The Innovation Hub

for Affordable Heating and Cooling

Final Sub-Project Knowledge Sharing report

IDS-04 Ambulance Victoria

Project IDS04

_v2.0 31 August 2021

The University of Melbourne

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

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.

The 'i-Hub IDS-04 Design Studio outcomes report_100%_inc_Appendices' is intended to be the main technical learnings and outcomes report of interest to industry when shared publicly.

Lead organisation	The University of Melbourne		
Sub-Project number	IDS-04		
Sub-Project commencement date	01 July 2020	Completion date	30th May 2021
Report date	21 May 2021		
Contact name	Dr Dominik Holzer		
Position in organisation	Associate Professor in Digital Architectural Design		
Phone	0416 214 165	Email	dominik.holzer@unimelb.edu.au

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IMPORTANT NOTE regarding reading of report:
The integrated design studios are repeating format studios conducting research on two levels:

1) Integrated Design: Each studio builds upon previous studios to explore how best to facilitate integrated design between architects and engineers. Research and lessons learned are cumulative across studios.
2) Zero Carbon Research: Each studio explores zero carbon design measures that are relevant to the building typology featuring in that studio. Research and lessons are specific to the building typology used in the studio.

To improve readability (for readers reading multiple reports), material that has been repeated from 'Knowledge sharing Reports' from previous IDSs such as common background, repeating cumulative research, or learnings, has been delineated and identified as such by showing on a greyed-out background.

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 programme 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.

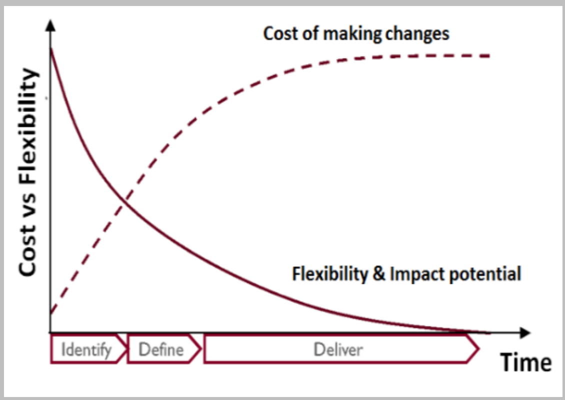


Figure 1: Decision value: opportunity with time.

Building Typology Research (Ambulance Station)

The studios use case study projects as a part of creating a design environment in which to test integrated design. As a result the studios also provide an opportunity for building specific research into potential integrated solutions.

The case study building typology used for IDS-04 is an Ambulance station. The design of this type of facility has a substantial impact on the environment due to the sheer number of stations existing across Victoria and beyond. With many of those requiring upgrades, refurbishments, or replacement over the coming years Ambulance Victoria (AV) as an organisation sees major benefits in aiming for Net Zero designs. Any gains in renewables use and zero carbon initiatives able to be implemented in this typology will have significant impact.

The studio brief was looking for ideas related to the design of one of a 'Zero Carbon Branch' for AV - a new standard for a local ambulance station, with an exemplar site chosen by them in regional Victoria (Clyde North).

The learnings from each of the integrated design studio sub-projects get collected and consolidated across the full program of IDSs in a separate 'knowledge sharing' sub-project IDS-KS.

The key partner organisations involved in IDS-04 were:

Ambulance Victoria – Client representative.

Atelier 10 – Multi-disciplinary consulting, engineering and architectural design assistance

Ewers Architecture – Architects with experience in the design of emergency response facilities for Ambulance Victoria.

The University of Melbourne – Academics from both the Melbourne School of Design (MSD), and the Melbourne School Engineering of with 12 Masters of Architecture students and approximately 4 Engineering students, supported by a part time research assistant.

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

IDS-04 was initiated late July 2020 with semester work running for 15 weeks until the beginning of October 2020. Technical feasibility vetting of the design ideas produced throughout the studio (by the consultants) took place over 4-6 weeks in the period after completion of the semester work.

Outcomes for industry include practical insight into how to enable integrated design in practice, along with design ideas and assessments of the potential for renewables and other zero carbon enabling initiatives on ambulance stations.

