The Innovation Hub

for Affordable Heating and Cooling

Lesson Learnt Report

Development and experimental implementation of transactive demand response management system through open ADR-approach for institutional buildings

Project DCH5

19th Nov 2021

Swinburne University of Technology

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 Lessons Learnt Report

Guidance notes for completion of the Lessons Learnt Report:

- This report is intended to be made public.
- Please use plain English, minimise jargon or unnecessary technical terms.
- Please use your organisation's branding for the report.
- The report should meet your organisation's publishing standards.
- Please use one template per each major lesson learnt and include as many as are relevant for your sub-Project. If what you learnt is more technical, this is the section to include technical information.
- The content of these Lessons Learnt Reports can be compiled (and updated, where necessary) for inclusion in the (public) Project Knowledge Sharing Report, for submission at the completion of your sub-Project.

Lead organisation	Swinburne University of Technology		
Sub-Project number	DCH5		
Sub-Project commencement date	26th February 2021	Completion date	29th June 2022
Report date	19th November 2021		
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Lessons learnt

Lesson learnt #1	Zone centric dynamic operational schedule for HVAC control in rooms with static occupancy rates for commercial building (university context) based on the operational envelop (timetabling based) to achieve improved energy performance.

Category	*Technical*					
Choose from:	*Technical*	*Commercial*	*Social*	*Regulatory*	*Logistical*	*Other (specify)*

Describe what you learnt about this aspect of the Project.

The operational scheduling of HVAC systems during business hours (6 a.m. to 8 p.m.) is a popular control method used in commercial facilities such as Universities. However, in the case of university classrooms and conference rooms, it was found that an appropriate operating envelope existed based on information collected from booking systems. However, despite the well-defined operating envelop, the HVAC systems covering these regions were run with a constant set-point throughout the working hours, resulting in lower energy efficiency. It was determined that controlling the HVAC system based on the operational envelope of these areas with a static occupancy rate would have a considerable influence on the energy efficiency of the buildings. As a result, each microgrid (building) included in the OpenTDR framework's Local Energy Management Systems (LMES) implements a basic zone-centric operational envelop-based HVAC management. A case study including historical data from smart metres linked into the BMS system and room timetabling demonstrated a performance boost of around 60%. When this management mechanism is deployed across the building, it is anticipated that we will see a significant increase in the energy efficiency of the buildings' HVAC systems..

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

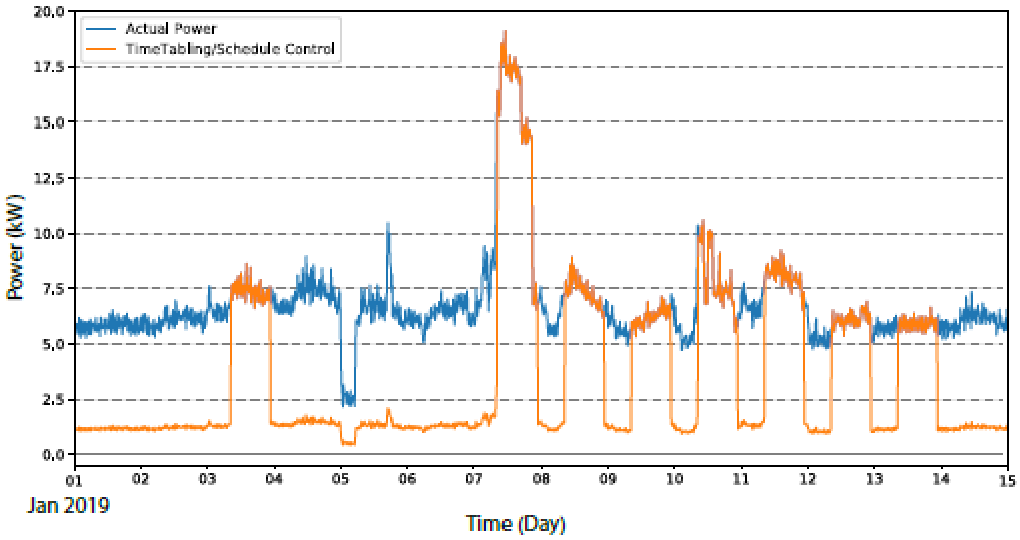
There is potential for developing a novel recommendation system that understands the energy patterns of each zone and provides an optimised recommendation for a new booking request based on the timeslot, number of participants and the previous utilisation of the zones.

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

The operational scheduling of the HVAC systems based on the timetabling envelop provides a substantial energy saving when compared to the conventional operational schedule based on working hours.

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.

