How manufacturers can decarbonise heat

Technology mini guide

Thermal energy storage

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Understand your options for decarbonisation technology

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“For industrial organisations, implementing decarbonisation technology is almost always the largest step to decarbonisation. It typically accounts for 50-70% of site emissions.

For most industries, there are an overwhelming number of solutions, possibilities and combinations to choose from on the path to decarbonisation.

Knowing what the options are is the first step and so we have created these mini guides to help you become more familiar with the potential solutions.”

Thanos Patsos, Associate Director, Head of Deliver for Zero, Corporates

Options overview

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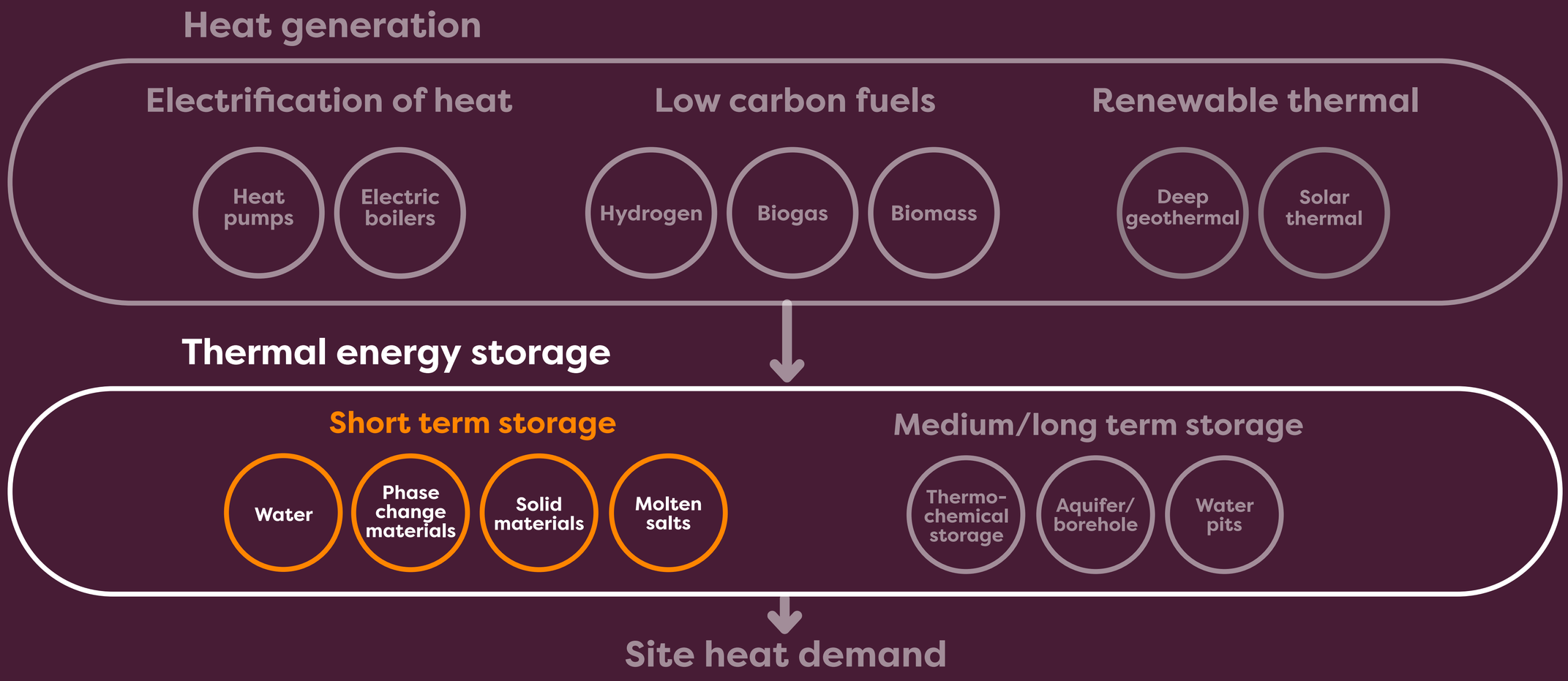
In previous guides, we have compared different technologies for generating low carbon heat. In this guide, we compare methods of storing heat to optimise the application of low carbon heat sources to meet site heat demands.



Why thermal energy storage?

