



NTNU – Trondheim
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How Can Experience from Real Estate and FM in User Phase Influence the Early Phase of Building Design?

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Master's Thesis

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Preface

This is a Master's Thesis in Real Estate and Facilities Management at the Department of Civil and Transport Engineering of Norwegian University of Science and Technology (NTNU), written during the spring semester of 2015. The thesis features the author's thoughts and findings regarding how important and necessary it is to adopt a holistic view in the designing of a building, and in what way it can greatly influence the building design when user phase experience is taken into consideration in the design scheme, especially when such intervention is introduced at the early stage.

The topic of this thesis was inspired by project OSCAR, a research project aiming to find out the optimal value proposition for all stakeholders within the building industry, which emphasizes on having different perspectives and inter-disciplinary approaches. Project OSCAR is carried out jointly by NTNU's Department of Civil and Transport Engineering and Norway's leading consulting firm, Multiconsult.

Readers with backgrounds such as civil engineering, architecture, and management shall find themselves in agreement/disagreement with the points made in this thesis. In either way, this thesis is meant to make a not so bold, but often neglected statement that what is being practiced in the industry nowadays has a huge potential for improvement. Yet, given the complexity of connections among all the systems involved, one still needs to think twice before action.

Trondheim, 2015-06-20



Qidi Jiang

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I would like to give my hearty acknowledgement and sincere thanks to many people. A special thanks goes to Prof. Marit Støre Valen of the Department of Civil and Transport Engineering of Norwegian University of Science and Technology (NTNU), who has acted as my advisor for this master thesis as well as for the majority of my thesis year at NTNU. Her guidance and instructions proved to be invaluable in the completion of this thesis and master programme. Also she has enlightened me with the truth of leading a balanced life between work and leisure. A second thank you goes to Prof. Svein Bjørberg of Multiconsult. He was one of my professors during the Facilities Management course and one of my supervisors in the OSCAR Project, who, with his profound knowledge and experience, benchmarked a passion-driven work ethic, a role model to which I can look up for life. I would be remiss if not telling how grateful I am to Prof. Nils Henrik Stensrud and Prof. Johannes Sigurjonsson of Department of Product Design. It is their patient mentoring and unconditional support, helped me overcome my struggle for thesis topic. I would also like to thank the remainder of the faculty of the Department of Civil and Transport Engineering for providing me with all the convenience and assistance, which created an inspiring and nurturing environment during the writing of this thesis.

Dedication

I could never think of enough names when it comes to my appreciation to give on this thesis. I would like to give my gratitude to my family who have loved and supported me from the very beginning. I would like to give my gratitude to my girlfriend, Yingzhou Chen, who comes into my life like a wondrous piece which I did not even know was long missing from the puzzle of a happy life. I would like to give my gratitude to all the fellow graduate students in the discipline of Real Estate and Facilities Management as well as all my faithful companions from the Department of Product Design, who have given me countless help and taught me how to triumph over hardships, especially during trying time. I would like to give my gratitude to my friends, both old and new, who have kept me well-grounded at all times. Without your continuing support and encouragement, the completion of this thesis would have never been possible.

Last but not least, in loving memory of my friend Jun Mi. You had so much talent and wisdom for a young man, and you fought bravely and honorably against the cancer that took your life away, reminding me henceforth that a fulfilling life is by no means measured by its length. May you rest in peace.

Q.J.

Summary and Conclusions

The practice of building design at large, focuses on the realization of physical features, which are based on different design philosophy and technical standards, creating spaces where different human behaviors are expected to take place. However, it should be noted, as people often forget, or sometimes intentionally neglect, that meeting the prerequisite will never guarantee an achieved goal, though failing to do so will absolutely undermine such goal. Quite often, there are buildings with excellent architectural design but with barely satisfactory user experience. The cause of such divided perception, is insufficient comprehension of the complexity in the interaction among users (also known as occupants) and between users and the building. Understanding the inner mechanism of the interaction between users and the building, and introduce such knowledge at the early phase of building design is believed to have great and positive influence over building design.

The thesis features the author's thoughts and findings regarding how important and necessary it is to adopt a holistic view in the designing of a building, and in what way it can greatly influence the building design when user phase experience is taken into consideration in the design scheme, especially when such intervention is introduced at the early stage. Given this thesis topic, keywords such as "user phase" and "early phase design" need to be studied and explained, such need justifies the approach of literature review. As a complement to literature review, in this thesis, theoretical analysis is used to evaluate different models of early phase influence in building design so as to find out their respective characteristics. Also, to give the readers an idea of how diverse the value proposition for different stakeholders could be, an internet-based survey which collects feedback from different stakeholders in the building sector is documented. Yet, when it comes to more detailed design requirements from the users, interviews are given in one of the case studies. Case study and pilot study are both considered significantly valuable in providing supporting details for developing observations and insights. The difference being a case study must be a project done by the author himself, whilst a pilot study could be an external project documented by someone else.

Some of the major findings of this thesis include:

- Mistaking any strategic or tactical approach for sustainable design with the actual goal of

achieving sustainability would be missing the point. And this problem is prominent in many of today's allegedly sustainable buildings with certified energy level.

- Users' inconsistent attitude towards sustainable building is reflected in the fact that most of them do appreciate having sustainable features in a building - only if this doesn't contradict the comfort of their energy-consuming life style.
- Users can help accomplish a genuinely sustainable building project even under unfavorable condition (socially, economically, etc.) as long as they are motivated by a strategic design of the building which successfully align the building's function with the users' core interests.

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Chapter 1

Introduction

This chapter provides background information, scope, and structure of the thesis. In this chapter, a guiding question will be asked, which gives rise to the discussion of what exactly has gone wrong and thus validate why such topic is chosen for the thesis. Scope, tools used, and structure of the thesis will also be introduced to explain under what context and procedure the research is conducted.

1.1 Aim of Research

1.1.1 It's all about the building, yet it's not just about the building

The noun of "building" is not new to us. According to Merriam-Webster Dictionary ([Merriam-Webster \(2008\)](#)), a building is "a structure (such as a house, hospital, school, etc.) with a roof and walls that is used as a place for people to live, work, do activities, store things, etc." In the definition, the physical features of a building are specified before its intended function. In other words, physical features (such as "a roof" and "walls") are considered the prerequisites as such a building can serve the purpose (function) it is there to serve. The practice of building design at large, focuses on the realization of these physical features, which is based on different design philosophy and technical standards, creating spaces where the above mentioned human behaviors are expected to take place. However, it should be noted, as people often forget, or sometimes intentionally neglect, that meeting the prerequisite will never guarantee an achieved

goal, though failing to do so will absolutely undermine such goal. Designing the building well doesn't necessarily mean designing the building right, for quite often, there are buildings with excellent architectural design but with barely satisfactory user experience. The cause of such divided perception, is insufficient comprehension of the complexity in the interaction among users (also known as occupants) and between users and the building, these are intertwined systems coupled with non-linear cause and effect. Designing the building just to have a building is missing the point of building design per se. It is very important to bear in mind these connections and adopt a holistic view when trying to solve this problem. And any attempt to solve this problem only by looking into the building design itself should not be encouraged at all, and is almost destined to fail, as argued by Albert Einstein: "**Problems cannot be solved with the same mind set that created them.**"

1.1.2 Seeing the whole picture

A good building design, should accommodate the triple bottom line proposed by [Elkington \(1998\)](#), which is social, economy, and environment (see [Figure 1.1](#)). That is to say, the design of a good building, should be socially positive, economically feasible, and environmentally friendly. And such goal can only be achieved when a holistic view and systems thinking mindset is adopted. The following example featuring a true story from Denmark, is a perfect example of what big difference it could mean when problem-solving with a holistic view and adopt the mindset of systems thinking. However, the solution is so good and out-of-the-box, it even changed the nature of the project, and it was, unfortunately, no longer a building design project after the solution was implemented.

A public swimming pool had been serving local residents and enjoying a high popularity among local community members for decades, it was getting old, but given all the years passed, its condition seemed reasonably satisfactory. Recently, the swimming pool had experienced a dramatic drop in revenue caused by the decrease in number of swimmers coming to that pool. Managers of that swimming pool were thinking maybe it's time for a major renovation, they were expecting to spend a lot of money updating the existing facilities of that swimming pool and as a result, an architect was hired to perform the design.

At the beginning, the architect was looking at physical factors which he believed could affect



Figure 1.1: The Triple-Bottomline (Anon (2015))

the use of the swimming pool, such as the infrastructures, where the pool is located, was there any newly-opened swimming pools around that area, and so on, hoping to come up with a design or marketing scheme that could make the swimming pool appear more attractive and highlight its irreplaceable value to the local community. And it wasn't until during traffic analysis when he found the root cause which had been overlooked: the bus schedule had been revised to make getting to the pool incredibly inconvenient. The problem wasn't the building, but the system of transportation that this building was serviced by.

The architect then suggested managers of that swimming pool to request a re-modified bus schedule from local community council, and it worked. Upon the implementation of the new bus schedule, the swimming pool immediately got its popularity back!

1.1.3 Leverage points

As an aftermath of that story, in spite of the admiration for the insightfulness and wisdom demonstrated by the architect, it is also quite crucial to think how differently this swimming pool story could have ended otherwise. The architect could have ended up with a fancy and expensive design which had some intentionally incorporated "sustainable features" and got paid handsomely, which seems more than normal and reasonable, and is after all, sustainable to some extent, but that is just not what a genuinely sustainable building design is about, compared to what he actually did, which was however, not even recognized as a building design project anymore. Such contradiction gives rise to the core question to be asked and inspected in this thesis:

What is considered an effective intervention to influence a building design process, and during which stage should this influence be introduced?

To answer this question, some very important observations concluded from the swimming pool story can be useful:

- Non-architectural factors (for example, the commuting experience to that building, as part of the user experience) can have a huge impact on the building design (in this case of extreme, the design was changed from an expected major renovation to doing nothing due to the re-modified bus schedule).
- Such user experience, for quite self-explanatory reason, can only be gathered during the user phase of the building.
- Because of the nature of a building design process, a building is only occupied and used after its completion, which causes a retardation in the feedback loop of the design process itself. However, such feedback (user phase experience) can also be used to influence the design of the next building in the early phase, or, to influence the renovation of the same building.
- The value of the a building can never be fully realized, namely, the optimal use of a building can never be best aligned with its intended function, if not taking into consideration the user experience in the deepest and broadest sense during the early stage of design.

The importance of having a holistic view and systems thinking mindset can never be over-emphasized.

With the above observations, the answer to the core question can be given as follow:

It is most effective to influence the design of a building at the early stage with experience from the user phase.

Such influence, in other words, can be also described as intervention. When it comes to intervention, choosing of "leverage points" (see Figure 1.2), which designated as places in the system where a small change could lead to a large shift in behavior (Meadows and Wright (2009)) becomes most favorable. And as discussed earlier, it is most effective to influence a building design at the early stage, during which, the users still has more saying in decision-making than the architect (because the architect is responsible for delivering the design which is believed to meet the requirements set by the clients, who might as well be the users). The process, during which the users and the architect communicate their ideas and draw up the strategic goals to be fulfilled by the building, is considered part of the facilities management process (will be discussed in later chapters), which has a very close relation with building design and real estate management.

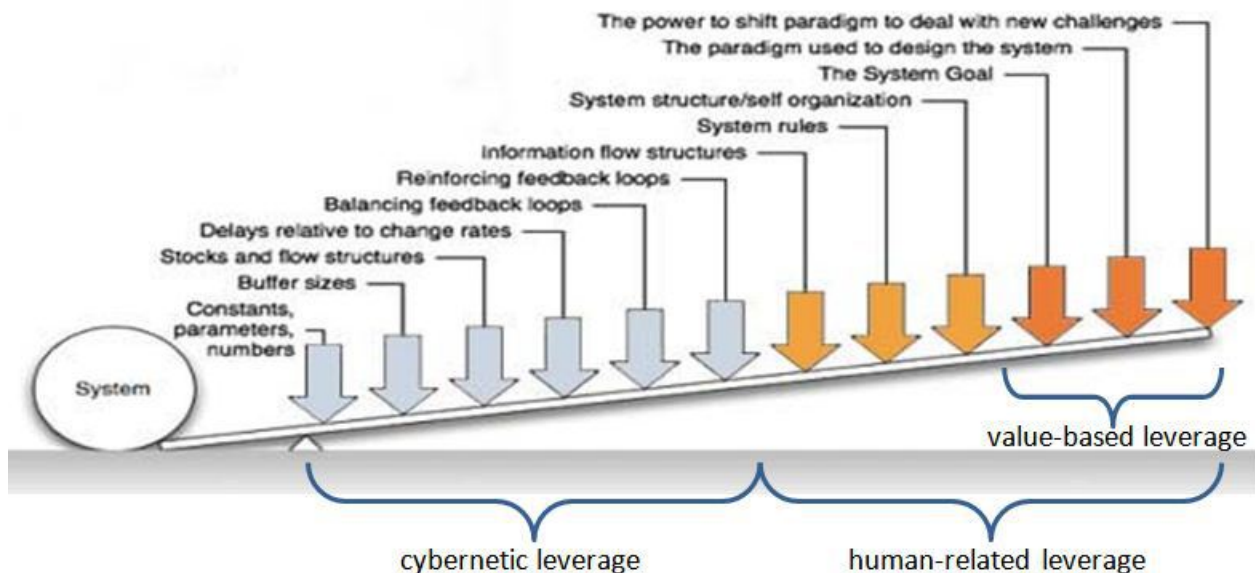


Figure 1.2: Leverage Points (van't Hof (2014))

Up to this point, the purpose for choosing the topic of this thesis is clear: if user phase expe-

rience from facilities management (FM) is considered an effective intervention (leverage point) on influencing the early stage of building design, it would be interesting to investigate, in this thesis, in which ways such influence takes place.

1.2 Scope of Research

As discussed above, the problems existing in nowadays' building industry is the failure to optimize the alignment between the occupants' core business and the building's intended use, and thus creating waste of money and loss of value. Such problems are often caused by the absence of communicated user phase experience, which has a huge and normally positive influence over the early phase of building design. It should be noted, however, in order to gather such information, not only the design team should engage the users more, and learn from the most relevant experience the users have or expect from the building, and perform their design accordingly, but also, within the design team (which usually consists of architects, designers, engineers, real estate developers and so on), they should adopt a new way of interaction and new type of work dynamic - as part of the integrated building design process. Therefore, this thesis not only investigates how design is changed at the early stage because of the influence from user phase experience, but also as equally important, how it is designed - is changed due to such influence. In other words, the user phase experience, which is highly diverse, challenges the design team to deliberate collectively and design with a broader vision that takes into consideration all the needs, as compared to the conventional work dynamic in which the work is passed on linearly from one to another without having much conversation in between. This changed work dynamic, as part of an integrated design process, will further change the building design at the early stage, adding value to the building, which is delivered to the users in terms of an enhanced experience. And this enhanced experience will again enter the next loop of feedback to the design team, thus generating a positive circle (see Figure 1.3), which is also the scope of the thesis, under which the researches were conducted. The key to understanding this circle is to understand what happens among different parts of the circle. To do that, it is necessary to conduct background research on the practices such as facilities management and building design, and analyze different models of influencing building design. It is also important and interesting to

include case studies in the thesis which not only serve as supporting details to the concepts being discussed, but also helps readers better comprehend how such circle works.

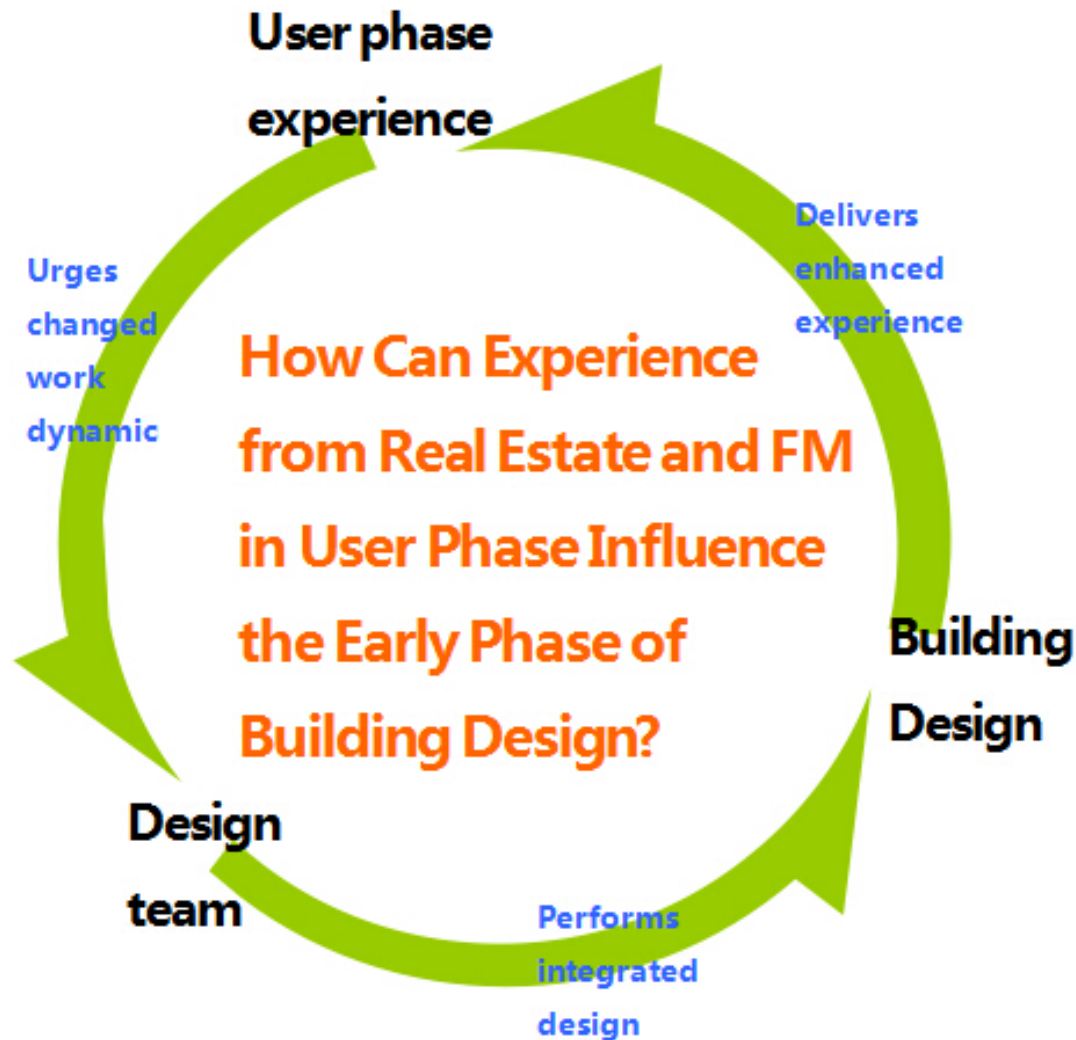


Figure 1.3: Scope of Research

1.3 Methods and Tools Used

As mentioned earlier, the objective of this thesis is to investigate in which ways can user phase experience influence the early phase of building design. To have a well-established theoretical framework which defines the scope for the research, keywords such as "user phase" and "early

phase design" need to be studied and explained, such need justifies the approach of literature review.

As a complement to literature review, in this thesis, theoretical analysis is used to evaluate different models of early phase influence in building design so as to find out their respective limitations.

Also, to give the readers an idea of how diverse the value proposition for different stakeholders could be, an internet-based survey is utilized to collect feedback from different stakeholders involved in a building project. Yet, when it comes to more detailed design requirements given by the users, interviews are given in one of the case studies.

Case study and pilot study are both considered significantly valuable in providing supporting details for developing observations and insights. The difference being a case study must be a project done by the author himself, whilst a pilot study could be an external project documented by someone else.

All methods and tools used are listed in the table below, see Table 1.1

Methods/tools	Used in
literature review, pilot study	Chapter 2: Background Research
theoretical analysis, survey	Chapter 3: Analysis and Evaluation
interview, case study	Chapter 4: Case Study

Table 1.1: Methods/tools used

1.4 Structure of the Thesis

Apart from the front pages and appendices, the thesis consists of 5 major chapters, each having several sections. Such structure is designed to guide readers through the "user journey" of this thesis, whose objective is to investigate in which ways does user phase experience from real estate and facilities management influence the early phase of building design.

To start with, in the introduction chapter, readers are presented with the guiding question that justifies the objective of the research, followed by the introduction of scope, methods and tools used.

Based on that introduction, readers are filled in with more background information, which is discussed in Chapter 2. This chapter provides an investigation into all the keywords and their relation with the thesis topic.

Having known all the basics and backgrounds of the research, readers are then led deep into the analysis part of the thesis in Chapter 3, which discusses the root cause for the problems facing building design nowadays, what kinds of available solutions are there and their respective characteristics. Such discussion is complemented by an internet-based survey conducted with real stakeholders from building industry.

Any research will fall short in reliability if not supported by case studies, that is why in the 4th chapter, 3 case studies are documented with regards to both how the work dynamic looks like in an integrated design team, and how the design team and stakeholders interact in an integrated building design process.

Finally, as a conclusion for the thesis, Chapter 5 gives an overview of the thesis, recaps all the points made and theorems arose in the preceding chapters, and summarizes the research with the updated concepts and solutions proposed by the author himself.

The following figure (see Figure 1.4) demonstrates what the structure (also described as the "reader journey") of the thesis looks like.

