IDS09 – Lightning Ridge Community Centre

Lightning Ridge Aboriginal Land Council (LRALC)

Vetting Report 26th April 2022

Image: Student 1 Assignment Submission, IDS09

Document Verification

Report Authors:

Alex Kobler
Navid Aghdaei
Peter Jameson

The report presented is a collaborative effort of the above noted authors.

Overview

The iHub Integrated Design Studio (IDS) ran during the second semester of 2021 and included Engineering major students from the University of Wollongong supported by the engineering faculty and consultants from industry.

The students investigated sustainable design options for a new Aboriginal Land Council community centre in Lightning Ridge. The studio explored concepts and solutions to achieve net-zero carbon in during operation through the use of both passive and active measures and on-site renewables.

This summary report documents the vetting process undertaken by the supporting consultants following the studios. The aim of this report is to summarise the process of the IDS and capture the key recommendations developed by the students, faculty, and consultants over the course of the semester.

The analysis and design undertaken during the studio demonstrated that the goal of net-zero carbon is possible to achieve by adopting a number of considered sustainability strategies.

Image: Group 3 Assignment Submission, IDS09

Image: Group 2 Assignment Submission, IDS09

Introduction

I-Hub is a program run by the Australian Institute of Refrigeration, Air Conditioning and Heating (AIRAH) alongside the University of Wollongong and supported by the Australian Renewable Energy Agency (ARENA). It aims to facilitate the HVAC industry's transition to a low emissions future, stimulate jobs growth and showcase HVAC innovation within buildings.

The Integrated Design Studios are a part of this initiative and explore innovative solutions for achieving net-zero carbon on complex design projects.

University of Wollongong students in the IDS09 design studio were given the task of designing a sustainable, net-zero, new Local Aboriginal Land Council facility in Lightning Ridge. A range of feasible opportunities for minimising the project carbon footprint and energy usage were to be considered including active and passive solutions.

Weekly studios were held over the semester, supported by the engineering faculty and industry consultants from Edmiston Jones Architects, Northrop, E-Lab Consulting and MIEngineers.

Australian Government
Australian Renewable Energy Agency
ARENA

AIRAH

UNIVERSITY OF WOLLONGONG AUSTRALIA

Edmiston Jones

NORTHROP

MIENGINEERS

Net-Zero Carbon

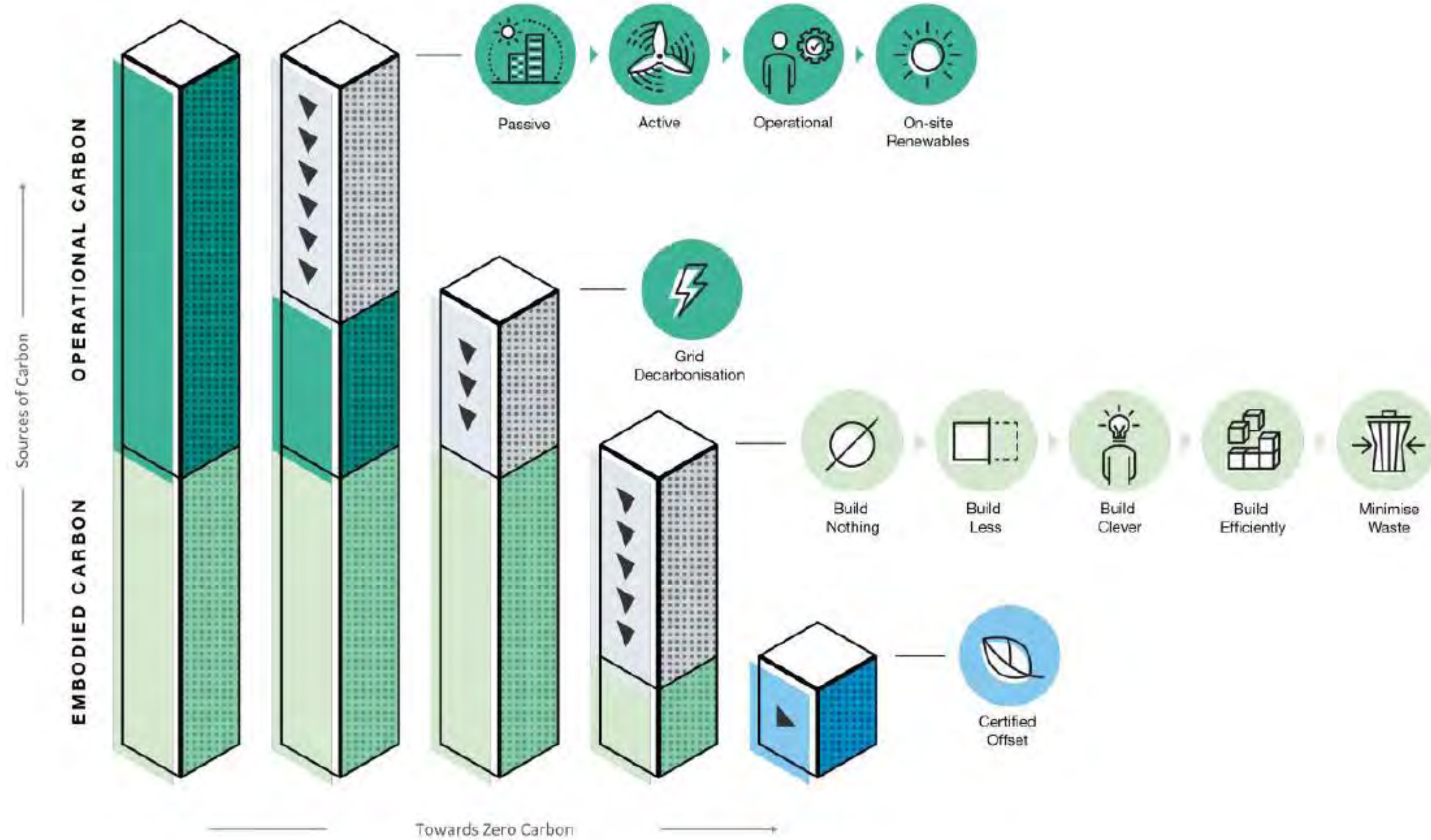
This term is commonly used across industry but its definition varies due to a lack of consensus on where the boundary for assessment is defined for a given building or system.

For the purposes of this studio, the term 'net-zero carbon' encapsulates both the operational carbon emissions and embodied carbon emissions.

Operational carbon emissions are those that are generated over the service life of the building.

Embodied carbon typically refers to carbon emissions generated by the construction, maintenance and demolition of the building with a particular focus on the construction phase as the most understood and quantifiable metric.

A truly net-zero building considers the whole lifecycle, with the emissions associated with building materials, construction, operation, and end of life all quantified and accounted for. Thus any emissions generated by embodied carbon during to construction must ultimately be offset during the operation of the building to achieve an overall net-zero.



Source: Arup - net-zero carbon buildings: three steps to take now (2020)

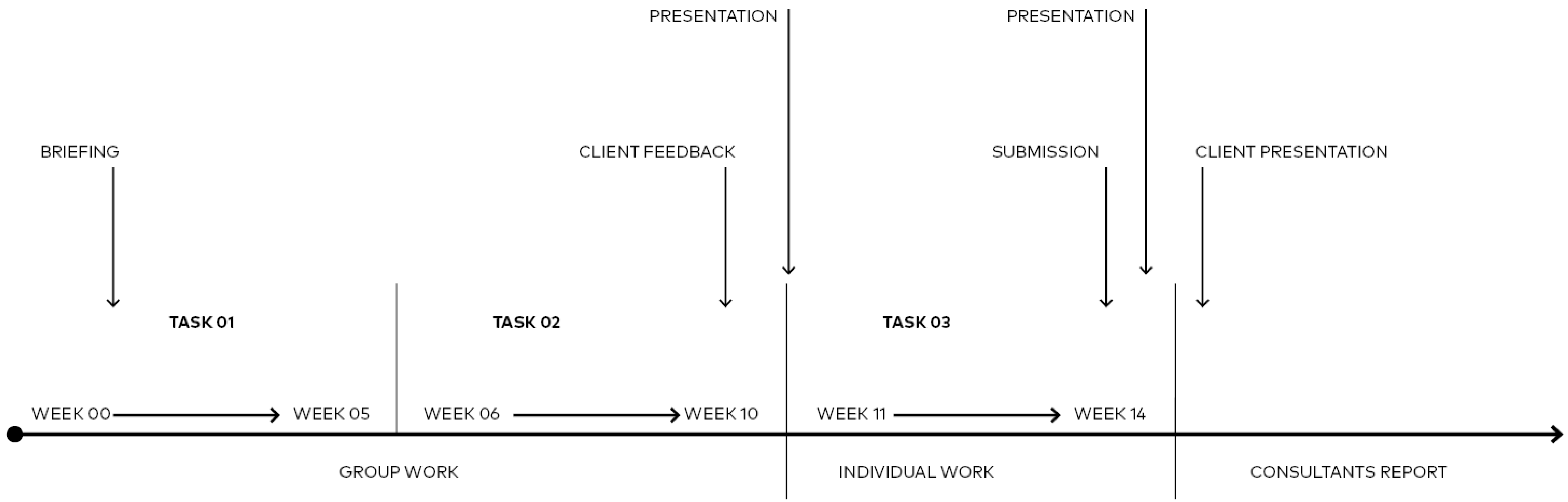
Studio Structure

The students met weekly throughout the semester to workshop and discuss ideas with the engineering faculty and industry consultants.

In the first few weeks, students were provided with a written design brief and video conference with Dr Steve Burroughs from the Dr Steve Burroughs Foundation representing the Lightning Ridge Local Aboriginal Land Council to direct the avenue of inquiry.

Following this, a range of initiatives were developed in the form of a return brief and site analysis. The initiative were subsequently assessed in a detailed matrix which included feasibility, cost, constructability, and a number of other criteria. These options were refined over the course of the semester to identify key changes that would have the most impact towards moving the building to net-zero.

The studio was structured around three assessment tasks where students presented their written submissions to the class and the clients. The first two tasks were developed in groups that required collaboration between a 'design team' of students from different engineering majors. For the final assessment, each student selected one or key initiatives to research in more detail and explore with computer modelling and analysis of building performance.



Studio Interactions

IDS09 was undertaken during a period of intermittent lockdowns due to the COVID-19 global pandemic. Consequently, the studio sessions were conducted in online environments rather than the typical face-to-face interactions preferred for these collaborative exercises.

Weekly *Zoom* sessions with breakout rooms were used to facilitate the interactions between students, the faculty, and consultant. Assessment presentations were also delivered through this platform.

A number of online collaboration tools supported the development of the designs. The university's *Moodle* platform provided a central location for shared studio information and resources. The online collaboration tool, *Miro*, was used during studio sessions to provide a communal, collaborative digital whiteboard for sharing text, images, and ideas in real-time.

