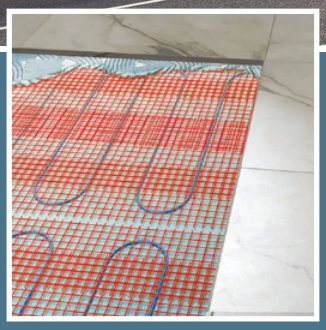


NO ONE WILL BE LEFT BEHIND ON THE ROAD TO NET ZERO

Low Carbon Heat by Design

October 2022

CONTENTS

SUMMARY

This paper attempts to explain why the UK, which has been decarbonising its electricity generation at almost twice the speed of any other major economy, has also been one of the slowest countries in Europe to adopt low carbon heating systems, specifically electric heating as a mass-market solution to the decarbonisation of heat.

In part, this is due to the long-standing dominance of the UK fossil fuel heating industry but this is not the only barrier to the adoption of low carbon heat sources. In comparison with many European countries, the UK lacks a cohesive and long-term policy framework to "fast-track" the take-up of low carbon technologies. Alongside this, UK regulations and compliance methodologies have been slow to recognise the full extent of the advantages that some of these technologies can contribute to the Net Zero objective.

The Government has largely recognised, following repeated demonstrations, that the pursuit of a single technology approach (or silver bullet) is misguided. Instead, it has rightly identified that the following range of heating technologies will play a pivotal role in the drive for decarbonisation:

HEAT PUMPS | HEAT NETWORKS | HYDROGEN

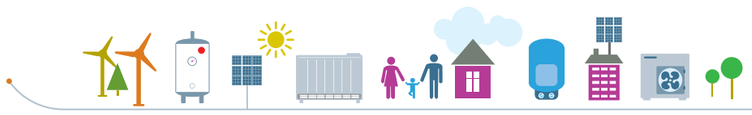
It has also conceded that the following technologies **may** be viable:

BIOENERGY | GEOTHERMAL HEAT | STORAGE HEATERS

However, in a market which repeatedly calls for a technology neutral approach to policy, segmenting solutions via a two-tier system risks impeding further investment and development opportunities in technologies outside of the top tier. Some of these, such as storage heaters and other direct electric heaters, are long-established and proven technologies, as well as being seen in many quarters, as a requisite for the decarbonisation of heat.

We will look back at the three years to the end of 2022 as a period of unprecedented challenge, culminating in the energy crisis caused by the spiralling costs of gas. While the Government's immediate support package will delay the short-term symptoms caused by this, it will take time to establish long term solutions to our energy supply problems. In the meantime, businesses and householders will seek assurances from Government that, despite recent pledges to grant new North Sea oil and gas licenses and lift the moratorium on fracking, Whitehall's commitment to Net Zero and the decarbonisation of heat remains unwavering.

Most householders change their heating system infrequently, usually when their existing system is beyond repair. It is therefore incumbent upon Government to ensure that with the heterogeneity of the UK's housing stock, all the potential low carbon heating technologies are fairly represented and available in the choice decision process for developers, landlords and homeowners.



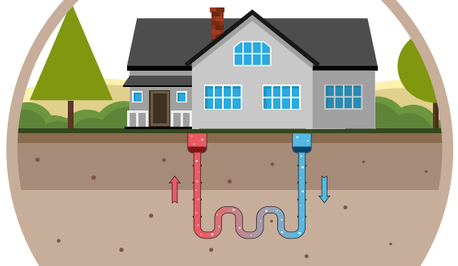
Heating technologies that the Gov. states *may* be more viable alternatives to the 'pivotal' technologies

Other electric resistance heaters

- Panel convectors
- Electric radiators
- Electric underfloor heating

(All viable and proven but not referenced as appropriate technologies).