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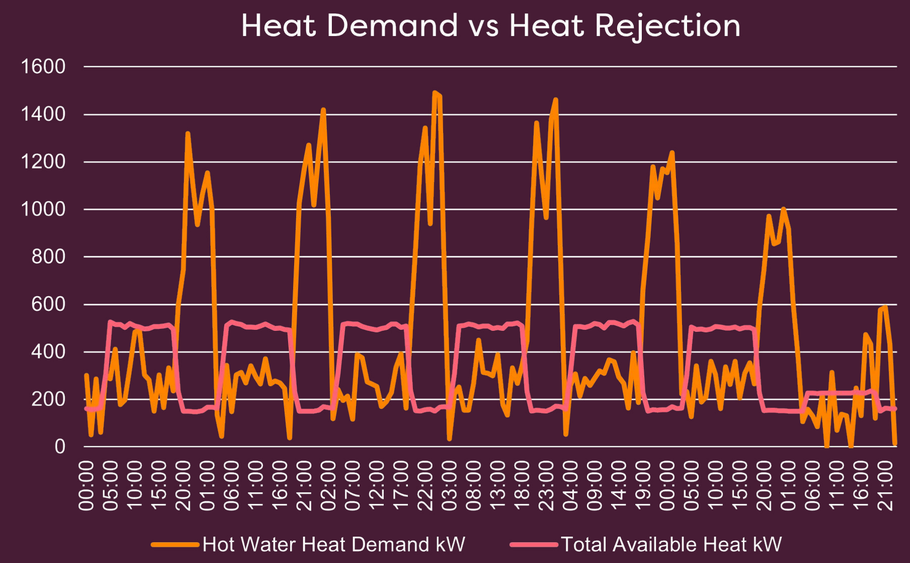
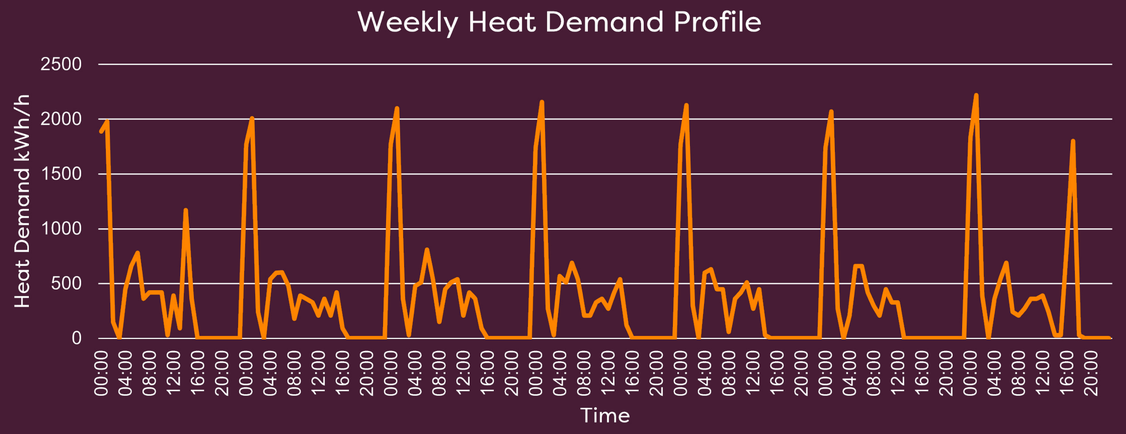
Thermal energy storage is widely used alongside renewable or other heat sources for a number of reasons including:

1) Balancing or ‘buffering’ non-coincident heat rejection and heat demand loads. Rejected heat can be stored to be used to meet heat demands later in the day/week.



Non-coincident hot water and heat rejection profiles.

2) ‘Load lopping’. Intermittent process loads can require large amounts of heat for short periods of time. Heat storage can enable heat production plant to be sized closer to the average load.



Example of process with short duration high peak loads.

Why thermal energy storage?

