Project case study: Intelligent Air-Sourcing to Zet Zero

Project theme:

Smart and flexible

Project lead:

Wondrwall

Partners:

Daikin UK

Contact:

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Funding:

£452,292

Project duration:

2022-2025

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What were the objectives of the project?

The Intelligent Air-Sourcing to Net Zero project aimed to:

1. **Minimise the running costs of heat pumps** in operation by automatically optimising their performance and integrating them with solar photovoltaic (PV) panels, battery storage and time of use (ToU) tariffs.

What activities were funded?

- Extending the functionality of Wondrwall's predictive models from direct electric heating to heat pumps. This involved factoring in slower response times for heat pumps and optimising combined space and water heating provision.
- Algorithm training to capture subjective feedback of end users.
- Developing the existing Wondrwall app user interface to include heat pump functionality.

- Physical and virtual integration of Wondrwall's control system to Daikin ASHPs and Daikin's customer app.
- Developing an optimised heat pump control strategy, including time-of-use tariffs and grid flexibility services.
- Developing functionality to randomise load start times during off-peak periods, reducing demand spikes.
- Running a trial in 7 homes to validate performance savings over a year, including 3 new builds and 4 retrofit properties. Although 9 additional new build properties have been added to the trial, due to delayed occupation, most data is from the original properties.
- Analysing predicted performance against actual performance in trial homes.
- 5 Customer interviews with trial participants to assess the usability of the system and customer satisfaction levels.

What did the project achieve?

The project successfully adapted its direct electric heating optimisation algorithm to enable heat pump optimisation. This facilitates the co-optimisation of the heat pump with solar generation, battery charging and a time-of-use tariff. Features such as schedule setting, away mode, automated schedule override based on home occupancy, adaptive start/stop, open window detection and user behaviour prompts were also built into the customer app.

Customer trials showed positive results from the Wondrwall system, with average customer bills across the seven homes of £685 between Feb 2024 and January 2025 inclusive. This shows an average saving of 61% compared to the cost of the actual metered energy demand of the heat pump and other electricity uses of the homes being met through grid-imported electricity alone on a flat p/kWh tariff. This bill reduction does not include the upfront capital cost of the battery and solar PV systems, which were covered by the housing developer in the case of the new-build properties and the consortium in the case of the retrofits. This project has also enabled Wondrwall to develop a new finance model where solar PV and battery can be provided for free, and savings can be 'sold' back to the customer. However, this was outside the scope of the project funded through Heat Pump Ready.

Wondrwall and Daikin are building off the learnings of this project into an ongoing collaborative offering for the new build market on a commercial basis. Additionally, Wondrwall is developing an Energy Service Contract model with the algorithms developed in this project at its heart, utilising its own recently launched Wondrwall heat pump. Under this model, Wondrwall intends to cover the upfront cost of ~£12,000 for the full Wondrwall system to be installed during the construction phase of a new build property (sensors, heat pump, solar, battery and control system) and recover the cost out of the savings generated as a monthly subscription.

Project objective 1: Minimise the running costs of heat pumps in operation by automatically optimising their performance and integrating them with solar photovoltaic (PV) panels, battery storage and time of use (ToU) tariffs.

Why is this important?

Poor heat pump operation can significantly impact customer bills. Optimising heat pump performance minimises the costs of running a heat pump, which is key to increasing their uptake. Using heat pumps flexibly can also significantly reduce the cost of transitioning to a Net Zero energy system. This is possible by matching heat pump electricity consumption to periods of high renewable energy output and reducing consumption at periods of low renewable energy output or lack of capacity on the electricity grid.

What activities were funded?

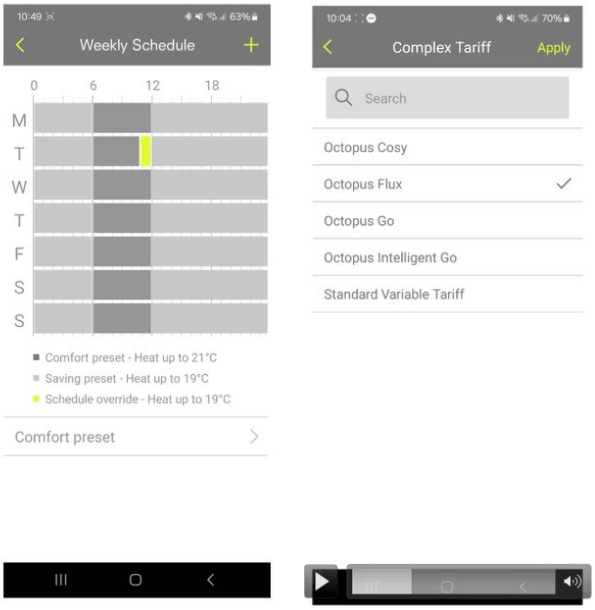

Figure 1: Example of heating schedule selection and tariff selection in the Wondrwall app

