Supplementary Information for the Article:

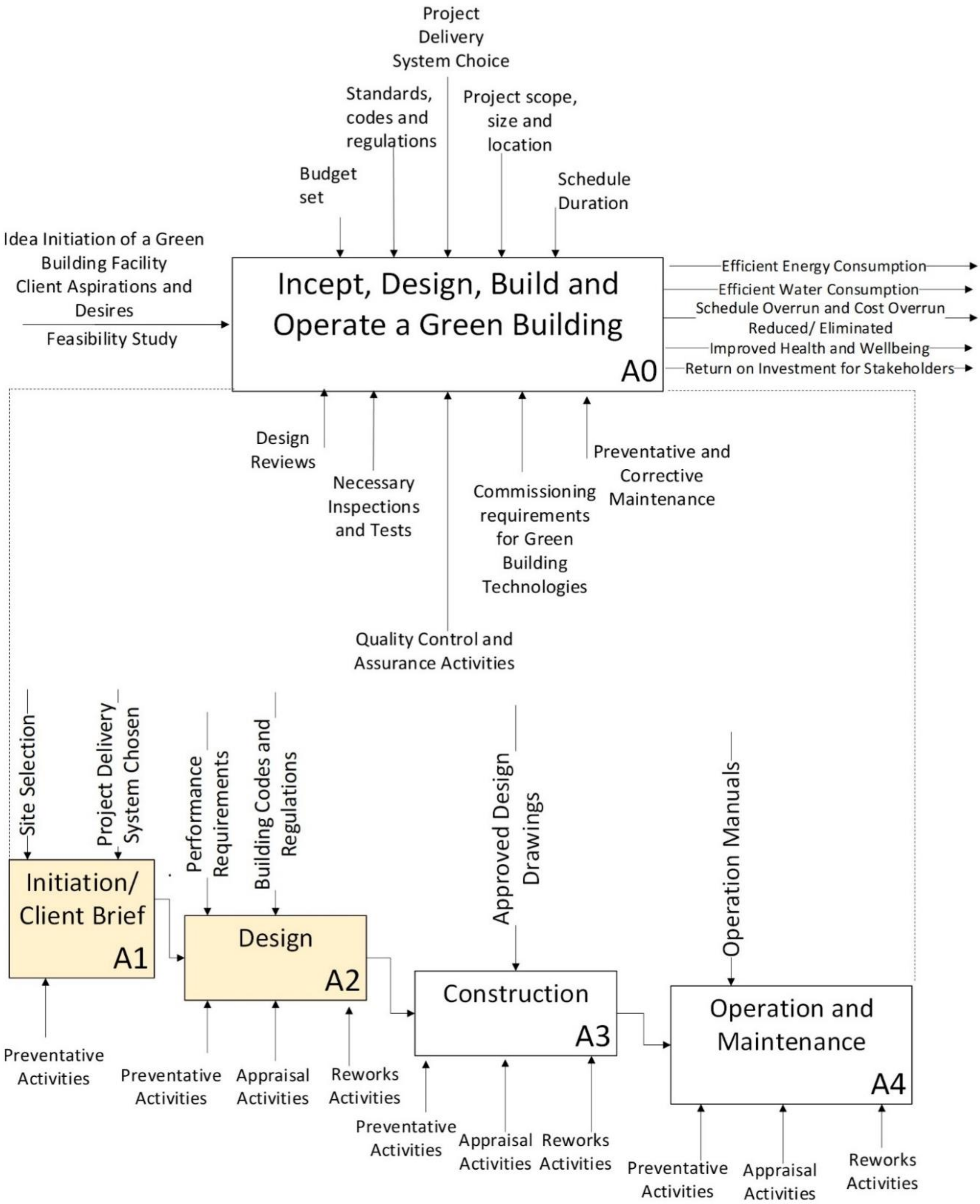
Framework to Evaluate Quality Performance of Green Building Delivery: Project Brief and Design Stage

This supplementary information document reinforces the works done in the article mentioned above focusing on two sections. The first section: Framework Details with References covers the framework details and the second section: Elaborate Interview Results is a thorough narrative of the interview participants contributions to the different research themes. In addition, containing what was mentioned by the different participants. Furthermore, a copy of the Institutional Review Board Letter of Approval is provided to affirm that the research procedures for interacting with human matters has met the ethical requirements of the IRB. A copy of the consent form given to the participants is also provided in section 4. Interviewee Consent Form. The questions asked to the interviewers with the themes covered and purpose of the questions is also included in Section 5. Interview Questions.

