International Conference On Artificial Intelligence, Embedded Systems and Renewable Energy (AEISRE)

Energy Management and Storage with Bio-Based Phase Change Materials

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Agenda

1. Peak Demand Costs
2. Latent Energy & Sensible Energy
3. Some Phase Change Materials
   - Latent Energy vs Sensible Energy
   - Ice Storage
   - Water boiling at 100°C / 212°F
   - Eutectic salts
   - Bio PCMs
4. Why Use Thermal Energy Storage System?
5. Applications – Cooling, Heating, Domestic Hot Water, Process, Heat Pumps, Geothermal
6. Portable Phase Change Systems
7. Case Studies
8. Cold Chain Logistics / Reefer Truck Transportation
9. Target Markets & Customers

Thermal Energy Storage Solutions

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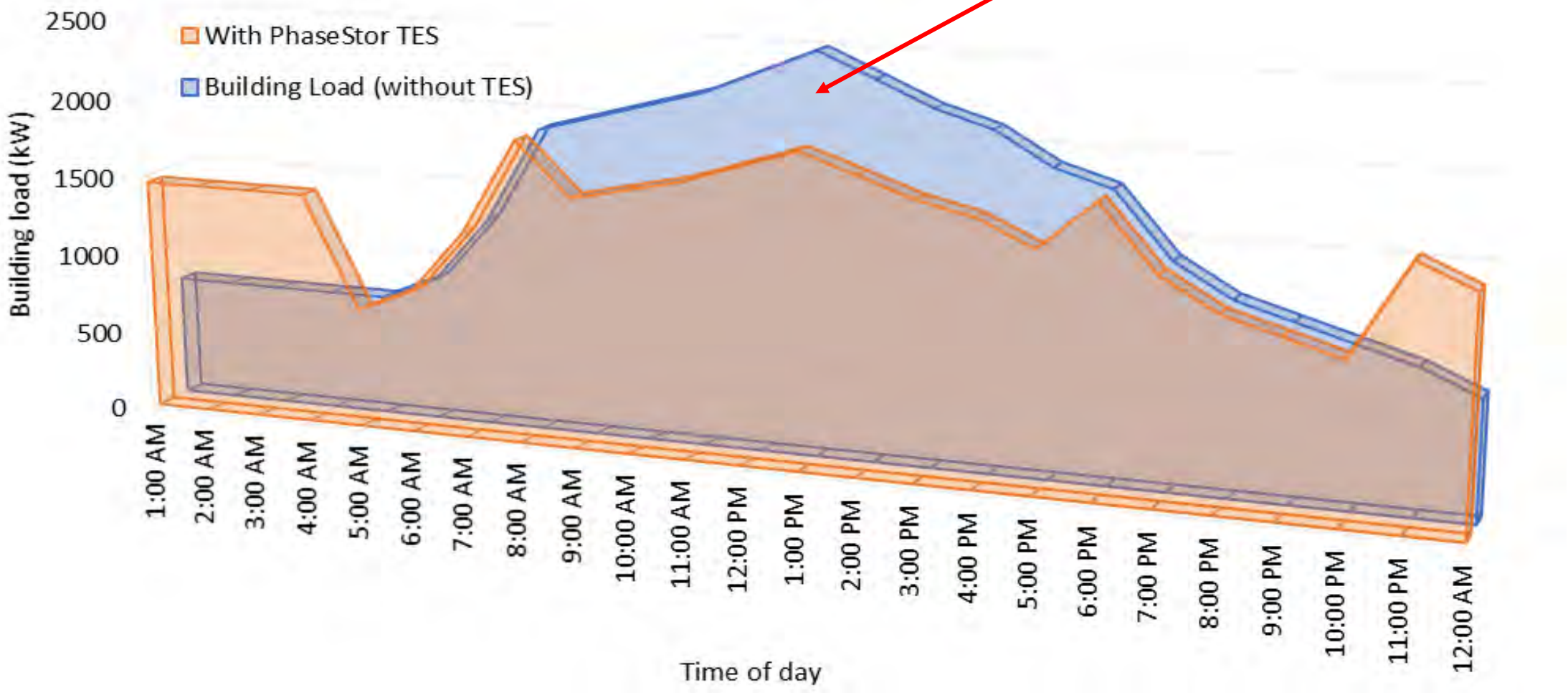
Peak Demand

The electric grid may require additional capacity that may require old less efficient generation with a higher Greenhouse Gas emmissions.



Latent Energy vs Sensible Energy

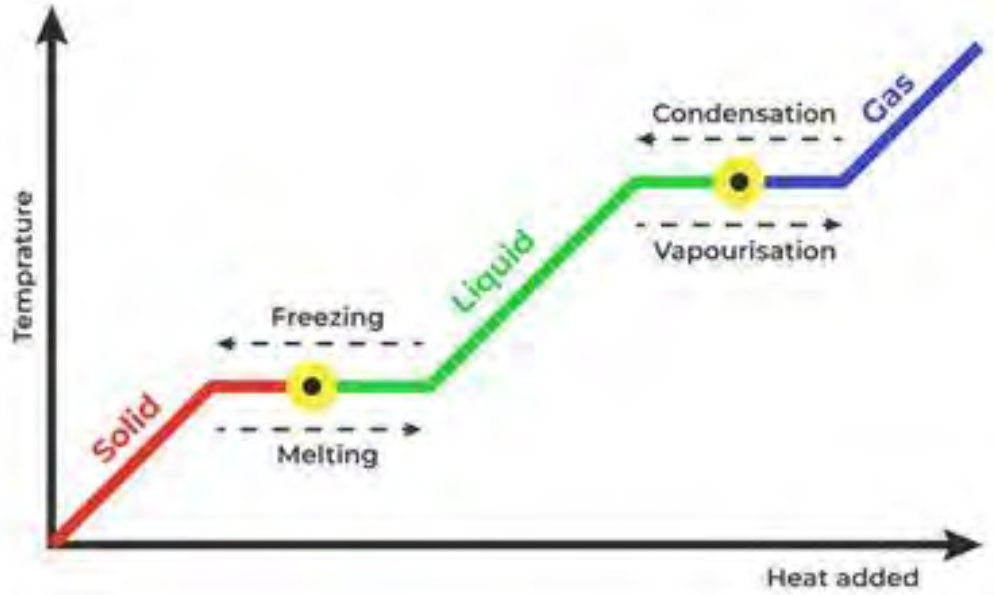
Sensible heat is the energy that causes a change in temperature of a substance without changing its phase.

Latent heat is the energy required for a substance to change its state (phase) without changing its temperature. ***Latent energy stores much more energy than sensible energy***

Sensible and Latent Heat

If we add heat to water, the temperature will increase, and this is called ***sensible heat.*** Sensible heat causes a change in temperature.

