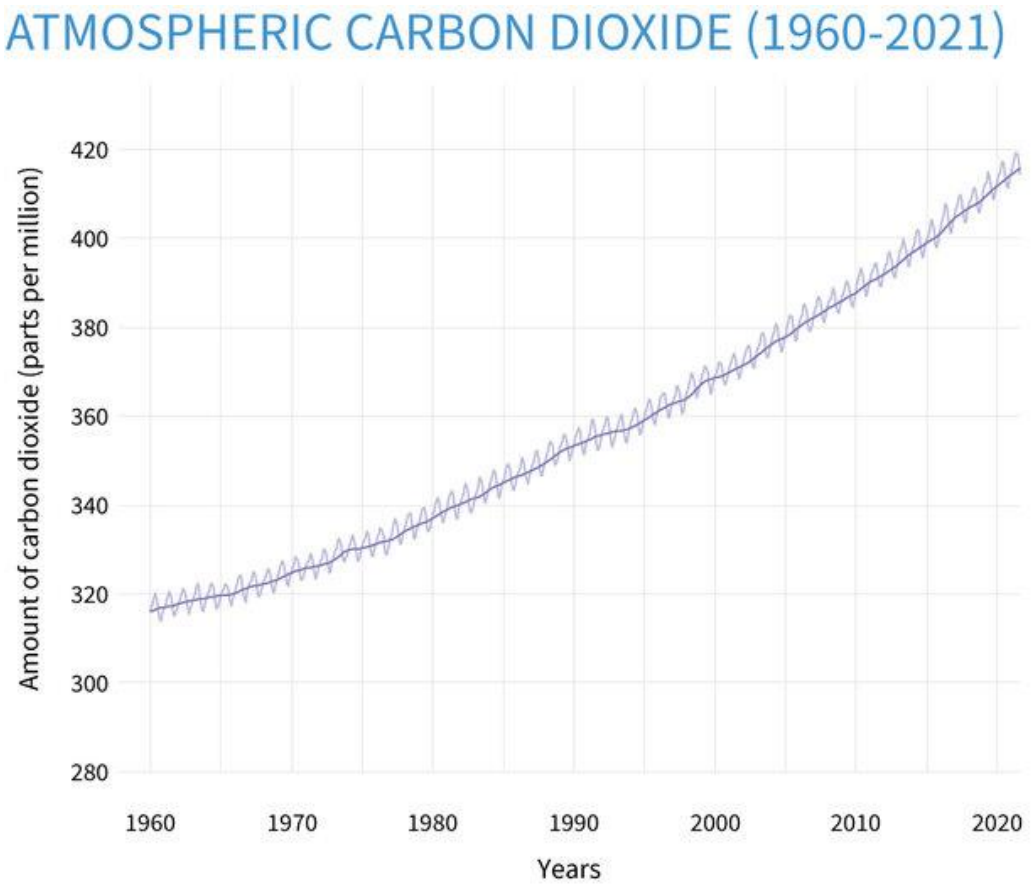
Session 4.1: Advances in Geosynthetics for Sustainability, Durability and Innovation