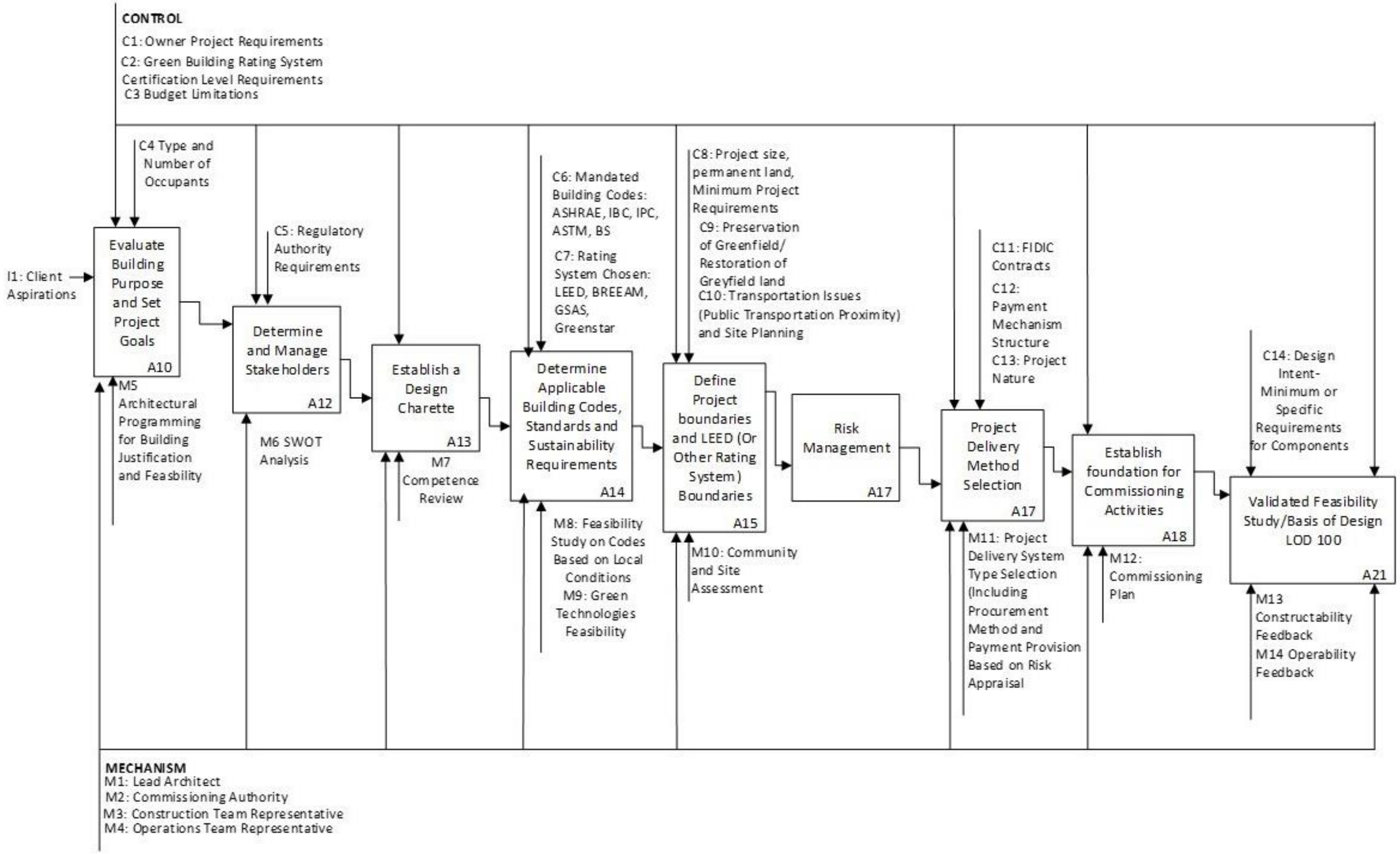
Supplementary Contents

1. Entire IDEF0 Process Model

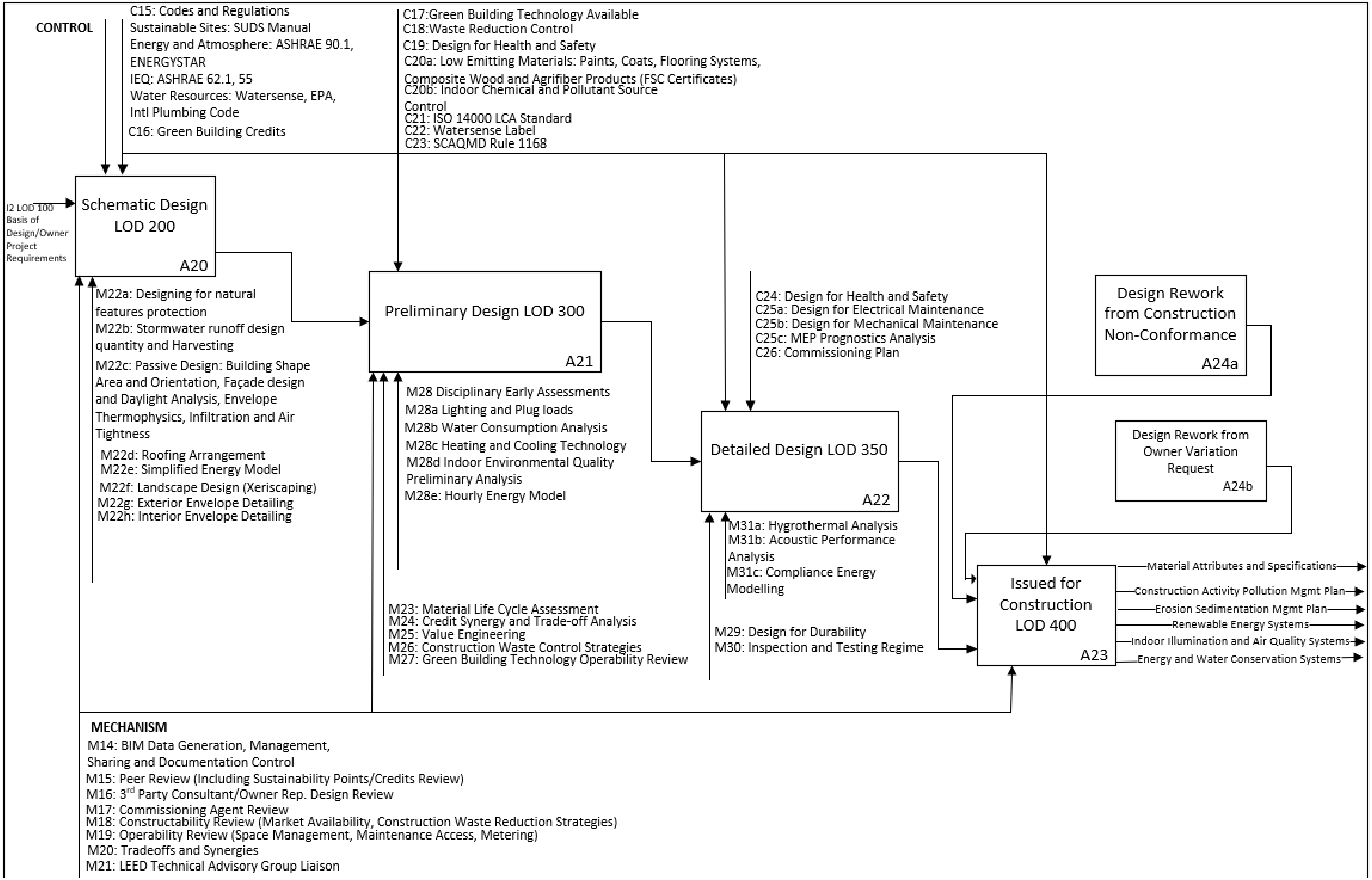
1.1 Master Node



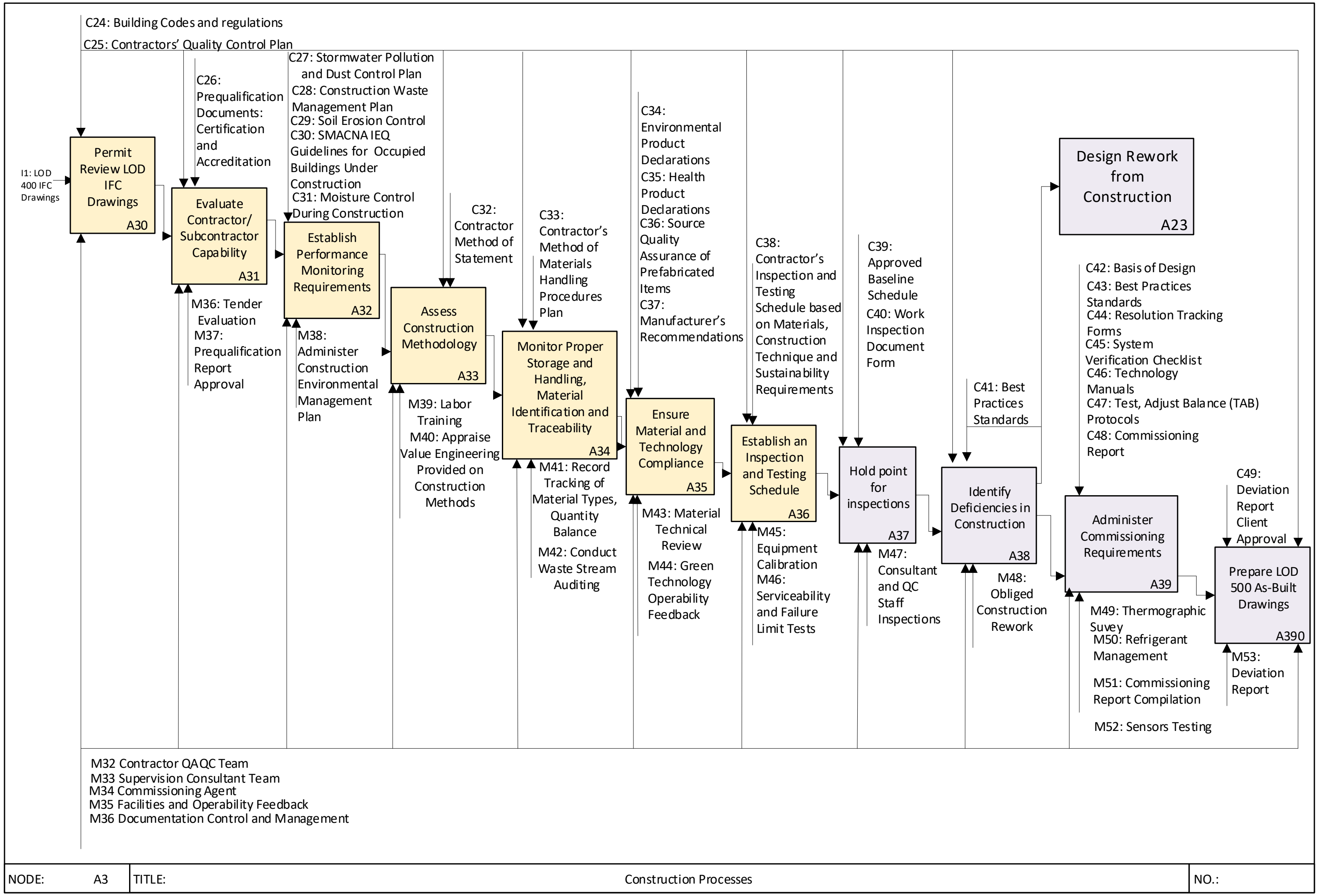
1.2 Node A1: Project Brief Node



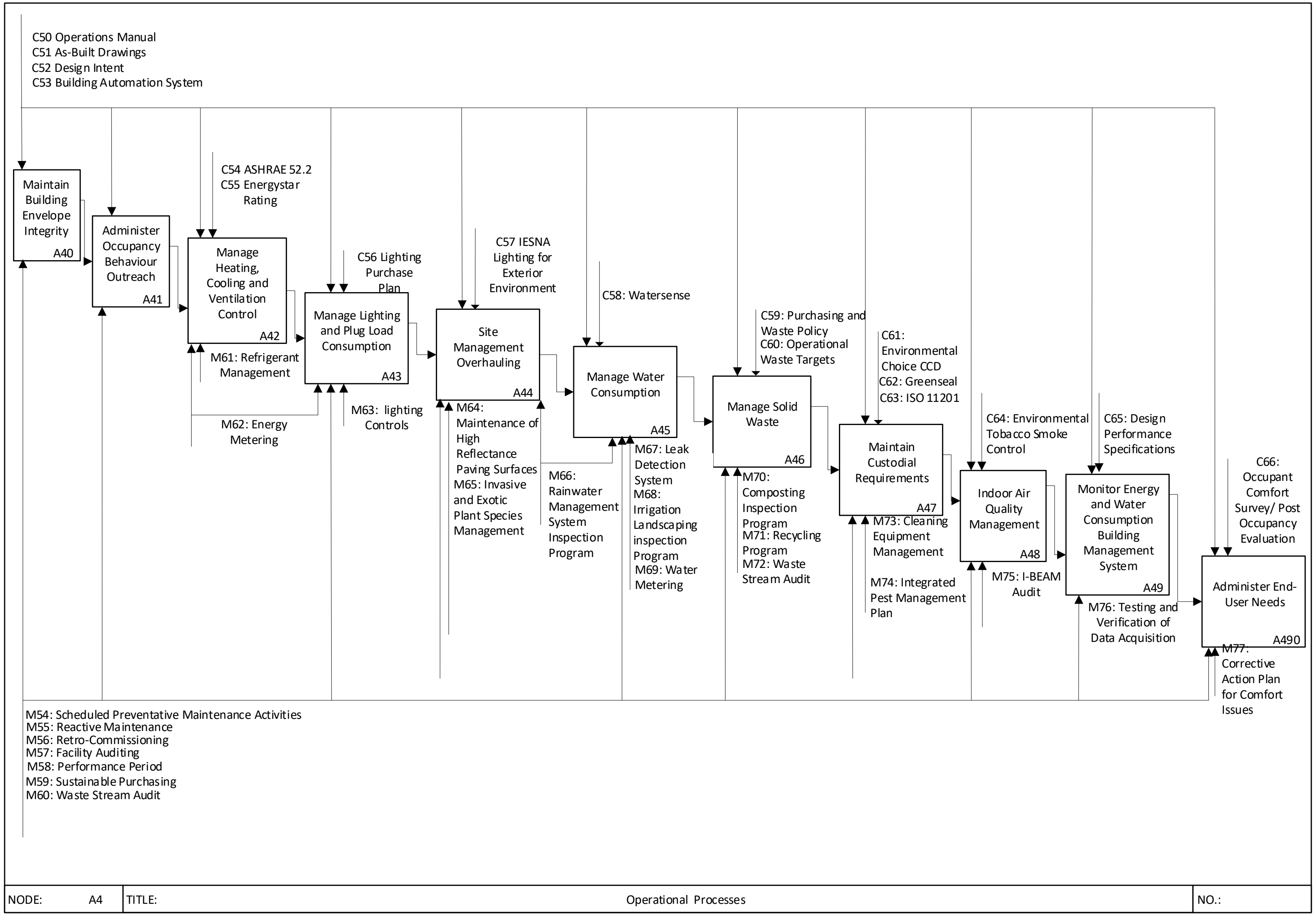
1.3 Node A2 Design Node



1.4 Node A3 Construction Node



1.5 Node A4 Operations Node



2. Framework Details with References

1.1. Node A10: Evaluate Building Purpose and Set Project Goals

A feasibility study is conducted to determine if there is a need for the building in the first place in a business case approach and how it will serve owner requirements or the general public the owner is serving [1]. An architectural programmer will commence defining the goals by providing diverse goal statements to guide the process including the functional objective of the built facility and end-user types it will accommodate, economical aspects (such as budgets, anticipated cashflows from expenses incurred in operational and maintenance costs and potential revenue anticipated), durational aspects (building age expectancy and potential changes, aesthetic and psychological aspects considered for the upcoming design or any contextual implications (historical or culture), expected) and sustainability aspects (energy and water consumption, IEQ, material usage) [2-4].

1.2. Node A11: Determine and Manage Stakeholders and End-Users

A stakeholder analysis is determined to identify all the primary (legally bounded stakeholders) and secondary stakeholders (parties that influence, affected by but are not engaged in the project nor impact its survival) and find if there are any conflicting priorities between them [5]. Considerations of all the legal obligations and regulations of the primary stakeholders are addressed. The stakeholders are also assessed in terms of their commitment, interest and power to determine what is necessary to achieve the objectives of the owner's project goals (including reconsiderations of the goals) [5].

1.3. Node A12: Establish a Design Charette Team

A design charette team of participants would engage in a workshop format to brainstorm ideas and provide expertise from their construction industry experience to provide initial solutions for the owner's objectives [6]. The team would review the green building certification requirements and determine the most suitable goals for the maximum certification level that the owner can pursue for the project [4,7]. It is essential to evaluate the team traits to ensure their capabilities in facing the challenges in the green building design [4,8].

1.4. Node A13: Determine Applicable Codes, Standards and Sustainability Requirements

The design charette will determine the applicable codes and regulations that the building project must adhere to. The green building rating system type in terms of its suitability for the local conditions are also discussed (given that previous studies had provided critique on unsuitability of rating systems for certain areas [9,10]).

