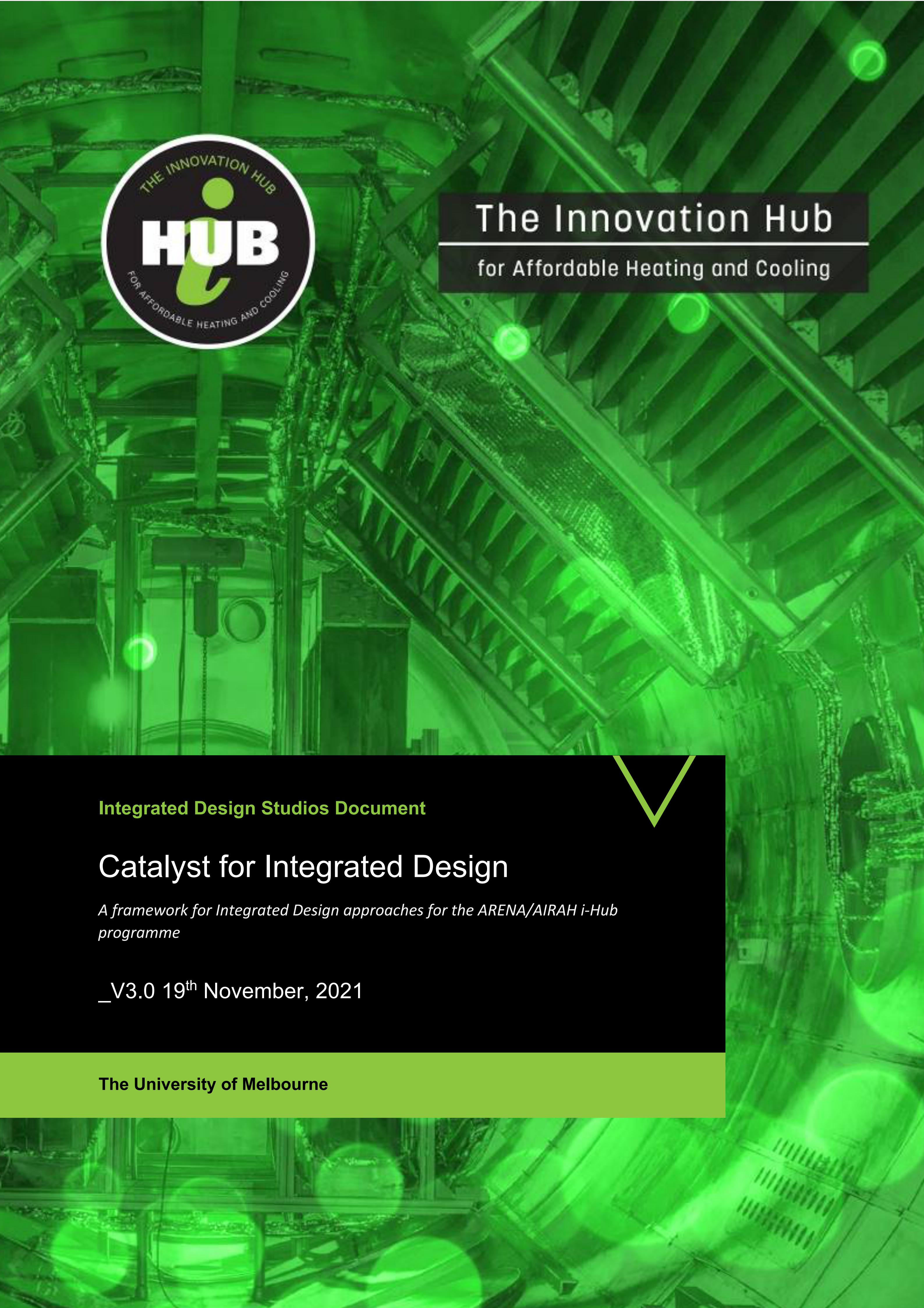

The Innovation Hub

for Affordable Heating and Cooling

Integrated Design Studios Document

Catalyst for Integrated Design

A framework for Integrated Design approaches for the ARENA/AIRAH i-Hub programme

_V3.0 19th November, 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.

