The Innovation Hub

for Affordable Heating and Cooling

Lesson Learnt Report

Hivve Transportable Classrooms: Impact of Heat Recovery Ventilation on Energy Use and Indoor Air Quality

Project – LLS3

25 May 2022

University of Wollongong

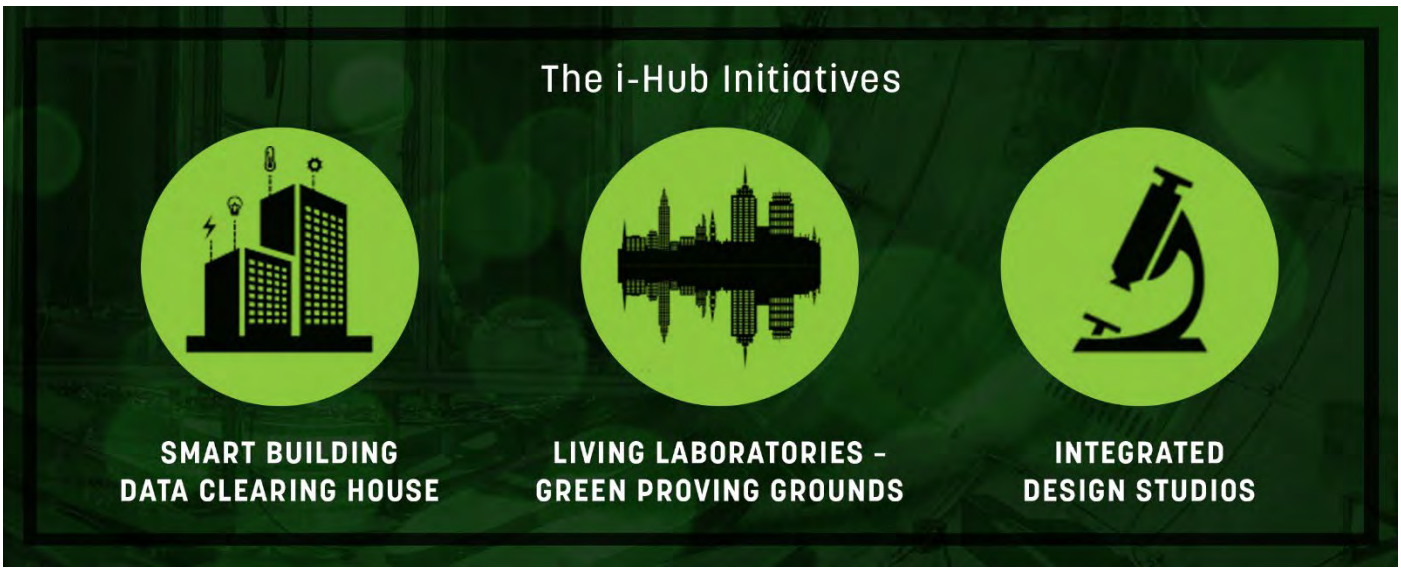
About i-Hub

The Innovation Hub for Affordable Heating and Cooling (i-Hub) is an initiative led by the Australian Institute of Refrigeration, Air Conditioning and Heating (AIRAH) in conjunction with CSIRO, Queensland University of Technology (QUT), the University of Melbourne and the University of Wollongong and supported by Australian Renewable Energy Agency (ARENA) to facilitate the heating, ventilation, air conditioning and refrigeration (HVAC&R) industry's transition to a low emissions future, stimulate jobs growth, and showcase HVAC&R innovation in buildings.

The objective of i-Hub is to support the broader HVAC&R industry with knowledge dissemination, skills-development and capacity-building. By facilitating a collaborative approach to innovation, i-Hub brings together leading universities, researchers, consultants, building owners and equipment manufacturers to create a connected research and development community in Australia.

This Project received funding from ARENA as part of ARENA's Advancing Renewables Program. The views expressed herein are not necessarily the views of the Australian Government, and the Australian Government does not accept responsibility for any information or advice contained herein.

Primary Project Partner



i-Hub Design Studio Lessons Learned Report

Transportable classrooms are a common feature of schools across Australia; these buildings typically have poor thermal performance. Hivve offers a transportable classroom package with many additional features designed to improve the thermal comfort and sustainability of these buildings, including higher performance thermal envelope relative to minimum standards, an energy efficient split system air-conditioning unit, a rooftop PV generation system, with the option of integrated battery storage. Previous i-Hub testing has provided an evaluation of the thermal envelope and heating system installed in a Hivve transportable

This report explores the lessons that have been learned through establishing this living laboratory with HRV retrofitted classrooms. The lessons learned were developed through evaluating the observations of the researchers and project team, and through interacting with the various stakeholders.

