The Innovation Hub

for Affordable Heating and Cooling

Final sub-project knowledge sharing report

Increasing the value of onsite renewables in Darwin through data driven analytics

Project DCH10

10 June 2022

Charles Darwin University

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

Charles Darwin University

i-Hub Final Knowledge Sharing Report – DCH10

Lead organisation	Charles Darwin University		
Sub-Project number	DCH10		
Sub-Project commencement date	December 2021	Completion date	June 2022
Report date	June 2022		
Contact name	Prof. Suresh N. Thennadil		
Position in organisation	Director, Energy and Resources Institute		
Phone	+61 8 8946 6564	Email	suresh.thennadil@cdu.edu.au

Contents

Increasing the value of onsite renewables in Darwin through data driven analytics (DCH10)

1. Project Overview

Building energy consumption in the Darwin region is high due to continuous climate control needs and use of legacy technologies. Darwin's tropical climate with a hot and humid wet season, and warm dry season, means that buildings require more energy for cooling than other Australian cities. This is reflected in household energy demand, where nearly 50% of household energy is used for cooling. Northern Territory (NT) government has set an ambitious target of 50% renewables by 2030 for electricity consumption including use of rooftop solar. Despite abundant solar energy resources, the rate of uptake of Distributed Energy Resources (DER) in NT is relatively low compared to other states with high solar radiation (23% of NT households have solar PV compared to 40% in Queensland). Lack of exemplar buildings that utilise DER efficiently in these regions is a key barrier for improving the uptake.

Project objectives

DCH10 had the following primary objectives:

- Identify energy efficiency, demand management opportunities for improving the value of onsite renewables through use of near real time data and micro services available in DCH
- Document the onboarding process associated with connecting three buildings in Darwin to DCH and develop a methodology to support upgrading of buildings in the region capable of handling digital technologies

Importance to built environment sector

Potential opportunities available through use of data driven methods in the built environment sector has been reported widely across the globe. The benefits range from use of data for improving HVAC energy efficiency, carrying out preventive maintenance, managing flexible loads in building to support higher uptake of renewable energy in the grid. Moreover, unlocking these opportunities do not require high capital investment such as equipment upgrades. Ability of the building sensors and control systems to provide data continually and reliably is the key requirement. However, legacy buildings often are not digitally ready and often times building owners end up spending lots of operating cost to upgrade the buildings to smart buildings negating the potential benefits. Addressing the barriers associated with switching a building to a smart building will facilitate new technology uptake.

This project outputs will play a key role in advancing the awareness of use of smart building technologies and identify opportunities for DER in the Darwin region. The learning and digital capacity built can directly assist new commercial buildings being delivered as part of the Darwin City Deal.

2. Challenges experienced – and how these were overcome

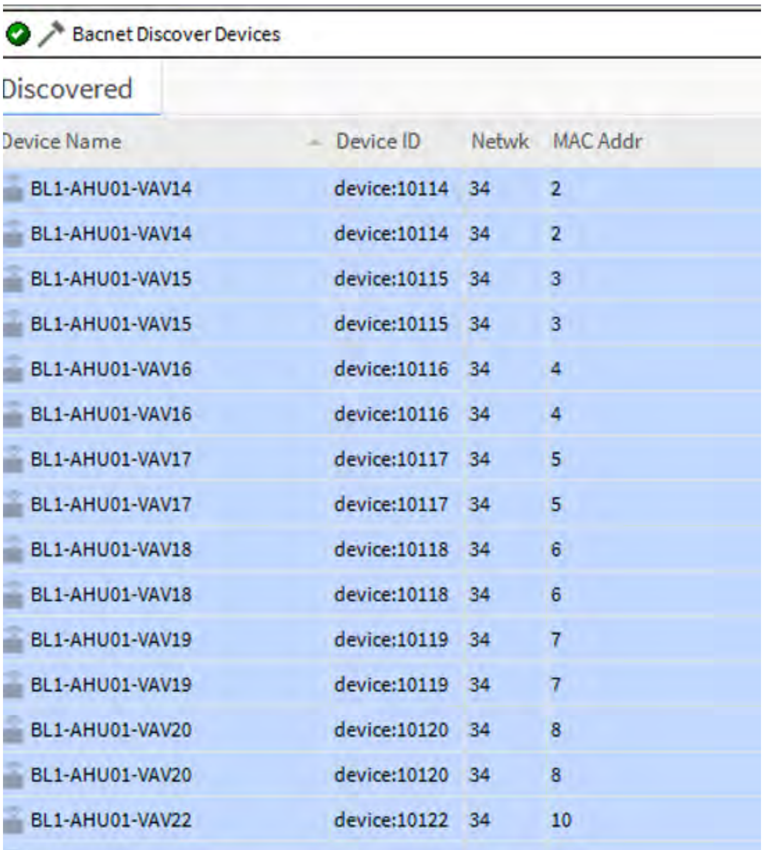
The following challenges were faced during the onboarding process:

