Project case study: Nusku Fully UK Designed and Manufactured Heat Pump for Distressed Purchases Accelerator

Project theme:

Innovation in heat pump technology

Project lead:

Nusku Ltd

Partners:

University of Salford

Contact:

Russell Murchie (russell.murchie@nusku.co.uk)

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What were the objectives of the project?

Nusku aimed to develop an innovative air source heat pump solution designed specifically to easily and cost-effectively be used to replace gas boilers without the need for major internal home rework. The project planned to develop its existing engineering prototype at Technology Readiness Level 5 (TRL 5) into a full, packaged prototype solution (TRL 7/8) with full controls, app functionality, and a subsequent testing and trialling phase. Specifically, Nusku aimed to:

- Facilitate heat pump installations in distress purchase situations and/or where internal space is limited **by developing a packaged heat pump and hot water cylinder unit** that can be sited outside the home, does not require major internal works, can be installed within 1-2 days and operates at high temperature, mitigating the need for radiator upgrades
- Achieve operating cost and comfort parity with a traditional gas boiler by **developing a novel controller** that optimises the operation of the Nusku heat pump system.

What activities were funded?:

- Hardware system design and build, including the physical build of a prototype system and the development of supply chain partnerships and planning production capabilities required to scale manufacturing.
- Development and testing of installation procedures and a Nusku heating system controller; prototype systems were installed at the Salford Energy House and in 5 trial homes.
- Development of a thermal model to simulate operational performance of heating systems across a heating season, allowing comparisons between the Nusku heat pump and conventional fossil fuel and heat pump heating systems.
- Business model development, including stakeholder engagement, refining Nusku's unique selling point (USP) and ideal price point, developing tailored propositions based on customer archetype and creating a high-level market entry plan.

The Nusku heat pump

Conventional heat pump installations involve an outdoor fan unit with a hot water cylinder and other plant equipment inside the home. Nusku's heat pump system packages all the required equipment – including the heat pump and a compact hot water cylinder – into a single unit that sits outside the home. The volume of the compact cylinder is sized to deliver 180 litres of 40°C water (as per MCS guidance for a 3-bed home) with a single charge by storing the hot water at a higher temperature and using mixing with cold water to deliver the required volume. Nusku believes that by creating a pre-packaged heat pump system that is easier to install, they can offer a solution that improves the installation journey for both customers and installers.

Figure 1: An illustration of Nusku's heat pump solution sited outside the home

What did the project achieve?:

Nusku has developed a novel heat pump design and controller[1] and tested the packaged unit for its space heating capability at Salford Energy House, as well as via ongoing real-world in-home testing in four homes in addition to lab testing. Nusku's heat pump's hot water production and storage capability has been tested in Nusku's lab and for the in-home trials, including residents' hot water demand behaviours[2].

Outcomes from the Salford Energy Test include:

- Nusku successfully installed its packaged heat pump unit within one working day.
- Modelling of a full heating season indicated that the Nusku heat pump can deliver equivalent levels of comfort to a gas boiler at up to 33% reduced cost, using the OVO Heat Pump Plus tariff, or 8% saving when using a time-of-use tariff and some pre-heating.
- Nusku's closed loop controller reduced power cycling by more than 25% (including defrost cycles) over a heating season compared to weather compensation, enhancing operational efficiency and extending compressor lifetimes.

[1] A heat pump controller is a device used to manage the operation of a heat pump system.

[2] Nusku chose not to test its heat pump's hot water production at Salford Energy House because it is contained within the packaged heat pump unit. Therefore, testing in a simulated domestic setting provides no additional benefit compared to lab testing and testing user behaviour in real home trials.

