THERMAL STORAGE

A vital component of zero carbon homes

October 2021

Introduction

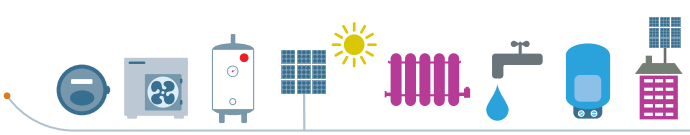
Net Zero and the electrification of heat

The UK Government has set ambitious targets for achieving Net Zero greenhouse gas emissions by 2050, with a target to reduce the UK's emissions by at least 68% by 2030 compared to 1990 levels.

Buildings currently contribute roughly a third of the UK's annual greenhouse gas emissions. This needs to be reduced to zero. This means that all or nearly all the UK's housing stock and its public and commercial buildings will need to rely solely on non-carbon sources of energy for space heating and hot water. The technologies and infrastructures enabling low- or zero-carbon gas heating remain some way off, so a large proportion of the energy generation required to meet the heating needs of UK buildings will be renewable electricity.

The intermittency of renewable generation and the variability of energy demand mean that the electricity grid of the future will need to be highly flexible and responsive. Some of this flexibility can exist in large, centralized storage centres, but much of it will be located closer to where it will be needed. Distributed energy storage in buildings, behind the meter, will be an integral part of the solution to the challenge of decarbonizing the electricity grid. There is, rightly, a lot of discussion about battery technologies and developments in electrochemical storage, but the market is still nascent. The most popular and common form of energy storage in homes is distributed thermal storage.

There are several forms that such thermal storage can take: the fabric of a building, for example insulation or trombe walls, is a form of thermal storage, though this is not explicitly extractable for flexibility purposes. The most recognizable thermal storage appliance in residential buildings is the hot water cylinder. Where space is at a premium, some buildings may instead use phase change material formulation, which can store up to four times more energy than a similarly sized water tank, alongside a high-powered heat exchanger charged by mains electricity.



What is the current situation?

There are currently around 7 million hot water cylinders in UK properties providing a potential 17.5GWh of demand response opportunity if managed correctly. This is declining at an alarming rate; most are replaced by combi boilers, which may not be the most appropriate solution for the property.

There are a number of reasons for this decline. The primary one is that they take up space: a standard tank is 150L, and most are between 90L and 300L in capacity; when wrapped in insulating material and boxed in, they can occupy most of an airing cupboard. Older models or tanks with poor insulation may also make a noise or leak heat into a room; as they are often installed in a bedroom, this can seem inconvenient.

Another important reason is that installers commonly fit fossil fuel boilers that are too large for the property (sized appropriately for the property's hot water needs, which is a fraction of the load, but often far too large for the space heating requirements). This, combined with the low price of gas relative to electricity, "hides" the improper sizing and encourages the replacement of hot water cylinders with combination boilers. Combi boilers have had a significant impact on the decline of hot water cylinders.

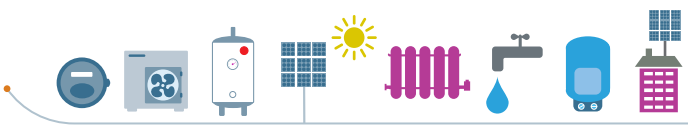
Another contributing factor is that is that many consumers do not currently see the benefit of a hot water cylinder. The flexibility it can provide is rarely measured or valued, and most homes have neither the smart controls, energy management system or dynamic time-of-use tariff that would allow a consumer to make noticeable savings on their energy bill by, for example, heating the cylinder's water when energy is cheap and releasing that stored heat in a controlled manner when it is needed but when energy is more expensive.

The fourth significant factor is an education and training problem. Either at the new-build stage or during a renovation, tradespeople are often not aware (or not convinced) of the benefits of thermal storage for hot water and thus do not encourage homeowners to install a hot water cylinder or keep their existing one.

Similarly, there are three main reasons why a homeowner will be advised to adopt gas heating over electricity. The first is one of cost: the upfront cost of a heat pump is almost always significantly more than the upfront cost of a gas boiler. There have been no Government schemes to adequately address this imbalance, whether past, current or proposed future incentives. Secondly, there are artificial disparities and market distortions in the relative costs of operating gas and electric systems, though these are beyond the scope of this paper. The third reason concerns convenience for the service provider, who whether designing, building or repairing a home's heating system, is likely to suggest a gas system. This is especially the case when the provider is called out to repair or replace a faulty gas boiler. Similarly, especially when the heating has failed, a consumer will lean towards a replacement that uses existing infrastructure, that is cheaper upfront, and that is most quickly and easily installed. In most cases that will be a new gas boiler rather than a heat pump or other electrical solution.

