How thermal stores work

A thermal store differs from a conventional hot water cylinder in that the water does not come out of your taps directly from the thermal store. Instead, it is heated up by passing through a heat exchanger that transfers heat from the thermal store water to the mains or tap water. Heat exchangers, especially flat-plate heat exchangers, can transfer lots of heat in a short time – so you can have a mains pressure shower or fill a bath very quickly.

A thermal store may have other heat exchangers connected to it, or inside it. This would be normal to transfer heat from a solar thermal system or heat pump as those technologies use expensive antifreeze in their working fluids, as they are outside in winter. Heating circuits (radiators or underfloor) may do this if they use additives to avoid fouling; if not, they can use the water from the thermal store directly.

Gas and oil boilers or biomass (solid fuel) boilers and boiler stoves can also use the same water as long as they are designed for use in a simple vented system. Since these heat-only boilers are very simple in their design, they tend to be cheaper, more reliable and last longer.

System boilers or communal heat mains can be used to heat thermal stores, but this would normally be done via a heat exchanger (indirectly). Combi boilers are not normally used with thermal stores.

A thermal store can contain more than one heat exchanger. A heat exchanger at the bottom of the store (the coldest part) allows for a useful exchange of heat even when the temperature of the fluid from the heat source is only tepid. This improves efficiency and is a very important in a solar water heating system as it enables the heat from the sky to be harvested even on less sunny days.

Thermal store design

Thermal stores are usually tall and thin to encourage the natural tendency of heated water to form layers of heat, with the coldest at the bottom and the hottest at the top – this is known as stratification. To help it, the cold feeds and returns are put at the bottom of the store and the movement of water within it is kept to a minimum - sometimes by using inner partitions, plates and diffusers.

Well-designed heating systems linked to thermal stores make the most of stratification by making sure all connections are placed at the point of maximum gain. For example, under-floor heating, which works at lower temperatures, would take heat from the lower part of the cylinder; heat for hot water would be taken from the top.

Methods of thermal energy storage

There are three methods for storing thermal energy:

- Sensible
- Latent
- hermochemical.

Sensible

Thermal energy storage is when a material is heated and its temperature increases. The heat is stored in the material and then released, causing the material to cool again. There is no change of phase from a liquid to a gas: the water does not become steam. For example, in a hot water cylinder water is heated from a lower temperature to a temperature below its boiling point.

Latent

Thermal energy storage happens when a material changes phase, from solid to liquid or liquid to gas. As this happens, the temperature of the material does not vary. Think of an ice cube: heat is required to melt the ice cube and change the water from a solid state to a liquid state, but while the ice is melting, the temperature of the water remains at zero degrees celsius. Latent thermal energy storage works on the same principle, with a range of phase change materials (PCM) giving the storage temperature required for potentially a lot less space than the equivalent size of water-based storage.

Thermochemical

Thermal energy storage is when a material is broken down into individual components, which then can be stored separately. This is the process of storing heat. The heat is then released by bringing the two components together again.

Latent and thermochemical thermal energy storage are not yet used in the heating of normal homes. But some companies are beginning to bring latent thermal energy stores to the market; so far, these products are untested in large numbers so the benefits are not yet fully realised. There are financial and environmental benefits, so latent thermal energy stores are likely to become more common.

Sensible heat storage is widely available and used in the domestic market. The normal material for domestic applications is water, as it has a high specific heat capacity, is cost effective and is not toxic. Many homes have a domestic hot water tank and this is a form of sensible heat storage.

Thermostats

Thermal stores are fitted with one or more thermostats that monitor the temperature of the stored water. If insufficient heat is being provided via the heat exchangers, a supplementary heating method such as a boiler or immersion heater can be used to bring the water up to the required temperature.

Thermostats are normally arranged in a hierarchy up the store so the cheapest or least carbon-intensive heat source is requested first. For example, solar energy i heats the whole store (as would input from wind or PV if you were using the thermal storage to store their excess electricity), but if more heat has been requested from the store than the solar puts in, the bottom section of the store would start to get cold.

As this cold section moves up the store, the lowest thermostat might ask a biomass boiler to turn on. If this boiler is not available or could not produce enough heat, the next thermostat up might ask for a gas or oil boiler to turn on. Finally, at the very top, the highest thermostat asks an electric immersion heater to turn on.

This content was developed by the Energy Saving Trust in partnership with the OCTES project, with funding from the Northern Periphery Programme (NPP) and the Scottish Government. Go to the OCTES website.