BURO HAPPOLD

Design Note

Project	Net Zero Terrace SIF Alpha
Subject	Subsystem Testing Methodology and Results
Deliverable	M6 D8 Subsystem (HEMS) Testing Report
Date	27 March 2024

Revision	Description	Issued by	Date	Approved (signature)
1	Description of subsystem (HEMS) testing approach	RL	27/03/2024	PP/VK

Contents

Glossary

Term	Definition
API	Application Programming Interface
ASHP	Air Source Heat Pump
CAD	Consumer Access Device
CEMS	Community Energy Management System
COP	Coefficient of Performance
DESNZ	Department for Energy Security and Net Zero
DFS	Demand Flexibility Service
DNO	Distribution Network Operator
ENWL	Electricity North West Limited
EV	Electric Vehicle
GSHP	Ground Source Heat Pump
HEMS	Home Energy Management System
LV	Low Voltage
NZT	Net Zero Terrace
PV	Photovoltaic
R&D	Research and Development
SAPC	Standalone Auxiliary Proportional Controller
SIF	Strategic Innovation Fund
SIF	Strategic Innovation Fund
UoS	University of Salford

1 Introduction

Buro Happold has been appointed by Electricity North West Limited (ENWL) to perform the subsystem testing for the Net Zero Terrace SIF Alpha project. This report outlines the following:

- Testing methodology
- Key insights from the testing
- Important gaps in the home energy management system (HEMS) demonstrations and/or provider capabilities
- Recommendations on the next steps for future project stages

1.1 Testing Methodology

The methodology used to complete the testing is simplified within the flow chart shown in Figure 1—1 below.

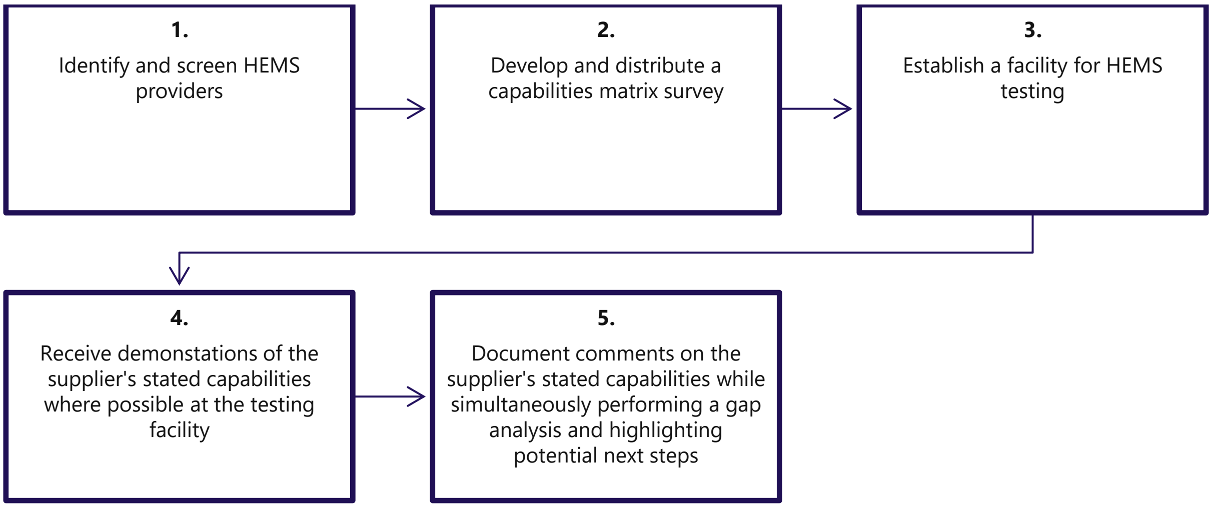

Figure 1—1 Simplified testing methodology flow chart

More detail on this methodology is as follows:

1. Identify potential HEMS suppliers and engage with them to understand which suppliers are interested in participating in the testing process and are willing to be shortlisted if deemed suitable for the next stages of the project.
2. Production of a HEMS Subsystem Testing Specification document to distribute to potential HEMS suppliers. This document aimed to provide the suppliers with project and system background information, a planned outline approach to the testing, and a functionality matrix/survey for their completion. The survey included a list of HEMS functionalities and descriptions with the expectation of the suppliers informing Buro Happold whether the functionality exists already and if not, whether they have plans to develop the functionality. The survey also allowed for the HEMS suppliers to add their comments..
3. Establish a test facility either at the University of Salford (UoS) testing houses/labs or at HEMS suppliers' own testing facilities.
4. Take notes at the testing demonstrations to confirm the stated capabilities of each HEMS where possible. Where a demonstration is not provided, request evidence from the HEMS suppliers in lieu.
5. Tabulate the comments and evidence retrieved from the testing while reporting gaps in the testing and/or HEMS capabilities. Use this information to recommend the next steps in future stages of this project.