Project objective 1: Develop a novel heat pump that is a quick to install, all-in-one replacement for a gas boiler

Why is this important?:

Research undertaken by the Energy Saving Trust and Ipsos MORI[3] indicates that 30% of all heating system replacements occur in a 'distress purchase' scenario, i.e. once the system has broken down, with a further 28% replaced when they are 'on their last legs'. With the average domestic heat pump adoption journey lasting several months, households experiencing a distress purchase scenario due to boiler failure will likely opt for a 'like-for-like' boiler replacement as the simplest and quickest solution to their actual or anticipated heating system breakdown. Creating a novel heat pump solution that can be installed in just 1-2 days without needing major internal home rework offers households experiencing boiler failure an opportunity to transition to a heat pump rather than purchasing a new boiler. Equally, eliminating the need for emitter upgrades (e.g., installation of larger radiators) and installing internal plant equipment offers a more streamlined and less disruptive installation process. Also, less than 45% of homes in the UK currently have a hot water cylinder and space to house a cylinder is often limited. By packaging the heat pump and cylinder together in an external unit, Nusku could also provide a solution for these homes that may otherwise not be able to accommodate a heat pump.

What activities were funded?:

- Design, development, manufacture and assembly of the heat pump system.
- Trial installations at the Salford Energy House and four real-world homes.

What were the project findings and did the project achieve this objective?:

Development of a high temperature refrigeration circuit that help mitigate the need for radiator upgrades in homes

Due to supply chain challenges, Nusku experienced a delay in procuring the refrigeration system. This means that the heat pump system tested at Salford Energy House and in real-world in-home testing used a 3rd party refrigeration system. The 3rd party refrigeration system's performance is not expected to be significantly different from that of the refrigeration system used in the final Nusku unit, which will be used for lab testing and beyond the end of Nusku's Heat Pump Ready project.

Development of an 'all in one' packaged heat pump unit can be installed in just 1-2 days and sited externally

Nusku's testing at Salford Energy House demonstrated that their novel 'all in one' packaged heat pump design (that includes a compact hot water cylinder) can be installed in a day by a plumber and an electrician, having installed two different units at the test centre. When a new hard standing is required for the heat pump, this installation time will increase to two days. Rapid installation requiring minimal changes to existing pipework and emitters represents not only a significant time saving, but a significant cost saving for the installation in terms of reduced expenditure on parts and labour.

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[3] Ipsos MORI and the Energy Saving Trust (2013), "Homeowners' Willingness To Take Up More Efficient Heating Systems", p39

Project objective 2: Develop a novel controller that enables the heating system to achieve cost and comfort parity with a traditional gas boiler

Why is this important?

The Nusku heat pump system is designed for rapid installation, requiring no emitter upgrades, and operates up to a higher flow temperature of 65°C at design outdoor temperature. Whilst this streamlines the installation process, higher flow temperatures result in less efficient heating than lower flow temperatures. To achieve cost parity with a gas boiler whilst maintaining equivalent comfort levels, Nusku developed its own controller to increase the operational performance of the heat pump system.

By designing a heat pump controller in-house, Nusku can give the controller full access to sensor data, control all components and manage how users (whether residents or installers) interact with the heating system. This enables Nusku to provide features such as predictive maintenance analytics, automatic heat pump calibration, and apps for installers that could support installers with commissioning and maintenance.

What activities were funded?

- Product testing at Salford Energy House and Nusku's lab, and real-world testing in 4 test homes.
- Heating system controls development and refinement after testing, as well as the development of an MVP user interface.
- Development and calibration of a thermal model to enable assessment of various heating options throughout a modelled heating season.

What were the project findings and did the project achieve this objective?

Note: the following assessments are for **space heating only** and not domestic hot water usage. The heat pump has hot water production and storage capability, which has been tested through real-world in-home trials and lab testing.

The Nusku heat pump achieved cost parity with a gas boiler in average winter conditions but was more expensive in sub-zero temperatures.