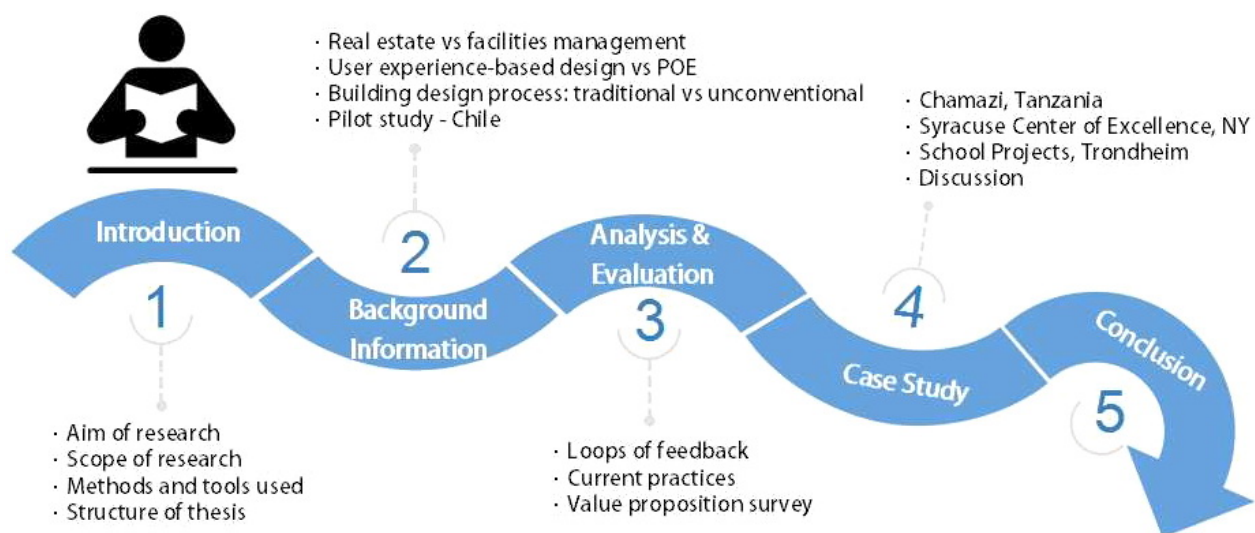


Figure 1.4: Structure of the Thesis/Reader Journey

Chapter 2

Background Research

In this chapter, the topic of the thesis will be deconstructed into several keywords. These keywords will then be discussed in depth and compared with other keywords to help readers better comprehend these meanings as well as the value of the research. A pilot study featuring a real case from Chile will be also included in the last section of this chapter.

2.1 Real Estate vs. Facilities Management

2.1.1 Real estate by definition and its role in a sustainable society

According to the Oxford English Dictionary, the term "real estate" has two layers of meaning ([OxfordUniversityPress \(2008\)](#)):

- Property consisting of land and the buildings on it, along with its natural resources such as crops, minerals, or water; immovable property of this nature (originally contrasted with personal estate n. at estate n. 11a); an interest vested in this; (also) an item of real property; (more generally) buildings or housing in general.
- The business of real estate; the profession of buying, selling, or renting land, buildings, or housing.

Although Real Estate and its related studies have only been recognized as a scientific subject during the past decades, real estate as a concept and a practice has come into existence and evo-

lution long before that. Here is a listing of major historical events related to real estate through time (Tyson (2012))

- 334 BC – Alexander the Great’s defeat of the Persians shows aggressive acquisition of real estate by force
- 1066 – William the Conqueror decrees that he owns all of the land in England after his defeat of the Normans
- 1689 – John Locke writes the Two Treatises on Civil Government, which outlines a man’s right to preserve “life, liberty, and estate.”
- 1783 – Napoleon begins seizing real estate in the form of countries
- 1803 – The U.S. acquires some swampy new land in the Louisiana Purchase
- 1867 – U.S. gains a bit of icy tundra from Russia in the Alaska Purchase
- 1916 – National Association of Real Estate Agents coins the term Realtor
- 1929 – The largest stock market crash sparks the Great Depression and the collapse of the real estate market
- 1934 – National Housing Act creates the FHA (Federal Housing Association)
- 1938 – The Federal National Mortgage Association – now Fannie Mae – is chartered by the federal government
- Late 1940s – Adoption of fixed-rate mortgage as industry standard
- Early 1960s – The National Association of Real Estate Boards creates national MLS system based on unilateral offer of cooperation
- 1970 – Congress charters Freddie Mac and the secondary loan market
- 1980s – Interest rates zoom upward and halt construction of new homes in the US
- 1994 – Property listings begin to become publicly available on the Internet

- 1999 – ZipRealty introduces Internet lead generation to Real Estate
- 2004 – Popular real estate blog, Curbed, is founded in New York City
- 2005 – Google announces Google Base, Google Earth, and Google Maps
- 2007 to 2010 – The “Housing Bubble” bursts, causing the financial crisis in the U.S.
- 2010 to Present – Foreclosures and Short Sales become the dominant listing type in the market

Apart from its long history, the real estate and construction (REC) industry also has a big impact on the world’s environment and climate. According to a report by the United Nations Environment Program (UNEP) in 2009 ([Lemmet et al. \(2009\)](#)), the role of buildings in climate change is often underestimated and the knowledge regarding the building sector’s extensive energy use is lagging behind. In the United States alone, studies ([McLaren \(2009\)](#)) indicate that buildings account for:

- 72% of electricity consumption
- 39% of energy use
- 38% of all carbon dioxide (CO₂) emissions
- 40% of raw materials use
- 30% of waste output (136 million tons annually)
- 14% of potable water consumption

According to another report by United Nations Population Fund (UNFPA), due to increased average life expectancy and decreased child mortality, the world’s population will continue to grow-at an even faster rate, even though compared to a much longer timeline of human history, the rapid growth of the world population is a recent phenomenon, and with the declines in fertility in most of the world, the global growth rate of population has been decreasing since its peak of 2.0 per cent in 1965-1970 ([Kollodge et al. \(2011\)](#)). Which means, with a growing population (see [Figure 2.1](#)) and the overall improvement of their living standard as well as their higher

demand of well-being, there will be more and more housing for residential, commercial, industrial use and so on, there's no doubt that the construction industry will experience a sustained rapid growth in the foreseeable future.

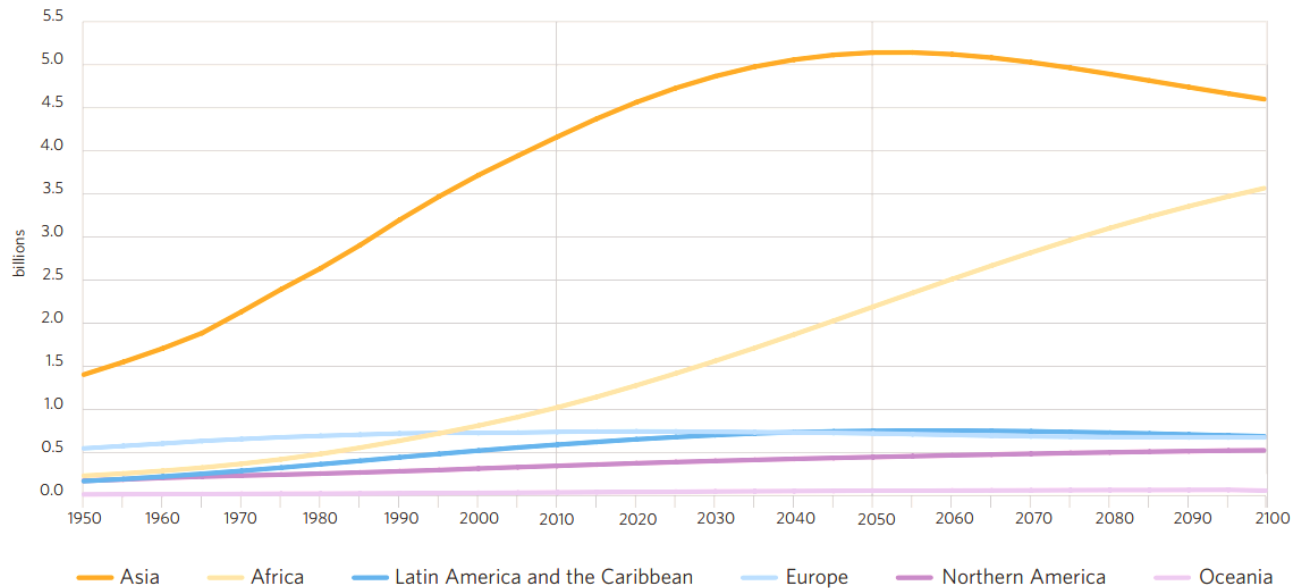


Figure 2.1: Estimated and Projected Population by Major Area, Medium Variant, 1950-2100 (Billions) (Kollodge et al. (2011))

Also according to the UNEP 2009 Report (Lemmet et al. (2009)), though the world's demand for energy resources has been growing massively, or even exponentially in some developing countries like China and India, the proportion taken up by fossil fuels such as oil and coal has hardly changed, nor is it likely to change in the near future. With more fossil fuels consumed, more green house gas (GHG) will be emitted into the earth's atmosphere, causing more severe global warming and some other climate disasters to occur on a more frequent basis. Such climate disaster will in return further deteriorate the earth's fragile environment, making people more dependent on anthropogenic acclimatization system which burdens the energy supply. Typically, when looking at a built environment which consumes about 35%-40% of the total energy produced today and the majority of energy consumption within built environment lies in the HVAC (heating, ventilation and air-conditioning) category, letting alone that this analysis usually excludes the energy consumption within the other phases of the life cycle of a building (according to the UNEP 2009 Report by Lemmet et al. (2009), there are five phases in a building's life cycle: (i) the manufacturing of building products and components; (ii) the transportation

of building products and components to the construction site; (iii) the construction itself; (iv) the operational phase; and (v) the final demotion and recycling). This supply-demand relation between buildings and energy forms a vicious circle over the environment.

With the above observation, it is evident that as the world's population keeps growing, more buildings will be built, thus more energy will be consumed for the buildings, yet the proportion of energy source of the world as well as the structure of energy consumption within built environment stays relatively stable, which indicates that the study of the built environment is not yet profound enough to reverse the current trend in its continued increase of energy consumption. These three aspects are intertwined, and has a very high level of complexity, calling for vast innovation in technology, massive investment, and most important of all, the awareness and participation of so many stakeholders, and apparently, though much endeavor has been made to turn the tide, the human race is still not ready for this challenge, and the current situation will not be changed in the foreseeable future.

Up to this point, it is safe to say that economic development and improvement of people's livelihood is an irreversible process - even at the cost of ecological crisis and climate disasters (which are all hard-learned lessons). However, such crisis can also be redirected into working for a better cause without causing further damage to our planet, as big crisis always comes with huge opportunities. Real estate, in its essence, is after all, a business. And based on the above listed facts and analysis, the role of real estate in a sustainable society, or in other words, the meaning of real estate to a sustainable society can be concluded as:

Built environment and especially the real estate and construction (REC) industry, is assessed to have the largest potential for profitable environmental burden reduction (McKinsey&Company (2009)).

2.1.2 What is FM, and what does it do?

According to the latest definition from International Facility Management Association (IFMA), **facility management (or facilities management or FM) is a profession that encompasses multiple disciplines to ensure functionality of the built environment by integrating people, place, process and technology (IFMA (2014)).**

In real practice, FM facilitates on a wider range of activities than just business services which

are referred to as non-core functions, and many of these non-core functions vary from one business sector to another. In 2009, a global job task analysis (GJTA) defined 11 core competencies of FM (GJTA (2009)). The GJTA included responses from facility managers in 62 countries. It is the most comprehensive to date and the first truly global survey and analysis. The core competencies are:

- Communication
- Emergency Preparedness and Business Continuity
- Environmental Stewardship and Sustainability
- Finance and Business
- Human Factors
- Leadership and Strategy
- Operations and Maintenance
- Project Management
- Quality
- Real Estate and Property Management
- Technology

FM is subject to continuous innovation and development, under pressure to reduce costs and to add value to the core business of the client organisation be they public or private sector where possible (Mudrak et al. (2004)). Hence, to sum up in a broader sense, the major purposes of FM can be distinguished in two aspects: to support and sustain the operations work and activities of organisations and their staff, and to manage work environment and support services (Chotipanich (2004)).

Because of the wide spectrum of responsibilities FM covers, many of its services can sometimes overlap each other. To achieve a more efficient FM, it is crucial to clearly identify different clusters of supporting services while amalgamating the overlapping practices to outline a more generic scope of FM services (as shown in Figure 2.2).

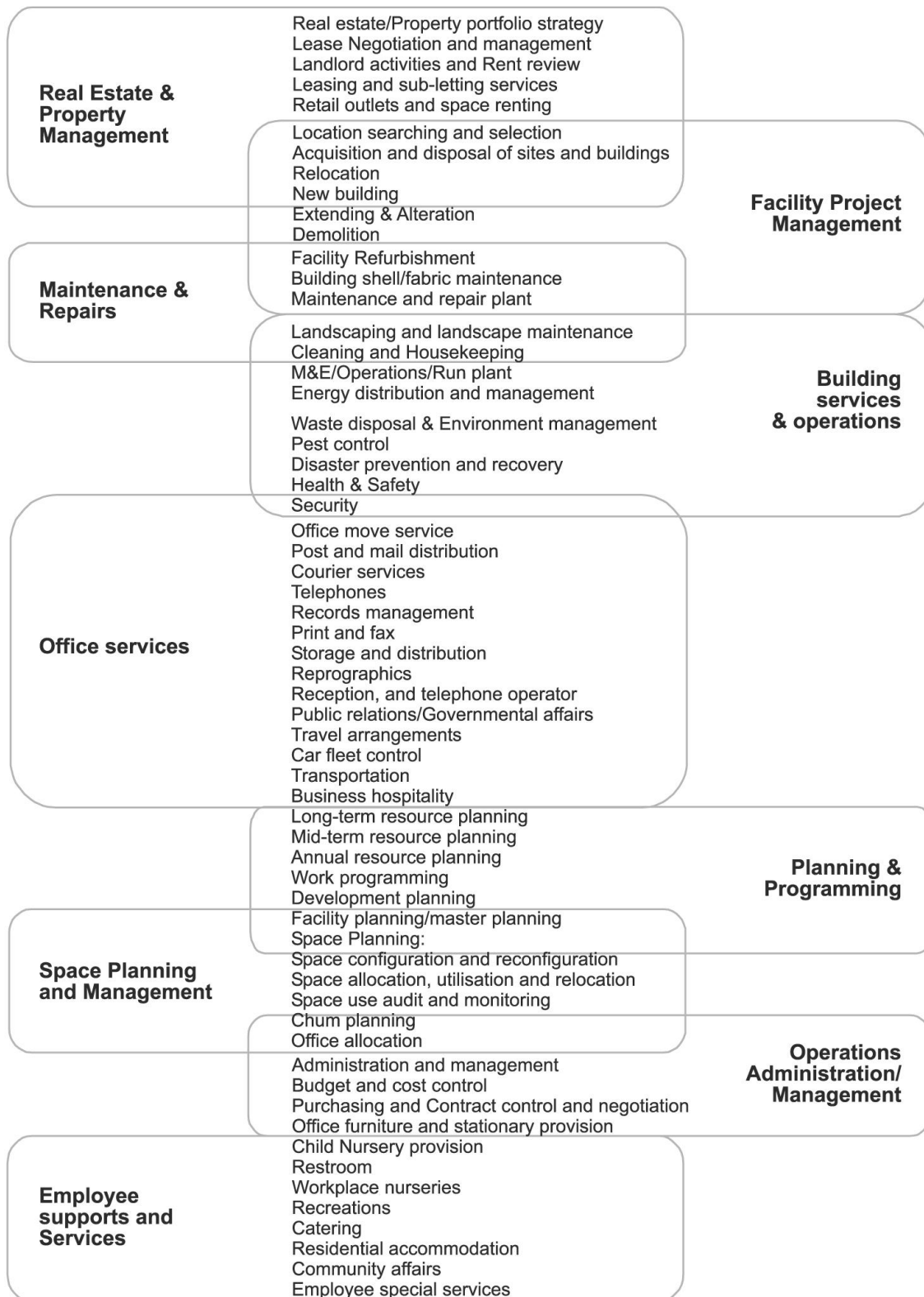


Figure 2.2: Cluster of Support Services(Chotipanich (2004))

2.1.3 FM in transition

Due to its multi-layered objective (FM is resource relocation at strategic level and management support at operational level) and the broad spectrum of responsibilities it covers as discussed earlier, FM is bound to be subject to drastic, or even radical transformation in an era of vast diversification and rapid changes. And it is never a recent event since the attempt to predict such change, or in other words, describe the future of FM, has been made by many researchers world-wide.

Based on the current practice of FM and the challenges imposed by external factors such as informatization, more flexible working hours and so on, [Nutt \(2000\)](#) proposed four basic possible trails for FM's future, which he refers to as the "four competing futures", which are:

- Financial resource trail (business): also known as the "pioneering trail", which has undergone fundamental change in the past two decades due to the introduction of Private Finance Initiative (PFI). Such trail features the prioritization of operational FM phase, replacing life-cycle costing approach with "effective-life" framework for facility finance, as well as promoting "use value" rather than "asset value".
- Human resource trail (people): as trail seen as the most radical route to the future of FM, annotated by the emerging trend of "flexible working", which challenges to alter the support facilities that used to be required fundamentally. The HR trail of FM has an emphasis on people, facilities and support services being the key business resource to be dynamically deployed for long-term advantage rather than short-term gain.
- Physical resource trail (property): the most predictable trail, for facilities all have, after all, a physical property. Future changes in this trail will be propelled by innovations within facility support and design in terms of management measures and spatial modification.
- Knowledge resource trail (information): known as the "primitive trail", which is believed to be mostly unexplored, or rephrased in today's context as "extremely low utilization of tremendously abundant big data". FM's future development in such trail is believed to address the following core questions, which are also the objective of this master's thesis:

- What management considerations should inform the design process? Yet what should be avoided?

- How will any given facility design affect its management when in use? What opportunities/limitations will it bring about?

For the above mentioned four trails, [Nutt \(2000\)](#) further argued that they will all undergo radical change in the coming decades, with parts of the four trails merge or diverge, splinter or spawn new pathways. To better describe each trail's status quo, [Nutt \(2000\)](#) also developed a matrix with nine strategic positions (see [Figure 2.3](#)) to place all the four trails, in which:

- Financial resource trail is starts from the "neutral" position.
- Human resource trail sets out from the "brave" position.
- Physical resource trail will work its way through from the "neutral" position.
- Knowledge resource trail, at its best case scenario, has a neutral effect on operational risks and opportunities, while at its worst pushing some corporate clients into the lower left area of the matrix.

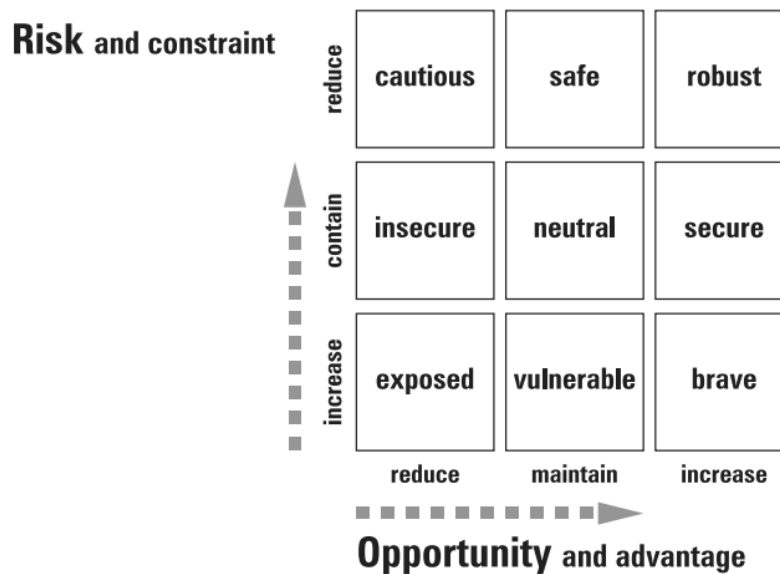


Figure 2.3: Nine Strategic Positions ([Nutt \(2000\)](#))

To sum up, FM, unlike real estate which sees the building mainly as commodity of financial interests, views the building as a key factor for improved production, in spite of having its well-defined core competencies, is subject to a high yet still increasing level of uncertainty as it is constantly being shaped and formed by the external factors affecting all the sectors it involves (such as corporate strategy design, building design). It covers a wide range of responsibilities related to the design and operation of buildings and has thus become an integral part of the core practices within built environment. It will gain higher importance and priority in affecting the decision-making in both the design and operation of buildings as more and more studies reveal the sustainable benefit of its practice.

2.2 Evidence-Based Design vs. POE

2.2.1 Experience-based design: referenceable example and transferable experience

Just like many of today's civil technologies such as cellphone, microwave all stem from their original military use, although these two fields are not closely related, the sector of real estate and construction or FM can also be influenced or gain great inspiration from external sectors such as business, media, social science and son on. Evidence-based design, also known as experience-based design (EBD), or experience-based co-design (EBCD) is a relatively new field of study emphasizing credible evidence to influence design. This approach has become popular in healthcare to improve patient and staff well-being, patient healing, stress reduction and safety. Evidence-based design borrows terminology and ideas from disciplines such as environmental psychology, architecture, neuroscience and behavioral economics. Although evidence-based design approach is first utilized in the healthcare sector, it has gained a lot of valuable insights and knowledge in providing patients with enhanced in-patient experience and designing a more patient-friendly hospital environment, as well as better aligning healthcare facilities with their intended function of serving the patients while eliminating unnecessary waste, which are all good reference and transferable experience for the real estate/FM sector.

Similar to the challenge facing many of today's buildings in terms of the adaptability in serv-

ing a changing use over time, the healthcare sector, as argued by Nedin (2011), has a an urgent need in the optimization of modern healthcare premises for tomorrow's medical demand, and evidence-based design plays a crucial role in accommodating such need. Based on the analysis of historical practice (such as the Renkioi Hospital designed by Brunel in the 1850s, see Figure 2.4), as well as the projected trend in increasing financial burden and technological innovation, Nedin proposed a sustainable framework which he believed should be followed when designing future hospitals. In this framework, Nedin started by re-stating all the principles that define a genuinely sustainable healthcare system, which include but not limited to equal accessibility, administrative independence, shared responsibility, good provision, and transparency. These principles are seen by the author as the prerequisite for the design of any healthcare facility, and should thus be thoroughly investigated and deeply influenced by designers.