2 Testing Insights and Observations

This section outlines the short-listed potential HEMS suppliers and provides a summary of the key insights and gaps observed from the testing process.

2.1 HEMS Supplier Identification

Five HEMS suppliers were identified at this stage as suitable candidates by Buro Happold and the University of Salford. Of these five, three were willing to collaborate with Buro Happold and perform the subsystem testing outlined to them. These three companies referred to as Supplier 1, Supplier 2, and Supplier 3.

2.2 Results Summary

This section details the key results and insights that were drawn from the demonstration and testing process as well as the capability matrix for each of the three HEMS suppliers. For more detail on the functionality matrix responses, and Buro Happold's testing comments and observations

2.2.1 Supplier 1

Supplier 1 demonstrated their HEMS at the UoS Energy House 1 facility using an Air-Source Heat Pump (ASHP). The Energy House itself and the equipment tested are shown in Figure 2—1 to Figure 2—4.

Key insights and results from their HEMS demonstration and capability matrix survey are given below:

- **User Interface:** Supplier 1 provides a user-friendly interface with iOS and Android apps (Figure 2—5). Users can set desired comfort levels and schedules and observe estimated costs. A level of flexibility is set by the user (between 1 and 5 degrees) with the greatest flexibility allowing for the greatest energy bill savings.
- **Application Programming Interface (API) Capability:** Supplier 1 can receive and send controls using their own and others' APIs. They are already integrated with third-party systems/apps and can receive "turn-up" and "turn-down" requests from external sources. They have also taken part in a National Grid demand flexibility service (DFS) and are willing to partake in bespoke projects/designs.
- **Building Physics/Consumer Profile Model:** Supplier 1 have created their own hierarchical (demand) models for predicting and meeting energy consumption rather than using a building physics model. These models also incorporate temperature and light sensors, with the light sensor being for predicting solar gains. Forecasted air temperature is also used to predict and incorporate heat pump coefficient of performance (COP)
- **In-Home Device Control Functionality:** Supplier 1 can control and optimise heating in collaboration with solar PV and home batteries and be EV aware. Being EV aware means incorporating the demands into the models rather than controlling them. Therefore, a smart EV charger would currently be required to optimise further. Furthermore, there are consumer override functions that were witnessed at the UoS testing centre (Figure 2—3 and Figure 2—6).
- **Oversight Platform:** Supplier 1 have an oversight platform that aggregates data from multiple meters. This could be useful for the project's community energy management system (CEMS) aspect.
- **Metering Information Extraction:** The system can extract metering information at 10-second intervals.

