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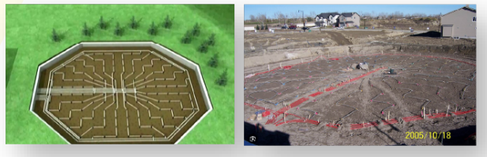
SUSTAINABLE DESIGN

Underground Thermal Energy Storage

IS THE FUTURE

Over 50 Installations Worldwide



2007
Okotoks Alberta
DRAKES LANDING COMMUNITY
Hot Only - Solar PVT

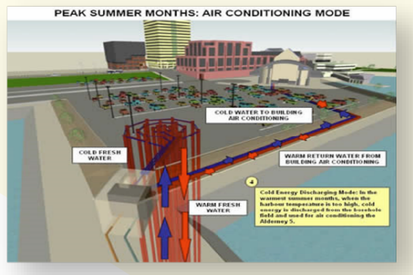
2015
Albany Georgia
US MARINE LOGISTICS BASE
Cold Only

2020
Drammen Sweden
SOLAR THERMAL HOT ONLY
Storage

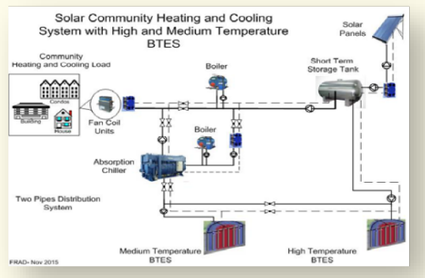
2024
Malt Belgium
MECHELEN STATION
BTES

1979
Alnarp Sweden
DE SYSTEM

2009
Halifax Canada
SEA WATER COOLING DE SYSTEM



2015
TMU Study
GTA SOLAR COMMUNITY
Hot + Cold Storage



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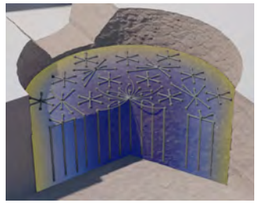
ESTCP Cost and Performance Report

https://apps.dtic.mil/sti/tr/pdf/AD1035611.pdf

"Generally, most users can quickly see the superiority of the BTES architecture over normal closed loop geothermal systems." [1]

"Cold or Hot storage allows Geo to move beyond 'Energy Efficiency' to true renewable architecture." [1]



- Marine Corps Logistics Military Base-Albany, GA underwent Cold BTES Installation
- Installed an adiabatic dry cooler to capture winter "cold" and store it underground for summer cooling, enabling seasonal energy shifting and improved system efficiency.
- Demonstrated a scalable, low-water-use BTES design tailored for cooling-dominated climates, with potential replication across DoD and commercial facilities.
- Integrated a high-efficiency HVAC system using six modular water-to-water heat recovery chillers capable of simultaneous heating and cooling
- Retrofit reused existing infrastructure like air handling units (AHUs) and ductwork while replacing 105 VAV boxes with new units featuring deeper hot water coils to handle lower temperature water.

Performance Objective	Reduction	Achieved
Facility GHP-USTES Heating, Ventilating and Air-Conditioning (HVAC) Energy Usage vs. Conventional HVAC	30%	√
Facility GHP-USTES HVAC Energy Usage vs. Conventional GHP HVAC	10%	√
Water Usage by On-Site Conventional Cooling Tower	80-100%	√
Direct On-Site Greenhouse Gas (GHG) Emissions for HVAC Space Heating	100%	√
Installed Cost Of GHP-BTES vs. Conventional GHP Systems	20%	√
Greater Perceived Energy Security of Base Personnel	100%	√