These issues affect new-builds and retrofits or renovations differently, but there are some common themes here that suggest some policy and market measures that would help arrest and reverse the decline in hot water cylinders, and in thermal storage capacity more generally. These recommendations are listed on page 5 of this document.

Another challenge is the complexity and diversity of our existing housing stock. This means that there are no easy, general infrastructure solutions that can be rolled out to all or nearly all the more than 26 million homes in the UK. It follows that there will a variety of solutions to the challenge of decarbonising the UK's housing stock, but we expect electrification to play a major role.



Why is this a problem?

A large proportion of UK homes that are currently heated by gas boilers will need to be heated with electricity, in most cases by installing a heat pump. This supports the argument for retaining and increasing the UK's stock of hot water cylinders in two ways.

Firstly, electrification will increase the demands on the electricity grid and may also demand more system flexibility. It would be perverse to enable the removal of flexibility assets at a time when we should be increasing our ability to manage load and stabilize the electricity grid.

Secondly, a heat pump must be operated in conjunction with a hot water cylinder. Therefore, if fewer homes already have an installed cylinder, the individual financial case for switching from a gas-fired boiler to an electric heating solution may be compromised. If we are going to prepare the UK housing stock for electrification, it makes sense to keep as many hot water cylinders in homes as possible – even if the installation of heat pumps is years away. In this way, UK homes may not be carbon neutral now, but at least we are not removing appliances from them that are essential to future carbon neutrality. Removing hot water cylinders from homes and then reinstalling them alongside heat pumps is an inefficient approach to the problem. Similarly, removing the hot water cylinder creates another barrier to consumer uptake of heat pumps at a time when industry and Government should be working together to support that market.

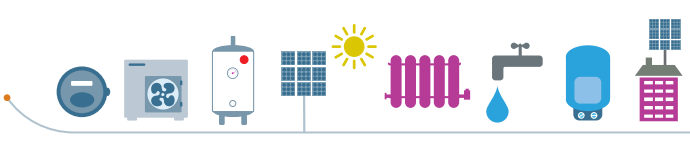
What should we do about it, and how do we make that happen?

The most important and significant intervention from Government in support of thermal storage would be to provide more incentives and subsidies to consumers to manage the upfront costs of such assets and to prepare homes for thermal storage and electrification with programs that swiftly and drastically improve the energy efficiency and thermal quality of the UK's building stock. These incentives should be supported by targeted regulations including to require energy flexibility in all existing homes and all suitable new-build homes to contain thermal storage.

We need more research into electrical system diversity across different energy pathway scenarios, the value of thermal storage and ways to deliver it cheaply and efficiently even in small homes.

As well as support for the upfront installation costs, consumers will need targeted support so that the running costs of low-carbon systems using thermal storage are on parity with the fossil fuel systems they displace.

Thermal storage will be most attractive and beneficial to consumers if the UK has a functional, efficient market that allows for the measurement (metering) of flexibility and enables flexibility providers to realize the value of the grid stability they deliver. Thermal storage needs to become an integral and expected part of the modern building, not left to the margins of individuals making altruistic but expensive personal choices. Smart tariffs, including dynamic time-of-use tariffs, will play a big role here but depending on margins (and the price of energy) may not be sufficient to drive the level of flexibility required. Market levers may form only part of the solution here.