- Cybersecurity protocols within organisations can present a challenge in configuring the gateway to share data and applications between the DCH and the client's building management system (BMS). In this project, engineers at CSIRO were not able to directly access CDU or City of Darwin's VPN due to cybersecurity policies. Several solutions were tested, but in the end an off-the-shelf Microsoft Windows 10 license was purchased by CSIRO and installed on a virtual machine (VM). CSIRO's VPN was disabled, CDU and City of Darwin's VPN software were downloaded on the VM and network testing was done. A Niagara license was also purchased to be used on the VM. Ports tcp_4911 and tcp_5011 were opened for our VPN access, while UDP and tcp_8883 were opened for the Jace gateway itself. This allowed us to configure and maintain the Jace remotely and send the site data to the DCH MQTT broker.
- Two of the BMSs onboarded related to legacy buildings (Civic Centre – City of Darwin, and Blue 1 – CDU). This has presented challenges in terms of the health of data that was ingested. Specific issues identified included:
  - No firewall between buildings at CDU, which meant that tens of thousands of points were ingested – with unclear labelling of points this obscured access to relevant data
  - Stale or faulty data points that provided no data or a single value with no temporal variation that did not reflect expected behaviour (e.g., energy demand profile for chillers). Further conversation with the BMS provider and facility managers at CDU is required to debug these issues and identify the correct HVAC and Plant points.
  - The BMS device itself (which contains HVAC and Plant points) was completely hidden from the JACE. The BMS provider uses I/NET protocol instead of BACnet. JACE does not have an I/NET driver since it is a dedicated protocol for BMS provider. Software-based gateways or additional hardware is required to ingest the data from the BMS.

Database

Name	Exts	Device ID	Status	Netwk	MAC Addr
Blue1					
Pink9					
BL1-AHU01-VAV14		device:10114	{ok}	34	2
BL1-AHU01-VAV15		device:-1	{fault}	34	2
BL1-AHU01-VAV16		device:10115	{ok}	34	3
BL1-AHU01-VAV17		device:-1	{fault}	34	3
BL1-AHU01-VAV18		device:10116	{ok}	34	4
BL1-AHU01-VAV19		device:-1	{fault}	34	4
BL1-AHU01-VAV20		device:10117	{ok}	34	5
BL1-AHU01-VAV21		device:-1	{fault}	34	5
BL1-AHU01-VAV22		device:10118	{ok}	34	6
BL1-AHU01-VAV23		device:-1	{fault}	34	6
BL1-AHU01-VAV24		device:10119	{ok}	34	7
BL1-AHU01-VAV25		device:-1	{fault}	34	7
BL1-AHU01-VAV26		device:10120	{ok}	34	8
BL1-AHU01-VAV27		device:-1	{fault}	34	8
BL1-AHU01-VAV28		device:10122	{ok}	34	10
BL1-AHU01-VAV29		device:-1	{fault}	34	10
BL1-AHU01-VAV30		device:10124	{ok}	34	12
BL1-AHU01-VAV31		device:-1	{fault}	34	12
BL1-AHU01-VAV32		device:-1	{fault}	34	12
BL1-AHU01-VAV33		device:10125	{ok}	34	13
BL1-AHU01-VAV34		device:-1	{fault}	34	13