A case study was conducted during the Milestone M6 with the data obtained from the BMS smart meters and the historical timetabling data for evaluating the operational envelop based zone centric HVAC control based on the timetabling and scheduling data. Results illustrated that this operational envelop based control provides an energy savings of about 60% for 15 days sample data considered from one of the smart meters in the BMSss.



Actual Energy(kW)	Energy consumption of the Operational Envelop Control (kW)	Energy saved (kW)	Percentage Reduction (%)
9197.36	3651.55	5545.8	60.3

Lesson learnt #2	Zone centric dynamic operational schedule for HVAC control in rooms with static occupancy rates for commercial building (university context) based on the occupancy and internal environmental parameters to achieve improved energy performance during transactive demand response.					
Category	Technical					
Choose from:	*Technical*	*Commercial*	*Social*	*Regulatory*	*Logistical*	*Other (specify)*

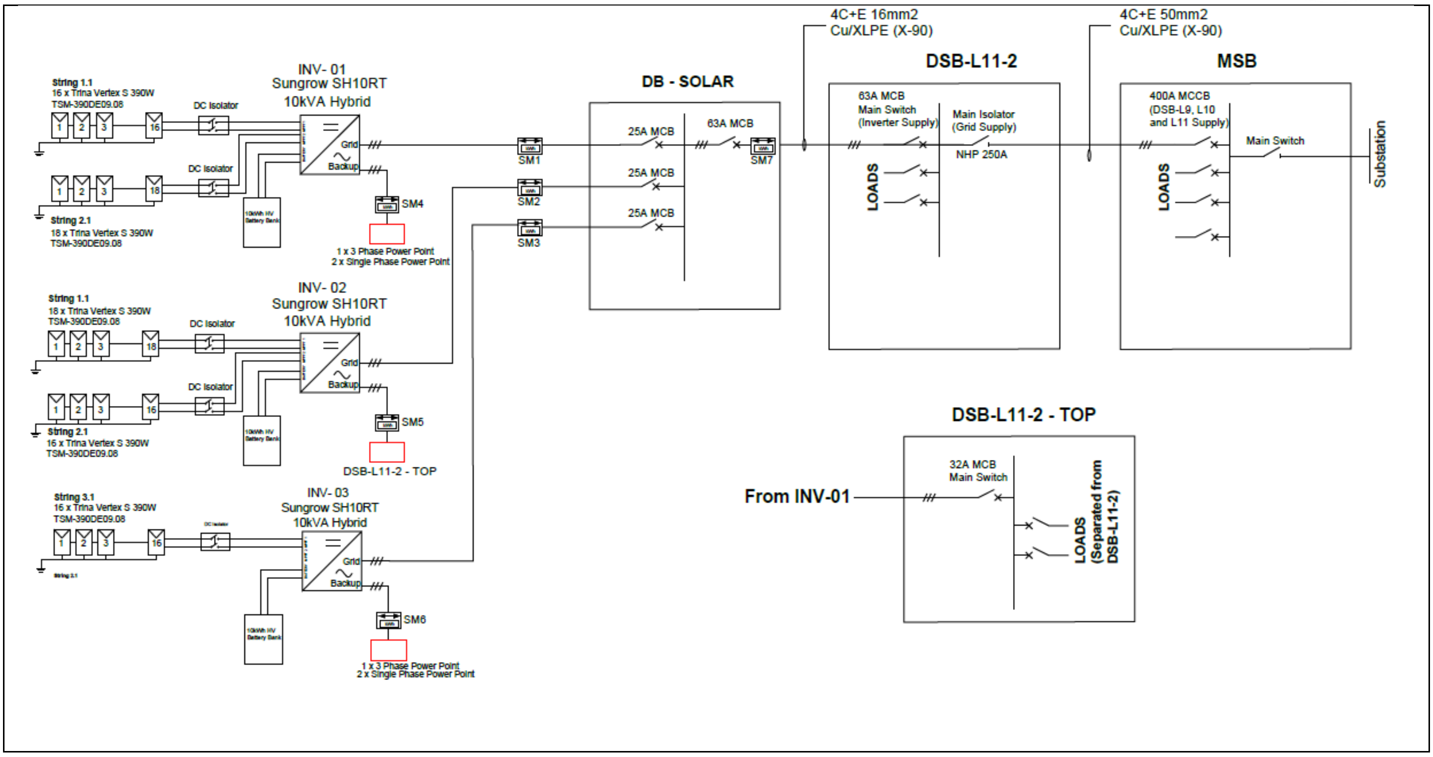
Describe what you learnt about this aspect of the Project.

Institutional buildings have a unique nature of dynamic occupancy in certain type of zones where the rate of usage is non-deterministic (private study areas and large lecture theatres). Knowing these zones and the corresponding HVAC systems help in estimating an adjustable load that can be used by the local microgrids to take part in the transactive demand response.