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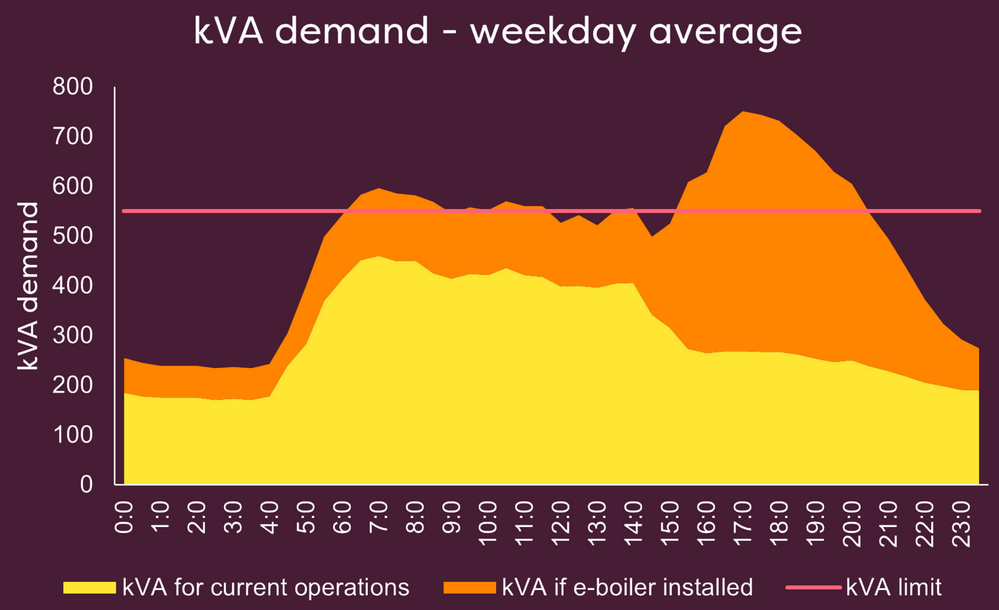
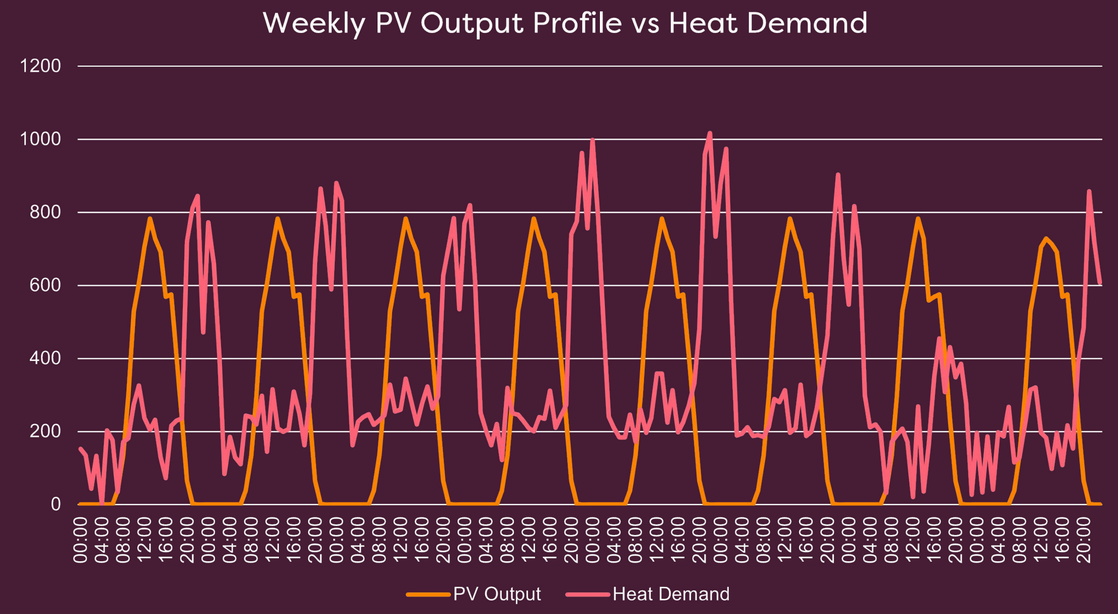
3) Load shifting. Heat storage can enable demands to be shifted to other parts of the day making use of cheaper rates and/or using supply headroom at periods of low demand.



Example of daily demand electrical profile if an e-boiler was installed.

4) Integration of renewable power sources. Excess power or heat from solar or wind turbines can be stored to offset demand at other times.



Example of PV output vs heat demand over a week.