Figure 2—1 University of Salford Energy House 1

Figure 2—2 Air source heat pump at University of Salford Energy House 1

Figure 2—3 Supplier 1 HEMS manual user override

Figure 2—4 Supplier 1 HEMS sensor node

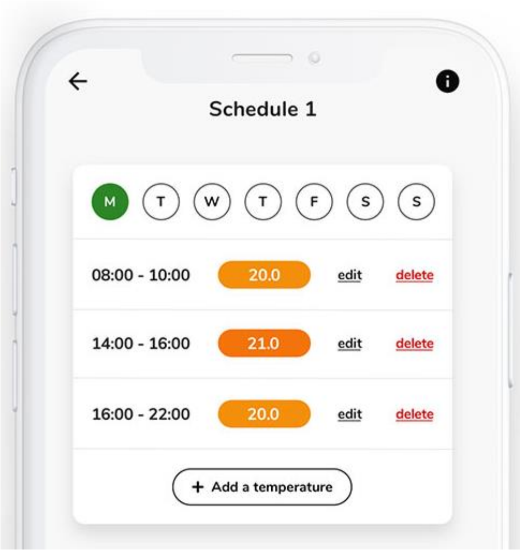

Figure 2—5 Supplier 1 daily/hourly temperature scheduling

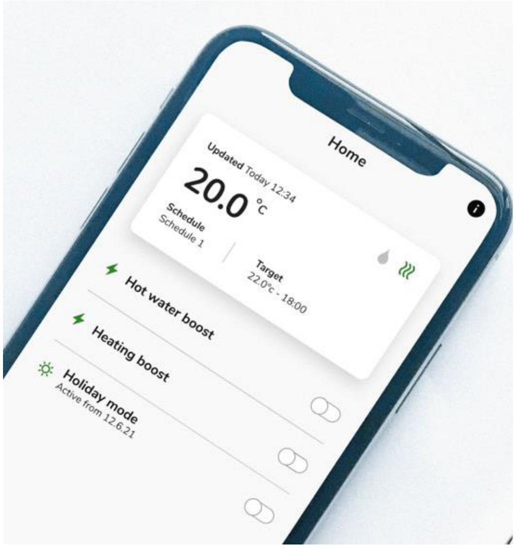

Figure 2—6 Supplier 1 user override via mobile application

2.2.2 Supplier 2

Supplier 2 have not yet completed the testing/demonstration process and therefore this section is not complete at this stage. A demonstration is expected to take place at Supplier 2 facilities (after the completion date for NZT Alpha phase).

Key insights revealed from their capability matrix are included in this section for the HEMS. These are given below:

- **User Interface:** The Smart Thermostat Programmer and Thermostats and a mobile application provides user interfaces to set desired comfort levels. The device can also provide estimated energy costs that are planned to be refined further for greater accuracy.
- **API Capability:** The system can use a third-party interface, such as the SERO App (used for Parc Eirin[1]). Future development is also planned for this functionality. Also, they are willing to expand this area further to accommodate bespoke systems.
- **Building Physics Model:** Passiv has patented algorithms for generating a building physics model.
- **In-Home Device Control Functionality:** This has been tested and proven in real-world homes (FLATLINE[2] and MADE[3] projects).
- **External Control (Receive):** The system can receive external control to deploy flexibility. It has a live first-to-market DFS flexibility via a unique Greener Grid Payments Scheme, exclusive to Supplier 2 customers. It can also incorporate time-of-use tariffs. Furthermore, Supplier 2 have taken part in many voltage and thermal management projects already and would like to develop their system further to aggregate and control systems at a low voltage (LV) network level, potentially being useful for the CEMS aspect of this project.

2.2.3 Supplier 3

Supplier 3 gave a virtual (Microsoft Teams) demonstration of their HEMS. The equipment (display and consumer access device (CAD), and temperature and humidity sensor) shown in Figure 2—7 and Figure 2—8 respectively were shown during the demonstration. Supplier 3 also offer a solar PV monitoring device as shown in Figure 2—9.

[1] https://www.passivuk.com/case-studies/flatline/
[2] https://sero.life/press-room/the-uks-largest-domestic-demand-side-response-trial-gets-off-the-ground-as-first-residents-move-in/
[3] https://www.passivuk.com/case-studies/made-project/

Key insights and results from their HEMS demonstration and capability matrix survey are given below:

- **User Interface:** The system uses the Bright mobile app (Figure 2—10 and Figure 2—11), which is user-friendly and ensures data protection compliance by giving the user the right to share data.
- **API Capability:** The system supports API capability for third-party interfaces. If they don't currently have the APIs/compatibility to work with desired equipment, they are willing to work towards doing so.
- **Metering Information Extraction:** The system can extract metering information at 10-second intervals.
- **Metering Information Display:** The system can display energy consumption data to users.
- **Building Physics / Consumer Profile Model:** The system develops an algorithm using a temperature sensor and 3 weeks of data (post-installation) to adjust and schedule heat requirements.
- **In-Home Device Control Functionality:** The system is developing this functionality as part of their standalone auxiliary proportional controller (SAPC) device (that is DESNZ funded). It is designed to be plug-and-play and could also be used for EV charging.
- **External Control (Receive):** The system is developing the ability to receive external control for flexibility deployment. Also, they have worked with an Australian distribution network operator (DNO) to control particular devices.
- **Air Source Heat Pump (ASHP):** The system is developing the ability to control and optimize an ASHP as part of Heat Pump Ready activity.
- **Voltage and Thermal Network Management:** The system is developing this functionality as part of SAPC device.
- **Local Historian:** The system can publish data to a cloud-based database. This could also be useful for integrating with the CEMS.
- **Standards Compliance:** The system is compliant with Zigbee SEP, Wifi, MQTT, CE.

