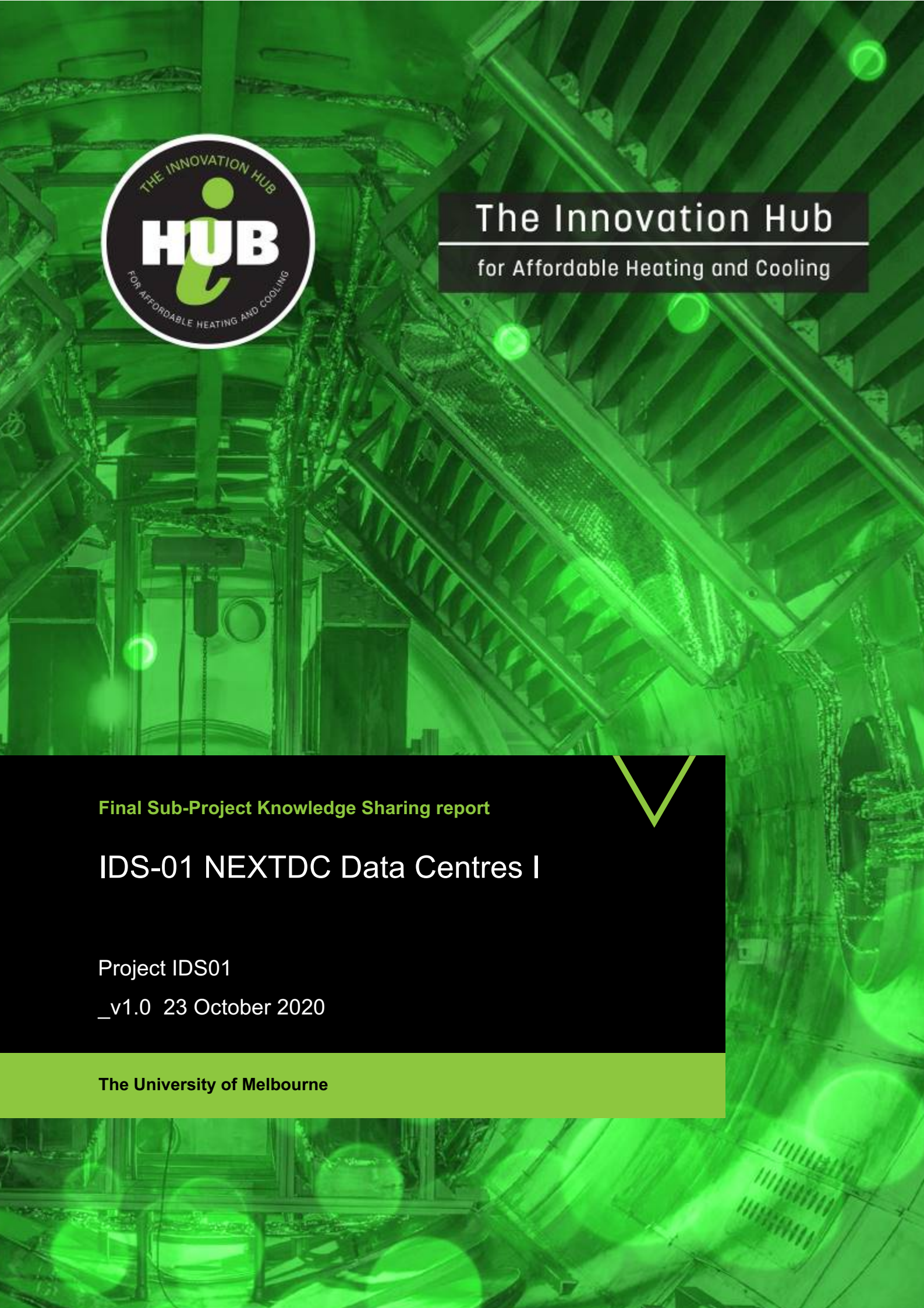


The Innovation Hub

for Affordable Heating and Cooling

Final Sub-Project Knowledge Sharing report

IDS-01 NEXTDC Data Centres I

Project IDS01

_v1.0 23 October 2020

The University of Melbourne

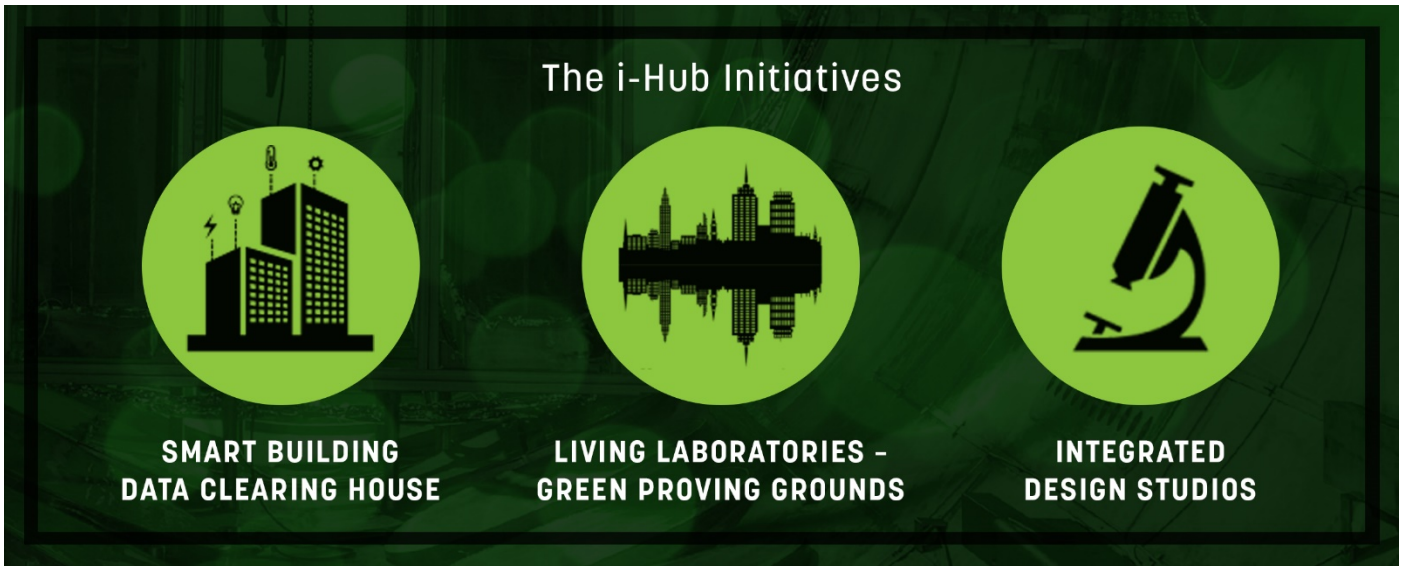
About i-Hub

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-01 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-01		
Sub-Project commencement date	20 January 2020	Completion date	30th November 2020
Report date	23 October 2020		
Contact name	Dr Dominik Holzer		
Position in organisation	Associate Professor in Digital Architectural Design		
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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.

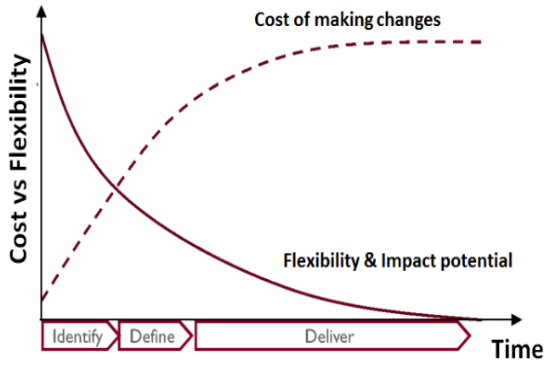

Figure 1: Decision value: opportunity with time.

