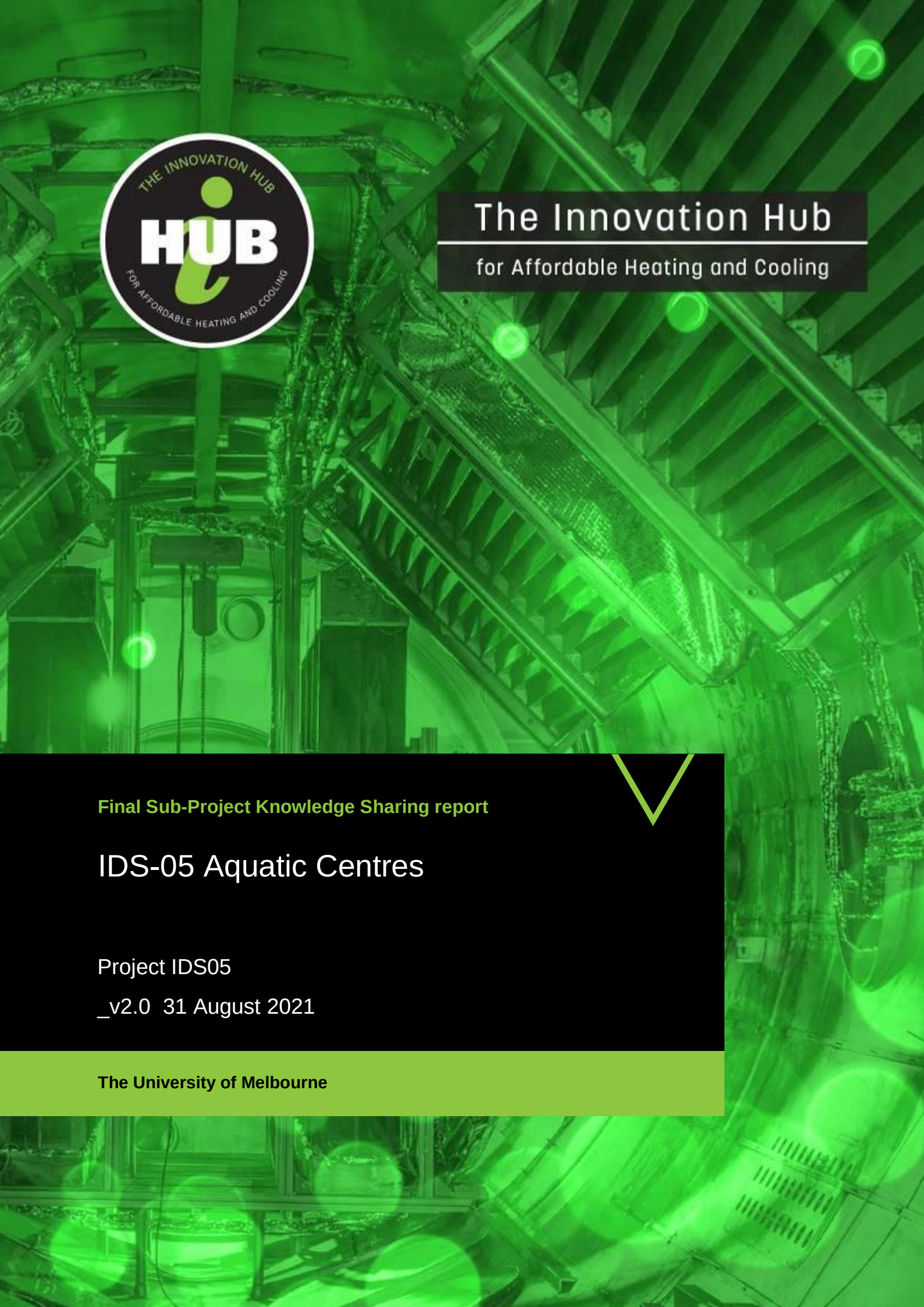

Final Sub-Project Knowledge Sharing report

IDS-05 Aquatic Centres

Project IDS05

_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-05 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-05		
Sub-Project commencement date	01 July 2020	Completion date	30th May 2021
Report date	21 May 2021		
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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.

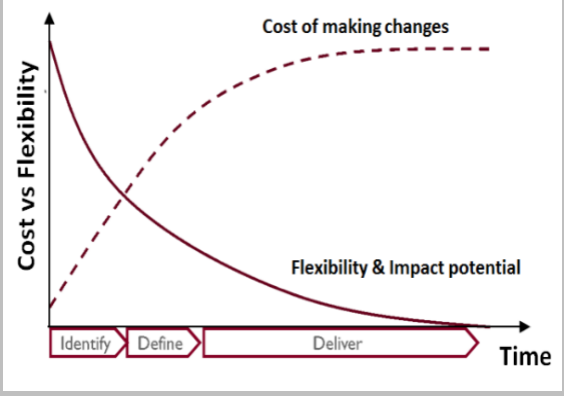

Figure 1: Decision value: opportunity with time.