Figure 2: Ambulance Station proposal by Kertina Qi Liu

2. Challenges experienced and how these were overcome

Challenges in the delivery of the studios were experienced on two main fronts:

1) Logistical delivery of the studios. Logistics issues related to the delivery of the studios themselves and were related to aspects such as the time required to elicit signing of agreements with the sub-project partners, and COVID-19 impacts such as the need to instigate remote delivery and limitations on the number of engineering students that were able to be enlisted. The final impact of these factors was felt to be minimal or able to be managed. The Lessons Learnt Report produced for the studio refers (details provided in Section 4).
2) Level of integrated design able to be achieved. Trialling of the best practice integrated design methodology formulated (from current literature) in the studio exposed many limitations and over-simplifications that impacted design integration. This was the reason for undertaking the studios in the first place and these challenges resulted in learnings that were then incorporated into the integrated design models for subsequent studios. As above refer to the Lessons Learnt Report produced for the studio for detail (details provided in Section 4).

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

Valuable learnings occurred in both objective areas of the studios, on how to implement integrated design in industry, and also on evaluation of potential technology solutions appropriate to the building typology used as a case study. Headline summary learnings are provided below:

Integrated Design Process

Note: learnings in relation to the integrated design process were formed across all IDS conducted so far (01/02/03/04/05) and hence this section of learnings repeats from those other IDS.

- There is a high level of excitement and buy in to the concept of integrated design meaning simply articulating this as a project goal achieves some gains.
- Integrated design requires a 'design co-author' mindset in all participant designers.
- Definition of common goals is a key priority with tasks set at a detailed level as well as aspirational level.
- Integrated design benefits from active third-party curation.
- Integrated design happens over a limited time window.
- Design innovation emerges from consolidating competing interests.
- Architects are initially often not familiar with the implications of different technologies on their project layout.
- Academic education plays a key role, in particular when bridging the Architect/Engineer divide.

Ambulance Station design (Building Typology Technical initiatives)

- Achieving carbon neutrality in the design of ambulance stations is possible. Initiatives explored included:
    - Passive design measures
        - Passive solar orientation
        - Stack / cross ventilation
        - Introducing Green Roof strategies
        - Passive House building fabric
        - Maximising good daylight access
        - Introducing double skin façade
        - Introducing innovative thermal mass

- Active design measures
  - Photovoltaics (+batteries)
  - Decentralised through-the-wall heat recovery systems
  - Mechanical ventilation with heat recovery
  - Displacement ventilation
  - Ground source heat pumps
  - BIPV (Building Integrated Photovoltaics)
  - Underfloor heating
  - Air-source heat pumps

The resultant EUI for these initiatives depend on the level of implementation (e.g., PV array and battery sizes, area covered by BiPV, capacity of the ground source heat pump etc.). They were beyond the scopes of the student design exercises.

Studio Logistics

Note: learnings in relation to studio logistics were formed across all IDS conducted so far (01/02/03/04/05) and hence this section of learnings repeats from those other IDS.

- Future studios will benefit from the groundwork done on understanding sub-project partners concerns with agreements required for participation.
- It was difficult to maintain active engineering student participation for the duration of the studios, due to different time-fraction allocated to engineering subjects and different assessment criteria than those by architectural students.

More detail on the above summary learnings may be found in the Lessons Learnt Report produced for the studio, and on the technical evaluation in the Design Studio Outcomes 100% Report (details provided in Section 4). Note that the summary nature of the learnings above belies the depth of work behind them. A rich volume of material representing the work undertaken may be found in the 'Design Studio Outcome Report' (intended to be the main technical knowledge sharing report for the studio (details in Section 4).