Thermal energy stores - operating temperatures

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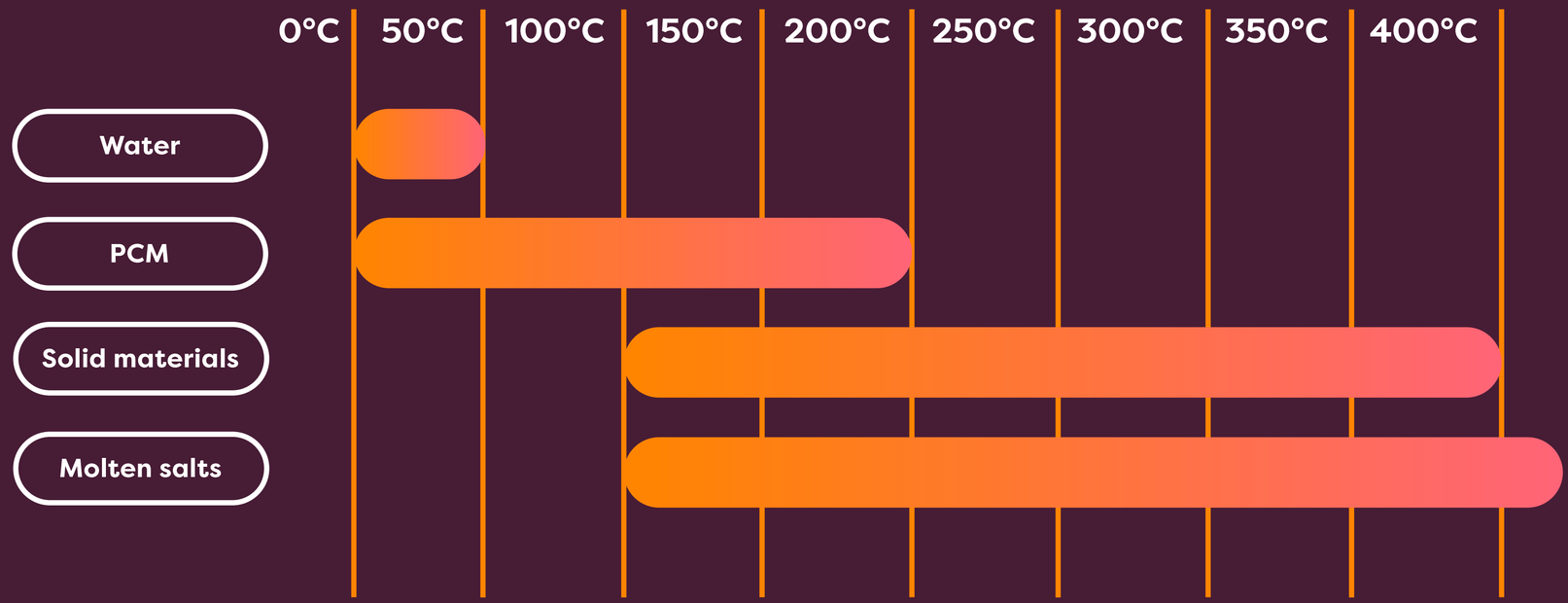


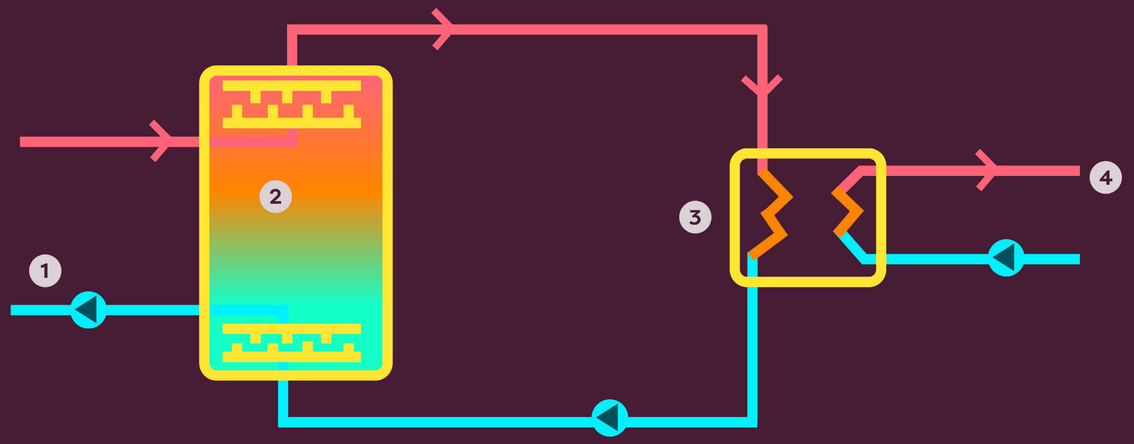
Thermal storage media operate at different temperature ranges.