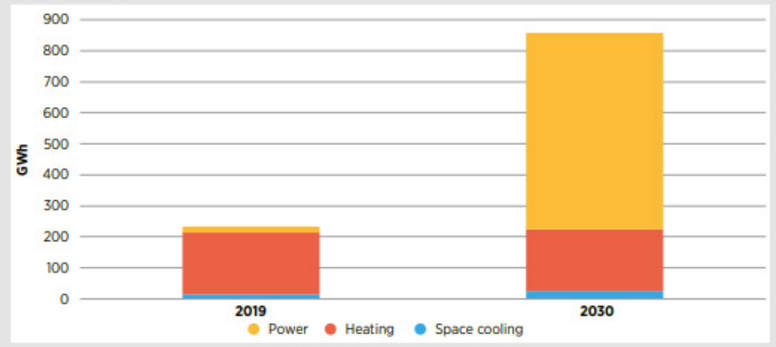
IRENA Innovation Outlook Thermal Energy Storage

https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Nov/IRENA_Innovation_Outlook_TES_2020.pdf

"TES can help to integrate the power, heating and cooling sectors in a smart approach that benefits power as well as thermal systems." [2]

"By 2030 TES could experience threefold growth, reaching over 800 GWh of installed" [2]

Figure 3: Installed TES capacity projections according to IRENA's Paris Agreement-aligned Transforming Energy Scenario

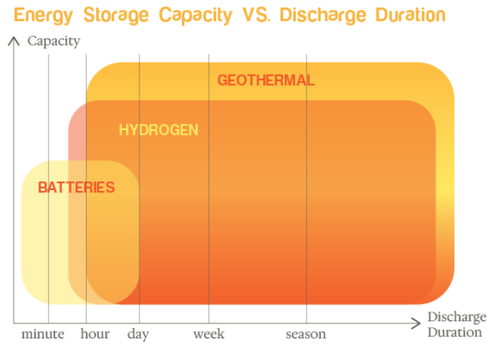


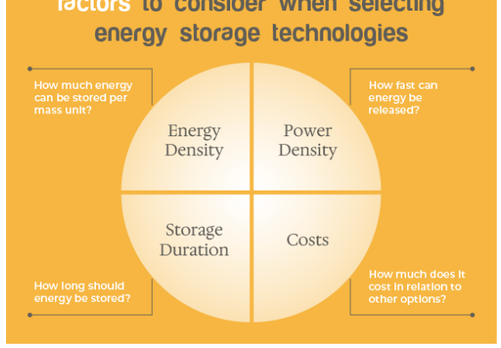
- Enables seasonal heat storage: Stores excess thermal energy underground during warmer months and delivers heat during colder seasons, balancing supply and demand over long periods.
- Supports renewable integration: BTES decouples heating demand from renewable power generation, enabling higher shares of solar and wind in energy systems.
- Decarbonizes heating: Facilitates electrification of heating in buildings and industry, reducing reliance on fossil fuels and aligning with climate goals.
- Widely proven in district heating: Used extensively in district heating networks to
- Cost-effective infrastructure: Reduces peak heating loads, lowering operational costs and avoiding expensive grid reinforcements.
- Flexible application: Can be combined with heat pumps, solar thermal, and waste heat recovery systems to optimize energy use.
- EU leadership and growth: Supported by EU research and projects, BTES is rapidly advancing towards broader commercial adoption.

SWECO 2019 Urban Energy Report

https://www.swecogroup.com/wp-content/uploads/sites/2/2022/12/report_future-energy-storage_a4.pdf

"Today's Praxis of not using seasonal storage for heating and cooling is like throwing these resources in the bin one season and paying for them the next" [3]





- Enables the shift from fossil fuels to renewable energy in line with the Paris Agreement.
- Supports the electrification of transport, buildings, and industry.
- Critical to decarbonizing heating and cooling—currently only 18% renewable in the EU.
- Increases energy security by enabling local production and storage.
- Reduces strain on energy grids by balancing supply and demand.
- Plays a central role in "sector coupling" integrating electricity, heating, and transport systems.
- Reduces fossil fuel use by supplying renewable heating and cooling.
- Enhance grid flexibility by shifting heating and cooling loads off-peak.
- Improves energy efficiency by recovering and storing waste heat from buildings and industry.
- Requires minimal maintenance and offers long system lifespans with no moving parts.
- Boosts energy resilience with inside-the-fence solutions that reduce grid reliance.