- Extending the functionality of Wondrwall's predictive models from direct electric heating to heat pumps. This involves factoring in heat pumps' slower response times and optimising combined space and water heating provision.
- Algorithm training to capture subjective feedback from end users.
- Physical integration with hardware and API connectivity of Wondrwall's control system to Daikin ASHPs and Daikin's customer app.
- Developing an optimised heat pump control strategy, including time-of-use tariffs and the Demand Flexibility Service (DFS).
- Developing functionality to randomise load start times during off-peak periods, reducing spikes in demand.

- Running a trial in 7 homes to validate performance savings over a year, including 3 new-builds and 4 retrofit properties.
- Analysing predicted performance against actual performance in trial homes.

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

The project achieved its objective of developing a home energy management system to co-optimise heat pump operation with solar PV, battery storage, and time-of-use tariffs. This was tested in 7 trial homes, consisting of 3 new-builds and 4 retrofits, between February 2024 and January 2025.

Overall, the trial showed positive results from the Wondrwall system; average customer bills across the seven homes were £685 between Feb 2024 and January 2025 inclusive, as a result of optimising heat pump usage with solar generation and a time of use tariff. This shows an average saving of 61% compared to the cost of the actual metered energy demand of the heat pump and other electricity uses of the homes being met through grid-imported electricity alone on a flat p/kWh tariff. This bill reduction does not include the upfront capital costs of the battery and solar PV systems, which were covered by the housing developer in the case of the new-build properties and the consortium in the case of the retrofits.

The consortium also compared its system's performance to the SAP estimations for the trial homes, which showed an average reduction in energy bills of 80%. The difference in savings calculated from SAP compared to the actual metered energy consumption of the home indicates that further improvements to the SAP methodology would be beneficial.

Findings indicated that substantial customer savings could be achieved in both new builds and retrofit contexts, with results showing 62% and 37% reductions in energy costs, respectively. However, it should be noted that the sample size is too small to be statistically significant, and further large-scale demonstration would be beneficial in order to validate these results.

The large differences between the two categories are a result of two main factors:

- Lower performing building fabric in the retrofit properties, despite all retrofit properties being built in the last 20 years. This led to a reduction in the ability to pre-heat homes in off-peak tariff times, with 51% of grid electricity consumed during peak times, compared to 33% in the new builds.
- Lower solar generation on the retrofit properties due to dormers limiting the size of the available roof space, and therefore the solar PV array, and often poorer roof orientation, resulting in lower revenue generation from the export of solar PV.

Monitoring the homes throughout the 12-month period showed that across the portfolio as a whole:

- Heating was 33% of the total energy consumption of the homes.
- Solar generation covered 39% of the total energy consumption of the homes, with the remaining 61% imported from the grid. The system optimised this grid import to occur at off-peak tariff times, and over the year, 65% of grid import occurred during these windows.
- Homes were net exporters from April through to August, resulting in negative bills in May, June and July, when solar generation was sufficiently high to exceed standing charges.

- During the second winter heating season, some evidence of customer comfort-taking was observed as customers adjusted to the new lower bills. In essence, customers feel empowered by lower bills to increase comfort levels in the home. This consumer behaviour can, therefore, reduce the potential positive impacts obtained through energy savings.

