



World leading thermal storage technologies

May 2023

Thermal Management Expo
May 2023

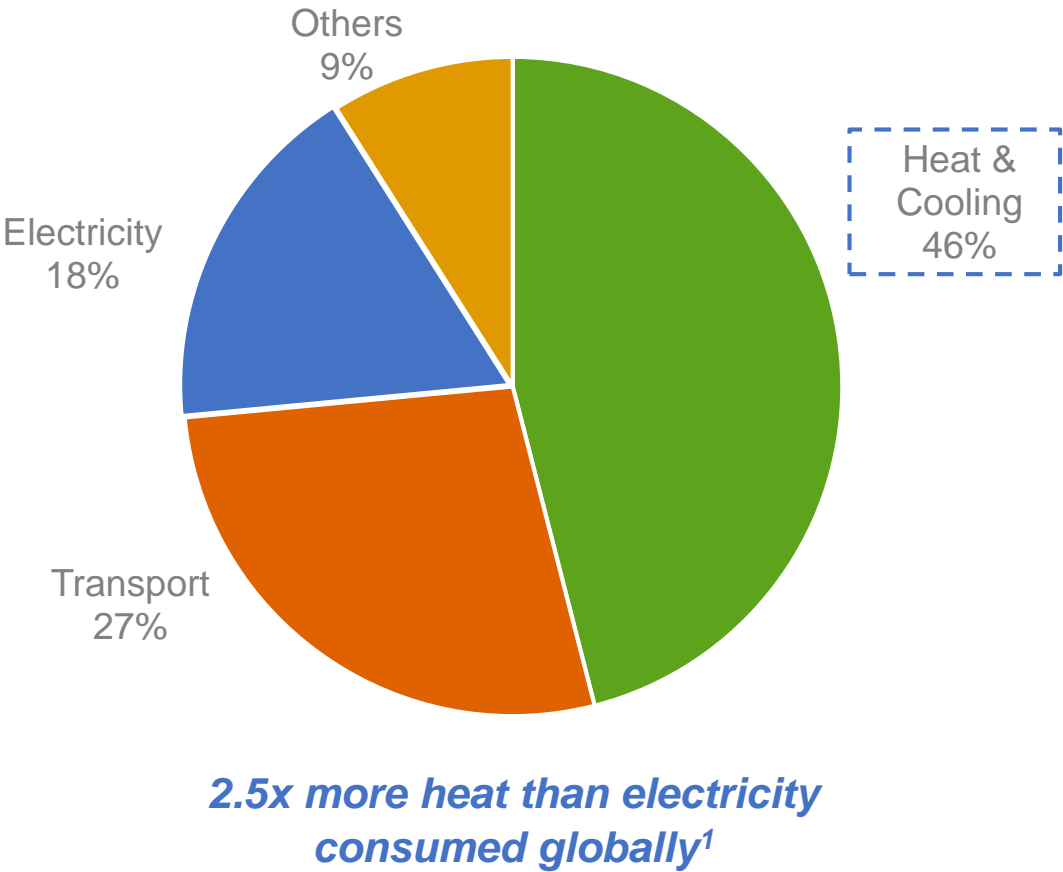


Dr David Oliver
Head of Materials

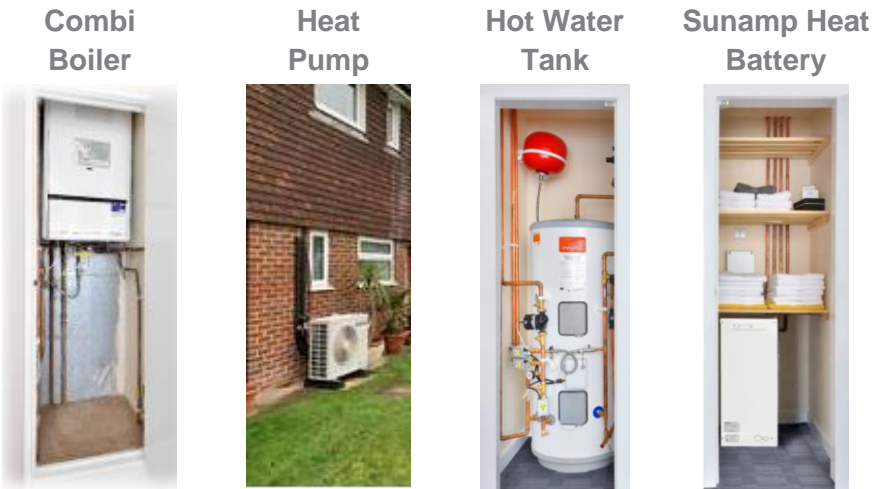
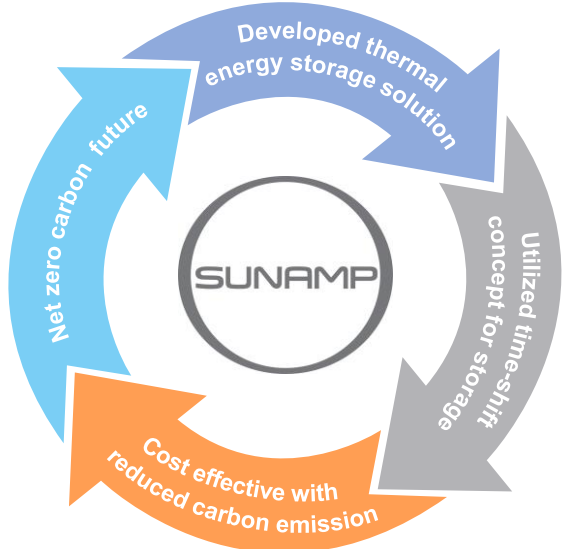
We are a leading disruptor of thermal energy storage solutions... ... accelerating global decarbonization goals



World energy consumption



Sunamp solution



- ✓ Cut out 'burn on-demand' fossil energy
- ✓ Enable renewable heating and cooling
- ✓ Link rapid growth in renewable electricity to heating and cooling

A world decarbonized by affordable, renewable energy sustained by compact thermal storage

Note: ¹ Heating Without Global Warming (IEA, 2014)

Successful integration of chemistry and engineering innovations has enabled Sunamp to develop the world's first commercial PCM heat battery

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Plentigrade® Phase Change Material (PCM)