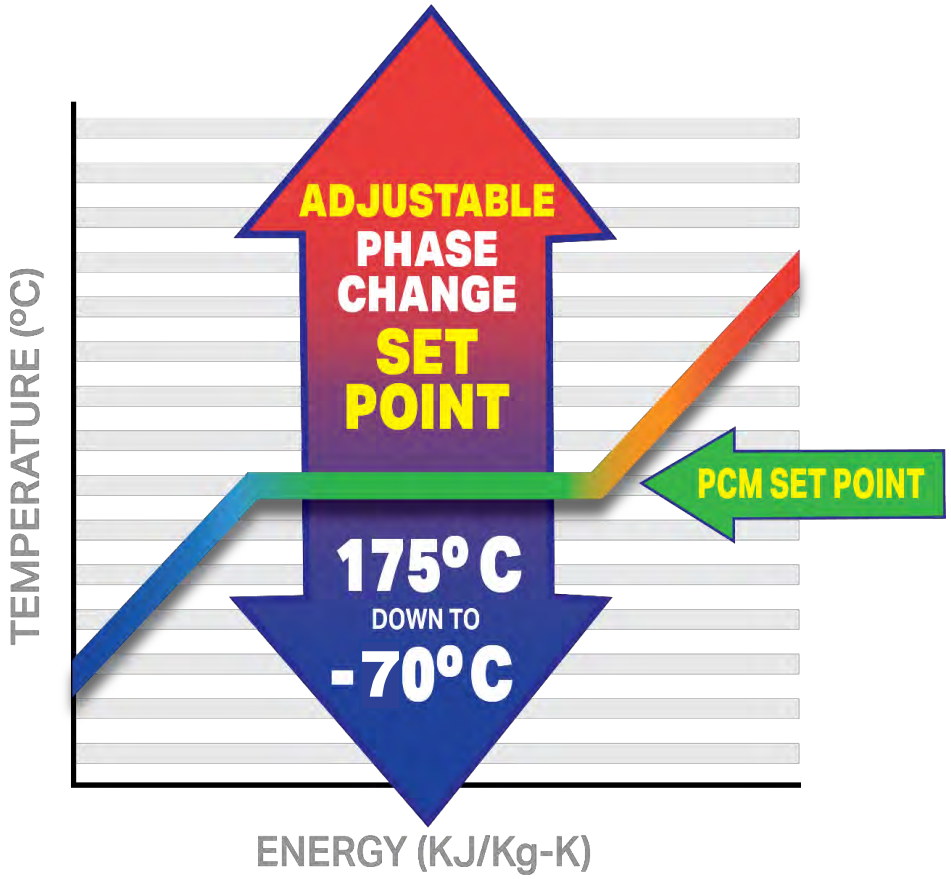
If we add heat to ice at 32° F or to water at 212° F, the temperature **will not** increase. The added heat will melt some of the ice or boil some of the water. This is called ***latent heat.*** Latent heat causes a change in state but not a change in temperature. This heat energy changes the molecular bond within the molecule.



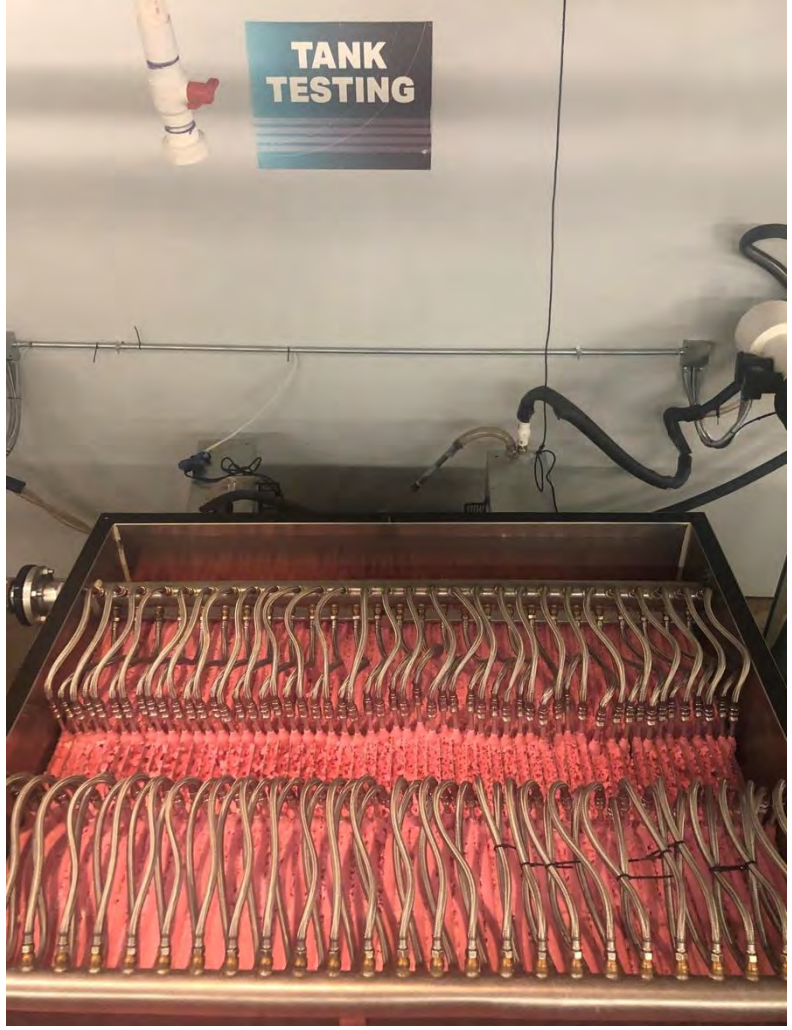
Some Phase Change Materials

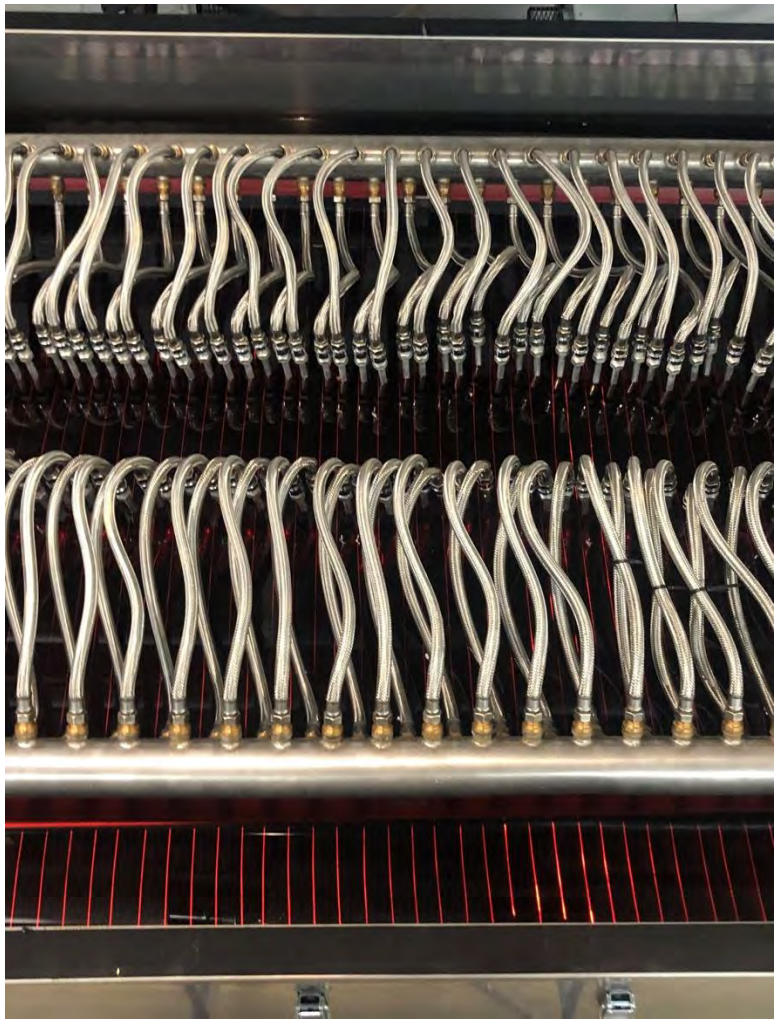
- Latent Energy vs Sensible Energy
- Ice Storage 0°C / 32°F 0
- Water boiling at 100°C / 212°F
- Eutectic Salts (*Phase Change Material*)
- Bio Based Phase Change Materials (BioPCMs)

PCMs enable a change in the melt / freeze temperature and the ability to store significantly more energy in a smaller space



- ✓ **Solid-to-gel, or solid-to-solid transitions** Readily available and cost effective
- ✓ Renewably derived from vegetable oils and their by-products
- ✓ Widely used in different areas such as food, medicine, cosmetics, shipping, etc.
- ✓ Melting temperature varies from −70 °C to 175°C
- ✓ Latent heat of fusion varies from 150-275 kJ/kg,
- ✓ 1” of BioPCM stores as much thermal energy as 24” of concrete
- ✓ Tunable thermal conductivity from 0.1-10 W/mK
- ✓ Non-Toxic and biodegradable
- ✓ Long term stability >100 years of thermal cycling with no thermal degradation.