Figure 1: Faulty nodes for onboarded BMS



Bacnet Discover Devices

Discovered

Device Name	Device ID	Netwk	MAC Addr
BL1-AHU01-VAV14	device:10114	34	2
BL1-AHU01-VAV14	device:10114	34	2
BL1-AHU01-VAV15	device:10115	34	3
BL1-AHU01-VAV15	device:10115	34	3
BL1-AHU01-VAV16	device:10116	34	4
BL1-AHU01-VAV16	device:10116	34	4
BL1-AHU01-VAV17	device:10117	34	5
BL1-AHU01-VAV17	device:10117	34	5
BL1-AHU01-VAV18	device:10118	34	6
BL1-AHU01-VAV18	device:10118	34	6
BL1-AHU01-VAV19	device:10119	34	7
BL1-AHU01-VAV19	device:10119	34	7
BL1-AHU01-VAV20	device:10120	34	8
BL1-AHU01-VAV20	device:10120	34	8
BL1-AHU01-VAV22	device:10122	34	10

Figure 2: No valid MAC address to refer to

3. Summary of DCH10 Lessons Learnt

Overcoming challenges in onboarding legacy buildings

There is the need for ongoing, effective coordination from the start of the project between BMS provider, IT team and facilities teams to ensure JACE can access relevant data and identify then address data quality issues. This is particularly critical for older buildings where knowledge of the system can be lacking with redundant points and inadequate documentation. Onboarding of legacy buildings presents a challenge as the understanding of the BMS is often fragmented across the organisation and the BMS service provider, while staff turnover can present challenges in knowledge retention given inadequate documentation and lack of data to ensure quality.

Opportunities to improve remote access to building management systems

This was the first project where CSIRO maintained the clients' gateways and this solution proved to be a scalable, secure and inexpensive method when working outside of an organisation's firewall to configure and maintain and send data to the DCH. If the client's contract BMS or IoT providers, CSIRO is no longer providing JACE maintenance and onboarding would not require Cybersecurity risk mitigations and the JACE can be managed by the providers with access to the client's network.

Increasing focus of organisations on managing cybersecurity threats means that configuring and maintaining JACEs to transfer data across different networks is likely to remain a challenge that needs to be considered in project design and inception. There is the need to consider cross domain solutions that enable efficient sharing of data and information while considering cybersecurity protocols.

Define focus of energy demand opportunities and renewables optimisation as bottom-up process that focuses onboarding

The onboarding process should be initiated with a focussed workshop that involves all key parties to scope out a relevant and feasible focus for the onboarding that addresses an operational priority for the building. There is the need for a co-development process in identifying the intended optimisation of demand management and renewables strategies to ensure it can be supported by available applications and the sensors and information flows available through the BMS. Ensuring that specific strategy to be explored has high-level sign off and support in the organisation can motivate and engage staff, as well as ensure that BMS service providers are involved.

4. Project Outcomes

Buildings on-boarded

The project team onboarded two buildings from CDU CDU's Casuarina campus:

- Blue 1 is an older (legacy) building with a Honeywell BMS, multiples of zone sensors controlling VAV's in the ceiling space. One large chilled water cooled AHU supplies air to the majority of the building, with two smaller ones supplying other zones.
- Pink 9 is a newer two storey building with a Trane (Trend) BMS. Pink 9 is fitted with rooftop solar PV with a capacity of 123kW with the power monitored using AZZO via the Schneider BMS. Utility data and onsite generation data will be ingested to DCH.

The other building onboarded was the Civic Centre, which is a legacy building of City of Darwin. Monitoring of this building will provide a baseline that can inform design of new buildings and improve the energy efficiency of the existing building and identify opportunities for use of on-site renewable energy. The existing

Process

The process of installing the Tridium JACE-8000 gateways was relatively simple. Our main points of contact were the IT and Facility teams at CDU and City of Darwin. Several meetings were held with these teams to determine the process and permissions needed to install the gateways and ingest data for the DCH. This included being granted network permissions to set up the JACEs.

