Final Sub-Project Knowledge Sharing report

IDS-09 Lightning Ridge LALC Multi-Purpose Building – Knowledge Sharing Report

Project – IDS09

27 May 2022

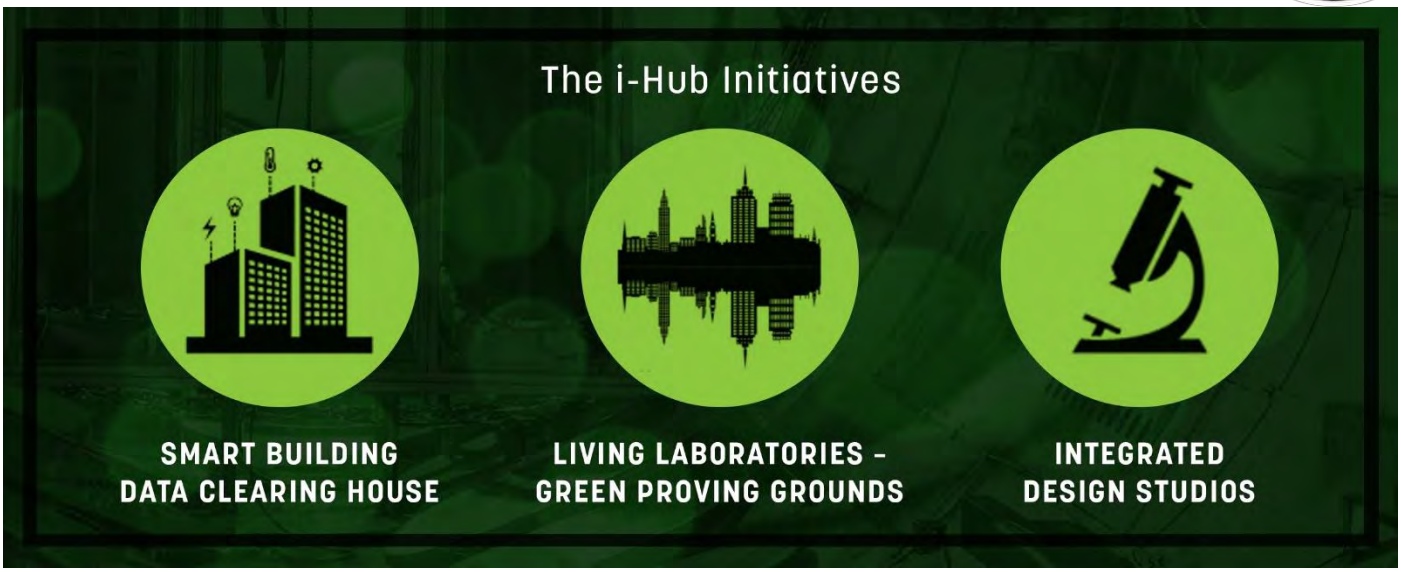
The University of Wollongong

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.



Final Sub-Project Knowledge Sharing Report

This report is produced at the completion of each IDS sub-project and captures the breadth of activities and information produced in the sub-project including studio logistics. It makes use of cross referencing the individual reports produced in each sub-project rather than repeating information wholesale.

Lead organisation	University of Wollongong		
Sub-Project number	IDS09		
Sub-Project commencement date	29th July 2021	Completion Date	27th May 2022
Report date	25th May 2022		
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Important Note: The Integrated Design Studios build upon the findings and lessons learned obtained from previous IDS's undertaken at University of Melbourne (UoM), Queensland University of Technology (QUT) and University of Wollongong (UOW), on exploring the interactions between architectural and engineering students. Due to the cumulative nature of the research and lessons learned, there is a degree of repetition witnessed in the reports. To improve readability (particularly for those reading multiple IDS reports), any information of a general nature and similar to knowledge shared in other IDS knowledge sharing reports will be highlighted in a greyed-out background (as show here).

Additionally, cumulative research, learnings, and outcomes associated with IDS09 are interrelated with the learnings and outcomes of IDS12 (due to both IDS's running in parallel). For this reason, any overlapping results between these IDS streams will be highlighted in a blued-out background (as shown here).