351 Kw Heat Storage Tank at 48.8°C / 120°F

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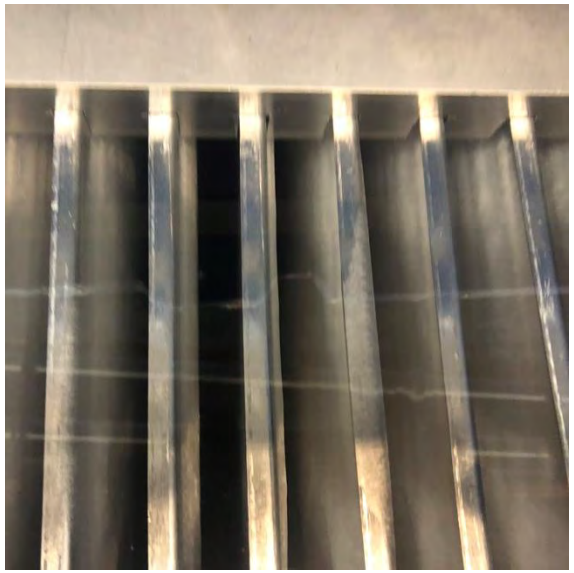
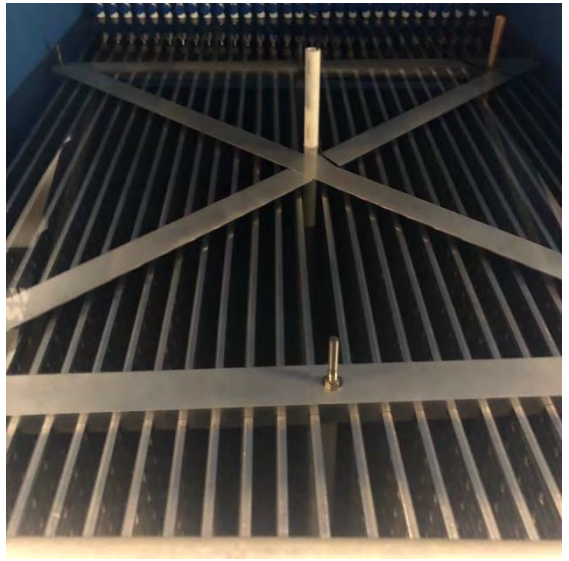
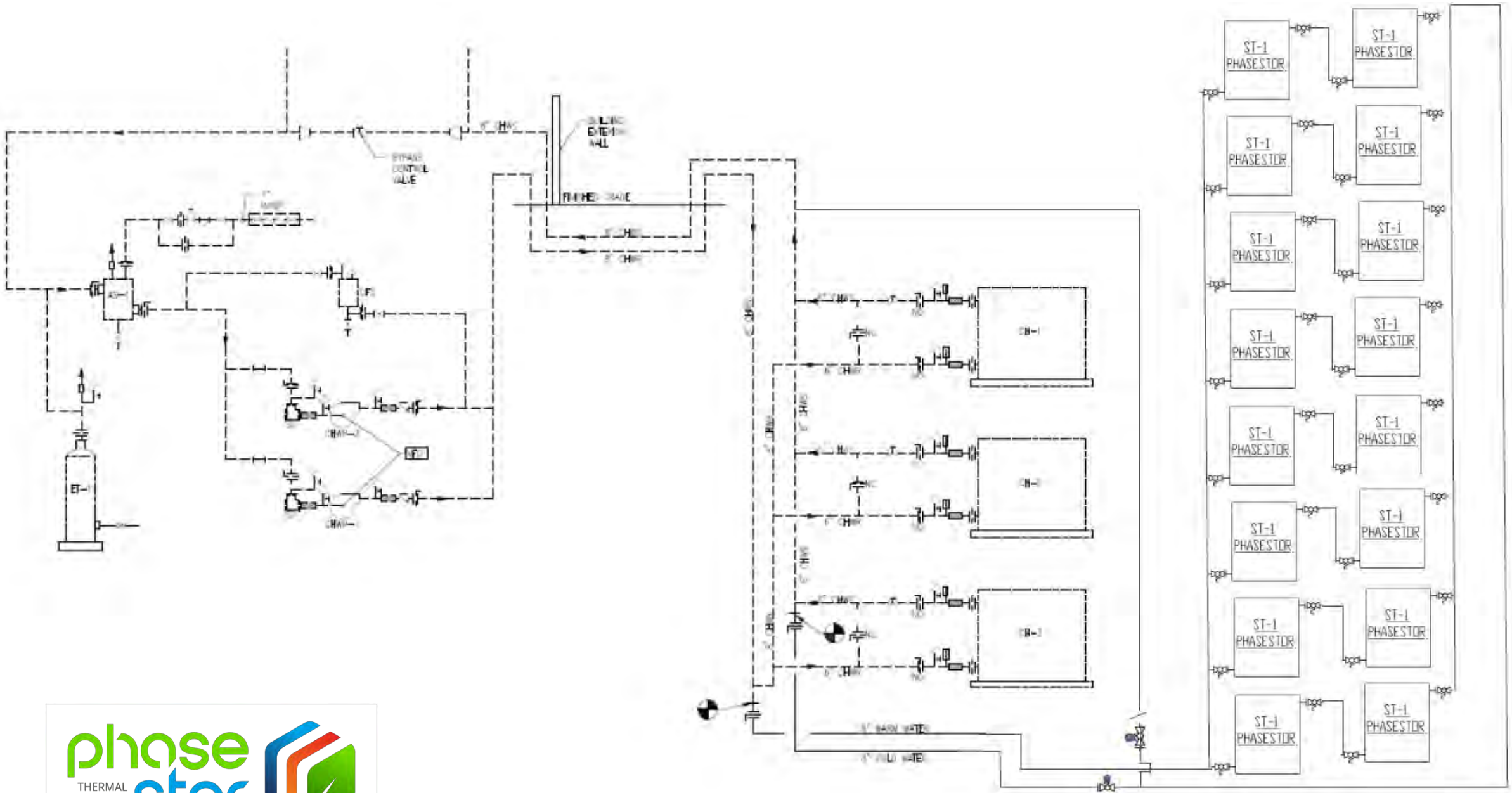




