Project Case Study: Therma Hub

Project theme: Innovation in Heat Pump Technology

Project lead:

Vital Energi Solutions Limited

Partners:

University of Birmingham

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£563,436.40

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What were the objectives of the project?

The overarching objective of the Therma Hub project was to develop a commercially attractive solution for deploying heat pumps in mid- and high-rise buildings. Specifically, Vital Energi aimed to:

1. **Develop an 'off the shelf' solution for communally heated mid- and high-rise buildings** (the Therma Hub) that can be externally sited, has a small footprint, and can be prefabricated at scale to reduce manufacturing and installation timelines. This addresses a common challenge for mid- and high-rise buildings where space for a heating plant is often constrained, and options for siting heat pump units can be limited.
2. **Deliver an integrated, highly flexible heat pump system that incorporates a Composite Phase Change Material thermal store, which could support a competitive fixed price heat tariff for residents**

What activities were funded?

The project funding supported the following activities:

- Designing and manufacturing the Therma Hub, including procurement, fabrication, and assembly.
- Commissioning, testing, and product verification of the Therma Hub.
- Progressing the technology from a basic prototype in a simulated environment to a final prototype, demonstrating the capital cost of the unit with some initial performance testing in real-world conditions.

Figure 1: An illustration of Vital Energi's 'Therma Hub' heat pump solution sited outside the building

What did the project achieve?

Vital Energi has designed, manufactured and assembled the Therma Hub prototype, which has been tested via real-world connection to Vital Energi's offices in Blackburn. The project was successful in:

- **Developing an off-site manufactured, pre-fabricated heat pump solution for mid- and high-rise buildings at a commercially viable cost**. Performance highlights included achieving a flow temperature higher than the targeted 80°C, matching gas boiler performance. The Therma Hub also achieved the targeted noise performance requirements.
- **Delivering an integrated, highly flexible heat pump system that incorporates a Composite Phase Change Material thermal store.** Both heat pump power output and thermal store energy density was higher than expected. However, real-world testing of performance across a full heating season has not yet been completed and so the project is yet to complete validation of Therma Hub's fixed price heat tariff proposition.

Project objective 1: Develop an 'off the shelf' solution for communally heated buildings (the Therma Hub)

Why is this important?:

The UK Government has previously estimated that there are 2.32 million homes across 90,500 residential mid- and high-rise buildings[1] in England[2], with an estimated 50% of homes in high-rise buildings designated as social housing. Deploying heat pumps in mid- and high-rise buildings can be technically complex due to internal and external space constraints, and commercially challenging due to the proportion of social housing homes within such buildings. By producing an externally-sited heating solution, this avoids any internal space challenges encountered when siting heat pumps and thermal storage, with the Therma Hub designed to minimise footprint and volume to fit in the available outdoor space. Bespoke energy centres are expensive to produce in terms of labour, time and capital. The Therma Hub was designed as an 'off the shelf' solution that can be prefabricated at scale, using standardisation to improve the speed and cost of manufacture, installation and maintenance.

What activities were funded?:

- Detailed design, procurement and fabrication of the Therma Hub
- Testing and inspection of the Therma Hub
- Creation of product literature for certification

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

Yes, Vital Energi successfully developed an off-site manufactured, pre-fabricated heat pump solution for mid- and high-rise buildings and tested it in-situ at the company's office building. The unit's footprint was larger than initially designed, but it still provides a viable solution for buildings with internal space constraints. The capital cost of development fell within the desired range, indicating that it could be manufactured at scale at a commercially viable price point.

Specific technical findings included:

- The Therma Hub achieved an 84°C flow temperature, sufficient to supply most homes without needing to increase the size of existing emitters.
- The final fabricated unit's footprint was approximately 20m² (not including room required for access), but Vital Energi believes that maintenance access does not need to be permanent, reducing the area required.
- The Therma Hub achieved noise performance levels of 40dB(A) at 10m distance, meeting MCS's requirement for domestic air source heat pump system design.

[1] Mid-rise is defined as 4-6 floors; high-rise is defined as 7 or more floors.

[2] Department for Levelling Up, Housing & Communities (2023) 'Building Safety Programme: Monthly Data Release, England: 31 August 2023'

Project objective 2: Deliver an integrated, highly flexible heat pump system that incorporates a Composite Phase Change Material thermal store, which could (with further testing) support a competitive fixed price heat tariff for residents

Why is this important?

The Therma Hub is designed to deliver a high flow temperature of up to 80°C to mitigate the need for emitter upgrades. This results in higher operational costs when compared to heat pumps operating with a lower flow temperature and to gas. Therma Hub was therefore designed to operate flexibly, enabled by its thermal storage capacity, so that it can deliver a fixed-price tariff for heat at a more affordable price (with some margin for the operator) by charging up the high-temperature store at times of lower-priced electricity.