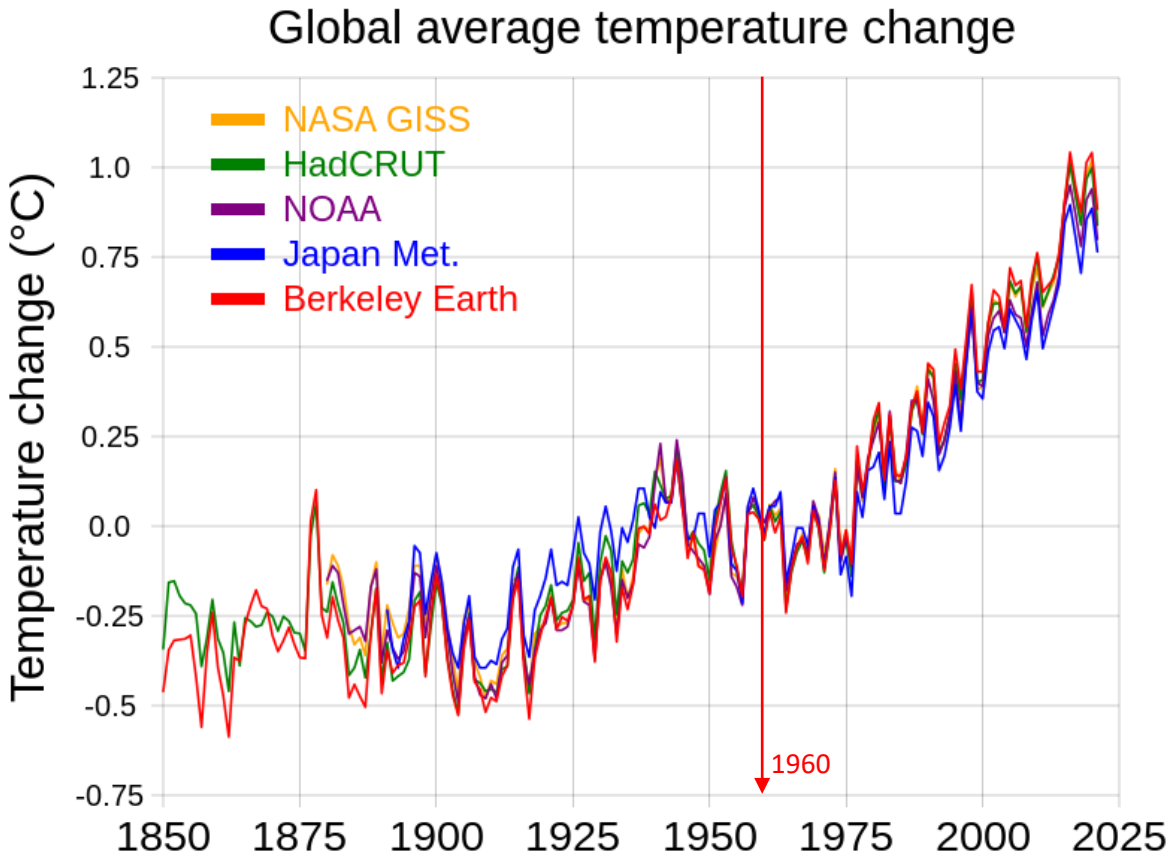
GEOANZ #1 ADVANCES IN GEOSYNTHETICS
7–9 JUNE 2022 | BRISBANE CONVENTION & EXHIBITION CENTRE

Effective Geosynthetics Solution for Pit Thermal Energy Storage

Motivation for greener energy



Source: NOAA



Source: Wikipedia

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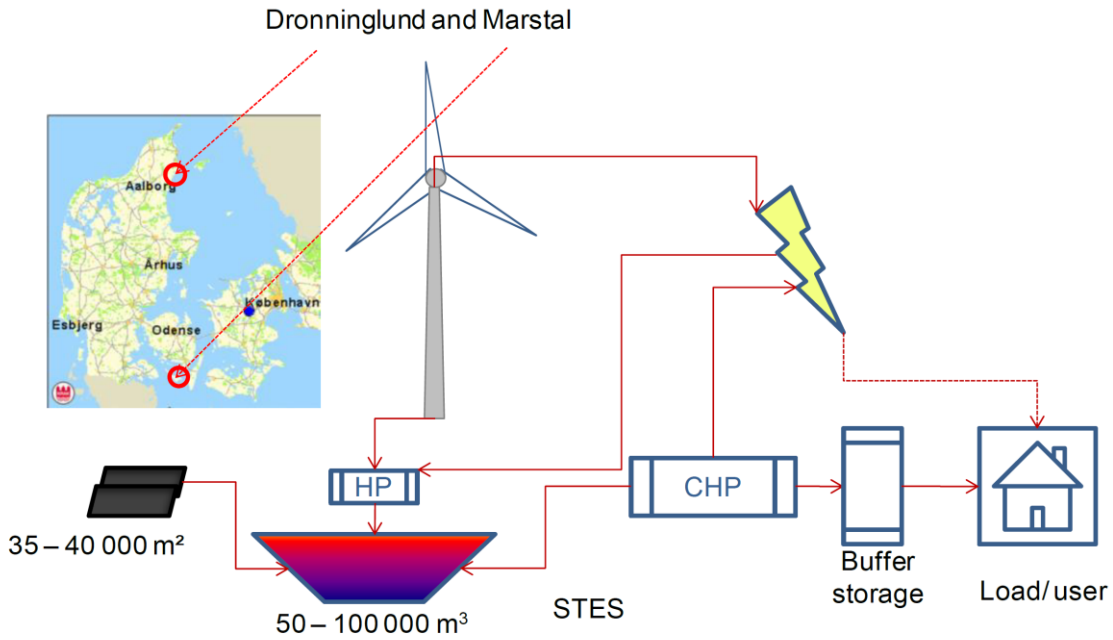
Introduction to thermal energy storage

Thermal energy storage (**TES**) is achieved with widely different technologies. Depending on the specific technology, it allows excess thermal energy to be stored and used hours, days, months later, at scales ranging from the individual process, building, multiuser-building, district, town, or region. Usage examples are the balancing of energy demand between daytime and nighttime, storing summer heat for winter heating, or winter cold for summer air conditioning (Seasonal thermal energy storage). (Wikipedia)

Modern district heating and cooling (DHC) systems are a key technology for the energy transition to a green economy. They enable at a large scale to couple the heat and electricity sector and hence to increase the flexibility of the overall energy system.