Building Typology Research (Data 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-01 is Data Centres. The rapid and continuing growth of the ICT industry means that data centres will be one of the worlds large energy users in the future. Significant opportunities exist for building strategies involving energy capture, generation (through renewables), and waste heat recovery.

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-01 were:

NEXTDC – An experienced data centre operator recognised for innovation

Aurecon - Consulting Engineers with experience in the design of data centres

Greenbox Architects – Consulting Architects also with experience in data centre design

The University of Melbourne – Academics from both the Melbourne School of Design (MSD), and the Melbourne School of with 16 masters of architecture students, supported by a part time research assistant.

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

IDS-01 was initiated early March with semester work running for 15 weeks until the end of June 2019. Technical feasibility vetting of the design ideas produced throughout the studio (by the consultants) took place in the 4-6 weeks 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 data centres as a building.

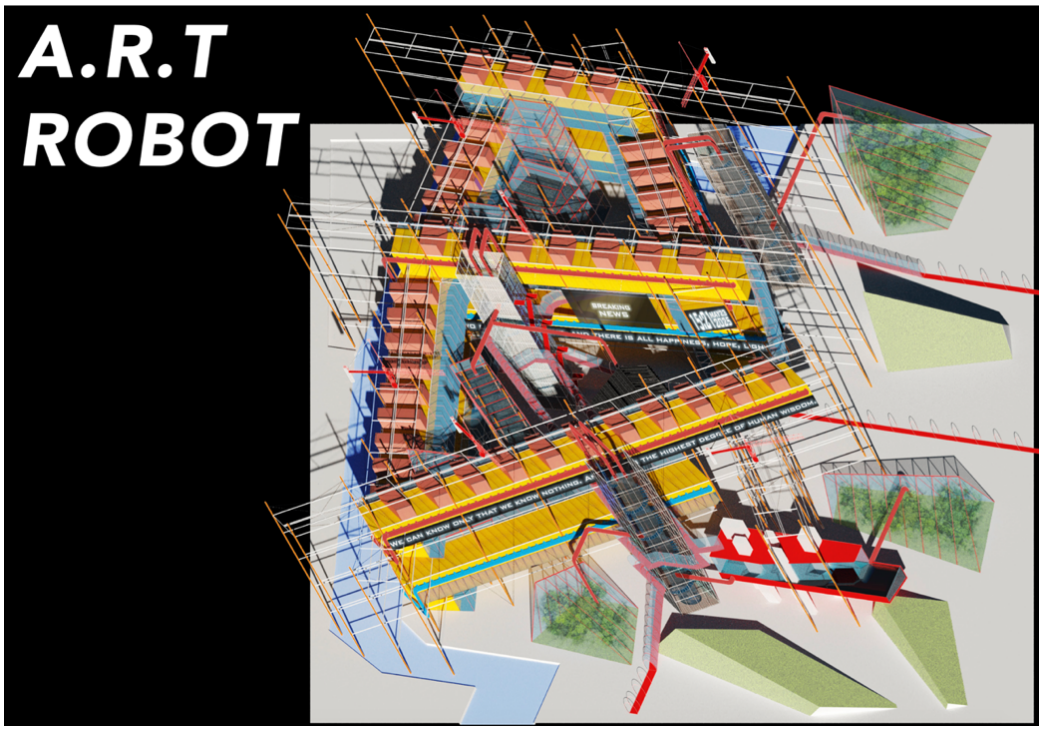

Figure 2: A.R.T. Robot by Shi Pan – A modular construction data centre concept enabling extension and easy updating of technology into the future.

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

- 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.

