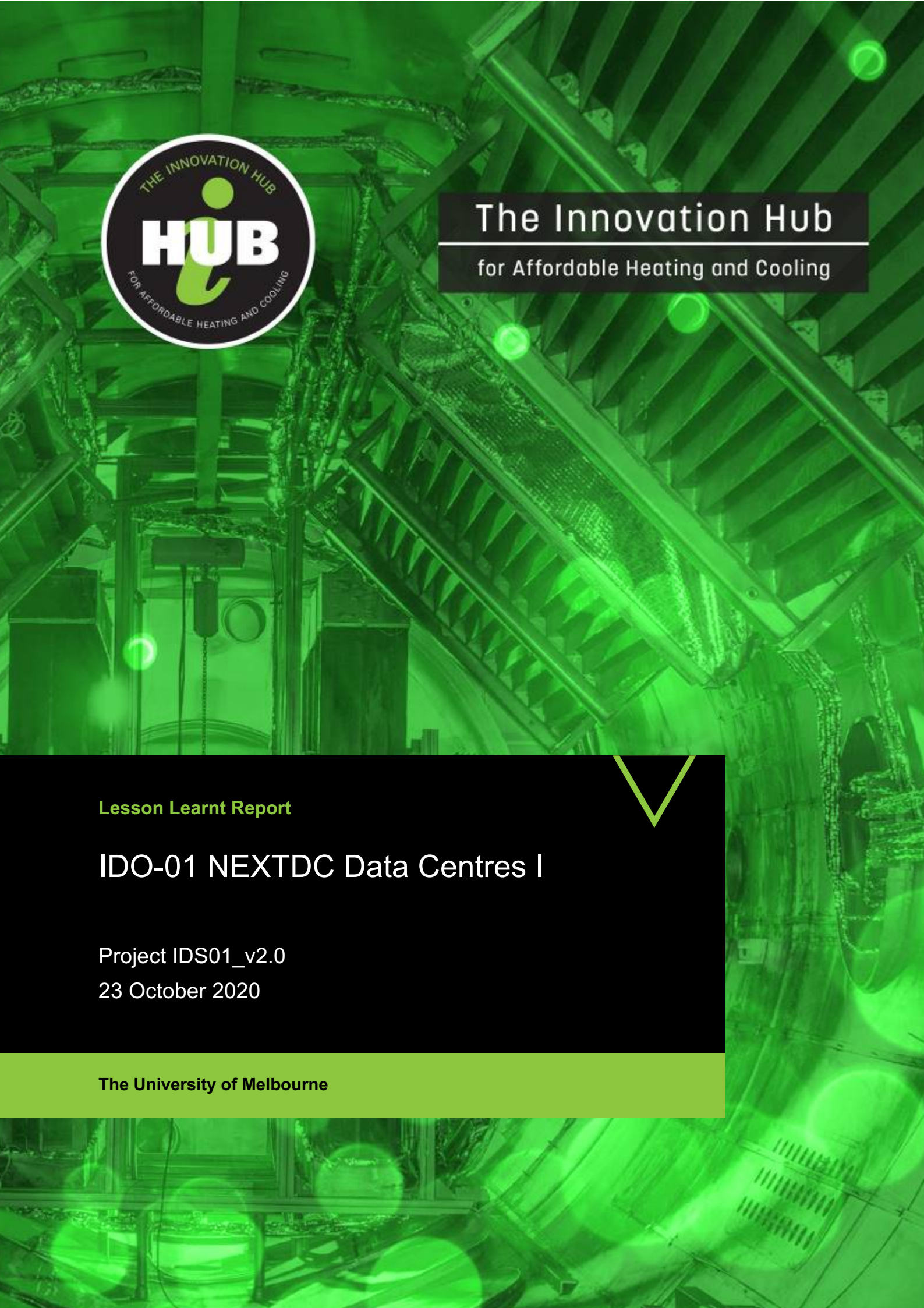

Lesson Learnt Report

IDO-01 NEXTDC Data Centres I

Project IDS01_v2.0

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.
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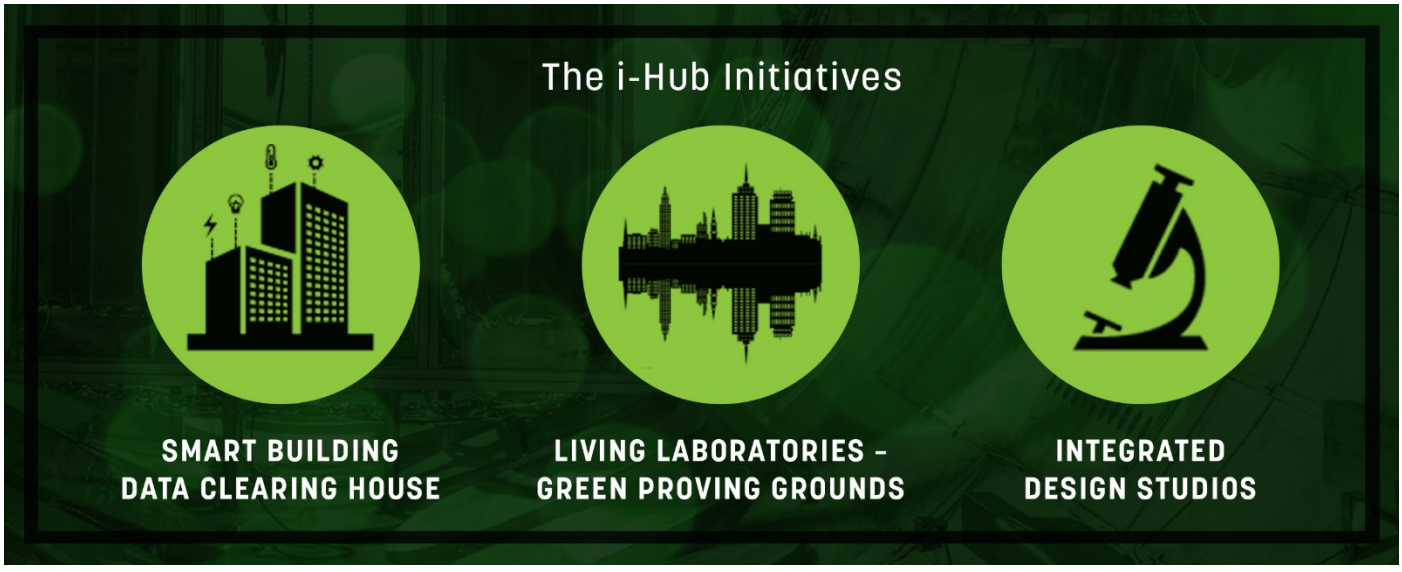

i-Hub Lessons Learnt Report

Guidance notes for completion of the Lessons Learnt Report:

- This report is intended to be made public.
- Please use plain English, minimise jargon or unnecessary technical terms.
- Please use your organisation's branding for the report.
- The report should meet your organisation's publishing standards.
- Please use one template per each major lesson learnt and include as many as are relevant for your sub-Project. If what you learnt is more technical, this is the section to include technical information.
- The content of these Lessons Learnt Reports can be compiled (and updated, where necessary) for inclusion in the (public) Project Knowledge Sharing Report, for submission at the completion of your sub-Project.

Lead organisation	The University of Melbourne		
Sub-Project number	IDS-01		
Sub-Project commencement date	20th January 2020	Completion date	30th November 2020
Report date	23 October 2020		
Contact name	Brendon McNiven		
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Note: This report builds upon the previous Lessons Learnt report v1.1 provided at 50% studio completion (Studio Semester work currently 100% complete). Previous lessons have been refined/confirmed where required and further lessons added.

The purpose of the integrated design studios is to progressively learn more with each studio as lessons are incorporate into the studio format and tested. As such Lessons Learnt reports include a summary of applicable lessons learnt in previous studios (in greyed out format), with updates included in non-greyed out text.

Lessons learnt

Lesson learnt IDS-01 #1	Good integrated design requires a 'design co-author' mindset in all participant designers.
	Note: This lesson was taken from studios IDS-01 & IDS-02 and will feed into the development of the "Catalyst for Integrated Design" document intended to be further refined and tested through future studios.

Category	Technical					
Choose from:	*Technical*	*Commercial*	*Social*	*Regulatory*	*Logistical*	*Other (specify)*

Describe what you learnt about this aspect of the Project.

Integrated design is the coming together of multiple disciplines to produce design solutions that meet 'whole of project' visions. Early observations in the Integrated Design Studios (IDS's) currently underway is that not all designers are used to working in this way.

Current design paradigms often place engineering as following architecture in the design process. This encourages a consulting type approach to the engineering where engineers are asked to comment on preformed ideas. Design integration can occur in this model however to a reduced potential with the initial ideation missing ideas founded in engineering aspects of the project.