What activities were funded?

- Detailed design and modelling of the high-temperature thermal energy store
- Composite Phase Change Material (CPCM)[3] manufacture and testing
- Assembly and commissioning of the integrated system

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

The project successfully developed a solution that can meet the targeted heat demand (see **Thermal Output**) so that sufficient heat is delivered to the building for space heating and hot water. The project also successfully demonstrated that the Therma Hub has achieved the targeted thermal storage performance to be able to operate flexibly to take advantage of periods of lower-priced electricity (see **Energy & Power density**). Real-world testing of performance across a full heating season has not yet been completed, and so overall in-situ performance levels have not yet been verified. Therefore, the project has yet to validate Therma Hub's ability to support an attractive fixed price heat tariff for residents.

- **Thermal output:** Thermal output must be sufficient to ensure that the peak instantaneous heat demand of the building can be met by the Therma Hub. The heat pump was designed to meet a target thermal output of 100kW(th) at ambient temperatures of -5°C and above. However, during testing at 15°C, the it exceeded expectations by achieving 158kW(th). Although performance at lower ambient temperatures has not yet been demonstrated, the project believes that the results to date suggest no indication of insufficient capacity. The thermal store's peak output was lowered from 200kW(th) to 100kW(th) due to significant airflow requirements at higher peak outputs (airflow is used to extract energy from the thermal store). However, the thermal store is still capable of a charging rate of 200kW(th), allowing the unit to charge quickly during periods of lower-priced electricity. The Therma Hub's total peak thermal output is therefore believed to be 258kW(th) rather than the target of 300kW(th). This limit is the capacity of the Therma Hub's

[3] Phase change materials (PCM) absorb or release large amo0unts of latent heat when they change phase (typically from solid to liquid or vice versa). A composite phase change material (CPCM) combined a PCM with supporting materials that enhance its thermal, mechanical or structural properties.

heat exchanger, which would connect to a building's own hydronic system with its own storage buffer. Vital Energi believe that this lower than targeted heat exchanger capacity could be mitigated by increasing the size of the building's thermal storage to be able to deliver heat at the level required, subject to building specifics. Any shortfall in the Therma Hub's thermal output could then be met with the additional volume of thermal storage taken from the building's hydronic system.

- **Energy & power density:** Energy density requirements ensure that the Therma Hub can store sufficient thermal energy within its physical volume to provide operational flexibility to minimise electricity costs. Power density requirements ensure the unit can discharge heat at a rate that meets residential demand or charge quickly during periods of low wholesale electricity prices. The Therma Hub's power density was similar to the original target, achieving 3.4 kW/m³ (target 3.6 kW/m³) based on a 200 kW peak output. The Therma Hub's energy density was higher than expected, tested at 108 kWh/m³ (target 71kWh/m³) based on 400 kW(th) storage. However, this doesn't account for heat extraction via airflow, which would reduce the energy density figure depending on where the relevant system boundary is determined.

Summary:

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

The Therma Hub could enable the rapid deployment of heat pumps in mid- and high-rise buildings sooner than would otherwise be possible by overcoming three primary barriers to the deployment of heat pumps:

- **Space constraints**: the unit is sited externally in available space around the buildings.
- **Heating capacity constraints**: the Therma Hub provides a communal heating supply that diversifies heat demand, lowering the potential upstream peak electrical demand. The use of storage and the versatility of the units will also provide intelligent interaction with the grid to take account of constraints at the generation or local network levels.
- **Installation challenges**: the design of the Therma Hub means it's technically capable and economically flexible enough to decarbonise homes where energy efficiency upgrades or a ground source heat pump connection are not immediately available.

What next?

Vital Energi's Therma Hub demonstrator, created as part of the Heat Pump Ready programme, will remain at the test site outside Vital Energi's Blackburn offices to be used for further research and development. Vital Energi is talking to two prospective clients who are interested in purchasing a Therma Hub and wish to discuss what the next iteration of the unit could look like. One prospective client is SGN, a British gas distribution company, who own over 4,000 high-rise (6+ storey) buildings and 40,000 mid-rise buildings.

Opportunities for future research

At project close, the Therma Hub was tested to TRL7-8[4]. Additional testing beyond the end of this Heat Pump Ready project will allow Vital Energi to demonstrate that the Therma Hub fully meets the requirements of TRL8. Further real-world testing throughout an entire heating system will validate the Therma Hub's modelled level of performance and demonstrate the viability of Vital Energi's HaaS proposition. Further testing could also demonstrate the capability of the Therma Hub unit to deliver grid services, such as via the Balancing Mechanism or frequency response services.

Where to find out more

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[4] The UK Research and Innovation's Science and Technology Facilities Council defines TRL 7 as 'technology prototype demonstration in an operational environment' and TRL 8 as 'actual technology completed and qualified through test and demonstration'.

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