1.5. Node A14: Define Project Location, Boundaries and LEED (or Other Rating System) Boundaries

The project size requirements are addressed with consideration of the project functional goals and the minimum requirements sought by the rating systems to be considered for green building application. [ADD REF ABOUT MPR]. Considerations for site selection to meet certification requirements such as not building in sensitive land, preference of previously developed or contaminated land (with forethought on remediation requirements), site proximity to amenities and public transportation systems and the building's integration with society overall and also considering the proximity to building material resources [11].

1.6. Node A15: Risk Management

The charette team will collate all the potential design and construction risks that can occur in the green building project and devise a risk management plan to cater for this. Risk types include inexperience of contractors to adhere to stringent standards, inexperience with new products and technologies, apprehensiveness regarding the long-term viability of new and untested products, materials, and technologies [12].

1.7. Node A16: Project Delivery System Selection and Procurement Methods

Based on the complexity nature of the project (that may require constructability analysis) , the stakeholders involved (communication requirements, payment mechanisms), and their associated risks (allocation and avoidance) and priorities (speed of delivery, cost or quality), the team will evaluate the most appropriate project delivery system to adopt [13,14]. The criteria for selecting the designer and constructor and the expected engagement timing is defined. An initial assessment for the availability of suitable entities to execute the project [15]. It is essential to evaluate the team traits to ensure their capabilities in facing the challenges in the green building design. Therefore, an assuring that the key personnel against the qualification requirements is essential for meeting the design expectations [4,8].

1.8. Node A17: Establish Foundation for Commissioning Activities

Level of commissioning that the project will resume will be determined early on and will dictate the engagement level of a commissioning authority in the project [4]. The commissioning scope is developed in terms of the building components that will be commissioned and the procedures used [16]. [17] recommends involving a commissioning agent early in the design process and to be engaged in formulating the Basis of Design (BOD) to use them to evaluating the designs in terms of their efficiency in performances and the building systems' operational requirements.

1.9. Node A18: Validated Feasibility Study/Basis of Design LOD 100

The owner's project requirements produced in a BoD as an end-product of the A1 stage becomes an input for the design stage which transforms such requirements into a conceptualized model comprising of procedures, technical specifications and drawings [18]. The Basis of Design document depicts the logical rationale of the thinking behind the designs that the team conjured [19].

1.10. Node A20: Schematic Design LOD 200

The schematic design process determines the building's functional requirements with its objectives more defined and owner priorities more established, as well as consideration of the codes and regulations that control the design outlook [20]. Options of the building envelope type and the mechanical systems to adopt are considered by the designers after accounting for constraints in owners' requirements, site conditions and footprint area and the codes and regulations [21,22].

The design team tackles design aspects that relate to the building periphery such as site assessment (site conditions are evaluated in understanding the existing topography, present landscape in order to promote the native plants, neighborhood daylight access, heat island reduction considerations, cultural significance of site and surroundings [23] and development (protection or restoration measures for the natural habitat through minimizing landform disruption, sensitivities of site and surroundings to air pollution, human health, noise and water pollution[23]). Stormwater drainage patterns are considered for designing against land erosion and flooding of the inhabited area through Low Impact Development (LID) techniques such as detention/retention basins or permeable pavements [11,24]. Passive design strategies involving natural elements of sunlight, shading and prevailing winds to determine the building shape, orientation, façade design and daylight analysis are then considered for a building as a single mass and establishes preliminary information on energy consumption reduction to conduct a simplified energy model [11,25]. This is done in parallel with approximate sizing the building and the floor configurations to serve the end-user needs and the owner requirements. [26] considers the importance of liaison with owners to articulate any functional changes that can potentially impact the energy consumption of the building spaces early in the design process. The end product of node A20 is a generic system building model with building components in approximate quantities which will then be incorporated into LOD 300 the building model to be more specific.

1.11. Node A21 Preliminary Design LOD 300

The schematic concept designs are then further developed with more detailed analyses of the building systems. This involves certain interrelationships between systems are also considered (for example the building envelope and HVAC systems relationships to reduce energy consumption) [27]. The design team performs further detailing of the building outer and inner envelope with considerations of fenestration design, thermal bridging and continuities of the thermal envelopes through insulation detailing, air infiltration ventilation. The wall, window (especially for daylight analysis) and roof system structural configuration (including green roofs as a LID form) is further articulated in LOD300. The design teams also conduct interdisciplinary analyses on issues that are energy related (such as lighting illumination intensity and plug loads, heating and cooling technologies and hourly energy models), IEQ related (acoustic performance through spatial configuration, ventilation requirements, designing against dampness, thermal comfort, measures to prevent contamination during construction through contaminating material elimination), water consumption related (plumbing fixtures, rainwater harvesting and irrigation strategies), and material related (preliminary environmental life cycle assessments for material selection and construction waste reduction strategies). Feedback on the compatibility of the green building technologies in achieving the objectives with consideration of market availability.

1.12. Node A22: Detailed Design LOD 350

Design is done to greater rigor in LOD 350 with the BIM model exhibiting characteristics to do with the constructability of the building components and highlighting the connections of building composites. Construction waste reduction strategies are further embedded in terms of sizing the components [28]. Maintenance issues can be designed against through a prognostics analysis for architectural (e.g. dampness protection from moisture prone areas, specifications to prevent corrosion in ironmongery, painting and render detachment [29,30], structural (concrete reinforcement and mesh detailing to prevent cracks, coatings for preventing timber warping, structural steel protection, mechanical (HVAC subsystem redundancies, sensing system improperly calibrated, pipelines provision of access, provision of shut-off valves for partial water supply closure for maintenance, preventing roof ponding, consideration for pipes prone to leakage or corrosion, [31]) and electrical (designing for grounding systems, accessible mainboard circuit breakers, accommodation of back-up power supplies, cable management and prevention of total power cut-off from fire or overload [32] and building components. The building model also undergoes a more thorough life cycle assessment of the materials as further detail has been achieved in the LOD 350 model. Certain modeling activities become possible to perform given the reached level of detailing of the exterior and interior walls such as hygrothermal analysis and acoustic performance analysis.

Quality related constructability issues such as inspection and testing regimes are discussed in the constructability and commissioning authority reviews to better prepare the team on the quality control and assurance levels expected in the construction phase to finetune decisions to not compromise the owner's budget for testing regimes that standards stipulate.

1.13. Node A23: Issued for Construction Designs LOD 400

Node A23 produces final construction documents that are detailed to a level suitable for the construction entity to execute the works. A final review is conducted in LOD 400 to avoid any design defects. Baseline schedule and cost analysis. The drawings are then submitted for government/private authority approval in the construction stage (Node A3).

1.14. Node A24a: Design Rework from Construction

Node A23a is a manifestation from non-conformances occurring in the construction phase where the constructor has not conformed to the stringent design specification set for several reasons such as material availability, procurement and purchasing issues. The constructor's experience has led to an alternative design solution postulated but requires verification from the design team on the alternative solution.

1.15. Node A24b: Design Rework from Owner Variation Request

The owner is entitled in contracts to issue for variation orders in the design scope as construction continues.

2. Institutional Review Board Letter of Approval

QBRI
معهد قطر لبحوث الطب الحيوي
Qatar Biomedical Research Institute
جامعة حمد بن خليفة
HAMAD BIN KHALIFA UNIVERSITY

Qatar Biomedical Research Institute
Institutional Review Board

June 16, 2019

Sami Al-Ghamdi
Assistant Professor
College of Science and Engineering
HBKU
Doha, Qatar

Ref.: Approval for QBRI-IRB
Review Type: Exempt Review
IRB Approval Date: June 16, 2019
IRB Expiration Date: June 16, 2020
IRB Project Number: 2019-025
Project Title: Quality Performance Framework for Design, Construction and Operations of Green Buildings.

Dear Dr. Sami Al-Ghamdi,

The QBRI Institutional Review Board (IRB) has reviewed your research proposal that was submitted for the above referenced protocol (2019-025). **It has been determined that your research proposal is eligible for exempt status and requires no further review.** This falls under the category two in MOPH guidelines, regulations and policies for research involving de-identified human subjects that includes *research the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.*

Although your research proposal falls under the exempt status, the research must be conducted according to the submitted research protocol outlined in the approved proposal. Any changes/modifications to the original submitted protocol should be reported to the IRB committee for guidance and review. **Please note that any modifications to the referenced research proposal may render this approval invalid and you may need to submit a new IRB application.**

Request for a renewal, if required, should be submitted to IRB at least one month prior to the expiry date to allow the IRB sufficient time to review and approve the request. It is the sole responsibility of the investigator to ensure the timely renewal of the IRB.

Wishing you all the success in conducting your research.

Sincerely,

Dr. Khalid Al-Ali
Chairperson

QATAR BIOMEDICAL RESEARCH INSTITUTE
IRB APPROVED
APPROVAL DATE: 16 JUN 2019
EXPIRATION DATE: 16 JUN 2020

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3. Interviewee Consent Form

SOLICITING FOR RESEARCH INTERVIEW

Dear Participant,

The Sustainability Division of the School of Science and Engineering in Hamad bin Khalifa University is currently engaging in a research project to tackle the quality performance in delivering green buildings.

The research as part of [redacted]'s PhD study, under the supervision of [redacted], which establishes a quality management framework for the construction industry to adopt in measuring the quality performance during the Design, Construction and Operation of a green building facility.

To achieve robust findings, the research requires an interview to be conducted with a construction industry expert to attain feedback to make the framework more practical and efficient and to affirm the facts obtained from a literature collection that the researchers have conducted to achieve validity and reliability of the research outcome.

This letter is to solicit your permission to be interviewed on this subject.

The framework is presumed to enable decision makers to make more judicious judgements on the contractual approaches and the investment needed for quality performance for green buildings.

The following interview will require approximately 30 minutes to complete. There is no compensation for participating nor is there any known risks. To ensure that all information will remain confidential, please do not write your name anywhere other than signing the consent form. If you choose to participate in this study, please answer all questions to the researcher as honestly as possible.

Participation is strictly voluntary, and you may withdraw at any time. The information collected will provide useful insight regarding the green building delivery process. Please note that there are 15 other mutually exclusive participants who will be interviewed with the same questions.

Strict confidentiality will be maintained, and the research is covered with all research ethics principles and practice. The interview will be transcribed but with anonymity maintained.

At completion of research, a copy of the works will be forwarded to you for record purpose.

We count on you for the achievement of this research success.

Thanks for the anticipated support.