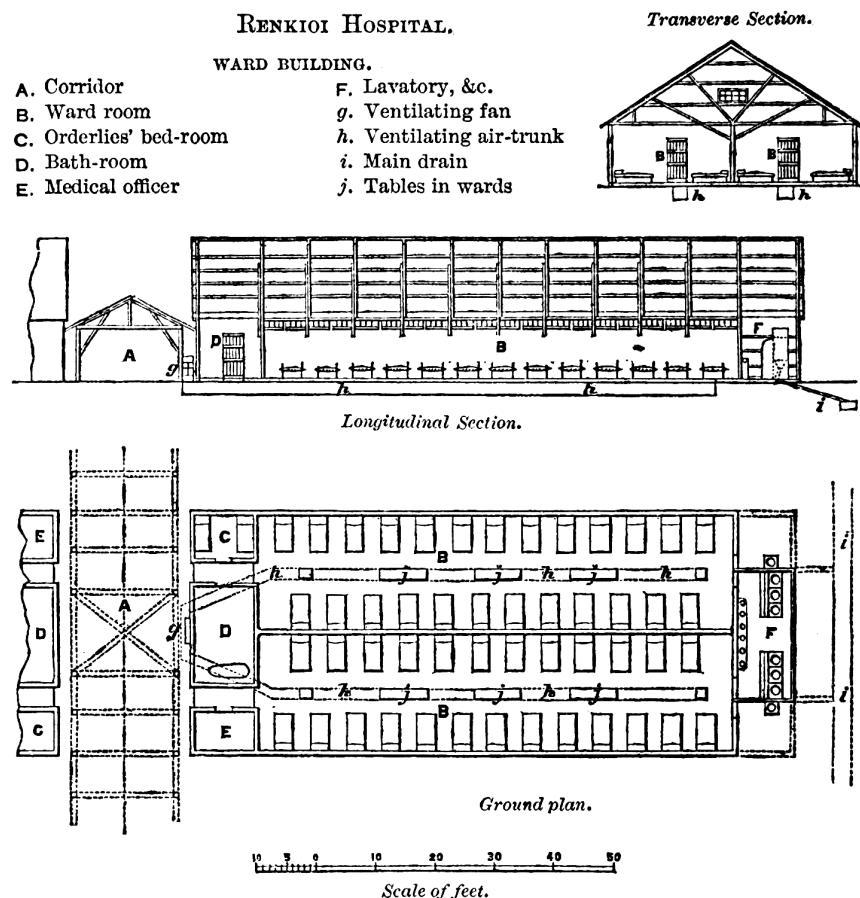


Figure 2.4: Brunel's c. 1855 design for a prefabricated field hospital in Renkioi, Turkey: with only a single nurse on duty, 24 beds in a single room with a hospital 'street' in the middle was then considered an optimum ward layout (TheArupJournal (1981))

One of the fundamental misunderstandings for many designers, as pointed out by Nedin, is to think of future flexibility of a hospital simply as the possibility to increase bed numbers, while in reality this number has been decreasing due to decreased average length of stay (ALOS) as a result of technological progress. Such example serves as a basis for Nedin to develop other discussions between a sustainable rationale and current practice, which are (also see Figure 2.5):

- Whole life cost vs first cost

To achieve a holistic view, two financial discomfort should be addressed:

1. Best value as opposed to cheapest first cost.
2. Those in need are not receiving the most benefit from the current system

- Future vs current needs

Though many still regard flexibility as the possibility to add more beds in the future, practical statistics indicate otherwise, i.e. the bed number in the acute environment will need to be reduced in the future, not increased.

- Low carbon vs high carbon

Breaking down of carbon emission will help a design to decide which is the best direction to go for low carbon solutions. Although it is not practical for all climates to use natural ventilation all the year around, since the energy price is very likely to continue growing, it is always good to keep in mind a mixed-mode technical solutions at the design stage, for every little bit counts.

- Innovation vs prescription

Bad problem solving will likely to trigger a more vicious chain reaction in terms of indoor thermal comfort, energy consumption and carbon emission.

- Therapeutic environment vs clinical efficiency

Departmental adjacency does not necessarily equal to clinical efficiency, and insisting on this mantra will inevitably cause designers to practice deep-plan building solutions, which will in return worsen the case on energy consumption. A successful hospital premise should create an environment which is patient-friendly, while encourage staff morale at the same time. The author believes that single room occupancy is a future trend which

allows a patient to be treated with privacy, dignity, and lower risk for hospital acquired infection (HAI). Although therapeutic environment is beneficial both for patients and staff morale, its importance cannot be identified on a quantitative basis due to the uniqueness of individual patients, and hence its financial justification is hard to be validated.

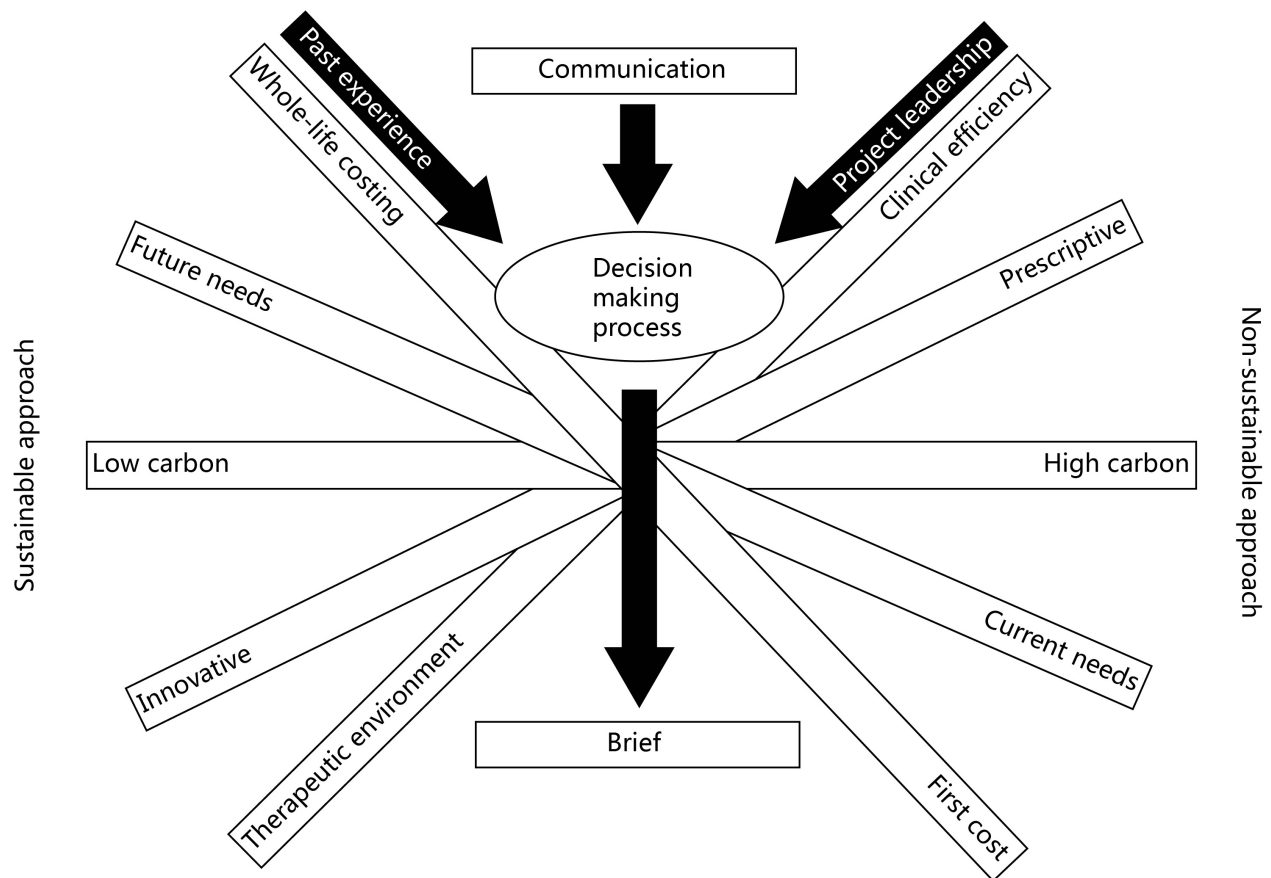


Figure 2.5: A framework for the provision of a sustainable healthcare estate (Nedin (2011))

2.2.2 POE in a nutshell/bigger picture

Originated in the USA, post-occupancy evaluation (POE) bears a lot of resemblance to its British counterpart of EBD, and is also recommended by the British Council for Offices (BCO) as part of the EBD process, where the project usually refers to a building design fit-out or refurbishment, or to inform the project brief where the project is the introduction of a new initiative, system or process (Oseland (2007)). POE is also summarized by BCO as a tool that provides feedback of

how successful the workplace is in supporting the occupying organisation and individual end-user requirements, or in other words, whether a project brief has been met - although its original definition is rather simple and straight forward:

POE is the process of evaluating buildings in a systematic and rigorous manner after they have been built and occupied for some time (Preiser et al. (1988)).

Notably, The term “post-occupancy evaluation” is a misnomer, according to some experts, in the sense that critical evaluation and review should not only occur in a facility once constructed and occupied, but it should occur throughout the entire building delivery cycle (Preiser (1995)). Such concern also gave rise to a more general building evaluation tool known as Building Performance Evaluation (BPE), whose core concepts are predominantly inherited from POE, and to which, POE has become an integral part of.

According to Preiser and Vischer (2006), as a more general tool of assessing building performance, BPE systematically relates buildings and settings to users and their environmental needs. It represents a conceptual, process-oriented approach that accommodates relational concepts and can be applied to any type of building or environment. BPE is the process of systematically comparing the actual performance of buildings, places and systems to explicitly documented criteria for their expected performance. The performance assessment contains the following 6 phases which goes through the entirely life cycle of a building:

- Strategic planning - effectiveness review

The effectiveness review happens at a stage when a project has not yet taken any solid shape or form. With the help of market analysis and study of needs, options were proposed as the corporation's strategy. Followed by interviews to departmental managers, business needs were learned and recorded. After that, series of group interviews were organized where user groups provide their basic requirements, upon which performance criteria are deduced, and grouped into different categories. Finally, only a few possible options are selected, which are believed to be most viable.

- Programming/briefing - programme review

During this stage, instructions for the design and construction/refurbishment of a new/existing building are developed. In some cases (there are no unified terminology for pro-

gramming/briefing), such instructions are called strategic brief. Within the framework of BPE, briefing is positioned after planning and before design, while in reality, some briefing happens as early as in the planning stage. Also, much of the detailed briefing can occur during the design stage. The purpose of briefing is to reflect the values and aspirations of the occupying organization and help communicate them to users and the public as a whole.

- Design - design review

The core activity of design review is Participatory Design (PD), an approach of design attempting to actively involve all stakeholders (e.g. employees, partners, customers, citizens, end users) in the design process to help ensure the result meets their needs and is usable. However, [Preiser and Vischer \(2006\)](#) also argues that it is important not to forget the immeasurably valuable and very personal contribution of those carrying out the creative act of design.

- Construction - commissioning

The term “commissioning”, is officially known as the practice to provide documented confirmation that building systems function in compliance with criteria set forth in the project documents to satisfy the owner’s operational needs. There is a fine line between construction administration and commissioning. The former mainly refers to the fulfilling of technical and legal requirements, while the latter means to make sure the delivery also live up to the users expectations. In other words, construction administration makes users feel assured, commissioning makes users feel happy.

- Occupancy - post-occupancy evaluation

The deterioration of corporate synergy usually happens when decision makers underestimate the important role played by the building performance assessment during the occupancy phase, which is an equally important part of building delivery and the building’s life cycle. In other words, POE (post-occupancy evaluation) addresses the question of how a building perform as a whole during actual operation, and is responsible of providing both feed-back for improving current situation within the building as well as feed-forward for future reference by other (possibly new) buildings. Notably, for future reference, POE (as

a sub process of BPE) also consists of 6 phases which are quite similar to that of BPE's.

- Adaptive reuse/recycling - market needs assessment

Many corporate managers fail to see the correlation between the evolution of their core business and the supporting building infrastructure (or real estate) that houses these resources. Yet many successful examples (such as the HQ of Twitter and Airbnb) demonstrate the importance of having such adaptability in quite possibly the corporate's second most important asset (this is, unfortunately, often ignored by many), through measuring performance in terms of the relationship between operational facilities and business outcomes. To do that, Key Performance Indicators (KPIs) need to be selected and justified using a rational framework shown below (see Figure 2.6).

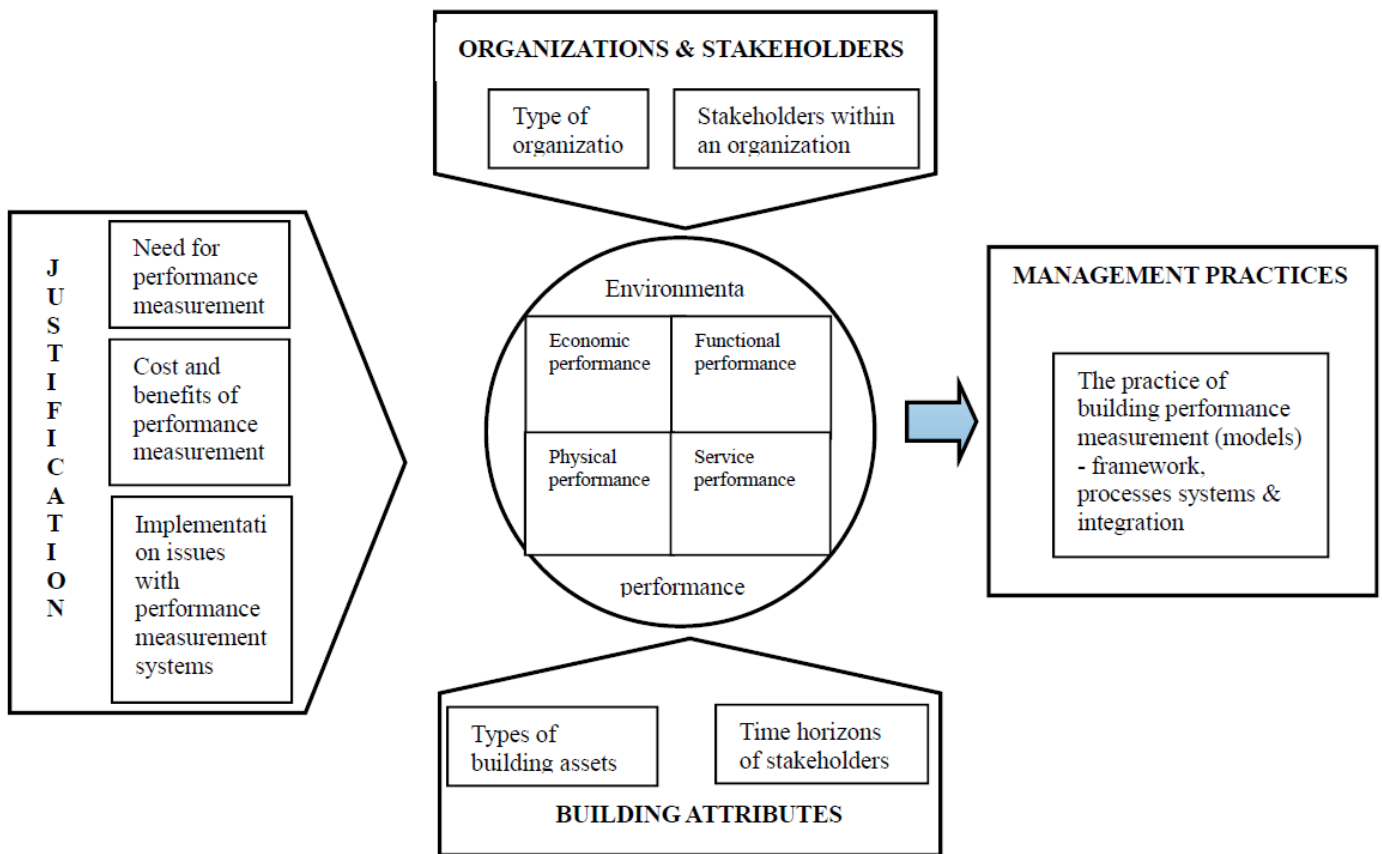


Figure 2.6: Conceptual framework for building performance measurement (Eccles (1990))

To conclude the concepts introduced in this section, the idea of BPE is introduced to the building sector as a relatively new type of assessment tool. According to Preiser and Vischer

(2006), BPE is an innovative approach to the planning, design, construction and occupancy of buildings. The intention of BPE is to construct a set of standardized KPIs to assess a building's entire life cycle, especially during its operational phase, and yield suggestions on how to best adopt the building's physical function to the core businesses of its occupants (note that the occupants and their respective core businesses are most likely subject to change during the entire life cycle of a building) so that maximum benefit can be achieved at a minimum cost, and therefore, indirectly minimize the environmental impact of the building.

The BPE tool, which is predominantly based on POE, takes a more holistic view with less doctrine of sustainability, and addresses the core value of different stakeholders as well as that of the occupying organization as a whole. It bridges the gap between building professionals and facility managers and encourages them to take a more systematic approach to designing and monitoring building performance, aiming to keep down costs, reduce every usage and making the best of building systems.

2.3 Building Design Process: Traditional vs. Unconventional

2.3.1 Building design: how it is done traditionally

The traditional process of building design, or what is still largely considered as a standard practice today, is a fairly linear one. During the process, responsibility is defined and assigned to different divisions in charge, and the design work is passed on from one division to another as the design progresses - without having too much dialogue in between. That being said, such process does allow radical changes to be made at any stage, the only problem being how the change can backfire on the team dynamic, and thus have a negative impact on the time management and budgeting. To better understand this process and what disadvantages it has, it is important to first have a clear view over what players are involved:

- Architect: Responsible for overall site planning and interior spaces.
- Landscape architect: Responsible for selecting the proper vegetation to create shading, the design of ground water irrigation, as well as green roof upon request by clients.

- Civil engineer: Responsible for site design (such as footing and retaining wall), structural design (such as concrete/timber/steel framework), and rainwater management
- Mechanical/electrical/plumbing (MEP) engineer: Responsible for designing the heating, cooling, ventilation, mechanical, electrical, and plumbing systems of the building.
- Contractor: Normally referred to as general contractor (GC), is responsible for realizing the blueprint, i.e. the construction, including site work.
- Facility manager: Sometimes also known as the building engineer, is responsible for the maintenance of the building and its site during operation.
- Commissioning authority: Responsible for the commissioning throughout the entire process, including reviewing drawing during design, and monitoring during construction.
- Owner: Defines the triple bottom line goal (as discussed in Chapter 1), and selects the project team. Does not have to be an end user.
- Occupant: Also known as the end user, the inhabitant of the building, who should be therefore, at the center of any design decision made towards a better comfortability and productivity.

A traditional building design/construction process, which also known as the "design-bid-build" process, covers the following stages and phases in a chronicle manner (see also Figure 2.7 for a visualization of each phase and the stakeholders involved):

- **Design Stage**

Preliminary phase: The owner hires a civil/environmental engineering team after obtaining a piece of property. The team makes environmental reports as a guidance for how the building should fit on the site.

Programming phase: The architect works with the owner to detail the program requirements.

Schematic design phase: The architect designs the building.

Design development phase: The architect works with an engineering team mainly consisting structural engineer and MEP engineer to fulfill the design made by the architect. Each professional will produce a set of construction documents (CDs), which are used for permit review by local municipality, while the CDs are also used for bidding a GC. The contractor is then given a short period of time to evaluate the drawings and get familiar with the project. During that time, requests for information (RFIs) can be filed to obtain more information about the project. Normally, contractor offering the lowest bid will be selected.

- **Construction Stage**

Construction phase: Upon receiving the construction permit from local municipality, and agreeing on construction cost, the construction commences. Traditionally, this phase has very little design team involvement.

Substantial completion phase: Final inspection by the owner, during which time a "punch list" is issued.

Final completion phase

Certification of occupancy phase: after receiving the certificate of occupancy, the building is ready to be occupied.