The diagram illustrates the typical operating ranges.

Note: PCMs operate at a specific temperature and not across a temperature band.

Water heat storage

Water heat storage



1. Heat rejection circuit to/from thermal store
2. Water storage thermal stratification tank
3. Heat exchanger to process heat circuit
4. Process heat circuit to/from heat users

Using water as a heat storage medium is well understood and commonly used. Typical applications included circulating water to recover heat from industrial processes or storing heat from heat sources such as CHP sets for peak load control.

Heat storage relies on the sensible heat capacity of water and close temperature control is required. Water heat storage is often used with stratification storage tanks to control the temperature of the water. Temperature ranges are typically in the range 50C to 90C.

To the left is an example of using a hot water stratification tank to store rejected heat to be used directly at a later time for process loads.

Alternatively, heat pumps could be used to lift rejected heat temperatures.

Phase Change Material (PCM) heat storage

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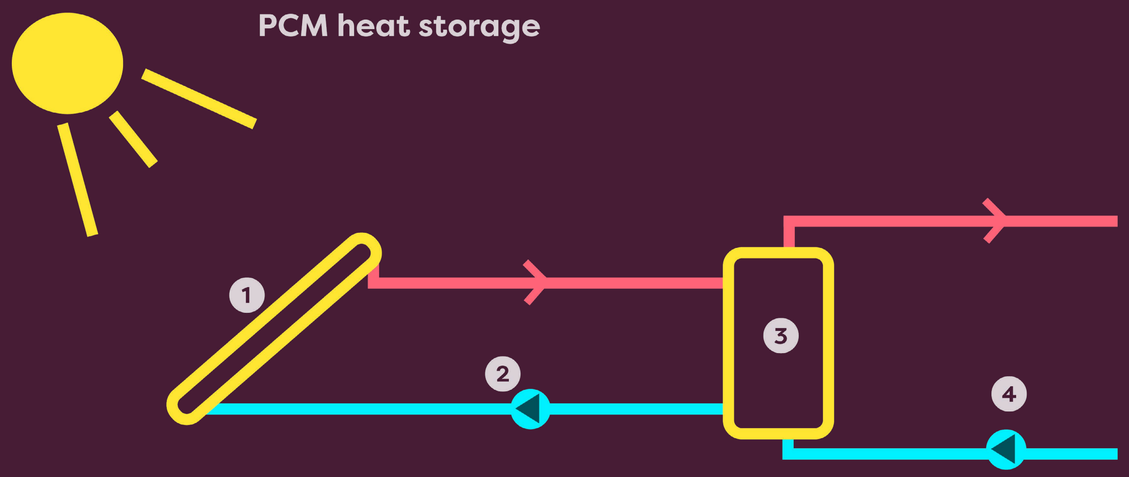

1. Solar thermal collector
2. Heat distribution circuit to thermal store
3. Thermal store - PCM encapsulated in buffer vessel
4. Heat distribution circuit to heat users

Phase Change Materials (PCMs) store heat as latent energy though a phase change from solid to liquid. As a result PCMs can have a high heat storage density and be used to store heat at specific temperatures.

PCM's tend to be more expensive to implement that sensible heat storage and are not as widely utilised. The use of PCMs for cold temperature storage is more common than medium and high temperatures for heat storage.

The example to the left is a deployment of PCMs for heat storage. In this example PCM's are encapsulated and stored in a buffer vessel with water as a heat exchange fluid to store heat from a solar thermal system. This application achieves a high heat storage density at a consistent temperature to the heat user circuit.