Yours Sincerely,

[redacted], Assistant Professor
College of Science and Engineering
Hamad bin Khalifa University
[redacted]

[redacted], PhD Candidate in Sustainable Environment
College of Science and Engineering
Hamad bin Khalifa University
[redacted]

CONSENT TO ACT AS A PARTICIPANT IN AN INTERVIEW STUDY

TITLE: Quality Performance Framework for Design, Construction and Operations of Green Buildings
PRINCIPAL INVESTIGATORS: [redacted]

SOURCE OF SUPPORT: HAMAD BIN KHALIFA UNIVERSITY – QATAR FOUNDATION

CONSENT FORM

1. Description
This study involves developing a framework to tackle the quality performance in delivering a green building project. This will involve conducting interviews with industry professionals on the design, construction and operational activities of green buildings. The interview will take 30 minutes to complete.

2. Risks
There are no risks associated with participating.

3. Right to Withdraw
I understand that I am free to withdraw from this study at any time.

4. Confidentiality & Right to Privacy
I understand that any information about me obtained from this research, including answers to the interview will be kept confidential. It has been explained to me that my identity will not be revealed in any description or publication of this research. Therefore, I consent publication for scientific and scholarly purposes.

5. Cost and Payment
I understand that there is no cost associated with participation in this study nor is there payment of any kind.

6. Signatures
Both parties: the researchers of this study as well as the participants are signing on the following:
- Researchers: As the representative of this study, researchers have clarified the purpose of this research study. All quest ions asked by the participant were answered.
- The Participant: I acknowledge that I have been informed by the undersigned of the purpose of this study, and I am aware of my right to print and retain copies of this consent. I also know that I can ask any questions to researchers at any time, either before or after the participation. I willingly agree to participate in this study.

Do you agree to participate in this study?

☐Yes. I agree and would like to take part in the interview.

☐I do not agree to participate.

Do you agree to be audio-recorded?

☐Yes. I agree to be audio-recorded.
☐No. I do not agree to be audio-recorded.

4. Elaborate Interview Results

4.1. Project Brief and Design Process

The framework's design philosophy from outside-in adopted for a green building setting was approved by Participants 2, 8, 10, 11 and 12, 13 and 16. However, P1 questioned how the air quality and light control interaction between the outside and inside environment would be catered for. P1 stressed on extra emphasis needed on a sensitive design issue to balance daylighting and artificial lighting contribution with the cooling loads for a building in a warm environment. P4 and 9 asserted the need to consider the function of the building which will dictate the form which will precede the building form's contribution in passive design as well as considering the aesthetics of the building shape if the owner prioritizes this. The majority of the participants find the design process commences with passive design procedures for building orientation, its envelope and space planning. P16 states that it is not possible to rely fully on passive strategies due to the hot and humid environment with dusty conditions and requires active design strategies to supplement the overall solution. Such reliance on active design strategies pose a challenge to attain a LEED Platinum level credit compared to weathers faced in North America and Europe. P13 indicates that passive design strategies form the basis of design and are rarely modified as the design develops further but it is mainly the active design strategies that are the source of design changes.

Regarding compliance to green certification credit themes, the design stage is more pronounced than the project brief stage in initiating to devise solutions. Site surroundings and natural environment however initiates in project brief is assessed according to P5 and 7 for local habitat (transferring vegetation to nurseries and allowing escape routes for fauna to adjacent sites), storm water flow and groundwater levels. P8 indicates that provisions for sediment and erosion control are provided in the design but it is for the construction team to provide the necessary solutions.

P2, P4, P10 and 17 concurred that simplified, hourly and compliance energy modelling are done in the concept, preliminary and detailed design stages. P9 and P16 only left the energy modelling for the detailed design stage after the spacing planning and building envelope configuration were finalized. IEQ is highly intertwined with the energy demand expectations for lighting, cooling, and ventilation which is why P2 and 4 find it good practice to specify the wall and roof envelope as well as the glazing in the concept stage especially because of the heavy reliance on active design strategies to satisfy cooling and ventilation requirements.

Designing for watering metering and leak detection system is also fulfilled by most of the design stage participants. P2 stressed on the importance to for indoor potable and non-potable water design to have the meters incorporated in branches and networks to capture 80% coverage for measurement. For outdoor irrigation, the responses varied in the level of design detail and building typology, with P8 and 17 for commercial buildings omitting the irrigation calculation demand requirements for the type of vegetation present under the view that this is left for the operations team to handle whereas P10, 11 and 12 for outdoor sports venues consider this as part of the design.

For materials and resources, construction waste control is considered in the building typology type choice selected according to P10, 11 and 12. Although lifecycle assessment of materials to compare environmental impact of material choices was not done in the design stage by any the participants, an environmental product declaration report was however requested for by the designer for the construction team to comply with. In addition, specifying recycled content of materials and adherence to a chain of custody requirements were also considered as requisites in design for the construction team to comply with. The overall responses indicated that materials' technical performance measures prevail over environmental aspects and it was the challenge for sustainability specialists P11 and P12 to persist on having the materials adhered due to in the construction stage.

The subsequent sections tackle other responses focused on various project brief and design themes.

4.2. Green Building Credits/Points Selection Process

Participants 3, 5 and 7 indicated that the procedures for selecting the credits or points to pursue for the green certification system was for the designer in the design stage and not discussed thoroughly in the project brief stage. The project brief stage only defines the overall certification level to attain and it is up to the designer how to achieve this. There is no articulation of how much energy or water consumption per say needs to be reduced by in the project brief stage. P10 and 15 found the project brief to be vague and unspecific and insists that the client to be more involved in the selection of the credits. As a sustainability manager, there was dissatisfaction on the vagueness of the project brief but ultimately you have to get an agreement or roadmap to achieve the goal. Participant 3 states: "only in issues related to renewable technologies or major cost cutting issues that there will be a owner specific requirement for the designer to follow". Participant 16 concurred this in the designer comes up with a strategy in fulfilling the client aspiration to find what is best to be achievable in the project. Participant 8 as a designer preferred this practice because it gives flexibility to the designer to have more freedom deriving schematic design solutions for the owner rather than being restrained from the beginning as per the owner project requirements. When asked about liability of design, the Participant 8 stated that the client may have the wrong perception of what the point and credit would represent. As a designer, there is a greater research capability and cognizance of what goes on behind the credit.

An important green building feature was the selection of site to build in, and the participants unanimously stated there was no engagement with the owner in selecting the site but is already defined to the project brief. Participant 8 stated implications on the design quality of the solution in how it meets the sustainability requirements (i.e. interconnectivity to site, protection of natural habitat, storm water runoff plans). Participant 16 stated that the certification bodies assume that the designers have a say in choosing the site, but the participant had never experienced site selection before. The common practice is to work within the parameters of the site. The authors hypothesize that the framework can contribute to have the process standardized in engaging the project brief and design staff in selecting the project boundaries and instill a more comprehensive decision-making process on the certification credits to choose.

4.3. Design Iterations and Design-Sensitive Issues

Participants 19 found energy modelling to be susceptible to design iterations as a result of space planning being modified from client requirements. P2 corroborated this and found designers also omitting sensitive issues in complicated building envelope claddings causing to overlook thermal breaks which needs the energy models to have a safety factor to consider for such discrepancies. Participant 10 was not able to indicate a particular building component to be sensitive to design but indicated that there are thumb rules to consider in passive design strategies that need to be followed depending on the site characteristics such as thermal masses and tight envelopes. There are complicated codes for simulations for active design but there needs to be stages to be followed in the simpler passive strategies followed by active strategies. P10 echoed the lack of diligence of the designer in depending heavily on the active strategies for ventilation and lighting and did not give proper forethought for passive design strategies. Furthermore, P10 found designers specify certain types of chillers but with suppliers providing similar products with slightly lower efficiencies. This poses a significant challenge to comply with energy requirements because the calculations involved have other integrated components with reduced U-values, lower lighting performance densities and exacerbates the threshold energy level that was supposed to be achieved.

P10 indicates that the schematic design stage “has the greater scope for early change and in particular the architectural components scope on setting the tone from the beginning because it is in the front end and in the pre-planning that goes into the building”. The mechanical, electrical and plumbing (MEP) would relate to the architectural aspects and work around how energy and thermal comfort is handled. With BIM’s introduction, there is more simulation in the early design process to determine how the energy and thermal comfort performance is achieved. P2 concurred that the architect needs to fully develop the wall, window and roof details with full specifications for the U-values in the schematic stage before P2 can engage in providing active design strategies because the lack of design development can further exacerbate situations of non-compliance. There were issues of thermal breaks that needed to be catered for especially with MEP conduit pipes need to run through the building envelope. P2 echoed for architectural spacing configuration to not be further modified after schematic design stage and has sensitive implications on natural ventilation because of its implications on pressurization calculations for the air inside the buildings in particular for kitchens, cafeterias and corridors. The reality is that in pretender stage and as construction is about to commence that the spacing layout is not fully finalized yet.

P9 found design iterations depend on the client engagement on whether the client chooses to provide inputs in the design. Design aspects with subjectivity traits include space functionality, lighting, building envelope components and overall structure. The space functionality particularly can change during the design progression and it may even happen when the building is already built, and the designer would have to redesign the interior envelopes to serve the purpose (a view also shared by P2). P4 reflects on the challenge of having multiple clients involved in a single project that made the project brief becoming more of a dynamic document and had implications on the design process.

P11 and P12 concurred the building envelope to be the most sensitive design even with the best HVAC technology provided. P11 highlighted also design for occupancy behavior in particular for system control and providing awareness for the end-users. The thermal insulation had several design iterations in which it was questioned whether to have the insulation in some parts of the envelope and whether thickness could be varied by the contractor and were questioning why insulation cannot be modified. There is a mentality of not knowing the tangible results of the insulation on the active design strategies. Furthermore, material selection containing recycled content, chemical content and resource responsibility makes difficult circumstances for the DB contractor to have a design approved especially with the price tags on the materials. It leads to iterations to balance out between the variables.

P1 highlighted subsurface drainage design due to site reconnaissance discrepancies that happens in project brief is a design sensitive issue. Manholes supposedly near the site vicinity were not physically present and led to the whole stormwater drainage system to be reviewed which would otherwise have led to flooding consequences if not done properly.

4.4. Inspection and Testing Requirements

Participant 10 indicated that the designer specifying the materials does not consider the inspection and testing requirements involved as initially it was assumed possible to bring in a specialist from overseas to do the testing requirements, but the current political situation hindered this. A particular struggle faced is when opting for Enhanced Commissioning as a credit and facing the challenges of conducting blower pressure tests and infiltration testing through the envelope. P10 insists that a true integrated design will have a contractor and commissioning agent to provide a design feedback to ensure this.

Participants 11 and 12 finds designers more focused on the performance requirements that the material needs to perform within a certain range. P11 highlights that if the designer is involved in the tender and establishing a baseline schedule that considers inspection and testing requirements. However, this is not as possible when the project could be a strategic project with a strict delivery date. P11 states that “as a sustainability representative in a project, you would be more aware of the testing requirements than others in the design team might be because you are constantly fighting a battle to get these aspects into a building, such as VOC paints. Once you have been through one project, you know how hard it is to get accurately skilled contractors to execute matters”. P11 finds that material requirements requiring overseas testing would need to be addressed with the client from the beginning to reconsider whether they would still opt for a certain material. P8 concurs this as a sustainability representative with examples of asking a VOC requirement of a paint coating that would need a quality assurance testing on site to compare against the laboratory certificate. There is an issue of not being able to do the test locally and has to be shipped overseas. This faced further in new materials that are not commonly used in the industry. The U-values of insulation configurations are especially a challenge to test for compliance by contractors due to lack of 3rd party laboratory availability.