Although the "design-bid-build" process has been practiced for decades, it's disadvantages are quite prominent. For example, during the design development phase, the architect has already designed the building, and the work is handed off to the engineers, who basically work independently of each other, and their responsibilities are segmented just as the communication fragmented. And during the design development phase, when contractor is being selected, although RFIs can be filed to help the contractor know more about the project, the given time is too short for the contractor to have a comprehensive understanding of the project, yet, as long as the contractor provides the lowest bid, he will usually get the bid regardless. So when the lowest bidder wins the job, where are they cutting corners? Is quality being compromised? Was a critical element omitted? No one likes to lose money, as that is just bad business, but is this really the best way to select a contractor? (Cottrell (2014))

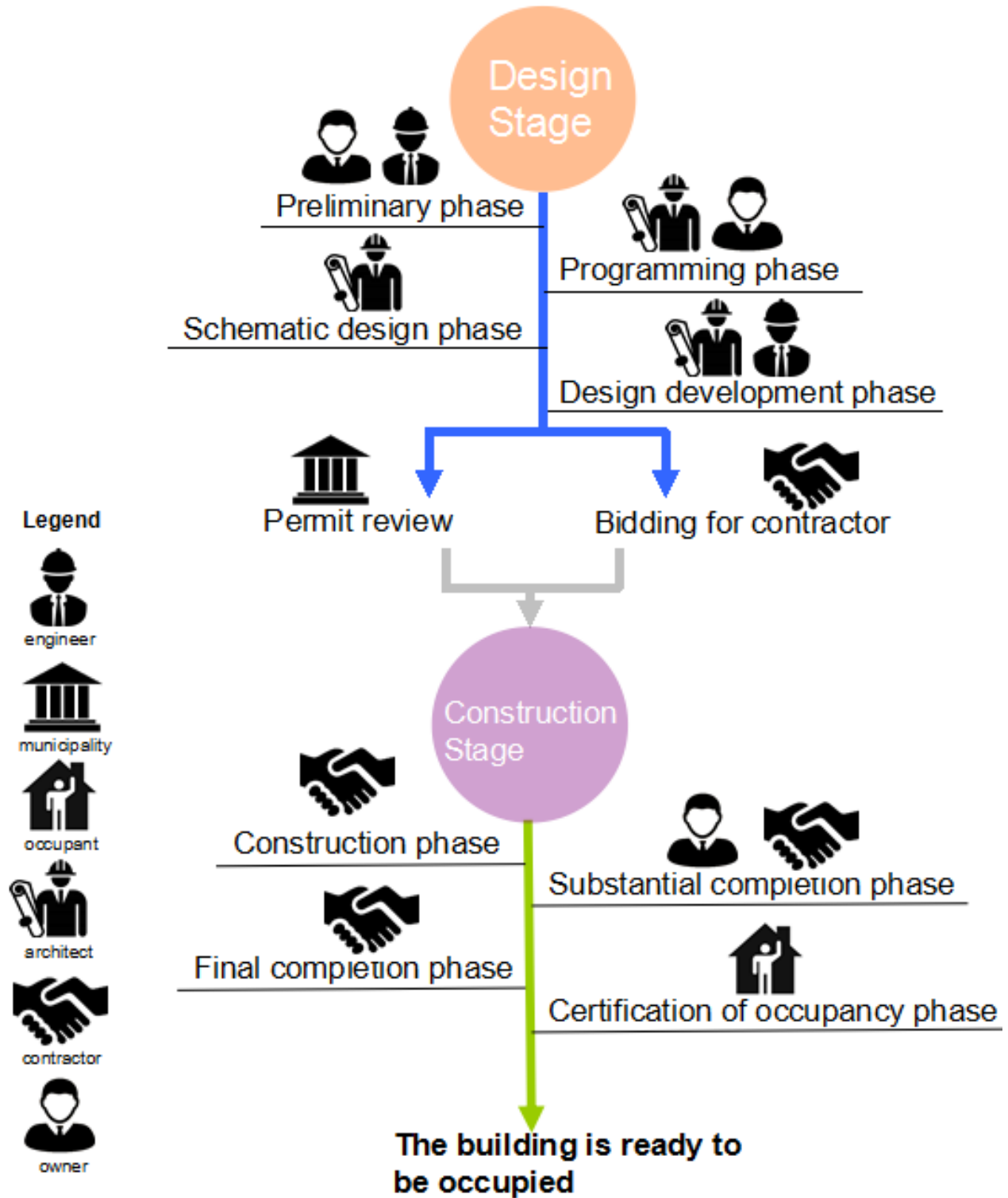


Figure 2.7: Stages and phases within a typical "design-bid-build" process and their respective stakeholders

2.3.2 The integrative process to design and construction

Unlike the traditional design-bid-build process, the integrative process to design and construct a building encourages a project team to balance the triple bottom line concepts so as to deliver a sustainable solution. When compared to the traditional project delivery method, the integrative process for sustainable design projects requires a different approach, a different mindset, perhaps requiring new skills for critical thinking, teamwork, and communication to “enhance the efficiency and effectiveness of every system.” (USGBC (2014))

A typical integrative process normally consists of three stages:

- Discovery Stage

Although traditionally, the owner would only hire an environmental engineer to help select the site, the integrative process encourages the entire design team to participate the site selection to ensure a proper site selection. Also, to guarantee a sustainable delivery in design and construction, the following principles are adopted:

Adopt the right process: a right process promises a successful outcome.

Get in the process as early as possible: so that the most cost-effective approach is ensured.

Follow through the entire project life: supervise the implementation of strategies while collect meaningful feedback to feed forward for future reference.

Look beyond first cost to long-term savings: it is crucial to understand the necessity of up-front investments in systems efficiency to gain saving over time.

Engage everyone: bring together all the professionals to collaboratively plan and execute the project from a holistic angle.

One of the major features that distinguishes an integrative process from the traditional process is its non-linear approach. In an integrative design, ideas are continually being developed by the entire team, researched and refined by smaller groups, and then brought back to the team to consider critical next steps and make final decisions. Such iterative process, also known as *charrette* (see Figure 2.8), allows for numerous feedback loops to establish goals and assess design, construction, and operational strategies against those

goals. Note that in a traditional design-bid-build process, the owner engages different design teams linearly and doesn't have the chance to have all the professionals work together, and always seeks for lowest bid at the risk of building quality. Whereas in an integrative project delivery (IPD) process, the project team is brought together to produce a closed loop of continuous iteration, and looks for the best low bid ([Cottrell \(2014\)](#)).



Figure 2.8: The word charrette is French for "cart" or "chariot". In Paris in the 19th century, it was not unusual for student architects to continue working furiously in teams at the end of the allotted term, up until a deadline, when a charrette would be wheeled among the students to pick up their scale models and other work for review while they, each working furiously to apply the finishing touches ([Bonda and Sosnowchik \(2006\)](#)). Today, the word may refer to an intense period of design or planning activity, in which a group of different professionals drafts a solution to a design problem. Conducting charrettes helps to facilitate critical thinking and collaborations between disciplines to find synergies between a building and its site. Photo source: [UniversityOfSouthernMississippi \(2008\)](#).

- Design and Construction Stage

As the project moves forward and enters the design and construction stage, the following tasks are addressed:

Goal setting: It is critical for a project team to set clear goals defined by metrics.

Site observation: This step allows a project team to have a thorough understanding of characteristics of the site and its existing facilities. These site findings will also be iterated back to the integrative process and complement the project.

Exploration and selection of technologies and strategies: The concept of the integrative process is, in its essence, to spend more time up front to identify synergies, and ultimately save time and money in both short and long term while optimizing resources. Such concept sets up a goal for the design team to find out the technologies and solutions which not only perform best in a model, but also perform best over the life of the project (USGBC (2014)).

Implementation: Construction occurs during the implementation phase of the project. All implementation activities should be well documented so as to track performance as well as providing information for third-party verification, and feed forward to the next project of a similar kind.

- Occupancy, Operations, and Performance Feedback Stage

A genuinely sustainable project is an ongoing process - even after the construction crew has left, for the collection of feedback is critical to not only the determination of success of project goals, but also the information gathering and trouble-shooting during building operations.

To sum up, compared to the traditional design-bid-build process which adopts a linear work flow and usually selects the bid with lowest cost, the integrative process highlights the value of group synergies, and encourage all design team members to work together and follow through the entire building and construction process to make sure an optimal output will be yielded, and meet the demands of the users. The integrative process values long term savings over low first cost, and selects the contractor based on best low cost, instead of lowest first cost.

2.4 Pilot Study: From Shelter to Equity

2.4.1 Executive summary

By the beginning of the 21st century, Chile had surpassed most of its Latin American neighbors in terms of economic development and political stability. Yet, there were still many families living in informal settlement, and the government's housing policy was still like it was before - nothing more than a crisis mitigation mechanism. Low income families were provided with housing subsidy and were relocated to newly-built standardized houses at the suburbs where the land was cheap to acquire. Such solution usually led to a segregated community almost entirely cut off from the public transportation system of the city and its career networks, creating an even higher unemployment among residents, and a depreciating property price over time.

This case study by [Cook and Boyer \(2012\)](#) talks about an innovative housing project done by Elemental, an architectural “do tank” based in Chile, which has been selected as the top 10 most innovative companies of Latin America in 2015 ([STAFF \(2015\)](#)). During the project, Elemental managed to design houses for 100 families on the original plot of their informal settlement, which was an expensive, privately-owned land in the city, while allowing them to harmonically expand their houses over time, so the house actually became an asset with increasing area and value, which in return, improved the families' status both economically and socially (see [Figure 2.9](#)).

Here is an overview of major insights gained from this project:

- The Chilean Government's outdated approach to housing shortage, as of today, is still based on crisis provisioning.
- Elemental helped re-identify the question from a matter of housing shortage to the design of equity. Such approach may not yield a unique solution, but will definitely create the guideline towards an optimal solution.
- By embracing the deficit in funding, the smart design concept of “half a good asset is better than all of a bad asset” really triggered the power of self construction, which was often ignored by the policy makers from the government.



Figure 2.9: Collage depicting three stages of development. Left: models used in a co-design session with future residents. Middle: completed construction. Right: after being lived in for some time, showing modifications by the residents. Source: Elemental

- The adoption of the practice of participatory design between the multidisciplinary team and the residents ensured the houses and community to have a high quality in terms of architectural execution, as well as a perfect alignment with the needs from the direct users.
- Unconventional design solutions, whose proposed results often seem quite risky both politically and financially, are only justifiable if future owners are rigorously engaged at the early stage of the process.
- To bring the poor into the middle class, formal housing that increases in value is essential.

2.4.2 Project background

Chile's rise has been rapid. Since 1985, GDP has increased by nearly 1000%; by contrast US GDP has increased less than 200%. Although it's no longer a poor country, when it comes to solving

the housing shortage, the government's mindset is still the same as before.

As recently as 1973 the government was overthrown by military coup, and runaway inflation was destabilizing Chile's economy. Thus, civil crisis is a relatively recent challenge for Chile's government. Crises mitigation is a significant factor in public policy development and even formation of the government itself. As is true for most governments, the first response to crisis is to deliver quantity-based solutions that have an immediate impact. This so-called enabling markets housing policy (Navarro (2005)) was pioneered in Chile as the government sought a balance between state intervention and private sector housing delivery mechanisms. The government would issue a one-time subsidy to qualifying families but was not involved in delivery of housing units.

Prior to 2001, 3 major types of social housing units were available in Chile, each having its own challenge:

- Medium/high rise buildings normally with an area of 40-45 m^2 per family. Units of this type are often subject to illegal expansion, inadequate public space both in and out of the building, and problems related to structural integrity.
- Row houses with walk-through rooms which are poor in privacy and windowless "blind rooms", such design is also under criticism for the inefficient use of land, which is believed to be one of the reasons for Chile's overcrowdedness.
- Single-family houses with an area of 36 m^2 , was once a popular model in the 1990s for its original intention provide urban poor with middle class amenities. Yet, such design is only feasible when residents are relocated to the outskirts of the city where there is still cheap land available, and thus get cut off from the public transportation and job opportunities.

For any family eligible of receiving housing subsidy, the Chilean state would order a one-time cash payment from the government (USD 3,700) which was combined with family savings (USD 300) and a private bank loan secured by the family (USD 7,000) for a total per-unit budget of USD 11,000. (Aravena (2010))

The social housing system was meant to provide the urban poor with middle class amenity, and as a result, the houses all had middle class style, though being minimized in size and

relocated to some communities far from the urban norm of security, education, public transportation and jobs. Under such context, the houses were depreciating all the time, deviating the social housing system from its goal of promoting social equity to actually duplicating or even worsen the problem.

In a changed time and political ecosystem of Chile, eliminating the chronic deficit of housing shortage calls for innovative approaches. Previous practice might be considered successful in terms of providing shelter to the needed, yet it never addressed the core problem of eradicating poverty, and nor would expedients such as tampering with the subsidy amount, real estate prices, or seeking external donation lead to any genuinely sustainable solutions to this problem.

With a determination to design within the given constraints, which was believed to be the prerequisite in justifying the cause politically, architects of Elemental formulated the following precepts (Cook and Boyer (2012)):

- Quality in parallel with quantity is possible
- Social housing could potentially be an asset instead of an expense
- The value of social housing can, just like other types of property, increase over time

Based on these precepts, Elemental developed several design principles:

- Social housing must have a good location, where urban poor could benefit from the network of opportunities they need the most.
- Families were encouraged to form groups of 20-30 within a bigger community, these sub communities were considered groups sharing collective space and relationship, which could contribute to an improved security and democracy.
- Social housing units must be constructed in a way which allows them to, instead of randomly expand, harmonically develop over time, so that the residents wouldn't be impoverished again by depreciated property.
- Government benefits should be redirected towards elements that were most difficult to obtain by families on their own, as opposed to ensuring a home with all the necessities but with lower quality.

- Similarly, subsidy should be invested in the structural design of housing units allowing the flexibility in expansion which would be possible for the families to execute on their own.

2.4.3 The real problems

In their first real case of innovative re-housing project, Quinta Monroy, a settlement consisting of 100 families (see Figure 2.10) located in the coastal town of Iquique, 1600 km to the north of Santiago, Elemental organized workshops among families, giving them alternative options (for example, to choose between a bathtub and a water heater) of similar necessity to discern preferences, even if it meant difference between two immediate neighbors (see Figure 2.11). Such effort was well paid-off, families felt the “half of a good house” strategy really provided them with what they needed most while allowing them to build upon that platform their own wealth and dignity, that they were motivated to defend their interests in public.



Figure 2.10: Quinta Monroy, as seen here before Elemental’s project, is representative of Chile’s informal urban settlements. Source: Elemental



Figure 2.11: Future owners were involved in the design process through a series of workshops. These sessions included the group making difficult choices about what to build now and what to leave for later. As construction began, the workshops focused on how the owners would be able to make best use of the new homes and expand them safely. Source: Elemental

A noticeable detail in the participatory design process of Quinta Monroy was when Elemental decided to replace the water heater (which was demanded by the housing policy as a basic appliance in new housing) with a bathtub, due to the experience from residents who usually sold water heater for cash at the early stage of occupancy and repurchased it later as their condition improved. A bathtub on the other hand, was vastly welcomed by the residents for it provided irreplaceable convenience for families with babies, and most important of all, it was hard to retrofit a bathtub after the construction.

However, if the water heater example is what makes the readers think that participatory design is so peaceful and smooth like a hippie, romantic, let's-all-do-it-together-for-the-future kind of thing, the message would be misleading, to say the very least. In reality, residents of Quinta Monroy lacked enough visible assets to make themselves eligible in receiving help from financial institutions and the state, and to make matter worse, a change in the housing policy had reduced the budget to USD 7,500 (USD 7,200 subsidy + USD 300 family savings) compared

to the previously mentioned budget of USD 11,000 (USD 3,700 one-time cash payment from government + USD 300 family savings + USD 7,000 private bank loan). Such financial constraints created a lot of struggles for Elemental's design team. If Elemental was to adopt the single-family model, the plot of land could only accommodate 32 families, letting alone the fact that it was not possible for the 32 families to acquire the land with the money they had. Building row houses seemed to be a better idea, yet still, only 60 out of 100 families could be fitted into that area. Medium-rise buildings was the only viable option which could accommodate all 100 families, but the families threatened to go on a hunger strike if such plan was ever proposed, because of all the bad reputation medium-rise buildings had gained over the years, such as illegal expansion, insufficient public space, and hindered structural integrity.

By adding these new constraints to the existing ones, Elemental finally set its delivery goals to be (Cook and Boyer (2012)):

- The Quita Monroy community would keep its prime location
- The community would be planned as a whole, as opposed to the mere assemblage of 100 homes
- The housing units would be designed in a way that allows them to expand over time in a harmonious manner (see Figure 2.12)
- As agreed by the families, the buildings would only be installed with elements they needed the most, in the belief that it could help reduce cost, and whatever was omitted would be installed by the families in the future (see Figure 2.13)

Up to this point, the challenges facing Elemental were only solved design-wise, for all of that design, no matter how appealing it appeared to the clients, would stay on paper unless a contractor was willing to implement that design. This was because all interior finishing of the buildings, which were considered parts that could generate most profits for the contractor, was intentionally omitted in the design to reduce cost. Luckily, there was after all, one company willing to take the risk solely out of the goodwill of community empowerment.

By 2004, the Quita Monroy re-housing project completed, as families started moving in, their subsequent expansion started almost immediately. After the expansion, the size of the house



Figure 2.12: Left: Quinta Monroy as it appeared when construction was complete. Right: Quinta Monroy after self-construction. Source: Elemental

increased, and together with it, the price of their legal assets (it was estimated that after expansion, each housing unit had an area of 60 m^2 and value of USD 20,000). Hence, the success of the project could be concluded with an equation:

$$\$7,500 \text{ (subsidy)} + \$750 \text{ (value of self-built additions/improvements)} = \$20,000 \text{ (home value)}$$

2.4.4 The aftermath

As an aftermath of the Quinta Monroy project, Elemental decided to pursue a for-profit incorporation whose mission is to rigorously pursue better solution to complex challenges in built environment while maintaining its good academic ties with all of its sponsor institutions.

Elemental's success had also drawn attention from big companies who cared about good causes. In 2006, Chilean Oil Company (COPEC) purchased 40% of Elemental's stake, in an effort to fulfill its corporate social responsibility, for Elemental's design philosophy of embracing the



Figure 2.13: Interior views of a unit in Quinta Monroy showing before (up) and after (down). Self-constructed modifications include windows, floor surfaces, and painting. Source: Elemental

constraints really appealed to COPEC's values. The funds raised from this purchase were used to building more similar projects which would eventually make Elemental's practice profitable (Cook and Boyer (2012)).

Element's success was also way beyond housing, with the success in the Quinta Monroy project as well as several subsequent housing projects, Element's approach of problem-solving had also helped develop a decision-making framework based on keenly observed evidence of needs (which serves as irrefutable supports for some seemingly bold design decisions), and the awareness of actual consequences. Such framework opened up opportunities for problem-

solving in a much greater quantity and scale whilst delivering growing value and promoting social equity.

2.4.5 Conclusion

None of the techniques used in the Quinta Monroy project was rocket science, most of them were actually simple and low-tech approaches so that anyone with a common sense could do it. Thanks to all that common sense, Quinta Monroy was transformed from a simple housing project into a genuinely sustainable project that provided people with a growing asset and opened up opportunities for social equity. So the lesson learned was: sustainability is nothing but the rigorous use of common sense.

The driving force for the success of the Quinta Monroy project was self-construction, a deep rooted Chilean tradition. Yet, the force needs to be translated into form, and what that form is modelling and shaping is not cement, bricks or woods, it is life itself. Design's power of synthesis is just an attempt to put at the inner-most core of architecture, the force of life.([Aravena \(2014\)](#))

Chapter 3

Analysis and Evaluation

In this chapter, the user experience's influence on early phase building design will be investigated and discussed in detail so as to validate its underrated importance. Pertaining to the ways in which the user phase experience's influence over the early phase of building design is measured, there are quite a few different approaches, they will be discussed in this chapter in terms of respective characteristics. Finally, a survey is presented to showcase the diverse value proposition within the specific stakeholder group of owners, who are, in some cases, also the users of the building, yet their positive influence over building design is sometimes underrepresented in the decision making during the design process. The survey provides a good speculation into what are the major concerns from the owners/users of the building, and to what extent are these concerns appreciated, or neglected in the building design process.

3.1 Loops of Feedback

Both concepts of positive and negative feedback loop have been widely applied in many fields such as biology, mathematics, digital electronics and so on. Generally speaking, a positive feedback loop has an effect of "A produces more of B which in turn produces more of A" ([Keesing \(1981\)](#)). For example, agriculture and human population can be considered to be in a positive feedback mode, which means that one drives the other with increasing intensity (see [fig. 3.1](#)). Considering such definition, the actual cause and effect of a positive feedback loop isn't always necessarily positive, the global warming cycle of "climate warms-buy/use more air condition-

ing - more energy use + CO2 emissions" is one of the most known case of positive feedback loop, which is also known as a vicious circle. And as a contrast, a negative feedback loop normally means "the results of a change act to reduce or counteract the change itself." (Zeigler et al. (2000)). For example, population of predators and prey - if the numbers of prey decreases, then some predators will starve, and their numbers will decrease as well. As discussed in the scope of this thesis in Chapter 1, the influence of user phase experience over early phase building design also works in a cycle similar to the mechanism of a feedback loop. Yet, such loop can be labeled as either "positive" or "negative" depending on different perspectives. From a synergy perspective, such cycle suggests a positive feedback loop (as shown in fig. 1.3) in which the user experience urges the design team to have an optimal work dynamic, and as a result, the design team is more likely to perform an integrated design in the building design process, which will in return further enhance the user phase experience. Yet, from another perspective of lean manufacturing, this is a negative feedback loop in which all the "muda" (a Japanese word meaning "futility; uselessness; idleness; superfluity; waste; wastage; wastefulness", and is a key concept in the Toyota Production System (TPS) Kenkyusha (2003)) is reduced along the loop.

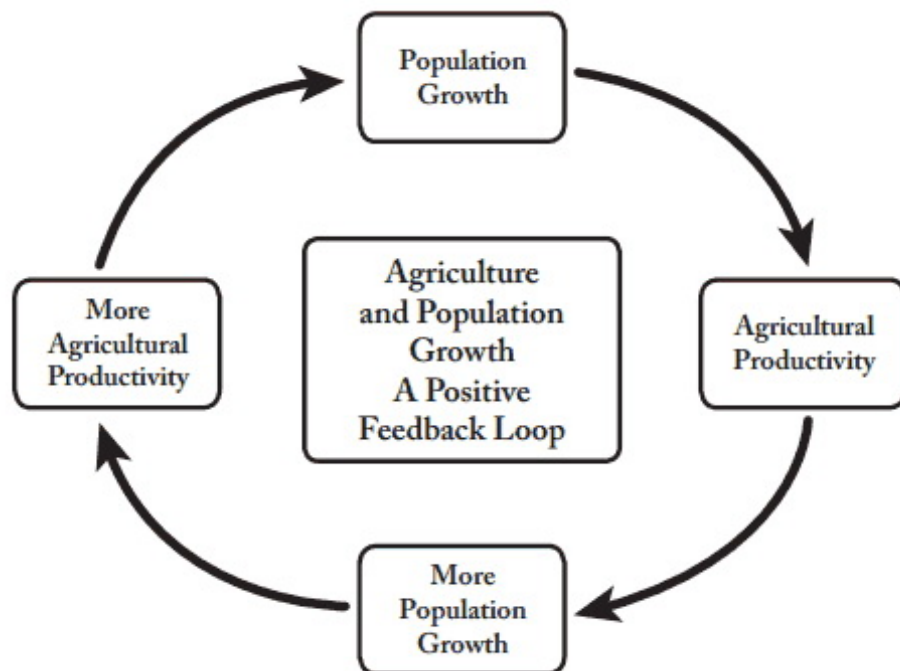


Figure 3.1: The positive feedback loop between agriculture and population growth (University-ofCaliforniaLosAngeles)

3.2 Current Practices

3.2.1 Seeing beyond cost

The practice of building design is, if understood in the context of market economy, a procurement process in which the design team offers its work of knowledge in exchange of economic interests from the owners/users. The owners/users on the other hand, expect this procurement to provide the best "value for money" which is defined by [HMTreasury \(2006\)](#) as the optimum combination of whole of life costs and quality (or fitness for purpose) of the good or service to meet the users' requirement. Value for money is not the choice of goods and services based on the lowest cost bid. To undertake a well-managed procurement, it is necessary to consider up-front, and at the earliest stage of procurement, what the key drivers of value for money in the procurement process will be. For such procurement, a recommended approach would be to, with the help of sensitivity and scenario analysis, create options and values, including those for a *base case* situation that is adjustable to having non-monetary impacts and uncertainty about the building's future use. To create these options, it requires the analysis of all stakeholders' opinion so as to have an accurate identification of the potential project's functional objectives. While the list of objectives always contain the *Do Minimum* option, also known as the *base case* which can be interpreted as doing nothing at all, the base case is rarely a zero-cost option, and is very often not the least-cost option either, thus fails to provide best value for money [Kelly et al. \(2015\)](#).