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Note: This document has been produced as a part of the i-Hub Integrated Design Studio Program. It is the result of literature review and research work undertaken as a part of the Integrated Design Studios activity stream and is intended to be a live document which is updated as further studios are carried out. The i-Hub program has received funding from ARENA as a part of ARENA's Advancing Renewables program.

1. Introduction

In a collaborative process, such as architectural design, one would assume that activities are by nature integrated across different stakeholders. Achieving common design goals requires a high degree of collaboration and cooperation across professional boundaries, typically unfolding on a project level. Yet, feedback from design practice, as well as in-depth studies in existing literature illustrate that design across disciplines is often *not* integrated. There exist many reasons for this schism. Some relate to tight project timelines, budget constraints, and contractual frameworks in practice, others relate to professional boundaries that are deeply rooted in a disciplinary cultural context of isolation, a 'traditional mindset', and an education that occurs predominantly in silos.

The *Principles of Integrated Design* presented here offer an alternative to the status quo often encountered by both professionals, and tertiary students. They describe possible pathways for design processes that embrace co-rationalisation rather than a sequential exchange of information that sits segregated within individual (professional) boundaries. It encourages connections to be made across disciplines, bringing new insights and ideas that would not have been apparent in one discipline alone, and design outcomes where "The whole is much larger than the sum of the parts"[1]. The way integrated design unfolds on the joint MSD/MSE IDS program is as much about generating the right context, as it is about promoting and nurturing the integrated design process itself over the duration of the 13-week semester.

This document serves as a guide to the establishment of integrated design processes in multi-disciplinary design teams, in the context of the IDS research program. One of the early findings of the research was that integrated design processes need to be adaptable so as to cater to individual designers preferred methods of working. This document should therefore be used as a flexible framework for discussion with the design team in question to structure an integrated design process that is bespoke to the situation at hand.

1-Radcliffe, D. F. (2006). Shaping the Discipline of Engineering Education. *Journal of Engineering Education*, *95*(4), 263–264. https://doi.org/10.1002/j.2168-9830.2006.tb00901.x

2. Context

The IDS program is set up as a testbed for new ideas that cut across architectural and engineering domains. Conducted in a mostly 'risk-free' environment of tertiary education, the IDSs run each semester are used to test the opportunities for architects and engineers to work collaboratively on common goals whilst closely observing the key moments/instances that lead to integrated design outcomes. In order for this to work, the project's initiators spent nearly two years liaising with key parties to fine-tune the development of the IDS structure in its current form. It foresees the involvement of design students from architecture and engineering background, who jointly develop ideas and design concepts with input from industry professionals and academic experts. This process, which runs under the umbrella of the existing MSD Masters-level CDE studio program (with adjunct engineering subjects), gets closely monitored by researchers from both the MSD and the MSE. For each IDS, a client provides essential references, both in terms of the upfront brief for a hypothetical project to be developed by the students, as well as the desired deliverable at the end of semester. An experienced studio tutor guides the students through the 13 week semester. Architecture and Engineering students are encouraged to design and present jointly. As in industry however, there are unavoidable differences, in the case of the studios it is a number of different education outcomes (competencies), required to be delivered by the course accrediting bodies. This means the different students are supervised and assessed by the respective schools. The overarching design process is however delivered as integratively as possible. While integrated design is applicable to all technical disciplines the tendency is for integration to focus environmental sustainability (goals). This is due to the inherent multidisciplinary nature of sustainability as well as the underlying remit of improving energy performance; the Studios are currently supported by The Australian Institute of Refrigeration, Air conditioning and Heating (AIRAH), and funded by Australia Renewable Energy Agency (ARENA). The intent of the program is to examine how architects and engineers put their heads together when aiming for transformative solutions that go beyond simply adding the input of each discrete discipline.

