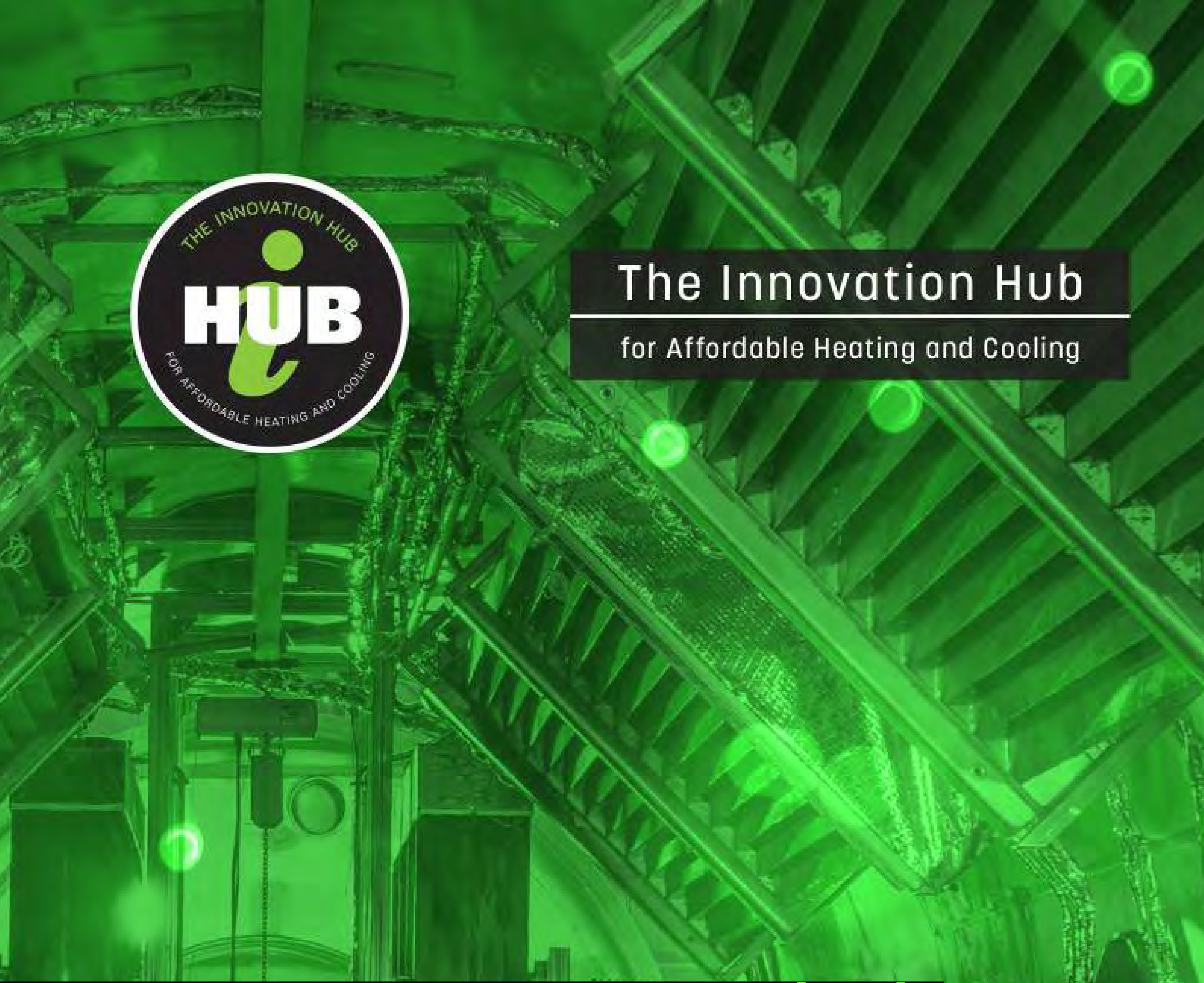


The Innovation Hub
for Affordable Heating and Cooling

Lesson Learnt Report

Subtropical and Tropical Mixed-use Buildings

Project IDS 13 and 14

20 May 2022

QUEENSLAND UNIVERSITY OF TECHNOLOGY

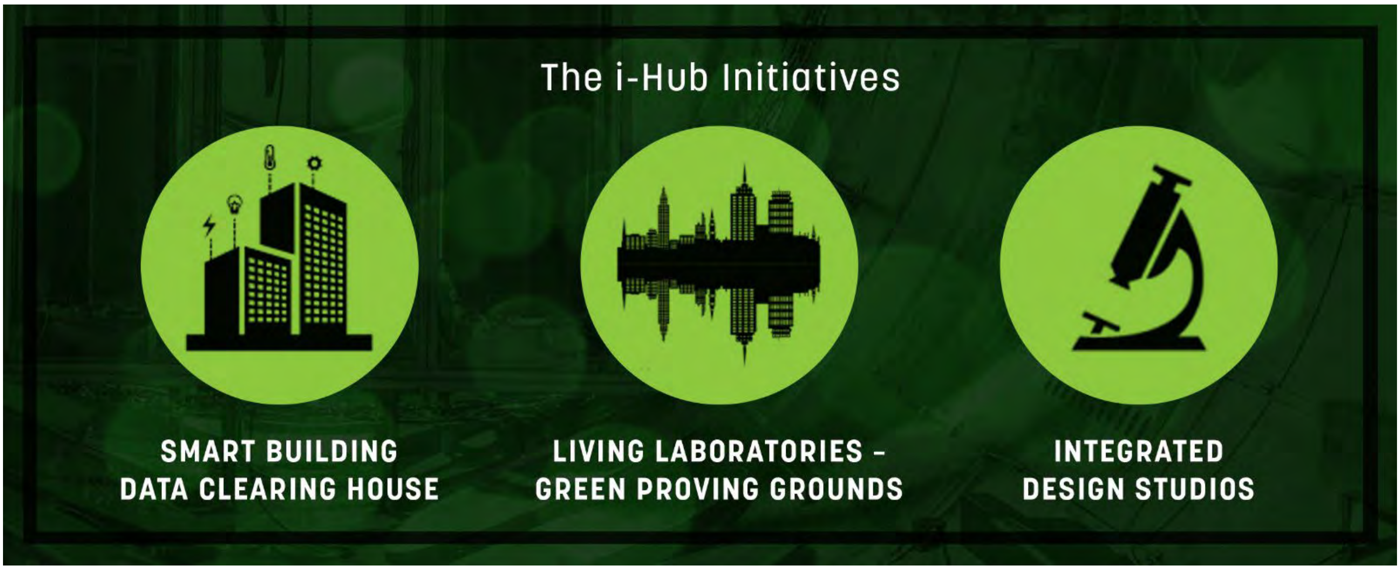
About i-Hub

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	Queensland University of Technology		
Sub-Project number	IDS 13 and 14		
Sub-Project commencement date	03/03/2021	Completion date	30/06/2022
Report date	20 May 2022		
Contact name	Wendy Miller		
Position in organisation	Associate Professor, School of Architecture and Built Environment		
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Lessons learnt

Lesson learnt #1	Co-design is a terminology that needs clarification					
Category	Other: Social / Cultural / Professional Practice					
Choose from:	*Technical*	*Commercial*	*Social*	*Regulatory*	*Logistical*	*Other (specify)*
Describe what you learnt about this aspect of the Project.						
The term ‘co-design’ appears to be understood differently by different professions. Architectural students appeared to interpret it as ‘others’ contributing to ‘their’ design, i.e. the architect being in charge of the design, and inviting input from other parties. The architect can then choose to incorporate this input or not. Non-architecture participants (students and consultants) also appeared to reinforce this idea, by seeing themselves as technical advisors or contributors to specific aspects requested by architects. These views / roles may be reflective of common practice.						
Please describe what you would do differently next time and how this would help. What are the implications for future Projects?						
In future IDS activities we would include, at the initial stage, ‘co-design’ as a terminology that needs to be discussed by participants. Participants in an IDS project would need to collectively determine how co-design will be interpreted and implemented for that particular project. Some questions that need to be resolved within an IDS team include: • Are all participants considered equal contributors to the design, albeit with different inputs? Or is there a hierarchy of designers? • Who, within the multidisciplinary team, should be the ‘manager’ of the design process? • How will decisions about inclusion/exclusion of design ideas into the overall design be made?						
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.						

Lesson learnt #2	Integrated thinking is difficult for all participants at the early stage where no building form is yet determined					
Category	Other: Professional Practice					
Choose from:	*Technical*	*Commercial*	*Social*	*Regulatory*	*Logistical*	*Other (specify)*

Describe what you learnt about this aspect of the Project.

Both architecture and non-architecture participants experienced difficulty in approaching energy efficiency, renewable energy, HVAC and sustainability (ESD) considerations and options at the initial phase of the project (prior to the emergence of any building form). It may be that engineering and ESD professions typically provided input at a later stage of design development, and that architects first want to consider building form (before function). This presents a challenge to the IDS goal. This challenge was also exacerbated by the very different levels of technical knowledge between architecture, engineering and construction management students; and between students and academic/industry professionals.

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

For future IDS projects within a university setting, it would be beneficial to first address the knowledge gap in architectural science and building services, by providing units/subjects that could be undertaken by students in architecture, engineering or construction management degree programs.
It would also help to break the IDS 'whole of project' concept into discrete segments, so that inexperienced (early career) professionals can focus on one aspect at a time, rather than trying to integrate all requirements into a single project. For professional practice, there may be a need for some interdisciplinary workshops to determine ways in which design concept can emerge collectively prior to building form being established.