Image: UoW Moodle Platform for IDS09

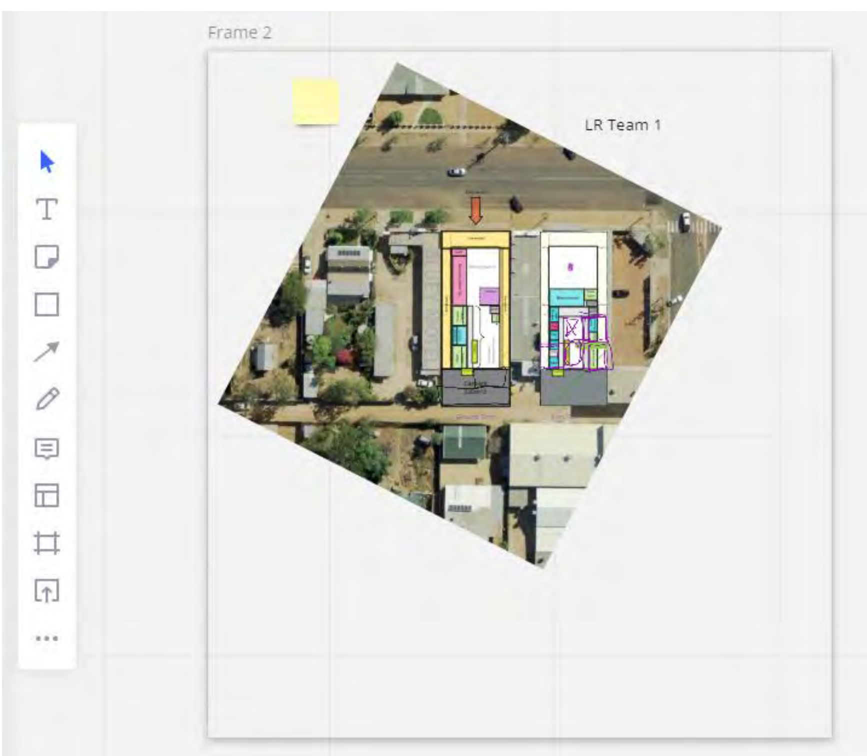


Image: Miro online collaboration environment from IDS09

Image: Miro online collaboration environment from IDS09

Introduction

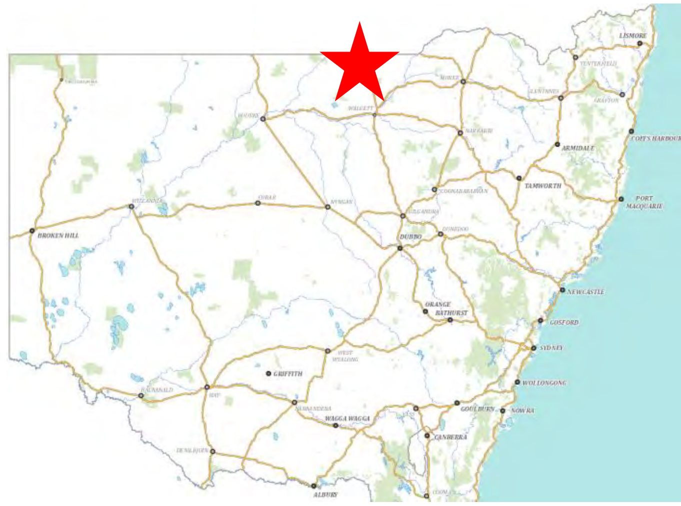
Location and Site

The site is located in Lightning Ridge, NSW in Walgett Shire, approximately 70km north of Walgett.

The site is currently vacant with an approximate area of 900m^2. The site is bound by Morilla Street to the North, and a slip street to the South providing two access points. The site has a central position in Lightning Ridge and the design was to consider the context of the surrounding area that included shops, a bowling club and cafes.

Geographical considerations such as the proximity to nearby mining facilities and the remote location were also considered in the development of initiatives.

As a facility for indigenous peoples, the consideration of cultural heritage and the history of the Gamilaraay people (also known as the Kamilaroi people) was also important for understanding the usage of this building and the development of materials and spaces.



Source: NSW SixMaps

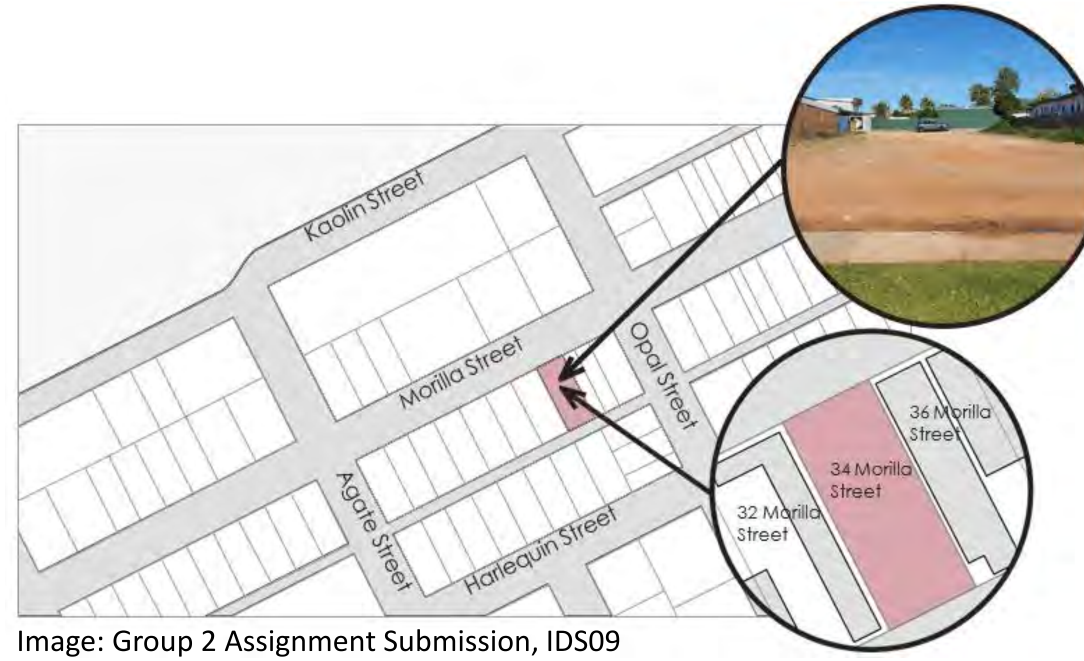


Image: Group 2 Assignment Submission, IDS09

Image: Dr Steve Burrows Foundation

The Local Climate

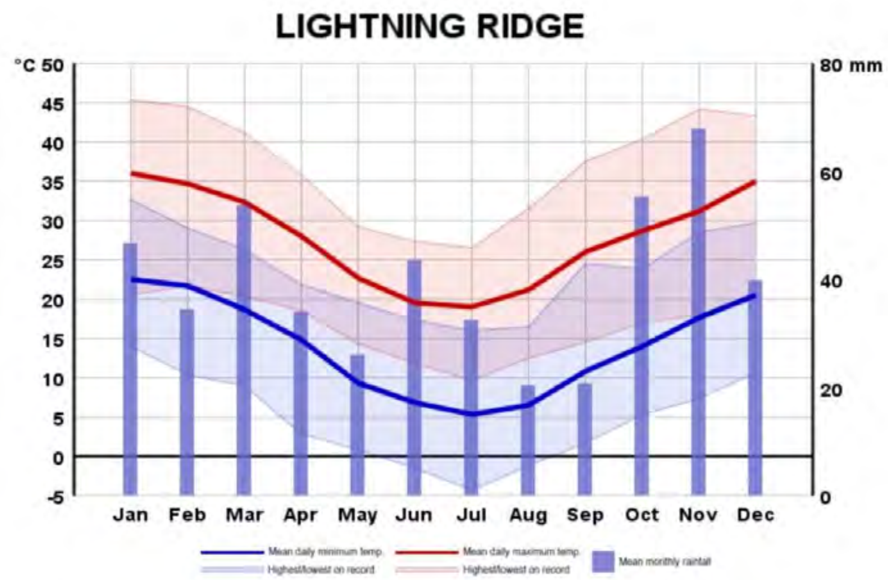
This region experiences hot dry summers and cool winters and has distinct seasons with low humidity all year round.

The annual rainfall is low with the area only receiving approximately 431 mm on average of precipitation per year.

The site is prone to extreme hot weather, the climate is semi-arid with mostly dry weather. The weather can get up to 45 degrees in the summer and drop below 0 degrees in the winter. The area is quite dry, so humidity is seldom an issue. There is a significant shortage of water, but a prevalence of sunlight.

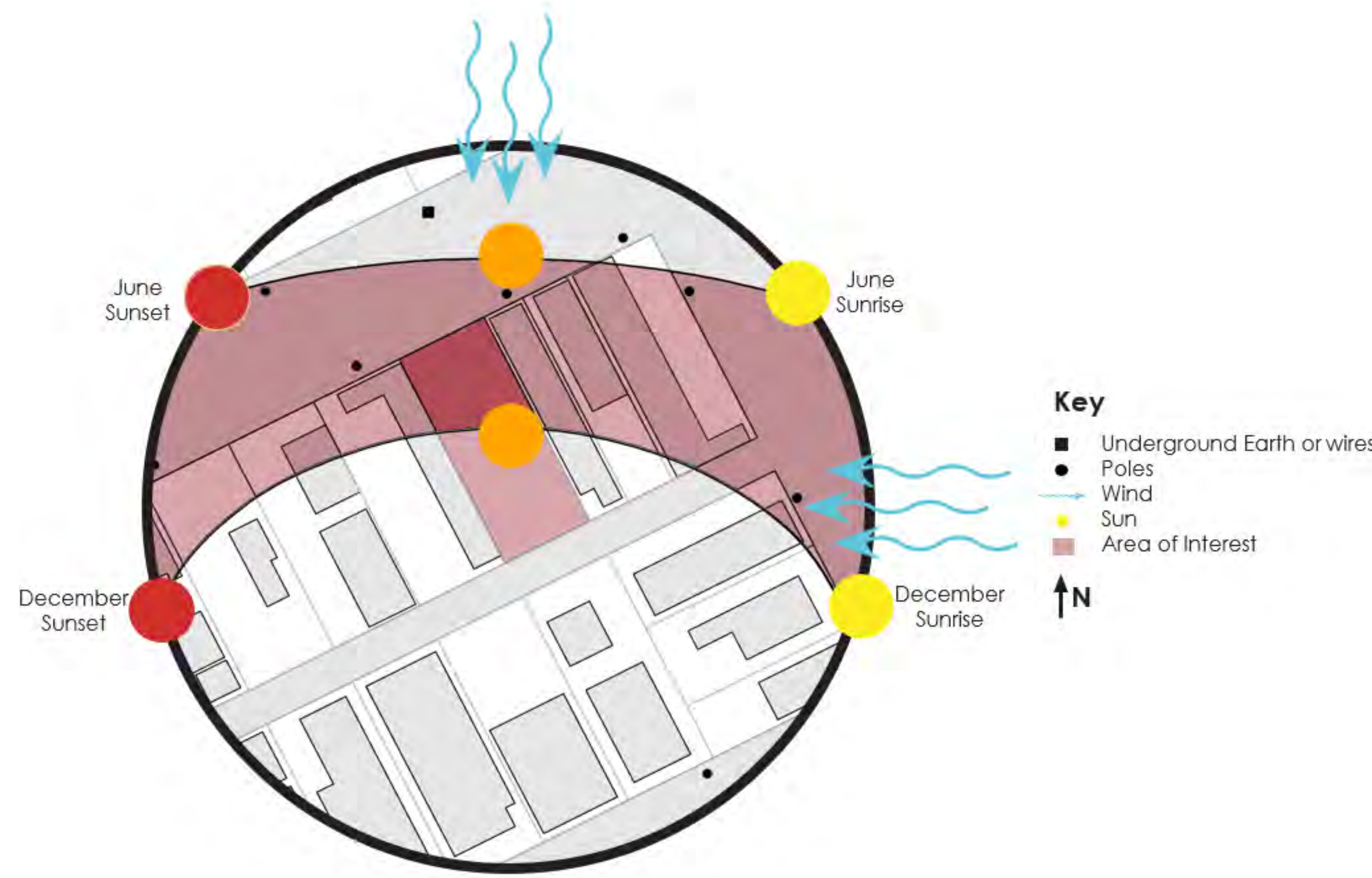
Solar is quite is accessible, as the nearby buildings to the site or only one story and the weather is rarely cloudy.

Prevailing Winds are from the east, however the site is well protected by the neighbouring properties.