Example of smart district heating system in Denmark

Source: PlanEnergi

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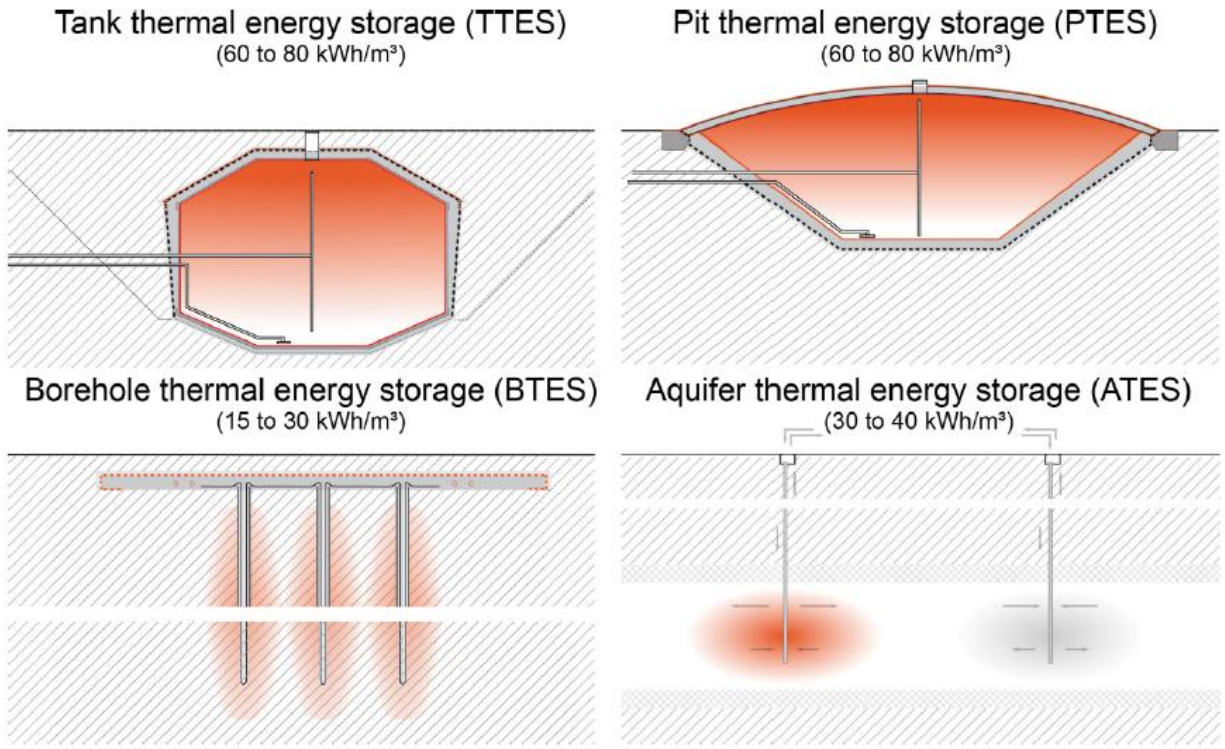
Current technology on thermal energy storage

- **TTES** – Tank Thermal Energy Storage , Steel tanks, insulated
- **PTES** – Pit Thermal Energy Storage – Pit storage, can be insulated
- **BTES** – Borehole Thermal Energy Storage, uses the underground itself as the storage material (Water, rock), cannot be insulated.
- **ATES** – Aquifer Thermal Energy Storage- the water used is naturally occurring, cannot be insulated



Source: Design Aspects for Large-Scale Aquifer and Pit Thermal Energy Storage for District Heating and Cooling, 2018