4.5. Design for Durability

P2, 8, 10 and 11 indicated there was no formal Design for Durability process but finds contributions if it was formally implemented. For example, there are sensitivities towards high performance glazing when there are gases such as argon or kryptonite which reduces in pressure after 5-10 years and cause the initial U-value to diminish. Other aspects for extra design verifications on flashings and other water repelling mechanisms to avoid moisture intrusion, mold and mildew growth, finishes and detailing of cladding materials and windows to not crack from heating and cooling cycles through joints. P2 indicates some design issues that were rescued from the designer's own experience that could have been also avoided if a formal design for durability system was implemented. The first example was in choosing the steel pipe materials for carbon steel versus stainless steel for laboratory facilities to avoid corrosion or pipe scaling. Secondly, the designer removed incorporating a greywater recycling system in a school because its idleness will cause filters to dry out and must be replaced.

4.6. Constructability and Operability Feedback

The participants gave mixed responses on the constructability and operability feedback. P11 and P12 highlighted the type of constructability feedback given to the designer is that the sequencing does not allow for certain design aspects to be done, sensitive areas that are not within reach for insulation or paint material availability. P16 indicates that the vendors of the products provide their own design drawings that are based on previously constructed installations and so the designers incorporate the vendors' drawings into their own. P13 however had not experienced any constructability or operability feedback in the design stage.

P5 and 6 revealed that there were no preparations of commissioning requirements in project brief and it depends on the complexity of the project especially if it was an industrial project. P15 reports that commissioning requirements needs to be driven by the client but is not usually the case happening in green building projects. P11, P12 and P16 value the role of the commissioning agent (but was not actually occurring in for P11 and P12) for concealed items in the design in how to access the components, comparison of the credit requirements, conducts design reviews, contributes to the specifications and provides a dynamic commissioning plan document during the design stages. P17 highlights that commissioning agents do not provide much review on energy and water performance and is mainly focused on the accessibility for maintenance and if the electrical systems are isolated in separate circuits. Peak flow rates and volumes of chiller systems may be measured but the energy performance that is associated with it cannot be measured and verified because it will require the commissioning agent to have a prolonged contract after project handover. There is a disconnect between the design and construction commissioning agent and the retro-commissioning process according to P17, and the role is only limited to devising a metering strategy for the components in design.

4.7. Building Information Modelling Usage

P3 highlights that in part of the project brief, the client would specify the usage of BIM in the design tender. However, BIM is not used in the early stages in pre-schematic stage. As the designer starts getting engaged, a BIM specialist would be summoned to commence with BIM models. P3 informed that LOD100 is not a standard project brief procedure. From a client perspective, the brief is done at a high level and is difficult to detail matters out in the early project brief stage. P7 however found using LOD100 as a standardized method in the client brief as reasonable enough to provide details at a level enough for the designer to be acquainted with what exactly are the owner's expectation of the building to be designed. P3 also encouraged for standardization of LOD100 but highlighted the difficulty of application because of the client level of knowledge and their willingness to engage thoroughly in the project brief.

There were mixed responses in the involvement of designers in using BIM. For example, Participant 1 and 8 follow the BIM LODs and incorporate a BIM management system that does data interoperability and process control whereas Participants P11 and P12 are not involved with BIM usage although there are models are implemented in the project. P10 finds BIM's introduction allows more simulation and iterative testing in the early design process to determine how the energy and thermal comfort performance is achieved. Furthermore, P10 confirmed the Level of Development (LOD) to be consistent with the design stages. P9 uses

LOD100 at schematic stage but the idea of fully using BIM at LOD350 and LOD400 depends on the client and the size and complexity of the project (a view also shared by P15 with the additional emphasis that sustainability requirements will not dictate the decision to use BIM). A simpler project can be provided with a LOD300 and be ready for construction. In P9's green building project, LOD500 was done and were engaged on site to ensure that anything being built needed to be modelled and coordinated before. There was an instance of an overcast concrete structure that led the design team to go on site with laser technology to check on model clashes. Without an LOD500, the clash would have not been realized. P9 emphasizes that that the model is not given to the contractor but rather is converted to a 2D drawings which are contractual drawings. There will always be a BIM and a 2D CAD deliverable in a BIM project setting. P15 finds the LOD levels to comply with will be time consuming and counterintuitive in schematic design stage because client is time restricted in the beginning to seek out solutions from the designer and it would be more practical to allow the designer to make initial sketches. Only after completion of the schematic stage that P15 encourages BIM to be used as a tool but not as a deliverable.

The question of BIM's efficiency in fostering innovation was not supported by participants 1, 2 and 4. P1 finds BIM does not reduce design submission iterations but is rather a performance issue of the consultant. It was perceived as working on drawings in 3D and converting to 2D and compliance issues of setting up BIM and ensuring it works properly. P1 quotes the binary nature of BIM, "In the project it was proven to be a very time-consuming exercise because we found 10,000 clashes in the model and about 30% of them are actually real clashes. Some can be dealt with construction and shop drawings. But it gets sent back with rejection. The process time of redoing and resubmitting and redoing is long time. BIM however as tool as helped in visualizing the project much better.". Although in face value that it was useful in providing a clash analysis, Participant 2 found that it depends heavily on the BIM manager's awareness to ask questions on the clash. Otherwise, it can lead to reckless decisions to omit a certain mechanical piping component because of a clash without liaising with the MEP engineer. Participant 19 uses BIM as a modelling tool but explains that the background calculations are still conventional. He only uses it as a means of presenting results and makes documentation simpler. BIM is used for daylight analysis, shading and glare analysis. P9 found efficiency in BIM from design resubmissions reduced because it helps in more detail clarity from the beginning. Everything is also interoperable.

4.8. Specifying Product Attributes

P16 states the high performance expected from green buildings requires certain materials and products to be specified and are not always available in the local market. Consequently, contractors can bring in materials of a lower level and can jeopardize attaining a certain credit. Examples include installing thicker insulations and extra meters (the client was persuaded to remove extra meters for energy and water monitoring). P9 also shared the same view of contractors trying to save money through attempts to modify the specifications. However, if they are contractually held to the specifications. They need to comply with the identical materials or equivalent to what was specified. P8 states that a designer can easily go for the higher specification of materials but if it is not available in the market it opens the door for putting the certification at risk. He claims, "we have been put in situations where even the reviewers for a certain material or aspect, for example energy performance, they questioned it and they told us if we can prove the material was available in the market. We had to submit datasheets from two or three suppliers that are available in the market to prove that a performance spec is available".

P12 provides insight on the designer and builder mentality in green building projects and states, "you as a designer want a good reputation and a nice portfolio through designing a high performance and high-quality building. The designers usually produce something that is better than any contractor can deliver. As a designer, you are mistaken because you need to do a market research first to see if it is available and expensive. You need to design within a budget. You really need to investigate if your proposals are matching with the budget. But the contractor faces delays or unexpected expenses and tries to do cuts later on. The contractor doesn't have the staff that is educated to understand the changes of the decisions.". P12 advises to give a performance range in specifications rather than being restricted on a single performance amount.

4.9. Designing Green Building Technologies

P3 and P5 revealed that in most project brief stages, there is a lack of formal mechanism in deciding on particular green building technologies and conducting market analyses on their availability and operability. However, unless the client wants a particular system implemented, then an initial feasibility study is done. For example, the client had a desire for a wind turbine system implemented. Therefore, a few manufacturers that can provide wind turbines that meet a particular shape were considered. There was a difficulty for maintenance services for such wind turbines in the long run and it was not thought of thoroughly in project brief. For the same reason of maintenance restrictions, P15 discourages using technologies that are not prevalent in the market. Regardless of the novelty of the technology, a system that is not tried and tested will pose a risk in the lifespan of the building. P15 indicated that external stakeholders can pose resistance on certain technologies and encouraged a stakeholder management system in the project brief to discuss the feasibility of implementing green building technologies. In one project, P1 and P2 explained how government authorities were against bringing electricity produced from renewable energy technologies into the grid because it reduces their control on the local jurisdiction's input and output.

P2 states a challenge for a mechanical engineer in space planning in that the plant rooms need to be prioritized but unfortunately the client and architects focus more on retail spaces and neglect the needs for mechanical services. This is specially in energy related technology systems such as Variable Air Volume units that require larger ceiling spaces which are overlooked and puts energy related credits for green buildings at risk. P2 asserts for extra caution when designing greywater recycling systems (GRS). If the system sits idle, the filters will dry out and must be replaced because there is no mandatory continuous circulation occurring. GRS are not for every building unless the building is operating throughout the year that you can have a GRS. P6 and P8 also highlight the issue of volume needed for GRS systems to function and are not properly considered in the design stages of the volume amount produced in the building to have a GRS to be useful. Certain technologies such as audio-visual systems become outdated as the design progresses especially when the design stage delays and the client requires the latest technology to be implemented.

4.10. Value Engineering

P6, 7, 8, 10 and P16 report that the value engineering exercise (maximising performance in the design under a lower cost) when done by the DB contractor puts sustainability traits at risk because the client is ready to lower down the upfront cost caused high performance materials or technologies. Examples include the building envelope and height, stormwater drainage, adding solar energy systems without considering the need for mechanical rooms, removing greywater recycling, metering, submetering, and landscaping modifications. P8 states “you have to look at the entire lifecycle of the project but what is being done now is cost cutting and not value engineering”. P2 finds LEED certified buildings that do not involve a LEED consultant on board in Schematic Design can lead to the main consultant giving a poor excuse that something is not cost effective. There is a risk of design-sub-optimization to happen where the designer removes something thinking it is not cost-effective in the short run. In addition, P2 denotes the challenge faced when value engineering is done in the end of the design process because it will have change implications for previously designed components where the new DB contractor would not hold design liability for such components. P6 would like to promulgate the understanding in the construction industry that value engineering will be associated with a slight cost overrun but will reap its return over the long-term period to get efficiency.