PCM in action at 8.8°C / 48 °F



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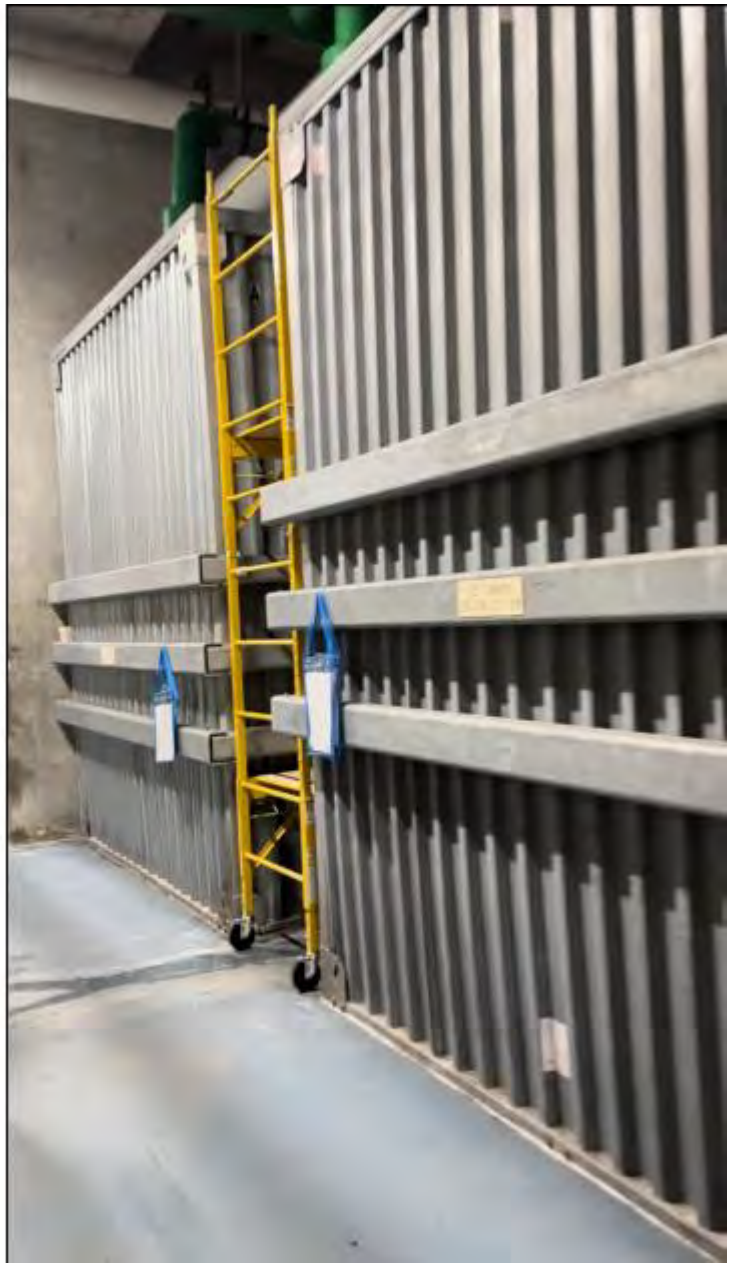
350 KwH PhaseStor Ton Hour 82.2°C / 180°F Heat Storage for a boiler in UK

Chicago Field Museum
48,000 Ton Hours of TES

Air Conditioning

The Museum utilizes a chiller/thermal storage system, which keeps the building's climate cool in the warmer months and ensures proper humidity for the collections year round. The system works by producing ice during evening hours when citywide demand for energy is lower. The ice is placed in thermal storage containers, and water flow introduced. Air is blown around the containers and then circulated through the building during the day. This reduces the Museum's impact on the region's grid system and prevents brownouts, as air conditioning usage is highest during mid-day.



PhaseStor Modular Tanks

The eSTOR™ Mod harnesses thermal energy efficiently, offering versatile applications such as cooling or heating buildings, and improving manufacturing processes.

CASE STUDY

Software Manufacture

Facility at a glance

Name
Microsoft

Location
Seattle, WA USA

Facility size
40,000 ft² laboratory

Issue

A large capacity chiller is required 4 hours a day to meet the process load of the building. Then the remaining 20 hours of the day, the chiller is short cycling.

Solution

PhaseStor thermal storage system

Microsoft was able to reduce their maintenance cost by 50% and save 22% in energy cost by adding a PhaseStor thermal storage system.

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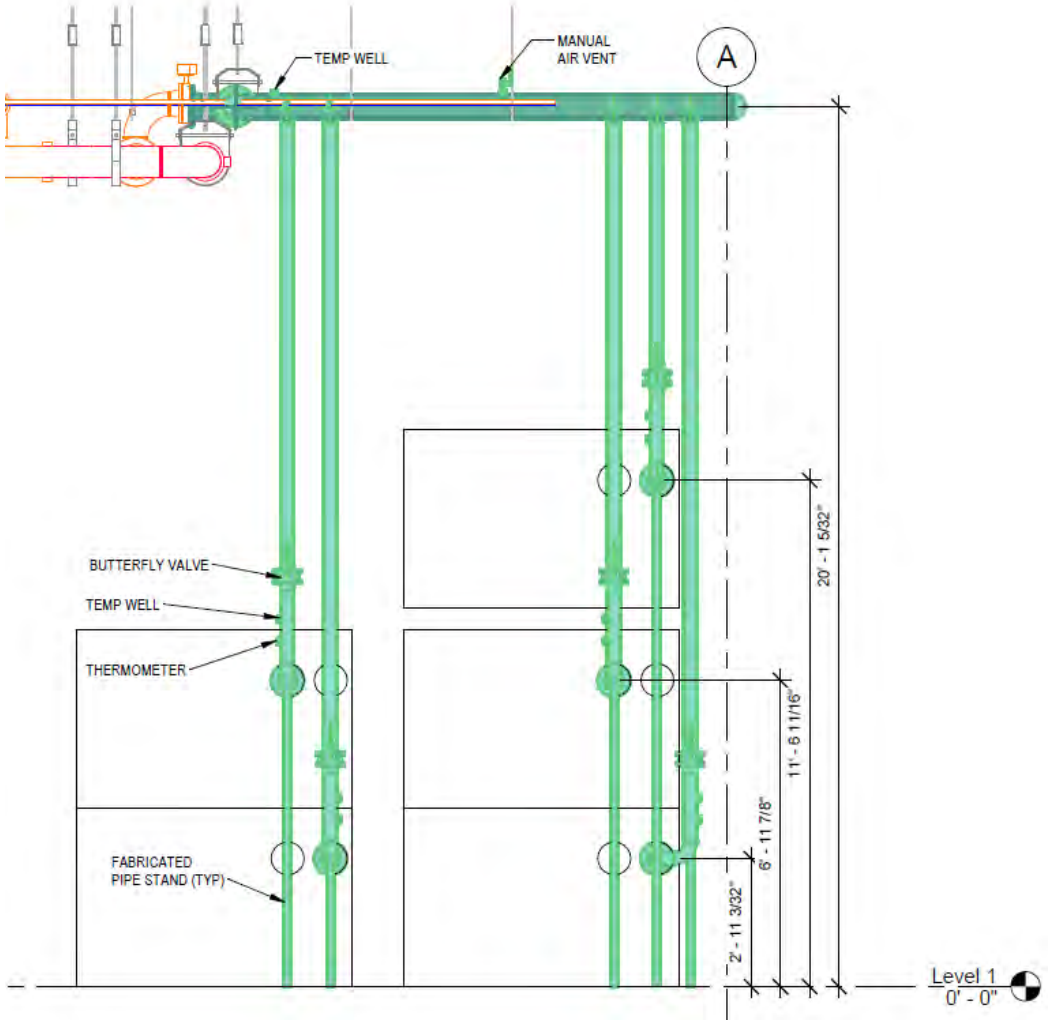
PhaseStor 1050 KwH featured at the South Landing Eco District Net Zero Project



Melink Solar Project featuring (2) PhaseStor 350 KwH tanks that are storing 60 °C (140°F) thermal energy.