The partner organisations allocated a physical location for the gateway to be installed and also provided network cabling to connect the gateways in their designated network (*Figure* 3). A CSIRO engineer travelled to Darwin to help oversee the installation of the JACE gateways, which was undertaken by qualified personnel from CDU and City of Darwin. The indicative system architecture to connect JACEs to DCH is provided in Figure 3.

Figure 3: Installation of JACE gateway at Building Pink 9 (CDU)

Analysis of opportunities

This section provides an analysis of opportunities for energy use reduction and improving value of onsite generation for onboarded buildings.

Energy simulation was undertaken for two buildings (Blue1 and Pink 9) at Charles Darwin University, which were onboarded to the DCH in the current project. The objective of the analysis was to produce:

- Energy use analysis of pilot buildings to inform net zero pathway for these buildings
- Insights on parameters such as HVAC energy use and PV generation.

The cooling load of each building including all spaces within the buildings was simulated using Hourly Analysis Program 5.11 (HAP 5.11), and a comprehensive report was provided. For each space of the buildings, the contribution of different factors such as windows, walls, roofs, floors, doors, partitions, lighting, electric equipment and people on the cooling load (sensible, latent and total) of each space with a safety factor of 10% were simulated.

The results showed that for the older legacy building (Blue 1) the building feature that contributed the most to cooling loads during peak periods was window solar loads. While for the new building (Pink 9) the built feature that contributes the most to the cooling load is roof transmission.