Testing at the Salford Energy House was conducted for two primary ambient temperatures in controlled conditions. The testing demonstrated that, in average heating season conditions (4.5°C outdoor air temperature), Nusku's closed-loop control algorithm can achieve cost and comfort parity with a gas boiler based on current single rate tariffs. In colder heating season conditions (-3°C outdoor air temperature), the gas boiler was around 40% cheaper to run than Nusku's heat pump, based on current single rate tariffs. Whilst the gas boiler achieved a lower level of comfort than the Nusku heat pump operating with a 17°C setback[4], a significant compromise in comfort would be required for the Nusku heat pump to achieve cost parity with a boiler when using a single rate tariff at these temperatures.

[4] The lowest internal temperature the heat pump controller allows the household to reach before turning the heat pump system on, regardless of scheduling.

Modelling indicates that across a UK heating season, Nusku's heat pump can deliver equivalent levels of comfort to a gas boiler at up to 33% reduced cost

Nusku developed a heating season model to simulate the system's performance under various meteorological conditions throughout the heating season. The model was calibrated using empirical data from the Salford Energy House tests. With this calibrated model, Nusku simulated the heating of a typical Bristol home during the UK heating season, spanning from October to May. Further details about the model are provided in **Annex A: Heating season modelling further details**. The results indicate that the Nusku heat pump can deliver equivalent levels of comfort to a gas boiler at up to 33% reduced cost (OVO Heat Pump Plus tariff, 15p per kWh electricity for heat pump operation only). Nusku achieved an 8% reduced operating cost compared to a gas boiler through the Octopus Cosy tariff. This was achieved by modelling the Octopus Cosy time-of-use tariff with one hour of pre-heating (22°C set point temperature) before the 7-9am and 4-11pm primary heating periods[5], and with a 17°C setback temperature at other times. Additionally, Nusku's closed-loop control algorithm reduced power cycling by more than 25% over a modelled heating season compared to weather compensation control, which should increase the overall life of the product.

Using a single rate energy tariff in line with the price cap (e.g. British Gas Fixed), the Nusku heat pump costs 5% more to run than a gas boiler (space heating only).