4.11. Suitability of Project Delivery Systems for Achieving Quality

P3 finds that the choice of PDS system has an impact on the level of owner provided design, in the DBB project brief only covers the design stage expectations whereas the DB project brief covers for both the design and construction. P15 held an opposing view in that the DBB system will have a more substantial brief because the contractors will be ultimately bidding against a thorough contract with design elements already in place. In DB contract, overarching principles or the target can be put out there and it becomes up to the contractor in how to achieve the target. However, P3 reveals that a DB contractor is cost-driven and agrees on a lumpsum, and if the lumpsum amount was not initially thought well through, then the DB contractor will cut corners to achieve the target requirements. P10 experienced a DB and DBB green building project and finds the DBB owner had a “hand-off approach” and had little involvement from the owner in providing details for the project brief. The brief just stated to achieve a 3-star GSAS certification and consequently led to avoiding the fit-out related credits but compiled with energy and water requirements. P10 finds the designer would not go the extra mile of doing rigorous energy and water performance calculations and simulations if the owner is not serious about sustainability needs. P10’s views mirror the perception P6 as an owner representative involvement in project brief in that hiring a professional designer would not require P6 to provide extra engagement and it is not necessary to provide extra details to the designer. However, P6 finds that for a DB contractual arrangement to be efficient to fast-track a project, it will require tough guidelines and specifications to be stipulated early on to avoid causing the quality of the end-product to be challenged, and this was consistently realized by P10 in the end of DB projects. On level of design detail, P8, 9, P10 and P16 indicate that in DBB, the level of design detail provided also specifies the supply vendors of the materials which is not the formal case for DB. As a result, there is greater likelihood the construction stage to comply with the design requirements.

P10 indicates that after the schematic design was done, the usual case is that the DB contractor would implement a revised schematic design and take responsibility ownership of the design. The DB contractor finds that any changes in spacing arrangement by the client after the revised schematic design will substantiate a variation order for the contractor to make a claim on. P1 finds that in DB contracts, there is conflict between the DB contractor in design and the initial design done in schematic. For example, for ambient temperature for cooling, we specified a temperature requirement. But the contractor comes and challenges the AC units specified in concept design would not comply with the ambient performances expected. The DB contractor specified in his scope to comply with the ambient temperature but finds what was specified for AC units will not fulfill. We go with an initial design and contractor comes back and says "I didn't expect that. It will be a huge variation on what is needed on site to offer you the performance specified."

The views on the opportunistic behavior of the DB contractor in cutting own cost were shared by several respondents 4, 6, 7, 8 and 16. P7 states that if the project is straightforward copy and paste, then DB can be suitable. But in a complexity of green buildings, the contractor as a DB would be engaged in an opportunistic manner and exploits the situation in making variation orders and cost cutting under pressure that the client is forced to subdue. The participant argues that contrary to belief that DB provides a quicker project execution, there are complexities in having the Design consultant approve the DB contractor's design proposals (especially if the owner forces the DB contractor to design approvals from a 3rd party design consultant). The DB contractor becomes more risk averse from the mechanism because of the lack of confidence on the unique project compared to if the project was already mimicked before and has been tested and tried. However, P10 offered a different view that a contractor in DBB projects simply builds as per what was given as approved designs regardless if it had discrepancies. The contractor discourages their technical staff to bring up any issues for extra pumps or oversized equipment but to simply follow instructions of the designs.

P11 explained how the DB delivery system helped in curtailing the issues faced with dewatering and excavation in the brownfield site. The DBB system would not be adequate where the characteristics of the site are not fully determined and when the dynamics of the project surroundings suddenly change. P11 gives an example of dewatering that was experienced where the neighboring projects stopped dewatering and the contractor suddenly had to increase the duration of dewatering regime which required to submit a new permit with the environmental regulatory authorities for the increased treatment process for the underground water before discharging. In the DBB model, the design would not adopt for such dynamics and can lead to risks of not fulfilling the sudden construction circumstances that will require redesign for dewatering. Furthermore, DBB may also not price matters correctly in the tender stage.

P12 revealed the challenges of the rushed nature of a DB contract in that the construction is always going ahead of the design and it is difficult to maintain getting the design completed before the execution of works. The DB contractor will continue to take the risk and execute the works which leads to sustainability traits to be compromised. P13 however disagreed to such compromises because of the procurement purchasing system that was implemented in their DB project to increase the level of influence on the contractor. A Sustainability Management Plan and Certification Management Plan was used as a foundation with the contractor's procurement team when choosing materials. In addition, the contractor still needed to seek approval from P13 as a consultant before procuring the materials. In a DBB setting, P13 finds that there is no longer such influence on the DB contractor because their responsibility ends in design stage after getting a Design Letter of Conformance from the GSAS certification system.

P15 finds that the DB contract would need the client to articulate more thoroughly the credits and points to seek for, as when there is no specific requirement from the client, there will be no need for details. From a quality of the design, P15 finds that "the traditional way will actually have building for the actuals. So, the chances of getting good quality is only broken by workmanship issues, In a DB contract, it will depend on the final rate agreed upon. If the contractor is desperate to get the project and make a large win, the contractor will take the project on board and assume that the DB contractor will execute matters on a minimal cost and when it does not work out, it will take a hit on the quality" Thus it will depend on the margin the contractor as set up for in executing the project.

P16 agrees that the choice of delivery system in terms of timing of engagement and risk responsibility will have an impact on the overall project quality but reveals there was no engagement with the client in which delivery system to adopt for the project. P2 on the other hand was involved in deciding the type of project delivery system but emphasized an important issue of the fiscal year the client faced. P2's project commenced as DBB but then modified into DB during the design process and had implications on the entity that owns design responsibility. The fiscal year coalesced with the gateway for delivery and led the team to phase out the project. P2 explains that the designs tendered into DB were relatively raw and put the client on the mercy of the DB contractor, which is risky in terms of the quality expectations to be met. P6 and 10 (49:00) voiced a corroborating opinion on a certain design level necessary before engaging a DB contractor owing to the latter's opportunistic nature that can be contained through the level of design detail. P10 states "Giving a DB contractor an early schematic design is a risky proposition. You are better off giving a detailed design to the DB contractor to have a less scope for the contractor to play games with the final delivery." It was perceived that the DB contractors locally do not have a strong design team in their organization that can deal with the perks for acoustics, audiovisual components or simulations for testing. Unless it is explicitly stated in the project brief to do certain green building related analyses (for example computational visual dynamics for natural ventilation at different times of the year). However, in simpler projects, a DB contractor can be engaged in the project from schematic stage and take the design responsibility. But for maximum efficiency, P6 suggests only after preliminary design stage that a DB contractor can be engaged in the project.

P13 did not find any difference from DB and DBB on level of detail of project brief contrary to P10 in which the documentations and specifications are more thorough. P10 highlighted that the professional indemnity insurance and the liability will be upon the contractor in DB and so the client would not be as stringent from early on to ensure details in the project brief.

P8 finds DBB having more opportunity for innovation as designers to take their time and look into what more can be done. P8 and P16 find DB contracts vulnerable to cost cutting sustainability traits but masked as a value engineering exercise. The client under financial pressure as construction progresses readily accept the immediate solution to be part of value engineering without considering the long-term impacts of the decision. P8 advises that what constitutes to value engineering needs to be stipulated with a time duration of its benefits when it comes to sustainability requirements for a green building. P2 had a converse argument and observed that tenderers for DB contractors very competitive and innovation is essential for them to stand out from one another although they would take the risk. P2 reflects however on the issue of the DB contractor introducing their own patented technology in design that leads to the owner making royalty payments.

5. Interview Questions

5.1 Project Brief Stage Interview Questions

Interview Questions	Discussion Areas or Probes	Purpose
Is there a baseline schedule/budget established in the Basis of Design/Design Intent/LOD100? Is there discussion on whether to adopt BIM modelling for the design work? Are types of green building technologies discussed? E.g. ERV/HRV, rainwater harvesting systems composting toilets etc. Have you considered which technologies are readily available/repairable in the market? How important do you find this? Are sustainability goals defined in project brief? For example, energy consumption, water consumption, IEQ expectations, materials used?	General Process	To examine how the sustainability traits related to the green building are initially discussed/formulated; the extent of detail that the project brief covers sustainability requirements; discussion of risks and how to mitigate them
How is the site selected? Any green considerations i.e. brownfield site? Stormwater assessment? Topography and flooding? Preservation of natural habitat Do you consider connectivity issues? Such as transit? What is the mechanism to control that the selection is suitable to build on? Is there any discussion about construction and operational waste management? Perhaps it has an impact on site selection? Is there any form of design development in project brief that will lead to potential protection of natural habitat, passive design strategies? Are there any preparations/discussions on commissioning requirements?	Site Selection and Assessment	To find out about the mechanisms involved in selecting a site that would fulfil passive design strategies more effectively; Activities involved in site assessment and reconnaissance early on and if there are discussions on remedies necessary to protect the site. Lifecycle thinking for other stages (i.e. integrated design procedures)
When determining the sizes of the building overall and the rooms expected, do you consider the building energy consumption for HVAC? Do you consider opportunities for passive design? Is there any discussion of alternative/renewable energy on the project based on the site chosen? Explain any of the decisions done on water consumption: for	Energy and Water Consumption	To capture any formulation for energy and water performance measures in the project brief. And if any potential issues can arise.

Interview Questions	Discussion Areas or Probes	Purpose
instance, the landscape water requirement and the system efficiency expected? Is that articulated in project brief?		
Are there any decisions made regarding the psychological and social wellbeing of end-users through the building sizes or the views exposed? Does IEQ impact the site selection chosen? In terms of noise disturbance? Or in capturing views? Or in daylighting?	Indoor Environmental Quality	To find out how indoor environmental quality issues are conveyed in the project brief.
Is there any discussion about construction and operational waste management? Perhaps it has an impact on site selection? Building reuse/furniture reuse/material reuse/interior reuse:	Material Selection	To identify whether issues to do with waste management are discussed early in the project brief and if material selection criteria are established.
Are there team members involved in the project brief that are not usually present in conventional projects (e.g. construction team, facilities team, commissioning authority?) When choosing sustainability requirements, do you consider synergies and trade-offs? And are these reviewed by an independent 3rd party? We spoke on many items regarding the formulation of a brief to define the end-product expectations. Are these reviewed by an independent third party? As an integrated process do you consider the green building objectives synergies opportunities?	Integrated Design	To attain information on the integrated design procedures in the intricacies that are involved. If synergies and trade-offs between points or credits are discussed.
Is there a risk management/stakeholder management process that happens? Is there a decision on project delivery systems to adopt earlier on? And if so, what was the basis to choose so? As an owner/contractor: do you think the PDS type impacts the quality management process? And how so? Does it affect the inspection and testing expectations or material quality etc. Usually designers complain that the project brief/basis of design is not well defined enough for the designers to make solutions to meet the owner project	Project Delivery Systems	To find out how project delivery systems are chosen in the project brief stage, if any views and perspectives on the different PDSs in terms of preference. Implications of PDS on the level of detail of Basis of Design.

Interview Questions	Discussion Areas or Probes	Purpose
requirements. In your view, do you think the PDS system has an impact on this? In terms of level of owner-provided design? What degree of confidence do you find the local industry capable of meeting the goal of developing designs to meet the building owner's expectations.		
Common problems faced in green building e.g. mold/mildew growth, flooding, energy consumption related issues. Are they discussed now or left for the design stage? Have you considered any Post Occupancy Surveys of similar projects to determine lessons learnt from previous projects and avoid doing in this project?	Lessons Learnt from Previous Projects	To ascertain whether a lessons learnt mechanism was in place and if Post Occupancy Surveys were evaluated early in the project brief stage.

