Project case study: Digitising the customer journey of heat pumps in social housing

Project theme: Smart and flexible

Project lead:

Switchee Ltd

Partners:

Leeds Beckett University, Daikin Airconditioning UK

Contact:

Adam Fudakowski, adam@switchee.co

Funding:

£468,656

Project duration:

2022-24

Date of case study publication:

December 2024

What were the objectives of the project?

This project aimed to further develop Switchee's Econa Smart Thermostat to improve the performance and operation of heat pumps post-installation for social housing residents and landlords. Specifically, this project had the following objectives:

1. **Reduce maintenance costs and disruption** by developing remote diagnostics for heat pumps, without the need for WiFi, in the Econa Smart Thermostat. This aims to reduce the number of maintenance site visits and improve the customer experience for social housing residents and landlords.
2. **Reduce the running costs of heat pumps** by developing specific algorithms that can detect and alert landlords on heat pump performance issues, which can then help support efficient operation.
3. **Support positive energy consumption behaviours** by developing tailored heat pump advice based on household consumption data and delivered through the Econa Smart Thermostat display.

What activities were funded?:

The funding for this project was split between technical upgrades to the Econa Smart Thermostat and education and engagement activities to help residents operate their heat pumps efficiently. These consisted of:

- Modbus communication protocol[1] research and development (R&D) so that heat pump error messages can be read remotely by the Switchee system without needing WiFi.
- Field trials in 40 homes of Modbus communication protocol and alerts with Daikin Altherma heat pumps.
- Developing an alert system for performance issues based on:
    - Thermostat data alone
    - Thermostat data with energy consumption data
    - Thermostat data, energy consumption data and heat pump diagnostic data.
- Developing algorithms to assess heat pump usage patterns over winter 2022/23 and winter 2023/24 and to group residents by their usage patterns.
- Drafting survey industry best practices to identify recommendations to share with residents on how to most efficiently use their heat pump.
- Developing material for new residents of heat pump homes to upskill them on efficiently operating their heat pump, delivered through their Econa Smart Thermostat.
- Monitoring heat pump operation and developing tailored advice to residents based on their usage patterns, to help them operate their heat pumps efficiently.

What did the project achieve?:

The project has successfully developed the technology to provide remote access to heat pump diagnostics and fault codes with Daikin heat pumps, using Modbus communication protocols. This has been found to work reliably during field trials in 40 social housing units. As errors and faults could be identified remotely without needing site visits and potentially before the resident notices a problem, this has reduced disruption to the household and costs to the landlord or installer. Additionally, faults were identified that were previously unknown to the resident or the landlord. This has the potential to enhance resident health and well-being by ensuring successful legionella disinfection cycles and allows for improved efficiency in heat pump operation, reducing running costs for residents.

[1] Modbus is an open communication protocol used for transmitting information between two electronic devices connected with cables and connected to the same ethernet or wirelessly connected. It provides a hardware-agnostic, cost-effective way to enable interoperability between devices, including those from different manufacturers.

Algorithmic analysis of household smart thermostat data alone showed that there were distinctive groups of households with similar behaviours likely to lead to inefficient heat pump operation. These included changing the target temperature on the thermostat often, being on a heating schedule but overriding it frequently and ramping the thermostat up to a high target temperature or down to a very low one. When paired with energy consumption data, these behaviours correlated with higher-than-average consumption for the floor area of the property. The project team successfully developed tailored energy advice for these groups, which was delivered to them via their Econa Smart Thermostat in-home display and the Switchee mobile app. Field trial results showed that 75% of households made positive behavioural changes following this advice, including setting schedules for their heating system and avoiding frequent overrides. These findings have been incorporated into upgrades to the Switchee mobile app to promote efficient heat pump usage by their existing user base of >2300 residents.

Project objective 1: Reduce maintenance costs and disruption through remote diagnostics

Why is this important?:

Currently, over 80% of heat pumps are installed without being connected to the internet and without any smart controls, even in more mature heat pump markets than the UK[2]. This is particularly true in social housing, where broadband and WiFi penetration is lower. This means that:

a) Data on how the heat pumps are performing is missing; and
b) Any errors or faults that may occur can go undiscovered for some time until the system displays clear signs of issues.

Installers or engineers then need to visit properties in person to diagnose and fix heat pump problems. This can negatively impact the post-installation experience for residents, damaging their perceptions of heat pumps and increasing maintenance costs for landlords.

Switchee sought to overcome these challenges by connecting its Econa Smart Thermostat to heat pumps via a non-WiFi-connected method. This would be achieved via a Modbus connection protocol working over Global System for Mobile Communications (GSM). This approach would allow the Econa Smart Thermostat to read heat pump performance metrics and error codes, which could be fed back to the landlord and residents to improve the operation of the heat pumps and hence reduce operation and maintenance costs. Moreover, any site visits that take place (which can be scheduled via the app) could be faster, as the fault is pre-identified, allowing the right equipment to be brought to the site and reducing on-site investigations for the engineer, minimising the need for follow-up visits.