- ✓ Stabilised
- ✓ Low-cost
- ✓ Safe
- ✓ Salt-based
- ✓ Proprietary
- ✓ Patented
- ✓ Long-life
- ✓ 40k cycles+
- ✓ Circular

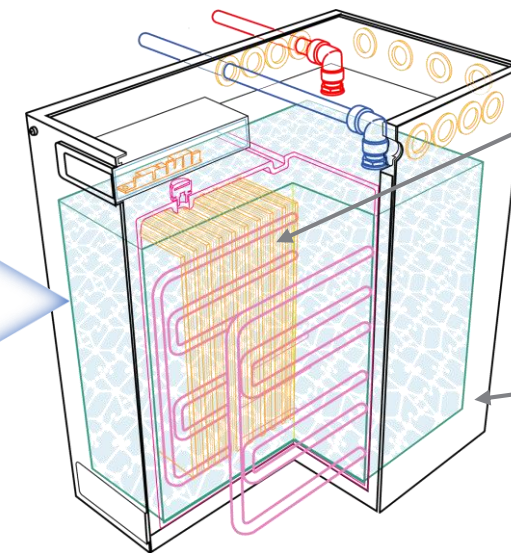
Plentigrade® PCM materials cover applications from **-30 to 300 °C**

Developing additional formulations from **-74 °C to 580 °C**

9 materials patent families

Plentigrade delivers
high energy density

Engineering breakthroughs



High power heat exchanger
delivers unprecedented
high flow rate hot water

A+ Energy Efficiency
Rating Class

Vacuum insulation
delivers class-leading
low heat loss

Exceptionally compact form factor enables rapid adoption of
heat pumps and solar PV self-consumption
displacing gas boilers and hot water tanks

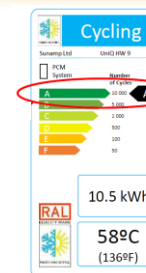
>25,000 batteries
sold to date



Grade A certified

by RAL-PCM¹

The only heat battery in the world with
RAL certification



248
(152 / 96)
total patents
(granted / pending)