5.2 Design Stage Interview Questions

Interview Questions	Discussion Areas or Probes	Purpose
How do you compare green buildings to conventional buildings in its delivery process? Which building component do you find most sensitive to deliver? What are the common defects you experience in design? Do you find certain aspects requiring more design iterations? And Why? Do you find standards and specifications at a level that a contractor is/was competent to follow? When choosing a building typology system (i.e. steel, concrete, masonry, timber) do you consider the expected inspections and testing during construction? Is the inspection and testing requirements for the building system type considered in the design phase or is it left to construction? Do you consider durability as part of your design? Can you give examples for cases sensitive to green buildings E.g. Building envelope and IEQ. Is there constant liaison with the LEED Technical Advisory Group/independent advisory group?	Design Process; BIM; Design Sensitive Issues; Inspection and Testing regimes; design for durability; liaison with other life cycle stage practitioners or technical advisory groups; BIM Implementation; Commissioning	To examine the sensitive issues faced in green building design; performance of contractors to the specifications formulated by designers; how durability of design is incorporated, inspection and testing requirements implemented, how BIM is incorporated in design and its degree of effectiveness in expedited design process and innovation; Designing from Outside-In concept used as a basis for the node A2 framework: Role of Commissioning in Design

Interview Questions	Discussion Areas or Probes	Purpose
Does the design stages follow the BIM LODs? Compared to non-BIM, do you find design iterations occurring more/less? Does BIM bring about more efficiency in the design process of more innovation and compliance to meet expectations? Is there a BIM management system for data generation, interoperability and documentation control? Is there any members who are involved in construction active in design development? In LOD 400, does the construction team conduct a constructability review? What do you think about the Design from Outside-In Philosophy? Is it adopted in the design work? What do you think about the whole building design concept? Do you think that the project brief was done in a detail enough to produce designs that will satisfy the owner requirements? Is there a role for the commissioning agent in the design process? Please explain.		
Does the site assessment enable for erosion and sediment control plan for construction and operations? Are the measures for protecting the natural habitat in your view practical enough for the construction team to easily follow without jeopardizing the conventional goals of on budget and on time delivery?	Site Assessment and Passive Design Strategies; site assessment measures done in design;	To find out how the design for surrounding environment is implemented and if the site is pre-assessed to determine the constraints to design for.
Any passive design strategies considered for Energy and Atmosphere? How do you verify that these strategies are effective? Any third party that considers it? Are these strategies complex for construction? If so, any constructability feedback? Do you prepare energy models: simple, hourly, compliance energy modelling? In which design stage do you consider water efficiency strategies? For example, outdoor irrigation, xeriscaping? In which design stage do you consider water efficiency	Energy Modelling and Water Performance	To explore how energy and water related points/credits achieved in the design process and if there are any challenges faced in meeting the energy performance requirements.

Interview Questions	Discussion Areas or Probes	Purpose
strategies? For example, outdoor irrigation, xeriscaping? Does the design specify water performance management? For measuring and monitoring. Do you consider operational usage considerations in design?		
Is there any construction waste control strategies occurring in the design? Is there an LCA conducted in the design process? When specifying the material attributes, do you consider its availability in the market? As this may be a cause of deviation in construction. Any codes that you follow for low emitting materials, paints, flooring systems, coats, furniture etc? e.g. FTC. IEQ And EA for instance In LOD 400 do you consider construction sequencing in design?	Material Selection and Waste Management	To discuss the designers' role in specifying materials and if there are any sustainability traits reinforced in material selection; waste management measures covered in design to reduce waste consequences in construction stage.
Is there any passive design approaches done that consider the building nearby environment i.e. daylight, shading, wind directions for natural ventilation? At what stage do you consider details for the building envelope that impact IEQ e.g. moisture intrusion, thermal bridging, pressurization, acoustic performance?	Indoor Environmental Quality	To attain information on how the design process caters for indoor environmental quality issues and the design challenges faced.
Can you give me an example of IDP occurring in a green building? For example, when you have multiple disciplines working together. Does the PDS adopted affect the potential for innovation to occur? I.e. especially from the owner involvement in the design. Do you think that the BoD provided in Design Brief can be impacted by the PDS type chosen? DB contracts: do you find the benefit of constructability impact on design or not so much?	Integrated design and Project Delivery Systems	To gather information on how project delivery systems impacts the design stage process. Also perspectives of design stage practitioners on the outputs from the Project Brief stage.
Design Rework: construction non-conformances are sometimes more feasible to be reworked in design. Does that happen? And If so, do you think its negligence from the contractor? Or that the contractor does not have the capability to execute matters?	Design Rework, Lessons Learnt	To depict the sources for design rework to happen and what were the causes for it. If there is any liaison with the operations team through Post Occupancy Surveys for lessons learnt from previous

Interview Questions	Discussion Areas or Probes	Purpose
Variation orders from owner: do you think this is caused from the Basis of Design not being practical enough? Or is it spontaneous? Any mechanisms to achieve operability feedback on the designs?		projects to improve the design process.

6. Elaborate Focus Group Study Results

Research Problem Definition

Green buildings have a higher technical requirements to meet a superior performance expectations. This comes at a cost, and this is the main obstacle of green buildings are known to have a 10-30% cost overrun. Part of this comes from measures to meet quality level. So when I say quality, in project brief and design, what I mean is the clients have aspirations and dreams to have a green building. These aspirations and dreams get converted into design specifications and IFC drawings. So when it comes to quality, how well did the aspirations and dreams get converted to a basis of design. Have you understand the client needs well in what they want. Have you made a feasibility study on the requirements. Are they compatible with the cost ands schedule available. When it comes to sustainability, have the requirements been converted to traits to improve energy and water performance, enhancing health and wellbeing of occupants. In terms of design verifications that happen in design stage, do they meet with the specific standards. Is there any problems of liaison between different disciplines. All this feeds into quality.

Importance of the Research

The hypothesis that I'm putting out is that quality affects sustainability level of a green building. So I previously did a review paper on compilations of studies on a subject called a project delivery systems. See you have a client, contractor and designer as you all know, and what dictates the relationship is the project delivery system that's put in place.. whether it is design bid build, design and build, CM@R. it dictates timing of engagement and risk ownership between different entities. In the review I have done, it was found a research gap of how to evaluate delivery systems in terms of quality especially as this is more sensitive for green buildings.

What is Expected From You

So I started by doing survey and gave a questionnaire to 70 practitioerns, some of you answered the survey. And I got a positive response on relationship between quality performance and sustainability requirements. I then did a one-on-one interview that some you participated in and we got insight on how the industry is working on quality performance. Today you are all here in part 3. We re having a workshop together to discuss the statements and to share your views about what I am about to say.

Confidentiality

One of my responsibilities as a research is to ensure your identity is kept confidential. So I have here a confidentiality agreement to ensure that your name is not published in research. Please do not mention names of projects or their locations.

Discussions

“Basis of Design only states the certification level but not the actual green credits/points to pursue. Roadmap to sustainability goals can be vulnerable to client changes.”

There should be a wish list that comes from the client. In his wish list, it must not be me as a designer to tell him that if he wants to get to this level of Platinum, you need to have certain points and to have them, these are the items you need to consider. Actually someone from the client side should participate and say that “my wish list is this”. My points are in saving water and saving energy. I don’t care about landscape or something related to façade material. If this did not come at the beginning, it will cause a gap in design development that would cause a design gap.

Other participant: at the start, the client himself must be included. There should be no change in the objectives. Those objectives and later on you will see that the system will be followed. Before the checklist, the designer has one more challenge.

Other participant: Based on the RFP we have gotten, it states we need a level of certification and what level of rating system it is. We get a guideline of what is easiest to get, what is of least cost to client and what is to achieve the minimum weighting. Theres no objective where client is giving occupant welfare and wellness as a priority. We don’t tackle it because its one of the hard ones. We just choose the ones easy to achieve and easy to cost quickly.

Other participant: I agree and disagree. If I look back when LEED started. At that point of time, they didn’t have a lot of water efficiencies and energy performances so you can actually achieve leed certifications if you buy credits. You don’t need to be actually sustainable as long as you have an aspiration to get something. The first versions of LEED for example are effectively stating that the sustainability as a concept was not really met. But for this particular project it was made in by globally in buying carbon footprints somewhere else and offset it by points. Now leed and many other certification programs find it much more difficult to buy credits. Its still possible to buy certain credits but it costs substantially more. Theres a cost of water and energy. I would say today its not as important to specify actual credits. But I do agree that it comes to budget. Theres nothing wrong in going into detail and specifying what you want to achieve. In the same time, once you become specific it leads to main contractual issues.

“Better for Design Process to select the credits and points because designer has greater knowledge and research capabilities and can accept design liability instead of the Basis of Design to specify the points”

This is a totally false statement because the designer usually mimic other projects. Especially when it comes to design from companies outside our country. From international companies. They will mimic a tower and do an adjustment to meet my requirements. But it doesn’t fit. There are some aspects that are required in future operations and maintenance that have high costs that I don’t know about because it is cheaper in other countries.

So I will go for the first statement of going for a detailed BoD.

Other participant: yes I agree the other persons’ statement. I feel that its just a name and recognition only. So the point on cost for a designer shouldn’t give me a 5 star but it will kill me financially. But don’t give me one that is tough to achieve in the long run.

As a owner, they usually say I want a 5 star and you are the expert and certifying body. But budgets become a big constraint when such is done.

Other participant: when I am going for a green building, it means I am willing to pay money. If I am doing soemthnig against my financial will, then it needs an expert to have a detailed wish list and convey it to the designer.

Other participant: I ll give you a practical example. Probably I would disagree in actually specify the credits. You have to in the owner requirements to be more specific I the actual systems you want. For example, in this region it is a perfect region to have a solar water heating system if you have a residential villa or a big building. You have sun 365 days a year but again the temperatures make no difference in this case. We can operate the system 365 days a year. The consultants mean it and the mindset is an expensive system and im not gonna do it. That's how they kill the system in the beginning. The reality is that no one looks at the overall costs. The solar heating system in isolation is more expensive than a water heater in a ceiling space. However if you look at the decentralized approach, and have hundreds of water heaters, plus labor costs, plus maintenance plus electricity. If you actually apply the costs of feeders, and architectural access and compare it to a solar water heating system. Everything compact and centralized, when you look at this compared to first scenario, you will make saving in architectural spacing, you ll make operational savings, actually the initial cost is the same. But the operations cost is much lower.

Its not really the points and credits but more on the owner requirements on the type of systems. That does require to have integrative design process between different systems.

"Design from Outside-In" philosophy: considering outside site surroundings then considering exterior building envelope and designing inwards as an efficient design process method for green buildings. You begin to do passive design strategies and then you look at the function"

I like the idea because you are adapting to the surrounding. But the function in terms of the usage of the building.