Solid materials based heat storage

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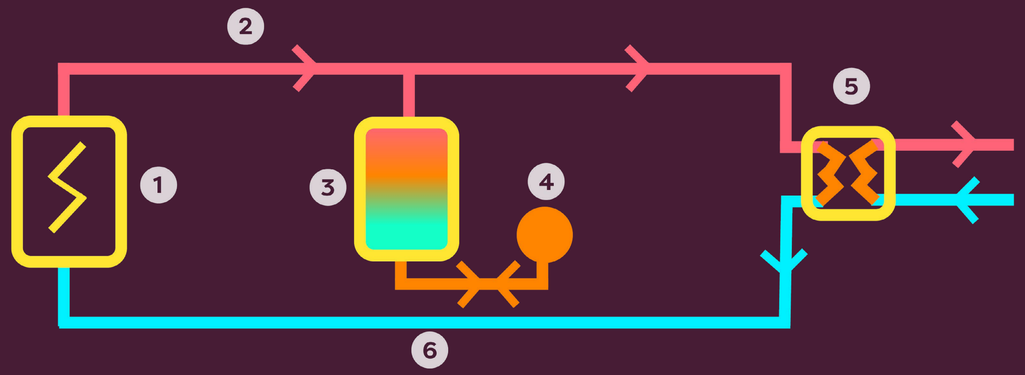
Solid materials heat storage



1. Electric steam boiler
2. Steam line
3. Thermal store e.g. concrete
4. Collector
5. Heat users
6. Condensate return

Heat storage based on solid materials uses the sensible heat capacity of materials with high specific heat capacities. Inexpensive materials such as concrete and rock are widely used and several proprietary systems are available as turnkey solutions.

Solid material heat storage systems are deployed at medium to high temperatures typically up to 300C for the generation of steam. Charging is commonly done by steam for load buffering or direct electric to make use of off peak electricity or excess output from renewable energy generators.

The example to the left is a deployment of solid material such as concrete for heat storage. In this example, the store is used for peak load lopping to limit the size of an electric boiler and make use of site incoming electrical capacity. At times of low demand the boiler generates steam to charge the store and condensate is stored in the collector, at times of high demand the condensate is pumped back through through the store to generate steam and supplement the boiler.

Other applications can include direct electric heating of the store.

Molten salts heat storage

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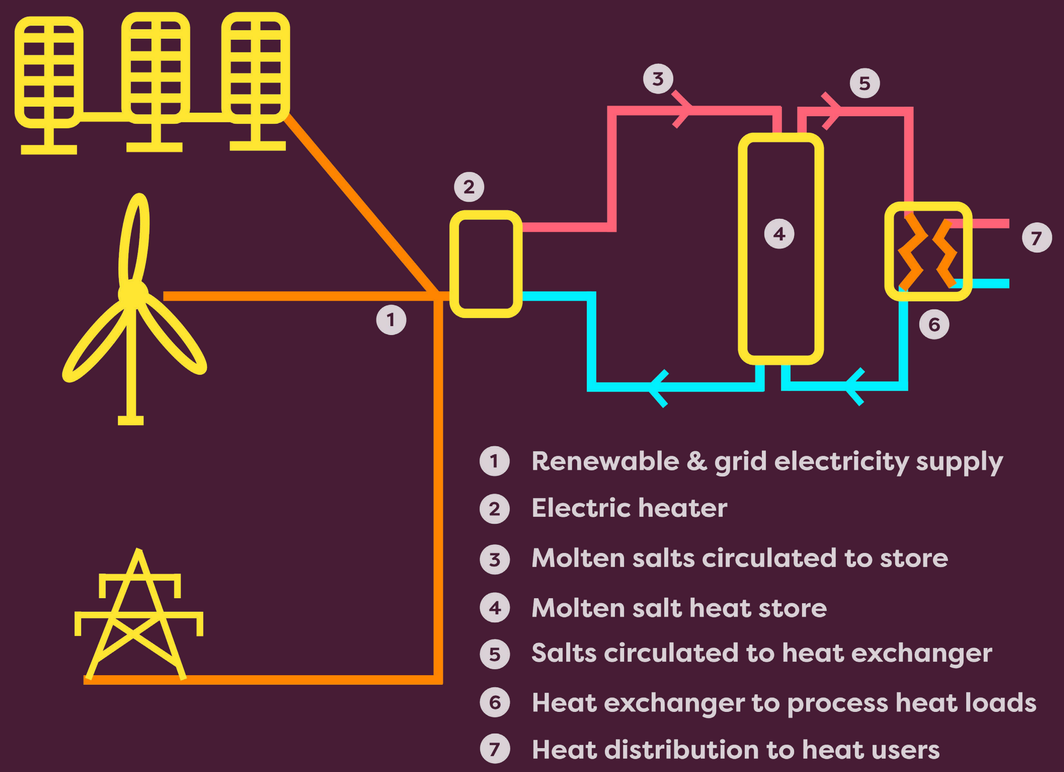
Molten salts



1. Renewable & grid electricity supply
2. Electric heater
3. Molten salts circulated to store
4. Molten salt heat store
5. Salts circulated to heat exchanger
6. Heat exchanger to process heat loads
7. Heat distribution to heat users

Proprietary heat storage systems based on the use of molten salts are also available. The use of molten salts enables a high density of heat storage at medium to high temperatures and quick response times as the material remains in a liquid state.