1. Sub-Project overview, objectives and importance to market/industry

The overall objective of the integrated design studio activity is to examine how integrated design occurs on case study projects with outcomes on two fronts:

Enabling of Integrated Design

Significant cultural barriers exist in the design of sustainable buildings in relation to achieving the high technical performance required in tandem with the architectural building amenity desired. The root cause of many of these barriers is the relationship of the engineering and architectural disciplines in the design environment. The integrated design studio programme has been designed to study how to best overcome these barriers.

Much has been written on how to achieve integrated design and yet its realisation in practice is often ad-hoc or poorly executed. The integrated design studio program tests best practice integrated design methodologies in a working design environments. The methodologies trialled are refined through subsequent design studios.

The 'i-Hub IDS-KS Catalyst for Integrated Design' document provides the most up to date iteration of the integrated design methodology to be trialled in the IDSs (refer Section 4 for more detail).

The focus of the studios is on mobilising both engineering and architectural input into the conceptual ideation stages of project formation. Renewable energy and zero carbon are used as target outcomes. Concentrating on this key stage in the design of projects creates maximum downstream impact.

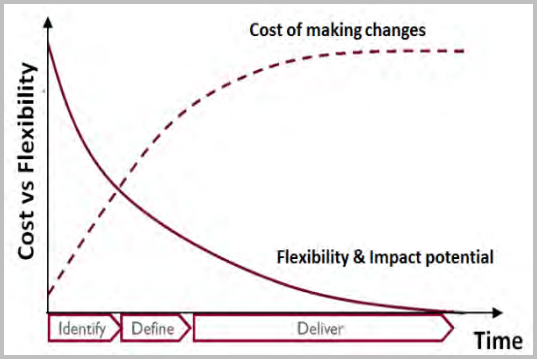

Figure 1 – Decision value: opportunity with time

Building Typology Analysis (Mixed-use)

The IDS-09 Lightning Ridge Local Aboriginal Land Council (LALC) Multi-Purpose Building Integrated Design Studio investigates design innovation to reduce net energy consumption of a proposed multi-purpose community centre to be constructed in central Lightning Ridge, to be owned and operated by the Lightning Ridge Local Aboriginal Land Council (LRLALC). Over a 13-week period, a group of multidisciplinary students, consultants and academics worked collaboratively to develop several design proposals for the client (The Dr. Steve Burroughs Foundation) who is acting on behalf of the LRLALC. These designs will be conscious of the land councils concern towards environmental impact and energy usage, while also promoting inclusion within the community of Lightning Ridge and incorporating indigenous design principles.

The indigenous community are concerned around the effect of climate change, and the contribution that they may have on the environment now and into the future. Any development involving the land council is required to be conscious of these factors, while also being of benefit to the Lightning Ridge community at large. Lightning Ridge, being a small, rural town in northern NSW, largely relies on income generated through tourism to help sustain the community. The proposed multi-purpose building can assist with this by offering commercial opportunities to generate revenue, while also increasing employment opportunities for those living in the surrounding region.

Based on the brief provided by Dr. Steve Burroughs, studio participants explored novel approaches to address the environmental concerns of the land council with the aim to achieve a net-zero carbon solution through inclusion of renewable energy technologies, efficient building strategies and building materials. Considerations were given to capital versus operation and life cycle costs, while also being mindful of the limited capital available for development, and the limited variety of construction materials in the surrounding region.

The key partner organisations involved in developing, overseeing, assessing and reporting on IDS-09 were:

Dr. Steve Burroughs Foundation – Client representative

E-lab Consulting – ESD consultant

MI Engineers – Structural engineering consultant

Northrop - Structural engineering consultant

Edmiston Jones– Architectural consultants

The University of Wollongong – Academics from both the Sustainable Buildings Research Centre (SBRC), and the School of Civil, Mining, Environmental and Architecture Engineering. A diverse range of students were involved in the design studios, including a mix of 2nd, 3rd and 4th year Bachelor of Architectural Engineering, Civil Engineering and Environmental Engineering Students.

AIRAH – The Australian Institute of Refrigeration, Air Conditioning and Heating.

IDS-09 was initiated in Semester 2 2021 (29th July) with semester work running for 13 weeks until the middle of November 2021. Following the studio, the consultants completed a vetting process, extracting relevant design ideas produced throughout the studio, examining them for potential performance improvements against the buildings energy business as usual (BAU) baseline. The conclusion of this analysis was output into a vetting report (IDS09 Lightning Ridge LALC Vetting Report), attached as an appendix with the final design studio outcomes report (IDS09 Design Studio Outcomes Report 100%).