3. Integrated Design Process Guidance

The following guidance has been produced in the context of the 13 week integrated design studios. This guidance is intended to be transferable to practice. Note that red text indicates changes since last revision (v2.1)

3.1 Integrated Design Process development

Before the start of semester, it is essential for the studio leader to liaise with the client to develop an integrated design process that balances technical aspects with non-technical, thereby offering the participating students a program that cuts across profession-specific domains. Students should not be seen as either from architecture or engineering background, but as co-designers who jointly advance their idea. The process should be formulated in a way that allows the tutor to conceive a fitting constellation of students into smaller or larger groups (depending on final student numbers, and in consideration of likely changes over the duration of the semester), and the potential for students to present their final design as individual proposition. Main considerations may include:

- **Common Goals** – Key to the formulation of the integrated design process is the articulation of common goals that are (equally) relevant to engineers as well as architects (over individual goals by either group). Ensure all participants feel involved right from the start.

- **Avoiding/minimising individual agendas -** Seen in the context of achieving common goals, design collaborators frequently work towards specific 'individual' goals and agendas that are not clearly communicated to the rest of the team. Even worse, these agendas may at times even conflict with the common goals of the design team. An integrated design approach therefore requires a consolidation of individual goals into a broader agenda, or at least a clear delineation about how and where individual goals need to be 'spun-off' the joint effort. Clarity and transparency related to these issues is essential for integrated design to succeed.

- **Developing a brief that provokes a different way of thinking -** One key element of integrated design is to foster a different attitude about collaboration among project participants. The design brief hence needs to move away from familiar approaches and instead trigger novel approaches to design that – at times – may take participants out of their comfort zone in terms of 'Business as Usual (BAU)'. In some instances, the formulation of the brief can be left open to allow collaborators to develop their own approach. This needs to be complemented by clear targets to be achieved by the designers, in order to provide them with a strong framework to define their collaborative process.

• **Creativity and innovation** – The integrated design process should facilitate an environment where creativity and innovation can unfold. Too many, or too tight deliverables will likely over-constrain the students' and limit their ability to explore novel design solutions. Students should have 'permission to fail', when searching for integrated design solutions.

• **Vision, intent, strategy and culture first** – The integrated design process should trigger students to first reflect on *why* they design in a certain way, over *what* the immediate output might be.

• **Balancing individual and integrated approaches** – The integrated design process should facilitate an appropriate balance to group thought (time interacting) and individual thought. It should articulate the desired project outcomes both from architectural and engineering perspectives, encouraging designers to understand what the 'other' has to offer, and to value this in the interest of embracing and incorporating it into their own ideas.
• Embrace **design** as an **open-ended solution-finding** activity. Make it clear to students that it is **not** merely **about solving well-defined problems**.

• **Considering 'extreme design' as a starting point-** Not necessarily the only approach, but nevertheless a rewarding alternative to common team-collaboration approaches, 'extreme architecture' and 'extreme engineering' ask project team members to first consider only their own goals and to work on concepts that only respond to those. These can then be shared with the design partners to highlight what solutions might look like if their input wasn't considered. It is a great discussion-starter for teams with a strong integrated design agenda. In this context it is crucial to establish the engineers as co-designers and not simply as 'consultants how help realise the architects' ideas'.

• **Establishing the role of a Design Integrator -** Based on feedback from the IDS participants interaction, it was observed that typically one member from each collaborating group emerged as integration facilitator. This role proved to be highly beneficial in orchestrating design integration processes and remind group participants of overarching goals or specific task-oriented output. To push this idea further, the role of Design Integrator (or Integration Facilitator) could/should be rotated across all group members to increase the quality of outcomes. Overall, research shows the advantages of clearly defined roles and responsibilities, spread across the design collaboration process.

• **Avoiding to** focus on **detailed solutions** too **early** as well as the production of captivating visuals, that **mainly address aesthetic** aspects of the project. Accept that **integrated design can be messy**, with many options to be explored and discarded early on, and **results emerging** from interactive collaboration.