What activities were funded?:

- Research and development to create updated firmware for Switchee's Econa hub, which implements the Modbus protocol and the additional Daikin-specific extensions required to access the necessary data from the heat pump.
- Testing the communication protocol in the lab and then rolling it out over winter 2023/24to 40 trial homes that did not have WiFi.
- Analysis of field trial data and interpretation of results.

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

The lab and field tests confirmed that the development of the Modbus communication protocol was successful and able to consistently provide the necessary data on heat pump performance remotely. The project team was able to successfully access error messages from heat pumps in the field without the need for a WiFi connection, and were also able to access broader diagnostic data from heat pumps (eg. flow and return temperature, flow rates etc.). Most existing remote diagnostic solutions require a WiFi connection to achieve this, so this project has created an alternative solution, which is expected to be particularly relevant for social housing.

[2] Final-report_Connected-HPs-in-NL-FAN-version-1.02.pdf

The field test results showed the value of accessing this data, with 43% of the properties reporting at least one heat pump fault during the first 4 weeks of monitoring. Whilst the majority of these faults were transient and self-resolved with no impact on the customer, the data showed that heat pumps in 33% of properties failed to execute a legionella disinfection cycle at least once, and this seemed to be an ongoing problem in 20% of properties, potentially putting residents' health at risk. However, significant development and maintenance would be required to replicate the approach across a wider range of heat pump manufacturers and models, reducing the business case for fully launching this proposition. Further investigation is required to complete a cost benefit analysis for this proposition.

Project objective 2: Reduce the running costs of heat pumps through performance analysis

Why is this important?:

Building on the benefits of remote diagnostics outlined in Objective 1, remotely monitoring heat pumps can also help ensure optimal performance even when faults are not present. Without remote monitoring or smart controls, inefficient heat pump operation, potentially due to user behaviour, can go unnoticed, resulting in higher running costs. Heat pump performance analysis can lower ongoing running costs for residents, reduce emissions and prolong the heat pump's lifespan (e.g., reduce on/off cycling). Switchee was looking to analyse the live and historical data it receives from its Econa Smart Thermostat to develop heat pump-specific algorithms that can detect and alert heat pump performance issues.

What activities were funded?:

- Testing three approaches for using data analysis to monitor and improve heat pump performance:
    1. Using smart thermostat data alone to identify inefficient usage patterns
    2. Using thermostat data and energy consumption data for each heat pump (using energy clamps to measure the heat pump electricity consumption directly)
    3. Using thermostat data, energy consumption data and the heat pump diagnostic data collected via the Econa hubs
- Using these three datasets to detect inefficient patterns of heat pump usage algorithmically.
- Running lab trials followed by field testing in 40 trial homes over winter 2022/23 and winter 2023/24.

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

Using smart thermostat data alone, Switchee algorithmically detected inefficient heat pump usage patterns resulting from user behaviours. The usage patterns identified were broadly grouped to suggest actions to residents through the smart thermostat in-home display to improve overall efficiency and reinforce 'good behaviour'. The benefit of this work can easily be extended to all homes with a Switchee heat pump controller (currently >2000 homes) without needing to install additional equipment, delivering benefits at scale relatively quickly and at low cost.

Incorporating electricity consumption via energy clamps allows for the energy consumption of the heat pump to be calculated. This enables potential savings to be communicated more accurately to the resident, theoretically leading to greater likelihood of action being taken. However, this was not studied in detail as part of this trial and further investigation is needed to prove this impact. From the data collected from the energy clamps, it was shown that days with many instances of inefficient behaviour events were observed to consume twice as much energy (per degree day) as days with minimal such events. Additionally, the least efficient of the 40 similar homes in the field trial were observed to use twice as much energy than median homes, correlating to a £21/week difference in running cost[3]. These findings would suggest that the ~£100 cost of the energy clamps could be made back quickly via

[3] Assuming an energy tariff of 29p/kWh

energy savings from reducing incidences of inefficient behaviour, making a case to install the equipment in all homes using a Switchee device to control the heat pump.

Including heat pump diagnostic data provided the richest data set, allowing the coefficient of performance (COP) to be calculated and monitored continuously. The field trial observed COP differences of up to 30% in identical heat pumps installed in similar houses, highlighting the importance of accessing this data. Expert interviews with Daikin engineers suggested a COP drop of 1.5 could happen over a year due to maintenance needs. At 29p/kWh, this could lead to savings of £203/yr if the period of poorer performance (lowered COP) was reduced by 2 months. This again highlights the benefit of combining thermostat, energy consumption, and heat pump diagnostic data, which are linked to automatic monitoring and alerts on heat pump systems.

Project objective 3: Support positive energy consumption behaviours by developing tailored heat pump advice for residents

Why is this important?

