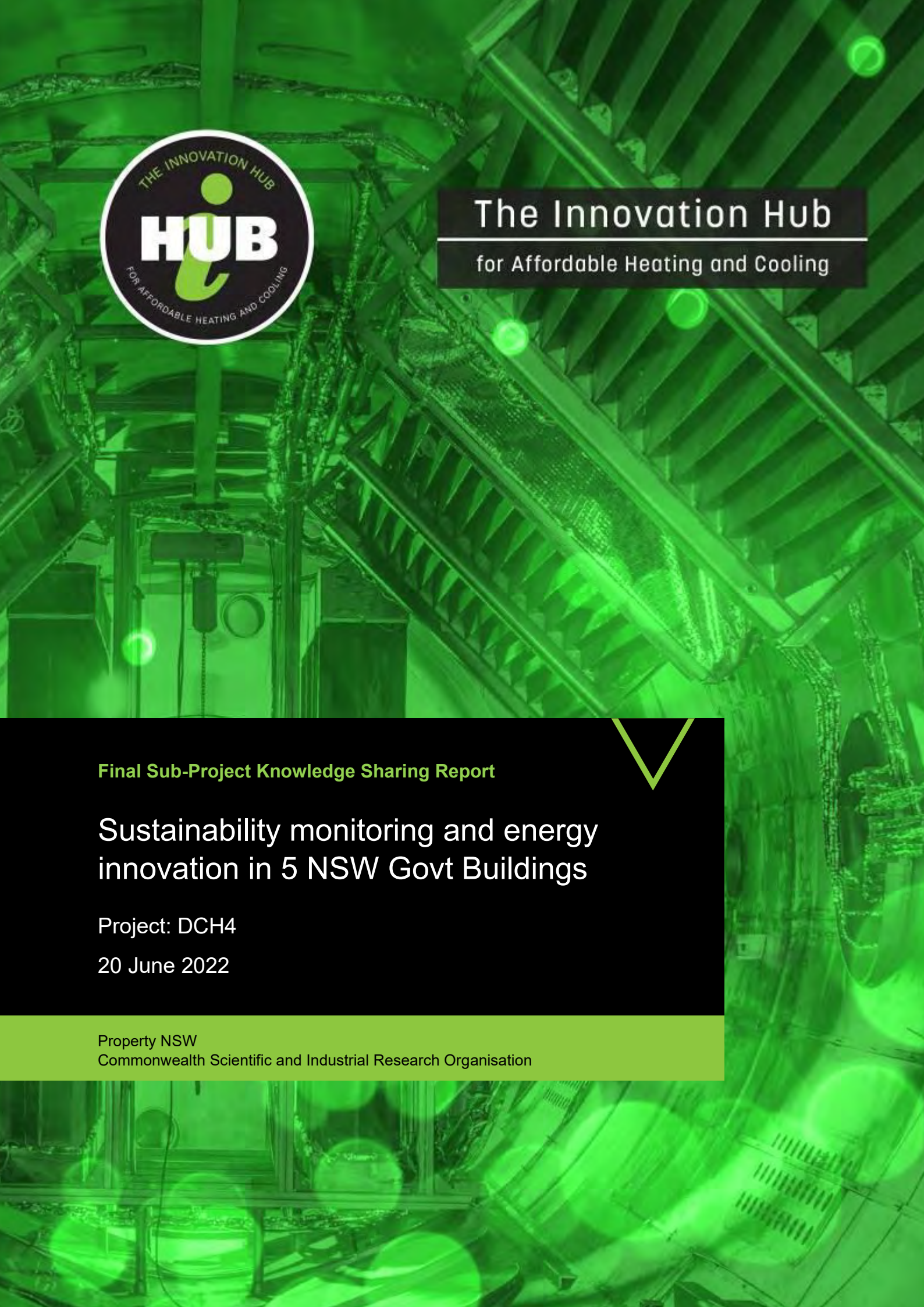


The Innovation Hub

for Affordable Heating and Cooling

Final Sub-Project Knowledge Sharing Report

Sustainability monitoring and energy innovation in 5 NSW Govt Buildings

Project: DCH4

20 June 2022

Property NSW
Commonwealth Scientific and Industrial Research Organisation

About i-Hub

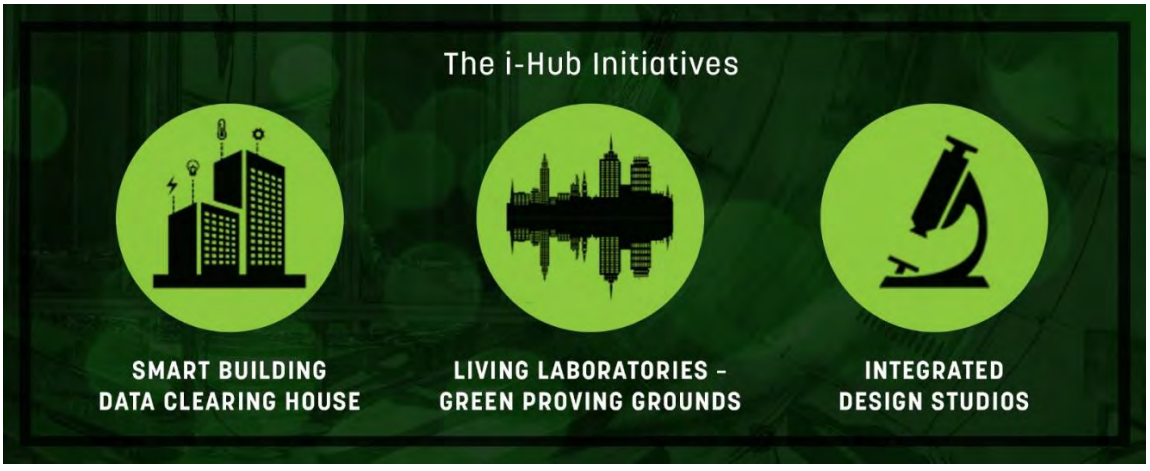
The Innovation Hub for Affordable Heating and Cooling (i-Hub) is an initiative led by the Australian Institute of Refrigeration, Air Conditioning and Heating (AIRAH) in conjunction with CSIRO, Queensland University of Technology (QUT), the University of Melbourne and the University of Wollongong and 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

Property NSW



DCH4 Final sub-project Knowledge Sharing Report

Sustainability monitoring and energy innovation in 5 NSW Govt Buildings

Property NSW has commenced the implementation and s continuing to review the need and application of IOT Smart Building technologies for its property portfolio. Property NSW has a diverse portfolio of commercial buildings across NSW, including properties and tenancies in Sydney and major regional centres, to properties in rural and remoted remote areas of NSW.

This project aim was to ingest data from 5 buildings into the DCH, and evaluate the ability of the DCH to store, organise and structure the data in a standardised framework, such that anyone can query the information with high level of confidence, in order to generate business insights and actions that help optimise building performance, manage energy consumption and solar PV generation, and reduce R&M costs.

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1 SUMMARY

1.1 Executive summary

The purpose of this report is to publicly share the technical content, the lessons learned and the final results and findings for i-Hub DCH4 – Sustainability monitoring and energy innovation in 5 NSW Govt Buildings sub project.

This is a public facing report and outlines:

- Project Overview
- Project Outcomes and Challenges
    - Implementation of DCH applications
    - Stakeholder Consultation
- Lessons Learnt
- Next Steps

1.2 Project Overview

This project aim is to ingest data from 5 buildings into the DCH, and evaluate the ability of the DCH to store, organise and structure the data in a standardised framework, such that anyone can query the information with high level of confidence, in order to generate business insights and actions that help optimise building performance, manage energy consumption and solar PV generation, and reduce R&M costs.

Property NSW has a diverse portfolio of commercial buildings across NSW, including properties and tenancies in Sydney and major regional centres as well as properties in rural and remoted remote areas of NSW.

- Management of these properties presents several operational challenges that the IOT Smart Building System is seeking to address. These issues include the following:
- Many of the smaller buildings have little automated controls and no remote monitoring and / or control capabilities with consequent inability for facility management to review conditions and triage service calls and complaints.
- Where buildings are equipped with a building control system there is no consistency with respect to the user interface, remote monitoring capability, integration of various services and the like.
- Related information such as floorplans, service manuals and the like are separately stored and not easily accessible to facility management users.
- Building services data and other building meta-data is not consistently stored, usually in disparate databases and therefore not able to be easily accessed and related to each other.