300L DHW tank v 12kWh PCM

- Thermal Energy Storage Cylinder
- Strong Dual wall high R-Value containment
- All-natural bio-based high latent pcm technology
- Peak demand Emersion Heat options also
- 6, 10, 12, 25, 50, 100kW Options
- Standby Loss up to 5 days
- Heat Pump, PV and Boiler Compatible
- Emergency Backup Storage
- Space Heat Buffering

Space saving solution

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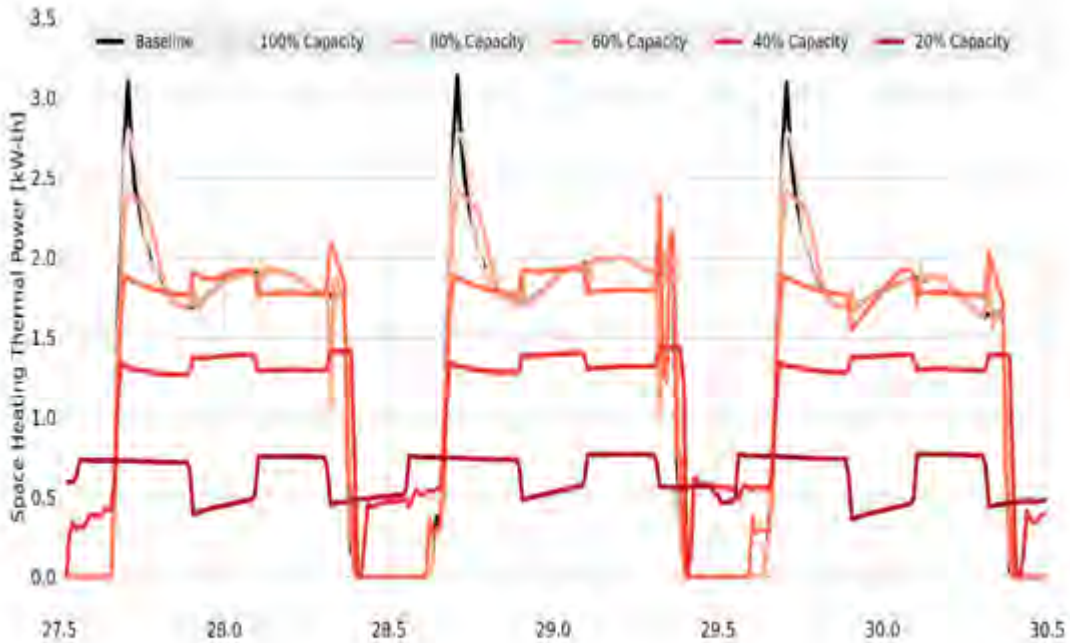
EN16147 Test returned 376 Ltrs hot water

How it all works



Can PhaseStor reduce the Heat Pump size? What the load profile look like?

The heating profiles for the conventional system and combo system of TES systems like PhaseStor with five different hear pump sizes is illustrated in the figure below. The graph depicts the results for the 8-hour load shed period. The system provides space heating thermal power by combining the heat pump and PCM TES system.

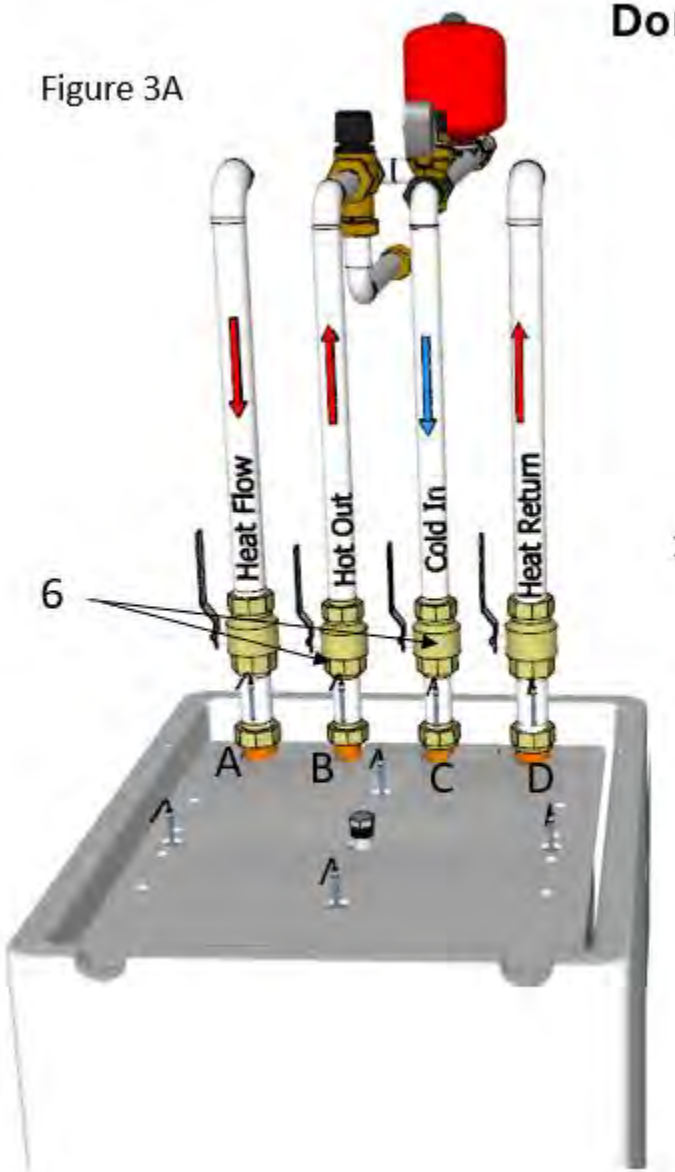
What are the main proven takeaways:

The results proved that a compo of heat pump and PCM TES systems, like PhaseStor, can downsize the size of the heat pump by up to 60%. The set point of the system was maintained within 96% of it's baseline (conventional, no TES case) down until the 40% heat pump size reference case (60% downsizing). In summary:

- With the heat pump capacity coupled to PCM TES being 60% smaller the system was still meeting space conditioning setpoints within a deviation of 2°C only.
- The system also performed better than the baseline system in reliably delivering hot water.
- The system can reduce energy use by half (50% energy use) during peak demand period.
- The downsized HP capacity resulted in significant electricity demand reduction, which is promising for an increasingly electrified grid.