The studios found this consulting model to be difficult to break free from. Attention needs to be paid to create a mindset of 'design co-authorship' in all participants (engineers and architects alike).

The reasons for this are not immediately clear however we believe may be related to:

- Potential deficiencies in creative thinking education in degree content.
- Established practices in industry (i.e. accepted established role as consultants).
- Early career stage (more experienced engineers were found to be better at ideation that younger engineers).
- Disparity in time available to be dedicated to studio ideation.

Please describe what you would do differently next time and how this would help. What are the implications for future Projects?

A degree of effort was made to articulate the desire for co-authorship of ideas with participants prior to the IDS commencement. We feel this did not reach its full potential due to the way relations were set up between designers. In future studios we aim to:

- Emphasise the concept of co-authorship in ideation more heavily.
- Aim for a better balance in numbers between architects and engineers.
- Aim for a better balance of seniority between architects and engineers (to encourage approachability and reduce fear of failure in putting ideas forward).
- Introduce common tasks at a detailed analysis level as well as the high aspirations level to encourage interaction between architects and engineers with common goals. This is anticipated to foster more detailed generation of ideas between the two disciplines.

Other potential causes (related to those listed above in 'what was learnt') will be further explored in future studio stakeholder interviews.

If your Project learnings have identified any knowledge gaps that need to be filled, please state it below.
This aspect of design is sensitive to the relationship of individual designers which can be complex. We feel it is an important point to have uncovered however believe it will take some iteration in adjustments of the studio mix and nature of the integrated design process being trialled. This iterative nature of the research, refining the findings and adjustments over multiple studios, is one of the reasons multiple IDS's were planned. Future studios will help refine the findings and close the gaps that currently exist.
Please include any other information you feel is relevant or helpful in sharing the knowledge you learnt through this stage of the Project. This may be qualitative or quantitative and may include a graph, chart, infographic or table as appropriate.
Reference should be made to the journal article produced on best practice integrated design to provide context.

Lesson learnt IDS-01 #2	Integrated design happens over a limited time window.
	Note: This lesson was taken from studios IDS-01 & IDS-02 and will feed into the development of the "Catalyst for Integrated Design" document intended to be further refined and tested through future studios.

Category	Technical					
Choose from:	*Technical*	*Commercial*	*Social*	*Regulatory*	*Logistical*	*Other (specify)*

Describe what you learnt about this aspect of the Project.

In observing the design processes around ideation, it was clear that the design window with respect for coming up with integrated designs was short. In a 13-15-week design programme much of the front end is taken up with briefing and bringing design parties up to speed with each other's discipline (in general knowledge terms), the back end is conversely dominated by design development and documentation type activities.

In-between these two general phases is a very brief period when core design ideas are generated and formed. Once design ideas are formed it is difficult to materially change direction due to the momentum involved. Designers hold preconceptions after this initial ideation and the natural tendency is to adjust direction rather than to discard totally to start again.

This means it is important to recognised when this ideation period is happening ensuring everything and everyone is in place to make it as successful as it can be.

Contrary to expectations the most fertile period for ideation was found to be mid-semester and the ensuing week or two. We believe this is because designers spend the first half of semester gaining the understanding required to produce 'normal' or business as usual (BAU) solutions. It is only once these 'normal' solutions are understood that designers feel comfortable in experimenting more. This indicates that integrated design happens more readily with more experienced designers (who have less of a learning curve in relation to the basics).

Please describe what you would do differently next time and how this would help. What are the implications for future Projects?

In future studios more attention will be placed on this important ideation time. We may even give it a name so that the participants are aware of it and treat it with the degree of importance and priority it requires.

If your Project learnings have identified any knowledge gaps that need to be filled, please state it below.

As described above in Lesson #1, exploration and refinement of the integrated design process on points such as this is intended to be an iterative process that occurs over multiple studios.

Future more detailed studies on the effects of precedent knowledge and single disciplinary skills as well as knowledge of building typology and the typical (normal or BAU) solutions that apply on integrated design may be worthwhile. Such design exploration is outside the scope and capability of the IDSs.

Please include any other information you feel is relevant or helpful in sharing the knowledge you learnt through this stage of the Project. This may be qualitative or quantitative and may include a graph, chart, infographic or table as appropriate.

None.