Source: Mean Monthly Rainfall and Temperature in Lightning Ridge (FarmOnline 2021)

Source: Rainfall and Relative Humidity at Walgett Airport between August 2019 and 2021 (Willy Weather 2021a)



Source: Group 2 Assignment, IDS09

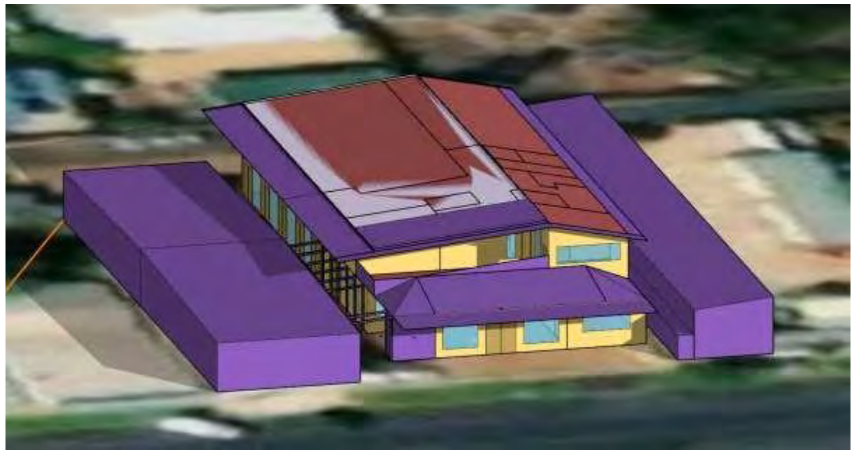
Integrated Design Studio

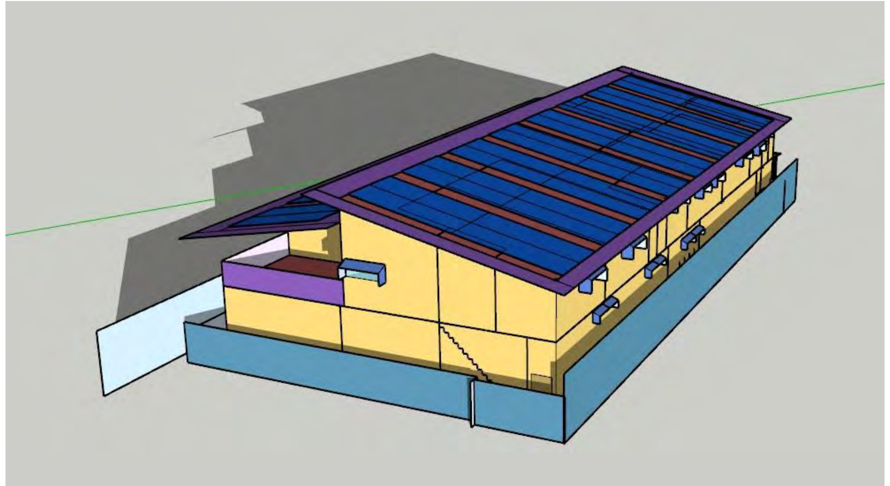
Through the IDS process, the students and tutors worked to explore alternate design elements and positive actions that could be taken to improve the current performance and help the building move towards net-zero carbon in operation.

Students would suggest ideas within the context of the Lightning Ridge Function Centre, and together teams would assess the viability of these options in the context of the project.

These were tested through literature reviews, exploring the site-specific restraints and modelling the performance improvements in programs used in industry to assess thermal and overall energy performance.

The following pages show examples from students work where they have addressed the key tasks set out for them in the studio.





Images: Group Final Assignments, IDS09

Studio

Task 1 Site Analysis and Return Brief

To better understand the building requirements, the students developed a site analysis and return brief. This brief detailed such items as; the existing condition of the building; the local environmental conditions; and end user requirements which would inform the direction of their investigation of sustainable initiatives.

In the initial brief, examples of the areas of consideration were:

- Natural features
- Indigenous heritage
- Heritage
- Transportation & connectivity
- Needs Analysis
- Character of built environment
- Services – existing and new
- Climate/microclimate, solar access, predominant wind direction
- Constraints & opportunities

Bubble diagrams were developed to explore the interactions between internal spaces and the possible options for usage.

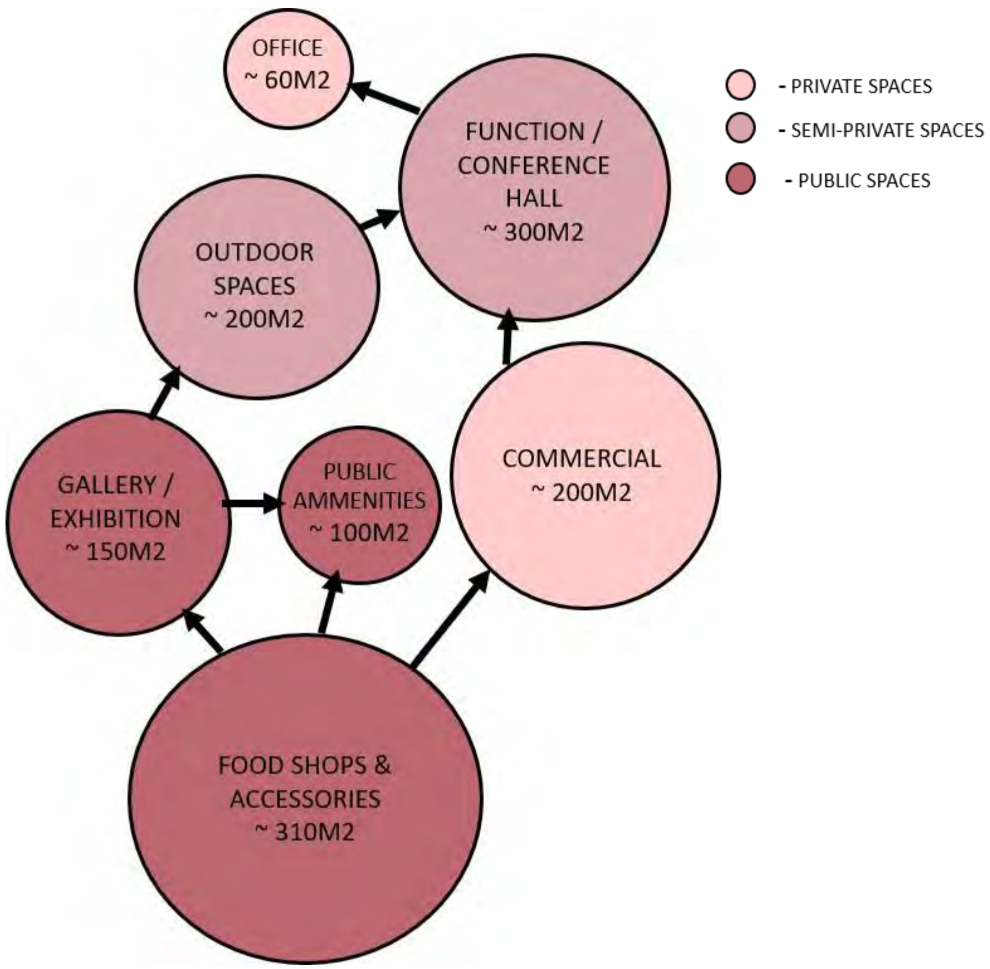


Image: Group 2 Assignment, IDS09

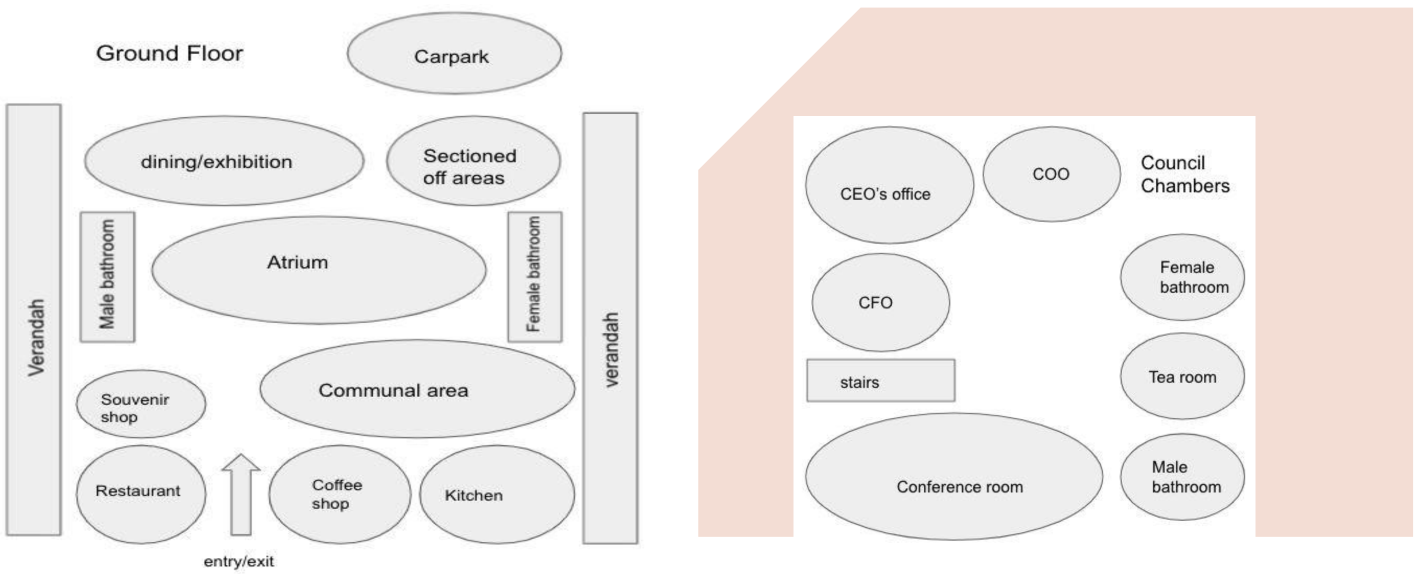


Image: Group 1 Assignment, IDS09

Task 1 Site Analysis and Return Brief

Students were also challenged to explore sustainability benchmarks that may be appropriate to the site. Students developed standard practice benchmarks for performance for water, energy and thermal comfort.

They also explored third-party standards that could be applied to the development to drive the design decisions forward.

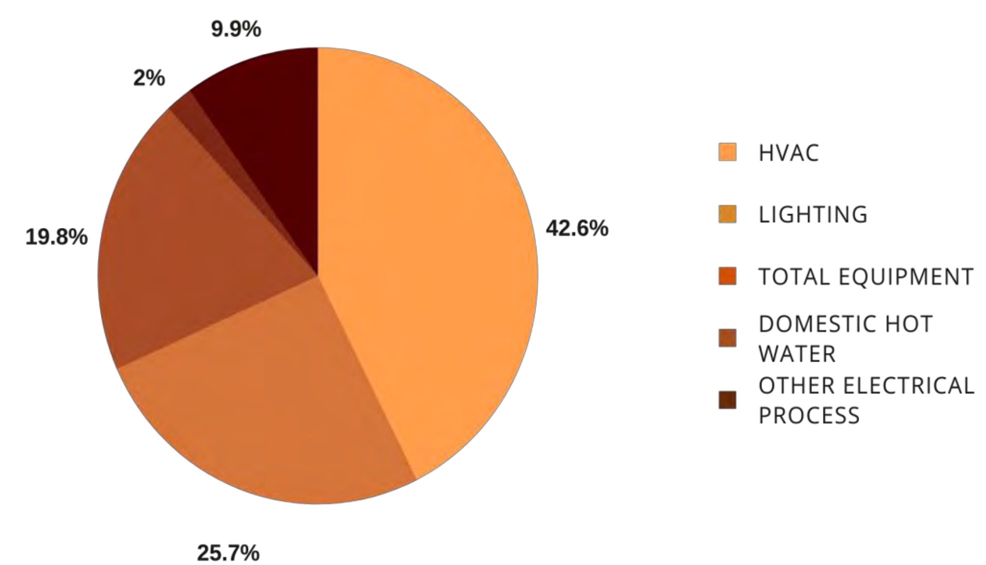
This encouraged design to meet holisitc sustainability approaches, while simultaneously focussing on the energy and water consumption reduction targets.