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.

Lesson learnt #3	Procurement methods can inhibit or support integrated design					
Category	Commercial (contract management)					
Choose from:	*Technical*	*Commercial*	*Social*	*Regulatory*	*Logistical*	*Other (specify)*
Describe what you learnt about this aspect of the Project.						
All building projects are subject to a procurement contract of some sort (e.g. fixed price contracts such as lump sum or Design and Construct; or collaborative contracting such as early contractor involvement or managing contractor). Integrated Project Delivery (IDP) contracts appear to be best aligned with the integrated design objectives and process, particularly an Alliance Contract.						
Please describe what you would do differently next time and how this would help. What are the implications for future Projects?						
For IDS projects within a university setting, we would advise that the participant team establish an IDP Alliance Contract – both as a means of agreeing to roles, responsibilities, values and shared risks; and as a means of emulating what could be industry 'best practice'. For industry application: it would be helpful for professional bodies (e.g. Australian Institute of Architects; Engineers Australia and Australian Institute of Builders) to examine some emerging Alliance Contract forms (from the UK) and collectively develop Australian appropriate contract templates that can be used to enable integrated design to occur from a commercial and legal perspective.						
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.						

Contracting Models	Typical Outcomes
Traditional methods (e.g. fixed price contracts such as; lump sum, D&C, EPC)	• Contractor incentivised to submit a bid based on incomplete information, leading to perverse outcomes (exclusions, change orders, hidden exclusions); • Often results in cost (and time) overruns; • Parties attempt to transfer risks.
Collaborative Contracting (e.g. early contractor involvement (ECI), and managing contractor (MC))	• All parties given an incentive to see a project succeed; • Flexibility to cater for different levels of collaboration, and associated adjustments to price and risk; • Non-adversarial approach; • Shared liability; • Potential cost savings to all parties (not likely for small projects); • Contractor margins may be lower (but profit-sharing opportunity may be higher); • Contract establishment costs may be higher initially (but reduce with increased corporate learning).
Integrated Project Delivery (IDP) (In its pure form, a single, multi-party contract between owner, general contractor and designer/s)	• All parties accept, manage, and share design and construction risks; • Financial risks and rewards shared through an agreed profit/incentive pool based on quantifiable project outcomes; • Establishes individual and group accountability; • Encourages candid communication; • Cost dictates design; • Cost and design validation and optimisation happens as opportunities arise; • Coordination enhanced through use of BIM (for design coordination) and Project Management Information System (PMIS).
Sample Contracts to support Integrated Design	
NEC4 Design, Build and Operate Contract (DBO)[1]	• A contract for an integrated whole-life delivery solution; • Suitable for contracts extending into operational phase.
NEC4 Alliance Contract (an IDP type contract)[2]	• Multi-party contract for projects requiring deep collaboration between all project partners; • All partners have an equal voice; • Values shared performance instead of individual performance.

[1] https://www.neccontract.com/NEC4-Products/NEC4-Contracts/NEC4-Design-Build-and-Operate-Contract
[2] https://www.neccontract.com/NEC4-Products/NEC4-Contracts/NEC4-Alliance-Contract

Lesson learnt #4	Mixed-Use Buildings present design challenges					
Category	Technical / Regulatory / Social					
Choose from:	*Technical*	*Commercial*	*Social*	*Regulatory*	*Logistical*	*Other (specify)*

Describe what you learnt about this aspect of the Project.

Mixed use building typologies present a number of challenges for achieving net zero energy, such as:

- There is no 'business as usual' (BAU) energy use intensity (EUI) data for this building typology. BAU estimation requires obtaining average EUI data for each of the building classes expected to be incorporated into the mixed-use building. Current and relevant data can be difficult to obtain.
- Spaces within a mixed-use building can be used for different purposes, and b different classes of buildings, over time. This means that measurement of energy performance against BAU becomes even more problematic
- There is no clear methodology for allocating energy consumption and generation data (whole and parts) for mixed-use buildings, making it difficult to assign energy consumption costs, renewable energy benefits and demand response capability (who pays, who benefits, who decides?). This presents challenges for setting and meeting net zero carbon or net zero energy goals.
- Mixed-use buildings that incorporate residential services present a unique problem in that the building is both a home and a workplace, creating additional challenges relating to HVAC technology selection, system sizing, design and operation

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

It would be helpful to gather data on EUI of all building classes. Some helpful data may include

- EUI for office tenancies from NABERS FY2020 ratings (excluding outliers), as reported in *Determining office tenancies energy end use*. Final Report June 2021. Energy Efficiency Council. www.eec.org.au
- average energy intensity of retail tenancies (2012) as reported in *Baseline Energy Consumption and Greenhouse Gas Emissions in Commercial Buildings in Australia. Part 1 – Report*. November 2012. Council of Australian Governments (COAG) National Strategy on Energy Efficiency

However the currency of the data is also important. For example, if using the 2012 report mentioned above, a discount (percentage improvement in efficiency) may be feasible to apply, reflecting changes to the market and regulations and technology availability. The EUI for each class needs to be agree by ID participants, and applied to each relevant area of the proposed design, to obtain a more accurate estimation of site energy consumption.