Figure 2—7 Supplier 3 display and CAD

Figure 2—8 Temperature and humidity sensor

Figure 2—9 Solar PV monitor

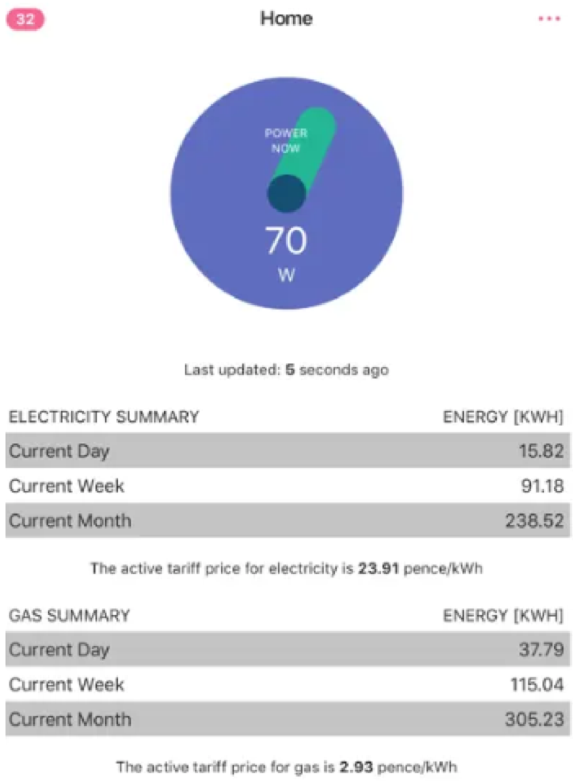

Figure 2—10 Supplier 3's Bright mobile application - summary

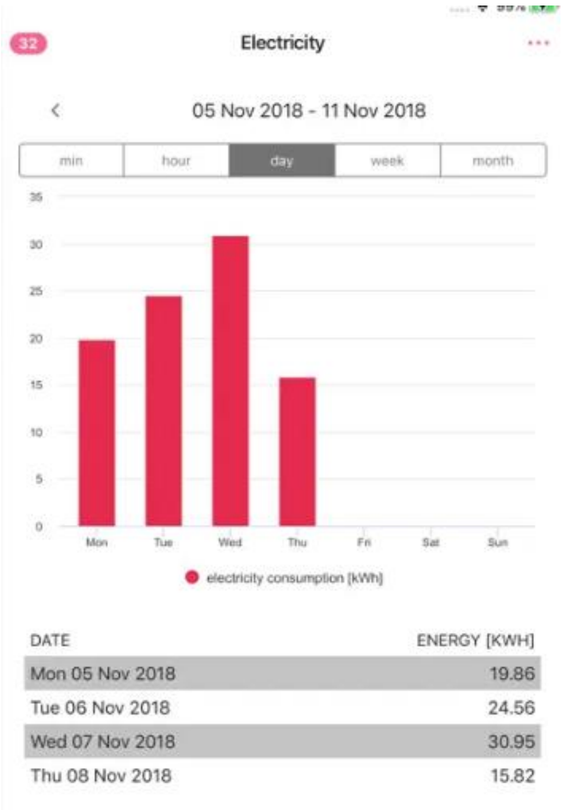

Figure 2—11 Supplier 3's Bright mobile application - electricity

2.3 Gap Analysis

This section details the key gaps in the HEMS providers' capabilities as well as in the testing process for each provider.