Rating	Benchmark with cooling towers	Benchmark without cooling towers
Best practice	0.77 kilolitres/m^2/year	0.40 kilolitres/m^2/year
Efficient	0.84 kilolitres/m^2/year	0.47 kilolitres/m^2/year
Fair	1.01 kilolitres/m^2/year	0.64 kilolitres/m^2/year

***Figure 1**: Water usage ratings for office building (Sydney Water)*

Rating	Benchmark
Efficient	<35 litres per food cover
Fair	35 to 45 litres per food cover
Inefficient	> 45 litres per food cover

***Figure 2**: Water usage ratings for cafe/fast food building (Sydney Water)*



Task 2 Research

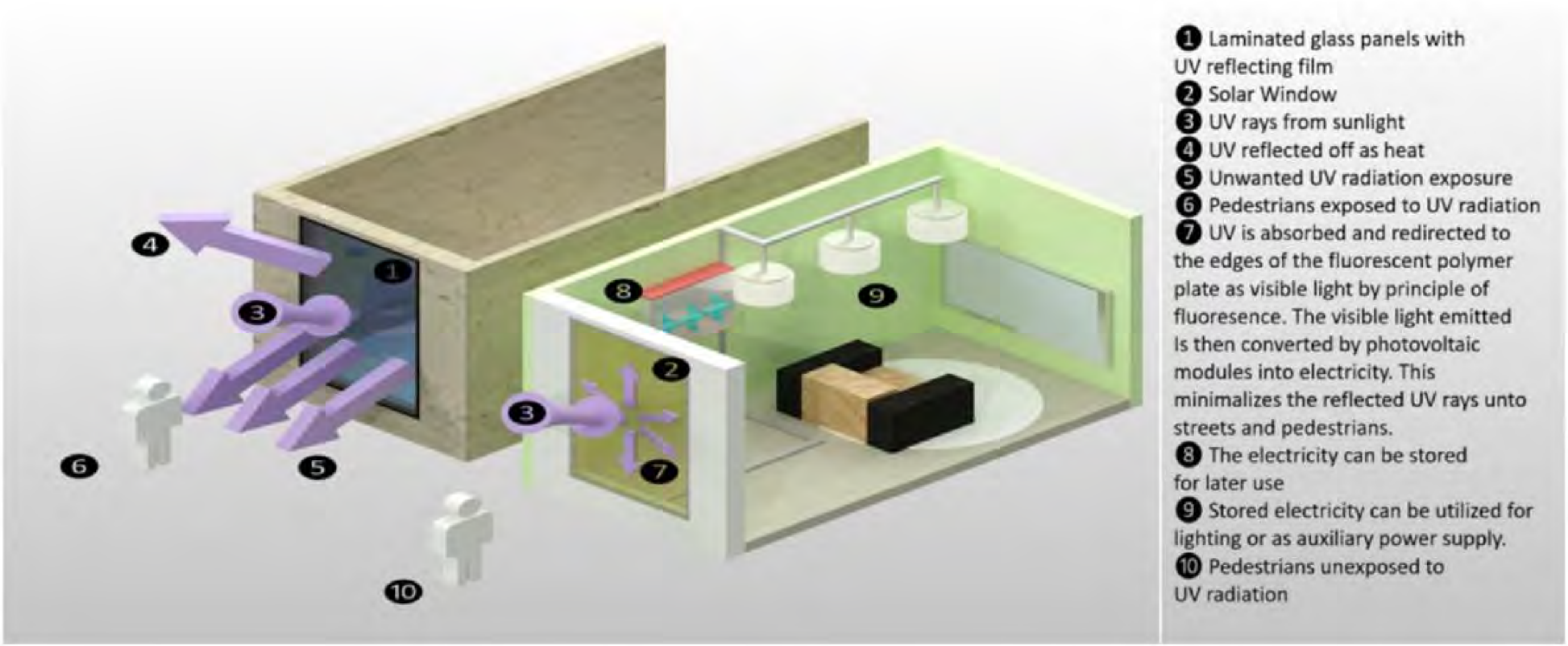
With the brief defined, and the facility details confirmed, the students reviewed technology and processes that may address any perceived any energy efficiency issues. Examples of the items reviewed and shown below and on the following page.

The students were encouraged to review critically each process and assess their potential contribution to the overall site goals.

Although primarily focused on reduction in carbon intensity, students were also encouraged to review other potential benefits such as water efficiency and contribution to wellness.

The approach adopted was primarily to develop a scoring matrix to assess their ideas.

Students explored a range of technologies from standard design improvements such as LED lighting and solar hot water, all the way up to electro-chromatic glass to find the most appropriate, project-specific applications.



[Figure 4. Borealis window compared to conventional window]

Studio

Task 2 Research

Matrix example

The below is a small snapshot of a full feasibility matrix produced by the students to assess the feasibility of concepts in the project.

Design Measures	Business-As-Usual Case	Measure Description	Feasibility 0.17	Innovation 0.03	Green Star Impact 0.08	WELL Impact 0.11	Energy Savings Potential 0.22
Solar Panels	Fossil Fuels (Petroleum, Natural Gas and Coal)	Solar panels (also known as PV panels) are small photovoltaic (PV) cells that convert sunlight into energy. These cells are often made up of silicon, a semi-conductive material, which conducts electricity while maintaining the electrical imbalance required to create an electric field.	High feasibility, as solar panels are a source of renewable energy, reducing carbon emissions and the dependence of fossil fuels. They require low maintenace once installed, with the benefit of paying less for electricity depending on the size of the chosen solar panel system and daily electricity usage. Value: 3/3	Low innovation, having been used for around 100 years. Solar batteries allow for energy that is produced by a solar panel system during the day to be stored and distributed to appliances that require ongoing energy consumption to be utilised during the night. Solar battery storages have the potential to almost double a households self-consumption of solar energy. Value: 1/3	Credit 15.0: Greenhouse gas emissions Credit 16.0: Peak electricity demand reduction Value: 2 credits	I06B.3 Carbon reduction (3 points) L03.1 Meet lighting for day-active people (3 points) Value: 6 points + 0 requirements	High energy savings potential. Installation of solar panels reduces energy bills by approximately $400/year/kW of solar. Energy savings also varies with the size of the solar panel system and how much energy the building uses. Value: 3/3
Transpired Solar Collector	Heat Recovery Units (Heat Pump System and Heat Exchanger types)	A Transpired Solar Collector (TSC) is a type of Solar Air Heater (SAH) that works by reducing the overall load on a building's heating system. This is done by drawing in warm air heated by the sun, which will then flow to the top of the building where it is circulated throughout the building. This can be done by using a mechanical ventilation system, such as a HVAC system, where it heats up the heating system or the warmed air can flow directly into the building.	High feasbility, as a TSC is 80% efficient, with low maintenance once installed. They are durable, having a long life span of about 30 years. Installation is simple, as it does not need to operate off of existing heating systems in a building. TSCs are quiet, with little impact on daily living and can act as a rain-screen, which allows for proper drainage and evaporation, also collecting heat that attempts to escape the building through the air cavity. TSCs can be connected to a HVAC system where the heated air heats up the heating system. A TSC was found to have a SIR of 1.86 and an IRR of 5.59%. Value: 3/3	Low innovation, as TSCs have been used for over 20 years. Payback for TSCs is 3-7 years, shorter than any other technology using renewable energy. They also have a high GHG emissions savings potential by replacing fossil fuel energy sources with solar energy. Unglazed TSCs (UTSCs) have a perforated metal cladding used to preheat fresh air through a cavity (15cm) between the metal and the building's wall. UTSCs are being tested for optimal geometries and perforation positionings that give greater thermal efficiencies. Value: 1/3	Credit 14.0: Thermal comfort Credit 15.0: Greenhouse gas emissions Value: 2 credits	T01.1 Provide acceptable thermal environment (required) M01.1 Provide mental health and well-being (required) I06B.3 Carbon reduction (3 points) Value: 3 points + 2 requirements	High energy savings potential. TSCs can reduce energy consumption by 10-50% of conventional heating loads. This only takes into consideration the building's distribution system, as distribution grids and other external systems do not affect the amount of energy generated. A 25m2 TSC was found to have saved about 14000kWh/year, though energy savings will vary depending on climate conditions and differing locations. Higher thermal efficiencies have been achieved with UTSCs of up to 40%. Value: 3/3

Studio

Task 2 Research

Matrix example

The full matrix assessed 20 initiatives across 8 categories – far too large to present here. The below is included to show how the matrix appears.

Net Zero Energy Design Strategy

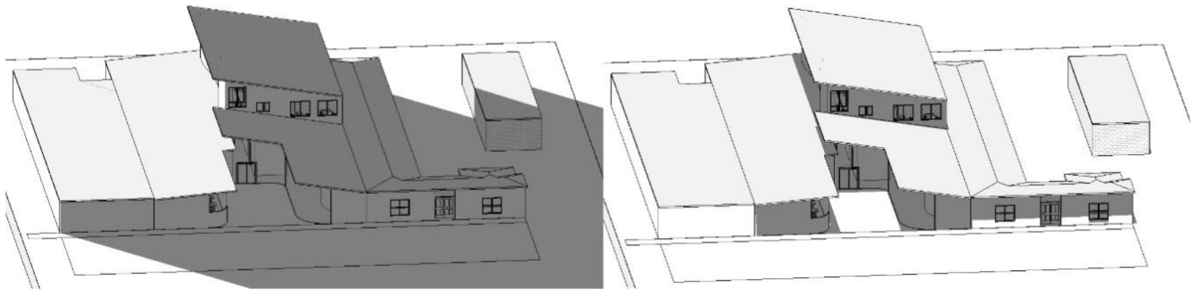
Design Measures	Business-As-Usual Case	Measure Description	Feasibility 0.17	Innovation 0.03	Green Star Impact 0.08	WELL Impact 0.11	Energy Savings Potential 0.22	Carbon Savings Potential 0.19	Capital Cost 0.06	Operational Cost 0.14	Weighted Value (Higher is Better Practice)	Overall Ranking (1 = Best Practice)
Solar Panels	Fossil Fuels (Petroleum, Natural Gas and Coal)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.07	6
Transpired Solar Collector	Heat Recovery Units (Heat Pump System and Heat Exchanger types)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.02	5
Power Purchase Agreement	No Power Purchase Agreement and Purchase of Electrical Generating Equipment	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.3	4
Hydronic Radiant Floor Heating	Forced Air Heating	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.44	15
Electric Radiant Floor Heating		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.61	13

Task 3 Proposals

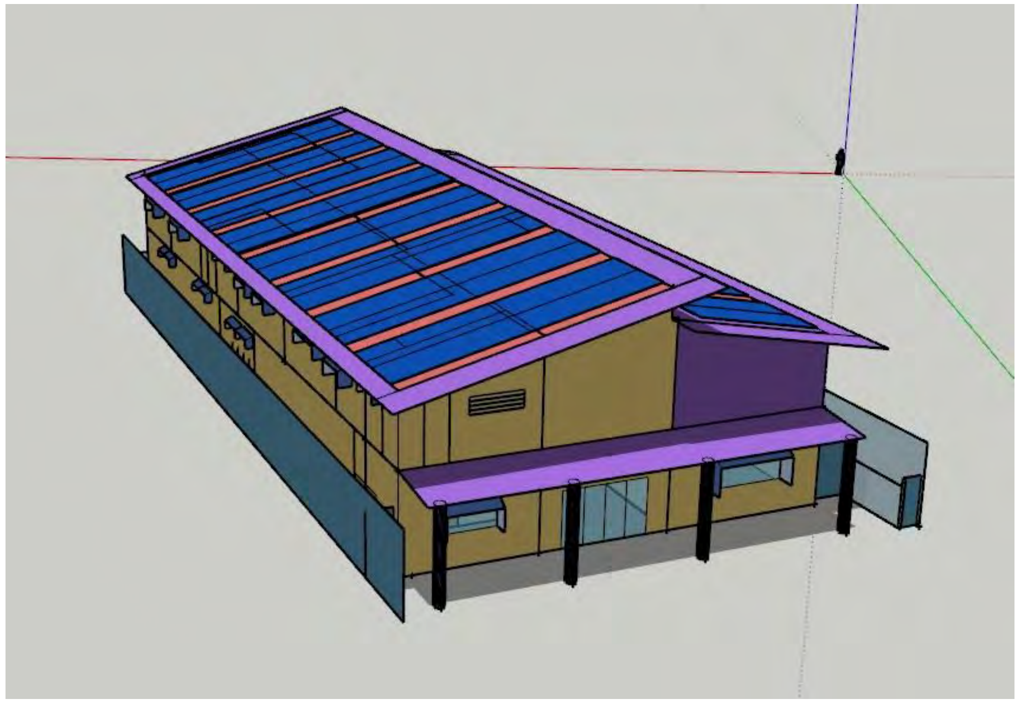
The final assignment had each student working on assessing in detail their proposed initiatives. This included where appropriate energy modelling of the facility to identify the potential carbon saving benefit.