Building Typology Research (Aquatic Centres)

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-05 is aquatic centres. These types of public facilities represent a major consumer of carbon due to the extensive requirements for heating and cooling and management of water for the pool areas. As such any gains in renewables use and zero carbon initiatives able to be implemented in this typology will have significant impact.

The studio brief included new build components for both indoor as well as outdoor facilities at an imaginary St.Kilda site. The results from the study assist the local councils in their decision-making on how to achieve substantial carbon reductions for their aquatic centres, both existing, as well as those newly planned.

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-05 were:

City of Yarra, Banyule City Council, Moreland Council, and **Brimbank Council** – Client representatives

WSP – Multi-disciplinary consulting, engineering

Alan Pears – Industry specialist in heat pump technology

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-05 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 aquatic centres.

Figure 2: Zero Carbon project proposal by Hon Chun Hin

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.

Aquatic Centre design (Building Typology Technical initiatives)

Achieving carbon neutrality in the design of aquatic centre is possible. Initiatives explored included:

- Passive design measures
  - Orientation to capture passive solar radiation while excluding peak summer sun,
  - Exposed external pools to capture solar radiation,
  - Insulation within the building envelope, for the floors, walls and roof,
  - Judicious rationalisation of glazing extent to balance natural daylighting while minimising heat transfer,
  - The use of green roofs and planting elements to provide natural insulation,
  - Thermal mass inside the building to help stabilise and moderate internal temperatures.

- Active design measures
  - LED lighting.
  - Rooftop Solar PV.
  - Rainwater Harvesting.
  - Electric heat Pump.
  - Hydro-botanic filter pond.
  - Microinverter technology to harvest energy from gym equipment.
  - Piezoelectric energy system harvesting energy from foot traffic.
  - Solar PV as shade structures

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).

Solar PV shades, image by Tingjun Bai, University of Melbourne

Piezoelectric walking mats, image sourced by Haziq Azul Rahmam, Uni Melbourne

Figure 3: Sample ESD design initiatives from student Projects.

Sub-Project Impact (linked to studio planned objectives)

Overcome too narrow focus on Aquatic Centre design: Student projects developed under the DS-05 umbrella demonstrated that there are ample passive as well as active measures that can be undertaken to improve the thermal performance of aquatic centres and address other Net Carbon related issues. One noteworthy design concept relates to opportunities to include additional public functions/program to the project site to take advantage of the local Zero Carbon loop.

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.

The potential contribution of innovations to increasing the fraction of building energy that can be economically provided by on-site: Among the main innovations the following stand out: Material selection, façade 'tightness' and the use of PVs (incl batteries for storage) and heat pumps are some key.

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.