Data Centre design (Building Typology Technical Initiatives)

- Relative renewable energy contributions to data centres are small (1.0 - 2.5% of overall energy consumption) due to the extensive (80+ MW) base loads. ‘Net Zero’ targets are impossible to achieve via technology interventions.
- Capture and recovery of waste heat through adjacent symbiotic uses such as aquatic centres and greenhouses provides opportunities for better community engagement and potential competitive edges for data centre developers in competing for sites.
- Modular construction offers benefits in expansion and periodic technology updates.
-

Studio Logistics

- Future studios will benefit from the groundwork done on understanding sub-project partners concerns with agreements required for participation.
- It was more difficult enlisting engineering students to the studios than architectural due to breadth of engineering disciplines and options.

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).

Sub-Project Impact (linked to studio planned objectives)

Overcome discipline prioritisation and risk-management barriers that prevent design consultants from providing innovative designs for their clients: Data Centres are arguably one of the most technically driven building typologies there are. The steep learning curve of architects getting their minds around kilowatts of energy required per rack and the strict spatial consequences this translated to along with all of the other maintenance and access considerations was interesting to observe. The learnings helped advance practical knowledge of integrated design implementation significantly contributing to breaking down the barriers referred to in this metric. Participants in the studio definitely benefitted from this, wider impact will depend upon industry take up of the learnings.

Contribute to the knowledge and development of the IDS process being developed and facilitated by i-Hub: *Significant 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 renewable energy (target 25% increase relative to BAU) is assessed: Fractional benefit of renewables in reducing data canter operation was found to be small. Significant opportunities were identified for reductions in potential adjacent uses such as aquatic centres and greenhouses. Will contribute to overall 25% increase if taken up.

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.

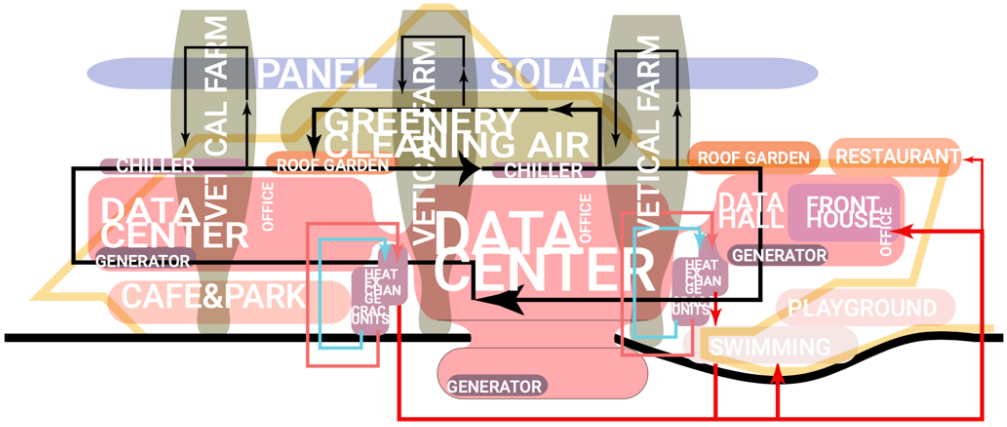

Figure 3: Zero C data loop diagram demonstrating importance of adjacencies by Kun Feng.

4. Links to reports

The following reports were produced for public sharing as a part of or in relation to IDS-01. All reports have been uploaded to the i-Hub SharePoint site, titles link to latest version associated with this report.

- **i-Hub IDS-01 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-KS Catalyst for Integrated Design** : Live integrated design methodology document (updated with learnings from each successive IDS).
- **i-Hub IDS-01 Lessons Learnt Report** : Details of lessons learnt (Technical and logistical).
- **IDS-KS JP01-HighPerformanceBuilding(LA-17Jan2020Draft)** : Journal paper manuscript – note: not to be released prior to acceptance and publication in Journal.
- **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 MA03 Ecolibrium Data centre Article** : PDF of article published Ecolibrium October issue.
- **IDS-KS WB ihub-summit-ids** : PDF of IDS June 2020 webinar slides.
- **i-Hub IDS-01 Final Sub-Project Knowledge Sharing Report :** This report

6. 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 a 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.