HEATSTORE: Underground Thermal Energy Storage (UTES)

https://www.heatstore.eu/documents/HEATSTORE_UTES%20State%20of%20the%20Art_WP1_D1.1_Final_2019.04.26.pdf

"The application of UTES can therefore help solve the problem of seasonality in heat demand and can reduce the carbon footprint of the energy sector" [4]

- BTES uses deep boreholes to store heat underground, a safe, closed-loop system with no groundwater contamination.
- Successfully implemented across Europe for decades, with applications from single buildings to district heating for 1,500+ homes.
- Requires minimal surface space, is environmentally friendly, and uses no rare earth materials.
- Integrates seamlessly with solar, geothermal, and waste heat, allowing storage of renewable energy when it's available.
- Supports power-to-heat conversion, relieving stress on the electricity grid and reducing fossil fuel dependency.
- Identified in EU energy models as essential to meet 2050 climate goals—a cornerstone of sustainable heating networks.

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Novel Thermal Energy Storage in the European Union

https://setis.ec.europa.eu/novel-thermal-energy-storage-european-union_en

"TES enables the storage of excess energy during periods of abundant supply and subsequently uses it during periods of supply scarcity. Likewise, it achieves cost savings as inexpensive energy can be stored and then used during more expensive periods" [5]

BTES Enables Renewable Integration & Decarbonization

- Stores excess heat during high supply and release it when demand rises.
- Supports higher shares of wind and solar by storing surplus renewable electricity as heat.
- Reduces fossil fuel use and helps electrify heating with heat pumps and power-to-heat systems.
- Endorsed by the European Commission for flexible, decarbonized energy systems.
- Integrates with district heating and waste heat recovery, improving overall efficiency.
- Flattens energy demand peaks, lowering system costs and infrastructure needs.
- Enables long-term or seasonal heat storage, matching supply with demand over months.

BTES Technical Strengths & Market Potential

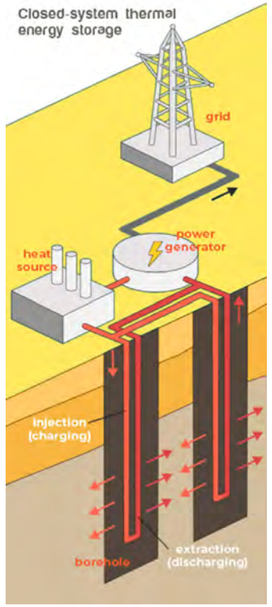
- Adds grid flexibility by decoupling heat generation from immediate demand
- Higher energy density than conventional TES, reducing space and costs.
- Active research and pilots advancing novel TES technologies, including BTES.
- Enhances electricity storage efficiency in CAES and LAES by capturing heat.
- Costs expected to drop, making BTES competitive with gas boilers.

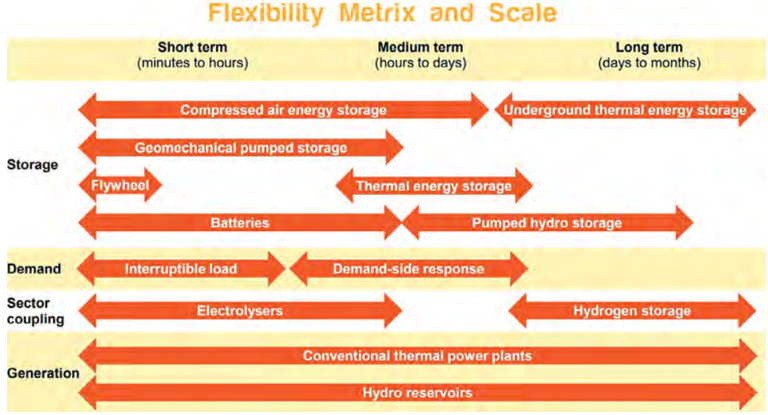
	TRL (Technology Readiness Level)								
Sub-Technology	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Thermal tank energy storage									■
Solid media thermal energy storage					■	■	■	■	■
Borehole thermal energy storage									■
Tank-Pit thermal energy storage									■
Aquifer thermal energy storage									■
Molten salts thermal energy storage									■
Ice Storage									■
Sub-zero temperature PCMs						■	■	■	■
Low-Temperature phase change material				■	■	■	■	■	■
High-Temperature phase change material				■	■	■	■	■	
Reversible-based reaction thermal energy storage		■	■	■	■				
Sorption-based thermal energy storage					■	■	■		
Adiabatic Compressed Air Energy Storage			■	■	■	■	■		
Liquid Air Energy Storage				■	■	■	■		
Pumped Heat Electricity Storage				■	■	■	■		