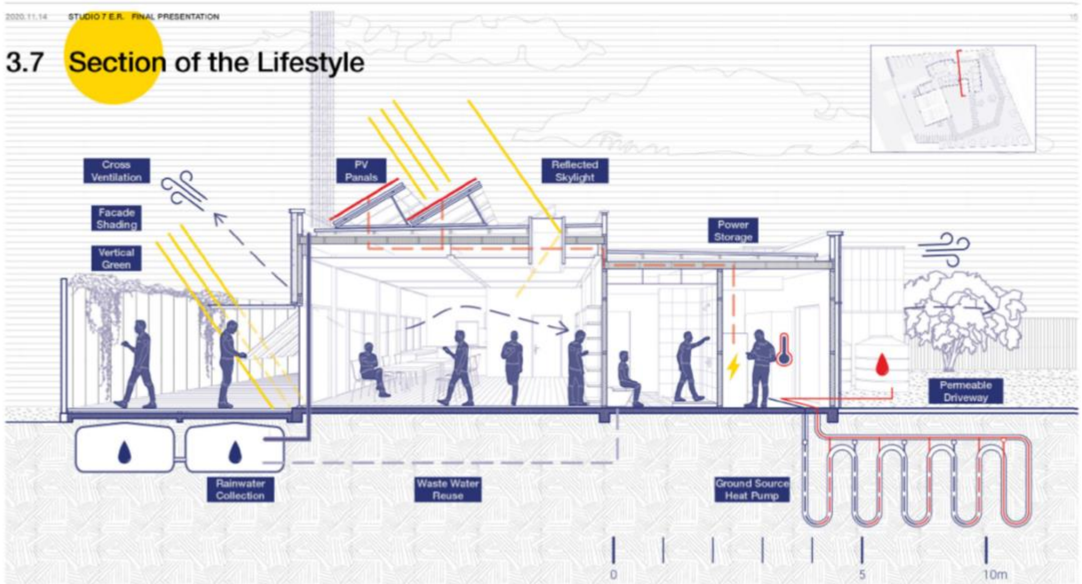


Figure 3: Active and Passive measures – proposal by Jason Leung

Sub-Project Impact (linked to studio planned objectives)

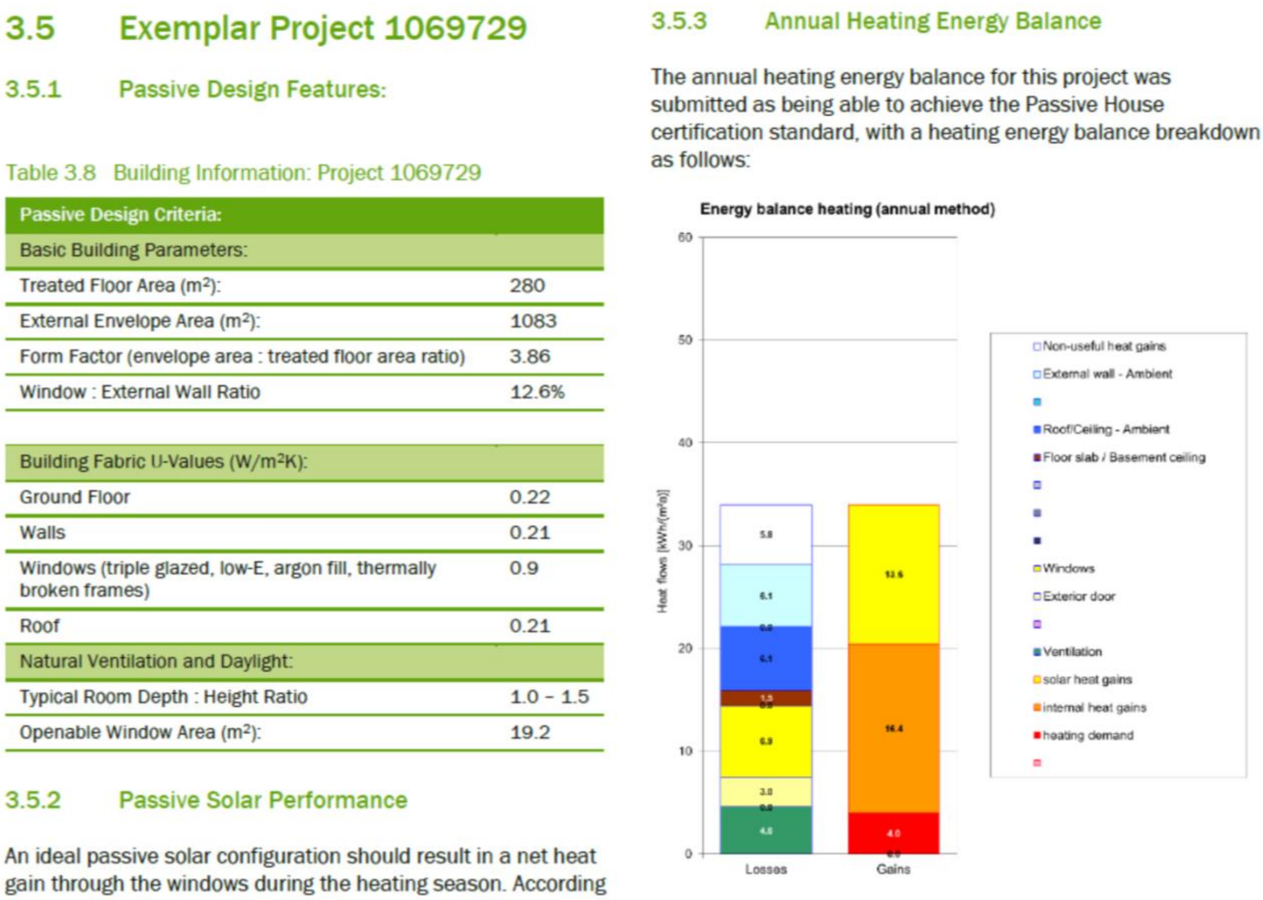
Overcome discipline prioritisation and broader opportunities for Ambulance Station design: The close collaboration with AV was essential to understanding the requirements of the design of their station. The way design was approached during the studio, did not solemnly focus on studying environmental issue related to the station building itself, but it also addressed how its immediate site context can contribute to Net Carbon outcomes, in addition to offering access to the wider public as recreational space.