Figure 2: Extract of Student Work – Lightning Ridge LALC Multi-Purpose Building Design Concept

2. Challenges experienced and how these were overcome

Some challenges were experienced in the setup and delivery of the studios. These challenges and the strategies implemented to overcome these are outlined below:

1) **Logistical issues for studio development.** Initial delays experienced at studio inception in addition to an outbreak of Covid-19 resulted in an inability to obtain an executed agreement with the sub-project client. This similarly impacted the ability of studio facilitators and project partners (client and consultants) from developing preliminary studio content to provide to studio participants. However, unlike previous studios, ethics application was submitted ahead of schedule and approved prior to studio commencement. The final impact of these factors was felt to be minimal, though to mitigate any similar impacts in future projects, where possible agreements should be sought well in advance of studio commencement, with content being developed in preparation for delivery to participants prior to studio commencement.

2) **Engagement of participants.** An outbreak of Covid-19 required a transition to 100% remote delivery options for students, client, consultants, and studio tutors. This allowed students to participate within the studios, but only in a remote setting, presenting limitations to the level of engagement. Alternate methods of communication were introduced in an attempt to improve engagement (both with consultants and tutors, but also between student teams) and minimised the effects associated with remote learning. This is further discussed in Section 4 of the outcomes report (IDS09 Design Studio Outcomes Report 100%).

3) **Communication hesitancy limits outcome development**. Utilisation of the framework established through previous design studios was found to be very successful, allowing participants to progress their design in a logical manner which built upon the findings of the previous work. However, initial communication hesitancies slowed preliminary design development, which ultimately delayed and limited the final designs presented by participants. Some relaxation of submission times was afforded to participants, allowing for greater detail in submitted reports. Extended studio lengths may see further outcomes, however, the outcomes achieved were still considered to be a great success, with participants gaining greater insights into integrated design practices. This is further discussed in Section 4 of the outcomes report (IDS09 Design Studio Outcomes Report 100%).

4) **Flexibility of design opportunities.** A greenfield site provided students many opportunities to explore sustainable design initiatives, both through passive design strategies and operational/technological improvements. However, the inexperience of many participants became evident, particularly in earlier stages of the design, with the multitude of opportunities proving to be overwhelming for students. Consultants were able to step in and provide renewed focus, allowing students to prioritise solving one challenge before moving to another, narrowing student scope temporarily in an effort to minimise confusion. Studios, while providing a safe environment for students to explore design opportunities, need to be mindful of the participant education and experience, and tailor outcomes accordingly. This is explored further in the lessons learned report (IDS09 Lessons Learned Report), with further information found in the outcomes report (IDS09 Design Studio Outcomes Report 100%)

5) **Consultant employment transitions**. While participating consultants were integral to the operation of the studio with contracts ensuring their involvement having been executed, this did not prevent consultants from changing professions or employers throughout the studio. One consultant left the employ of a consultancy later in the studio (approximately 10 weeks in), though continued to participate in the studio due to their belief in the great opportunity provided to the participants. Another consultant changed employers earlier in the studio, however an agreement was able to be organised with the new employer, confirming the consultants' ongoing involvement. While it is difficult to mitigate these potential challenges, they are worth considering when vetting potential participating consultants.

3. Summary of lessons learnt and Evaluation of the Sub-Project impact and technology

Technical and social learnings were attained through conducting the design studio, relating to both the integrated design process, and the building typology. These learnings are detailed further in the lessons learned report (IDS09 Lessons Learned Report), and also explored in the outcomes report (IDS09 Design Studio Outcomes Report 100%). A summary of these lessons learned are outline below:

Key Lessons Learned

Note: The lessons learned outlined below were attained through conducting IDS09 and IDS12 in parallel, so some lessons learned relate to both studios. Additional lessons relating to other IDS's can be found in their respective lessons learned reports.

- Unrestricted design opportunities can overwhelm inexperienced designers.
- Misconception of client responsibilities and perceived IDS outcomes.
- Online working environments are less effective than in person design development sessions.