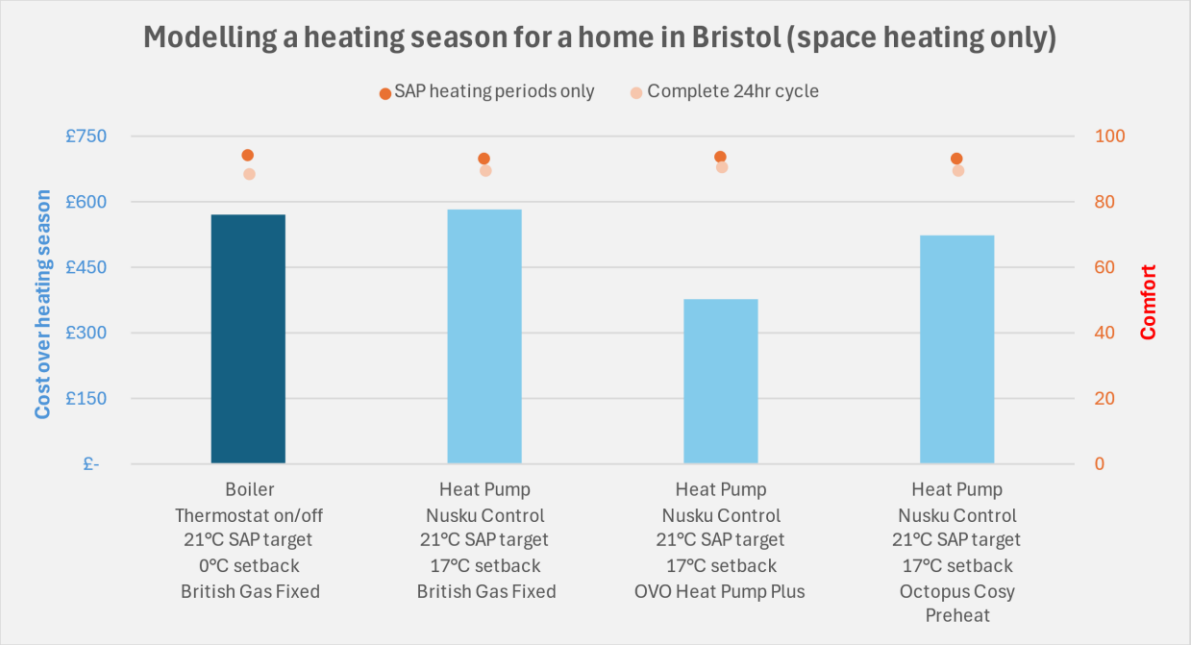

Figure 1: Cost comparison of the Nusku heat pump system (light blue) across a variety of tariffs compared to conventional natural gas heating system (dark blue).

[5] As defined by SAP 10.2 Table 9

Naming convention:

e.g. Heat Pump	Heat source
e.g. Nusku Control	Control type
e.g. 21°C SAP target	Temperature target (7-9am and 4-11pm)
e.g. 17°C setback	Setback temperature (outside of above hours)
e.g. Octopus Cosy	Tariff
e.g. Preheat	If used, 22°C target applied 6-7am and 3-4pm

Potential further research

Opportunities for future research

Further validation of Nusku's heat pump performance

Supply chain challenges meant that the refrigeration system was not available in time for testing at Salford Energy House. Once Nusku's entire heat pump system has been assembled fully, further testing will validate its existing findings. Additionally, Nusku could also validate its heating season modelling and analysis using data from its real-world testing, once a sufficient volume of data has been accumulated.

Investigation of post-COVID heating profiles and associated performance testing

Nusku has taken a user-centric approach to performance testing, focusing on key cost and comfort metrics. The heating schedule used for the testing was the SAP 10.2 Table 9 heating schedule, which defines two heating periods targeting 21°C running from 7-9 am & 4-11 pm, and setback temperatures of 0°C/17°C/21°C outside of these periods. However, with the proliferation of 'working from home' since the COVID-19 pandemic[6], it could be instructive to explore whether these SAP heating schedules accurately reflect the average household's needs. If these heating periods were extended to more accurately reflect the schedules of those working from home, this could more fairly reflect heat pumps' capability to deliver efficient performance in homes with more prolonged heat demand.

Investigating performance, including hot water usage

Nusku's testing to date has focused on space heating requirements, whilst hot water tank estimation has been tested in the lab and for in-home installations. The overall performance of the heat pump and associated running costs should incorporate domestic hot water usage in addition to space heating and so should be investigated. A particular point of interest is the impact of siting the hot water cylinder in the packaged Nusku unit outside the home rather than inside.

Design outdoor temperature selection for regulations

Nusku has demonstrated that its heat pump can achieve cost and comfort parity with a gas boiler at an external air temperature of 4.5°C, but is more expensive at -3°C. This lower temperature, the design outdoor temperature, is specified by MCS regulations as the lowest temperature at which a heat pump must meet 100% of a home's heating load. Further research could explore the trade-off between capital and operational costs when designing a heat pump system to meet 100% of the home heating load at a higher outdoor air temperature (e.g., above -3°C); when the outdoor air temperature drops below the heat pump's capacity, an auxiliary heating system, such as plug-in electric heaters, could provide the additional heat needed. This would improve the heat pump system's performance by being sized for the majority, but not the entirety, of the year. Although this would mean less efficient heating performance for the coldest days of the year and would potentially require a smaller heat pump unit, it would lead to reduced upfront capital costs.

[6] 44% of workers surveyed between 5th February and 2nd March 2025 worked from home 'all of time' or 'some of the time' (ONS, 'Public opinions and social trends, Great Britain: working arrangements', 2025)

Summary:

Nusku has:

- **Developed a novel packaged heat pump design that** does not require major internal works and can be installed within 1-2 days.
- **Developed a novel controller to optimise the performance of the heat pump system.** The heat pump system and controller have been tested under a series of controlled conditions, with subsequent modelling used to simulate longer periods (e.g., over a full heating season). Modelling indicates **that the heating system can achieve cost and comfort parity with a traditional gas boiler**.

