Technology Innovation:
Making Efficient Systems around Heat-pumps (MESH)

The findings will be relevant to the heat pump industry, specifically designers, manufacturers, installers. It will also be relevant to utility companies.

Project lead:

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Partners:

Vaillant and Centrica

Contact:

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Funding:

Funding requested from DESNZ: £455,215

Project duration:

2022-2025

Date of publication:

July 2025

What were the objectives of the project?

The project team set out to develop an advanced heat pump system design and control approach to tackle key challenges in the heat pump market. These challenges include high installation costs, system complexity, and low seasonally adjusted Coefficient of Performance (sCOP) in real-world applications. The project integrated Mixergy's intelligent thermal storage technology, Aggregated Thermal Inertia (ATI). The ATI approach combines software innovation with hardware system design to optimise thermal inertia usage across central heating circuits, building fabric, and the hot water tank. This effectively reduces short-cycle efficiency losses in the heat pump and removes the need for ancillary components like buffer vessels. Unlike conventional heat pump setups, which require multiple separate components (e.g., buffer vessels and low-loss headers), the ATI method combines these elements for a more streamlined system.

Specific project objectives were:

1. **Develop a comprehensive heat pump system design and control strategy** to improve system efficiency and reduce operational costs by 20%.

2. **Optimise component integration and sizing** to reduce capital expenses associated with the system's hydraulic components by 30% by minimising part count and streamlining the installation process. The integrated design aims to reduce installation time to a single day, significantly decreasing labour requirements.
3. **Test and validate the technology platform and installation process**, establishing a foundation for large-scale deployment and testing through a housing developer. In addition, **obtain a regulatory endorsement** to support widespread deployment.

What activities were funded?

Several key activities within the MESH project were funded to develop, test and commercialise the Mixergy ATI system. The ATI system architecture was developed, and numerical simulations were carried out to assess key architectural design choices, including component sizing and power rating across various house types. Software development was carried out at the device level for system controls, and at the device and server levels for technology platform integrations. At the server level, this involved mapping household thermal inertia and heat pump Coefficient of Performance (COP) data into the existing Mixergy machine learning control algorithm. Additionally, field trials were conducted across 10 commercial trial sites, including installing the Mixergy ATI cylinder and testing and validating the Mixergy ATI system. Lastly, the project team worked with the project partners to assess the ATI proposition's commercial potential and understand how it could be best positioned before the product launch post-trial.

What did the project achieve?

The ATI cylinder was successfully engineered as a multifunctional component, integrating thermal energy storage and heat distribution functions. Figure 1 below shows the Mixergy ATI system and how it combines the central heating buffer vessel and hot water cylinder in one tank.

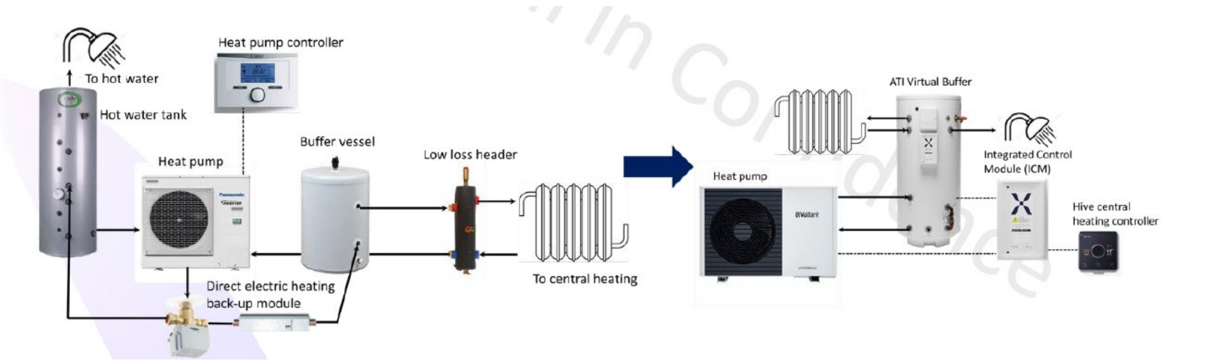

Figure 1: Conventional heating system with separate buffer vessel and hot water cylinder (left) and Mixergy ATI system (right)

The project successfully developed and manufactured prototype ATI cylinders and prepared additional units for trials. Initial testing of the prototypes demonstrated the ATI cylinder’s potential to reduce heat pump short cycling, boost space heating, and support heat pump defrosting in extreme conditions, resulting in improved efficiencies. The project team conducted further performance testing before the trials to optimise the ATI system. The team used numerical simulations to validate the ATI system performance and built a test rig to conduct extensive climate-controlled chamber testing.