This integrated design studio evaluated the Lightning Ridge LALC Multi-Purpose Building, a greensite development located within the township of remote Lightning Ridge. It was found that integrated design can be successfully implemented for the associated building typology (mixed-use structures). The following summarises the implemented initiatives to achieve this successful design. Further details of these designs can be found in Sections 5 and 6 of the outcomes report (IDS09 Design Studio Outcomes Report 100%), with additional assessment of the designs found in the consultant vetting report (IDS09 Vetting Report)

Lightning Ridge LALC Multi-Purpose Building (Greenfield Site)

- Passive design measures
    - Sustainably sourced and reclaimed materials (e.g. local cypress timber, rammed earth walls, etc.)
    - Internal/external green wall and green roof
    - Solar irradiance and thermal mass (e.g. Trombe wall)
    - Improved glazing solutions (e.g. window films, double/triple glazing, etc.)
    - Exterior and interior shading
    - Geothermal heating/cooling
    - Natural and mixed-mode ventilation strategies (e.g. malqaf, solar chimneys, etc.)
- Active design measures
    - Building Management System (BMS)
    - Efficient HVAC systems paired with Energy/Heat Recovery Ventilation (ERV/HRV)
    - Photovoltaic systems and energy storage (e.g. battery storage, phase change material)
    - Efficient appliances and lighting strategies
    - Low-cost air circulation (i.e. ceiling fans)
- Other design measures
    - Proximity of gendered bathrooms
    - Functionality of commercial spaces
    - Façades which recognise indigenous artistry, history and culture
    - Separation of commercial and office spaces and their security

Sub-Project Impact (linked to studio planned objectives)

Overcome discipline prioritisation and broader opportunities for the Lightning Ridge LALC Multi-Purpose Building: The collaboration with the Dr. Steve Burroughs Foundation was key in better understanding the technical operational requirements and functionality associated with their prospective building, while also gaining greater insights into the cultural inclusions and sensitivities for working with an indigenous stakeholder in a remote community. The client brief primarily focused on the functional inclusions associated with the typical daily operations of the building, with little information provided as to the technical operations (i.e. energy usage, comfort bands, etc.). Though these operational targets were not specified, student participants considered active systems (i.e. HVAC) in conjunction with passive solutions to maintain thermal comfort while attempting to reduce energy demand, in keeping with the carbon abatement aspirations of the indigenous stakeholders.

Opportunities for both passive and active measures to achieve a reduction in energy consumption: The examination of strategies undertaken throughout the design studio identified a number of both passive and active measures which may be implemented within the multi-purpose building to reduce energy consumption in keeping with the brief. An apparent focus on passive design solutions was witnessed, which may have been due to the shortage of mechanical engineers participating within the studio, however this may also be due to the opportunity of working on a greenfield site, with the potential to incorporate many passive design solutions during construction (as opposed to retrofitting).

Benchmark and test concepts developed against current industry standards identifying ideas worthy of further investigation and development: Student participants developed a business-as-usual (BAU) energy baseline to measure the impact of different technological and strategic inclusions, to measure how they reduce the overall operational energy demands of the building. These were developed using energy data of similar case study building typologies (or a combination of typologies) for the same (or similar) climatic regions to that of Lightning Ridge. These results were aided by computer models, used to simulate the approximated annual energy usage as well as the Renewable Energy Fraction. These simulations were able to assess a variety of active and passive solutions considered within the designs, providing more reliable estimations for consideration by the client.

Contribute to the knowledge and development of the IDS process being developed and facilitated by i-Hub: The studio successfully examined designs suitable to the client brief for the Lightning Ridge LALC Multi-Purpose Building, contributing valuable findings to the integrated design process. This is further elaborated in the lessons learned report (IDS09 Lessons Learned Report) and outlined in Section 4 of the studio report (IDS09 Design Studio Outcomes Report 100%).

Maximise the local use of on-site renewable energy: Findings from this sub-project fed into the establishment of a 'Carbon Catalogue' where the IDS team will consolidate benchmarks related to different technologies in the context of a range of different project types. In return, this will inform the 'Knowledge Sharing' aspect of this project stream, as each sub-project will have an impact on the wider IDS program.

In addition, the design of the projects specifically requested the quantification of the impact every design change will have on the hourly Renewable Energy Fraction (REF) of the building.

4. Links to reports

The following reports were developed for public sharing while undertaking IDS09, and relate primarily to lessons learned, project outcomes, and knowledge dissemination. All reports have been provided directly to i-Hub, with the titles being linked to the most up-to-date version of the associated report.