What impact could this have on accelerating the heat pump rollout?:

Nusku's heat pump solution could help to support the significant proportion (~58%) of homeowners who currently replace their heating system as a distress purchase (i.e. when their heating system has failed or is close to failure). Rather than defaulting to a boiler replacement, this unit's speed and ease of installation could enable homeowners to transition to a heat pump. Minimising the need for changes to existing pipework and emitters also makes the solution well-suited to situations where internal space is a constraint. It also reduces upfront costs, improving the affordability of purchasing a Nusku heat pump.

What next?

Nusku is in the process of completing in-home testing in four homes as well as its ongoing lab testing, both of which are helping to refine its control strategies and test user interaction with the unit.

Where to find out more

www.nusku.co.uk

Name of key contact:

Russell Murchie

Email of key contact:

russell.murchie@nusku.co.uk

Annex A: Heating season modelling further details

Nusku modelled the heating of a Bristol home throughout the UK heating season (October to May). The test used a **thermal system model** for the physics of the home and a **heating system model** for the meteorological conditions experienced throughout the heating season.

The physics-based **thermal system model** models a house, heating system and heat source. The characteristics of the building and heating system were calibrated to those of the configured Salford Energy House test facility[7] using Nusku's test data. The **heating season model** runs for a UK heating season: 240 days from October to May, following the typical meteorological year for Bristol, including wind speeds and solar gains.

For the **heating schedule**, the SAP 10.2 Table 9 heating schedule was used for the testing. This defines:

- Two heating periods targeting 21°C running from 7-9 am & 4-11 pm.
- All other times are periods with no set temperature.

The following table describes the different **heating systems** tested:

	Boiler	Heat Pump 1	Heat Pump 2
Heat source	24kW combi boiler with a space heating output of 18.8kW, equivalent to Intergas Xclusive 24kW combi boiler (as used at Salford Energy House)	Heat pump similar to that of the Nusku system, using manufacturer-supplied power and efficiency data	Heat pump similar to that of the Nusku system, using manufacturer-supplied power and efficiency data
Controls	Fixed flow temperature with on-off control	Nusku heating controls: weather compensation with a range of set-back temperatures	Nusku heating controls: Nusku's closed-loop control algorithms with a range of set-back temperatures

Three **electricity tariffs** were compared against a standard gas rate of 6.5p/kWh and a gas standing charge (31.6p/day):

- **Octopus Cosy**: 25.88p/kWh with one peak period and three cheaper rate periods
- **British Gas Fixed Rate**: 24.53p/kWh
- **OVO Heat Pump Plus**: 15p/kWh

Note: heat pump usage was not optimised to minimise operating costs other than varying the setpoint temperature and any usage of pre-heating for one hour prior to the defined SAP heating hours.

[7] Testing was conducted at Salford Energy House 1, a 1920s two-bedroom red-brick solid wall end-of-terrace house within an environmental chamber, which is typical of the type of property for which the Nusku heat pump is designed. The house was configured to include double glazing and 100mm of loft insulation to achieve an EPC rating similar to that of an average UK home, with CIBSE calculated heat loss at -3°C of 6.6kW. The installed radiator output was 8.6kW at dT50, providing 6.5kW output with a design dT = 42°C.

Test data was assessed for two key metrics:

- **Cost:** calculated by energy usage and an appropriate energy tariff.
- **Comfort:** using the BS7730 comfort standard using a variant of the percentage of people dissatisfied, with comfort defined here as (1 – *[percentage of people dissatisfied]*). The comfort assessment was made for both the SAP heating period and the comfort potential for the whole 24-hour period.