A critical barrier to the integration of HVAC flexible demand with solar PV (and smart building data analytics and optimisation technologies in general) in lower grade (B & C) buildings, is the lack of access and the high cost of data to enable the use of these technologies. The project intent is to demonstrate that a wide range of building data sources and types can be cost effectively integrated to a single data store and utilised to provide real outcomes in identifying issues, optimising building operation and enabling sophisticated energy management strategies such as demand response. Overcoming these barriers would enable Property NSW to fulfill its strategic and policy mandates.

2 PROJECT OUTCOMES AND CHALLENGES

The key outcomes of the project that were as follows:

- 5 Buildings are onboarded onto the DCH platform in a technically and costs effective manner.
- The value of energy management, building comfort analysis and demand response is demonstrated.
- The role of the DCH platform as an enabling technology is assessed.
- The appetite for third party software service providers to engage the DCH as a preferred data platform is assessed.

2.1 Enabling of 5 off PNSW Buildings onto the DCH

Property NSW IOT service provider Jones Lag LaSalle (JLL) implemented their Command Centre IOT platform prior to the commencement of the DCH4 project across 11 off Property NSW sites in Sydney and across regional NSW. Depending on the specific requirements of each building data was integrated to IOT Gateways via wired sensors, wireless sensors or via integration to building management systems (BMS). Where required JLL installed wireless PIR (Passive Infrared) sensors for monitoring occupancy (motion), temperature, humidity, and light levels.

The BMS data available on the BACnet networks on sites was integrated via the IOT Gateways on site and ingested to JLL's cloud platform Intellicommand (Command Centre).

The first objective of the DCH4 project was focussed on onboarding data from the Property NSW IOT Systems to the Data Clearing House. CSIRO and JLL / PNSW working together to establish preferred methodologies to establish the data connections between the systems and to provide the contextual data to allow the DCH to build the semantic model of the building.

The following key activities were undertaken to onboard the IOT data to the DCH:

- Data Integration across 5 off buildings established across the 5 NSW Government Buildings, comprising a total of 4000 unique data points across the 5 buildings.
- Modelling of the data using Brick Modelling schema completed across two off largest buildings, creating a total of over 3000 data nodes in the DCH.
- DCH data access provided to PNSW provider, Buildings Alive, who have completed initial testing of data access and analysis of the data to determine at least two off possible use cases for the DCH data.

The 5 off Buildings that were integrated into the DCH were:

- 1 Prince Albert Road, Sydney
- 43 – 45 Johnston Street, Wagga Wagga
- 87 Cooper Street, Cootamundra
- 104-110 Banna Ave Griffith
- 61 Railway Parade Lithgow