IEA: The Future of Geothermal Energy

https://iea.blob.core.windows.net/assets/cbe6ad3a-eb3e-463f-8b2a-5d1fa4ce39bf/TheFutureofGeothermal.pdf

"Energy storage and flexibility are becoming increasingly essential components of resilient energy systems, particularly as the integration of variable renewable energy sources becomes more important." [6]





- Stores heat or cold underground to balance energy demand and supply.
- Enables seasonal energy storage for heating and cooling systems.
- Takes up little above-ground space, ideal for urban integration.
- Pilot projects across Europe prove their technical feasibility.
- Supports flexible use of renewables by storing excess electricity as heat.
- Can turn unused subsurface areas into clean energy storage assets.
- Offers long-duration storage to match intermittent solar and wind.
- Expected cost drops will improve competitiveness with other storage.
- Combines with geothermal plants for dual heat and power solutions.
- Unlocks deep subsurface potential for large-scale, low-emission energy.

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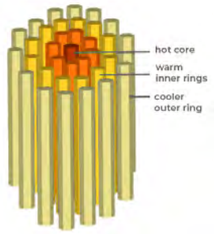
EU-China Energy Innovation

http://www.ececp.eu/en/energy-innovation-special-en/

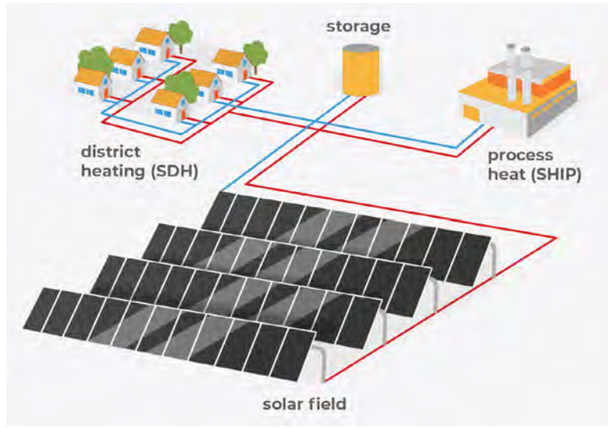
"Thermal energy storage is a key component in achieving this goal, as it allows the capture of excess heat when it is available for use when it is needed, helping to balance heating supply and demand and so reduce energy waste." [7]



- Seasonal Heat Storage: BTES stores excess heat from summer underground for winter use, enabling year-round heating.
- Boosts Heat Pump Efficiency: By providing a more stable and warmer heat source, BTES improves the performance and COP of heat pumps.
- Supports Fossil Fuel Free Heating: Integrated systems using BTES can meet >90% of heating demand with renewable sources, replacing gas or oil heating.
- Low Operating Costs: The system has low maintenance requirements and relies mainly on circulation pumps, reducing ongoing costs.
- Compact and Scalable: Systems can be tailored in borehole depth and spacing to suit different site sizes and energy needs.
- Minimal Electrical Demand: Most energy used is for circulation, not heating, reducing grid dependence and operating costs.
- Optimised Efficiency: Using predictive AI and smart controls on BTES systems can ensure optimal operation and low energy use.

Integration with multiple sources

- Waste Heat: the largest untapped energy source in the world, producers of waste heat include supermarkets, data centres, manufacturing plants, and sewage treatment plants
- Solar Thermal: BTES works efficiently with solar collectors to store heat over the summer
- District Energy Applications: Repurpose heat for applications in neighboring buildings. Access green and cheap energy to effectively and efficiently meet facility needs.



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