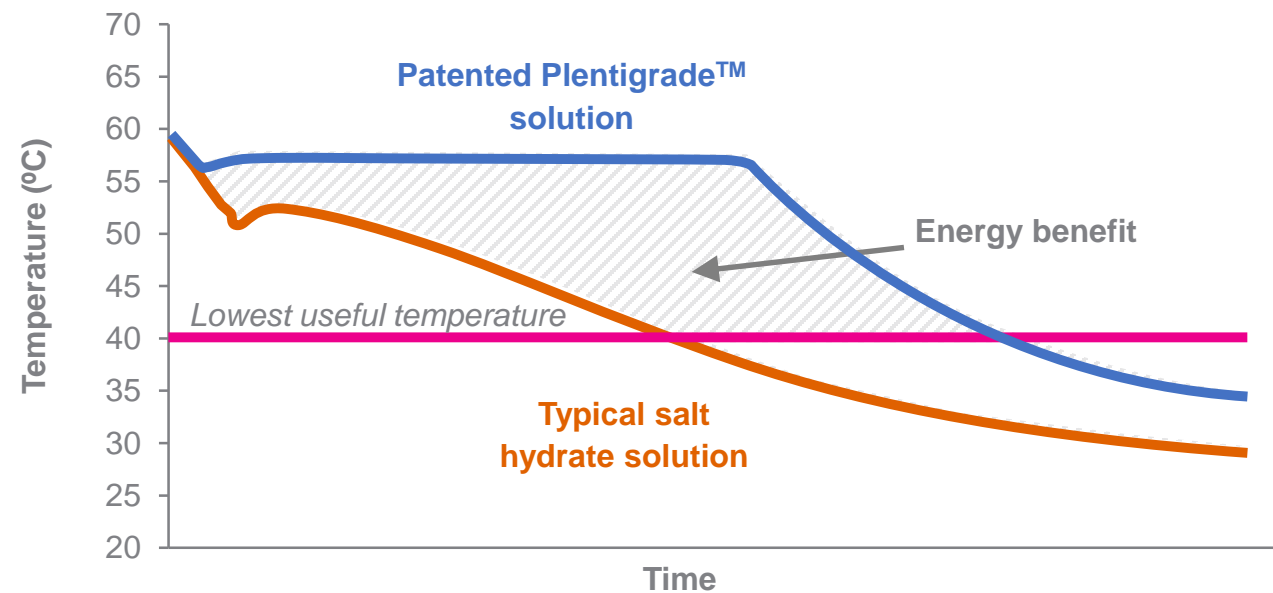
Note: ¹ P58 in a thermal store heat battery reached the required 10,000 cycles in 2019 "with no significant differences"

Our unique salt-hydrate Plentigrade (PCM) technology solves key problems that were unsolved 1947-2012, then solved by Sunamp and University of Edinburgh ...

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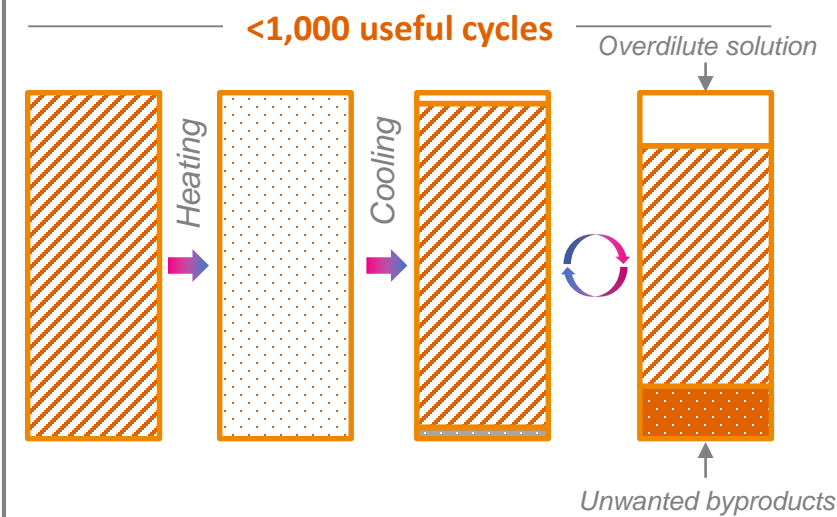


Plentigrade vs. traditional PCM heat release cycle



- ✓ Plentigrade™ releases heat at constant useful temperature ranges for extended time durations
- ✓ Potential to discharge to piped circuits (hot water / heating)
- ✓ Patented formulations including stability and triggering chemicals (no mechanical trigger required)