Storage heaters



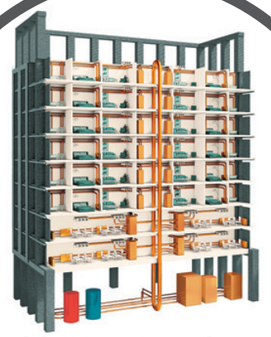
Geothermal Heat

Bioenergy

- 3.5 million storage heaters in the UK in use today
- The storage capacity of the average storage heater is 3 times greater than a Tesla Powerwall
- The total energy capacity of all 3.5 million storage heaters is 56GWh, with a connected load of 7.7GW. This is 6 times greater than the 9.1 GWh energy storage capacity of Dinorwig, the UK's largest hydro-electric power station.

LOW CARBON HEAT

Heat Pumps
- Air source
- Ground source
- Hybrid



Heat networks

Hydrogen
(unproven viability)

Heating technologies that the Gov. states *will* play a pivotal role in the decarbonisation of heat

Descriptions of pivotal heat sources

Air source heat pumps
Extract heat from the outside air to heat your home and hot water.

Ground source heat pumps
Extract heat from pipes that are buried in the ground to heat your home and hot water.

Hybrid heat pumps
Combine heat pump and standard gas boiler technology to heat your home and hot water. Use of smart controls help optimise the system based on cost or efficiency.

Hydrogen boilers
Work in a similar way to standard gas boilers to heat your home and hot water but use hydrogen gas rather than natural gas as fuel.

This technology is not commercially available in the UK and is dependent on the extent to which hydrogen could replace natural gas in the gas grid.

Hydrogen-ready boilers
Optimally designed to run using 100% hydrogen gas but are initially configured for use with natural gas to heat your home and hot water.

Minimal component conversion is required to convert appliances to use with hydrogen. This technology is not yet commercially available.

Heat networks
Provide heat or cooling from a central source and distribute it to multiple customers in a building or across several buildings.

PATH DEPENDENCY

History is littered with examples of path dependency, which is the tendency of past practice or preference to shape current and future decisions ,even if better alternatives are now available. Even when past circumstances are no longer relevant, the decisions people and businesses face at any given time are frequently limited by what has been decided in the past.

In practical terms this occurs when a particular technology gains an initial lead in adoption in the market relative to the competition. In time, its performance advantages lead to further uptake and from this a whole supporting infrastructure evolves. Eventually, this increasing return effectively ensures that competing technologies become uncompetitive and incompatible with consumer needs or expectations, industry standards, technological networks, or the skills and expertise required to exploit the rival technologies. Ultimately this technology becomes "locked in".

Many commentators have argued that for a number of European countries the path dependant "locked in" states of incumbent high carbon technologies have had a negative influence on the success of low carbon alternatives and associated policy. The UK has been cited as perhaps the best example of this, with natural gas dominating as the principal heating fuel for nearly 50 years, and its energy infrastructure, distribution, installer network and regulatory framework oriented towards servicing it.

By contrast, over the same time, electric heating in its various guises has always struggled to gain traction in the UK. As a result, in comparison with other European countries, we now appear to be the laggards in the adoption of low carbon electric heating.

WHAT CAN WE LEARN FROM OTHER COUNTRIES?

Many would argue that a country's primary heating energy choice is entirely due to resource availability.

However, Norway, which has large natural gas reserves on its doorstep, does not use gas for domestic heating. Instead, electric heating has been their dominant primary heating fuel for some considerable time. Other Nordic countries, which have not dissimilar climatic conditions to our own, have also been much quicker and more successful than the UK in adopting low carbon heating.

Key to the success of the Nordic and many other European countries in low carbon heating adoption has been the range of government interventions, such as grants and other financial incentives, coupled with stringent building regulations. There have also been consistent and sustained information campaigns for consumers and installers to support the roll-out and market development of these technologies. The common denominator in all those countries, however, has been the unrelenting determination and single-mindedness of their governments to develop and introduce the policies and measures that will guarantee success and support them with regulations and incentives for decades if necessary.

UK POLICY SUPPORT

In the UK over the last decade, the Government has introduced a range of policies to promote renewable heating. The most significant of these was the Renewable Heat Incentive (RHI) scheme, followed by the Green Homes Grant (GHG), and now the Boiler Upgrade Scheme (BUS).