Contribute to the knowledge and development of the IDS process being developed and facilitated by i-Hub: Valuable contribution to development of the integrated design process as per above commentary.

Opportunities for both passive as well as active measures to achieve Zero Carbon targets for Ambulance Station design: The renewable initiatives (and associated enabling technologies) examined in this studio identified ambulance stations as a feasible building typology in which energy generated could more than offset demand.

Maximise the local use of on-site renewable energy: Contributed to overall impact goal as per commentary above.

Findings from this sub-project will progressively feed 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 initiative, as each sub-project will have an impact on the wider IDS program.



3.5 Exemplar Project 1069729

3.5.1 Passive Design Features:

Table 3.8 Building Information: Project 1069729

Passive Design Criteria:	
Basic Building Parameters:	
Treated Floor Area (m²):	280
External Envelope Area (m²):	1083
Form Factor (envelope area : treated floor area ratio)	3.86
Window : External Wall Ratio	12.6%
Building Fabric U-Values (W/m²K):	
Ground Floor	0.22
Walls	0.21
Windows (triple glazed, low-E, argon fill, thermally broken frames)	0.9
Roof	0.21
Natural Ventilation and Daylight:	
Typical Room Depth : Height Ratio	1.0 – 1.5
Openable Window Area (m²):	19.2

3.5.2 Passive Solar Performance

An ideal passive solar configuration should result in a net heat gain through the windows during the heating season. According

3.5.3 Annual Heating Energy Balance

The annual heating energy balance for this project was submitted as being able to achieve the Passive House certification standard, with a heating energy balance breakdown as follows:

Figure 4: Exemplar project – Vetting by the Engineering Consultants (Atelier 10).

4. Links to reports

The following reports were produced for public sharing as a part of or in relation to IDS-04. All reports have been uploaded to the i-Hub SharePoint site, titles link to latest version associated with this report.

IDS-04 Specific Reports

- **i-Hub IDS-04 Design Studio outcomes report_100%_v1.0_inc_Appendices**: Main technical learning/outcomes knowledge sharing report. Includes selected student work, consultant feasibility vetting report etc.
- **i-Hub IDS-04 Lessons Learnt Report :** Details of lessons learnt (Technical and logistical).
- **i-Hub IDS-04 Final Sub-Project Knowledge Sharing Report :** This report.