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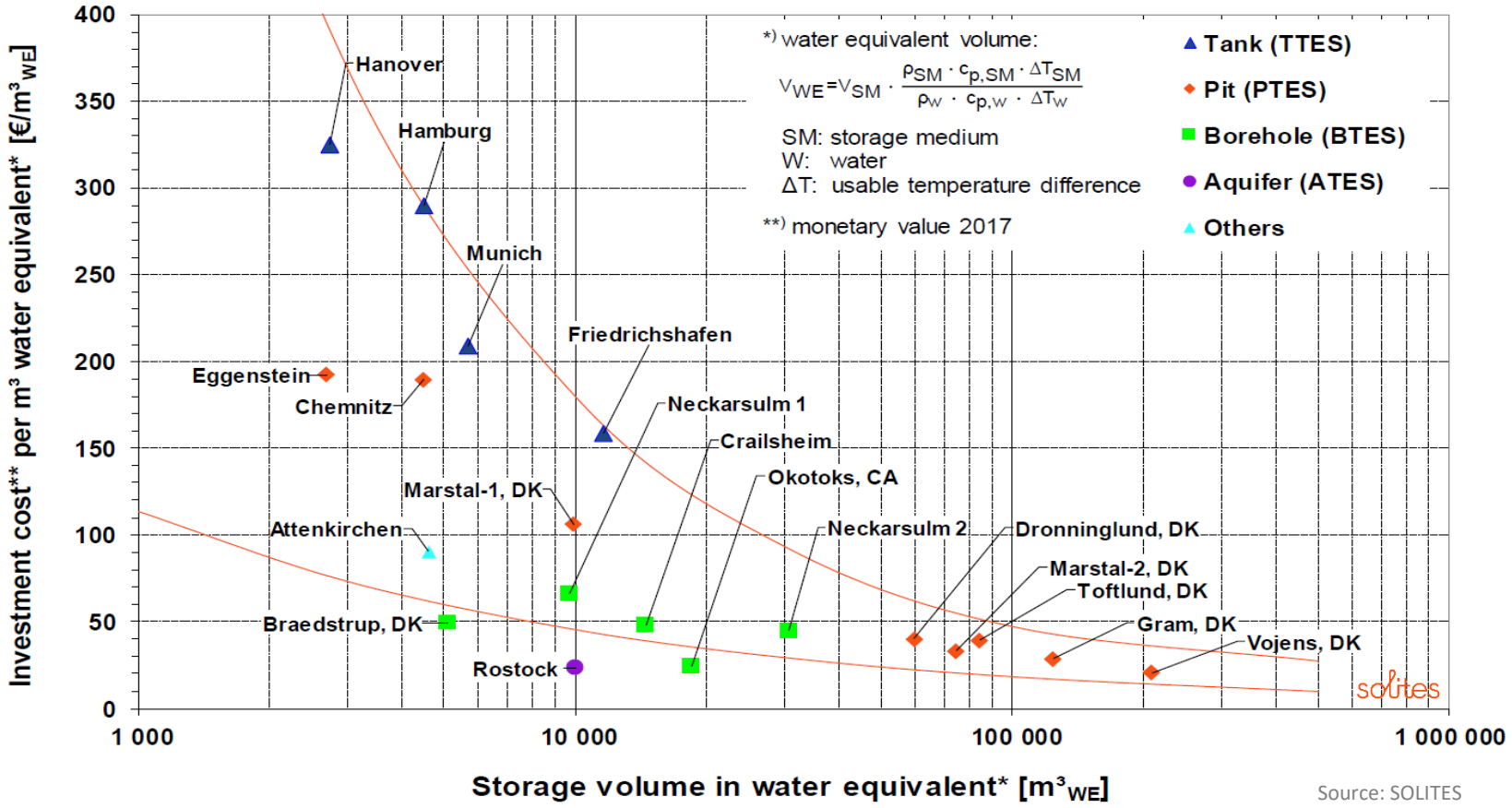
Investment cost for different heat storage types



Source: SOLITES

PTES

- PTES are competitive (by using geosynthetics)
- Profitability increases with increasing realizable storage size
- Economy ≠ investment costs

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Pit thermal energy storage – system principle

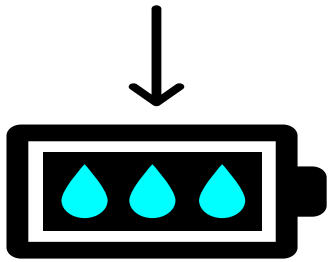
SYSTEM PRINCIPLE

- PTES are seasonal / multifunctional heat storage systems

  A BIG WATER BATTERY!

- Water is favorable because of its heat capacity compares to gravel-water mixture.
- The loading from different sources, e.g.
  - Renewable solar thermal
  - Industrial waste heat
  - CHP plants
  - Power to X
- Construction with geosynthetics