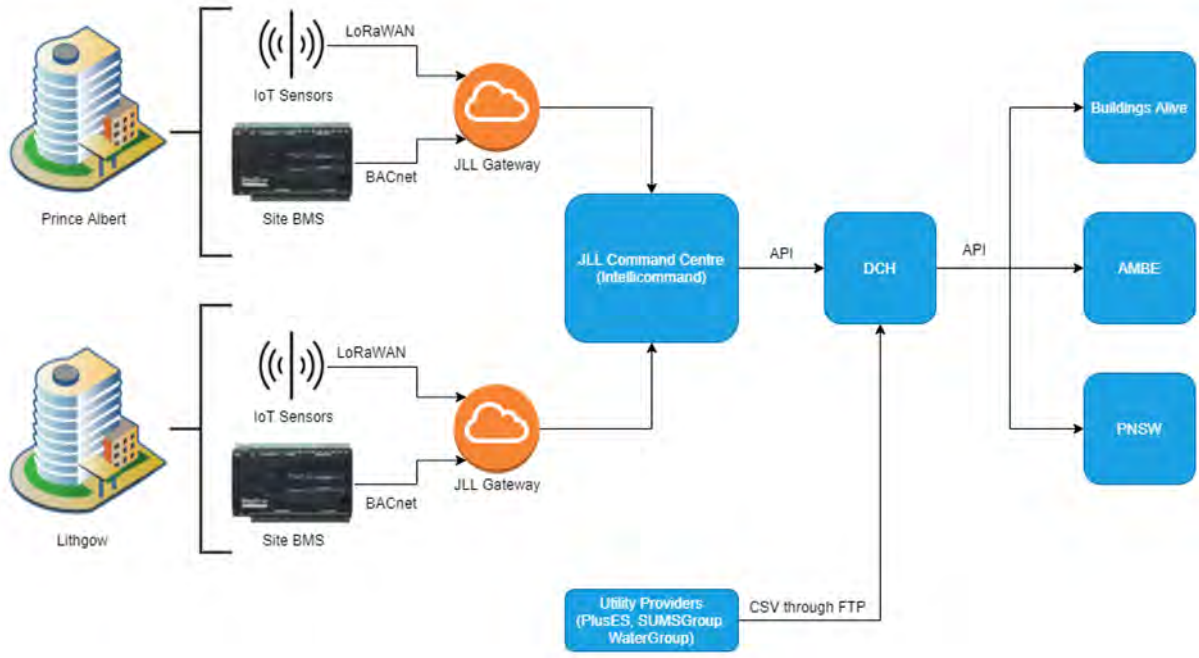

Figure 1: PNSW IOT System to DCH Integration Model

Working closely with the JLL software team in the U.S., JLL programmed a "bot" on the Intellicommand servers to package the data and metadata for each point and send them to DCH using the Senaps Application Programming Interface (API). A bot is a software application that runs automated tasks, can adapt and can handle more complex operations than a workflow. The advantage of this approach is that the bot acquires any point on Intellicommand with timeseries data available and automatically sends it to DCH. This means if new points are onboarded to JLL, they are automatically onboarded to DCH and no additional work is required.

The summary of data onboarded onto the DCH from the 5 off buildings is shown on the table below:

Site Name	Lithgow	Sydney (Prince Albert)	Cootamundra	Wagga Wagga	Griffith
Utility Meters	Electrical Solar Gas Water	Electrical Gas Water Private Submetering (included in BMS points)	Electrical Solar Gas Water	Electrical Solar Gas Water	Electrical Solar Gas Water
IoT Sensors	Temperature Humidity Occupancy Status Luminosity	Temperature Humidity Occupancy Status Luminosity	Temperature Humidity Occupancy Status Luminosity	Temperature Humidity Occupancy Status Luminosity	Temperature Humidity Occupancy Status Luminosity

Site Name	Lithgow	Sydney (Prince Albert)	Cootamundra	Wagga Wagga	Griffith
	CO2 levels Particulate Matter (PM_{10} and $PM_{2.5}$) Total Volatile Organic compounds (TVOC)	CO2 levels Particulate Matter (PM_{10} and $PM_{2.5}$) Total Volatile Organic compounds (TVOC) People Counters	CO2 levels Particulate Matter (PM_{10} and $PM_{2.5}$) Total Volatile Organic compounds (TVOC)	CO2 levels Particulate Matter (PM_{10} and $PM_{2.5}$) Total Volatile Organic compounds (TVOC)	CO2 levels Particulate Matter (PM_{10} and $PM_{2.5}$) Total Volatile Organic compounds (TVOC)
BMS Data	Yes	Yes	No	No	No
Control Algorithms	N/A	Demand and Response Strategy Points (PlantPro)	N/A	N/A	N/A
Total Number of Points (Last updated 8th of Nov 2021)	1810	1730	283	185	250

Figure 2: Summary of Data Types and Methods integrated into the DCH

Following the successful integration of the initial; five off buildings into the DCH the decision was made to integrate a further 6 off sites. As the JLL Command Centre system had already developed the API data interface onboarding the data to the DCH was achieved very quickly and at a low costs per data point. The buildings are located throughout regional NSW and will provide a further wide range of data across commercial office space. The additional sites are located at:

- 83-85 Faulkner Street Armidale
- 49-51 Victoria Street, Grafton
- 127 Otho Street, Inverell
- 66-68 Frome Street, Moree
- 55 Maitland Street, Narrabri
- 130 Brisbane St, Dubbo

2.2 Implementation of Applications on DCH Platform – M&V Application

CSIRO implemented three off applications using the PNWSW buildings data. The Modelling and Verification (M&V) energy analysis application and the Modelling Predictive Control (MPC) application and the Predicted Mean Vote (PMV) Thermal Comfort application.