• **Combining face-to-face and online collaboration & Making decisions explicit! -** Research shows that a key element to successful integrated design is co-experience of participants. Some elements of this can occur via face-to-face meetings and presentations, others happen offline. Recent COVID experience shows that online collaboration platforms such as TEAMS or the blackboarding tool Miro assist collaborators to engage online and share/log their work-inprogress and the associated decision-making process. This is an essential step to build up knowledge across collaborators and to increase their understanding about their tasks, and the tasks of their peers in other disciplines.

• **Flexible Structure –** It is important for any integrated design process or structure developed to be flexible and non-judging enough to cater for the different skills and often idiosyncratic ways of working different designers will bring to the collective table to extract the best input from all designers involved.

• **Complementing aesthetic and functional design considerations with associated performance feedback** - Feedback from the IDS highlights the tendency of engineering designers to lean towards the integration of project specifics, whilst architectural designers thrive in a context of visual form-making. In order to allow a shared perspective to emerge, it is highly beneficial to consolidate these two approaches and allow solutions to emerge via multiple design iterations. Being able to discuss design options with different visual and performative information combined, boosts the designers'' capability to confidently advance their design-thinking and decision-making.

• **Introduce basic environmental simulation – include energy performance tools -** Focusing predominantly on architectural designers, the research suggests that a crash-course in environmental simulation boosts their understanding on how to extract trend analysis regarding the physical building performance of their projects. Adding a component for energy performance analysis opens the door to work towards specific (carbon) targets. The introduction of associated tools/processes has to be facilitated with great care as there is a danger that designers who are new to these tools at times lose sight of holistic design considerations and focus on meeting performance targets instead. It becomes essential that performance guides design, but does not 'drive' it.

• **Accepting that better performance outcomes don't necessarily improve the aesthetics -** As much as it is a declared goal of integrated design to improve the quality of a project, there is no guarantee that it will benefit/improve its aesthetics. Feedback from the IDS clearly points towards an understanding that optimising performative aspects of design (if done well) does not compromise a project's aesthetic qualities. At the same time, these optimised solutions are often not immediately recognisable in the formal expression of a project. They are frequently embedded in various choices that form a holistic total. There may be some cases where the aesthetics are closely tied to physical building performance, but those involved on integrated design projects ought to be aware that this likely will be the exception.

Project Inception > Weeks 1-3

The very first interaction between student, studio tutor, client, consultants, and academics are of outmost importance to the success of the Integrated Design process. This is where the tone for the coming 13 weeks is set. This is where the seed it planted to establish the culture behind integrated design concepts. In the first three weeks of semester, students will become familiar with the particular IDS setup and its goals, as well as getting exposed to a broad variety of environmental / building services design concepts and associated technology. This period is highly formative for the students' development and should be accompanied by a great variety of *'information downloads'* that address various aspects of integrated design and associated environmental design approaches (Knowledge and

Comprehension in terms of Bloom's Taxonomy). Next to joint introductory workshops in weeks 1 and 2, there are likely going to be several guest presentations by project participants within this period.

- Introduce project participants to each other and establish **trust** among them (open/non-judgmental/sensitized/willing/etc).
- Discuss the **limitations of traditional**, non-integrated design (solutions).
- **Aim to remove all barriers between disciples** – these may be, cultural (language, work methods, customs etc.), availability/time etc.
- Select **assessment tasks** (or sub-tasks) that need to be tackled by Architecture and Engineering students **jointly**, and not simply in isolation (where everyone just does 'their part').
- **Empathy** – Allow every participant to understand what the other does and why it is important.
- **Discuss the expected roles of each participant** (Arch/Eng students / consultants / client / tutor / observers).
- Explain the **process** each participant (group) typically goes through, in order to derive their desired **output**.
    - for engineers
      > reasons for the non-linear architectural design process
      > how architects respond to a functional brief, the site, and social/human factors
      > how architects address aesthetic considerations
      > how architects factor environmental considerations into their design
    - for architects:
      > give a sense of how engineers approach problem solving
      > how engineers respond to a functional brief
      > what feedback is typically expected from engineers and when
      > how do engineers measure the success of their design
      > how engineers factor environmental considerations into their design
- Understand **why** we often see things **different**ly, and
- develop a **common language** that cuts across discipline silos (metaphors/analogies/co-experience). Engineering should empower architecture and vice versa.

