

HEAT PUMPS

Smart hybrid technology for heat decarbonisation

There are many routes to decarbonisation of heating, but the use of heat pumps – alongside gas boilers and controls designed to minimise costs and emissions – could be influential. PassivSystems' Colin Calder writes.

Domestic heating is not usually a topic to get people excited. But the recent report published by the Committee on Climate Change (CCC): *Hydrogen in the low-carbon economy*, proposed the deployment of 10mn hybrid heat pumps by 2035. This would represent an exciting step-change in the way we heat our homes – a change that would bring significant benefits to consumers, gas and electricity network operators and the environment.

PassivSystems' Freedom Project, a trial of hybrid heating across 75 homes, provided the hard evidence needed by CCC to conclude that heat pumps offer the most effective pathway to decarbonising heat. It measured the consumer, network and energy system implications of hybrid heating system deployments, where domestic heating systems had the option of operating using a standard gas boiler, an air source heat pump (ASHP), or both.

The collaborative project, managed by PassivSystems, proved beyond doubt how multi-fuel, hybrid home heating systems can play a pivotal role in reducing carbon emissions to the 2050 levels, as mandated by the Climate Change Act.

Freedom demonstrated how hybrid heat systems can significantly lower running costs for consumers – both on and off the gas grid – while improving comfort levels. The project further showed how hybrid heating can help to decarbonise domestic heating with no increase in peak load, if operating within the context of a demand 'flexibility' solution that is designed specifically for householders.

Lord Deben, Chairman of the CCC, commenting on the report, recognised the potential of the technology, and said, 'Most exciting of all is the prospect of producing low carbon heat; using smart hybrid



Two air source heat pumps connected to homes in the Bridgend trial

Photo: PassivSystems

heat pumps in combination with natural gas in the short-term, with the potential for hydrogen in the long-term.'

The Freedom Project

The Freedom project's hybrid heating system comprises an exterior ASHP, a reliable, high-efficiency boiler inside the home, and a hybrid control panel. The hybrid heating solution was installed in 75 homes – a mix of social and private housing, including some that are off the gas grid – in and around Bridgend, South Wales.

For the first time, this project brought together the gas and electricity network operators in the field trial region and provided robust, field-tested data to enable long-term network investment planning. The cross-sector scope made this a unique project, which 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.

Decarbonising heat

Recent developments in the CCC's modelling of future energy system scenarios have helped inform its assessment of the most feasible approach to decarbonising heat for buildings.

According to the CCC, the path to near-full decarbonisation by 2050 now entails near-term deployment at scale of hybrid heat pumps in buildings on the gas grid, alongside substantial improvements in energy efficiency, low carbon new-build and other 'low-regrets' heat decarbonisation deployment.

The CCC acknowledges that retrofitting smart hybrid heat pumps: 'would lead to greater reductions in near-term emissions from buildings and provide greater confidence that very low levels of emissions can be reached by 2050. This would keep open the option of switching the remaining gas supply to hydrogen at a later date...'

Reducing costs

Hybrid heating systems can help householders save money on heating and hot water bills while supporting the shift towards the decarbonisation of heat. Avoiding the use of electricity during times of peak demand will help reduce the need for further investment in generation capacity. It also enables the heating system to take advantage of time-of-use price differences between the two fuels – so-called 'fuel arbitrage'.

The heating system is especially cost effective in homes off the gas grid. One family, who live in a rural former hill-farmer's cottage in the Welsh Valleys, saved £736 on their heating bill between October 2017 and April 2018. This significant saving was achieved without the need to improve the thermal efficiency of the cottage or replace any radiators.

For the first time, this project brought together the gas and electricity network operators in the field trial region and provided robust, field-tested data to enable long-term network investment planning

According to the homeowner: 'Before having our new heating system installed, we used LPG gas, which was very expensive. We wanted to find a solution that kept us warm, was cheaper and greener too.'

The systems optimise fuel use for a range of fuel price scenarios. For example, gas boiler use is strongly favoured due to the very low cost of gas compared with electricity. However, homes running on liquefied petroleum gas (LPG) achieved cost savings by switching around 80% of their heating load to the ASHP.

Supporting flexibility

As the UK replaces its traditional, centralised power stations with distributed renewables on the grid, the lack of flexibility inherent in renewable sources of power leads to increasing difficulty in balancing supply and demand.

Demand-side response (DSR) – the ability to turn down, turn off or time-shift electrical loads in response to a request from the National Grid – is an established approach to grid balancing in industrial and commercial contexts. DSR provides a valuable source of flexibility back to the grid.

The Freedom hybrid heating system trials show that smart switching between the gas and

electric load can be effective in delivering flexible DSR in a domestic setting.

PassivEnergy, PassivSystems' smart energy management platform, considers the heat storage of the home (including the thermal mass of the building, multi-vector heat, and hot water storage). It switches to gas or oil when the carbon intensity of the grid is at its highest, or when the heat pump needs additional energy to provide the heat needed, such as on very cold days when the coefficient of performance is low, or the heat pump can't provide enough heat.

A typical scenario would see the heat pump warm the house using cheap electricity overnight ready for the morning. Come mid-afternoon, the smart controls 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 adding to peak electricity demands on an overloaded grid.

The system uses smart controls to manage network load using two strategies. The heating controls use predictive optimisation of running costs so that the heat pump can pre-heat the building ahead of an occupancy period. This spreads the heating load, timing the demand ahead of current system peaks, and

enabling the ASHP to operate at a low flow temperature for efficiency. In addition, the aggregated load of all homes was forecast by the half hour for the coming 24-hour period.

The demand forecast uses weather data, learned building thermal properties and schedules for each home to predict the expected demand shape. Demand can be constrained individually for each home or at a portfolio level.

Key results

According to Freedom project partner Imperial College, using gas in conjunction with an air source heat pump and conventional boiler could achieve savings up to £15bn per year – compared to full electrification – in a 25 g/kWh energy system.

With smart hybrid heating technology, the UK has an opportunity to transform the domestic heating market to deliver carbon reduction obligations whilst creating jobs and export opportunities in markets targeted by the UK's industrial strategy. ●

Colin Calder is the CEO at PassivSystems, passivsystems.com

Download the Committee on Climate Change report: *Hydrogen in a low-carbon economy* report at: theccc.org.uk

Download the Freedom project report at: www.utilities.co.uk/media/2829



Membership

Are you a leader in the energy industry?

If you are working in a senior level energy-related role, you could be eligible to upgrade your membership to Fellow of the Energy Institute (FEI) status.

Fellowship of the EI is awarded to energy's leaders and influencers, providing the highest level of recognition for outstanding members of the EI community.

Anyone can apply to become a Fellow. To be successful, you'll need to show that you have played a significant role in providing innovation, problem-solving and thought-leadership in the sector.

Visit our website to find out more

energy-inst.org/membership