PTES in Toftlund, Dänemark



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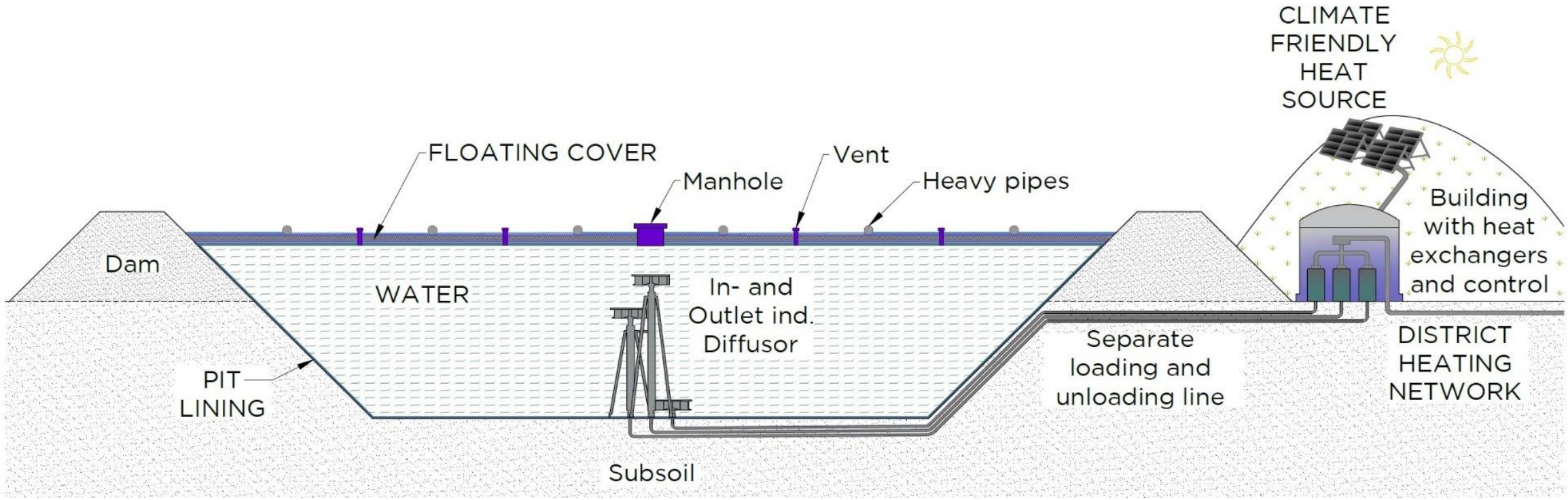
Pit thermal energy storage – system principle



Publication: Labda, T.; Tarnowski, C. (2020): Pit Thermal Energy Storages (PTES) with innovative Sealing for a successful Energy Turnaround. GeoResources Journal (3-2020), pp. 9–16.

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Pit thermal energy storage – lining system challenge

SYSTEM CHALLENGE

- Stored water could be as high as 80 – 90°C for an extended period of time.
- Recommended temperature for standard geomembrane ≤ 60°C.
- Durability of the geomembrane needs to take into consideration.
- Typically the design life of the lining system under high temperature needs to achieve 20 years.
- Good welding quality with liner laying orientation for minimal extrusion.

To ensure the workability of the system, getting the right material for the lining system is crucial

In Service Temperature (°C)	Stage "A" (years)			Stage "B" (years)	Stage "C" (years)	Total Prediction* (years)
	Standard OIT	High Press. OIT	Average OIT			
20 ↓	200	215	208	30	208	446 ↑
25	135	144	140	25	100	265
30	95	98	97	20	49	166
35	65	67	66	15	25	106
40 ↓	45	47	46	10	13	69 ↑

*Total = Stage A (average) + Stage B + Stage C

Table: Lifetime Prediction of HDPE (nonexposed) at various field temperatures, Designing with Geosynthetics, 6th edition

Temperature ↑

=

Geomembrane service life ↓

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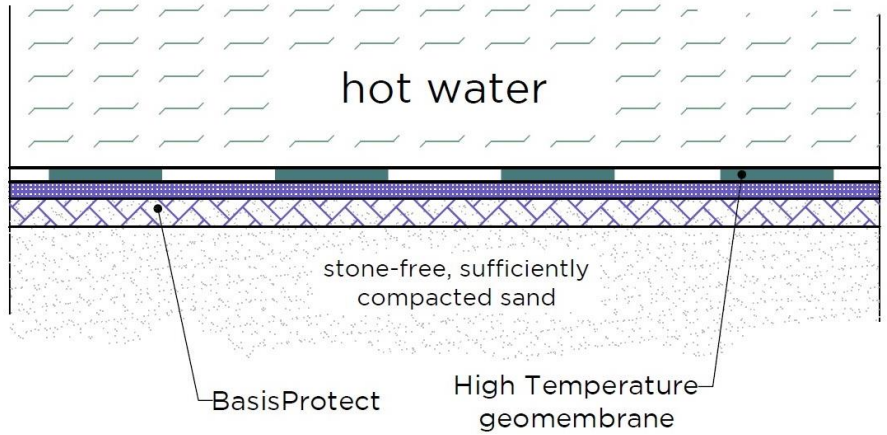
System principle – pit lining system

GEOSYNTHETICS FOR PIT STRUCTURE

- Geocomposites - Protection Function based on subsoil conditions, stabilization might be required
- Geomembrane - High temperature resistance
- Prolonged service life at temperatures above 80°C – Sufficient resistance against leaching & oxidation
- Excellent chemical stability at elevated temperature
- Flexibility at low temperatures and excellent strength at elevated temperature
- Stress crack resistance for a wide temperature window
- Weldability /long-term performance