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.

Lesson learnt #5	A set of design principles could be beneficial					
Category	Other: design process; professional practice					
Choose from:	*Technical*	*Commercial*	*Social*	*Regulatory*	*Logistical*	*Other (specify)*

Describe what you learnt about this aspect of the Project.

Mixed-use building typologies is complex; designing for net zero energy or net zero carbon goals is complex; and the integrated design process can be considered complex. A set of guiding principles could be helpful in fleshing out the process while keeping focus on the core goal/s. A good starting point is the Factor Ten Engineering Design Principles, developed by the Rocky Mountain Institute over a decade ago. Factor Ten Engineering demonstrated that very large energy resources savings (a factor of 10) could be profitable through transforming design and engineering practice via whole-system thinking and integrative design. These principles were used as a basis for proposing design principles for net zero carbon buildings.

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

Future integrated design studios / projects could start with an examination of the proposed principles, and modification to suit the specific context. This could help to focus the attention of the collaborative design team on the core objective, and to assist in the ID process.

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.

Design phase	Factor 10 Engineering Design Principles	Integrated Design Principles for Net-Zero Energy Buildings
Before design starts	**1.** Define shared and aggressive goals	Establish a clear, shared, ambitious NZE goal and timeframe for achieving that goal. Consider including other related goals, such as resilience, adaptation, grid autonomy. Determine KPIs that reflect the goals, including ambitious energy efficiency.
	2. Collaborate across disciplines	Convene a transdisciplinary design team (e.g. engineers, architects, construction contractor, building owner/manager/occupants, ID specialist/facilitator) with diverse skills and experiences.
	3. Design nonlinearly	Avoid the linear march through traditional design phases (project objectives and aspirations; design concept development; master planning; design development; feasibility evaluation). ID is iterative, with successive stages informing earlier ideas.
	4. Reward desired outcomes	Implement an Integrated Project Delivery contract that rewards teams for meeting KPIs and providing savings, rather than producing documents.
Focus on the right problem	**5.** Define the end-use	Understand the purpose of the building and the needs of the people who will occupy it. What energy services will be required and what environmental, regulatory, technical and social contexts are likely to exist over this period?
	6. Seek systemic causes and ultimate purposes	Push past end-uses (e.g. HVAC), resulting services (e.g. comfort) and ultimate benefits (e.g. health, productivity) to understand the full range of ways to fulfill the purpose/s.
	7. Optimise over time and space	Take a whole-of-life approach to designs and their consequences (i.e consider current and future occupants and environmental context).
	8. Establish baseline parametric values	Establish BAU benchmarks for the KPIs, and whole-system, lifecycle value of savings (e.g. in kWh, kW, CO2e, HVAC kVa, PV kWp etc)
	9. Establish the minimum resource theoretically required, then identify and minimise constraints to achieving that minimum in practice	Use science and the plethora of simulation and modelling tools available to determine the theoretical minimum amount of energy needed to provide the energy services (especially HVAC). Consider how far each practical design constraint (e.g. cost, safety, performance, accessibility) moves away from that theoretical minimum.
Design Integratively	**10.** Start with a clean sheet	Don't start with a familiar or previous design or conventional assumptions or methods. Start afresh with no preconceptions.
	11. Use measured data and explicit analysis, not assumptions and rules	Question all rules of thumb and assumptions. Require all proposed design options to demonstrate performance against the KPIs.
	12. Start downstream	Establish a hierarchy of approaches: super energy efficient building envelope (design and materials), building services (technologies and controls), and renewable energy (generation, storage, control). This will produce compounding savings upstream.
	13. Seek radical simplicity	Simplify systems and components, valuing passive solutions over active solutions wherever possible
	14. Tunnel through the cost barrier	Think beyond current benefit:cost evaluations and minimum performance standards. Incorporate whole-of-life, total cost of ownership, and non-monetary value evaluations
	15. Wring multiple benefits from single expenditures	Create enhanced value by ensuring each part, subsystem or system provides multiple benefits.
	16. Meet minimised peak demand; optimise over integrated demand	Optimise energy systems to meet the diverse annual and seasonal conditions (use and generation), and implement control strategies to minimise or shift peak demand and optimise self-consumption
	17. Include feedback in the design	Incorporate technologies (e.g. integrated BMS, EMS) and processes (e.g. post occupancy evaluation) to inform design success and future designs.