Domestic Hot & Cold-Water Connections

Figure 3A



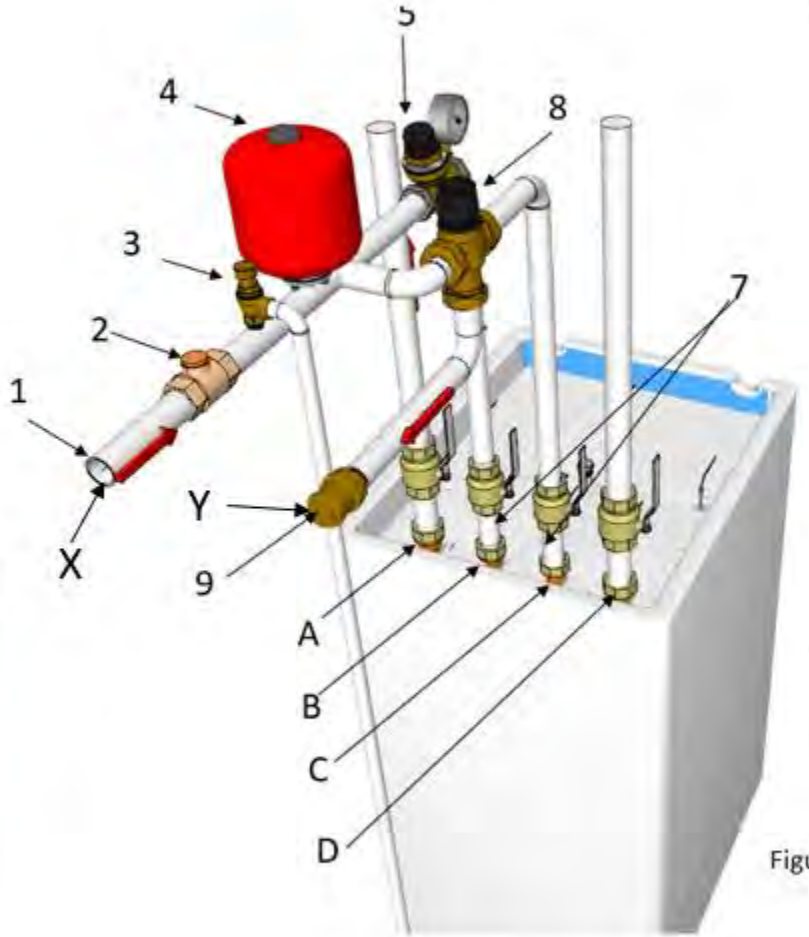


Figure 3B

Item	Description
1	Cold mains stop tap
2	Check valve
3	Mains water expansion relief valve / shock absorber
4	0.5 litre expansion vessel precharged to 3 bar
5	Pressure Reducing Valve. Pre-Set to 3 Bar
6	22mm Fullflow isolating valve
7	22mm x 3/4 inch connector
8	TMV 3 Variable Blending valve
9	Flow regulator
a	1 inch BSP Heating Flow connection
b	3/4 inch BSP Incoming domestic cold supply connection
c	3/4 inch BSP Outgoing Domestic Hot Water connection
d	1 inch BSP Heating Return connection
X	Incoming cold main supply
Y	Blended hot water supply to property

NSF 61 Certified for
Domestic water Systems

Challenge

Battery Energy Storage Systems (BESS) are used as power protection systems for data centers (DC) and in large utility power distribution systems to provide back-up electricity during a power outage. During an outage when the batteries discharge, a large amount of heat is generated. The installed HVAC systems draw a significant part of the stored battery power to offset this generated heat. This reduces the power delivered downstream and reduces resiliency.

Results achieved with PhaseStor System

Offset approximately 41kW of heat generated by battery discharge over a 4-6 hour window and deliver the greatest amount of downstream electrical power using only 400 watts of power to maintain the shelter at 25°C (77°F) with the PhaseStor system during an event.

TRUe Portable

TRUe portable units are designed to cater to a wide range of applications in the logistics industry, cold storage facilities, and industrial settings. Whether it's heating or cooling, this reliable unit ensures optimal temperature control wherever it's needed.

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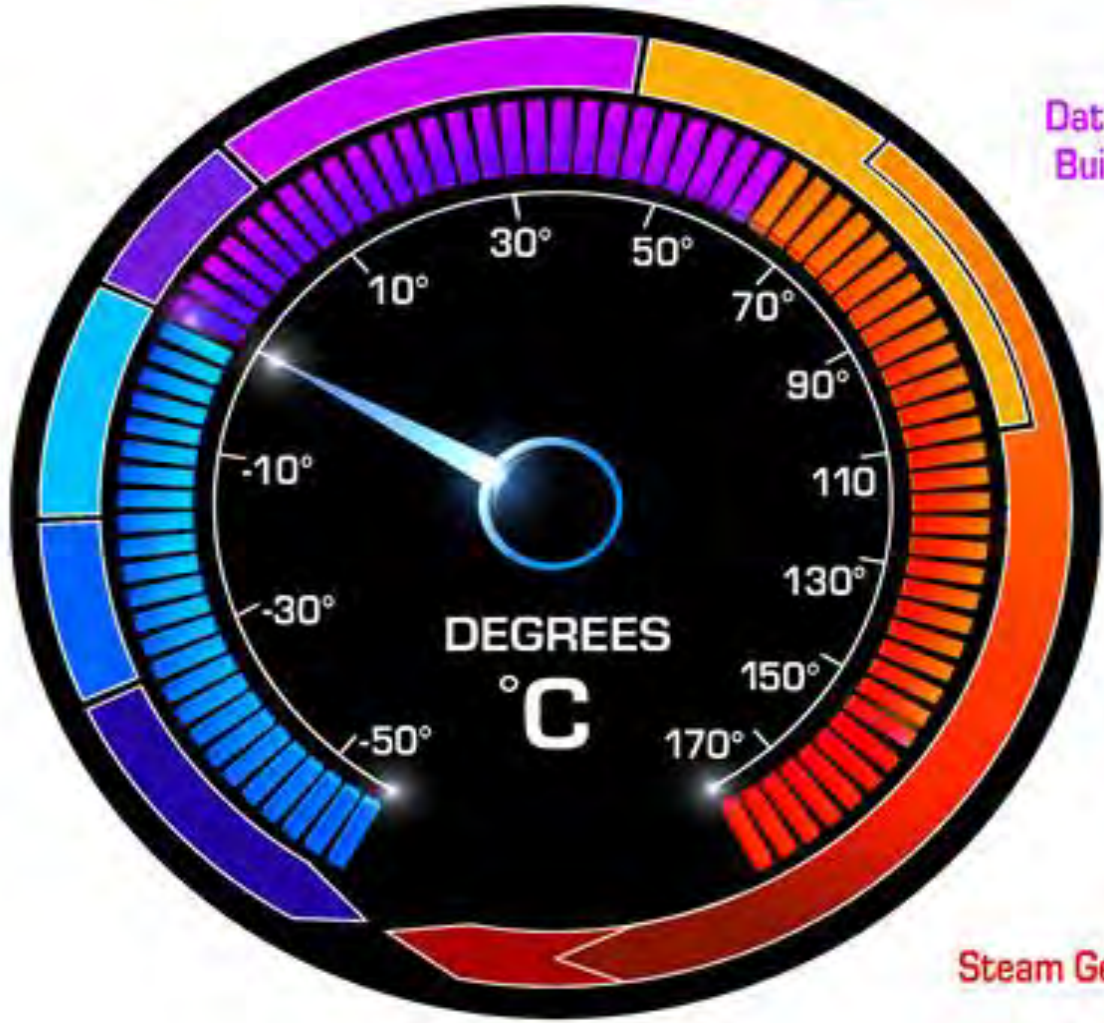
-70°C to 175°C

0° to 10° C
HVAC Energy Storage

-17° to 0° C
Subzero Energy Storage

-25° to -17° C
Freezers / Frozen Food

-70° to -25° C
Pharmaceutical
Scientific



10° to 55° C
Data Center Thermal Storage
Building Energy Management

55° to 70° C
Residential Hot Water

55° to 120° C
Industrial Processes
Commercial Hot Water

120° to 170° C
Steam Generation Waste Recovery

Target PhaseStor Markets

Cooling Sub Zero

- -5C to -20C
- Minimal Competition

Cooling Traditional

- -2C to 2C
- Low Temp Chiller
- Glycol Loop and Pumps
- P&F HX
- Additional Water Treatment
- Additional Piping & Controls
- Higher Energy Expense
- Higher Operating Expense