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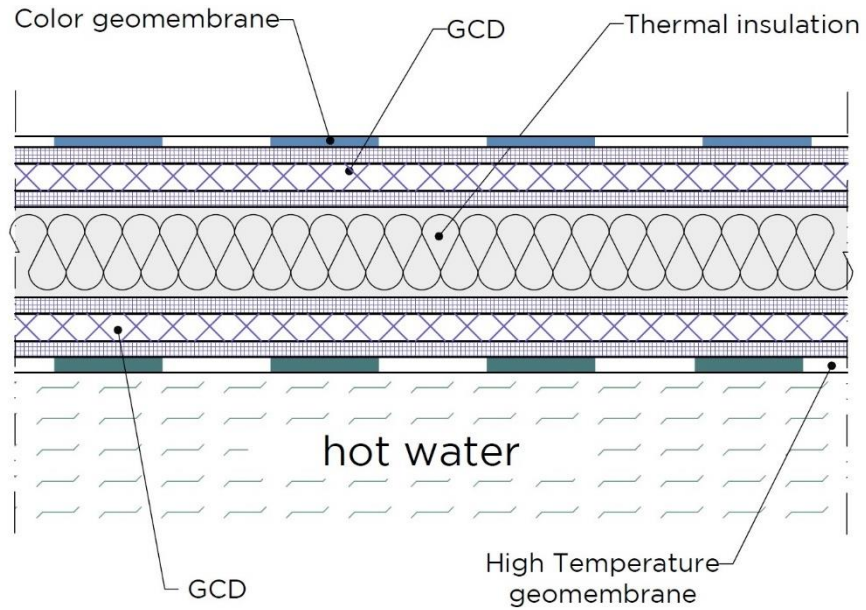
System principle – floating cover system

FLOATING COVER GEOSYNTHETICS

- Floating Cover lower liner = High temperature resistant, water vapor transmittance low
- Geocomposites as stabilization or separation layers between insulation layers - sufficient heat stable
- Exposed upper geomembrane: UV resistance, low thermal elongation, fitting into environment- color



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Current technology on thermal energy storage

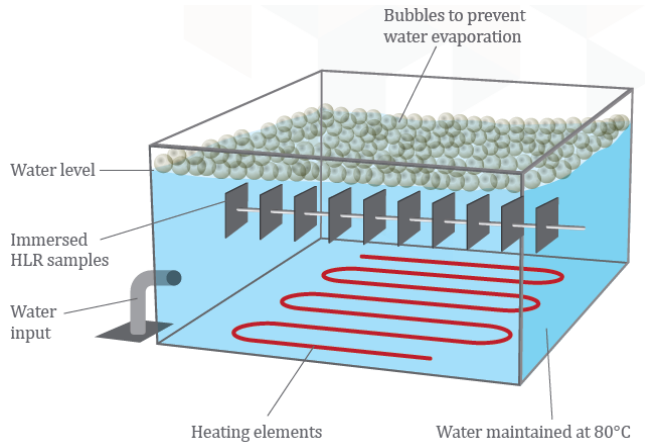
Projects where storage of hot processed water is required or in high temperature heap leaching, etc. We recommend High Temperature Resistance Geomembrane. The geomembrane uses a special HTR resin modified from high grade temperature resistance PE pipe resins.

Normal HDPE Geomembrane highest recommended temperature, T≤ 60 to 70 ˚C

High Temperature Liner highest allowable temperature, T ≤ 100 ˚C

To check on the performance of High Temperature liner, we test the durability with additional testing done at higher temperature. For example:

- Stress crack resistance @ 80°C (normally at 50°C)
- Oven aging @ 100°C for 90 days (normally at 85°C)
- Water bath test @ 80°C for 90 days (isn't a part of standard MQC)



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Current technology on thermal energy storage