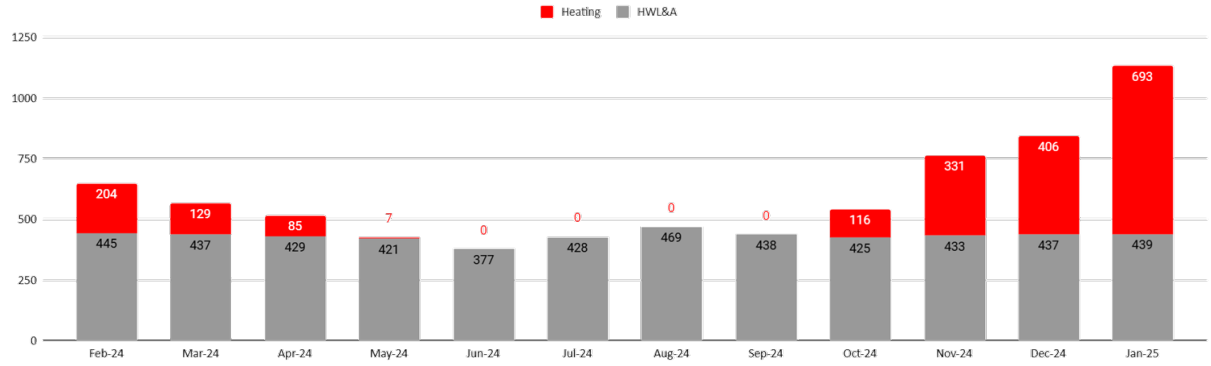

Figure 2: chart demonstrating customer 'comfort-taking', with far lower energy demand in February 2024 vs. winter 2025.

Additionally, simulations of participation in grid services were completed. These showed that the Wondrwall system could successfully charge the home battery and pre-heat hot water before the start of a service window. During the window, excess solar generation and energy from the battery were exported to the grid, maximising savings. Wondrwall estimates a reduction of £9-15 in energy bills could be gained per home per event once sufficient scale is reached to make offering this proposition a viable option for Wondrwall.

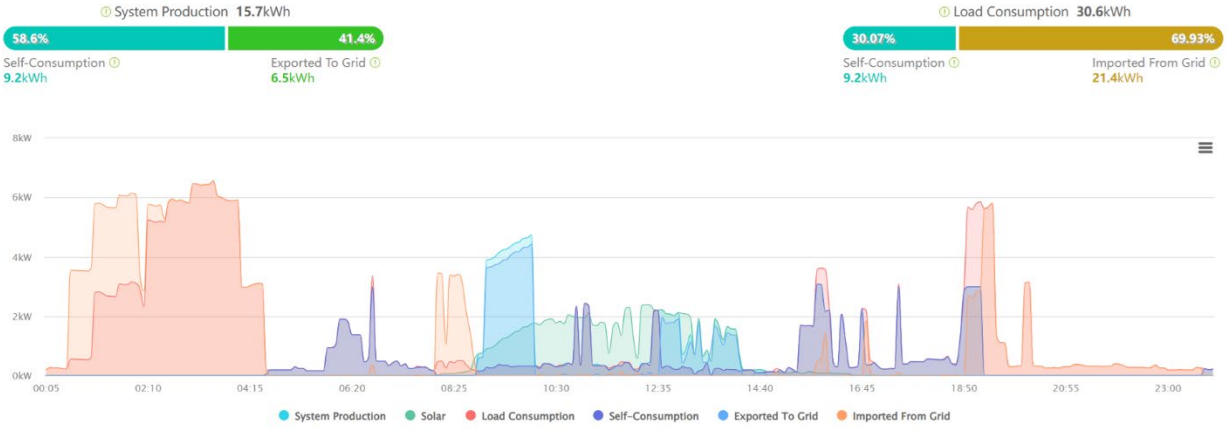

Figure 3: Operating profile for the Wondrwall system in a new build home on the day with a grid service event window

Summary:

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

The Wondrwall home energy management system demonstrates that it is possible to greatly reduce energy bills by optimising heat pump consumption with other energy assets in the home alongside time-of-use tariffs and flexibility services. This is particularly relevant in the new build space where reductions of up to 62% are achievable. It is a clear opportunity for house builders to propose a compelling proposition to potential buyers of a low-cost, low-carbon home. For both the new build and the retrofit sector, this project demonstrates significant enough cost reductions to make the uptake of a heat pump a more attractive option for customers, accelerating its deployment.

Additionally, this project provides evidence to inform future policy and regulatory decisions that could make this type of proposition more viable, including the Future Homes Standard, Mandatory Half Hourly Settlement, and Grid Code modifications, which enable flexibility from domestic customers.

What next?

The innovations developed in the project are being implemented in a commercial context by the project partners as an ongoing collaboration. Additionally, Wondrwall is looking to extend its capabilities to enable integration with other heat pump manufacturers alongside launching its own heat pump, enabling a fully interoperable system. This will be underpinned by the Energy Service Contract model Wondrwall are developing, enabling customers to pay back the upfront cost of the assets from the savings generated by the system.

Where to find out more

Home - Wondrwall

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