CSIR conducted energy baselining at two off sites using the M&V application for the period of 1 October 2020 – 30 September 2021 were undertaken. The results of the M&V application analysis are provided in detail at in the iHub i-Hub Sub-Project DCH4 M6_Data Integration and Energy Baselining Report referenced.

A summary of the M&V results for the 1 Prince Albert Rd site is shown below:

1 Prince Albert St, Sydney
Baseline period: 10-Oct-2020 to 13-Apr-2021
Analysis period: 14-Apr-2021 to 29-Sep-2021

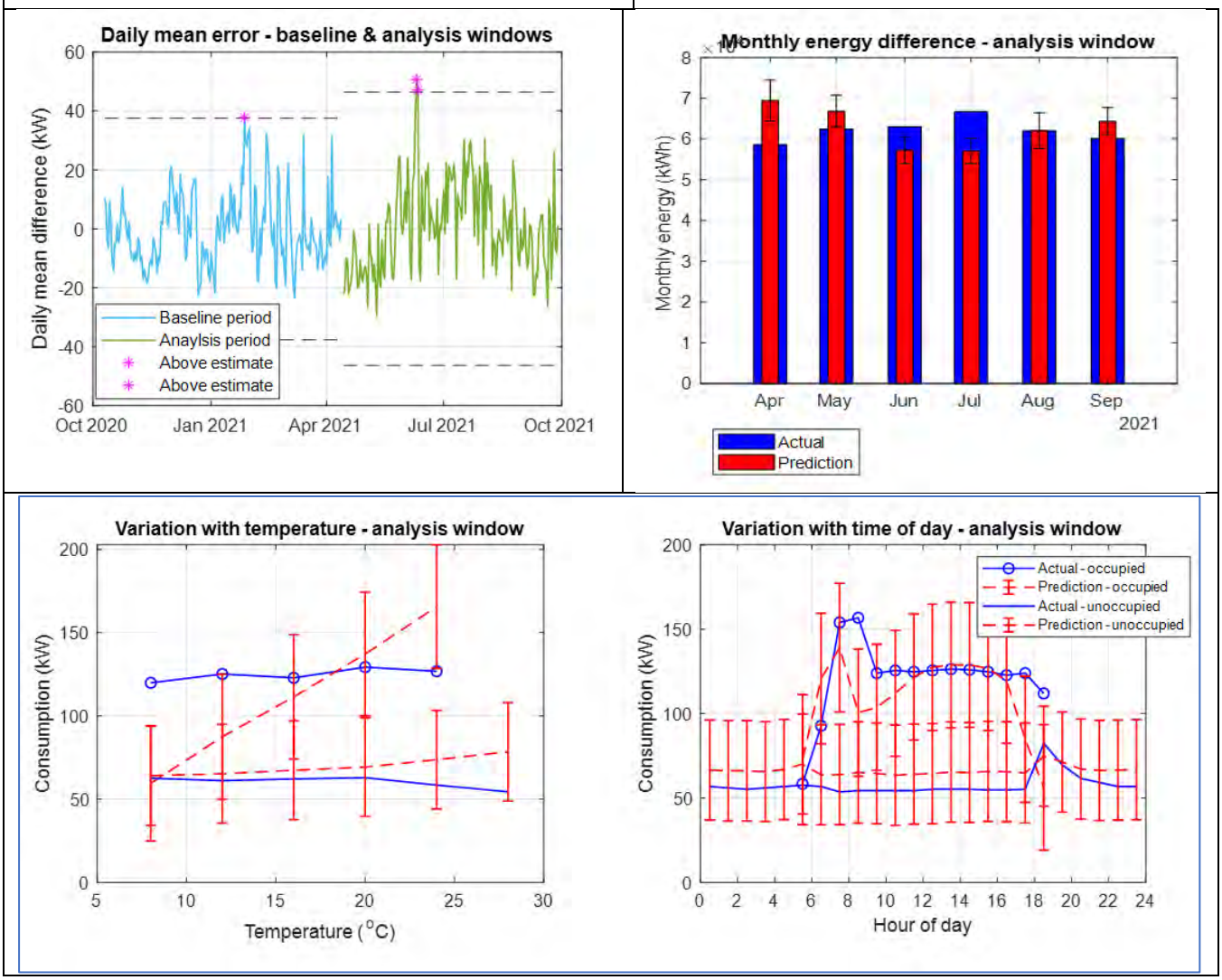

Figure 3: M&V Result for 1 Prince Albert Rd Site

In summary the results for the 1 Prince Albert Road site showed:

- A good fit of the model to the baseline data was obtained (CVRMSE=17.1, NBME=-0.11). Figure 1 indicates that there was only 1 day in the baseline period where the mean error was significant.
- The site has a baseline consumption of approximately 60kW that is largely independent of temperature. The typical workday daily pattern has a peak of approximately 150kW in the morning between 7 and 9am followed by a relatively steady ~120kW consumption throughout the day dropping back to the baseline consumption level after 6pm.
- Overall energy use increased by 2.3% (+-2.6%) over the analysis period compared to expected. However, the variation was not uniform with decreases in April and May followed by increases in June and July and a decrease again in September (Figure 2).
- The most striking feature is the change in variation of energy use with temperature for periods where the site is likely to be occupied (Figure 3 left). Over the analysis period the actual energy use

was almost independent of temperature, as compared to the baseline period where the energy use increased uniformly with increasing temperature.

2.3 Demand Response at 1 Prince Albert Rd

PNSW implemented a Demand Response (DR)system at the 1 Prince Albert Rd site which was completed in November 2021. The DR system is intended to respond to requests for demand reduction from the energy market during periods of high cooling loads by implementing a staged reduction of cooling energy at the site by increasing cooling setpoints as an initial stage of demand reductions and then undertaking direct load limiting of chiller capacity if required.

The project undertook testing of the DCH data interface to the 1 Prince Albert Building (1PA) Demand Response system, via the onsite BMS during the reporting period as there were problems initially with the DR System interface to the BMS. Following resolution and confirmation of the data integrating correctly PNSW and CSIRO project partner have been working to undertake a full DR Event test to allow analysis by the M&V App.

Unfortunately, a number of factors have contributed to the DR events being rarely initiated over the last six months and not being initiated and therefore there not being sufficient data to allow a detailed analysis to occur. These factors include low occupancy in the building due to COVID and other factors and generally low colling demand through the 2021-22 summer months due to low average maximum temperatures across the eastern part of Australia. At the time of writing this report the DCH project continues to collect data from the site and is anticipating undertaking further analysis and testing in the later part of 2022.

2.4 Consultations with Stakeholder and Software Providers on DCH

Following the successful onboarding of data from the 5 off building at the following sites the following activities were undertaken to assist in the project evaluation:

- Access to the DCH platform to PNSW Sustainability team to assess the DCH user interface.
- Access to the DCH platform and associated technical consultation to PNSW software service provider to provide feedback on the potential for them to utilise the DCH to access data and / or to develop applications on the DCH platform.

Consultations were undertaken with several stakeholders both internally to PNSW and from software provides to understand use cases for the DCH and to provide feedback to the DCH team. This feedback has been used to inform the DCH4 M7 Stakeholder Consultation and IoT Forward Plan Report referenced available on the DCH project website.

In summary there DCH user interface has made great progress during the milestone report period. Users are able to login the platform and reasonably easily access and review each building's data points and data model. For general usage within the PNSW context the DCH would be accessed primarily by 'power users' who have a high level of technical understanding to undertake the following:

- Access the Apps on the platform, administer and run those apps across the data in the platform.
- Manage the data model for the buildings, such as adding zones, etc
- To manage and create API keys for service providers usage

User find accessing the DCH applications easy to access and run. An example of using a DCH M&V application for the Wagga Wagga site is shown below. M&V of energy savings following implementation of energy savings activities is an important ongoing activity as initiatives are undertaken to show actual against predicted performance.

PNSW recommended to CSIRO as part of our consultation process that visualisation of the building data model is an area that will need to improve so that users can more easily see relationships between data points and the building infrastructure. At present CSIRO buildings the data models, however over time it will become more of a requirement for users to be able to undertake this activity.