Note: Any supplementary report titles which are not linked were submitted to AIRAH alongside this knowledge sharing report and will be uploaded along with this report to the AIRAH website for public dissemination.

IDS-09 Supplementary Reports

- **i-Hub IDS-09 Design Studio Outcomes Report 100%:** This report contains the primary lessons learned and outcomes of the Lightning Ridge LALC Multi-Purpose Building Integrated Design Studio. This report includes select examples of student work and the consultant vetting report. Additional feedback obtained from participating consultants, the client, and students is also contained, with an assessment of this feedback and conclusions regarding studio outcomes.
- **i-Hub IDS-09 Lessons Learnt Report:** This report highlights the key lessons learned through conducting the design studios.
- **i-Hub IDS-09 Consultant Vetting Report:** This report was completed by participating consultants, providing their assessment of the work completed by students, summarising and assessing the strategies and technologies implemented within student designs. Consultants also provided recommendations on initiatives worthy of consideration to further develop these projects.
- **IDS-KS-MA07 Applying an integrated design approach to improve the match between renewable energy supply and building energy demand**. Article to be published in July/Aug 2022 edition of Green Review magazine.

Related material of interest produced in wider IDS activity

- **i-Hub IDS-KS Catalyst for Integrated Design v3.0:** Live integrated design methodology document (updated with learnings from each successive IDS).
- **i-Hub IDS-KS Net Zero Carbon Catalogue:** Final outcomes of Integrated Design Studio's, incorporating a summary of all findings and recommendations based on lessons learned.
- **IDS-KS JP01 – Fostering integrated design in an academic environment: Process and a method**: Journal paper manuscript.
- **IDS-KS JP02- IDS: An integrated design approach for architect/engineer education using Zero Carbon targets**: Journal paper manuscript – note: not accessible publicly until published due to Journal IP restrictions. Link to be provided at that time.
- **IDS-KS MA01 What are we doing about integrated design:** PDF of published article in Ecolibrium August Issue.
- **IDS-KS MA02 Building Performance Attributes:** Article content (pending publishing).
- **IDS-KS MA03 Urge to Merge** PDF ~~of~~ published article in Ecolibrium May 2020 issue.
- **IDS-KS MA04 Interesting Tension** PDF ~~of~~ published article in Ecolibrium Jun-July 2021 issue.
- **IDS-KS MA05 Low Energy Design** PDF published article in Ageing Agenda Nov-Dec 2021 issue
- **IDS-KS MA06 Helping to build a greener future, together.** Published in Wollongong City Council Newsletter 7/Jan/2022.
- **IDS-KS-MA07 Applying an integrated design approach to improve the match between renewable energy supply and building energy demand**. Article to be published in July/Aug 2022 edition of Green Review magazine.
- **IDS-KS i-hub summit I_IDSs**: YouTube recording of IDS June 2020 webinar series.
- **IDS-KS i-hub summit II_IDSs**: YouTube recording of IDS December 2020 webinar series.
- **IDS-KS i-hub summit III_IDSs**: YouTube recording of IDS June 2021 webinar series.

- **IDS-KS i-hub summit IV_IDSs**: YouTube recording of IDS November 2021 webinar series.
- **IDS-KS i-Hub Symposium IDS's**: YouTube recording of IDS November 2021 webinar.
- **IDS-KS i-Hub summit V_IDS's:** YouTube recording of IDS May 2022 webinar.

5. Applicability beyond current contract.

The sub-project outcomes are envisaged to have the following applicability beyond the current contract:

- **Catalyst for Integrated Design document:** This document will be able to be used by industry in establishing integrated design practices within projects and establish integrated design environments within the workplace. Note that the current version has already been requested by and provided to individuals in industry.
- **Studio Outcomes Report:** May be freely downloaded by any individuals within the building industry looking to incorporate more sustainable features within their own mixed-use structures. Findings will also be relevant to projects with an indigenous client, partnering with indigenous groups, looking to incorporate indigenous design principles, or designing and constructing in a remote setting. Learnings from this report will also be incorporated into an IDS activity wide report planned to be produced as a compendium of integrated design findings across the various building typologies explored.
- **Carbon Catalogue:** Results from the project vetting will feed into a *Carbon Catalogue* per building typology that draws on the benchmarking undertaken by the IDS team and participating consultants.
- **Consultation with Industry:** It is anticipated that relationships developed between the IDS research team and consultants will continue to be beneficial into the future and may develop into other educational or research endeavours.
- **Publications:** Further publications of the integrated design studios or integrated design process are anticipated to follow well into the future, utilising the findings of the various studios undertaken throughout the i-Hub IDS program.
- **Integrated Design Studio Framework:** The integrated design studios have been welcomed by clients and participating consultants and have been received positively by student participants. This framework has been implemented in further integrated design studios outside of the i-Hub Integrated design studio program in tertiary education learning environments at University of Melbourne (UOM), Queensland University of Technology (QUT) and University of Wollongong (UOW). This framework may also be implemented within industry technical workshops to further develop interdisciplinary understanding and improve integrated design practices.
- **Professional development opportunities:** It was highlighted by both clients and consultants that experiential knowledge obtained by participating students make them more desirable in professional development programs (i.e. work placement, internships, traineeships, etc.) and in graduate positions. Both client and consultants indicated that in future they will be looking to employ or train students who have participated in these development programs.

6. CONCLUSIONS

Conclusions of the integrated design process

Progress of the studio was observed by the IDS team over the course of the 13-week period, noting the development of the younger participants and their respective designs. A well-defined framework of the integrated design process was found to be essential, guiding the student designers in advancing their respective designs. Additionally, feedback provided by clients, consultants and studio tutors was found to provide additional clarity and insight, allowing student participants to significantly improve their designs.

Design complexity in combination with a shorter timeframe has been a limiting factor impacting project outcomes, however through establishing guiding frameworks (i.e. successive deliverable submissions) and effective evaluation metrics, overcoming these limitations is possible. The incorporation of experienced consultants assist in guiding students toward achievable outcomes. Building typology and inexperience also affect desired outcomes, with project deliverables requiring tailored solutions so as to achieve improved results. Additionally, communication with the client is imperative to outline the detail and quality of the final deliverables.

Ultimately, integrated design practices and solutions have been identified as highly beneficial to both the student participants (i.e. gaining experience) and the client (i.e. identifying sustainable initiatives for their project examining more than just technological solutions), with consultants also benefiting from their involvement in the design studios (working in a multidisciplinary environment, networking with likeminded individuals, and identifying prospective students for workplace opportunities).

Integrated design is not an easy process to implement, with many different participants required to make it possible, all with the necessary skillsets, passion and motivation to achieve the desired outcomes. While this process can be time consuming, costly, and challenging, everyone involved within the process (participating consultants and the client) benefit from improved interdisciplinary communication and sympathetic design competencies, with the final design having improved operational and thermal efficiencies with a reduction in energy demand and operational carbon.

Summary of building typology learnings

A reduction in energy consumption and carbon abatement was found to be possible for the greenfield development of the Lightning Ridge LALC Multi-purpose building while keeping with the aspirations of both the client (Dr Steve Burroughs Foundation) and the owner/operator of the building (Lightning Ridge Local Aboriginal Land Council). Solutions investigated by the students were shown to successfully reduce energy consumption, with the consultant vetting report confirming that a saving of greater than 25% of operational carbon was possible. Additionally, it was shown that a renewable energy fraction (REF) of up to 0.7 was possible, indicating that up to 70% of all operational carbon could be abated through the strategies implemented within the student designs. These reductions were primarily due to passive strategies and through the inclusion of larger PV systems. The following strategies were recommended by the consultants:

- Low-carbon/low-process materials – Prioritising natural and repurposed materials to reduce carbon footprint.
- Passive design strategies – Abate operational carbon through lessening the requirements of active solutions.
- Operational improvements and solutions – Actively improving occupant comfort while reducing energy demand.
- Renewable energy generation – Optimising rooftop orientation to maximise PV output.
- End of life planning – Maximise material reuse and recycling opportunities, design for end of life disassembly.

The greater than 25% reductions in energy usage were determined through comparison to baseline business-as-usual (BAU) cases, derived from existing statistics of mixed-use building typologies in similar climatic zones, or assessing the BAU of multiple building typologies and operational requirements to derive an approximate baseline. The design work undertaken by students and the subsequent consultant vetting indicate that a significant reduction in energy consumption is possible for multi-purpose buildings, particularly in the remote regional settings of central Australia.