Related material of interest produced in wider IDS activity

- **i-Hub IDS-KS Catalyst for Integrated Design :** Live integrated design methodology document (updated with learnings from each successive IDS).
- **IDS-KS JP01-CREATING INTEGRATED DESIGN IN AN ACADEMIC ENVIRONMENT: PROCESS AND A METHOD** : Journal paper manuscript – note: not accessible publicly until published due to Journal IP restrictions. Link to be provided at that time.
- **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_published copy**: PDF of published Ecolibrium August Issue.
- **IDS-KS MA02 BuildingPerformanceAttributes** : Article content (pending publishing).
- **IDS-KS i-hub summit I_IDSs** : YouTube recording of IDS June 2020 webinar
- **IDS-KS i-hub summit II_IDSs** : YouTube recording of IDS June 2020 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: Envisaged this will be able to be used by industry in setting up integrated design environments. Note that the current version has already been requested by and provided to individuals in industry.
- Integrated Design Studio Framework: The integrated design studios have been welcomed by clients and participating consultants. The framework developed is envisaged to continue in a perhaps slightly modified unfunded format after completion of the current program of contracts.
- Studio Outcomes Report: Is envisaged to be referred to by people in the data centres industry interested in building more sustainable data centres.

  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.
- Papers and magazine articles produced will join the literature surrounding integrated design able to be interrogated into the future.

- Carbon Catalogue: Results from the project vetting will feed into a *Carbon Catalogue* per Building type that draws on the benchmarking undertaken by the IDS team.
- Consultation with Industry: Members of the IDS team will follow discuss results of the investigation with industry representatives about applicability of findings from the IDS on wider use in practice.

6. CONCLUSIONS

Conclusions and integration into the wider IDS programme

The IDS framework, paired with experienced educational experts, and equally proficient engineering and architecture consultants, supported students to challenge the existing dogma of (often sequential) design collaboration. Via the integrated design approach, nearly a dozen of environmentally optimised, and architecturally challenging proposals were developed by students over the course of the semester. The studio progress was logged by the IDS team via detailed observations. The observations reflect some of the conditions met by professionals in everyday practice, but they also offer ample suggestions for process-improvement, change in attitude, and suggestions on how to set up integrated design processes to maximise the output of all involved. At the same time, the reflections from those involved, also offer constructive criticism on how to improve the IDS program for future iterations.

The output generated by the students represents a dense array of solutions, that address the functional and operational requirements of the client, whilst challenging existing conventions. Inspired by the consultants and the studio tutor, the students included and tested a range of highly innovative technologies, both for the existing building stock as well as the new additions. These solutions provide highly beneficial feedback to the client and serve as an inspiration for discussions within their government organisation. Beyond this quality, some key solutions have been taken further by the consulting engineers, in order to produce an in-depth investigation about the renewable energy applications and energy performance of ambulance stations, with a detailed comparative study on zero Carbon interventions vs BAU.

The learnings will be further incorporated into an activity wide document consolidating building typology learnings and opportunities.

Summary of Building Typology Zero Carbon Design Learnings (reproduced from Lessons Learnt Report)

Zero carbon design was found to be possible for emergency response facilities along similar lines to the schools building typology. This was achieved through a combination of energy consumption (EUI) reduction (envelope, orientation, use of heat pumps etc.), and provision of locally generated renewable energy (typically solar PVs).

Differences with the schools typology centred around different building and programme planning. Emergency response facilities have a higher diversity of use requirements including garages, sleeping facilities, and respite areas. The specific technical requirements of each of these uses (acoustics, light, proximity to response etc.) were all considered in the architectural planning.

Design solutions that are on a credible pathway toward net zero carbon performance are shown in the graph below of annual energy (electricity) consumption. It can be seen that up to 50% energy saving compared to business-as-usual could be achieved through a cumulative combination of high-performance passive design measures, optimisation of HVAC systems, and consideration of on-going operational energy management.

A number of strategies and technologies were consistent in recommendations. Their prevalence across a wide variety of different design proposals indicates their suitability and achievability within the scope of a typical Ambulance Station. Key systems which were common across the studio and which offered the greatest benefits include:

- Optimised Passive Solar principles for winter heating and summer control.
- High-performance building fabric through enhanced U-values of the building fabric
- Reduction in thermal bridging and airtightness construction quality Assurance
- Mechanical ventilation with heat recovery for energy saving benefit in addition to other indoor environmental quality and health benefits.

- Photovoltaic panels were consistently applied across projects for on-site renewable energy generation.
- Selection of materials which minimise the impact of embodied carbon across the development.