To identify the optimal option of functional objectives which provides the best value for money, it is important to take into account the wider social costs and benefits to satisfy organizational strategies/policies, and ensure the proper use of resources by identifying and analyzing a number of potential approaches that achieve similar outcomes. It is advised that a project shall be adopted only if the following two questions are answered ([Kelly et al. \(2015\)](#)):

- Are there better ways to achieve this objective?
- Are there better uses for these resources?

3.2.2 Different assessment methods of building performance

To influence the early phase of building design with user experience, such experience needs to be (if not entirely) translated into metrics which can work as the design principles. To do that, many different assessment methods are developed to evaluate the building performance on both strategic and tactical level. In short, strategic assessment methods help derive objectives about what to do and what to achieve in the design, while tactical assessment methods deal with how to do it and include more technical details. In this thesis, some of the most widely used assessment methods will be discussed, which are:

- **Strategic:**

- The Balance Score Card (BSC)

- Feed forward loops and soft landing initiative

- MultiMap and its further development

- **Tactical:**

- Leadership in Energy and Environmental Design (LEED)

The Balanced Score Card (BSC)

Originally developed as a assessment in the business sector for corporate strategy, the BSC opens up opportunities to use more business-oriented tools for the purpose of building performance assessment. Or rather, it allows assessment of building performance to become an integral part of the business strategy. Using the tool of BSC, the essence of corporate synergy can be extracted from and for the practice of assessing building performance.

According to [Kaplan and Norton \(2006\)](#), the BSC is a strategic performance management framework, that allows organizations to define their strategic priorities and then design indicators and measures to monitor how well they are executing their strategy. It sits at the very top of the organization where definition on what this company is about and which direction the company is going into are made, it's called a vision. With that in mind, then it is possible to direct all business units to make sure they are all aligned for the right task. It identifies the most intuitive components of a company strategy in terms of several (if not just 4) perspectives:

- Financial perspective: such as where to grow revenue, to what level need the cost be cut.
- Customer perspective: with intention such as increasing brand awareness/satisfaction. Anything developed from the customer perspective will in return also help the financial perspective.
- Internal process perspective: such as optimizing the business process.
- Learning and growth perspective: probably the least understandable perspective (include human capital, information capital, etc.) With the help of the right people and the right information, a proper corporate strategy will be made.

The biggest benefit of utilizing the BSC method is that it enables the corporate to have an agreement on the strategic priorities on a single sheet of strategy map instead of a 30-pager report that nobody is going to read, and once the objective priorities are defined, everyone in the corporate can work towards the same goal.

To put it in a nutshell, the tool of BSC helps a corporate develop strategies by identifying the core value of different stakeholders and aligns it with the corporate's competitive edge, and thus make sure the right people are always doing the right job in the right way.

There are also other tools who share similar features with the BSC tool. The Osterwalder Business Canvas model is a strategic management and lean startup template for developing new or documenting existing business models. It is a visual chart with elements describing a firm's value proposition, infrastructure, customers, and finances. It assists firms in aligning their activities by illustrating potential trade-offs. Unlike the BSC tool which allows a user to add more modules into its structure where he sees fit, the Business Canvas model has fixed sections where the user inputs the corresponding information and eventually forms the business structure as a whole. (an example of the Osterwalder Business Canvas model can be found in Appendix B).

The feed-forward loop

In many of today's common practices, when there is a problem which hinders the alignment between the building's function and the users' core value, the design team will be informed of such problem as a feedback from user phase, the design team will then come up with solutions

(if not contingency) for the problem. Unfortunately, this is normally where it ends - the problem and its solution stays with the current project, and unless demanded as a case reference, will not provide any insight for any future projects with possibility of having the same or similar problem. In view of this lack of feed-forward loop from the design phase into user phase, [Leaman et al. \(2010\)](#) proposed a feed-forward loop as an intention to provide information concerning the use of the building to the implementation, design and justification phases. The research examined 5 types of feedback loops as shown in fig. 3.2. Out of the 5 types of feedback, level 2 and 3 work as hindsight and foresight which connects the users and the FM people with the planners, designers and the construction team, whereas level 1, 4, 5, and 6 are more related to the knowledge management of academic activity.

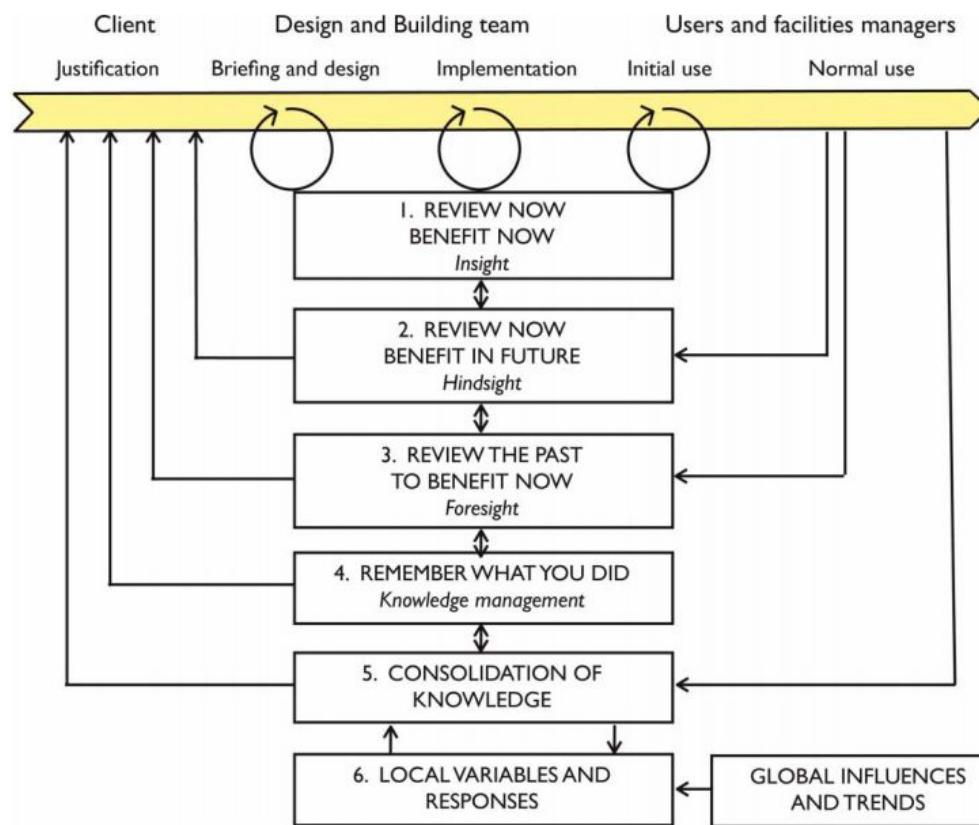


Figure 3.2: Five types of feedback ([Leaman et al. \(2010\)](#))

[Leaman et al. \(2010\)](#) also described another assessment method known as the Soft Landings initiative, which aims to smooth the transition from construction into operation/use by having a team going with the handing over of the building and stay until the operation of the building

runs smoothly. Such method, as concluded by Valen (2015) in her unpublished work, allows the team to collect data directly from the building and then feed the design team with better insight on the use of the building, thus closing the feedback loop which could as well be used to feed-forward to future projects. However, the method requires a lot of resource and is expensive in terms of all the cost for labor and time spent on observing the use of the building.

In another research conducted by Steinke et al. (2010), the feed-forward loop method was combined with the BSC method to evaluate building performance in health care design and performance of buildings in light of the long term strategies of the health care organizations. The feed-forward knowledge loop used in this methodology rephrased level 2 and 3 in the "5 types of feedback" model which are usually used for building performance evaluation and visualized it into the following diagram (see fig. 3.3):

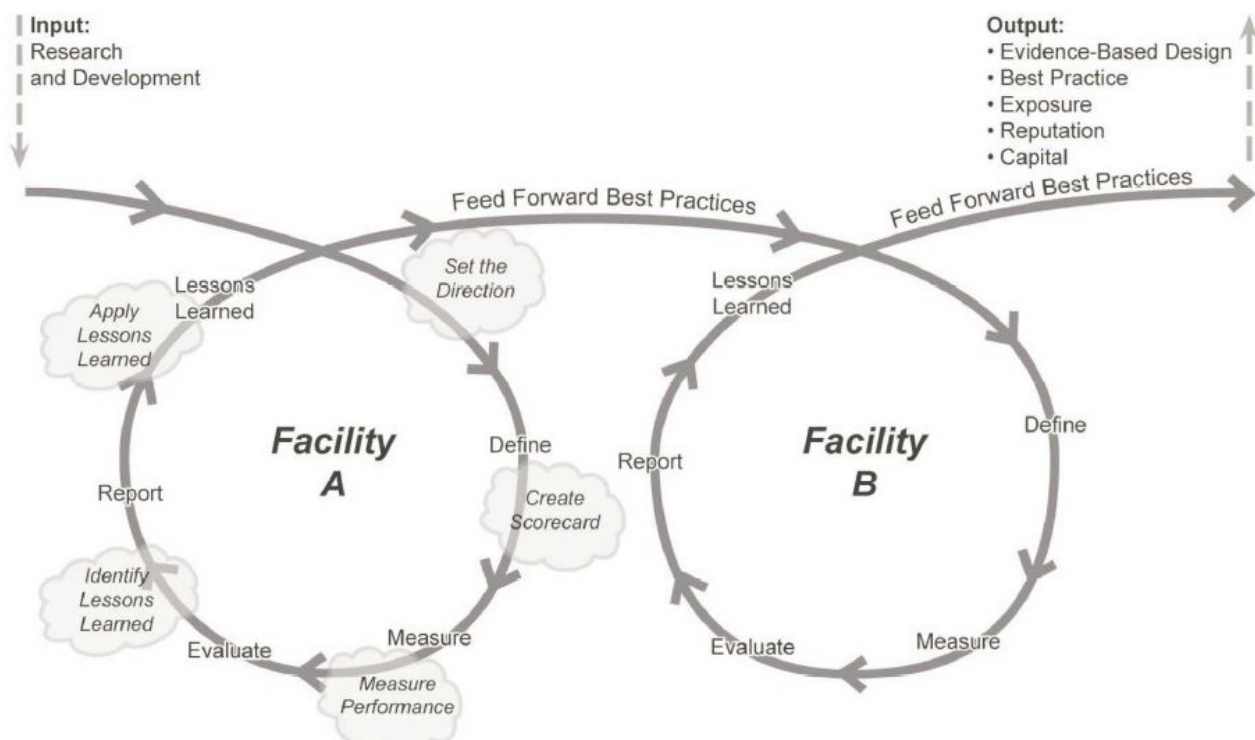


Figure 3.3: Feed-forward knowledge loop: Evaluating Building Performance (Steinke et al. (2010))

This model closes up the loop to pass insight from current project to the next one while engaging a number of stakeholders (Valen (2015)). This model has also proven the BSC method's ability to eliminate barriers between people, departments and industries in a way that encour-

ages communication awareness and accountability and encourages an inclusive way of thinking (Steinke et al. (2010)).

3.2.3 The MultiMap method and its further development

Originally intended for the purpose of providing information for the physical condition of buildings, the MultiMap method is a tool for strategic building analysis as well as mapping the physical properties of existing building portfolios. The method includes an analysis and assessment of the current situation with respect to core business needs, the building stock performance to support these needs, and the potential for further sustainable development. So far it is used on approx 25 million square meters (hospitals, public buildings), which is about 55% of the building mass in Norwegian public sector. Recently the method has been adapted to other types of infrastructure, i.e. roads and nautical installations (Bjørberg et al. (2012)).

The main purpose of the tool is to get a better model for gathering information needed to support the strategic planning within large portfolios to strengthen the interaction between core business and supporting services in a relatively short period of time. In order to achieve this purpose, the collection of large amount of data is necessary, this is usually done through means including but not limited to Literature studies, evaluation of available existing methods, document studies, interviews, workshops, large scale case studies, R&D projects and real life projects with clients.

The development of building performance assessment metrics of the MultiMap method are based on the principles of the Norwegian Standard NS3424, in which a grading scale ranging from 0 to 3 is adopted with 0 being the best grade and 3 the worst (see also table 3.1). Also, a color coding of green, yellow, and red is corresponding to this grading scale in the same way of a traffic light.

Condition grade	Description	Color
0	No symptoms	Green
1	Slight symptoms	Yellow
2	Medium-strong symptoms	Red
3	Strong symptoms	Red

Table 3.1: Aggregation of information (Bjørberg et al. (2012))

This grading scale is applied to a large quantity of parameters and requirements dedicated to the assessment of building portfolios which are categorized into following modules:

- Technical condition
- Usability
- Closeness/distance
- Fire safety
- Energy
- Maintenance plan
- Life Cycle Cost (LCC)
- Infrastructure and site
- Adaptability

When conducting the analysis, each building is mapped floor by floor for the purpose of both aggregating information and matching against predefined requirements. However, given all the parameters and requirements in all the modules, collected data won't be sufficiently useful unless interpreted and re-presented into an overview that is easy to understand. The MultiMap mainly communicates its data analysis through two ways:

- Show a map of the whole site, with links to detailed information on each building (see [fig. 3.4](#)).
- Use BIM (Building Information Modelling) tools such as Onuma Planning System together with Google Earth. The latter will provide an accurate site image for locating the project, while the former will generate color-coded models showing a building's condition in each floor on that site (see [fig. 3.5](#)).

Thanks to the big amount of information it collects, and its ability to collect massive data in a relatively short time window, the MultiMap method also provides good information base for the

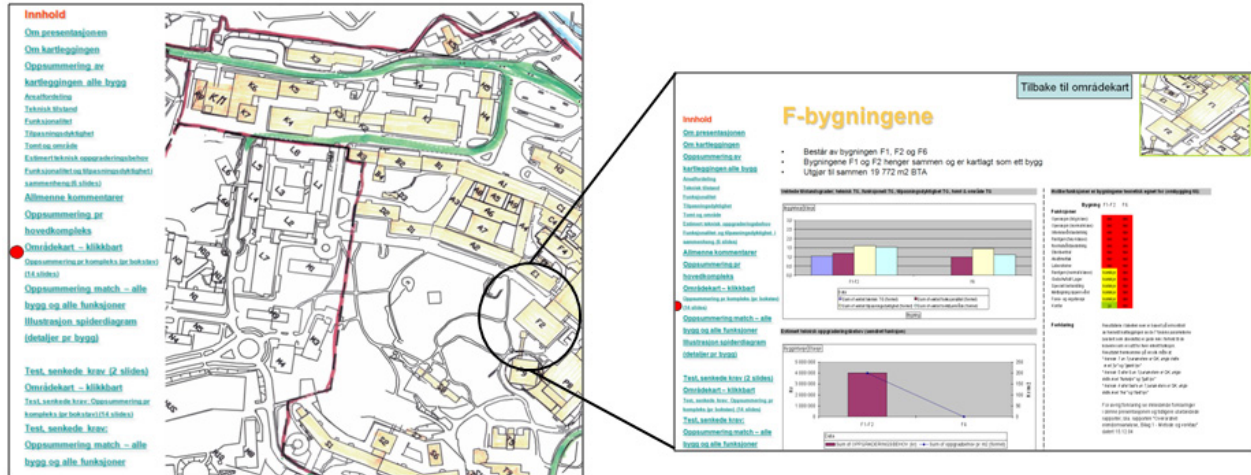


Figure 3.4: Presentation of results (Bjørberg et al. (2012))

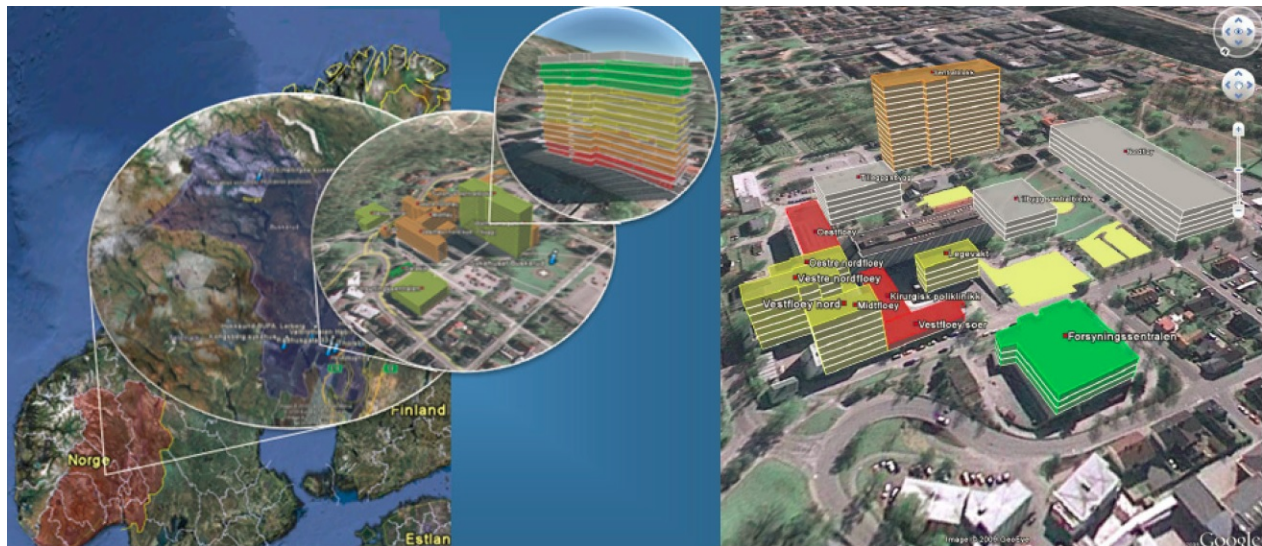


Figure 3.5: Feed-forward knowledge loop: Evaluating Building Performance (Bjørberg et al. (2012))

evaluation of potential for sustainability in existing buildings. In a research conducted by Hvide et al., he proposed a new method based on the cross comparison of several existing assessment tools including LCA(Life Cycle Assessment), LCC, SURE(Sustainable Refurbishment), BREEAM in-use, SIA(Sustainable Impact Assessment) and MultiMap, as well as feedback collected from survey and interviews. This new method was believed to be a qualitative method suitable for the preliminary evaluation of sustainability within existing buildings. The concept of triple bottom line (Elkington (1998)) has been emphasized in this new method to accentuate the importance of achieving a balanced review on the sustainability of an existing building. That is to say, a

sustainable renovation is only going to be carried out if the solution is predicted to be socially positive, economically feasible, and environmentally friendly. To do that, a 6-step process will be followed:

- The purpose of the building will be identified
- Fixed limit for sustainability renovation (such as special building regulation, conservation status etc.) is defined
- Evaluation of social and environmental factors (the non-economic factors)
- Evaluation of the cost of implementing the factors in step 3
- Such cost is again evaluated so as to see if it is truly feasible to achieve without understanding the environmental and social goals
- Based on previous steps, a conclusion will be drawn to decide whether such potential is realistic or only theoretical

The above steps are considered an iteration process of evaluating the gap between the level of ambition according to requirement/demand and the building's actual performance to date, which is known as the theoretical potential. The evaluation of theoretical potential against the triple bottom line will decide whether such potential can be realized. In general this MultiMap-integrated new assessment method points a good direction in looking at sustainable buildings in a more holistic and rational perspective while proposing a framework under which a more specific assessment tool for existing buildings is developed and perfected.

Leadership in Energy and Environmental Design (LEED)

The following figure (see fig. 3.6) shows different green building rating systems and their respective global distribution. According to [Reed \(2012\)](#), while there are positive and negative characteristics associated with each rating tool, it is important to continue monitoring their success with regards to their take-up rate and implementation. After considering all of the efforts to increase sustainability in the built environment, it is critical that the goal of more sustainable buildings is not hindered by the absence of a truly international rating system.