Lead organisation	University of Wollongong		
Sub-Project number	LLS3		
Sub-Project commencement date	1st December 2021	Completion date	30th June 2022
Report date	27th May 2022		
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Lessons learnt

Lesson learnt #1	Maintaining indoor air quality: HRV reduces measured CO_2 levels in classrooms
Category	Technical

Describe what you learnt about this aspect of the Project.

Electricity usage in schools has drastically increased because of COVID-19 ventilation policies being enacted to maintain indoor air quality conditions in classrooms, ensuring a well-ventilated space for students. The HRV is able to mitigate this increase by consistently operating with a lower CO_2 concentration compared to the adjacent classrooms and to the separate control rooms. For example, before the HRV was installed, 77% of days had at least one hour with a mean CO_2 concentration greater than 1000 ppm; there were no days after the HRV was installed that met this criterion. During the same period all other classrooms at Majura saw an increase in days with high CO_2 events, despite operating under COVID-19 ventilation protocols.
Furthermore, in Majura prior to HRV installation, the mean kWh/day usage of air-conditioning in the test room was 21% higher than the adjacent control room. Post HRV installation the combined HRV + AC mean kWh/day usage was 53% lower than the adjacent control room AC usage alone. However, some of these differences may be attributed to different scheduling between the two classrooms. The benefits of maintaining air quality at a reduced energy cost is highly beneficial to the off grid transportables that entirely rely on solar PV and batteries. Additionally with HVAC consuming a large portion on average of a building's electricity, any reduction in energy consumption while maintaining air quality and thermal comfort is highly beneficial.

Please describe what you would do differently next time and how this would help. What are the implications for future Projects?

The evaluation was significantly impacted by COVID-19 related supply chain issues. Procurement of the HRV units commenced in early 2022 with installation planned for summer 2021/22 school holidays, however there were substantial delays in receiving the HRV units by the supplier, and installation was not completed until the autumn school holidays (April 2022). This has resulted in i) a very short period for evaluation, limiting the ability to account and correct for differences in operation during side-by-side comparisons and ii) the evaluation occurring during a mild shoulder season, with only modest requirements for heating or cooling. This has presented significant challenges in evaluating the energy implications of HRV systems. A continuation of this technology evaluation, encompassing winter 2022 and summer 2022/23 has been in-principle agreed between UOW and the ACT education directorate, and this additional data will be invaluable in quantifying the impact of HRV units on energy use and thermal comfort, and the impact on energy availability of the solar battery system.

If your Project learnings have identified any knowledge gaps that need to be filled, please state it below.

A lengthier investigation between the implications from introducing natural ventilation and HRV in classrooms in relation to energy use would be beneficial, especially for off-grid classrooms that operate by following covid-related ventilation guidelines.

Please include any other information you feel is relevant or helpful in sharing the knowledge you learnt through this stage of the Project. This may be qualitative or quantitative and may include a graph, chart, infographic or table as appropriate.

Lesson learnt #2	HRV control operations: CO_2 setpoint demand response is effective and requires less energy
Category	Technical

Describe what you learnt about this aspect of the Project.

The two control operations for the HRV evaluated in this test are scheduled mode (fully on from 8am – 4pm) and setpoint demand response with the HRV set to activate once indoor mean CO_2 levels reached 800ppm. The scheduled operation used a mean of 4.8 kWh per day while the demand response had a mean of 1.3 kWh and appears to be the more energy efficient operation mode. Furthermore, the demand response operated on average for 2.2 hours/day compared to the 8 hours in scheduled mode, providing key energy savings. Both operation modes were able to effectively control CO2 concentrations below 1000 ppm, with the results clearly highlighting a difference in CO_2 concentrations with the non-HRV classrooms. The demand response control system supplied air quality for a lower total energy consumption and is more conducive to off grid transportables like St Felix where energy storage capacity is crucial to the operation of the classrooms.

Please describe what you would do differently next time and how this would help. What are the implications for future Projects?

Within the short testing period there where notable improvements to air quality and reduced AC energy consumption however, the challenges detailed in the evaluation report made it difficult to attribute these improvements to the HRV alone. A continuation of this technology evaluation has been in-principle agreed between UOW and the ACT education directorate. Additional data should allow for quantifying the impact of HRV units on energy use, CO_2 concentration and thermal comfort, and the impact on energy availability of the solar battery system.

If your Project learnings have identified any knowledge gaps that need to be filled, please state it below.

Please include any other information you feel is relevant or helpful in sharing the knowledge you learnt through this stage of the Project. This may be qualitative or quantitative and may include a graph, chart, infographic or table as appropriate.