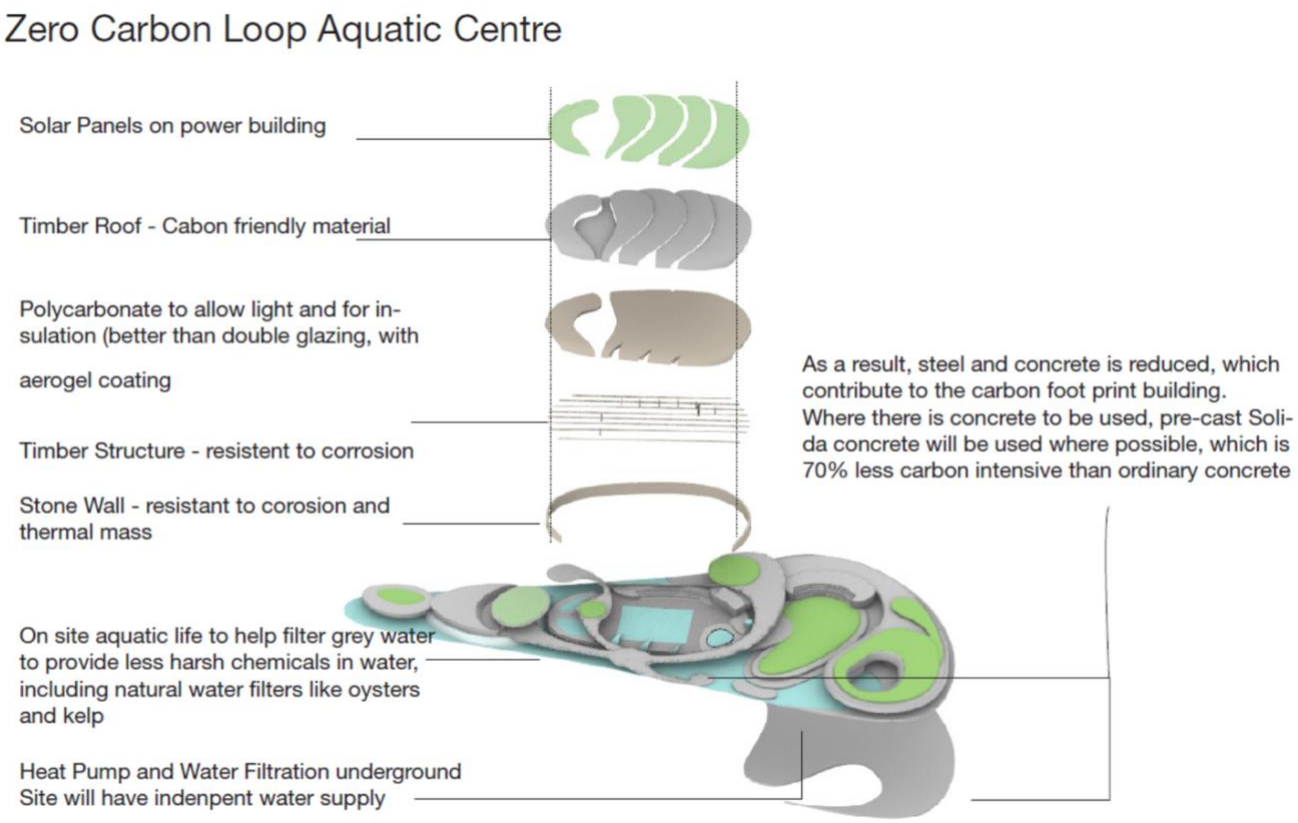

Figure 4: Zero Carbon Loop, by Billy Dong.

4. Links to reports

The following reports were produced for public sharing as a part of or in relation to IDS-05 and the wider IDS activity stream. Click on documents to be linked to publicly available copy.

IDS-05 Specific Reports

- **i-Hub IDS-05 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-05 Lessons Learnt Report :** Details of lessons learnt (Technical and logistical).
- **i-Hub IDS-05 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 local councils. 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 aquatic centres, 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.

8.4 ALL ELECTRIC DESIGN

There is increasing recognition of the need to design buildings to operate entirely on systems supplied by electricity and to transition away from natural gas, as gas is a fossil fuel which cannot easily be replaced with renewable alternatives.

Electric heat pumps are therefore an increasingly common and well proven technology for many buildings. For aquatic centres these systems pose potential but with the challenge of having to design for supply of large amounts of heat to multiple pools and air systems during conditions of low ambient air temperatures.

Electric heat pumps can harvest heat from the air, ground or water bodies. These can also operate from renewable supplies such as onsite or off-site solar.

Other key design implications in incorporating electric heat pumps include increased noise from the units, increased spatial requirements and the need to resize electrical infrastructure to cope with the increased use of electricity.

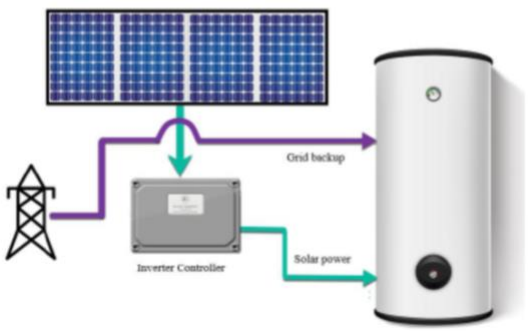

Figure 5: Extract from WSP Project Vetting Report

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

Aquatic centres are complex buildings with entrenched expectations from users such as large areas of glass facades or roof that don't align with energy efficiency. Achieving Integrated design from a standing start was found to be challenging for students.

Key energy initiatives explored included thermal zoning, passive heating envelop efficiency and various on-site renewables generation. Landscaped roofs were a popular initiative adopted yielding dual benefits of improved energy performance as well as providing additional public use space integrated within the building program.

Timber structure solutions as used more commonly overseas in aquatic centres were another popular choice bringing significant embodied carbon benefits.

The consultants (WSP) prepared a useful table of 'opportunities for net zero energy' which presented 'current best' and 'future' practices which will be a useful resource for designers.

Key future focus areas identified by the IDS to progress towards zero carbon were:

- Building Thermal Fabric
- Electrification of building services
- Smarter and more precise control strategies
- Design to performance metrics (benchmarking)