Heat pumps are a new technology for many people and are more complex to operate than gas boilers. Installing heat pumps without providing education and support to households before and after installation can lead to inefficient operation and higher running costs. In the able-to-pay market, the resident typically follows the conventional 'heat pump customer journey' where they progress from becoming aware of heat pump technology through to obtaining quotes and selecting installers, usually deepening their understanding of the technology throughout the process. However, many social housing residents start their 'heat pump journey' at the installation stage, with landlords conducting the earlier stages on their behalf, meaning they miss opportunities for building their awareness and understanding prior to installation. This can lead to lower awareness of efficient operation post-install.

Switchee aimed to detect inefficient user behaviour through the Econa Smart Thermostat and then advise residents on adjusting their behaviour to optimise their heat pump via the thermostat. This would potentially increase the heat pump's efficiency and save the resident money, whilst reducing energy and carbon emissions from the property. The small-scale trial conducted in this project reinforces this hypothesis. However, further statistically significant trials are required to quantify the exact benefits that could be achieved.

Additionally, social housing homes are more likely to have frequent changes in residents, leading to a need to repeat this process with new tenants. Switchee was looking to address this by generating relevant information for new residents on heat pump advice and educational material that will be available through the thermostat and mobile app and be gradually presented to the residents. This can also reduce the need for written manuals, which may get lost, or site visits from the landlord, which can be costly and disruptive to the resident. Site visits and large manuals can also provide an overwhelming amount of information in a short space of time making it difficult for the resident to usefully retain the information.

What activities were funded?

This objective was delivered by Switchee with significant input from Leeds Beckett University and Daikin. The main activities funded were:

- Using the data collected through objectives 1 and 2 to assess heat pump usage patterns and to group residents by patterns of usage (i.e. overriding timers, fluctuating set points, rapid changes in heat pump demand).
- Running the heat pump usage algorithms in a field trial of 40 homes over winter 2022/23 to form a baseline and then again over winter 2023/24.
- Developing tailored advice for residents based on their usage patterns on how to improve the efficiency of their system.
- Developing material for new residents to heat pump homes to upskill them on efficiently operating their heat pump, delivered through their Econa Smart Thermostat.

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

The algorithms developed were able to detect and count individual instances of specific inefficient patterns of behaviour based on smart thermostat usage, such as regularly changing the target temperature, overriding a timer or programmer, or ramping up the thermostat to a high temperature and then reducing it to very low temperatures. For each pattern of behaviour, tailored advice was delivered to residents via the smart thermostat display screen.

Through the performance analysis conducted in Objective 2, households demonstrating frequent inefficient behaviour patterns could be identified and shortlisted for receiving tailored advice. This list was further refined by removing households identified as being in high levels of fuel poverty, who are consistently underheating homes and not likely to receptive to the tailored advice. This left a small sample of 5 homes where tailored nudges were sent over an X month study period. As a result of this intervention, 4 out of 5 of these households reduced incidences of inefficient behaviour patterns, demonstrating the potential for including tailored advice as a feature of the smart thermostat. However, more research is required to find the styles of communication that best resonate with different types of residents to ensure the behaviours are made permanent. The use of energy clamps to both inform and measure the direct electricity usage change following communication to residents was explored, but due to the timeframes on the programme, there was not enough time to obtain meaningful results. This remains a key area of future investigation as this would enable monitoring accurate changes in energy usage (kWh).

Summary:

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

Many heat pumps are currently installed without any smart controls or monitoring capabilities, particularly in social housing where reliable broadband and WiFi penetration is lower. This not only reduces effective and efficient heat pump monitoring and operation, but also disproportionally affects some of the most vulnerable heat pump users, for whom efficient operation (enabling lower running costs and a healthier home) is especially important. The Switchee project has demonstrated that a GSM Modbus connection protocol is a viable way of enabling remote monitoring and diagnostics in these properties. The project has also shown the value of remote monitoring and error detection in creating safer homes for residents (i.e. detecting issues in legionella disinfection cycles) and enabling more efficient heat pump operation. This will improve user experience, lead to more positive heat pump stories, and support the wider adoption of heat pumps, especially in the social housing sector.

What next?

Switchee has successfully integrated several of the functionalities developed in this project into their customer propositions. This includes improving their mobile app for social housing residents, improving their ability to manage heating and hot water schedules remotely and providing default schedules tailored to efficient heat pump usage. This has led to a twofold increase in app usage. Additionally, the use of smart thermostat data to detect inefficient heat pump usage patterns at scale has been launched on a commercial basis, and learnings could be applied beyond the social housing sector.

Other elements of the project remain in R&D stages, such as wider beta trials to further refine the tailored home-specific advice provided to residents, with a view to commercially launching this proposition. Further research would be beneficial in investigating and quantifying the impacts of different occupancy profiles and differing levels of thermal performance on the project's findings.

Where to find out more

More information related to this project can be found on the Switchee website and the Heat Pump Ready programme website.

Name of key contact:

Adam Fudakowski

Email of key contact:

adam@switchee.co