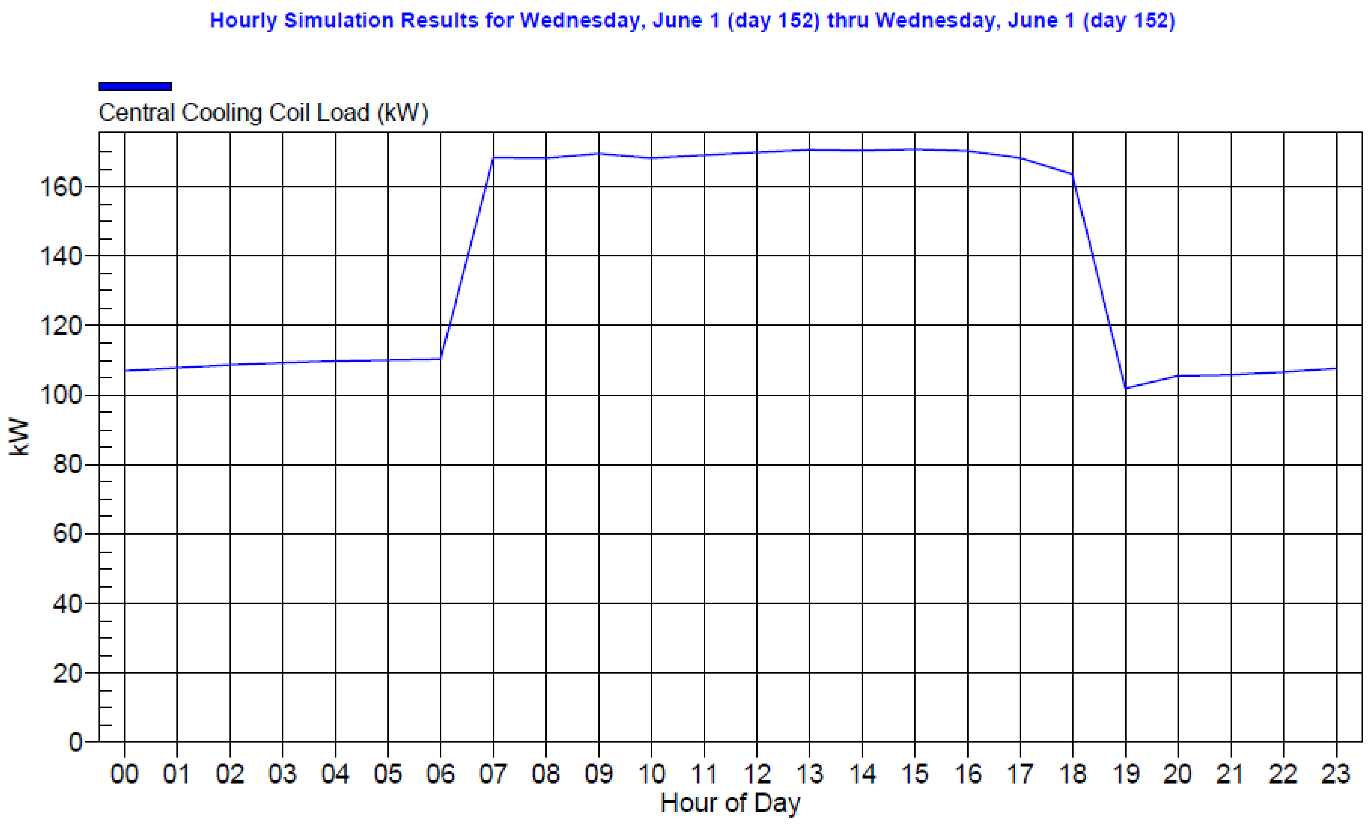


Figure 4: Example hourly simulation of cooling loads (Blue 1, CDU)

5. Evaluation of DCH10 Impact and outcomes

The project had the following objectives:

Identify onboarding barriers associated with upgrading of buildings in Darwin to be digital ready

This objective has been fully achieved. The buildings from City of Darwin and CDU are onboarded and viewable in SENAPS, which addresses the KPI for this objective - *Two buildings in CDU's Casuarina campus and one City of Darwin building use DCH for data monitoring, visualisation.* The project has identified and documented several barriers to onboarding legacy buildings that can inform subsequent projects. This will assist in realising the opportunities for older building in using data driven methods to improve HVAC energy efficiency and managing flexible loads to increase the uptake of renewables.

Use high resolution data available in DCH to identify opportunities for improving the value of onsite generation and reduction of energy use.

This objective has only partially been achieved yet as there is still no useful data flows from onboarded buildings that could be used for analytics or investigating energy efficiency strategies. However, the project has provided progress against the KPI - *clear guidance on energy use reduction, improving value of onsite generation.* The simulation has provided insights on the factors that influence energy demand in selected pilot buildings. The intention of the simulation was for calibration with observed data through the DCH, which could then inform the assessment of strategies that could provide pathway to net zero emissions for these buildings, such as optimising HVAC operation to reduce energy demand or maximising the use of onsite solar PV generation. At present the data available from the onboarded buildings (see lessons learnt report) is not providing meaningful and robust data for the analysis. We are still working to resolve this. The simulation set-up and parameterisations mean that there is now the ability to evaluate the influence of building changes (operations or physical layout) on energy demand in selected pilot buildings.

6. Contribution to i-Hub objectives

The DCH10 project has contributed to i-Hub objectives through the number of buildings connected to the DCH. This project has revealed unique challenges in onboarding legacy buildings, which are a significant proportion of Australia's commercial building stock. It is important to realise the opportunities for these legacy buildings that comes from access to high resolution data and networked operations of building services. Upscaling of lesson learnt from this project can help to allow managers and owners of legacy buildings to improve efficiencies and reduce costs, while transitioning to net zero buildings through addressing barriers for renewable energy uptake.

7. What comes next?

A workshop for the project is being held on the 22 June, with participation from all partners involved in the onboarding process. The objective of this session is to provide an opportunity to share the lessons from the onboarding process associated with connecting three existing buildings in Darwin to DCH (CDU - Blue 1 and Pink 9 and City of Darwin - Civic Centre), which can provide insights to support the upgrading of buildings in the region capable of handling digital technologies to identifying opportunities for more energy efficient building operation and the integration of renewables. Experiences of onboarding from other contexts will also be shared to provide context and knowledge exchange. The session will conclude by mapping out next steps for how current applications and capabilities of DCH can be of benefit to partners, as it is envisaged that the onboarding is only the first stage in the process.