With such implementations, it was found that energy usage across the site could be reduced by up to 50% when compared against current business as usual statistics. Furthermore, when tied in with a photovoltaic system, the students have shown that energy production potential can entirely meet and exceed the demands on site. As such, the student body of work has shown that with current and existing technologies, a net-zero carbon approach is possible.

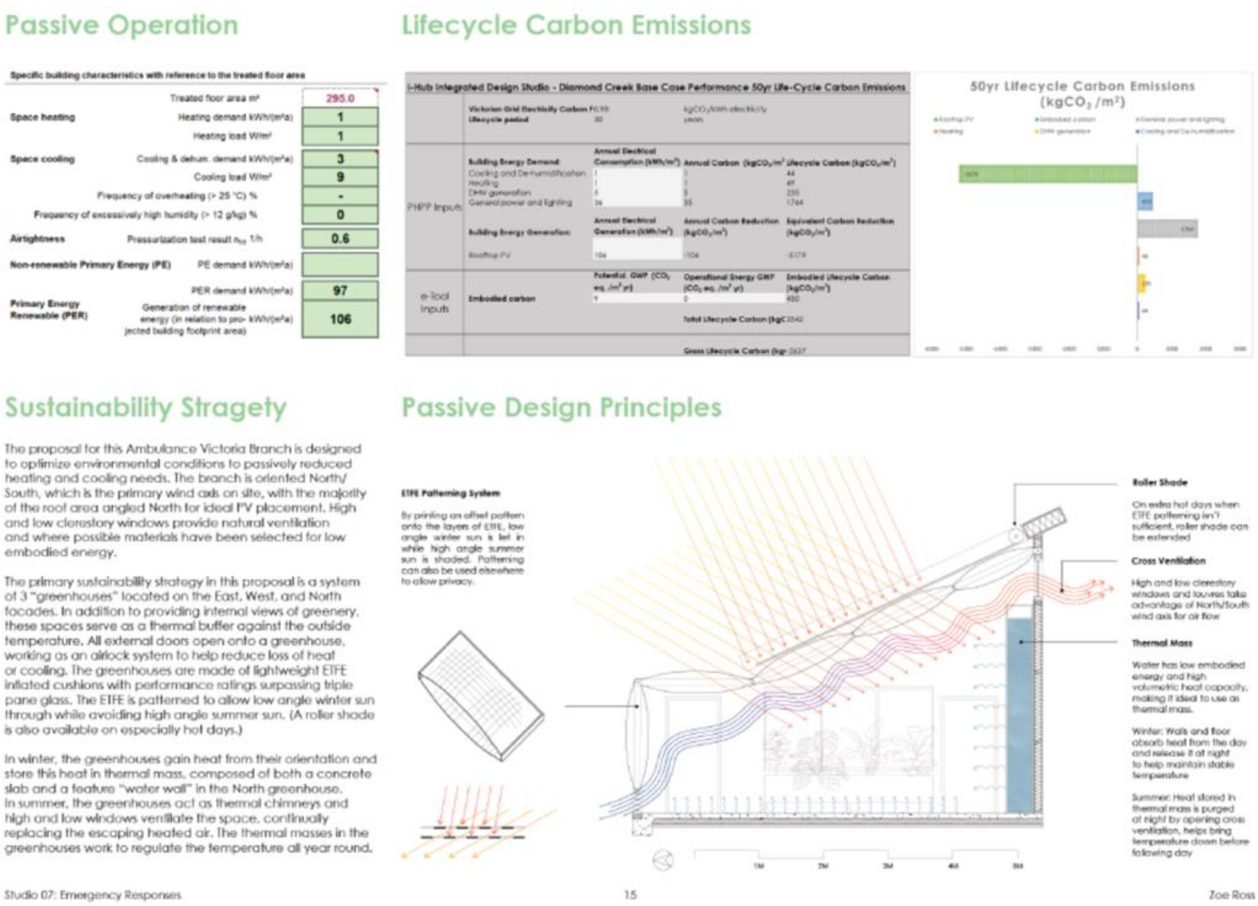


Figure 5: Example student submission material by Robyn Mackenzie.