Lesson learnt IDS-01 #3	Balance between architecture and engineering requires active curation.
	Note: This lesson was taken from studios IDS-01 & IDS-02 and will feed into the development of the "Catalyst for Integrated Design" document intended to be further refined and tested through future studios.

Category	Technical					
Choose from:	*Technical*	*Commercial*	*Social*	*Regulatory*	*Logistical*	*Other (specify)*

Describe what you learnt about this aspect of the Project.

This IDS took the approach of asking designers to approach the design from the two disciplinary extremes (architecture and engineering), from the beginning producing designs they felt represented each (ignoring the other).

This approach emphasised the differences in the two approaches in designer's minds and articulated the prospects of needing to navigate the spectrum in-between the extremes in future design. Once equipped with this perspective it was easier for designers to understand that it is a balance between the two. Observations in the other IDS observed found that designers tended to follow the information in front of them without necessarily understanding the extents of the design spectrum.

This learning is a subset of the larger learning that active curation of the process is beneficial. There were conflicting opinions coming out of the interviews as to where this curation should sit. Some believed this should be the job of the architect, others believed a third party.

Please describe what you would do differently next time and how this would help. What are the implications for future Projects?

In future studios we will consider adjusting the integrated design process to encourage this exploration of the extremes between the two disciplines views of the project.

We will also discuss where this curation role bests sits.

If your Project learnings have identified any knowledge gaps that need to be filled, please state it below.

None.

Please include any other information you feel is relevant or helpful in sharing the knowledge you learnt through this stage of the Project. This may be qualitative or quantitative and may include a graph, chart, infographic or table as appropriate.

Reference should be made to the journal article produced on best practice integrated design to provide context.

Lesson learnt IDS-01 #4	There is a high level of excitement and buy in to the concept of integrated design.
	Note: This lesson was taken from studios IDS-01 & IDS-02 and is intended to be further explored through future studios.

Category	Technical					
Choose from:	*Technical*	*Commercial*	*Social*	*Regulatory*	*Logistical*	*Other (specify)*

Describe what you learnt about this aspect of the Project.

A high level of excitement and buy in to the concept of integration was observed in all involved (demonstrated by studio popularity with students and keenness to be involved by participants). It is clear that the benefits are recognised. This may suggest that existing failures to follow a design integration path in industry occur as it is simply not an up-front agenda item.

Please describe what you would do differently next time and how this would help. What are the implications for future Projects?

Note only. Underlying indicator of the perceived value of integrated design.

If your Project learnings have identified any knowledge gaps that need to be filled, please state it below.

Further work identifying the gap between practitioners and clients buy in, and the failure to see integrated design realised more in industry is worthy of further research. This will be covered somewhat by discussions in future studios.

Please include any other information you feel is relevant or helpful in sharing the knowledge you learnt through this stage of the Project. This may be qualitative or quantitative and may include a graph, chart, infographic or table as appropriate.

None.

Lesson learnt IDS-01 #5	Extended time required in gaining agreement to contractual terms (due to unfamiliarity with research risk profiles by industry organisations).
	Note: This lesson was taken from studios IDS-01 & IDS-02 and will feed into the setup for future studios.

Category	Logistical					
Choose from:	*Technical*	*Commercial*	*Social*	*Regulatory*	*Logistical*	*Other (specify)*

Describe what you learnt about this aspect of the Project.

Negotiation of terms and conditions took much longer than anticipated due mainly to industry partners being unfamiliar with risk profiles around research orientated projects.

Please describe what you would do differently next time and how this would help. What are the implications for future Projects?

Starting earlier is an obvious measure to take however negotiations were started very early. The issue on this front was that organisations were unwilling to start serious negotiations until closer to the time of commencement due to the project being relatively small within their portfolio of work.

Next time around should be easier as we now have precedent and also better understand the arguments that need to be made and how to get around concerns if raised. Next time around we will be a position to advise of terms previously accepted in other IDS's much earlier (and will do this).

Noted that the main sticking point was unlimited liability with engineering consultants (architectural consultants were less concerned with this aspect of the contracts).

If your Project learnings have identified any knowledge gaps that need to be filled, please state it below.

No gaps.

Please include any other information you feel is relevant or helpful in sharing the knowledge you learnt through this stage of the Project. This may be qualitative or quantitative and may include a graph, chart, infographic or table as appropriate.

None.

Lesson learnt IDS-01 #6	It was more difficult recruiting engineers to the integrated design process than architects.
	Note: This lesson was taken from studios IDS-01 & IDS-02 and will feed into the setup for future studios.