However, in each case the schemes have been marred variously by the uncertainty regarding the future of the program, or faced challenges due to being launched too quickly, at the wrong time of the year, being too bureaucratic, with unworkable deadlines, and – in the case of the GHG – closing early, having achieved only 10% of the targeted uptake.

The BUS started late, and has only very limited funding for a maximum of three years, or a total of 90,000 heat pumps. This will not significantly impact the required sales trajectory needed to meet the decarbonisation target.

If the UK Government is truly committed to the decarbonisation of heat, it must look beyond the short-term, and be seen to introduce long-term, sustainable and workable policy measures. Most importantly, these interventions must be clearly seen by the public and the trade as long-term commitments to the objective of mass rollout of low carbon heating.

MANUFACTURERS NEED CONFIDENCE TO INVEST

Manufacturers also experience a form of path dependency. The stop-start nature of previous UK policy support mechanisms has made them wary of investing in the considerable resources needed to commit to building new premises, or expanding existing facilities, to support entering, or escalating their presence in a market.

This will also impact other investments such as the recruiting, training, and equipping of manufacturing, sales, service and installer personnel, unless there is evidence of a viable market and long-term government commitment to sustain it. If such a commitment is forthcoming, benefits accrue in terms of ensuring a continued manufacturing presence in servicing the local market needs whilst simultaneously safeguarding employment in the UK.

In many cases, however, these manufacturers are international or global businesses with the option to expand their operations overseas as an alternative to the UK. This will increasingly

be the case if these alternative countries have more favourable market conditions, more lucrative potential returns, fewer bureaucratic hurdles to clear, and a track record of sustained government support.

For businesses, these are long-term decisions often involving significant structural financial implications. They are not taken lightly, so they tend to be "locked in" to that development path once committed, because of the "sunk costs".

THE ROLE OF ELECTRIC RESISTANCE HEATING

This ability to get "locked in" to a financial decision on whether and where to invest in manufacturing facilities clearly applies to the electric heating market, in the form of heat pumps. However, it also applies to the most significant "other" low carbon heating system that has been referenced but largely ignored in the Government's thinking: electric resistance heating.

Electric resistance heating has been around for more than a century. It has been sold on a daily basis in electrical wholesalers throughout the UK for almost as long, and is the second most common means of home heating after natural gas. Yet it has been consistently overlooked in the long-term planning process by government.

Although this type of heating, most commonly represented by storage heaters, panel convectors, electric radiators, and electric underfloor, is less efficient than heat pump technology, the carbon emissions on a CO^2/kWh basis of electric resistance heating systems will still be lower than natural gas.

With an increasing amount of renewable generation coming onstream on a weekly basis, the carbon intensity of electricity will continue to drop for some time to come.

Despite electric resistance heating being referenced as an appropriate solution for the decarbonisation of heat by the Climate Change Committee, Element Energy and others., there has been a tacit reluctance in the corridors of Whitehall to promote this technology as an alternative to heat pumps. This is due to the perceived operating costs of these systems and the potential strain on the electricity grid at peak times if system take-up is high.

These concerns may be misplaced, however. One of the most frequent applications for electric resistance heating in the UK is in small flats and apartments with nearly 25% of all flats in England and 35% in Scotland using the technology. Of the two million households using this type of heating in the UK, the most common size of home is between 50-75m^2 in floor area. When considered with the extremely high insulation levels of most modern homes, the resulting low space heating demand, and therefore low operating costs, alongside the low capital costs of these systems, they make a lot of sense. Consequently, the space requirements needed, and capital, installation and maintenance costs of a heat pump system, as an option for such a property, when offset against relatively low space heating energy demand, make it a more difficult proposition to justify.