Cooling Medium Temperature

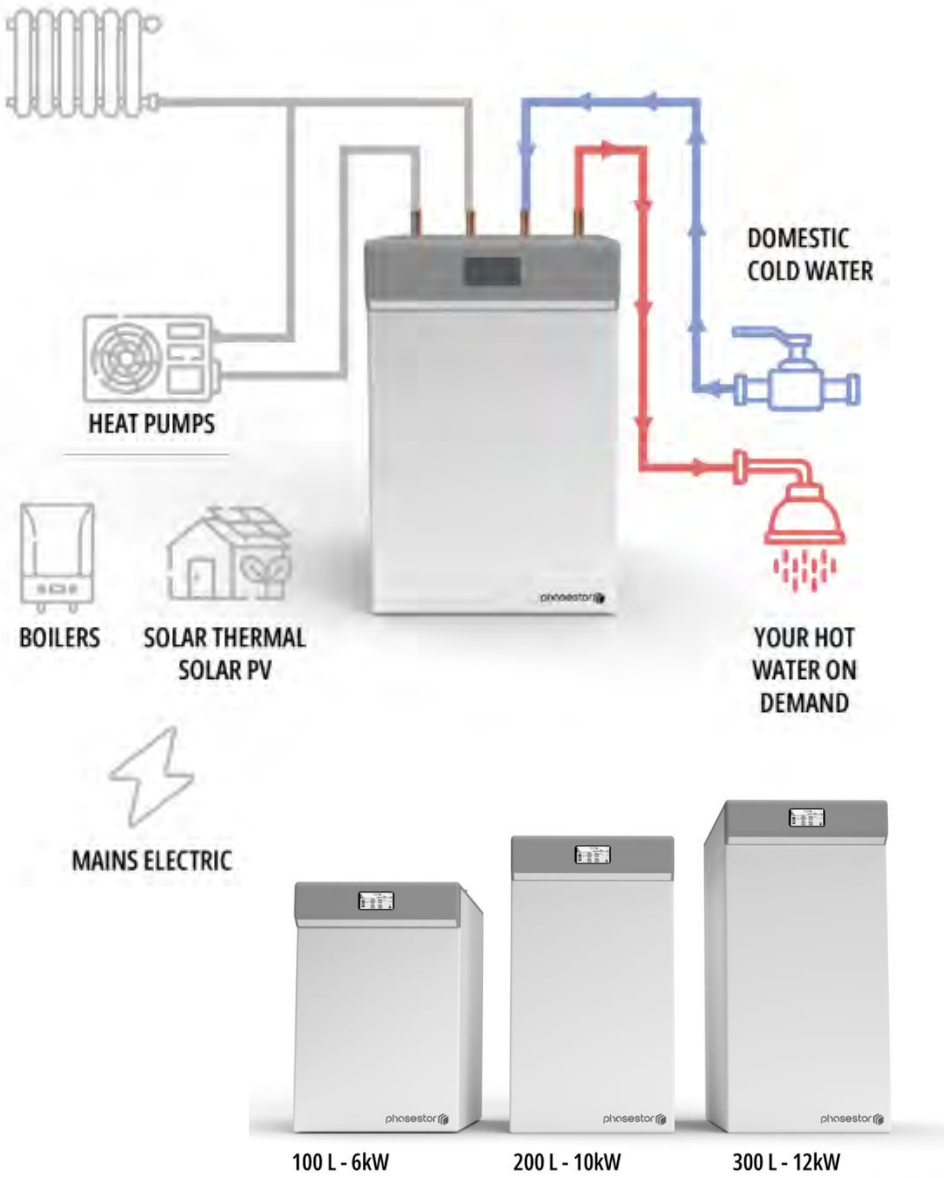
- 8C to 15C
- Minimal Competition

Heating

- 50C to 80C
- Minimal Competition

NEW Applications Driven by RESILIENCY

Heat Pump with BioPCM Phase Change Storage



Advantages

Heat Pump with Phase Change Storage

1.) 15 Year Warranty for Heat Pump Water Heater – Reduce Equipment Replacement Costs

2.) Reduce size of Heat Pump by 50% - 60%

3.) Reduce Energy Use & Cost

4.) Reduce Peak Demand Charges

5.) Reduce Energy Use Associated with Legionella Control Procedures

6.) Easy Install

7.) Fits through door

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Case Study

Domestic Hot Water Heating for Residential Application with Electric Emersion Heater and BioPCM PhaseStor

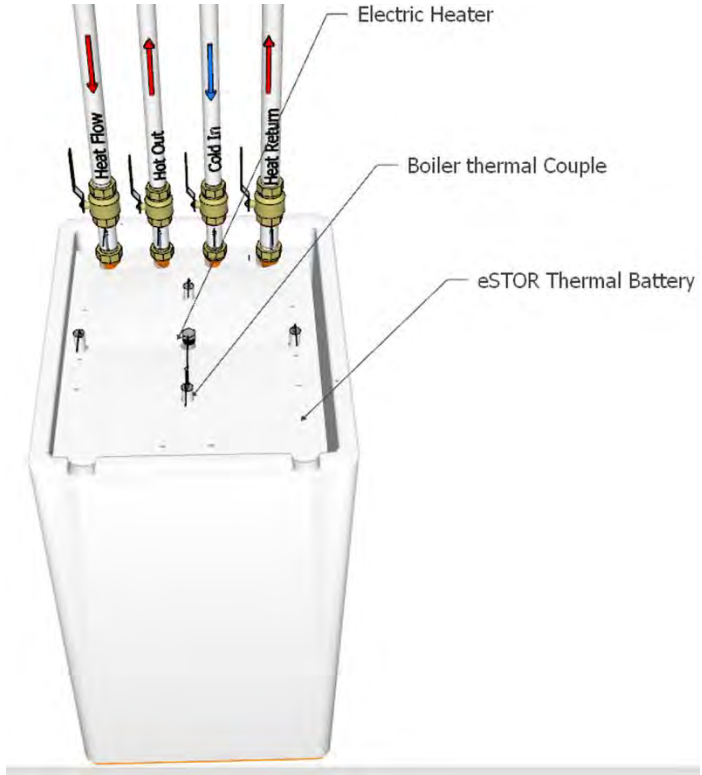
Residential Domestic Hot water Heating System

Estimated Domestic Hot Water Heating Cost Comparision

Typical Single Family Home Electric Resistance Hot Water Heater	
Requires 220V and 30 amps	
Estimated Watts used to heat hot water 3 hours per day:	4,000
Cost per kWh ($):	$ 0.20
Estimated Cost per year	**$ 2,920.00**
Single Family PhaseStor Thermal Storage with Electric Emersion Hot Water Heater	
Only Requires 220v and 15 amps	
Uses 52% less energy than Electric Resistance Hot Water Heater:	**$ 1,401.60**
Savings:	**$ 1,518.40**

Case Study

Domestic Hot Water Heating for University Heat Pump DHWH With BioPCM PhaseStor



Comparison of Three Water Heating Options		
University Dormitory with 150 students		
Estimated Domestic Hot Water Heating Cost Comparison		
Gallons of Water Heated:		282,750
Estimated kWh:		52,526
Exiting Water Supply Temperature:		54
Degrees Water heated to:		130
Change in Temperature:		76
Cost per kWh ($):	$	0.2163
Estimated Annual kWh Energy Cost Using a Electiriic hot water boiler($):	$	11,361
Heat Pump with Hot Water Storage Tank:	$	3,787
PhaseStor with Heat Pump (-50%):	$	1,893
PhaseStor Savings Compared to Electric Heater:	$	1,893

Hotel Refrigeration - PhaseStor Case Study

Project Strategy:

The thermal storage system is based on load trimming strategy (reducing kW peak demand). By reducing the maximum peak load demand by 570-600 kW per day, the customer's energy costs savings averages $12,000 per month ($144,000 per year) due to peak demand reduction. This system offers up to 470 tons of refrigeration energy that is readily available during power outage

Solution Deliverables:

470 tons of refrigeration - 30 PhaseStor® units with PhaseStor Bio-Based Phase Change Material (BioPCM).

