

Next Steps

The Freedom Project partners are now considering new projects that may seek to affirm and extend the work done to date. Projects include the application of **hybrid heating in non-domestic buildings**, exploring new **heat-as-a-service business models**, integrating other flexible home appliances to further develop 'Smart Living' within the **hybrid energy management system** and identifying opportunities for technology innovations to support supply chain cost optimisation.



Market, Regulatory & Policy Recommendations

The outcomes achieved by the Freedom Project demonstrate that hybrid heating is a viable, cost effective, consumer friendly, energy system supporting solution to decarbonise UK domestic heating. A lot of the benefits can be achieved quite simply, but according to analysis done by Imperial College the full power could be unleashed through a number of policy changes to enable and amplify a wide scale market for smart hybrid heating, including:

- The value of flexibility should be recognised across short, medium and long timescales to recognise frequency, intermittency and capacity benefits.
- Demand side access to the markets should be available to distributed forms of flexibility with respect to size of the demand and the length of service contracts.
- More dynamic market price signals and locational pricing and emissions could incentivise availability of flexibility when and where it is most needed by the energy system.
- Incentives should be tailored towards smart, optimised low carbon solutions that unlock benefits with the broader, integrated, whole energy system.
- Decarbonisation policy costs are added to electricity bills – removing these would improve the electricity:gas price ratio to support cost-optimised use of ASHPs in smart hybrids.

Delivering Clean Growth

Freedom has provided a viable option to transform the domestic heating market in the UK to deliver carbon reduction obligations, whilst creating export opportunities in markets targeted by the UK's Industrial Strategy to support the economy and retain competitive advantage.



Freedom Project

Briefing Brochure

Freedom Project

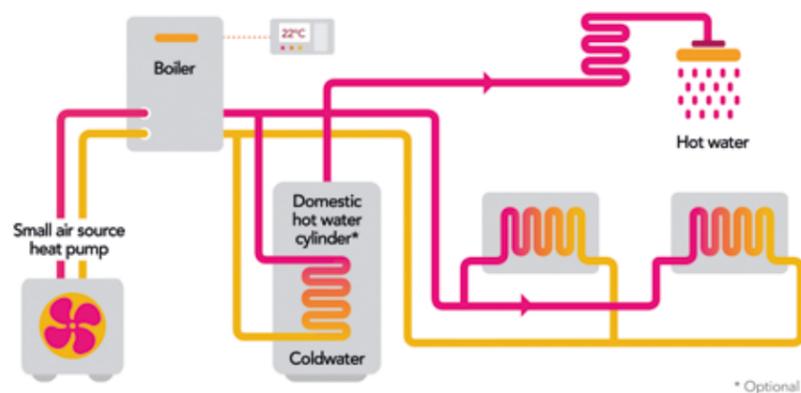
Smart hybrid heating technology could present a decarbonisation breakthrough for the future of home heating – avoiding over investment in power generation and energy infrastructure capacity and diverting that investment to flexible domestic assets for consumers.

- Analysis shows the solution could be the lowest cost pathway to fully decarbonise residential heat.
- Cost modelling shows up to £15.2b/year saving against full electrification.
- Deployed and tested in real homes with real people in South Wales.
- Affordable and low disruption solution for consumers.
- Works in domestic properties, whether currently serviced by the gas grid, LPG or oil.
- Optimises the use of renewable power and green gas in existing utility infrastructure.
- Flexibility controls support a secure low carbon energy system.
- Export-ready smart heating technology to help retain UK competitive advantage.

The Freedom Project has identified a potential breakthrough solution for home heating that uses unique optimising controls to provide the opportunity for flexible switching between renewable power and green gas that could fully decarbonise heat by 2050. Cutting-edge energy system modelling of smart hybrid heating systems, combining an air source heat pump (ASHP) and high-efficiency boiler, has demonstrated the significant benefits that an integrated whole energy system could deliver.

Whole System Heating

Freedom is an industry first cross-sector collaboration between electricity and gas distribution networks Western Power Distribution and Wales & West Utilities, who engaged PassivSystems to deliver the project, supported by partners Imperial College, Delta-ee and City University. Based in Bridgend, South Wales, the project has investigated the potential role of multi-vector solutions to deliver low cost domestic heat decarbonisation and investigate the consumer, network and energy system implications of hybrid heating systems.