The example shown here is a statistical analysis of the impact of different glazing on HVAC load across the year and a relative impact.

The students' final reports summarised the findings of their analysis and allowed them to provide their assessment of the achievable savings associated with specific technologies. As the task was focussed on specific initiatives, there is no overarching study which shows the total carbon savings.



Glazing Type	**Annual Energy (GJ)**				**Average**
	Heating	***Cooling***	***Net Site***	***Total Site***	**REF Value**
Clear	24.47	674.30	660.04	1096.45	0.396027
Low-E Clear	23.25	670.60	655.11	1091.52	0.397549
Green Tint	24.97	667.06	653.30	1089.71	0.398922
Bronze Tint	24.98	666.94	653.19	1089.59	0.398970
Blue Tint	24.98	666.90	653.15	1089.56	0.398984
Grey Tint	25.02	666.28	652.57	1088.98	0.399234
Low-E Spectrally Selective Clear	23.37	665.10	649.74	1086.15	0.399793
Low-E Tint	23.73	663.68	648.68	1085.09	0.400384
EC Ref Coloured	24.42	654.99	640.68	1077.09	0.403890
Low-E EC Abs Coloured	24.19	653.97	639.43	1075.84	0.404321
Low-E EC Ref Coloured	24.19	653.97	639.43	1075.84	0.404321
Low-E Spectrally Selective Tint	24.22	653.64	639.13	1075.54	0.404451
EC Abs Coloured	26.77	652.79	640.83	1077.24	0.406490



Task 3 Proposals - Summary

Throughout the IDS, multiple ideas were presented by students. These were tested and modelled to calculate the overall improvements that were expected to be realised. The lists below highlight some of these ideas, as appropriate to community facility.

In line with the noted net-zero carbon approach noted previously, the features have been collected into categories and are reviewed as noted in the following section.

The key focus is applied to passive design techniques and opportunities

Student Ideas
(O) High efficiency HVAC systems
(O) Energy Recovery Ventilator
(P) Natural ventilation and mixed mode ventilation
(R) PV systems
(I) Power Purchase Agreement
(O) High efficiency appliances and systems
(P) Double or triple glazed windows
(P) Increased insulation performance
(P) Use of phase change materials (PCM)
(O) Thermal zoning (thermostat control)
(O) Indoor Breathing Wall
(O) Battery Storage for excess PV production
(O) Use of Biogas plant
(P) Shading
(P) Rammed Earth Walls
(P) Thermal mass
(P) Trombe Wall
(P) Solar Chimney w/ Earth Tube

Additional Ideas Explored
(O) Automated blinds
(O) Occupancy detection
(O) Daylight Dimming
(O) Relaxed setpoints
(O) Adaptive comfort through ceiling fans
(O) EC Plug fans
(O) Centralised, efficient heating/cooling plant
(P) Improve quality of window/door seals beyond business as usual

Feature categorisation
(P) – Passive design
(O) – Operational efficiency
(R) – On-site renewables
(I) – Innovation/other

Energy Modelling

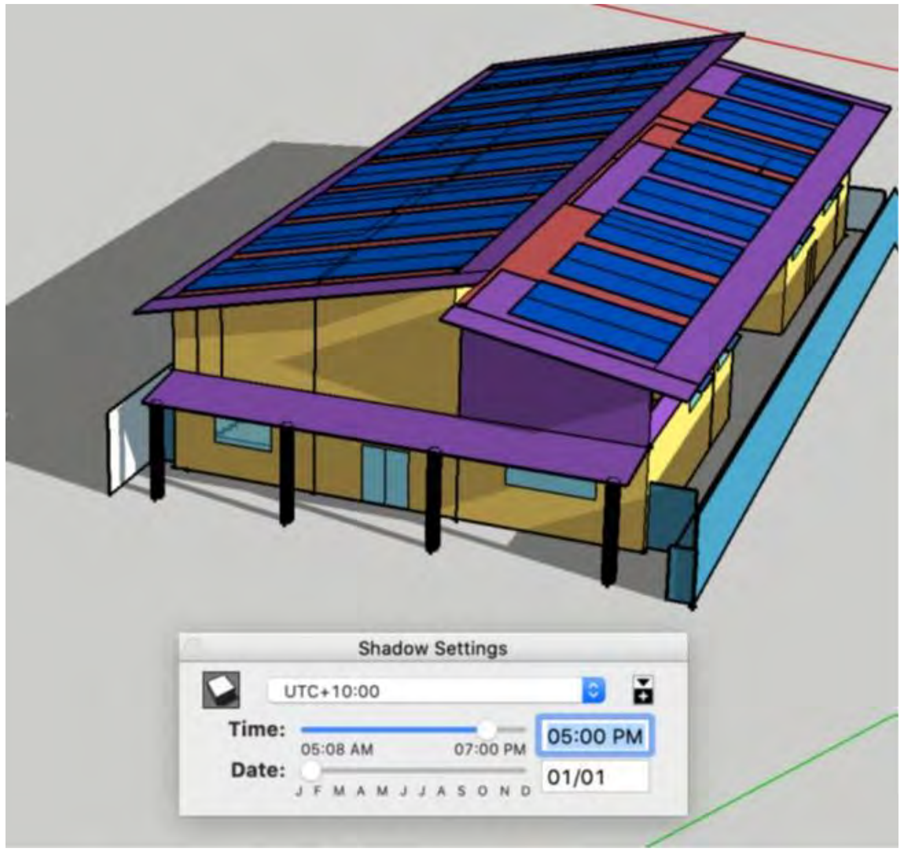
Energy models were developed by the students to assess their proposed improvements across the year. This design stage of verification allows the support of the development of the technology.

This was typically completed in either Google Sketchup and assessed using OpenStudio through the EnergyPlus energy modelling engine, or using DesignBuilder with their built-in engines which runs on EnergyPlus.

Students took on this task to develop the models themselves, but were guided by the Tutors and approached in a cross-discipline collaborative sense.

This allowed them to investigate how technologies could be applied and where the savings would come from. This is a critical step as it mimics how projects achieve this in a construction environment.

The common language used for all students was to achieve a Renewable Energy Fraction (REF) of at least 1.0 - indicating the overall development had achieved net-zero



$$REF\ Value = {}^{Renewable\ Energy\ Generation}/_{Total\ Site\ Energy\ Requirements}$$

Table 1: Renewable Energy Fraction values

REF Value	REF = 0	0 < REF < 0.3	0.31 < REF < 0.95	0.96 < REF < 1.05	1.05 < REF
Number of REF Hours	5	4263	2215	184	2093
Annual REF Value	0.67				

Passive Design

Students identified early on that there are significant opportunities to integrate passive design for new build designs.

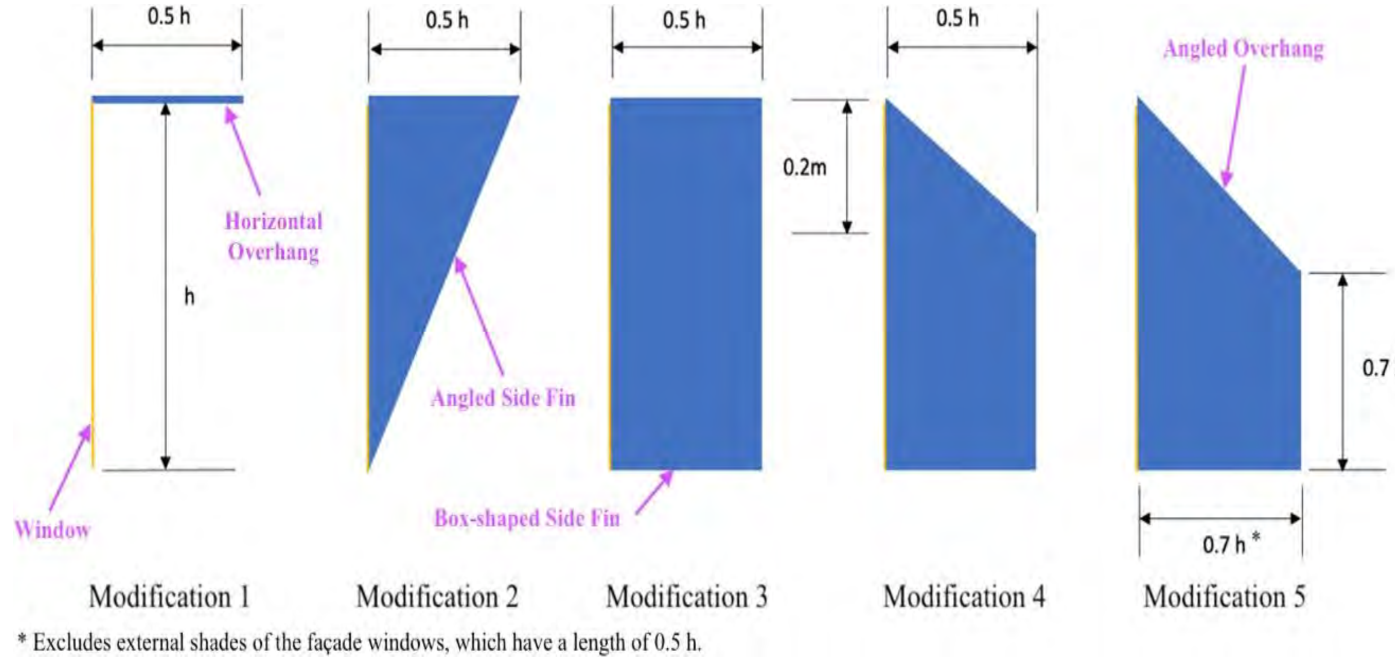
Massing of the building can be adjusted to optimise solar load for both cooling and heating, which offsets the need for actives systems.

Reduction in loads through increased façade or envelope performance were assessed.

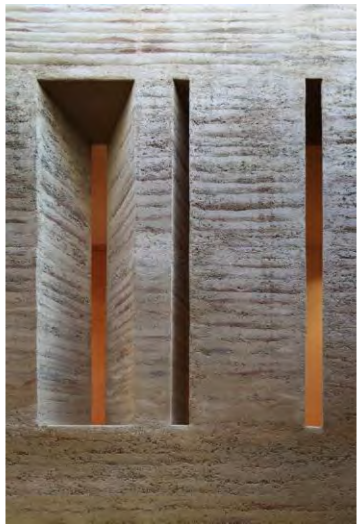
Given the significant heat profiles in Lightning Ridge, emphasis was provided on shading, quality of construction and high-performance facades.

