HEAT

Taking a hybrid approach to decarbonise domestic heating

Decarbonising heat is going to be challenging. *Colin Calder* from PassivSystems argues for an approach that utilises both electricity and gas on a domestic level to provide low carbon warmth.

To meet the UK's 2050 carbon targets 20,000 homes a week (from 2023) will have to be transitioned to low carbon heat, according to National Grid. How, exactly, we electrify the UK's domestic heating is one of the most challenging problems to solve as we continue down the path of decarbonising our energy systems.

Electric heat pumps offer a low carbon technology solution to replace traditional boilers, but the cost of doing so across the UK could exceed £100bn. With two or three boiler replacement cycles before 2050, any transition plan must avoid leaving consumers with 'stranded' assets but also guard against saddling householders with, what would be for many, unaffordable capital costs.

A hybrid heating approach, which would operate an electric heat pump alongside the ubiquitous gas boiler, could enable a source of funding for electrification while providing much-needed flexibility to help balance the grid. Unlocking the value of demand response capacity in domestic homes, enabled by hybrid heating, could provide the means to fund the transition to low carbon heat.

The energy landscape

The electrification of domestic heating, as well as the UK's transport systems, will increase generation demand. The Department for Business, Energy and Industrial Strategy (BEIS) forecasts that we will require 80 GW of new or replacement electricity capacity by 2035.

New demand is increasingly met by renewables in the energy mix, which is making it more challenging to balance overall system supply and demand. Fossil-fuelled power stations are flexible generators – operators can control power output, turning them up and down depending on the needs of the grid. Renewables, however, are largely inflexible – renewable intermittency is dictated by sun, wind and other environmental conditions.

To allow new sources of renewable power, we need to put flexibility back into the grid. Energy storage and demand management (such as demand side response – DSR) are important contributors to flexibility, which is why National Grid currently offers financial incentives to businesses who actively manage their demand.

Hybrid heat and demand response

Hybrid heating systems offer the potential to switch between gas and electric supply, thereby enabling a mechanism for delivering flexible DSR in a domestic setting.

A typical scenario would see the heat pump heat a house using cheap electricity overnight ready for the morning. Come mid-afternoon, smart controls would call on the gas boiler to quickly reheat the property. During early evening, the smart control system can switch between the gas boiler and electric heat pump to avoid

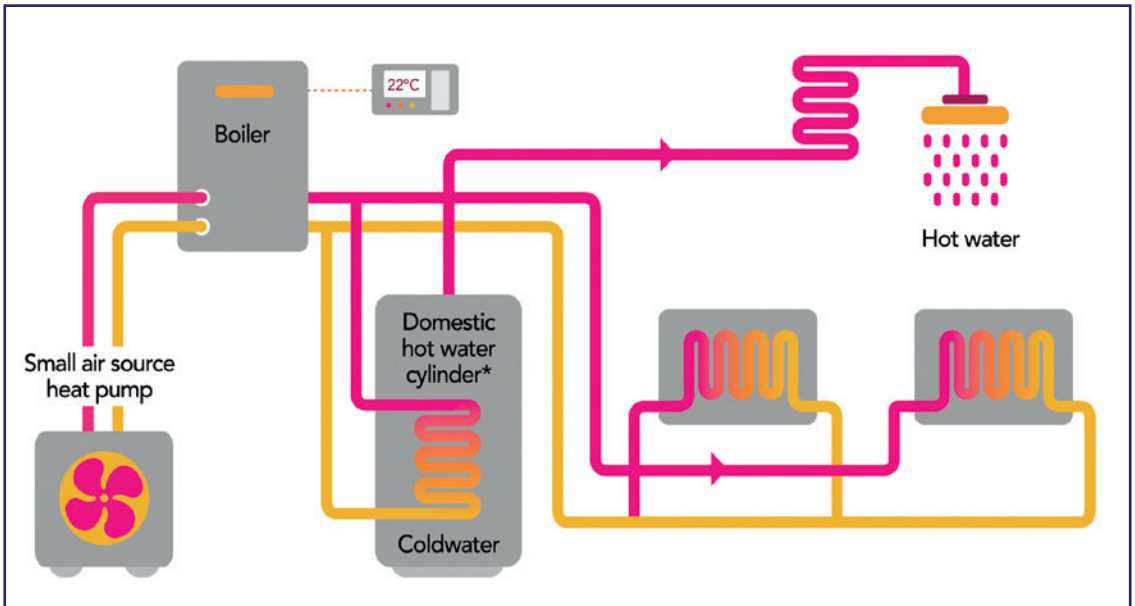

Figure 1. A typical hybrid heating system *Source: PassivSystems*

adding to peak electricity demands on an overloaded grid.

