Thermal Energy Storage: Building Perspective

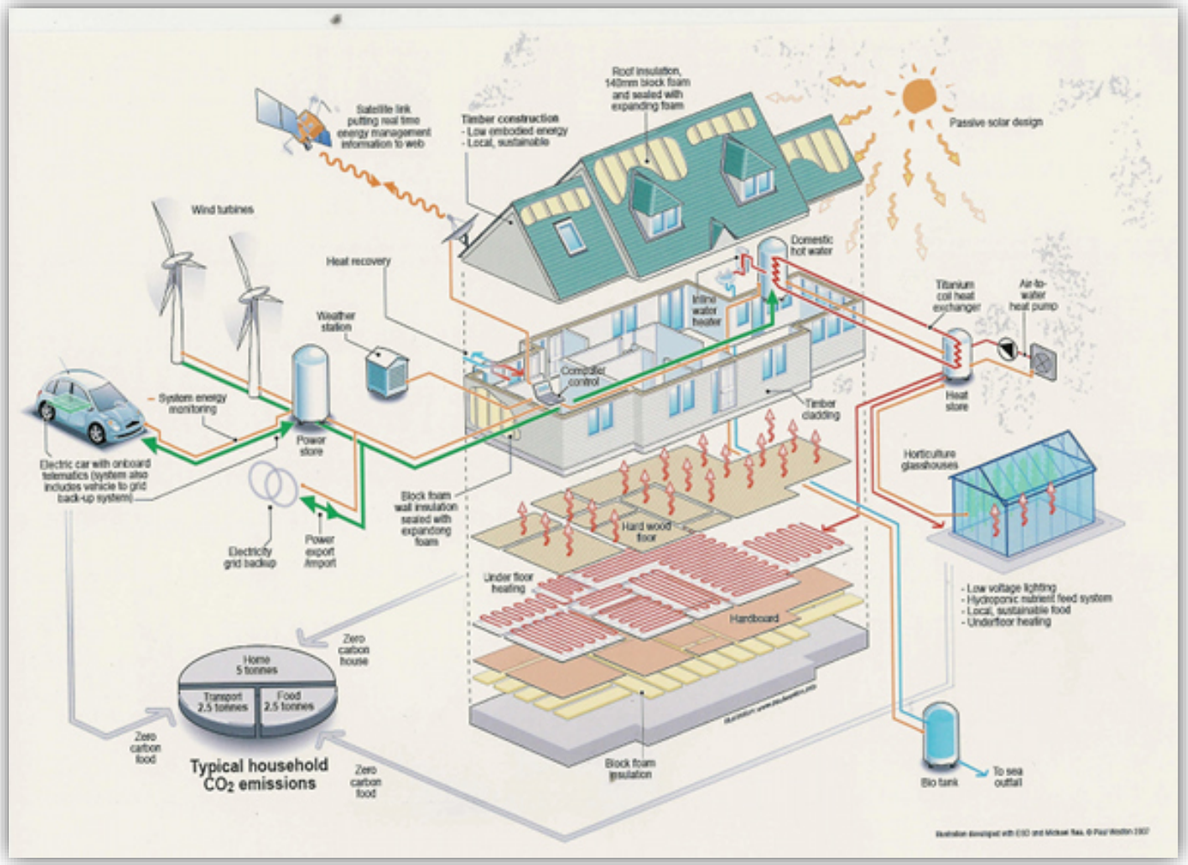
S. Ravi Annapragada, Principal Engineer

United Technologies Research Center

December 7- 8, 2017

A System View of Current Buildings

Ideally thermal systems should handle net thermal load over a “period"