"Design for Durability: a formal design for durability review system can be beneficial."

in my home country, there are houses that are built with mud for thousands of years and are still working. But you have the same theme and you have something built to last. But now in this time, we have money and variety of materials so its better to change. I want to give an example in an apartment I had that I left abandoned for 5 years. It used to be my dream to have the apartment. So peoples mindset changing. So better not to have something that is costly that will last but be practical for something to last.

Mediator: Actually what im asking is the actual building envelope as it was designed to do extra checks. For example building envelope the glass windows glazing to be having argon gas. You do extra checks to avoid leaks.

I agree with you. The manufacturer gives you a warranty for 5 years or 30 years so you get individual warranties for glazing system. But what is happening more often because of budget constraints that ppl look for a nice picture and lesser quality just to get it in. and they say any problems will come from a different budget.

Nowadays, there's a mentality of lets just get something in and later on we ll deal with how to operate it cost-wise.

There's a school for example is now operational with only the issue that the owner realized that he's paying more money in maintenance costs for operating the facility. I sensed he's either breaking even or loosing money or making compromises because for a building 1 year old once the contractor walked away, the maintenance bills are tremendous. Some of the brand new systems that are not operational. The building owner cant start certain programs because the brand new facility is not functioning. But it's a matter of time that the issues will be realized. It will operate as per design specs but no one looked at durability. From flooring, ceiling. So I recommend it as a mechanism in the design process.

"Integrative Design Process: constructability (material availability, sequencing of works, conformance testing possibility) and operability (access to repair, running cost) feedback is necessary to attain in design solution"

Does this happen in the real world?

Yes and no. we have two approaches to do this. Every department wants their engineers to design standalone. But they must meet regularly to coordinate and share autocad scripts to show the need to meet and avoid human error. We have programs like BIM. This is the yes answer. But the no part is the bad practice that they don't talk to each other and update one another. Even in BIM models for megaprojects, we are always ending up with not having final revision of BIM drawing. This guy is working on revision 3 and other on revision 4. The product that the contractor is providing is missing. So we always have bad practice.

Other participants: I agree that there is such issue. But recently there's a system being implemented that teams are working together. What we find is that if we don't meet on a regular basis, small projects progress meetings and detailing whatever discipline is done is not good. So it helps even in simple designs.

Other participant: just going back to Integrative design process, I just want to add that what we see in the industry in reality the LEED process entails we need a team from project inception of having a design charette and leed charette and the main reason is that sustainability is communication and team work so in theory the reason they have this is to get something right. But what is actually happening in reality unfortunately due to time constraints and budget and processes, the LEED consultant comes in board quite late the people that have titles are just paper pusher managers. So in my experience what is happening even though it is a designer. There's no proper coordination implementation because the consultant does not look at the impact of the facility management and the cost of operating the building. It is difficult to get a design team together that is talking to each other and we cant get the healthy buildings and easy to operate. We have buildings that you cant access equipment. There's a hotel there's a new ceiling repair and now they re not even fixing it anymore because its ongoing repairs. Its important to understand that overall a sustainability process needs a team there from day 1. Unfortunately this rarely happens.

Other participant: assume that in ideal life that ppl sit together and cooperate 100%. Once you go to site, constructability is different from design on site. There are things that will force you to change the design. If you change the design, you will find yourself deviating from the road. The deviation will cost you money, time and changing the theme you are after. You need to adapt and accept these changes.

It is not a common practice to have an integrative design process of hiring a construction manager and commissioning manager. Especially in concept designs that do not come from Qatar. We see a lot of compliance issues.

"Designers specifying materials do not consider the inspection and testing requirements because of belief that testing facilities are fully available."

When I design something, part of the design is to provide your own vendor lists that has specifications. The vendor list has a an ITP and the duration of testing and performance of material and system.

Its not a design responsibility. The designer would give a preferred vendor list and provide a statement 'or equivalent' and give a performance criteria which remains on the contractor to implement and get on board. At the same time, when it comes to frequency of testing, the QCS gives a lot of guidelines. For example, how often we test the asphalt. QCS updates on different methods. So the basis of design is on QCS and international standards and local standards. So I believe the designer should not be totally responsible as long as they put a ceiling level.

What we do as designers, we put in specifications that testing is required depending on the product. How the testing is performed has a different level of specification implemented. It depends on verifications of designers or standards and specifications required from different sources. Generally any specification will call for certain testing and commissioning. There are some products in some nature of the product. They will have to be internationally certified product. Some has structural testing to meet 60 year standard in certain corrosive conditions. How its done is a contractor's responsibility. Either the contractor goes to manufacturer and gets it or if they want to save costs and do it in-house by a third party laboratory.

Other participant-the elements that affect installing. Its not the specification or designer to ensure the quality is there as per design and meet requirements of sustainability. There are other elements that are affecting the installation at site. For example, time. I don't have time and procuring materials will take 12 months and I need it now. I have 1 month and I need to bring the element. Maybe I don't have money to do the job. Its to do with project dynamics. When you go through elements, you ll realize its not the design.

Project Delivery Systems

"Value Engineering: DB contractor can reduce sustainability traits when client is prepared to reduce up-front costs of high performance materials and technologies."

Value engineering is in essence cost cutting. It's a very bad practice. All the DB projects without any exceptions are all facing time extension and additional cost.

In DB they will lower the quality through design-sub optimization in giving a lower quality for a lower price. DB has its existence in the world but you really need to think twice in what you are trying to achieve. Ppl think if you go DB, they think it is faster and cheaper but in reality you get what you paid for. So if you do not define your requirements with a DB contractor, you will not get what you envisioned. But again it depends what you really want as a client, if you are an educated client and know exactly what you want and put your exact requirements, because at the beginning of project, maybe the DB contractor will be reluctant to deliver.

What I notice that value engineering is a cut cost, but it is to add value. VE is to add value. By adding 10 dollars in beginning, you ll save 100 dollars in operations. But the DB contractor will never do that because he doesn't see the benefit of that payback. Unless you manage to put it as part of contractor's deliverables, and build some sort of incentive to get a bonus in a year time if they see energy or water savings. But the contractors are not interested. Only if you give them a bonus in a order of magnitude. So in that point of view, the VE is not for cutting costs.

"About VE, do you feel sustainability traits are most lost?"

Yes, when contractor incorporated the VE, he omitted the whole inner ceiling roof which had helped the thermal performances and water intrusion. You will see the drips everywhere.

Another example, they can propose a stormwater storage tank to get an extra point without looking at the fact that in this region, we don't get practically any rain. But theres not enough rain for running it. But its cheaper and no headache. Just make a tank and put filtration system. But in reality, from operation point of view, once you have the filtration and theres no water in tank, all the equipment you specified involving a membrane will deteriorate if you re not running water in it.

So as an operator, you either have to fill tank with potable water and filtering it that you don't require, or abandon system you paid for and loose money. So the contractor does not care.

"Timing of engagement: a certain level of design needs to be complete before engaging a DB contractor. If I finish a level of design, and then get a DB contractor, is it a better practice"

The liability of the design being given to the contractor gives him the right to do whatever he wants even if he changes the level of design. There isn't a mechanism to do this. You are introducing him. But definitely both its not good.

Even the timing of engagement will not protect you with the problems of DB.

They engaged the contractor just the end of detailed design. Just to pass on the responsibility of design to the contractor. So I said for that that VE is a fancy term. Because they come up everytime is that they have a VE proposal. They give you all the reports to say that the performance is not better. They already got their lumpsum contract and come up in the mentality to saving money.

Theres a project where there is a very detailed set of design was done for tender. The DB contractor proposal seems that no one even read the scope of work. When you look at the proposal whether it is architectural, mechanical. They make a building with operations that do not meet the owner requirements. When we asked them if they read the scope of work, the room was quiet. They don’t have time to go through thousands of pages of documentation. Before we even awarded the contract, we had a contractual dispute even though there s no money yet at stake, the DB contractor already refuses to do it. So regardless of how much info. It depends on contractual issues on how to write the contract and force it. So from that we say ok it’s a liability and how you do it. Unless you go for an open bid and try to design.

I want to add something on VE. The VE comes in too late in the game. Its cost cutting. It has to be done at the concept latest schematic stage. Not in detailed design. Because you need to see something. Then apply VE. When VE comes in detailed design stage. There will be tremendous amount of abortive works. Someone will come back to you and claim a variation because they paid so much to do designs. So VE can be a very deceiving terminology because it should be adding value to project and not the cost.

“standards and codes”

I would like to talk about standards and codes. You know that the different standards give you guidelines and some are mandatory. Unfortunately, we are blind followers. For example, NFPA. We are following the code the every single clause that is mentioned there. It came from the united states. 50% of the US don’t follow nfpa. Some states follow their own buildings. Some states in the north have no need for sprinklers in structured parking buildings. In nfpa it is mentioned. Here in qatar and the middle east we are following this statement. Why? Because its standard code. But its not applicable to us. Another example, is the water tank. After you have your pump, you have 1000 gallons.

You need to not follow blindly the codes but need to do something. When you design cooling load for a room or building, you go through 14 equations and you add a safety factor. You end up with a chiller that is bigger that you need and a load consumption of less than 50% than power you are providing. Why because you are following the code.

But is the client mature enough to accept something different from codes.

Someone has to take the liability but no one wants to take the liability. The problem is you are hired and you need to follow certain regulations. Even if you try to initiate something, who do you go to.

There's no standardization body of professionals to formulate standards.

Here we are using too many standards such as American, British, Singaporean, Australian. Because the American system looks at health and safety of occupants. The British considers building protection. The standards have different perspectives. It has to be resolved in planning. No one wants to take the initiation to tell an authority that the standard is an overdesign. The merging of standards is causing a big problem in the industry. Something I wish to add to your model. There's something called 360 feedback from other disciplines and a lessons learnt register.

6.1 Framework Evaluation Form

Appropriateness: Agreement with the Construction and Operational Activity Nodes

1 Disagree	2	3	4	5	6	7	8	9	10 Agree

Comments:

Comprehensiveness: Completeness of the construction and operation activity nodes

1 Disagree	2	3	4	5	6	7	8	9	10 Agree

Comments:

Relevance: Applicability of construction and operations activity nodes

1 Disagree	2	3	4	5	6	7	8	9	10 Agree

Comments:

Effectiveness: Impact of the Framework in Achieving Construction and Operational Quality

1 Disagree	2	3	4	5	6	7	8	9	10 Agree

Comments:

6.2 Framework Evaluation Results

	Appropriateness	Comprehensiveness	Relevance	Effectiveness
	9	10	10	8
	8	9	6	9
	9	7	10	8
	9	8	9	9
	7	8	7	8
Upper Quartile	9	9	10	9
Lower Quartile	8	8	7	8
Median	9	8	9	8
Level of Agreement	0.89	0.88	0.67	0.88
Mean	8.4	8.4	8.4	8.4

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