The project made significant progress in commercialising the system by signing an agreement with a major UK housing developer to conduct field trials and monitoring at 20 trial sites. The project team launched an online monitoring platform to collect data and compare the performance of the 10 ATI and 10 conventional systems installed and commissioned at the trial sites. Initial results showed a 15-40% improvement in energy efficiency compared to conventional systems. These savings were achieved by combining ATI system energy efficiency measures and scheduling the heat pump operation at the right time (i.e. when the tariff is low) using AI-powered control algorithms. Feedback from installers was also collected, who reported that the ATI system installation process was straightforward and did not require any speciality upskills beyond existing heat pump installation training

The project's other key achievements include substantial progress in securing regulatory endorsement for the ATI system. The project team engaged with Ofgem and BRE, providing evidence for the simulated and real-life system performance, and, at the time of writing, is progressing ECO4 and SAP applications with the respective industry bodies. The project team is also continuing to develop the Mixergy supply chain. Developing the volume production supply chain could reduce the overall cost of materials used in manufacturing the hydraulic components by 30% compared to conventional heat pump systems. This represents a cost reduction of between £200 and £600, depending on the supply chain.

Project objective 1: Develop a comprehensive heat pump system design and control strategy

Why is this important?

Better integration with the heat pump directly translates to energy cost and carbon emission savings by enhancing system efficiency. Mixergy's ATI system integrates the space heating buffer vessel into the existing hot water cylinder and controls the heat pump more comprehensively to ensure its operation remains in optimal condition based on various factors, such as outdoor and indoor temperature, heat loss, and tariff. This improvement can make the heat pump's operating cost more comparable with a gas boiler, thus encouraging the wider adoption of heat pumps.

What activities were funded?

The activities undertaken in developing the heat pump system design and control strategy included designing and developing the ATI system and its architecture. Software and hardware development was also undertaken to support the integration of heat pump controls with the ATI system. The software developments enabled the devices to share data through local serial communication using Modbus RTU (Remote Terminal Unit). Additionally, the project team set up a lab testing facility and developed a numerical simulation platform to test and validate the performance of the ATI system.

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

The project delivered a comprehensive heat pump system design and control strategy, achieving significant energy efficiency improvements, operational cost savings, and enhanced system adaptability. These findings underline the potential for wide-scale deployment to support low-carbon heating solutions.

The simulation result demonstrated an energy cost saving of more than 20% by combining energy efficiency savings and using control algorithms to schedule heat pump operation at the times when tariffs were lowest. Following this, Mixergy is currently conducting a trial with a major UK housing developer, which involves monitoring the heat pump energy consumption of 20 occupied houses, 10 of which are installed with a Mixergy ATI system and 10 with a conventional heat pump system. Early results indicated that the project is on track to achieve a 20% reduction in operational expenses throughout the winter trial.

The key technology advancements that led to these savings are the following:

System Design Advancements:

- The ATI cylinder developed as part of this project can reduce the short cycling of heat pumps and enhance system flexibility.
- Integrated functions were developed to use excess thermal energy, enabling the system to boost heat quickly during ramp-up or defrost cycles.
- The ATI system was designed to work seamlessly under varied usage conditions (hot water and space heating) and tariff structures.

Control Strategy Development:

- Advanced control algorithms, including a virtual buffer function, were developed. These changes to the system controls were used to optimise heat pump efficiency.
- Hardware-in-the-loop (HIL) simulations were used to validate control strategies under real-world conditions.
- Optimising the control algorithms further demonstrated the potential for additional energy savings and operational cost reductions.
- Energy flexibility was demonstrated through tools developed with industry partners e.g., Centrica.

Project objective 2: Optimise component integration and sizing

Why is this important?

Optimising heat pump system component integration and sizing reduces capital costs and streamlines installations. It also reduces the number of components required, leading to lower maintenance needs and reduced maintenance costs. This makes heat pump technology more attractive to end users and installers, encouraging its adoption.

What activities were undertaken?

Key activities included optimising the Aggregated Thermal Inertia (ATI) system through laboratory testing. Trial installations were carried out across 20 sites (10 ATI and 10 conventional), with feedback collected from installers on the installation and commissioning process. The project team also collected feedback from customers during the trials.

What were the project findings, and did the project achieve its objective?

The project demonstrated the effective integration of the overall system's elements (e.g. heat pump, ATI cylinder and control systems) to maximise efficiency and performance across diverse scenarios. Laboratory and climate-controlled chamber tests validated the optimised sizing of system components, ensuring compatibility with real-world operational demands. In addition, numerical simulations and hardware-in-the-loop (HIL) tests supported the refinement of component integration. The assembled ATI test rig is shown in Figure 2.

Figure 2: ATI test rig

Streamlining the system and using advanced control strategies reduced the need for extra thermal storage or oversized heat pumps, which led to cost savings. Initial trials also indicated an average improvement of 32% in energy efficiency, which would result in significantly lower energy bills over the system's operational lifetime.