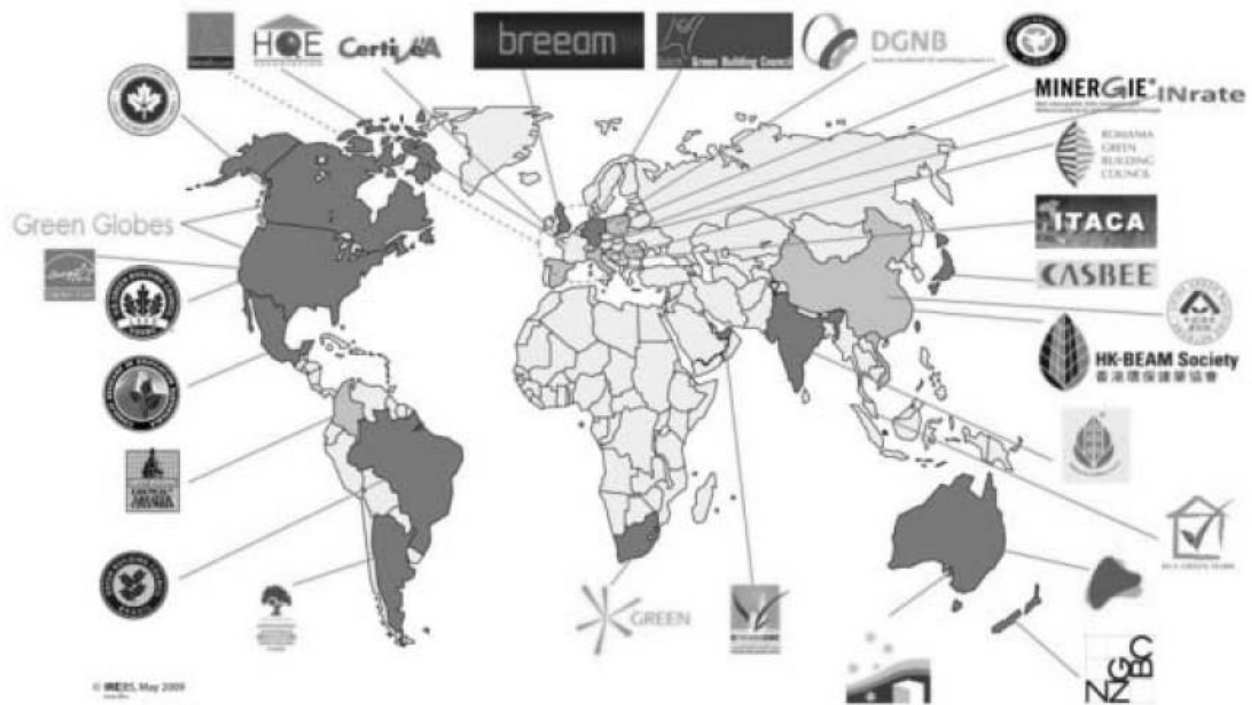
Exhibit 1 | Complex System of International Rating Tools

Figure 3.6: International Comparison of Sustainable Rating Tools (Reed (2012))

Although truly international rating system does not exist, it is worth noticing that LEED (Leadership in Energy and Environmental Design) is currently one of the most popular rating system in the world, and USGBC (US Green Building Council) claims itself to be a non-profit organization dedicated to the research, development, and promotion of such system. Yet, it is not mandatory for building owners to get a LEED certificate, and USGBC is making tremendous fortune out of the training of LEED practitioners as well as the assessment process. It is no doubt that LEED is so far the most successfully marketed green building rating system which creates a win-win situation among all the stakeholders involved, given the fact that LEED is a market-driven program that provides third-party verification of green buildings (to find out more details about the LEED system, and its connection with USGBC, see Appendix B). However, LEED is not necessarily the most technically advanced green building rating system compared to CASBEE (Comprehensive Assessment System for Built Environment Efficiency), which is a mandatory rating system enforced by the Japanese government.

To put the rating system in a nutshell, a chart (see Appendix B) was made to show the sub

systems within the latest LEED v4 system and their respective evaluation categories, under each category there are many tick-box evaluation criteria which are not shown here. As we can see, most subsystems such as new constructions, commercial interiors, schools and so on share the same evaluation categories, while homes and neighborhood have their own unique categories. All the numbers listed in the table are the maximum score one can earn for a certain category within that specific subsystem. Any building being evaluated will fall into one of the subsystems listed, and through the evaluation of all its categories, a total score will be given. According to the total score, the building will be certified as different level (certified/silver/gold/platinum). In other words, the higher score a building can earn, the higher level it will be certified, and thus more added value to the building.

To illustrate how to manipulate the score so as to get a higher certificate, an example of the subsystem of Homes and Multifamily Low-rise is made. Assumed a new residential building will be built on a new plot in Trondheim, Norway. To collect those easiest points, focus is placed on Energy and Atmosphere, as well as Indoor Environment Quality, which mainly involve optimized design in the HVAC system as well as the air tightness of the building envelope (e.g. Insulation, window, door). As a Nordic country, Norway has a high latitude and a cold climate, therefore the air tightness of building envelope is already part of the basic requirement of the building code (the Norwegian building code requires that the air tightness for a single family house should be below 4.0 ach at 50 Pa. In a high-performance building the necessary air flow rate is provided by the ventilation system, and a high air infiltration only leads to unnecessary heat losses (Hastings et al. (2006))). Also, investment in water efficiency technology such as rainwater catchment, high efficiency showerhead/toilet retrofits can help secure another 15 points under the Water Efficiency category, although water scarcity is hardly any issue in Norway thanks to the abundant precipitation and all the rushing streams along the mountainous terrain. Up to this point, there are already 12 (Water Efficiency) + 38 (Energy and Atmosphere) + 16 (Indoor Environment Quality) = 66, which qualifies the building for LEED Gold, and it is entirely possible to score another 1 or 2 points from the rest of the categories such as Material and Resources, Innovation in Design, Local and Linkages and so on. And then, a LEED Gold certified building is achieved, which indicates a building with outstanding energy performance and extremely low environmental impact. Or, does it?

The reason for the above mentioned example is based on the prediction that the population of Norway is expected to exceed 7 million by 2050, while the current population of Norway is about 5 million, cities will be expanding, and more and more residential buildings will be built to accommodate the growing population. Since the building sector consumes more than 40% of the total energy, it is more than meaningful to improve the energy performance of buildings, especially in residential buildings, whose energy consumption mainly comes from heating, cooling, cooking and lighting. However, problem remains as owners of residential buildings are less motivated to consider a LEED certification since it increases the expenditure which takes a long period to payback, not to mention that some sustainable solutions are unnecessary in the local context (water efficiency in Norway for example). In other words, owners of residential buildings are supposed to be one of the major players in the LEED rating system, yet, they either feel less motivated to involve, or become so obsessed with the idea of earning higher score for a better certificate and end up leaving an even bigger environmental impact.

To sum up, while LEED as a constantly developing system with its competitive edges in global recognition, relatively low operation cost, added value, and third-party objectivity (note that objectivity does not contradict with the fact of LEED being a market-driven programme), the disadvantages of LEED is also quite obvious: it is expensive to apply for and maintain a LEED certificate; its tick-box criteria allows it to give points without performing any calculation on the actual GHG emissions, leaving alone that the assessment process of LEED is based mostly on documentations, which might be convenient for those who forge their documentations. Last but not least, LEED is very inflexible about any local context, which often leads to a less meaningful but rather wasteful decision just for the sake of having the score. Yet, LEED is still considered one of the most comprehensive rating system which provides a good selection of technical guidance for built environment.

That being said, one should not however, mistake the approach of LEED with the purpose of achieving a genuinely sustainable society. LEED can only take us so far.

3.3 Value Proposition Survey

“Nowadays people know the price of everything and the value of nothing.” -Oscar Wilde, *The Picture of Dorian Gray*

Nowadays, there is a trend towards performance-based programming, design and management of facilities aiming to keep down costs, reduce energy usage and making the best of building systems. Project OSCAR is a project jointly carried out between Norway’s leading consulting company Multiconsult and the Norwegian University of Science and Technology. The focus of Project OSCAR is on developing competence, methods and analysis tool which makes it possible to optimize building design in a way that it will contribute to value creation for owners and end-users throughout its entire life cycle.

And as part of the project, a survey was conducted among owners of buildings to find out their respective value proposition during May 26th and June 12th of 2015. It was believed that the feedback could provide important information in helping establish definitions (and standards) for different value concepts and value creation. The survey was sent to a total of 5953 respondents, of which, 673 respondents (140 female and 533 male) aging from 25 to 58 were able to give effective response. The survey was conducted in Norwegian, original questions and answers can be found in Appendix B.

The response of the survey can be interpreted as follow:

- On respondents

Mostly respondents were from the private sector (49.8%), and most likely from senior positions given the average age of respondents was 54.73 years. Most respondents’ educational background was engineering/ technological/ environmental studies, which seemed to explain the gender composition of the respondents where the vast majority (79.2%) was male.

Among the respondents, the top 3 common roles were developer/ owner (26.8%), building/property manager (19.5%), and engineering consultant (17.9%). And the top 3 phases of building project in which the respondents were mostly involved were (overlapping apply) implementation (54.8%), early/project development (51%), operation (37.8%). Although respondents were from different occupations and positions, their working envi-

ronment seemed to bear more resemblance in which 49.7% were based their answer on building type of office, and most of them (72.4%) were willing to take the user's perspective when answering to the survey while only 27.6% took the owner's perspective, which resonated to the result that 59.6% of the respondents believed that users and owners would prioritize differently with regard to value aspects.

- On buildings

For building commissioning, the most measured and reported parameters were energy consumption (71.5%), area utilization (60.7%), condition grading on buildings (60.7%), indoor air quality (53.4%).

While current value of cash flow, effect on core activity, energy cost, investment cost, life cycle cost, economic risks were considered important in a building's life cycle, cost effective service (such as mail, canteen, etc.), cost effective cleaning, the building's market value on disposal, total cost per working area during operation period, payback were of less concern for the respondents. And problems such as lack of clear order for project, under-representation of roles, missing multidisciplinary understanding of project organization, lack of expertise on life cycle planning and economics, lack of knowledge during operation phase, insufficient involvement of end users were considered the biggest obstacles for a building's operation.

For the building's spatial design, most people appreciated user involvement, space dedicated to flexible working, places for formal/informal meeting, spaces emphasizing company value, good architectural quality. Respondents also embraced amenities such as possibility for individual control of lighting and temperature, interior well-being, intuitive way-finding, and security. On the other hand, respondents seemed to be mostly tolerant if there was no space dedicated to physical exercising such as exercise room with wardrobes.

Most respondents believed in the good cause of sustainability, and that's why most of them did believe the use of environmentally friendly product, use of recycled material, indoor climate and comfort, and effective waste management are crucial for a building. However, only a small proportion of them were convinced that energy efficiency, GHG emission over the building's life cycle, energy level certification (such as BREEAM

or LEED) are of equal importance.

It is good to see that most respondents actually thought less about having enough parking space for cars at their working place but paid more attention to parking space for bikes, which was considered as equally important as flexible floor plan, life cycle planning, and universal design in the building.

To sum up, although a building's environmental impact did concern most respondents who took a user's perspective in this survey, and they valued sustainability within the building, it was convenient for them to demand indoor comfort at the cost of a bigger carbon footprint as they quite contradictorily also displayed how much less they thought of the importance of energy efficiency. Such inconsistency in the respondents' perception of the building suggests a clear gap between a building's common status quo and the ideal standard it is yet to meet.

Chapter 4

Case Studies

In this chapter, three case studies are presented, followed by a discussion concluding what they have in common. Each case study has a different focus, the Chamazi case, similar to the Quinta Monroy case discussed in the pilot study in Chapter 2, is a fair example of participatory design in both improving people's living standard and empowering stakeholders with underprivileged social status. The case on the Syracuse Center of Excellence (SCOE), sets an example of how integrated design can be carried out inside an interdisciplinary design team, which not only helps the team itself to deliver a design better suited for the intended use, but also fosters a democratic culture along the process. Lastly, the school project case featuring a local story from Trondheim, is documented as an example of how a group representing many owners/users can help communicate their core value to the design team and thus achieve an optimal design that best meets the owners/users' demand.

4.1 Case Study - Chamazi: Beyond Walls

Out of all the three case studies documented in this chapter, Project Chamazi is presented the first, not only because these case studies are presented in a chronicle order, but also because this case is an extreme case showcasing how rigorously a design team can possibly engage the owners/users of a building, and through this exchange of knowledge, how drastically the design can be influenced and changed as a result. During the project, the design of a house had undergone two major modifications by different person/organization, each with a different intention. And

what this project has taught us, goes way beyond real estate, FM, and architecture, it reveals the power of people, who are at the center of all innovations, the power which propels the change for a better living while maintaining non-compromise in eco-friendliness, the power without which, the value of real estate and FM can never be exploited to the fullest.



Figure 4.1: From the right clockwise: Unplanned areas slated for demolishing *source: Google Map/Demolished house in Kurasini, photo by: Margaret Ricke/Demolished house in Kurasini, photo by: Margaret Ricke*

4.1.1 Project brief/status quo of Chamazi, as of 2013

Co-initiated by the Tanzania Urban Poor Federation (also known as "the Federation"), the Center for Community Initiatives (CCI), and the NGO of Homeless International, the Chamazi resettlement project aims to harbor part of the evicted residents from Kurasini. The Tanzanian Government's began its Kurasini redevelopment project in order to expand the size and capacity of Dar es Salaam Port, and as part of the project, more than 36,000 residents of Kurasini were evicted from their homes in 2006 and 2007, the majority of them were tenants, uncompensated (as shown in Figure 4.1).

The major goal of the Chamazi Project was to provide safe, secure and attainable housing for more than 500 families. The Federation and CCI had pursued a variety of strategies in pursuit of this goal. They had worked with municipal authorities in order to decrease the minimum plot size and to lower the cost of land to the home-owners. The Federation has also teamed up with Tanzania's Building Research Unit to utilize lower-cost building materials that can be produced on site by Federation members.

4.1.2 Building with flexibility - the incremental house

For the Chamazi residents, their biggest challenge was always insufficient funding, even with the least legit material such as inter-locking bricks containing only a tiny fraction of cement, they couldn't manage to complete most of the houses for each family. Ideally, a full house should consist of two bedrooms, one living room, a kitchen, and a bathroom. The construction used to be carried out in a way which views the house as a walled-compound with fixed functions and all the walls were erected at the same progress, which usually leads to an unfinished house. For those who were better off to construct a full house, they had been reportedly changing the usage of the rooms, some of them needed only one bedroom, and turned the other bedroom into a storage, some of them had such a big family, they turned the kitchen into a third bedroom, and had a simple kitchen attached externally to the house, some of them simply didn't that much space at all, and the house was only partly occupied. Yet for the families owning a full house, they were also in greater debt due to the cost of building a house was still to expensive for them. These unexpected results during the user phase due to the rigidity in the design were reported to

the architects by the Federation, which later inspired the proposal of a changed design concept called **the incremental house, a concept designed to spread the building costs over time while allowing the house to have a flexible use at different stages.**

The incremental building concept, by definition, is a process which does not build a house all at once but adds components to a building plot only when it's needed. Doing so allows the Chamazi residents to build their house and live in it even when they didn't have all the funding needed for a full house. Figure 4.2 is a floor plan of the existing houses in Chamazi, when practicing an incremental building approach, people build only one bedroom, the kitchen and the bathroom, leaving the other bedroom and the living unbuilt. Each of the first built rooms can be locked with a door. When more funding is available to finish the house, another bedroom and a living room will be added to the plot, the doors to previously built rooms will be inside the house itself and the house will then be accessed from the front door at the living room and the back door at the kitchen (see Figure 4.3).

4.1.3 Analysis of building techniques used in Chamazi's existing houses

In order to build an affordable house, the residents at Chamazi adopted a building technique called the "inter-locking brick" technique. To produce a piece of inter-locking brick needed for the construction of an incremental house, a mixture contains mostly sand and minimum amount of cement and water is put into a mold, and pressed into shape, usually after one week of curing, a brick is ready for use. A typical inter-locking brick (dimension: length-30cm, width-15cm, height-10cm) contains two major functionalities known as the male connector-two protrusions on the top, and the female connector-two dents at the bottom. There are two holes connecting the protrusions and the dents which can reduce the weight as well as the material needed for the brick. By stacking the inter-locking bricks in a manner like the normal bricks, the male connector on top of each brick is connected to the female connector at the bottom of another brick on top of it, creating a bond between these bricks solely out of gravity. After all bricks are stacked, cement plastering will be applied to the inner face of the wall. With the bond between the bricks and the cement plastering, a wall with normal bearing capacity is thus constructed. At openings on the wall where windows or doors will be added, a slightly different type of inter-locking brick with a same dimension will be used to hold the steel reinforcement acting

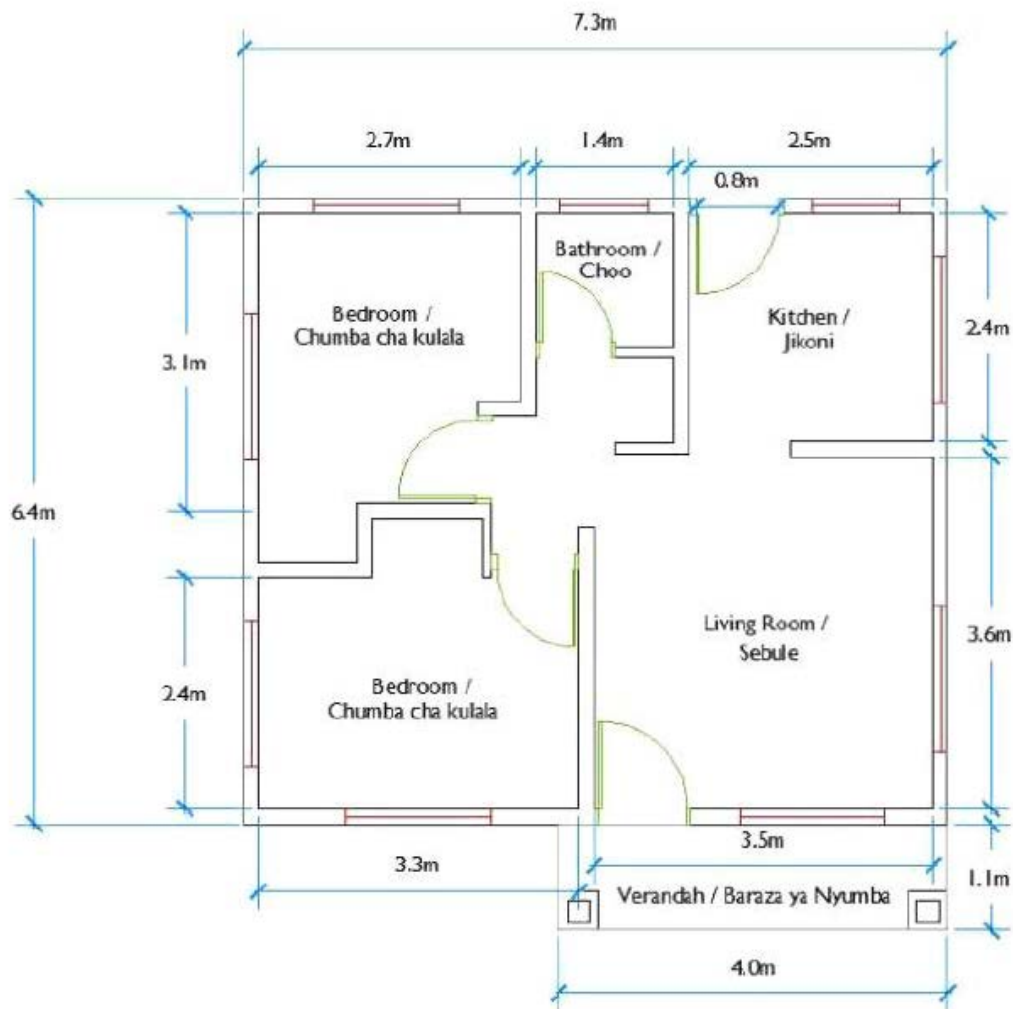


Figure 4.2: Floor plan of a full house which can be built incrementally

as a beam on top of the window or door. In places where a corner or a column is constructed, an inter-locking which is half in its length and number of male/female connector is used to build the shape needed. A wooden frame is then added on top of the walls to support roofing tiles. The roofing tiles used in an incremental house is made with a different mixture of sand, water, minimum amount of cement, some coloring and some wood fiber to add to its waterproof capacity. The mixture is then forged in shape and after three weeks of curing, a piece of tile is ready for use (Jiang (2013)).

The above mentioned building techniques used in existing buildings were quite simple, and also had very prominent pros and cons:



Figure 4.3: A partly built house in Chamazi, photo by: *Margaret Ricke, 2011*

Pros

- Cheaper to build: the inter-locking bricks can be manufactured manually using simple machinery with fewer cement, no electricity was needed.
- Easier to construct: the inter-locking mechanism makes it easier to construct a house compared to house constructed using normal bricks.

Cons

- Low durability: cured bricks are crisp and has a slightly lower bearing capacity compared to normal bricks because of the low content of cement. Such bricks are prone to humidity and weathering, and are not likely to be durable in the long run.



Figure 4.4: From the left counter-clockwise: Special bricks used above windows and doors, photo by: *Qidi Jiang, 2013*/Making of a typical inter-locking brick, photo by: *Qidi Jiang, 2013*/Making of a roofing tile, photo by: *Margaret Ricke, 2011*

- High overall cost: although it was cheaper to build with inter-locking bricks, the overall cost was still considered too high for most Chamazi residents, and the high overall cost was the main cause of Chamazi people's seeking for an even economic building technique that can serve the same purpose.

4.1.4 The bottle house as a stronger solution

In view of the above listed pros and cons of the building techniques used in the incremental house, it is clear that the incremental house has enabled the Chamazi residents to achieve their housing goal over a long period of time. However, such solution was only considered an expediency to work around the core problem of high building cost without solving it, and the inter-locking brick technique also had several disadvantages such as lower building quality, and high overall cost. In order to design a house which is truly cheap to build, and as strong as one built with inter-locking bricks, a technique known as the "bottle wall technique" was introduced to the Chamazi residents by a design group consisting an engineer, two architects, an urban planer, a designer, and an economist. The group decided to promote the bottle wall technique in Chamazi. As the name suggests, the bottle wall technique makes use of bottles to build a wall. Usually, plastic bottles such as mineral water bottles with a volume bigger than 500ml (0.75L, 1L, 1.5L.,etc) can be used as bricks to construct a wall. And based on this new building technique as well as taking into consideration the concerns of the residents regarding local context such as high temperature and humidity during rainy season, which called for greater shading and better natural ventilation, a new floor plan was also developed by the design team after close consultation with the Federation (See Figure 4.5).