Application of molten salt systems is primarily for load buffering/shifting or storage of excess renewable electricity output. Heat output is to steam.

To the left is an example of deployment of molten salts to store heat from renewable and grid electricity. Electricity is used to heat the store when available and heat extracted to the heat network via heat exchanger (steam generator).

Thermal Energy Storage

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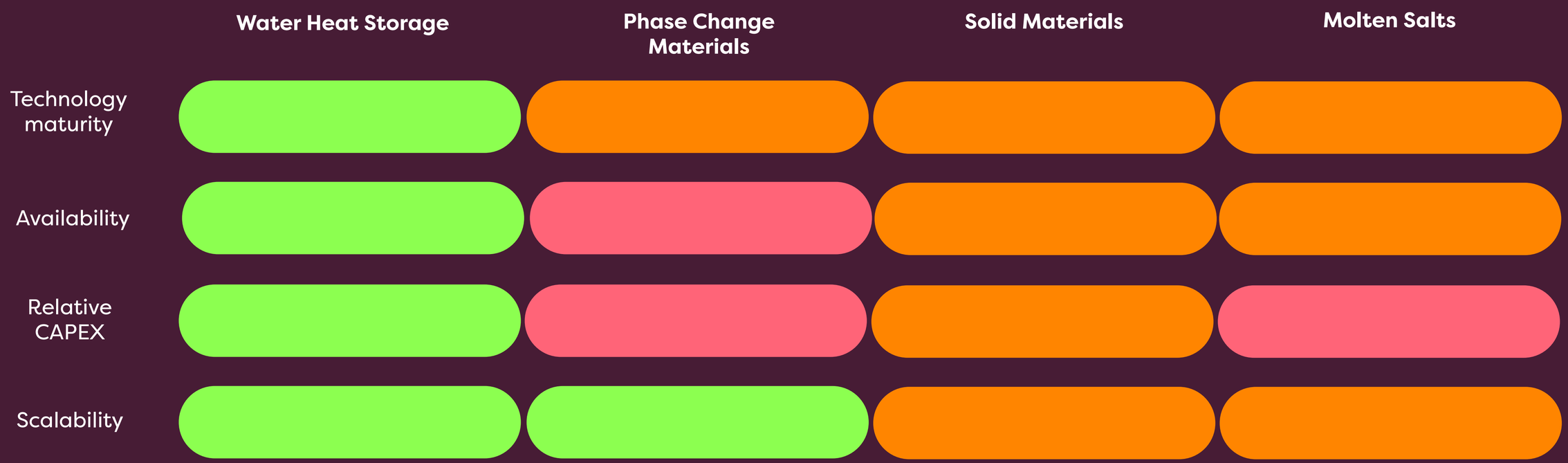

Expert overview

The use of heat storage is likely to become more commonplace with the transition to low carbon fuels and the electrification of heat. Heat storage in itself is not a mechanism to decarbonise but is to be integrated as part of an overall strategy for heat production and delivery.

The starting point for consideration of heat storage is to understand the profile of the heat demand and heat rejection processes on your site. A strategy can then be developed to use storage where there is benefit from load shifting, integration of renewables or making use of waste heat.

How we can help

Take a look at the other mini guides in this series:

- Renewable thermal mini guide
- Electrification of heat mini guide
- Low carbon fuels mini guide

Low-Carbon Heat Blueprint

If you've reached a point where you need to upgrade heat infrastructure quickly and don't have a full decarbonisation roadmap, you're probably trying to weigh up your options.

Our Low-Carbon Heat Blueprint service typically takes three to four weeks and is just ¼ of the cost of a full decarbonisation roadmap. It will give you the information you need to optimise heat use, generation and distribution, avoid carbon dead ends and make a clear and confident business case.

You'll get low-carbon heat solution concepts tailored to your site and business goals, a credible project definition, and a robust investment case - everything you need to fast-track effective decarbonisation.

Browse the service document to find out more