Installers indicated that the installation process for the Mixergy ATI system was straightforward, with no specialist upskilling required beyond standard heat pump installation training. Mixergy is still developing the volume production supply chain, which could reduce the overall cost of materials by 30% compared to conventional heat pump systems. It is important to note that this price difference applies only to the system's hydraulic components and does not include the premium cost of the Mixergy smart controller.

Project objective 3: Test and validate the technology platform and installation process and obtain regulatory endorsement

Why is this important?

It is important that the ATI technology’s proposition is proven with a commercial partner and through a real-world trial. This provides evidence that the system operates as designed and delivers the expected efficiency, reliability, and functionality under various real-world conditions. Real-world trials can also help to:

- Identify any differences between theoretical models and actual performance, allowing for refinements;
- Provide insights into how components interact, enabling designs to be fine-tuned for improved performance and cost-effectiveness;
- Detect potential issues or failures in the technology or installation process before widespread deployment;
- Allows for adjustments in the installation process to enhance efficiency, reduce time, and lower labour costs.

In addition, obtaining regulatory endorsement (ECO4 and SAP) is important for regulatory compliance, market access, and adopting energy-efficient technologies. ECO4 approval supports eligibility for government-backed subsidies, while SAP endorsement confirms compliance with building regulations and enhances Energy Performance Certificate (EPC) ratings, boosting property value and appeal. These endorsements build credibility and trust among consumers, investors, and industry stakeholders, demonstrating the product's quality and alignment with national Net Zero goals. They also support large-scale deployment and provide a competitive advantage in the low-carbon heating market, driving wider adoption and scalability.

What activities were funded?

The trial involved installing, commissioning, and monitoring the installed Mixergy ATI systems at the trial site and collecting feedback throughout the process. The system's commercial potential was explored by engaging with housing developers and social landlords to identify and secure trial sites. Partnering with organisations that manage large property portfolios would provide an opportunity to deploy Mixergy systems at scale. Additionally, industry regulators such as Ofgem and BRE were engaged to certify the Mixergy system for inclusion within ECO4 and SAP.

What were the project findings, and did the project achieve its objective?

Twenty trial systems (10 ATI and 10 conventional) were installed and monitored in residential settings. Figure 3 shows an example of a trial site installation.

Figure 3: Trial site installation. The heat pump system on the right is housed in building A, building B contains a conventional heat pump system.

Early results from the trials indicated a 32% improvement on average in energy efficiency for ATI systems compared to conventional setups where the buffer vessel was installed. Real-world testing confirmed the practicality of the installation process and the system's ability to integrate with existing heat pump configurations. The ATI system did not significantly impact installation time, as the majority of installation time is associated with installing the heat pump and pipework rather than the hot water tank and buffer vessel in a conventional set-up.

Commissioning trial systems demonstrated the feasibility of deploying ATI cylinders at scale. Mixergy has signed a contract with major UK housing developer Persimmon to explore and validate the ATI technology, with the potential to license the technology further based on trial results. So far, the project is on track to deliver the promised energy savings (> 20%).

An online platform was developed to monitor trial systems, enabling real-time performance tracking and data collection. The data provided insights into system operation, confirming energy efficiency gains and highlighting areas for further optimisation. The social landlord who owns part of the trial sites has also expressed strong interest in this software platform.

The project team actively engaged Ofgem and BRE to advance the ATI system's compliance with ECO4 and SAP requirements. Robust and validated energy efficiency and performance test results were submitted, including comprehensive reports summarising real-life testing and numerical simulation findings. During these initial consultations with BRE, Mixergy demonstrated the ATI controller’s ability to optimise based on the carbon or tariff saving. BRE encouraged submitting the application focusing on carbon saving so that the application was not tied to a specific tariff. These initial consultations and submissions provided strong evidence supporting the system’s compliance, while ongoing engagement with regulatory bodies ensures alignment and further progress.

Summary

What impact will this have?

If the system proves effective, Persimmon will consider gradually rolling it out to all their plots in the coming years. The system could be white-labelled for other housing developers, meaning Mixergy could offer a system to other housing developers which could be rebranded and customised for their housing portfolios. This would remove the need for in-house technology development and allow Mixergy systems to be rolled out across various housing developments. Furthermore, this system will help social landlords reduce tenants' fuel poverty through social retrofitting. By improving homes' energy efficiency and thermal comfort, tenants' fuel prices can be reduced. With the government's plan to build 1.5 million new homes in England over the current Parliament, implementing this technology in new-build homes could make an important contribution to decarbonising the housing sector.

What's next?

- Continued refinement of control algorithms and readiness for winter trials.
- Plans for further commercial exploitation and energy savings analysis using operational data.
- Continue engaging with Ofgem and BRE regarding regulatory endorsements.

Where to find out more

https://www.mixergy.co.uk/

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