Students concluded the best element to produce the best REF was to negate solar gains through shade.

The students were challenged with coming up with local material solutions that were available, possibly taking inspiration from Aboriginal culture and building techniques. Students explored novel traditional construction techniques such as using rammed earth which has excellent mass and provides great thermal protection from outdoor temperatures. It also provides stability.



A range of different shades were tested to find out which provided the best overall performance.



Rammed Earth is a sustainable construction material with great thermal properties
https://www.wsj.com/articles/rammed-earth-luxury-homes-1427989394 (left hand image)
https://www.archdaily.com/933353/how-rammed-earth-walls-are-built (right hand image)

Passive Design

The student's desire for passive concepts also explored clever design solutions and known technologies. This included phase change materials, enhanced window performance systems, utilising thermal mass and exploring ideas such as solar chimneys.

The students were quite keen to explore how passive solutions could affect an outcome. Significant research was completed and modelling of techniques to improve overall energy consumption without system integration was key.

Key passive solutions focussed on the geometry, but also took inspiration from nature to cool air. Ideas such as thermal labyrinths were explored, given the cool winters and warm summers. These systems, while expensive and not a full conditioning solution, could provide an element of heating/cooling to the overall design.

This passive attempt at reducing greenhouse gas emissions is the key first step to any design and is critical across both architecture and engineering.

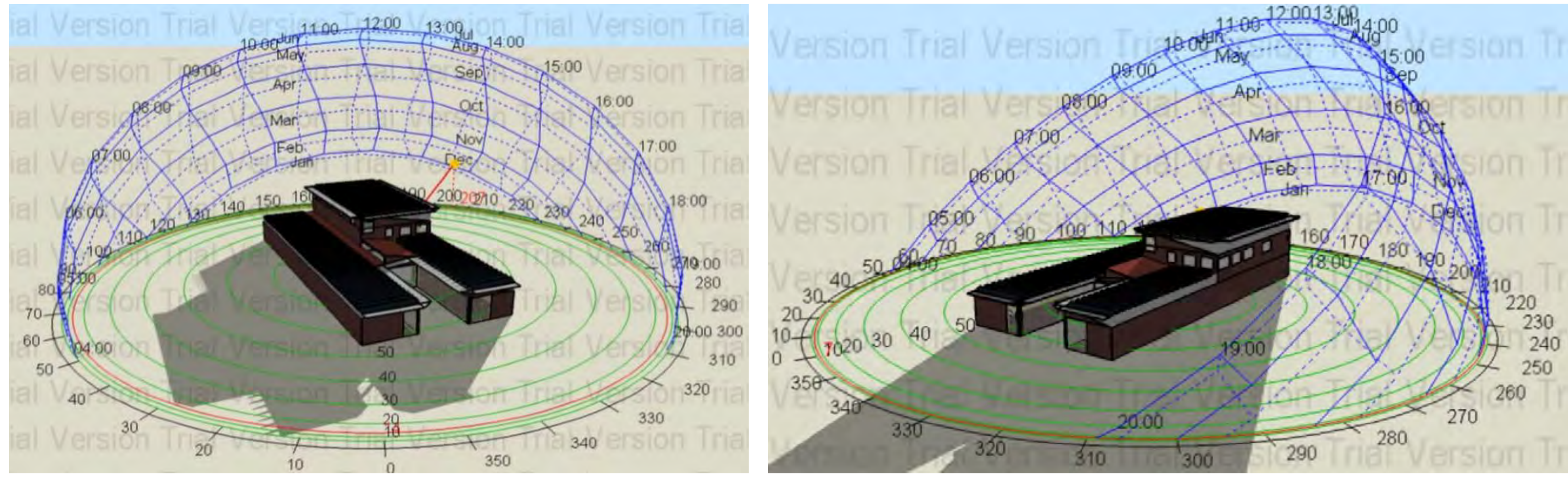


Image: Student 6 Assignment Submission, IDS09

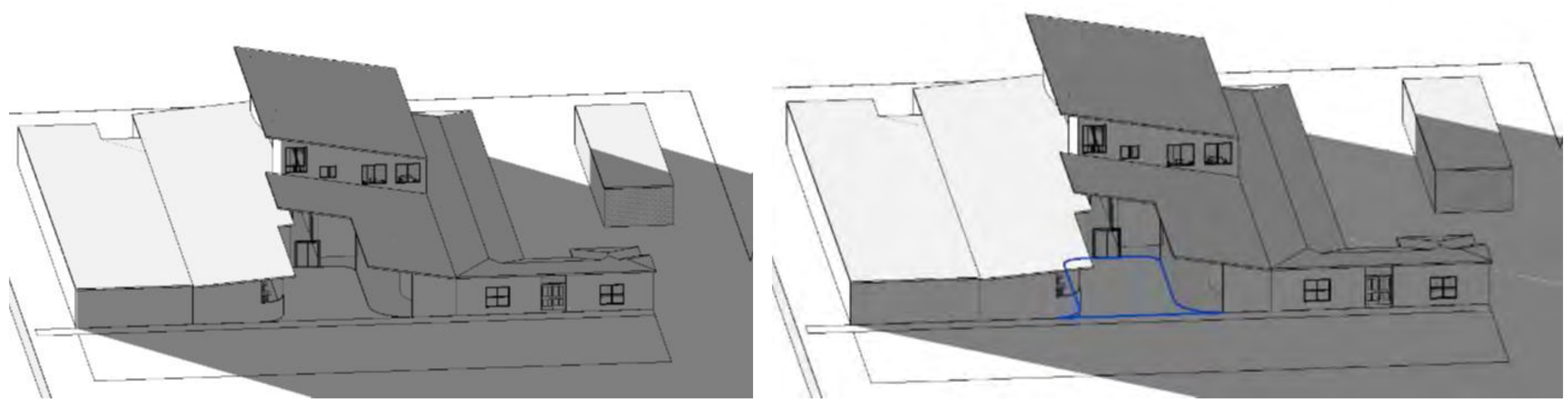


Image: Student 1 Assignment Submission, IDS09

On-Site Renewables

On-site renewables offer a simple and incredibly effective way to offset electricity consumption within the built form. All buildings providing amenity will consume energy. Once the building's energy consumption has been reduced as far as possible, the next step is to offset it through renewables.

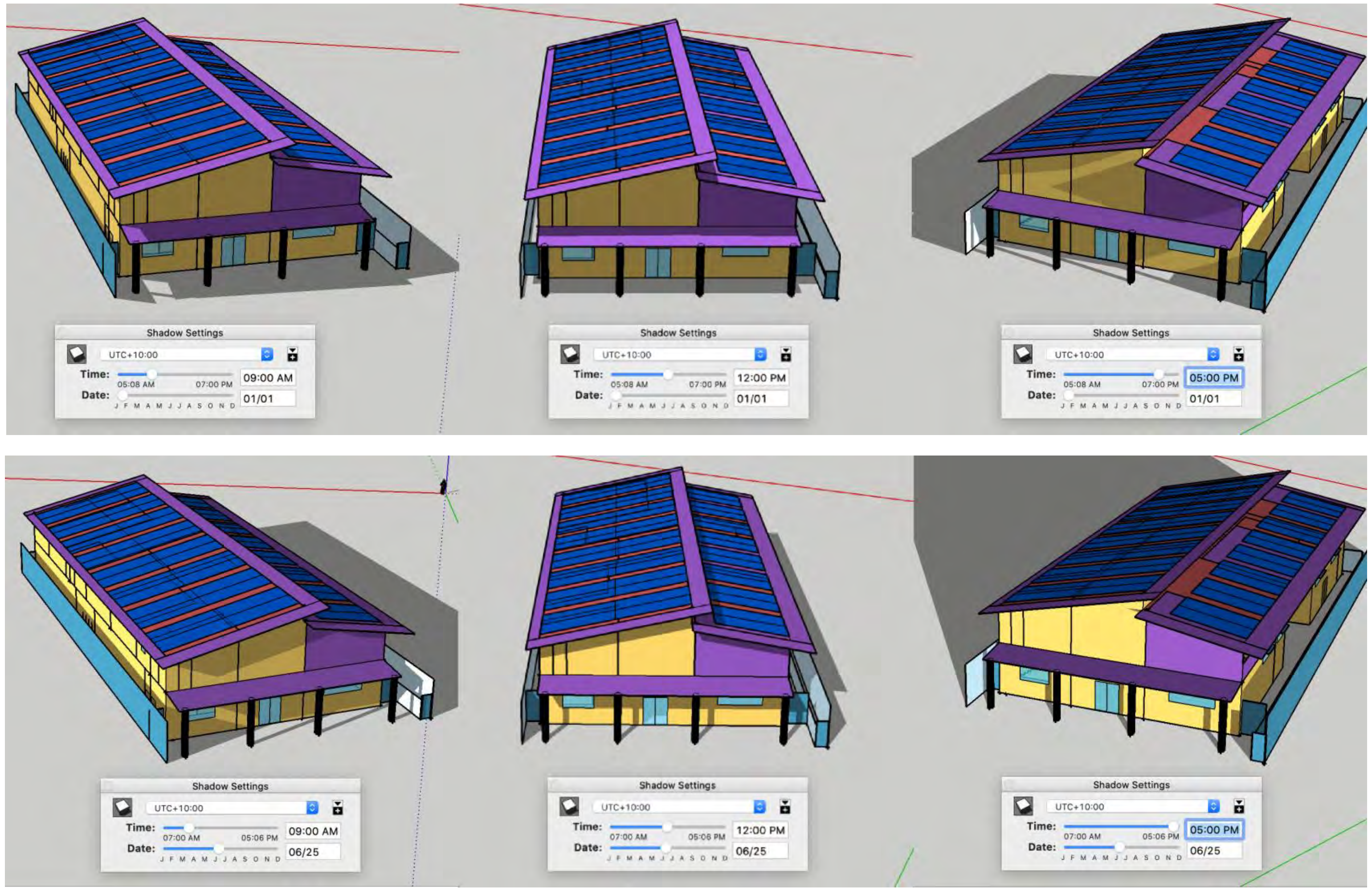
The return on investment is typically high with relatively short payback periods, making it an attractive option.

All new developments should aim to maximise PV, as it provides excellent payback, works towards net Zero and is the single best technology we have.

Most students found that PV had the largest jump in performance when aiming to improve their building performance.

PV systems design should be integrated into a larger site-wide energy strategy which should consider storage to maximise on-site usage of generated power.

A 60kW system was found to reduce the overall building annual energy consumption by 40% compared to a reference case building.



Operational Initiatives

Operational efficiencies are key to driving sustainability and moving towards net-zero. There was a strong focus from students on this area – initiatives associated with operational efficiency provide good opportunities to analyse carbon benefit, compared to passive examples where occupant behaviour may impact effectiveness.

At a high level, the operational measures fell into the following high level categories:

1. High efficiency systems
2. Energy recovery systems
3. Energy management systems

High efficiency:

Given the climate zone, students explored relevant solutions to maximise efficiency. This included designing climate-responsive systems, such as installing windows that meet both the hot summers and the cool winters.

Finding the right technology was pivotal to maximising efficiencies. Students considered the impacts of lighting, including daylight dimming, LED's throughout and pushing what was possible in terms of system choices.

Similarly, students were keen to explore alternates to active heating and cooling. Items such as high volume, low speed (HVLS) fans and thermal labrinths/Trombe Walls were discussed but not analysed – this may require changes to the project brief to enable inclusion.

EC Plug fans and newer technologies are now able to drive higher efficiencies, but the key element is the design of these systems to operate to their full capacity. These systems will always be limited by the underlying technologies.