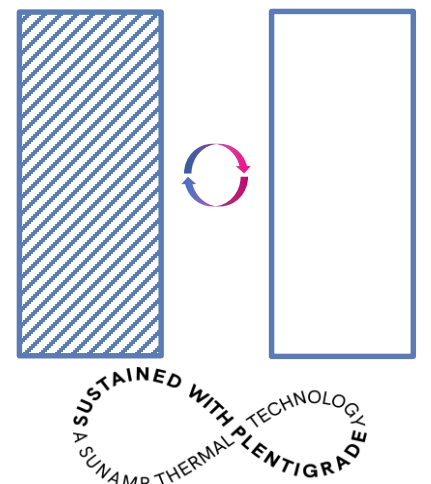
Traditional salt hydrate PCMs



- ✓ Reproducible performance over tens of thousands of heating/cooling cycles
- ✓ Long term (decade plus) chemical stability e.g. with respect to corrosion of construction materials
- ✓ Predictability of heat transfer and storage
- ✓ All Plentigrade™ subjected to multi year testing campaigns before being released to market

Plentigrade P58 PCM

40,000+ useful cycles



Sunamp has world leading scientific understanding of crystal structure chemistry creating significant barriers for entry

... is significantly superior PCM to traditional competitors ...



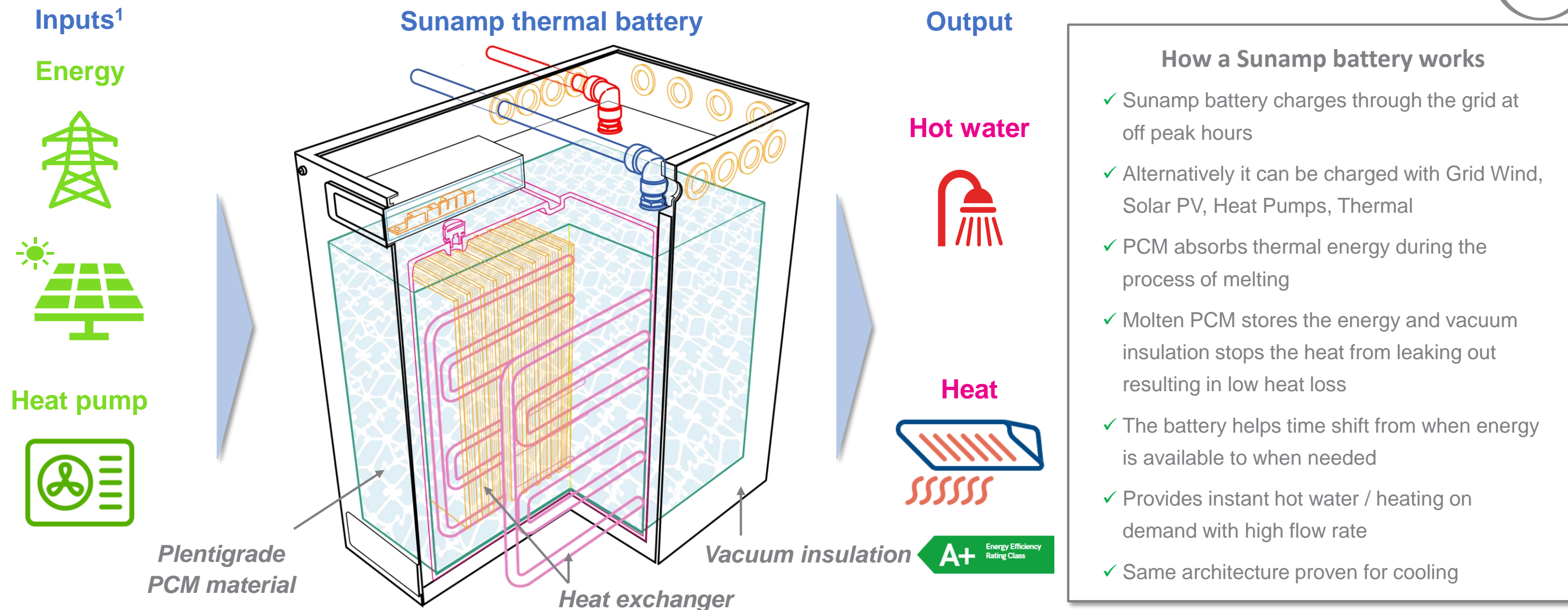
Characteristic	Traditional salt hydrate PCMs	Plentigrade P58
Cyclability and longevity	✗ <100 cycles ¹	✓ 95%+ capacity after 40,000 accelerated cycles
	✗ Additives needed for crystallization ¹	✓ Design eliminates sub cooling
Power and energy (heat release)	✗ Low thermal conductivity	✓ High flow rate, high power in a heat battery
	✗ High, degrading energy density	✓ High, stable energy density
Chemical properties	? Toxic materials; land use issues (palm oil deforestation, food vs PCM ²)	✓ Non-toxic materials; environmentally friendly
	✓ Intrinsically not combustible ²	✓ Non-flammable, non-combustible
Ease of handling/ sustainable sourcing	✗ High chemical skills; complex equipment and high energy to melt	✓ Plentigrade process makes hot liquid PCM to directly fill heat batteries
	✓ Good availability of major components ²	✓ No sourcing constraints; pathways to negative embodied carbon PCM
Costs	✗ Sell at inflated prices ²	✓ Inorganic salts with lower and stable pricing ³
	✗ Variable costs with limited suppliers ²	✓ <\$1/kg PCMs and complete batteries <\$75/kWh ⁴