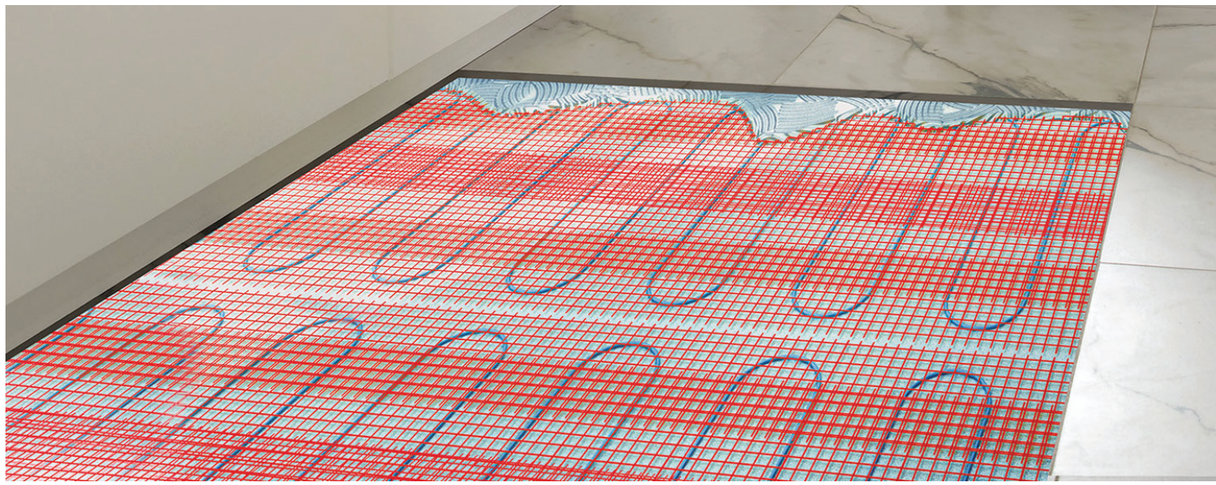
Further evidence to support the cost effectiveness and suitability of this type of heating comes from an independent study[1], and BEIS own CODE report[2]

This is something that the Scottish Government has recognised in its New Build Heat Standard Consultation. They are proposing that electric storage and direct acting heaters are listed as some of the zero direct emissions heating technologies necessary to achieve compliance from 2024.

Similarly, the German Government in their draft of the new "65% renewable energy rule" for new buildings from 2024, have accepted electric storage and direct – acting heating as officially recognised NZEB (Nearly Zero Energy Buildings) technologies on the basis that they are used in well-insulated buildings with low heat demand. They rationalise this on the assumption that "the electricity will be fully decarbonised over the useful lifetime of the heater".

It is not only the decarbonisation of the electricity grid which has created a rationale for supporting electric resistive heating. As we find new ways of meeting increasingly challenging environmental targets, building performance is increasingly being considered holistically, rather than just considering heating technologies in isolation. This is helping to find new ways in which to decarbonise hard to treat homes which may not be easily transitioned to a standalone heat pump. By using resistive electric heating, more homes can benefit from heat pump technology using a hybrid electric system. This could, for example, pair an electric radiator with a hot water only heat pump in a building taking a fabric first approach to the decarbonisation of heat. This approach to technologies as part of a system, rather than as individual technologies offer the benefits of electric resistive heating to UK homes whilst addressing fears of high running costs. Put simply, it considers the environment in which the technology is placed to judge its suitability.

However, there is another hitherto overlooked facet to some electric resistance heating systems.



[1] https://www.beama.org.uk/resourceLibrary/acp-analysis--energy-consumption-and-running-costs-of-electric-space-heating-systems.html

[2] https://www.gov.uk/government/publications/cost-optimal-domestic-electrification-code

STORAGE HEATERS – A DUAL ROLE

1.4 MILLION HOMES

in the UK are dependent on thermal storage heaters as their primary heating system.

Typically, these have an average of

2.5 HEATERS PER HOME

amounting to

3.5 MILLION STORAGE HEATERS

in active use.

The average storage capacity of the heaters in these homes is almost

THREE TIMES GREATER

than a Tesla Powerwall battery.