Criteria Design > Weeks 4-7

The weeks leading up to mid semester represent the major opportunity for architecture and engineering designers to advance (what the US AIA refers to as…) *criteria design*. After the major information download in the first few weeks, they should by now have embodied the major characteristics of their site (including its key environmental context), as well as having gained a basic understanding of environmental sustainability issues on the project. This period offers the best window to jointly develop and test innovative and integrated solutions across disciplines (Application, Analysis and Synthesis in terms of Bloom's Taxonomy). It is essential that studio tutors, as well as the industry participants, *actively curate* the integrated design processes within this period.

- Instil a sense of **joint ownership** – introduce a sense of **shared responsibility** across (group) participants. Everyone is a creator or 'co-author'.
- **Maintain strong engagement** between Arch. and Eng. students (even outside class times).
- **Passive before active** (& application before equipment) – students will explore the interdependences between architectural and engineering design where passive solutions (orientation/geometry/building materials/etc.) get prioritised over equipment (mechanical/electrical).
- Explore **common targets** that address **performance and functionality at the same time**.
- **Define clear performance targets for students to work towards** – E.g. % in carbon recduction
- **Knowing in action/heuristics**: discuss and advance integrated design solutions on the fly.
- **start with** educated guesses/**rule of thumb**, **then verify** validity of assumptions for preferred solutions.

At mid-semester the students will receive their first feedback by a panel including architecture and engineering experts. Arch/Eng students should **jointly present** their projects.

Refining Solutions > Weeks 8-13

The attention of the architecture students will now clearly shift towards their (individual) projects. The integrated design aspect will remain until the final weeks of semester with more detailed solutions (Synthesis and Evaluation in terms of Bloom's Taxonomy).

- Advance architectural and engineering design solutions as an **integrated whole**.
- Run designated design integration workshops to **advance design interatively**.
- Search for integrated design responses to human **comfort** and environmental **loads;** examine how various aspects of the Architecture and Engineering design are connected.
- Facilitate **larger-group** interaction, as well as **smaller/individual feedback** sessions between students and the industry participants. Encourage active engagement with the material presented (interactive sketching over sections/plans/3D/etc. by various participants).
- Apply end-use performance metrics for joint environmental **targets**
  - What are they and what are the mechanisms to address them in the **advanced** design stages?
- Foster **Multi-functional design** – Successful ID results in design elements performing more than one function across different disciplines at the same time.
- **Define** the **characteristics** that represent the '**integratedness**' of a design solution. That's what the success of this project should (also) be measured against!
- **Weave participant feedback into future pedagogy to advance integrated design teaching**

At the end of semester-crit, students will receive their final feedback by a panel including architecture and engineering experts. Arch/Eng students should jointly present their projects.

Appendix 1.0 - Integrated vs Conventional

Integrated Design Process		Conventional Design Process
Inclusive from the outset	vs	Involves team members only when essential
Front-loaded — time and energy invested early	vs	Less time, energy, and collaboration exhibited in early stages
Decisions influenced by broad team	vs	More decisions made by fewer people
Iterative process	vs	Linear process
Whole-systems thinking	vs	Systems often considered in isolation
Allows for full optimization	vs	Limited to constrained optimization
Seeks synergies	vs	Diminished opportunity for synergies
Life-cycle costing	vs	Emphasis on up-front costs
Process continues through post-occupancy	vs	Typically finished when construction is complete

Integrated design process (Source: Roadmap for the Integrated Design Process)