Perfected the combination of low-cost material, long-life, recyclability, safety and unmatched energy density

Note: ¹ Traditional organic PCM systems have good cyclability and sub cooling is not a concern; ² Traditional organic PCM systems are expensive (\$5-10/kg PCM and complete batteries >\$200+ kWh), combustible/flammable and unsustainable with volatile oil-linked prices; ³ Some trigger temperatures still require organic materials; Sunamp is working fast to replace these, meanwhile using the best possible materials e.g. non-combustible; ⁴ Pathway to further cost down to \$20/kWh



... bringing alive our concept of the thermal battery

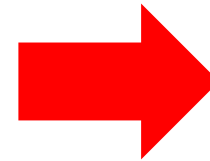


Patented breakthrough adapts standard heat exchangers to deliver unprecedented thermal power

¹ Subset of all inputs shown for illustrative purposes



What we set out to achieve - Extreme Compactness...

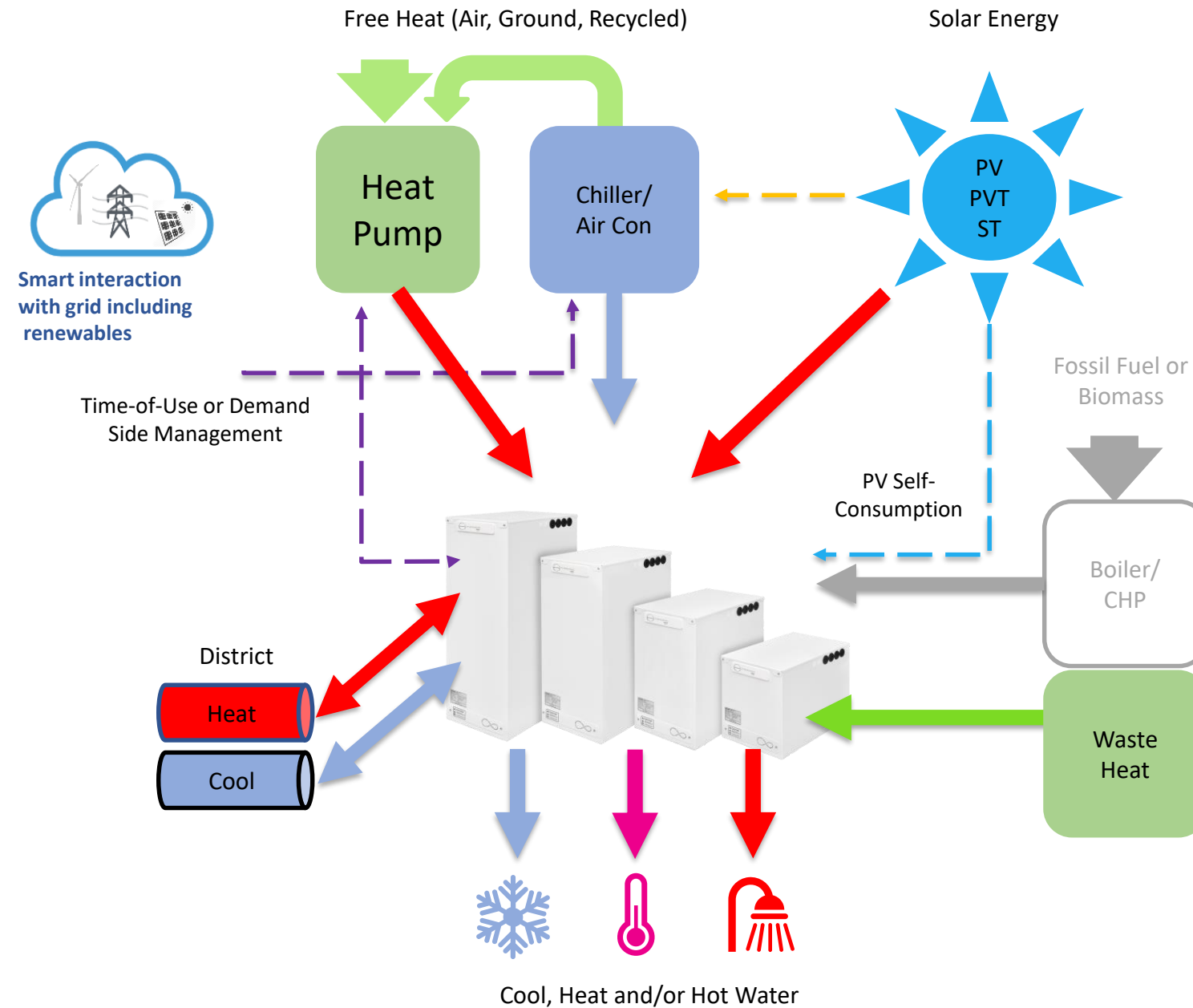


Phase Change
Material (PCM) was
identified as the best
way to achieve this

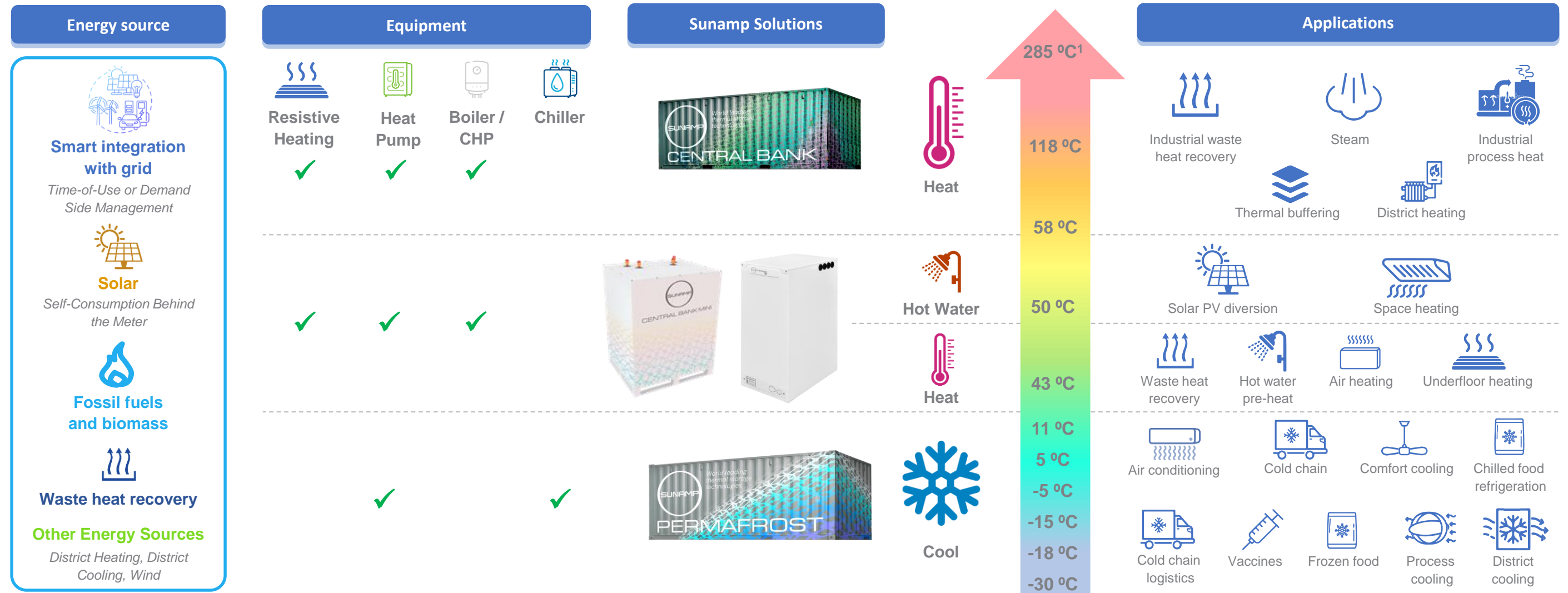
3 - 4x
smaller



... with extreme flexibility for system designers



... with technology that provides unparalleled temperature range and flexibility



Our thermal batteries can be charged by electricity, air / ground source heat pumps, boilers, waste heat and photovoltaics

Note: ¹ 285 °C and higher temperatures in development for applications including ceramics, cement and steel