To reverse the decline in distributed thermal storage:

Government should

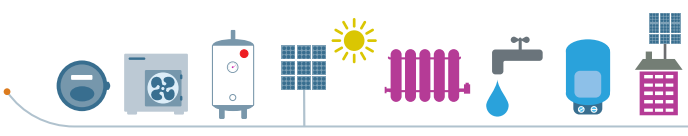
- Identify and target the properties that are most suitable for a retrofit heat pump
- Provide more support for consumers in the form of grants for system upgrades and insulation to make that cost effective
- Future-proof homes by improving the energy efficiency of properties and retaining hot water cylinders where appropriate, even if a heat pump installation is years away
- Support industry to train and re-skill installers
- Partner with industry for a targeted information campaign to educate consumers about the value of thermal storage
- Ensure that policy complements other emerging markets, such as for EV charge points

Industry should

- Future-proof new homes by allocating space for a hot water cylinder where possible (and alternative thermal storage measures where required)
- Anticipate incoming regulations and promote low-carbon heating solutions in all homes
- Avoid removing thermal storage assets, especially in homes that are suitable for heat pumps and will need a hot water cylinder
- Aim to provide well-insulated, energy efficient homes, whether new or retrofit

Summary headlines:

- Thermal storage is an integral element in all homes.
- Increasing thermal storage capacity is essential if we are to achieve Net Zero emissions from UK housing stock.
- Most thermal storage will be in the form of a hot water cylinder. These are necessary for the operation of a heat pump, so they should not be removed from dwellings where a heat pump is an appropriate heating solution.
- Removing hot water cylinders from suitable dwellings will only slow the pace of heat pump installations. This will jeopardize the path to heat electrification and Net Zero.
- Other thermal storage assets are available for where a hot water cylinder is not suitable. For example, a phase change system can produce excellent results while taking up less space than a hot water cylinder. An electric boiler may also be a suitable solution.
- Government should provide greater support for industry and consumers to retain existing thermal storage capacity or install new capacity.
- Government support for thermal storage assets should be coordinated with policies to promote electrification, energy efficiency and a functioning flexibility market.
- Industry should encourage consumers to retain or install thermal storage assets and should support efforts to train and educate its workforce (and consumers) about the benefits of thermal storage.
- Consumers with installed hot water cylinders should keep them in their properties even if the system runs on gas, in preparation for the nationwide rollout of heat pumps and other electric heating solutions.



To read more, download the BEAMA *Net Zero by Design Main report and white papers*

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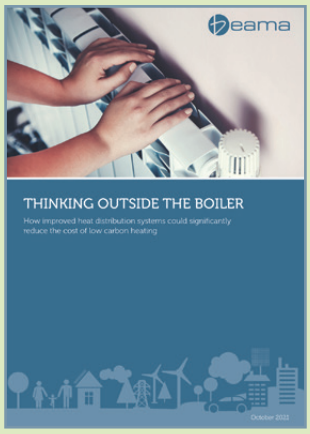

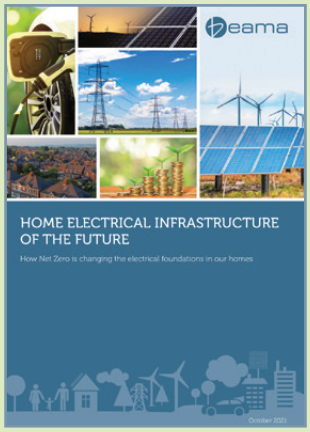

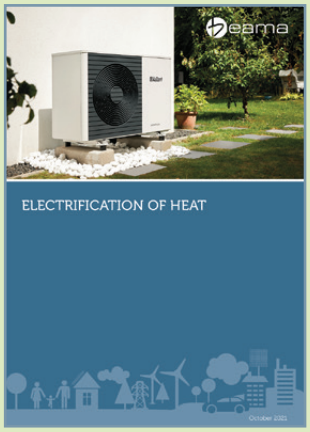

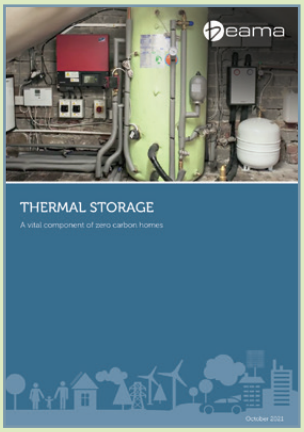

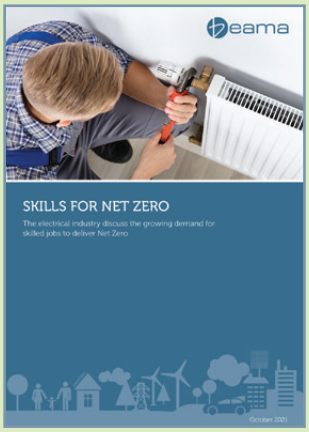

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