Energy recovery:

Energy recovery includes the capture of waste energy from required processes to provide inputs and/or offsets for other processes.

Energy recovery ventilators were reviewed by students as a means of capturing heat from exhaust air streams to preheat/cool ventilation air required for code compliance. This reduces the amount of conditioned air being rejected into the atmosphere.

Relaxed Setpoints:

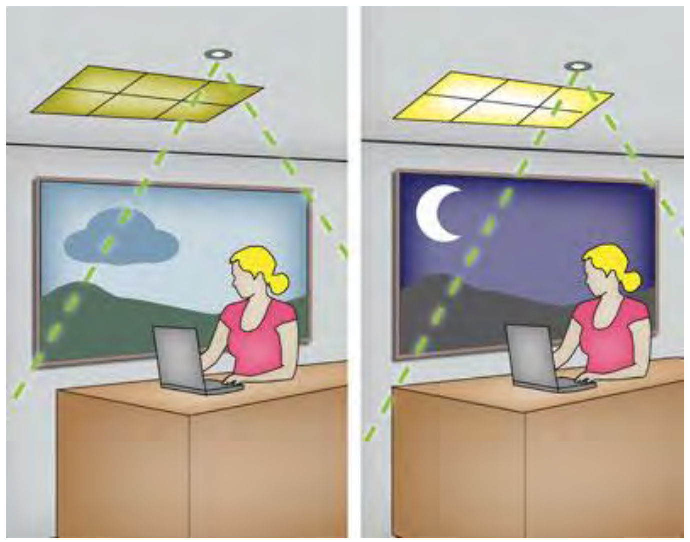
Typical offices are designed to an arbitrary 21-24degC. The students discussed with the tutors the opportunity to increase this temperature band beyond the range. Benefits include a significant saving in energy in both summer and winter, as well as achieving gender equity. The office space is designed for a 60kg middle-aged man in a three-piece suit. It is no longer relevant to the current climate, dress or population.

Students and tutors alike explored the opportunities to save energy by relaxing archaic temperature ranges, as well as designing for people whose clothing choices match the climate (I.e. warmer dressed in winter and cooler in summer.

https://www.abc.net.au/radionational/programs/greatmomentsinscience/freezing-in-office-because-air-conditioning-standards-sexist/8300132

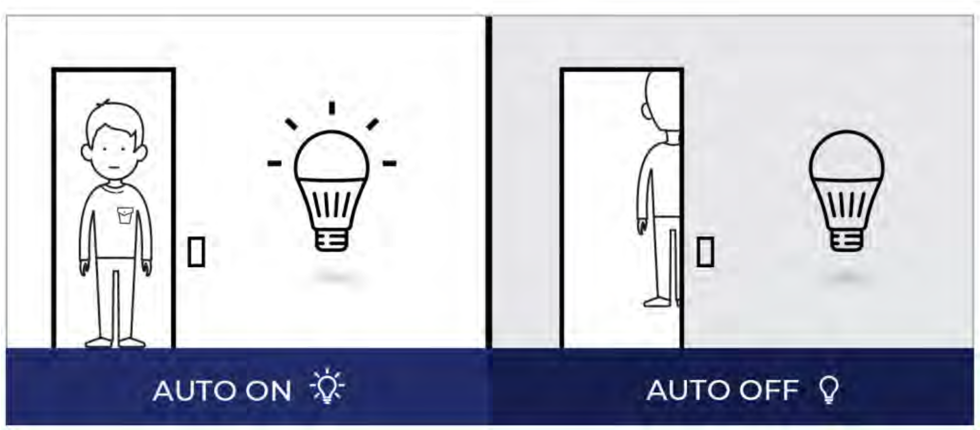
Operational

Daylight Dimming



Daylight Dimming is a method to reduce output of artificial light when ambient light is sufficient. This light is wasted and exceeds the required minimum provisions. It can also lead to glare, so this initiative will ensure adequate light, but reduce waste in energy and assist glare

Occupancy Sensors

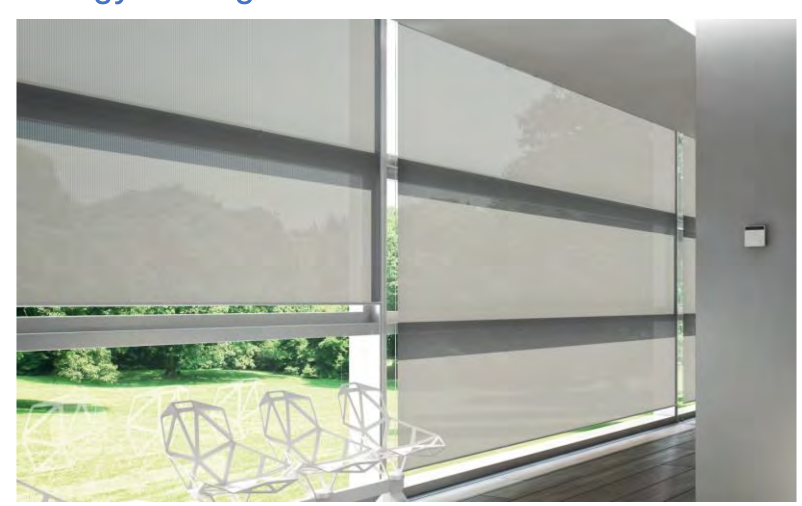


Occupancy Sensors are a tried and trusted technology that allows buildings to only use lighting or equipment when the space is in use. Mechanical systems and lights can turn off and on as required in the space

Air Tight Facades

Exploring Air Tightness is a key consideration in extreme climate zones. Controlling the internal air temperature and movement of air is critical to this. This can control energy, comfort and reduce losses.

Energy management



Automated blinds to control solar loads automatically without user intervention – blocking heat in cooling conditions, allowing solar in heating.
https://www.digitalhomesystems.com.au/about-smart-home/nice-blind-shutter-and-awning-automation

Studio

Embodied Carbon

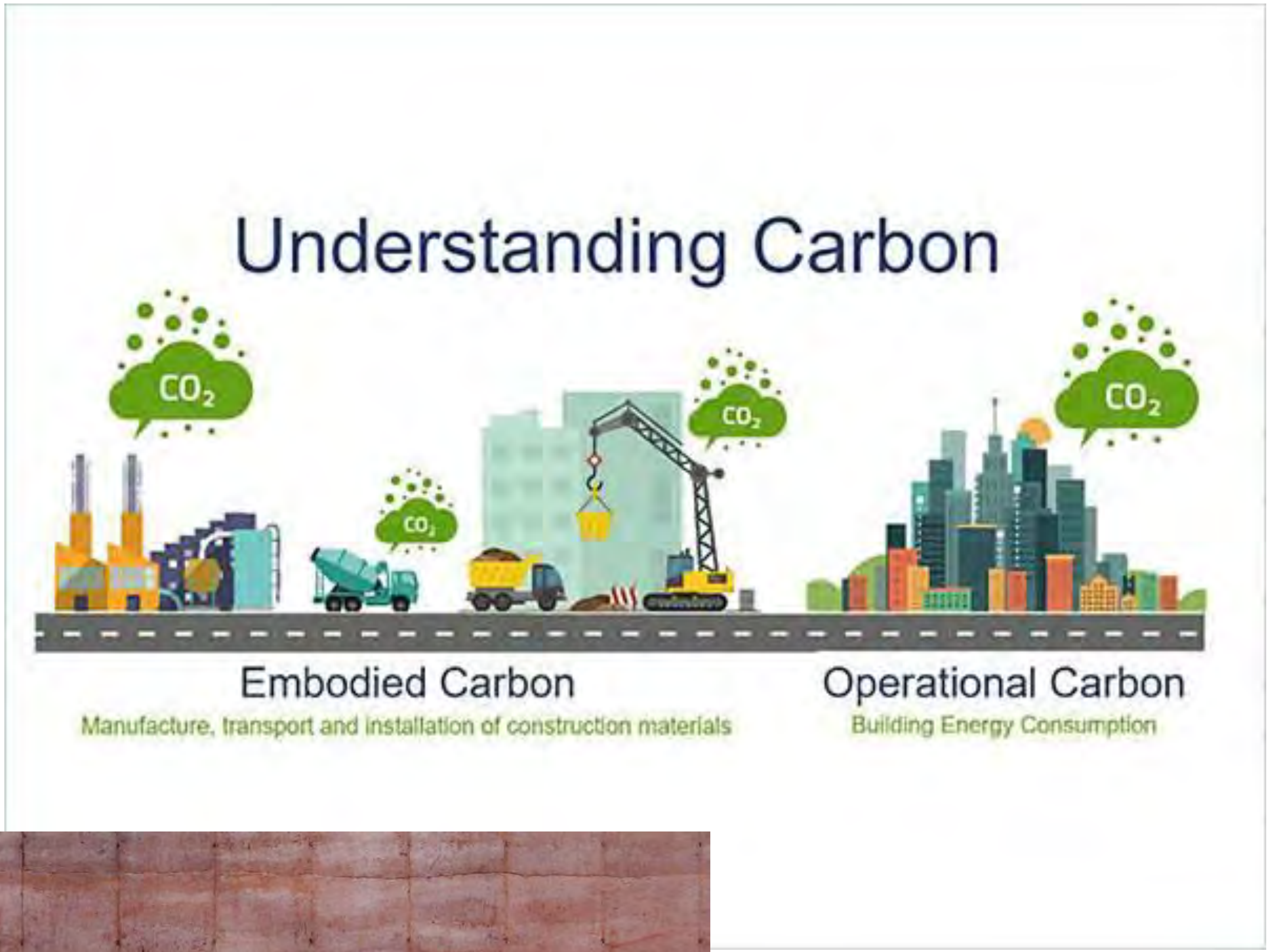
As the grid decarbonises, the importance of embodied carbon within the design continues to increase. In time, embodied carbon and materiality will be the most important metric in sustainable design.

Selection of low-process and low-carbon materials, minimisation and optimisation are key design elements within embodied design. Structural design efficiencies are key as building more with less has an immediate reduction in carbon.

Using alternate materials such as timber, muds, clays, or recycled/repurposed/ upscaled or reused products will reduce the embodied carbon of any development.

An option at Lightning Ridge could be to explore locally-sourced natural materials that can be used for construction. Performance solutions in structural and architectural designs can also reduce construction cost and embodied carbon.

Alternately, waste products locally sourced such as mining tailings could be used in a Rammed-Earth Wall construction. This could assist with multiple problems at once



Rammed earth construction using local soil/clay with timber framed roof – low embodied carbon building materials. https://www.archdaily.com/894341/rammed-earth-construction-15-exemplary-projects

Studio

End of life

Planning the end of life and deconstruction of a building starts in the design phase. The best technique is to ensure the structural life of the building is as long as possible, so the building can have many lives in its existing form.

Specific to the Lightning Ridge Site, it must be considered that there is likely no realistic recycling option for building material. As such, planning building elements to have an extended life, reducing material in construction and planning for how the building will be disassembled is more important than ever.

One concept that has not been explored in this report is the potential benefits of modular construction or prefabrication of façade elements. Considering the location, this could significantly reduce waste during construction, and put in place a stewardship (take-back) option at the end of the project to remove a vast portion of embodied carbon from the construction process.

Timber is also a fantastic material for pre-fab, being quick, accurate and light to bring to site.

Timber construction – designed properly for deconstruction can then be repurposed of recycled easily at end of life
https://givingcompass.org/article/mass-timber-construction-is-about-more-than-just-storing-carbon

Prefabricated units could significantly reduce the end-of-life waste issue, transport, speed of construction and cost.
https://medium.com/autodesk-university/integrated-bim-workflows-in-modular-prefabricated-construction-concept-to-fabricate-2cff9b3573e1

Improvement on Business as usual

Unlike commercial buildings which have NABERS or Residential developments that have BASIX, the variability in design of the size and usage of similar facilities means there is no single, definitive benchmark available for end of use energy. Similar buildings are necessarily normalised for climate zones, as Lightning Ridge is in itself an atypical site.