PhaseStor® System Specifications

PhaseStor® utilizes Bio-based PCM made from non-edible, non-toxic, non-corrosive, and naturally occurring plant-based ingredients that are sustainable and renewable.

Hotel Refrigeration - PhaseStor Case Study

Hotel Energy Use w/ No PhaseStor

Demand Charges/mo:

Peak Demand (KW):	2,553 KW
Peak Demand Rate:	$ 20.69/KW
Peak Demand Charges:	$ 52,821

Energy Charges

Part Energy Use:	454,319 kWhs
Peak Electric Rate:	$ 0.11035/kWh
Peak Electric Charges:	$ 50,134
Off Peak Electric Use:	410,722 kWhs
Off Peak Electric Rate:	$ 0.09420/kWh
Off Peak Electric Charges :	$ 38,690

Power factor Adjustment@ 89%	-$173
Utility Taxes:	$10,714
Total Electric Charges:	**$153,579**

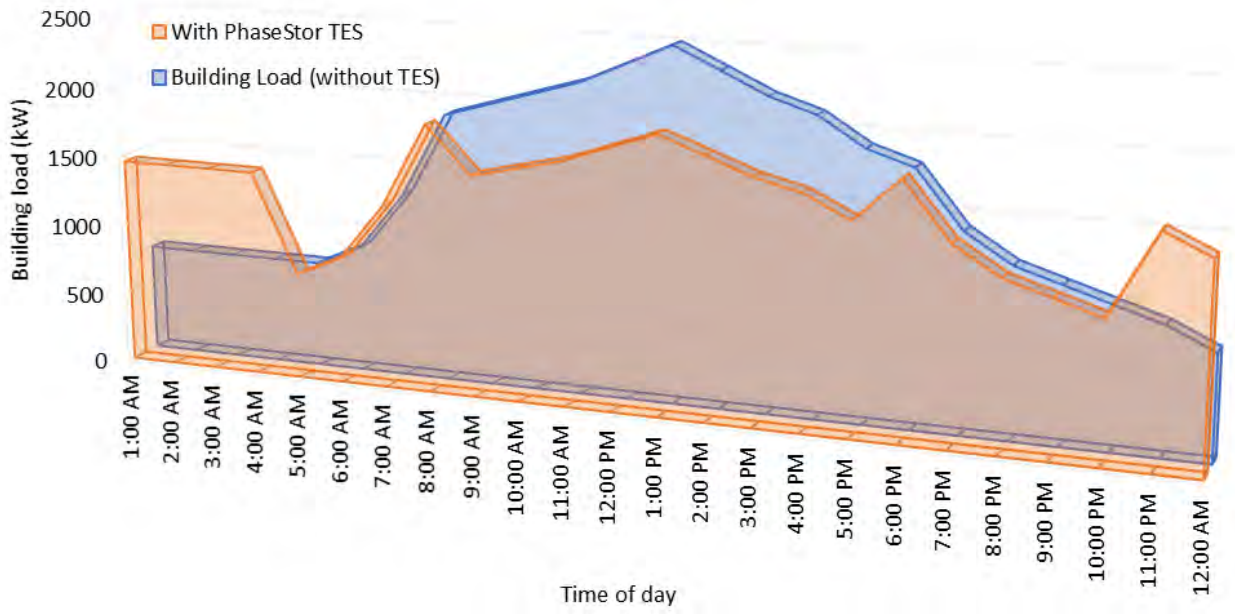
Hotel Energy Use With PhaseStor

Demand Charges/mo:

Max Part Energy Use:	1,962 KW
Peak Demand Rate:	$ 20.69/KW
Peak Demand Charges:	$ 40,604

Total Actual Savings **$144,924**

including partial Load Shifting:



Utility Incentives

In the U. S there are financial incentives for battery storage and thermal energy storage systems. For Example:

Duke Energy pays	$300 per KW
Florida Power & Lights pays	$600 per KW
U.S. Government Pays a Rebate	30%

(Solar & Wind Credits will be eliminated by the current administration on 12/31/25, But energy storage (batteries and Thermal credits continue through 3033)

Thermal Storage Systems are being installed at no cost with customer paying only for the labor to install

ENRG Panels installed

Cold Chain Logistics

We have the capabilities of managing the cold chain from start to finish. A complete Last-Mile approach, with sustainability at the forefront.

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Maximize Efficiency

Active Thermal Transport Systems (ATTS) revolutionizes refrigerated transport by reducing fuel consumption and carbon emissions. Utilizing advanced BioPCM technology, ATTS optimizes temperature control, resulting in minimal compressor use and enhanced energy efficiency

Slash Fuel Costs Dramatically

With ATTS, you can reduce fuel consumption by up to 70%. This not only lowers your operational costs but also extends the life of your refrigeration equipment by minimizing compressor runtime.

Ensures Peak Freshness for your Cargo

ATTS ensures consistent temperature control throughout the transport process. This stability reduces spoilage and maintains the quality of perishable goods, providing peace of mind for sensitive cargo.

Reduce Equipment Wear and Tear

ATTS minimizes compressor runtime, significantly reducing wear and tear on your refrigeration equipment and lowering maintenance costs.

Gas or Electric Services
Potential PhaseStor Target Markets

- Residential (DHWH Heating Cooling)
- Multifamily (DHWH Heating Cooling)
- Commercial (DHWH Heating Cooling)
- Colleges & Universities
  - Heating
  - Cooling
  - DHWH – *NSF 61 Certified*
  - Process
  - Distribution System Storage
- Healthcare
- Hospitality
- Industrial
- Data Centers
- Battery Energy Storage Systems (BESS)
  - Extends battery life
- Ground source heat pumps

- Solar water heating systems
- Agriculture
  - Dairy, Cheese, Apples, Chickens
  - Cold Storage
- Cold Storage
  - Grocery Stores
  - Ag
  - Pharma
  - Food Processing
  - Process
  - More
- Trucking – Preserve perishable shipments
- Portable Storage - Support needs for wide range of products
- District heating & cooling systems
- Cannabis facilities

Gas or Electric Services
PhaseStor Benefits to Customers

- Latent energy storage for heating and cooling systems
- Wide energy storage temp range -70°C to 275°C for wide range of products
- NON-Corrosive: Bio-Based Phase Change Material
- Long life: 15-year warranty (Back-up long term stability >100 years of thermal cycling with no thermal degradation)
- NSF 61 Certified
- Ultra efficient: 50% lower heat loss
- Save on space - compact energy storage
- Effective load shifting
- Reduce peak demand charges
- Addresses short cycling - chillers & boilers –
  - Saving energy
  - Extending equipment life
- Compatible with ANY Heating or Energy Source

- Compatible with high & low temp heat pumps
- Widely used in different areas such as food, medicine, cosmetics, shipping, etc.
- Tunable thermal conductivity from 0.1-1 0 W/mK
- Non-Toxic and Biodegradable
- No G3 Requirements
- No Legionella or high-temp cycling needed
- No mandatory annual servicing
- Rapid reheating
- Grid balancing & eliminates need for buffer tanks
- Supports time of use tariffs
- Peak demand management
- 4x energy storage - Patented high latent heat tech
- Easy to install: Minimal pipework & electrical needed
- Easy glide feet included
- Future-proof for any energy source
- Reduces the size of the HVAC System compared to HVAC in traditional battery storage shelters

Thank You For Your Time

Conservation Solutions
Health Energy & Water Efficient Buildings

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