2.3.1 Supplier 1

Key gaps identified for the Supplier 1 HEMS are given below:

- **User Interface:** Carbon estimates are not currently integrated or displayed and there are no plans to integrate them yet. Also, PV self-consumption cannot yet be viewed as a percentage but should be available by summer 2024.
- **Metering Information Extraction/Display:** Supplier 1 does not collect or display metering data directly from Smart meters.
- **Smart Device Interfacing:** There are no moisture or window sensors integrated currently.
- **Local Historian:** Currently, there is no storage capacity on the device and all data is sent to the cloud.
- **Costs:** Displayed costs are currently inaccurate by ~10-15% but is planned to be improved/refined soon.
- **Kensa Heat Pump Integration:** Supplier 1 have informed Buro Happold that Kensa only allows for an on/off control currently rather flow temperatures cannot be modulated. This is likely applicable to all HEMS suppliers and would need to be discussed further.

2.3.2 Supplier 2

Despite testing not performed for Supplier 2, key gaps have been identified for the HEMS from their capability matrix response and are given below:

- **Metering Information Extraction:** The current system cannot directly extract metering information from Smart meters but relies on a third-party API. A direct connection with 10s granularity is under development.

- **Consumer Profile Model:** Supplier 2 say heat pumps will be slower to react to any mistakes in their prediction models compared to boilers which could affect the suitability to integrate with their system. Currently, there are no plans for future development in this area as it's believed to be unsuitable for heat pumps despite Supplier 2 having previously provided heat pump control solutions.
- **Local Historian:** Currently, the device does not have storage capacity, and all data is sent to the cloud.

2.3.3 Supplier 3

Key gaps identified for the Supplier 3 HEMS are given below:

- **In-Home Device Control Functionality:** Can control other devices on a plug level but they do not want to get too involved in this territory due to fire risks and insurance concerns.
- **User Override Functionality:** This functionality is not yet available but is being developed.
- **External Control (Receive):** The capability to receive external control for flexibility deployment is not present but under development.
- **Ground Source Heat Pump Interface:** Interfaces are not yet available.
- **Air Source Heat Pump Interface:** Not yet available but are being developed as part of Heat Pump Ready.
- **Voltage and Thermal Network Management:** This functionality is not yet available but is being developed.
- **Tariff:** Octopus does not add tariffs onto Supplier 3's HEMS. However, this is assumed to be the case for all HEMS.

3 Recommendations and Conclusions

3.1 Recommendations

This section recommends the next steps related to subsystem testing for future project stages. These recommended next steps are not in order of priority and are as follows:

1. Complete the Supplier 2 testing/demonstration and discuss their concerns with integrating heat pumps into their systems.
2. Perform soft market testing to inform how subsystem selection should continue as well as tracking developments under other innovation projects and under provider research and development (R&D) spending.
3. Integrators should be selected for future phases to provide controls under the demonstrator. This is not a new HEMS development, it is a targeted connection and the control of items that can be done outside of the HEMS as a supplement.
4. Expand the evaluation to CEMS systems and agree on standards and governance arrangements under which the system will operate (see architecture package). This also includes engagement with HEMS providers to further understand their interests and timescales for developing a CEMS. CEMS testing should occur to visualise/witness the aggregation of the HEMS data as well as the controlling of devices.
5. Test the HEMS ability to receive an external control for an in-home device where possible.
6. Trial the HEMS devices further within buildings to reveal insights and gaps observed from a longer-term assessment.
7. Engage with alternate GSHP providers where possible to ensure flow temperature can be modulated as part of the HEMS.
8. Test HEMS devices with other sensors where possible (e.g. moisture and windows).
9. Test the storage of HEMS data in cloud-based locations where they have claimed to be able to.
10. A virtual test facility will be required at the Beta stage to de-risk all activities before any living lab testing takes place.
11. Kensa were unable to install their ground source heat pump (GSHP) at the testing centre for this stage. Testing was therefore completed using an air source heat pump (ASHP). The next stage should test using a GSHP where possible.

3.2 Conclusion

In conclusion, Supplier 3, Supplier 1, and Supplier 2 have completed matrix surveys. Of which, Supplier 1 and Supplier 3 have also completed a testing/demonstration session. The results matrix shows strong potential for commercial off-the-shelf solutions, but functionality varies between the suppliers. It is likely an integrator will be needed in Beta in conjunction with prioritisation of the functions required to deliver the demonstrator. However, many functions, if not present, were highlighted as future development items in their pipelines. Furthermore, no set standards were determined for the HEMSs, and some of them use different communications methods which is indicative of the lack of mandatory standards in the smart energy sector currently.