7. CONCLUSIONS

7.1 Conclusions and integration into the wider IDS programme

The NEXT-DC Data Centre IDS has received highly positive feedback from all involved, in particular the client. Against the backdrop of a difficult start to the semester, with engineering students unable to join, and the sudden move to online teaching, the IDS managed to create an environment of architect/engineer collaboration (with net zero carbon targets as a focus), in which to study how integrated design occurs. The design 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.

The applicability for renewables in Data Centre design was found to be relatively small (in terms of the overall energy used in the base facility), however significant opportunities for better ways of doing business were identified through the potential adjacencies of symbiotic high energy use facilities such as aquatic centres and greenhouses. These uses provide opportunities for greater community engagement and benefit, and also provide a potential competitive edge for data centre operators competing for sites.

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

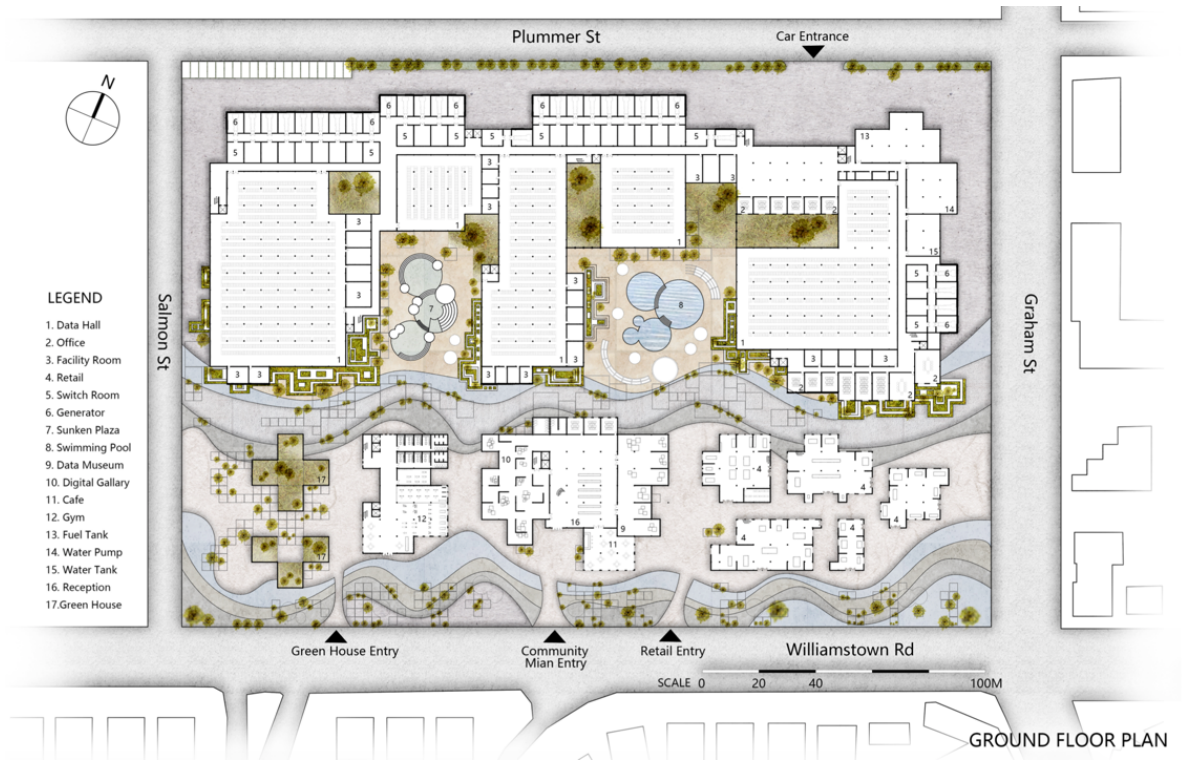

Figure 4: Example data centre layout showing public engagement initiatives by Wenting Gan.