We would recommend that best practice guidelines are developed as it continues to be an issue of conjecture as to how detailed the building models and relationships continue to be.

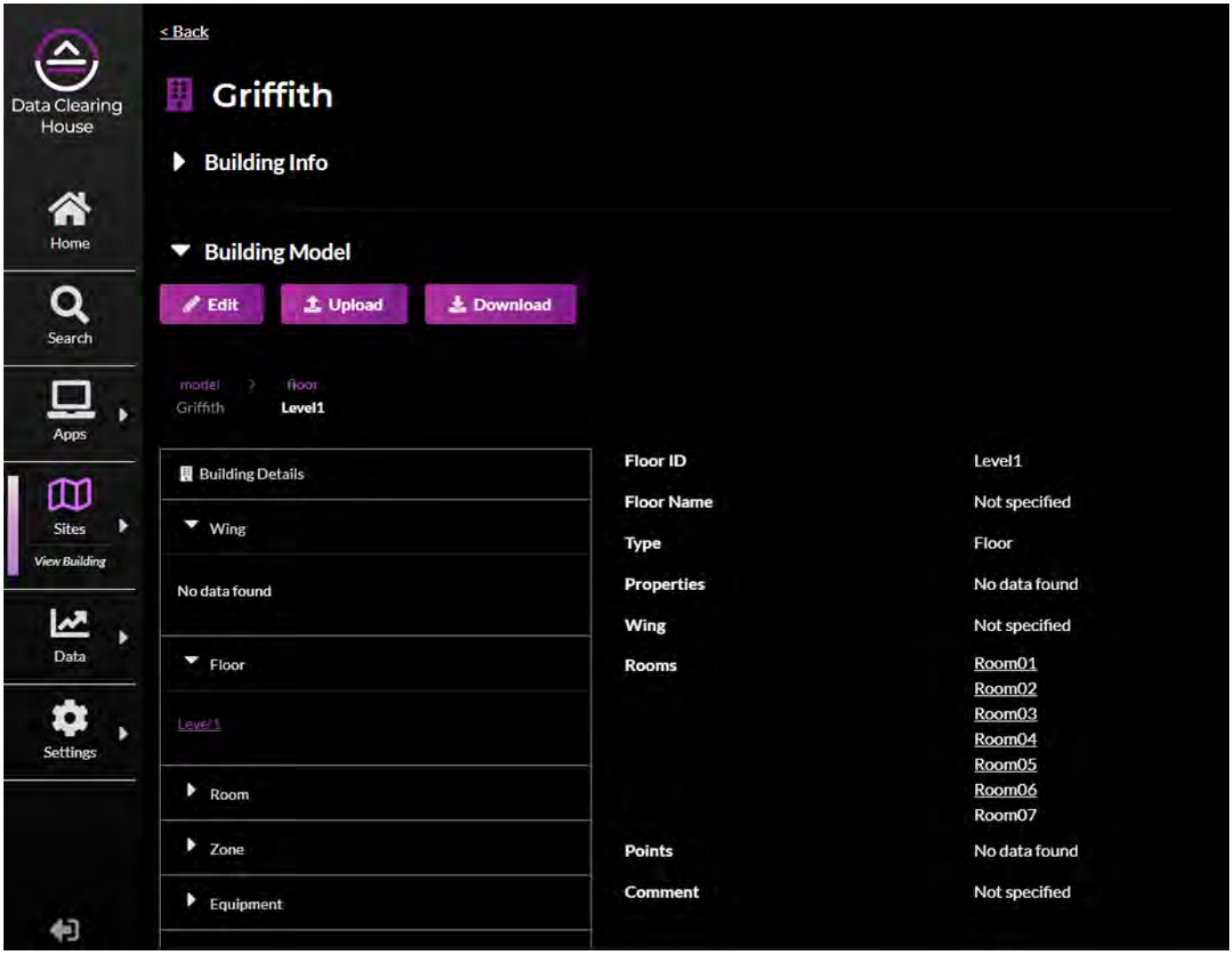

Figure 4: DCH Data Model configuration interface

PNSW engaged with both JLL with respect to their Command Centre IOT application and with a service provider to PNSW who provides ongoing energy and utility performance monitoring based on analysis of utility performance on a daily basis which are used the PNSW sustainability team to provide continuous review and management of building performance.