Hybrid heating systems can move as much demand to gas as is needed – they have complete load flexibility. What's also important is that the ready availability of the gas boiler alternative ensures that reducing demand for electricity never compromises the comfort of the occupants.

Over the long term, system modelling shows that the volume of natural gas used in the UK will reduce significantly, helping to meet decarbonisation objectives. However, the hybrid approach will increase the value of gas as consuming small volumes will enable peak electricity avoidance. Using some form of green gas (eg biogas) as it becomes more widely available will further contribute to decarbonisation.

As well as helping to balance the grid, DSR in a domestic setting enables District Network Operators to better manage grid constraints and control their investment in network reinforcement as they seek to manage local grid capacity.

Smart control is key to success

A smart control panel is needed to enable switching between the two heat sources to automatically use the most cost-effective heating mode at any time of the day or night.

One control unit, developed by PassivSystems, incorporates predictive demand control (PDC) technology, which learns the thermal characteristics of the property to create a model of the house and heating system.

PDC automatically tunes the algorithm to the properties of the house. So, for example, the system would choose continuous heating for a slow responding system such as underfloor heating, or turn off for some of the night if the house appears to lose heat quickly. There are no further modifications or interruptions required in customer properties.

The emerging control strategy for a hybrid heating system is to utilise the boiler to provide bursts of heat to warm the house up quickly, with the heat pump providing temperature maintenance and a 'baseload' during periods where a fully warm house is not required.

Independent testing

Imperial College London is working on data analysis and gas and electricity network impact modelling for the Freedom project (see box). Imperial's work so far suggests that the potential benefits of such a hybrid approach for the energy system as a whole are considerable.

Modelling the 2030 energy system, their analysis shows that for an increased annual spend of £178mn on the gas system, in preference to electric air-source heat pumps, the system is able to achieve gross savings of more than £1.3bn per year.

Imperial's modelling has also highlighted a counterintuitive carbon outcome. Conventional wisdom is that full electrification delivers a lower carbon output when compared to hybridisation; however, this is not always the case. On the coldest days when the electricity system is under greatest load, or when intermittent renewable generation is insufficient to meet demand, the additional air-source heat pump load would need to be met by marginal increases in flexible generation sources. Flexible generation equates to the use of traditional fossil-fuel power stations.

Burning gas in the home at 93% efficiency is more carbon efficient than burning fossil fuel at certain power stations. In addition to incurring more than 9% distribution and transmission network losses during peaks – coal, gas peaking open cycle turbines and gas combined cycle turbines return relatively poor efficiency.

A hybrid approach to heating has the potential to deliver benefits to consumers and the grid alike. It would cause minimum disruption and avoid reinforcement of network infrastructure. The key to unlocking new value in our energy system is to put an economic value on demand response capacity in domestic homes, and implement mechanisms that recognise that value and deploy resources accordingly. ●

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The Freedom project in South Wales

The aims of the Freedom project are to understand the potential of multi-fuel, hybrid home heating systems. The core objective is to achieve cost-effective decarbonisation of the energy system.

The project is investigating the consumer, network and energy system implications of hybrid heating system deployments, where domestic heating systems have the option of operating using a standard gas boiler, an air-source heat pump (ASHP), or both.

As part of the project, hybrid heating solutions have been installed in 75 homes – a mix of social and private housing – in and around Bridgend, South Wales. The Freedom project's hybrid heating system includes an exterior ASHP, a reliable, high-efficiency gas boiler inside the home, and a hybrid control panel.

For the first time, this project brings together the gas and electricity network operators in the field trial region and aims to provide robust, field-tested data that can make a meaningful contribution to long-term network investment planning. The cross-sector scope makes this a unique project, which aims to set the benchmark for holistic, 'whole systems' projects.

Designing heating systems that combine gas boilers with ASHPs, while employing smart switching between the gas and electric load, enables the choice of fuels to match consumer demand for heat. This highly flexible approach delivers multiple benefits.

Hybrid heating systems can help householders save money on heating and hot water bills while supporting the shift towards the decarbonisation of heat. It also enables the heating system to take advantage of time-of-use price differences between the two fuels – so-called 'fuel arbitrage'.

PassivSystems is leading the delivery of the Freedom project, developing control algorithms and designing the architecture of the smart switching system. It has overseen the recruitment of homes and the procurement and installation of hybrid heating systems. The project is funded through the Network Innovation Allowance by Western Power Distribution, the electricity distribution network operator and Wales & West Utilities, the gas distribution network operator.

For more information on the project see **bit.ly/2GfgFZx**

Heat pumps on one of the participating households in Bridgend
Photo: PassivSystems