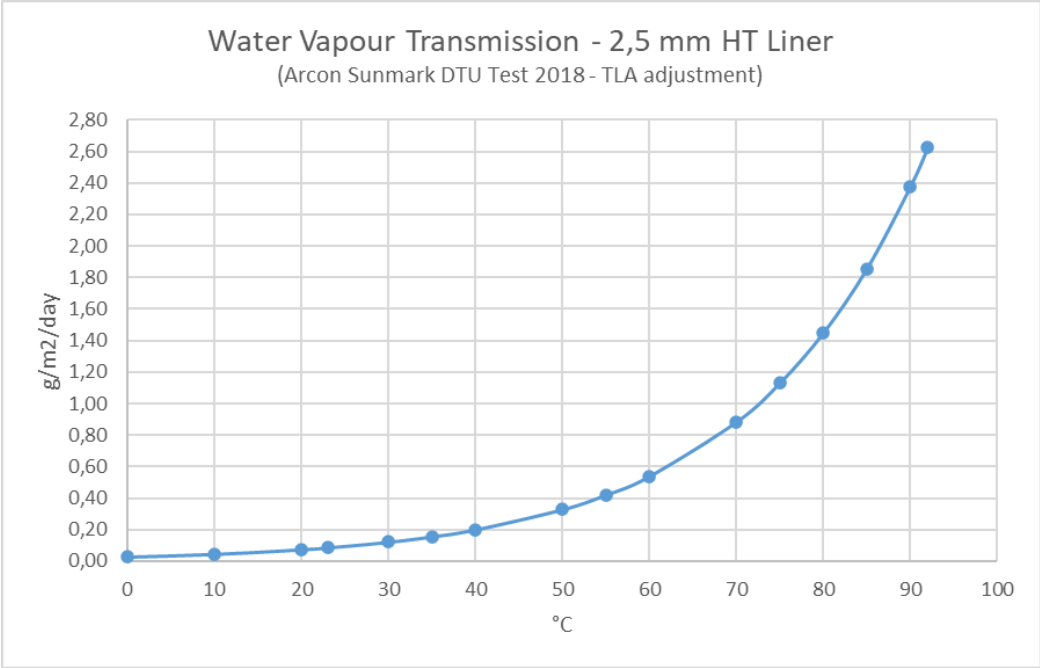
CHALLENGES

INSULATION

- Minimizing heat loss to the atmosphere
- High Temperature Resistance

OXYGEN AND WATER VAPOR

- Water Vapor – manage to have a dry insulation
- Avoid oxygen in the water to reduce corrosion of steel elements



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Summary – advantages of using PTES

PIT THERMAL ENERGY STORAGE

- Fast implementation of the energy transition, particularly in the heating sector is necessary & heat storages are a key factor for a successful heat transition
- Pit thermal energy storages with temperature-resistant geomembrane enable a competitive, cost-effective and long-service life solution and guarantee the security of supply
    - High storage volume can be realized
    - High degree of efficiency
    - Can be combined with existing systems
    - Stabilization / assurance of the heat price
    - Cost-effective construction

Picture: Arcon-Sunmark Large-scale Solar Systems Integration Co., Ltd, PTES Tibet

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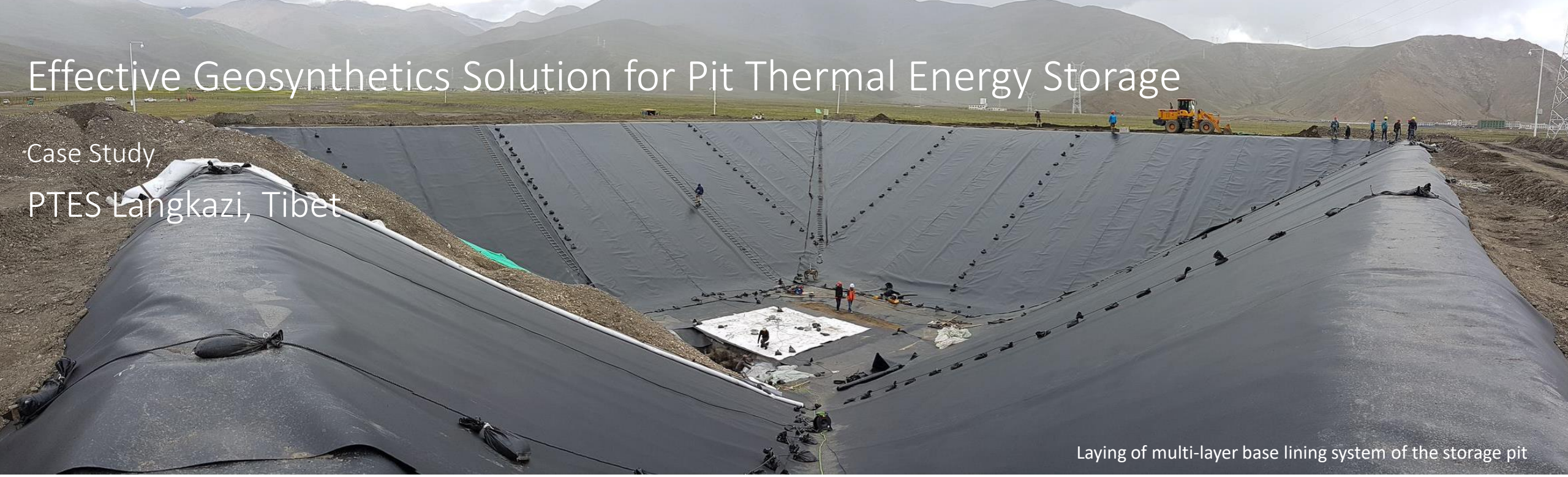
Case Study