The process of constructing a bottle wall is simple (also see Figure 4.6):

- Collect as many bottles as possible, they can have different volume, but a volume of 500ml and above, otherwise the bottles would be too small to be stacked as bricks. Big amount of sand or fine-grained soil should also be collected to fill the bottles.
- Fill the bottles with sand or fine-grained soil or the mixture of both, tamp the filled bottle with a stick to make sure that it is fully and firmly filled. A properly filled water bottle should feel just as hard and weigh just as heavy as a normal brick.
- Stack the bottles in a way similar to constructing a wall with bricks, make sure the bottles are precisely aligned in a row. A bottle will tend to be pointing down at one side because of the unbalanced weight in itself, elevate the lower side with some pebbles, make sure that each bottle is horizontally place in its longitudinal direction so that more bottles can

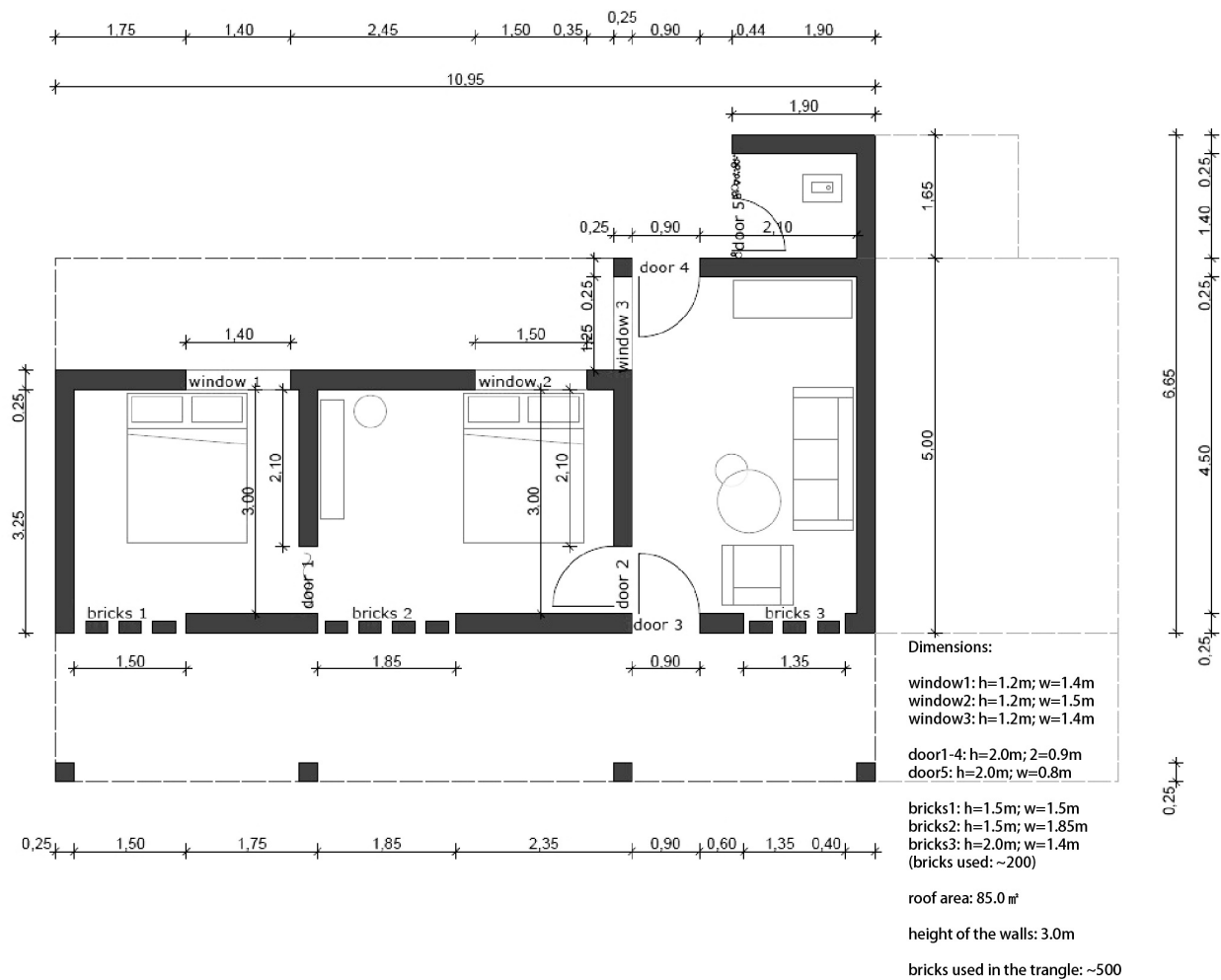


Figure 4.5: Floor plan of the new design, by *Gabriel Kerschbaumer, 2013*

be stacked on top of each layer of bottles without creating any horizontal displacement between the top and bottle of the wall and thus hinder the bearing capacity of the wall.

- Take a long and strong thread and make a knot around the neck of each bottle in the stack. The knots can add to the bond between the bottles so that they won't 'kick out' on both sides of the wall because of their own gravity. Also with this bond, the bottles will act like a net and absorb force together. Imagine a mighty punch on a bottle wall without knots, it might create a penetration, but with these knots, this is very unlikely to happen.
- Put cement plastering on both faces of the bottle wall, make sure that the wall gets entirely covered by the plastering.
- After one week of curing, the bottle wall will develop enough bearing capacity for further

construction of upper structure such as the roofing frame.



Figure 4.6: The experimental bottle wall constructed in Chamazi. The lower part of it, which was completed one week earlier, was covered with cement plastering. Photo by: *Qidi Jiang, 2013*

4.1.5 Research on the engineering feasibility of bottle wall

Although the experimental bottle wall constructed in Chamazi displays a sound consistency in its hardness after finishing, no upper structure was added to it, nor was it later connected to other bottle walls or structures of any other kind. To prove its bearing capacity, more experiments need to be conducted. The original idea was to build a same bottle wall within a laboratory context, and test its bearing capacity by exerting load/load combination to it. In view of the process needed for collecting and filling bottles as well as constructing a wall for experiment, which is a highly time consuming laboring, also given that in standard experimental procedure, several same walls have to be tested in advance before obtaining a more persuasive results, the idea of testing the bearing capacity of a bottle wall within laboratory is impractical in terms of the time, labor and money requested. Therefore, me and my partner resorted to another

approach-digitalized simulation using engineering software which is dedicated to purposes of such kind. With the help of ANSYS, a professional engineering simulation software, me and my partner started by assigning properties to virtual units, enabling them to have the same strength such as compressive strength (the capacity to bear load) and shear strength (the resistance of not to crack), by combining these units, we created a virtual bottle wall which will act and react just like a real wall (see Figure 4.7).

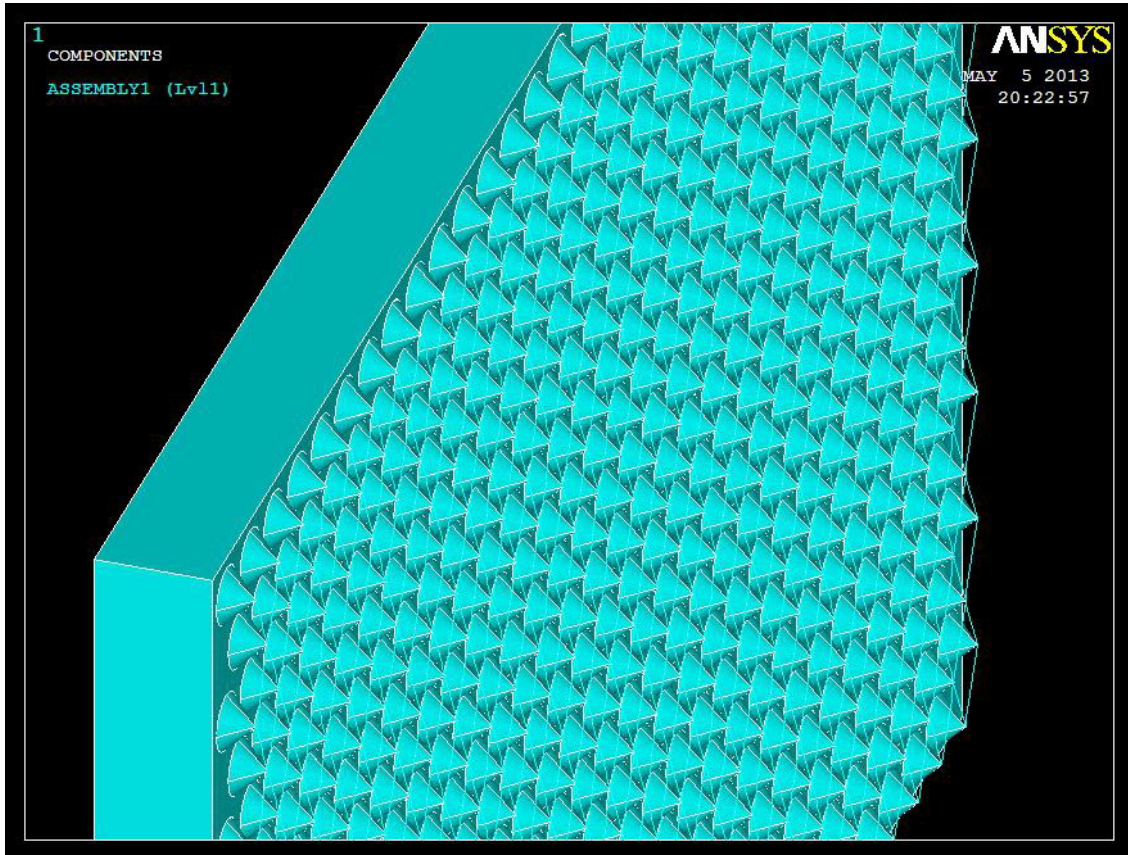


Figure 4.7: A typical virtual bottle wall with thread. Dimensions: length - 3.6m, height - 2.5m

After a series of simulation (for more detailed analysis and results, please read the bottle wall report in the appendices), the following observations were obtained:

- Empirically speaking, the maximum transverse deformation of 1 mm at the top will not lead the wall, which was 2.5-meter high and not supported by other walls, to fall due to strength failure or structural instability.
- The deformation-resistant capacity of the bottle wall was much better than that of the

brick wall ($0.595\text{mm}=43\%\times 1.38\text{mm}$). This phenomenon probably should be attributed to the bottle wall's thickness and the higher modulus of mortar used, though the modulus of bottle entity is much less than that of the brick's.

- The stress indexes of the block-wall seem prettier than that of the bottle wall, which can be explained by the simplification that the concave and convex connection design and their coarse interfaces are ignored and the fact that the vertical stress in bottle-wall transfers through mortar to a great extent. As a result, when its defects are taken into consideration, the block-wall constructed without cement layers shall see stress concentration developed.
- From a general perspective of structure design, brick wall constructed without cement layers bear much less capacity against tensile stress than those with cement layers though rather thin. Under loads like strong wind, earthquake, or change in structural component, block-wall houses are much more likely to fall.

To conclude, bottle wall has a higher load bearing capacity than brick wall, and is thus advisable to use bottle wall to construct house in Chamazi.

4.1.6 The bottle house as a cheaper solution

To conduct the cost evaluation of constructing a house mainly using the bottle wall technique, a cost list of a full house when it was built in 2011 was utilized. Then a text spreadsheet was generated in the software of MathCAD, where all variables can be defined and changed later, and the result will automatically update itself accordingly. The cost estimation about the new design was based on the latest price of material in Tanzania in 2013. Given the high inflation rate in Tanzania, the price for material had gone up about 30% between 2011 and 2013. So, the actual cost for a full house in 2013 would be 1.3 times of the price in 2011. With that in mind, a comparison was carried out between the cost of the new design and that of the existing full house, and the calculation indicated that the new design of house constructed mainly using bottle wall, which had a bigger plot area and a bigger roof area but with almost the same floor area, can save up to 20% of the total cost compared to the cost of a full house.

For more detailed cost estimation, please refer to the calculations in the appendices.

4.1.7 Lesson learned from Project Chamazi

From a building design point of view, the project serves as a good example of rigorous engagement of the stakeholders, especially the actual users (who are also the house owners). The initial design, which was made solely for the purpose of sheltering, was expensive to build, and didn't take into consideration the possibility to change use in the future. Upon receiving these feedbacks, the architect introduced the "building with flexibility" concept by proposing the solution of incremental housing, allowing house owners to take up the building plot with their own priority of usage, and complete the construction at their own pace, which would in return, alleviate the financial burden of the families. The bottle house solution, which was later proposed by another design team, took the initiative even further by strategically aiming at both improving the comfortability and durability of the house and most important of all, bringing down the construction cost (see Figure 4.8), turning the house from a pricey dream to an attainable and decent property, the backbone of a prospective community. Although the two modifications made to the design was done by different person/organization with different focus and approach, the guiding principle remained consistent: none of the above radical changes would've been made possible unless user phase experience from a real estate/FM perspective was acknowledged and utilized.

In an even broader sense of social development, the research on the engineering feasibility of bottle wall, which was based on scientific simulation, was a precise result and can guarantee a properly built bottle house to be stronger and more durable than a normal brick house. Since it is more durable, it is also environmentally and economically beneficial in the long run. The research on the economic feasibility of bottle house on the other hand, was based on cost estimation, and proved a considerable reduce in cost, but given the fluctuation in material and labor price caused by the inflation in Tanzania, it could not guarantee a 20% saving in building cost. The bottle house, which was built mainly with bottle wall, had a higher bearing capacity as well as a lower building cost compared to a full house built with inter-locking bricks. Since plastic water bottles are non-degradable, easy to collect and cheap to use. By constructing a bottle house, people can explore new building techniques together while saving money and reuse resource, the benefit of bottle house construction is socially positive, economically feasible, and environmentally friendly (Jiang (2013)).

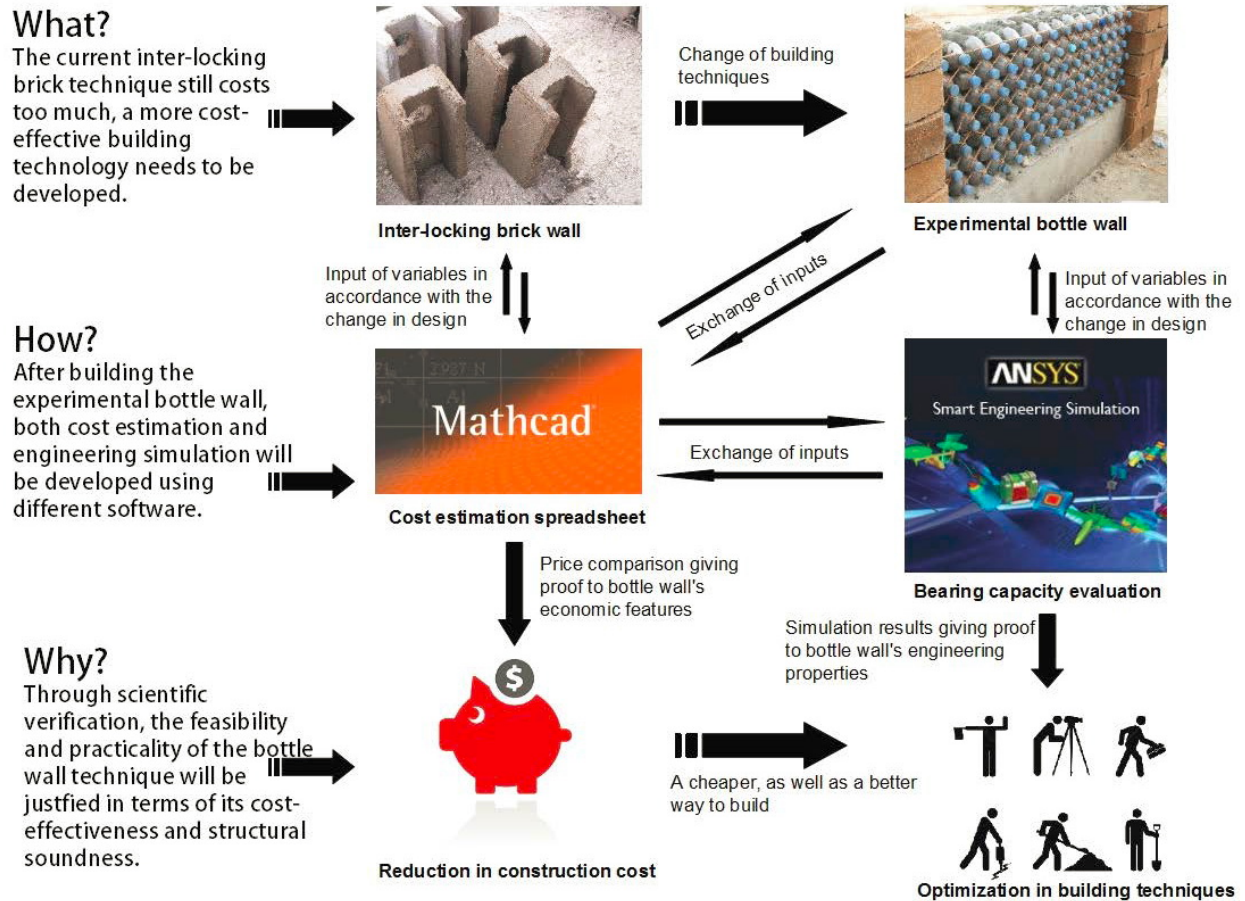


Figure 4.8: The work flow within and between the two objectives of Project Chamazi - building better house, costing less money (Jiang (2013))

4.2 Case Study - Syracuse: Rethinking Building Design

4.2.1 SyracuseCoE in a nutshell

Located in downtown Syracuse at Upstate New York, USA, the Syracuse Center of Excellence (SyracuseCoE) is a federation of more than 200 businesses and institutions that collaborate on sustainable innovations to improve built and urban environments (see Figure 4.9). SyracuseCoE partners work on research, development and educational projects relating to clean and renewable energy, indoor environmental quality and water resources (SyracuseUniversity (2009)). SyracuseCoE opened its Headquarters, with a dedication ceremony on March 5, 2010. The HQ's award-winning design is meant to showcase and create a test bed for innovations in

environmental and energy systems. This LEED-Platinum has both laboratory and office space for research and business collaborations on innovative products and services in SyracuseCoE's core focus areas of clean and renewable energy, indoor environmental quality, and water resources ([SyracuseCoE \(2015\)](#)).



Figure 4.9: The Syracuse Center of Excellence (SyracuseCoE), photo by: *Ivan Baan*. Housing 5,110 square metres of lab and classroom space, the Center of Excellence provides state-of-the-art lab space for pioneering research. The structure's green innovations provide these amenities with low environmental impact. To cut electricity use, a narrow building profile maximizes the penetration of daylight; windows employ glazing and automated microblinds to reduce glare; and lighting is activated by sensors in response to need. Rainwater reclamation supplies all toilets and the irrigation of the green roof. Radiant heating and cooling, natural ventilation and a geothermal borefield of 49 wells reduce the climate control's demand on the grid. Rapidly renewable materials were used wherever possible, including in the insulation. Even its site – formerly a brownfield contaminated with chromium, oil, and asbestos – has been renewed to represent the revitalization of an entire neighbourhood, a dash of green in an area once in danger of falling off the map. ([Dick-Agnew \(2011\)](#))

4.2.2 Motivation for redesign

SyracuseCoE's excellence is not only present in its outstanding sustainable features and unique architectural forms, but also in its own design process, which showcases a good example of an

unconventional work flow of integrated design. For example, the users expressed their wish to have the building's cooling and heating system powered by renewable energy, and was suggested by the mechanical engineer to adopt the heat pump solution. Normally the HVAC equipments are installed after the completion of the structure. Yet, in the SyracuseCoE case, its customized heat pump would end up too big to be moved into the basement and installed after the structure is finished unless part of the structure was demolished to make way for the heat pump if the design team followed a traditional design process. Luckily, the design team adopted the integrated design process from the very beginning, the mechanical engineer foresaw this problem and communicated the problem to the architect and structural engineer. And as a result, during the construction, the heat pump was moved in before the basement was capped with ground floor, thus shortened the construction period, lowered the construction cost, and most important of all, reduced waste and environmental impact.

To have a qualitative and quantitative understanding, as well as gaining a hands-on experience on the integrated design process, a virtual design studio (VDS) was carried out between Syracuse University's school of Architecture (SOA), L.C Smith College of Engineering and Computer Science and Nanjing University's School of Architecture and Urban Planning during the 19th and 30th of May, 2014 at Nanjing University in Nanjing, China. The VDS is a software platform currently under development at Syracuse University in support of an integrated, coordinated and optimized design of buildings and their energy and environmental systems. The project procurement, supported by the US Department of Energy, is intended to assist collaborating architects, engineers and project management team members throughout from the early phases to the detailed building design development. The platform helps to facilitate the work flow and the processing of information in combination with appropriate, task based performance simulation tools ([Zhang \(2014\)](#)).

4.2.3 Redesigning SyracuseCoE through an integrative process

Five students (an architect, a civil engineer, a structural engineer, a mechanical engineer, and a system engineer) were assigned the group assignment of redesigning the SyracuseCoE in a way which they believed would even better fit SyracuseCoE's designated function and highlight its green initiatives, which means that they had to come up with a design not only would keep the

existing sustainable features of the building, but also create new features that were expected add to the user experience of the building.