Thermal Systems

- HVAC
- Boilers/Furnace
- Building Envelope

Thermal Demand

Load types

- Internal loads
- External loads

Variations

- Temporal variation
- Spatial variation

Variations in load, system efficiency and pricing drive need for TES

Current Options in the Market

Several options exist but commercialization is limited

Cold Storage

Ice storage integrated with HVAC

CALMAC

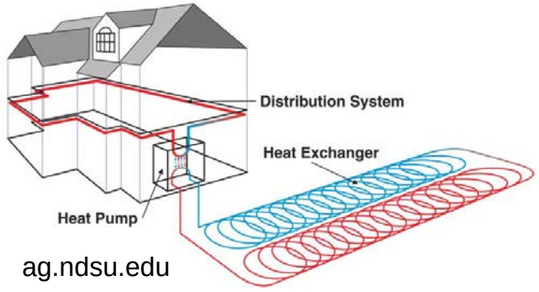
ice-energy.com

IceBear

Paraffin storage

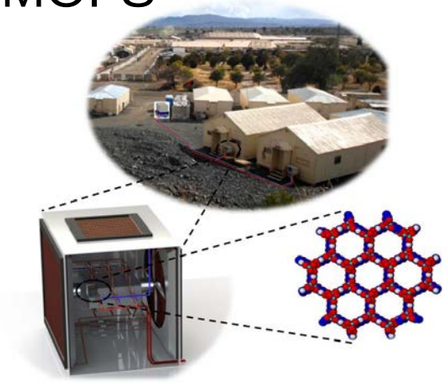
Syracuse/UTRC
APRA-E DELTA

Ground Source Heat Pump with underground thermal storage



ag.ndsu.edu

PNNL ARPA-E MOFS

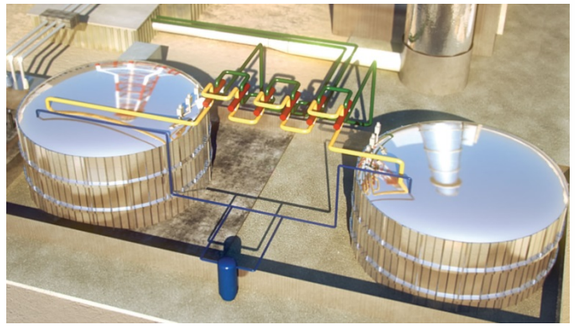


Hot Storage

Underground hot storage

darcoinc.com/thermal-storage/

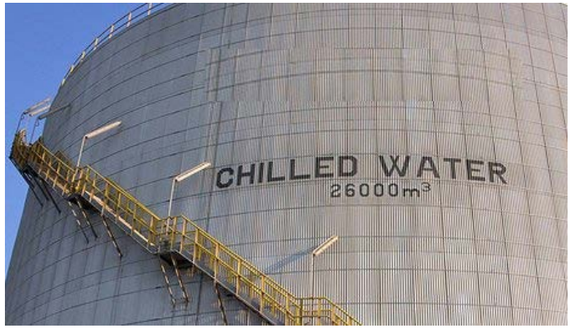
Molten Salt/Glass



HALOTECHNICS

Ice/Water TES: Commercial Solution with Good Market Penetration

Use of water makes the TES the most cost effective



- Cheap working fluid
- High energy density (333 kJ/kg)
- Scalable (kWhr - MWhr)

- Round trip efficiency low due to large lift and heat leakage
- Expensive for retro-fit only (~$120/kWhr)
- Payback very limited due to extreme pricing and rebate dependency

Material Options and Challenges

No silver bullet exists

	Steam/Water/Ice	Paraffin	Molten Salts
Energy density (kJ/kg)	✕	✕	✕
Power density (kW/kg)	✕	✕	✕
Temperature range (Summer temp/ Winter temp	Heating ✕ Cooling ✕	✕	✕
Cost ($/kg)	✕	✕	✕
Mobility	Heating ✕ Cooling ✕	✕	✕

500 W-hr → 12 kg PCM
5 Ton (8 hr) → 3375 kg PCM

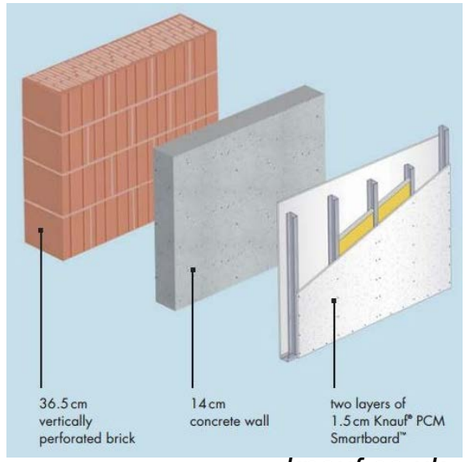
Need energy density and cost of water, at temperature operation range of paraffin for heating and cooling

Thermal Energy Storage System Challenges

Primary system challenges include integration, payback, efficiency and customer acceptability

Integration

ice-energy.com

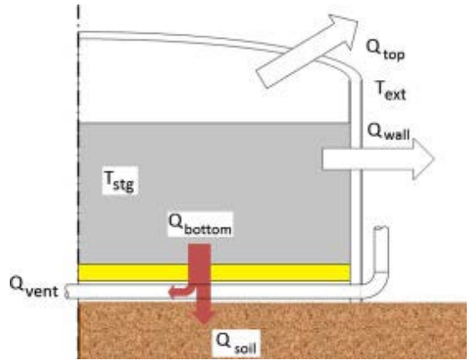


knauf.co.uk

Efficiency & Cost

Heating & Cooling

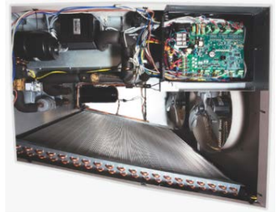
Weather based



Heat loss mitigation

Customer Acceptability

Retrofit capable



Stand alone

ice-energy.com