JLL developed the API connector to allow all data types in their IOT data platform and provided feedback that this approach was an efficient approach in terms of the software development activities and future proofed the application by ensuring data additions, deletions and changes to the IOT data platform were automatically reflected in the data feed to the DCH.

The approach taken with the JLL API meant that when six off additional buildings were added to the IOT platform the effort to onboard to the DCH allowed a rapid export of the additional data to the DCH.

A PNSW service provider reviewed the DCH platform with PNSW Sustainability team during the period November 2021 – March 2022 with the goal of addressing the following questions:

- What is the ease of getting data from DCH?
- What recommendations would you make to assist DCH in developing the platform to assist app developers?

In summary PNSW discussions with software service providers has shown that the DCH would be able to provide and alternative data source for their platforms, though further development and understanding of the interfaces is required. The wide range of data accessible through the DCH provide potential to develop performance models to integrate data such as occupancy and other BMS data to optimise energy models that assess building performance.

From a commercial perspective, software developers are likely to observe and assess whether the DCH is more widely adopted across the building space to determine their appetite to invest development resources in the data integration connectors, however the continual development of the DCH API should drive the actual costs down.

3 SUMMARY OF LESSONS LEARNT

3.1 Enterprise Level Integration using Senaps API

This aspect of the project is a key requirement to the success of the Data Clearing House project. The IOT provider for Property NSW collects a wide range of building data from various sources, including temperature, indoor air quality, occupancy and plant operating conditions from building management systems. The nature of building data is that it is dynamic with source of data being added, removed or changed in response to changing building requirements.

The choice of methodology to onboard data to the DCH using the Senaps API was driven primarily by ensuring that the method could adapt to changes on the IOT system side with minimal additional work to onboard the new or changed data. The API method using the Senaps API was preferred after careful consideration and the PNSW IOT provider developed a software application on their platform to package time series data and send to the DCH.

The process of developing the data ingestion capability in the IOT platform has highlighted the benefit of using the API approach. The DCH will benefit from the continued development of best practice guidelines for software developers to assist their development decision making.

3.2 Data Modelling Process

Semantic data modelling of the DCH received from the Property NSW IOT system contextualises data and describes relationships in a machine-readable format using the Brick schema (https://brickschema.org/). In the absence of widespread use of the schema a process of using various tools within the DCH along with an information gathering exercise for the buildings using drawings, BMS screenshots and other building services documentation. This process is time intensive and is heavily reliant on the quality and accuracy of data that is available for building, which can be challenging for older building stock.

The learning from this process is to further develop guidelines and templates for building owners and managers to provide information in a way that reduces the amount of manual handling and interpretation of data. It is also important to “right size” building models so that over complex relationships and models are not implemented for no practical benefit.

However, the continual development of the DCH API should drive the actual costs down.

4 CONCLUSION AND NEXT STEPS

The project demonstrated that the ingestion of a wide range of building data from a number of sources can be undertaken in a technically feasible and cost-effective manner. Particularly when ingesting data at an enterprise level, such as the JLL Command Centre platform the implementation of the Senaps API approach was the mode effective approach.

Consultation with users showed that the implementation of applications that CSIRO has developed on the DCH platform are reasonably simple for technically competent users to implement. The PNSW provided feedback to the SCIRO team to assist them in their ongoing development of the DCH platform. PNSW will continue to provide access to the building data to DCH to allow ongoing improvement of the analysis applications, particularly with respect to the Demand Response application at 1 Prince Albert Rd site which was somewhat frustrated by lack of conditions to allow reliable initiation of DR events at the site.

In the area of the implementation of the semantic modelling of building data relationships the development of visualisation tools to observe and configure continues to be a challenge for the industry. We recommend that the industry develop best practice guidelines to building data modelling to ensure consistency and right sizing of building data models to ensure over complexity is avoided.

Consultation with building software providers provided valuable feedback to CSIRO with respect to the adoption of DCH as the preferred data platform building analysis application development. The impact of several technical and commercial drivers will impact on these decisions and the project recommend that the DCH continues to consult widely with industry on understanding drivers impacting developers' decision making.