Category	Logistical					
Choose from:	*Technical*	*Commercial*	*Social*	*Regulatory*	*Logistical*	*Other (specify)*

Describe what you learnt about this aspect of the Project.

We found that we had a much higher application rate on the architectural side than the engineering one. This was due to two factors:

i) The studios could have been advertised better on the engineering side as they appeared relatively undifferentiated from other research options available.

ii) Engineering is much broader than just buildings and we feel many engineering students did not appreciate the potential pathways into various consulting firms integrated design experience offers.

Please describe what you would do differently next time and how this would help. What are the implications for future Projects?

Next time we would do more advertising with the engineers to articulate the benefits of taking up an integrated design studio. We would also tailor the subject to be a better fit (either a dedicated IDS 'elective', or a one semester design orientated core alternative.

The studio also needs to fit in with the delivery of the Masters of Engineering programme, these requirements can change and hence the above needs to be reassessed semester to semester.

If your Project learnings have identified any knowledge gaps that need to be filled, please state it below.

None noting finding still preliminary, will be borne out in further IDS's.

Please include any other information you feel is relevant or helpful in sharing the knowledge you learnt through this stage of the Project. This may be qualitative or quantitative and may include a graph, chart, infographic or table as appropriate.

None.

Lesson learnt IDS-01 #7	Technical Learnings applicable to Data Centres
	Note: These lessons are specific Data Centres (the building typology used as a case study for IDS-01)

Category	Technical					
Choose from:	*Technical*	*Commercial*	*Social*	*Regulatory*	*Logistical*	*Other (specify)*

Describe what you learnt about this aspect of the Project.

As a part of the studio fifteen individual design proposals were developed by architecture students, who advanced their ideas for analysis of 'Net Zero' design approaches for data centres offering an array of solutions, tackling environmental design in different ways. Recognising the speculative and highly experimental nature of the design explorations the design process was coupled with a 6-8-week feasibility vetting process that took place after the studio's completion (carried out by the consultants involved). Bespoke technology solutions were examined in greater detail and compared to 'Business As Usual' approaches. The findings of this vetting process were incorporated into a report, the summary findings are presented below:

The fifteen design solutions by students highlight the breadth of opportunities in the design of Data Centres, in particular when stepping away from a purely functional, and construction-cost optimised design. Selected key ideas that emerged were:

- Incorporation of renewable energy.
- Capture and recycling of waste heat through adjacent symbiotic uses (Aquatic centres and greenhouses for example).
- Incorporation of modular construction.
- Incorporation of self-building/updating mechanisms (gantry cranes etc that when combined with modular philosophies facilitate expansion or updating of technologies).

Due to the extensive (80+ MW) site power usage of a large Data Centre, 'Net Zero' targets are impossible to achieve via technology interventions and building envelope improvements. The main opportunities for improvement sat with the introduction of adjacent symbiotic programs.

As much as the renewable energy sources and the adjacent programs represented only a minor percentage of the overall energy involved in running data centres (less than 1.0-2.5%), they were significant in terms of the adjacent uses considered. Significantly reducing the operating energy bills of an aquatic centre or community greenhouse would be seen to solve what is often a major burden for local councils and therefore presents opportunities for the Data Centre industry to better engage with councils and local community. Importantly by adopting such an approach, data centre providers may find themselves able to better position themselves as preferred partners with councils in competing for sites, while at the same time providing real, tangible community benefits.

More detail is provided in the studio 100% reports which are intended to be made public through the knowledge sharing sub-project IDS-KS.

Please describe what you would do differently next time and how this would help. What are the implications for future Projects?
Further discussions with consultants in other studios, IDS-05 Aquatic Centres in particular highlighted the possibility for provision of cooling to the data centre through excess chilled water that is often available from aquatic centre facilities. This would be worthy of further exploration if a future data centres studio or a combined data centre/aquatic centre studio were to be undertaken. Implications for future data centre projects are an increased focus on adjacent symbiotic relationships and potential partnering or consortium development models with third parties including councils.
If your Project learnings have identified any knowledge gaps that need to be filled, please state it below.
Refer above.
Please include any other information you feel is relevant or helpful in sharing the knowledge you learnt through this stage of the Project. This may be qualitative or quantitative and may include a graph, chart, infographic or table as appropriate.
Refer to Studio 100% report and Feasibility Vetting report produced by Aurecon for further technical detail.