PTES Langkazi, Tibet



Laying of multi-layer base lining system of the storage pit

- Located at 4,600m above sea level.
- Construction started in April, operational since December 2018.
- Tibet's first large solar thermal heating system, supplies >90% of Langkazi town's heating demand with clean energy.
- Designed, planned and developed by Chinese/Danish JV
- Expected annual CO_2 saving of 37,000 tons

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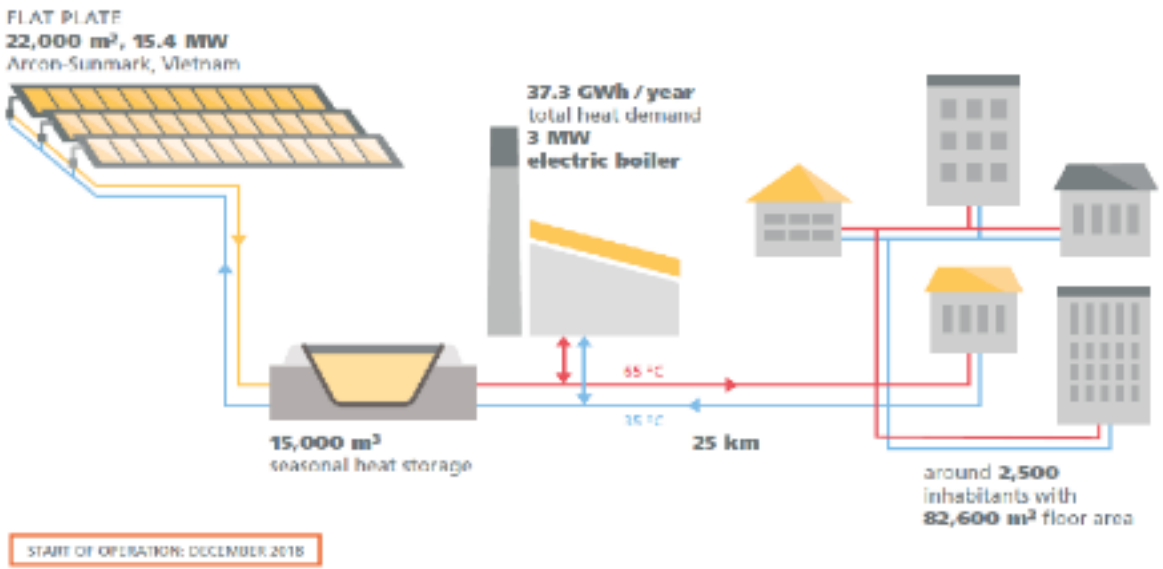
Case Study

PTES Langkazi, Tibet

Deployment of the cover liner after filling the pit.

- PTES system help ensure on-demand heat supply during peak periods (i.e. winter) when there is limited energy generation from the sun or other renewable energy sources.
- During summer, the excess solar heat produced by the solar heating plant is stored in the PTES. The excess heat warms up the water in the storage to approx. 80-90 °C.
- During winter, when the district heating demand increases and exceeds the solar heat produced, hot water from the storage is withdrawn.



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Case Study

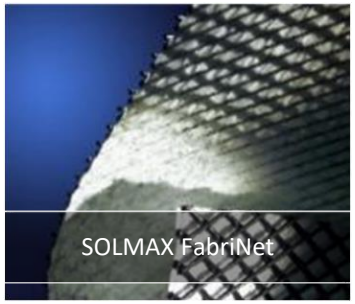
PTES Langkazi, Tibet

Storage pit shown in the photo with solar panel visible on the left

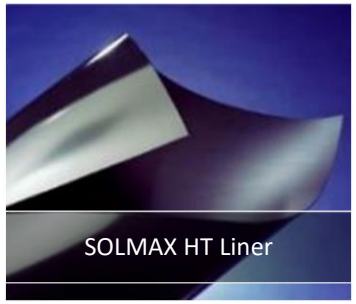
PRODUCTS FOR SEALING THE SEASONAL THERMAL STORAGE SYSTEM	
5,000 m²	Solmax Basis Protect 1.15
10,000 m²	Solmax High Temperature 2.5 mm
8,000 m²	Solmax FabriNet ST-E B201
5,000 m²	Solmax HD 1.0 mm
4,000 m²	Solmax HD Color 1.5 mm (light grey)

Multiple layers of HDPE geomembrane were used as the lining system and geocomposites as drainage layer.

SOLMAX Color Liner



SOLMAX FabriNet



SOLMAX HT Liner

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Thank you!