The students through their work have developed assessments of potential savings within their proposed scope of study. The combined savings associated with these end use energy components, combined with renewable energy potential would result in a significant reduction in the building operational energy compared to business as usual design.

Students have aimed to demonstrate a REF value as close to 1.0 as possible. Most students have found a REF Value to be possible in the range 0.6-0.7, suggesting up to 70% of the site's operational carbon can be abated.

This is typically achieved through a combination of operational and passive measures, complimented with compromise on operation and renewable sources

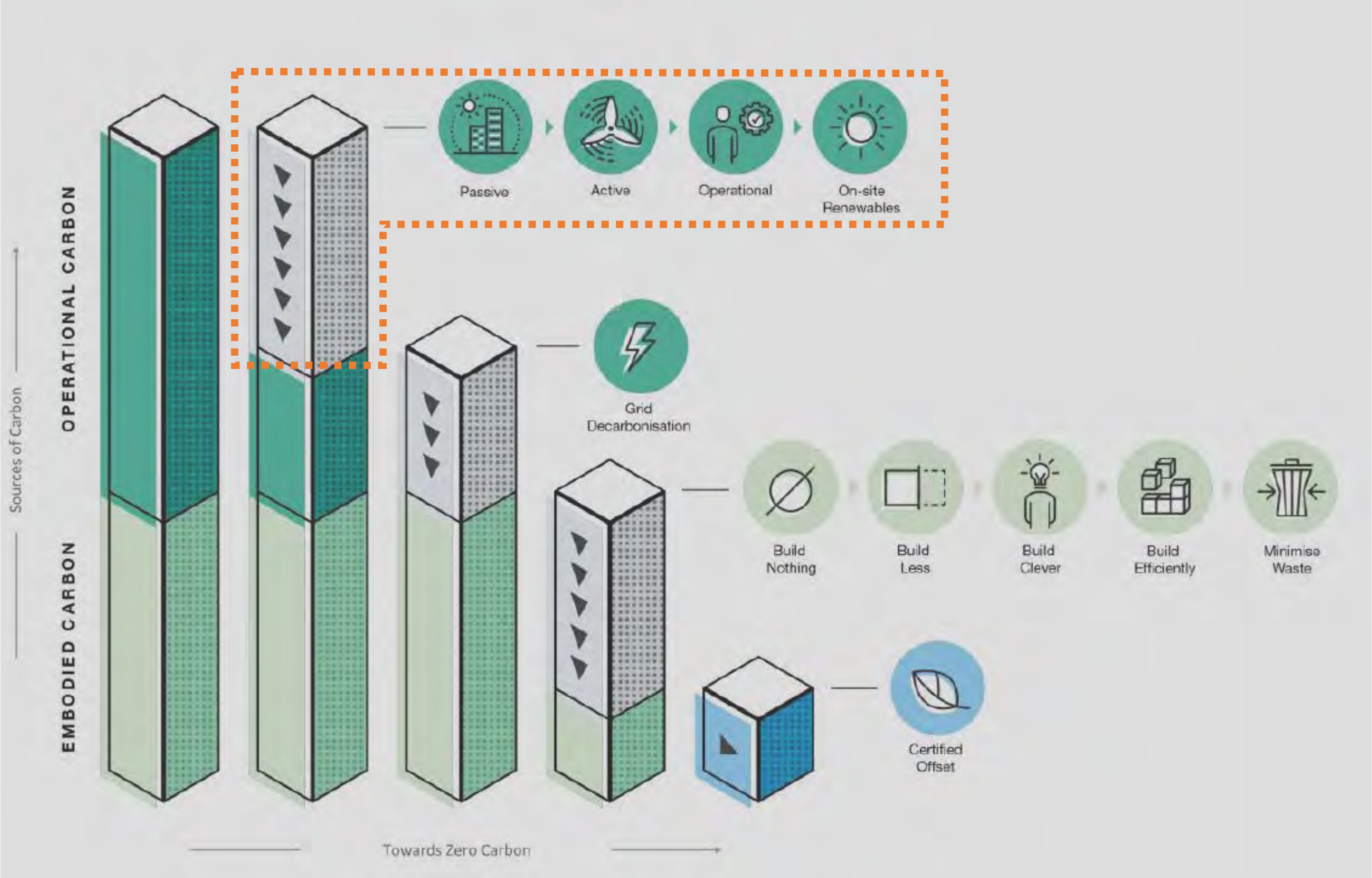
The options reviewed as part of the studio would be capable of achieving a reduction of well over 25% of operational carbon.

Minimal analysis was completed on economic effectiveness of the proposed measures – this may impact the adoption of specific initiatives which have lower return on investment.

While the scope of the studies were limited in parts, there were significant works undertaken to demonstrate opportunities across engineering and architecture to affect real change.

A range of design improvements, combined with onsite and offsite renewable the development could achieve net-zero operational carbon.

This is achievable with whole-of-life, whole-of-process thinking through design.



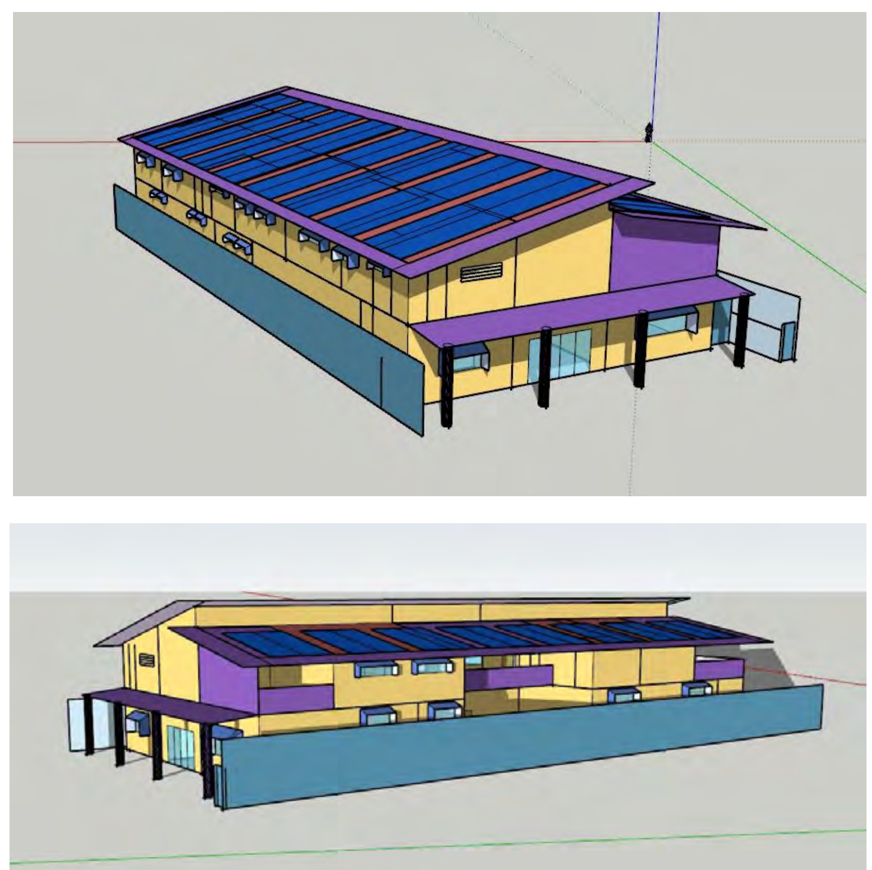
Adapted from: Arup.com - net-zero carbon buildings: three steps to take now (2020)

Conclusions

This studio concluded that there are many opportunities to reduce this building's carbon during construction and operation. The focus of this vetting report has typically been on operational carbon and drawn primarily from the students work. It is not exhaustive, and we note that there are other net-zero pathways available for community facilities such as this.

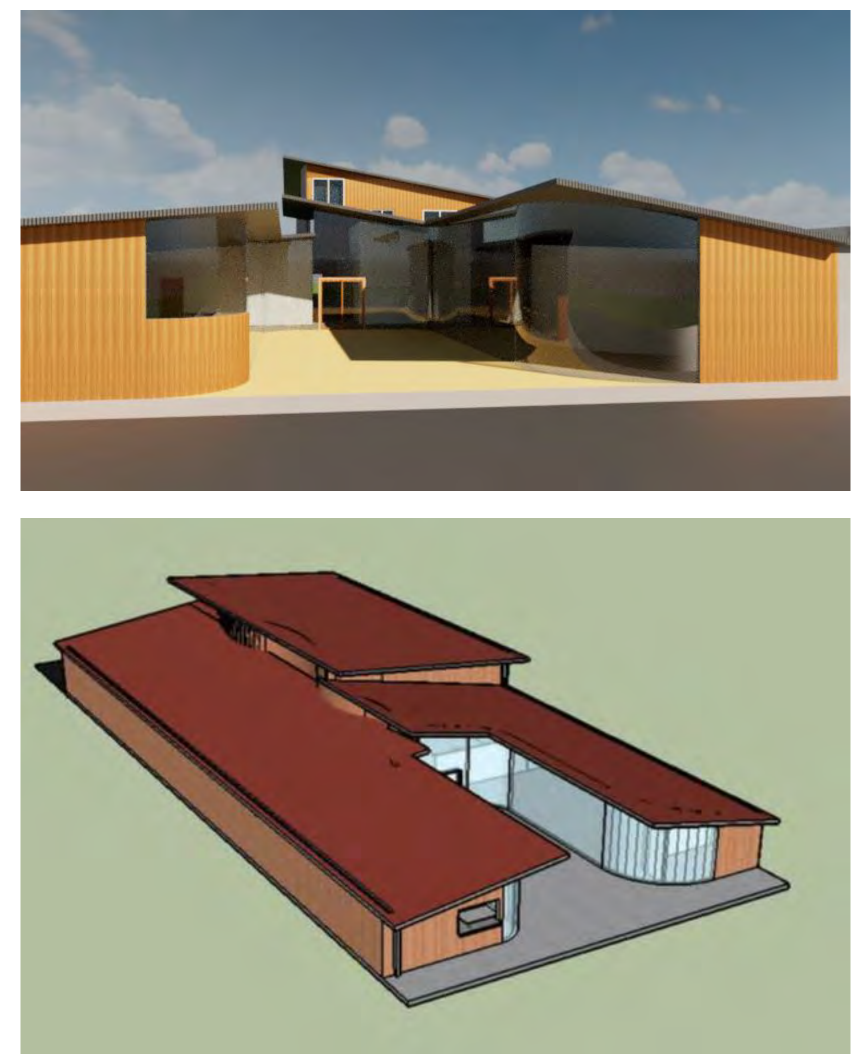
Building design should look to minimise energy use first through passive design minimising the building requirements. This may include adjustment to the user amenity, e.g. nominated thermal comfort requirements. Where energy use is still required, energy recovery and efficiency should be prioritised with management of the energy use playing a key role in optimising the environment. Renewable energy can then offset the remaining energy, looking to maximise this onsite first and potentially integrating energy storage. Where a shortfall still exists, there may be potential to combine this with an offsite renewable energy scheme.

As a facility which focusses on communal spaces, consideration should be given to features which can also have other more intangible benefits such as natural daylight providing both carbon reduction and a positive contribution to wellness of the facilities' users.



Images: Student 4 Assignment, IDS09

No overarching pathway for net-zero has been presented in the students' work, however, the individual reports do show a high level of savings is available. Design optimisation, higher minimum standards and renewables will continue to play a major role in any net zero strategy.



Images: Group 2 Assignment, IDS09