Key Learnings from the Project Team:

Whole energy systems modelling has demonstrated that **smart hybrid systems can deliver a no-regrets transition to low carbon heat, which offers a significant financial saving compared to a full electrification scenario.** Indeed, the carbon outcome improves with hybridisation, as during cold weather and periods of low renewable power generation natural gas is burned at higher efficiency in domestic boilers than if it were burned in peaking gas generation plants with the associated network losses during transmission to the home.

As the gas demand on the system is reduced by hybridisation, so the opportunity for green gas is presented to further reduce carbon emissions. **Green gas technology, such as biomethane, BioSNG and hydrogen blends combined with smart hybrid systems provides a long-term solution for low carbon heat.**

Off gas grid homes within the trial using LPG provided insight into a future energy system with a fuel price ratio representative of future renewable gas prices. One of these homes was an exposed stone-built miner's hillside cottage where **the heat pump carried 78% of heat demand** over the winter, significantly reducing gas consumption and saving the customer £736 on their winter heating bill without any requirement to improve the thermal efficiency of the building or replace any radiators. The customer said...

"We would be reluctant to use our heating before the hybrid heating system was installed, I was conscious of cost but now we are seeing huge savings and we did not need to top up LPG this winter. I feel more in control of my heating system and the home is always warm when we require heat."

The project successfully demonstrated that hybrid heating systems were able to maintain consumer comfort across a broad range of housing types, ages and sizes representative of existing housing stock, with consumers from a range of socio-economic groups (private and social housing). The smart control switched between appliances driven by cost – supporting the **decarbonisation of heat in an affordable way and with limited behaviour change.**

Systems met warmth and comfort demands in all homes over the winter without making any changes to the existing wet heating system or installing any thermal improvements to the property. This is in sharp contrast to a pure heat pump solution, which requires a thermally efficient building and larger radiators to deliver required set points using lower flow temperatures than a boiler.

The heating controls used predictive optimisation of running costs to enable the heat pump to pre-heat the building ahead of an occupancy period, thereby spreading the heating load and operating the ASHP at a low flow temperature to optimise efficiency. **The aggregated load of all homes was predicted** by half hour for the 24 hour period ahead **using weather forecast data, learned building thermal properties and comfort schedules** for each home. Constraint instructions were then added, for example to minimise carbon emissions or to limit power demand in each home or at portfolio level, resulting in a responsive change to the heating strategy from any signals received.

When there is insufficient renewable electricity generation, when it is very cold and/or when there are capacity constraints in the national or local electricity network, **the heat load can shift across to the gas network, and vice-versa, to provide uncompromised heat, flexibly using the vast energy storage within the gas system** (210TWh seasonally).

Freedom Project hybrid systems provide a potential solution to deliver mass market decarbonisation of domestic heating whilst providing comfort and value to consumers, avoiding demand peaks on the electricity system that would require large additional investments in electricity transmission and distribution networks and a substantial reserve of generation capacity.

The energy system benefits demonstrated in the field trial were modelled at a whole system level by Imperial College. In a low-flexible system, the Freedom **smart controlled hybrid heating controls, combined with flexibility and balancing services, indicated savings of up to £15.2 b/year compared to heat pumps alone**, with the greatest savings delivered in a system with stricter carbon intensity targets for electricity supply.

Project partner PassivSystems have identified an emerging proposition for heat as a service which can be deployed now, which benefits from third party assignment of rights to the Renewable Heat Incentive (RHI) and avoids the initial household conversion costs falling upon the consumer. PassivSystems believe that the combined value of fuel arbitrage and flexible energy system services could replace the RHI, however **a bridging incentive would still need to be in place post March 2021** until market changes have been effected and economies of scale have been achieved.

Freedom installations with new boilers, ASHPs and controls equipment are estimated to typically cost ~£7.5-9.5k per home with a ~50:50 split between hardware and installation costs. Initial dense roll-out could achieve a significant saving on this with reduced risk and early benefits from economies of scale, reducing to ~£4k with large-scale proliferation and an established market. Cost improvements could clearly be made where the existing boiler is able to be retained. **The up-front cost to consumers could be overcome with provision of heat as a service.**