The total energy storage capacity available from all these storage heaters is

56GWh

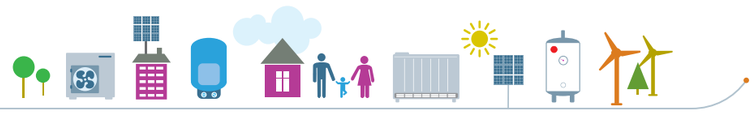
with a connected load of

7.7GW.

This is **six times** greater than the

9.1GWh

energy storage capacity of Dinorwig; the pumped storage hydroelectric power station and the largest energy storage asset on the UK network.



These heaters provide flexibility to the grid by absorbing energy during periods of low demand and delivering heat when required by users. Most homes with storage heaters will also have electrically heated stored hot water using an off-peak tariff. On aggregate these water cylinders will have an energy storage capacity of 10GWh.

The combination of these storage assets would help offset some of the rapidly increasing cost of curtailing UK wind generation (which reached £507million in 2021) when renewable generation outstrips demand.

If, however, the fundamental advantage of the off-peak tariff was eroded due to a substantial reduction in the scale of its cost savings – a worrying trend that we see beginning to emerge - then experience shows that most homeowners will switch from storage heaters to some form of direct acting electric heating, like panel convectors or electric radiators. This would mean that the peak electrical load for these homes would shift to early morning and evening, transferring some or all of the 7.7GW peak connected load to points in the day when it is far less convenient, and therefore more expensive and carbon intensive, to supply.

In this scenario, if all 1.4 million homes with storage heaters shifted to direct acting electric heating,the aggregate load on the electricity grid would be more than 4GW during peak winter demand periods.

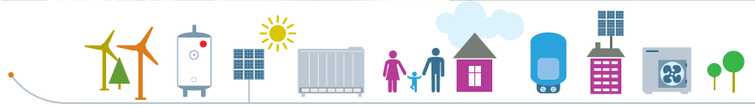
This is more than the 3.2GW additional capacity that will be available from the two new nuclear power stations being built at Hinkley Point at a cost of £25 billion.

Thankfully, the Government and Ofgem have now recognised that electric storage heaters can offer a range of services to help balance the generation system. This includes the potential to alleviate generation constraints, as well as addressing many of the challenges presented by a low carbon system. They have indicated that removing barriers and reforming markets to ensure they are valuing the flexibility that energy storage (including thermal) provides is a focus of the government. Critically, because of the locations of these systems, they create low carbon revenue streams in fuel poor households in a way that electric vehicles and heat pumps cannot yet consistently access.

The Government is also currently consulting on proposals for a smart mandate which will require electric heating appliances with flexibility potential, including heat pumps and storage heaters, to have smart functionality in the future.

It is however, already feasible to take advantage of the existing 3.5 million storage heaters by upgrading them to become connected smart thermal batteries, fitted with the latest demand-side management technology, thereby enabling their charging to be managed by power system aggregators. This would allow them to provide flexibility to transmission and network system operators and empower the householders to benefit from new energy supply tariffs which reward flexibility. Indeed , around ten percent of these heaters already have this technology.

Clearly, however, there does need to be an incentive to encourage householders to participate in this process. Therefore, as a matter of urgency, government must eliminate green energy surcharges and de-couple electricity prices from gas to reflect the lower cost of renewable and nuclear generation, which now dominates the generation mix. This will support the technologies that facilitate this low carbon generation, and therefore the people using that technology.



LEAVING NO ONE BEHIND

The UK Government has shown clear intentions that it wants to be a world leader on the Net Zero stage and has made a commitment that "no one will be left behind" as we make this journey. However, the reality is that path dependency and a lack of strong political leadership has caused the UK to fall behind other countries on the low carbon transition.

But this needn't remain the case. With decisive policy which supports all technologies that can help on the Net Zero transition, including those which help reduce wind power curtailment and address hard -to- treat homes, the UK can decarbonise heat and ensure that no one is left behind in homes which are thermally uncomfortable or cost prohibitive to run.

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