Please describe what you would do differently next time and how this would help. What are the implications for future Projects?
Since, the project is currently in the milestone M6, and early identification of these lessons has facilitated the implementation of the solution into the proposed OpenTDR framework. The Zone centric operational control of the HVAC systems in relation to the occupancy and the internal weather monitoring IoT devices help us device an optimized set point to adjust the load as an acknowledgement of the transactive demand response event raised within the community. This potentially increases the opportunity of the energy sharing with in the buildings/microgrids with the community to orchestrate the use of the adjustable load in response to the market situation or the forecasted onsite availability within the community.
If your Project learnings have identified any knowledge gaps that need to be filled, please state it below.
The operational scheduling of the HVAC systems based on the dynamic occupancy and inside environmental conditions provides an opportunity for the microgrid agents within the community to participate in the transactive energy demand response by adjusting the HVAC loads in the specific regions with low occupancy rate.
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.
A Case study was conducted to see the impact of the adjustable loads and the following table illustrates the results obtained after the game theory-based TDR simulation. Scenario 4 in the cases studies explained in the technical progress report explains the impact of the adjustable loads in increasing the energy efficiency of the system.

	Scenario 1		Scenario 2		Scenario 3		Scenario 4	
	Grid_sell_only (AUD/day)	Grid_buy_only (AUD/day)	CMG_sell_prioritised (AUD/day)	CMG_buy_prioritised (AUD/day)	CMG_sell_Auction (AUD/day)	CMG_buy_Auction (AUD/day)	CMG_sell_Auction (AUD/day)	CMG_buy_Auction (AUD/day)
Local storage	--		--		--		10%	
Surplus Sold to	Grid		Community		Community		Community	
Method sell	--		Fixed price		Auction		Auction	
Price	0.07$		0.11$		--		--	
CMG	89.39	0	140.47	0	150.34	0	150.34	0
ATC(MG1)	44.87	409.92	70.51	404.64	83.24	385.75	83.24	347.175
AMDC(MG2)	0	761.74	0	709.48	0	701.5	0	631.35
Total	134.26	1171.66	210.98	1114.12	233.58	1087.25	233.58	978.525
% Reduction in Expense	NA		4.9% Reduction		7.2% Reduction		16.4 % Reduction	

Lesson learnt #3	Sharing energy within the neighbourhood increases the energy efficiency.					
Category	Technical, Regulatory					
Choose from:	*Technical*	*Commercial*	*Social*	*Regulatory*	*Logistical*	*Other (specify)*
Describe what you learnt about this aspect of the Project.						
The potential of sharing the surplus energy within the community increases the market returns of the onsite energy through transactive demand response.						
Please describe what you would do differently next time and how this would help. What are the implications for future Projects?						
Since we have a regulatory limitation in terms of interconnecting the buildings which are sourced from two different substations, we were limited in the project context to have all the onsite generation installed in one building and emulate the three inverters to be considered as the three entities of the Community microgrid. The alternate method to try this simulation would be establish a separate DC line for the community to share the surplus with the other microgrids within the community.						
If your Project learnings have identified any knowledge gaps that need to be filled, please state it below.						
The knowledge gap identified in this milestone of the DCH 5 project highlights the regulatory restrictions which limit us from interconnecting building and the successful completion of the project outcome through the emulator setup would prove as evidence to advocate the changes to be done with to the legislative policies.						
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.						
The proposed emulator setup to simulate the transactive demand response in community microgrids is indicated in the following diagram.						



4C+E 16mm2
Cu/XLPE (X-90)
4C+E 50mm2
Cu/XLPE (X-90)
INV- 01
Sungrow SH10RT
10kVA Hybrid
DB - SOLAR
DSB-L11-2
MSB
String 1.1
16 x Trina Vertex S 390W
TSM-390DE09.08
DC Isolator
25A MCB
63A MCB
63A MCB
Main Switch
(Inverter Supply)
Main Isolator
(Grid Supply)
NHP 250A
400A MCCB
(DSB-L9, L10
and L11 Supply)
Main Switch
Substation
LOADS
SM1
SM2
SM3
SM4
SM5
SM6
SM7
Grid
Backup
String 2.1
18 x Trina Vertex S 390W
TSM-390DE09.08
1 x 3 Phase Power Point
2 x Single Phase Power Point
INV- 02
Sungrow SH10RT
10kVA Hybrid
DSB-L11-2 - TOP
INV- 03
Sungrow SH10RT
10kVA Hybrid
String 3.1
From INV-01
32A MCB
Main Switch
LOADS
(Separated from
DSB-L11-2)