After recapping the status quo of the existing SyracuseCoE, the design team started a charrette to identify the major design objectives to be achieved in the delivery:

- Create more interactive space
- Maximum south-facing daylighting in winter
- Enable the building to have accessible roof top with strong visual impact from highway
- Optimize natural ventilation

And based on these above objectives, the design team brainstormed around the following categories of metrics which were considered most relevant (detailed metrics not presented here):

- Solar orientation
- Natural ventilation
- Noise insulation
- Programming and zoning
- Safety

When it comes to division of work, the design team was well aware that dividing work load based on nature of task would be practicing the old design process all over again, during which work is passed on linearly without having too much communication in between. Therefore, according to each team member's strength of knowledge, the design team decided to work in a more interactive manner:

The architect would still be the person overseeing the project, but not making the calls. Site analysis was constantly carried out between the architect and mechanical engineer and building technologist regarding issues related to mechanical systems and climate research, which would yield the rationale for interior zoning. The building technologist would also propose suggested

construction material, which would have to be approved by the structural engineer. All the decisions made were then fed to the civil engineer in terms of simulation diagrams and tables of calculation. The civil engineer would then assist the architect in reinterpreting all the technicalities into architectural drawings and diagrams which were more rich in information yet easier to understand by anyone without a profound engineering knowledge. Figure 4.10 below illustrates the work flow within the design team:

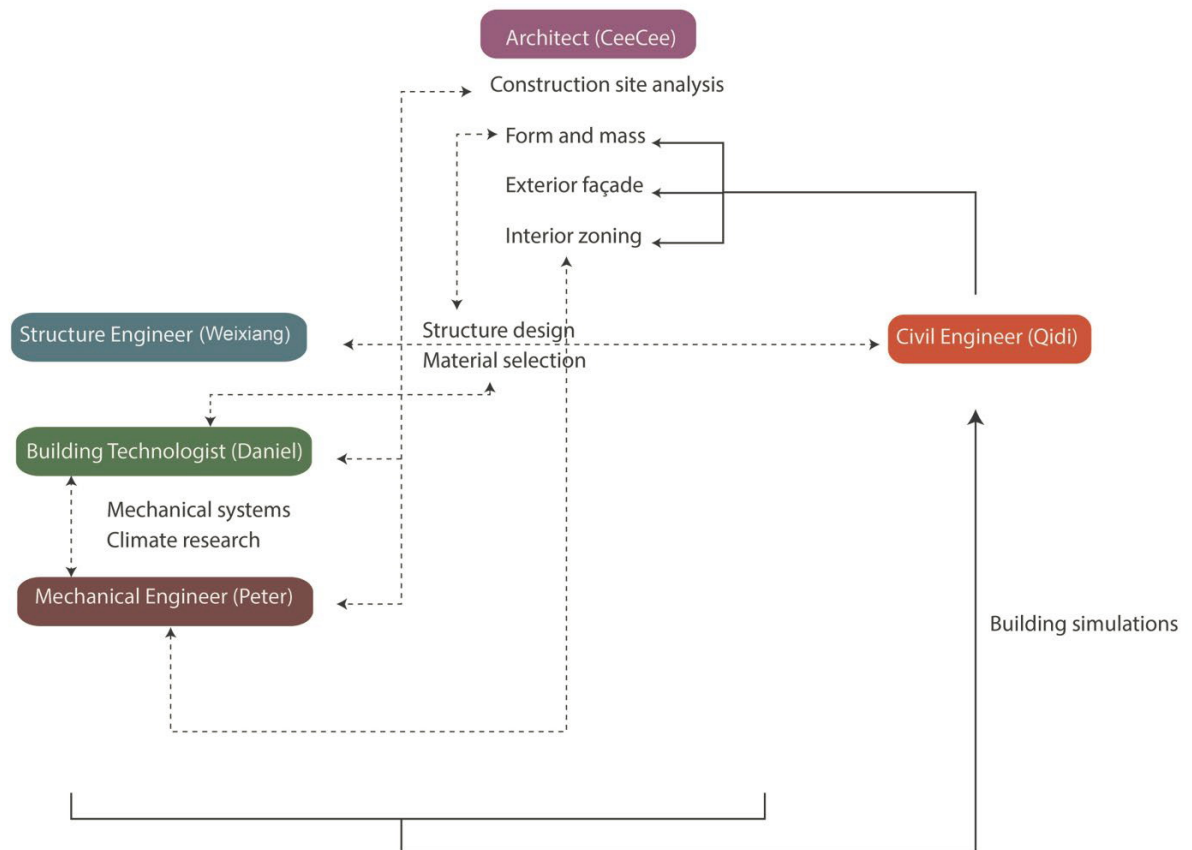


Figure 4.10: Work Flow within the Design Team (Jiang et al. (2014))

This unconventional work flow created a very positive team dynamic among all the members that each design proposal was iterated within the overall design process and examined by each team member in terms of feasibility and efficiency. For example, the architect wanted to make sure the SyracuseCoE can be part of the winter landscape since the city of Syracuse is so famous for its massive snowfall during winter. Inspired by Bjarke Ingels' Amager Resource Center in

Copenhagen, the civil engineer suggested modifying the building's green roof into a downhill skiing slope (see Figure 4.11).

Views from highway



Figure 4.11: From left to right: the "before" and "after" street view of SyracuseCoE, the building's architectural form was modified in a way as such its green roof will be more accessible to the public during all seasons. (Jiang et al. (2014))

Upon reaching the agreement by all team members on the skiing slope idea, the civil engineer consulted with the structural engineer to come up with the structural plan for the length, width, and angle of the slope of the green roof, as well as the positioning of structural elements such as columns, beams, and floor panels (see Figure 4.12).

Up to this point, the building technologist would also have to communicate with the structural engineer regarding the orientation of different parts of the building and the material of its different facades so that the building would reach the highest possible level of natural ventilation, maximum natural lighting during winter, and minimum heat up in summer, structural engineer would change some of the structural elements accordingly (see Figure 4.13).

All these adjustments with their respective reasoning were fed back to the architect, who would then, in accordance with these adjustments, tweak around the volume, angles, and edges of the building, and before it was finalized, the architect also had to check with the mechanical engineer on the massing and zoning (see Figure 4.14) to see if the space was too harsh on the

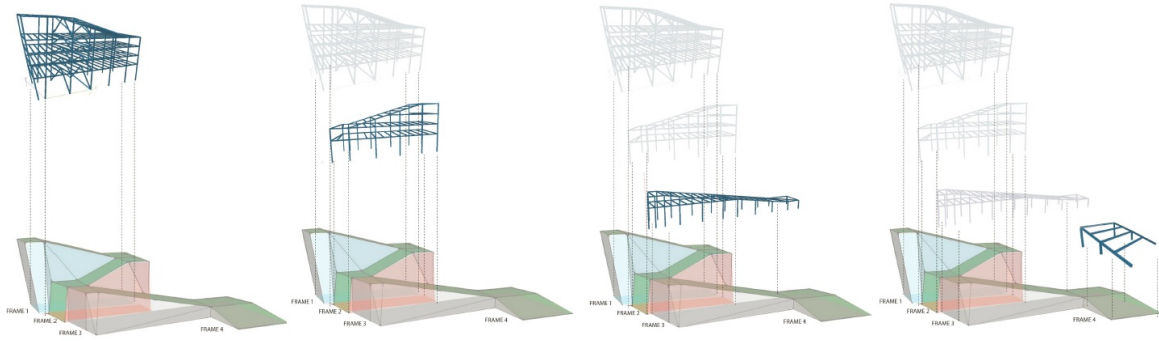


Figure 4.12: Structure partitioning of redesigned SyracuseCoE. Due to huge difference of self weight and load in different parts of the building, which could cause uneven settlement in the footings, as well as uneven stiffness, the whole structure was divided into four frames. (Jiang et al. (2014))

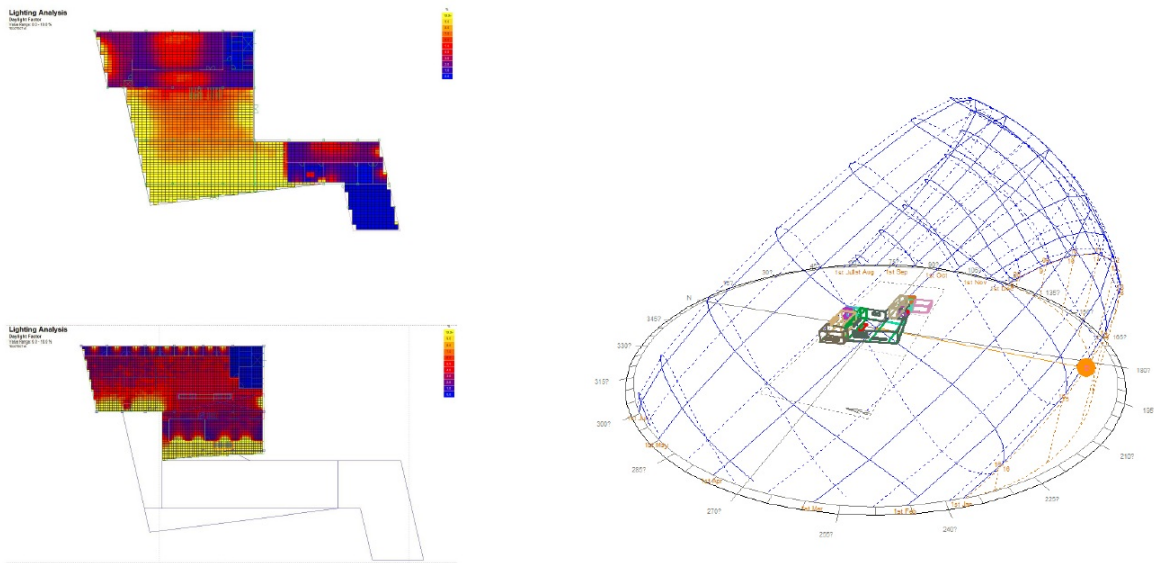


Figure 4.13: Simulation of sun path during winter on different floors of SyracuseCoE (Jiang et al. (2014))

wiring and piping for the HVAC system, and make further changes where necessary.

4.2.4 Rethinking design through redesign

The above mentioned interactive team dynamic was triggered by an intention to meet the criteria proposed by the users, namely to keep the existing sustainable features such as green roof of the building while adding to the user experience with more innovative solutions. Then, this

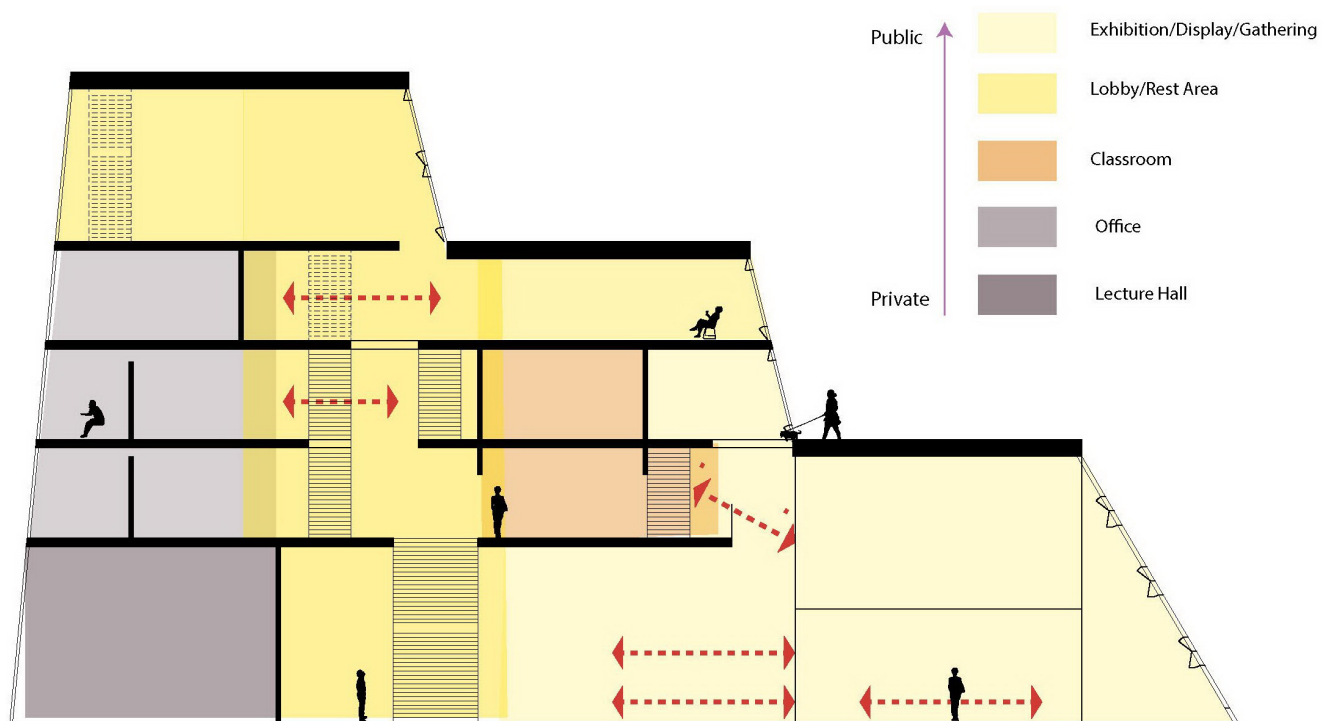


Figure 4.14: Massing and zoning of redesigned of SyracuseCoE: creating interactive space (Jiang et al. (2014))

team dynamic gave rise to an iterative design process which further created two frameworks: an intangible framework under which the team could communicate more efficiently and could in turn help improve the iterative design process itself, thus speed up the design progress while reducing wastes; a tangible framework which was evident in the design itself, allowing follow-ups to be carried out more smoothly and easily since all initial design decisions made were already carefully examined by all design team members. All the design decisions made would then be fed back to the users in terms of enhanced user experience, which would trigger another cycle of iterative design process (see Figure 4.15).

4.3 Case Study - Trondheim: Planning the Unplanned

4.3.1 Trondheim, and its building sector

As home to Norway's best technical university - Norwegian University of Science and Technology (NTNU), the Trondheim Municipality at Sør-Trøndelag County of Middle Norway harbors

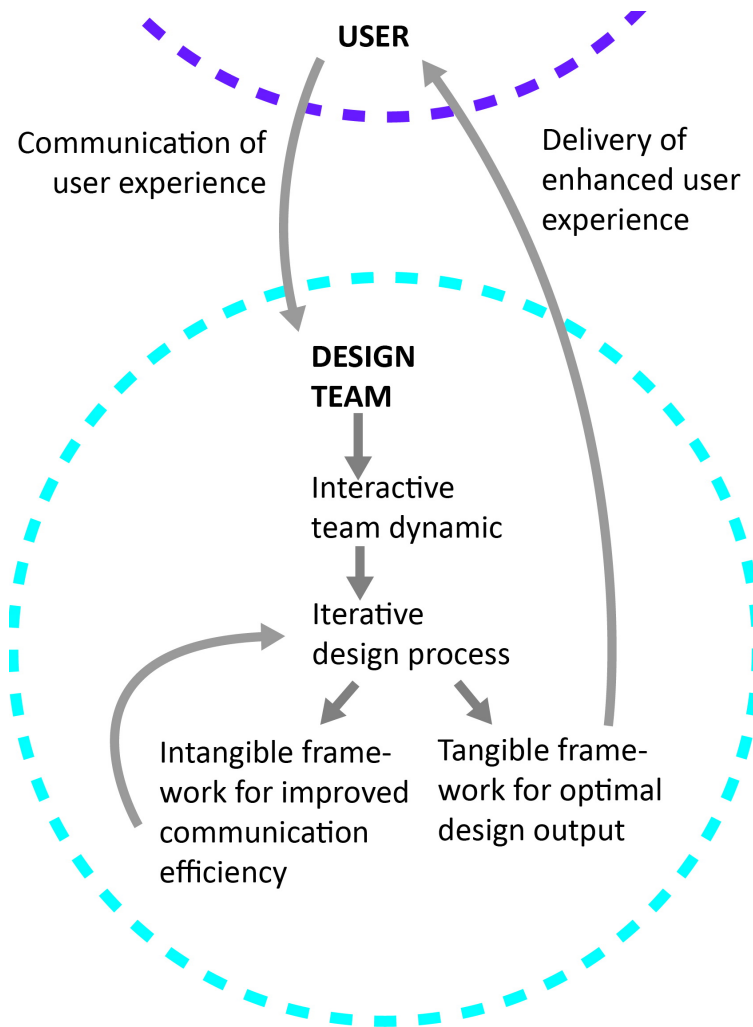


Figure 4.15: The dynamic within the integrative design team and its interaction with the users

a lot of research institutions and companies. It is also Norway's third most populous city (after Oslo and Bergen). Due to this demographic characteristic, there is always a growing demand for better education facilities such as schools, or working space such as office buildings. While the former demand is catered by the public sector as Norway being a welfare state, the latter is usually a spontaneous activity from the private sector. In this case study, interviews were given to stakeholders from both public and private sector regarding their understanding and common practice on user engagement during the early phase of building design. The questioning follows a template as shown below:

About the organization

- Please introduce yourself. Who do you work for? What is your job responsibility?

- Can you tell me more about (name of the organization)?

About the design process

- What would be a typical design process in the projects you've done?
- In which of the stages you described were users involved?
- How did the users involve the design process?

About user engagement

- Do you think it is important to involve the users during the design process?
- Do you think user experience is given enough attention by the designers?
- Would you like to talk about any specific example of user engagement? Like one of the projects you did?

The answer to these questions yielded some very interesting points. Just like there is a fine line between the for-profit/non-profit nature of private/public sector although they both highly appreciate the value of human well being, their opinions towards accommodating all the user needs inevitably differ, although they both try to deliver the best possible user experience.

4.3.2 User engagement in the public sector - Trondheim eiendom

Trondheim eiendom

The property division under Trondheim Municipality, also known as *Trondheim eiendom* in Norwegian, is a government agency that takes care of all the activities related to real estate economy in the region, including but not limited to the proprietary, sharing, sectioning, limit adjustment, taxation, mapping, concession and address assignment of properties ([TrondheimEiendom \(2013\)](#)). Trondheim eiendom has ownership for buildings such as schools, kindergartens, health and welfare centers, health center, cultural and administrative buildings. The municipal entities are tenants in Trondheim eiendom. In addition, Trondheim eiendom is responsible for

approximately 4000 homes in private owned buildings, cooperatives, associations and foundations . In total this amounts to 950,000 m^2 (TrondheimEiendom (2014)). The unit is responsible for:

- Planning and execution of the daily management and operation of buildings owned by the municipality
- Planning and implementation of maintenance of municipal buildings
- Planning and execution of cleaning services in municipal and leased buildings
- Providing expertise in many disciplines through its faculty of building technology
- Collection of rent from housing disposed by the municipality

Trondheim eiendom and local schools/kindergartens

As the designated planner of maintenance for local kindergartens, Mr. M (the interviewee so demanded that he be anonymous in the documentary of this interview) is in charge of planning and scheduling maintenance for local kindergartens, a practice similar to retrofitting in the FM terminology but with a wider range of responsibility also including landscape architecture. His job mostly deals with buildings in use, as the Norwegian building regulation demands a building must undergo regular check up every four years. And all the buildings being checked that year will be ranked on a list of priority for maintenance and upgrading depending on the condition reported by the check up, buildings with least agreeable condition will be given highest priority while those with the best condition are the last ones receiving maintenance and upgrading, which usually involve the building's HVAC (heating, ventilation, air conditioning) system, and automation system (for example, installation of sensors in the kindergartens to help the central control unit remotely supervise and control the room temperature, making sure it is always adjusted to the most comfortable temperature during occupancy).

For any maintenance and upgrading being planned, although it is common practice in Norway that a stakeholder meeting (a meeting similar to the practice of *Charrette* introduced in Chapter 2) be held for such work, only major modification requires such meeting, whereas for

minor maintenance work such as changing of lamp a stakeholder meeting is not needed. For any major upgrading, a total budget will be assigned by the city council to sustain the entire project from the beginning of the planning phase throughout the entire design and building process.

For a new public school or kindergarten to be built, the following procedures shall be performed and different stakeholders are involved during different phases (based on working procedures described by the interviewee during the interview):

- The initial phase: the public express their demand for a new school/kindergarten, or the adjustment of the boarder between two schools/kindergarten.

Stakeholders involved: the public, the city council, architect

- The programming phase: the permission to do so is then granted after the internal discussion within the city council based on the financial situation, for there is always a constraint on total budget for new projects. There is a same situation on the state level. Such process also takes time, in which, typically if a project is approved, depending on the project size, the actual planning phase will not start in another three or four years, again, has to be according to the financial situation.

Stakeholders involved: users, the planner responsible for writing the budget proposal to the city council, project owner, architects, the secondary users (such as employees).

- The design phase: the project is then planned in detail. During which time, pre-qualified contractors are also presenting the meeting with their ideas of how the project should be designed. Users are often not involved anymore during the planning phase. Cost is one of the decisive factor in choosing a contractor, the qualification, financial situation of the contractor are also taken into consideration. Normally, the factors concerning choosing a contractor have the following weighing: Environmental impact 20%, comprehension of project objective 20%, budget 60% (estimations/ approximations by the interviewee based on his previous project experience).

Stakeholders involved: project owner, architects, engineers, contractors

- Project phase: detailed planning, construction, project management.

Stakeholders involved: project owner, contractors, consultants, architects. Normally no

users involved in this phase.

(After the last phase of the above mentioned procedures follows the operation phase...)

Note that the project owners are **not** owners to the building but the people who finance the project. And apart from the stakeholders who are directly involved along the design process, usually, the media is also following the entire process the whole time so as to keep the public constantly updated about the project's progress. So in a way, the media is actually the mostly involved party, although it is not a direct stakeholder in the project.

Real cases

- User experience as complement to loss of convention

In one of the school relocation projects, the school being relocated used to have a concert hall in the premises where students held their activities, a facility which is not normal to see in every school, and the students all wanted to have the same concert hall in their new school. Such demand was communicated to the architect at the early design phase and as a result, a concert hall was included in the new school building, where not only the students could hold their activities, but also the residents of local community could utilize such facility at their convenience.

- User experience as correction for faulty prior knowledge

In one of the new kindergarten projects, the architect initially designed a child care room at the center of a playroom, and placed the janitor's storage at the rear of the child care room - a design seen by the architect as an optimal use of space. Yet, such design was seen as problematic by the kindergarten teachers for every time when a janitor needed his cleaning equipment, he had to enter and walk through the child care room get it, which could be quite disturbing to the child caring work. Luckily, such concern was communicated to the architect and the mistake was corrected in the later phase of design. In the final solution, the janitor's storage room was separated from the child care room and placed right next to the entrance of the playroom. Such case serves as a perfect example in which user experience plays an irreplaceable role in designing a genuinely efficient space, for there is always subtle details which are easily neglectable but can fundamentally

undermine the user friendliness of the space.

- User experience as inspiration for optimal design

Also in one of the kindergarten projects, the kindergarten was not so satisfied with the spacial arrangement within the premises in which a small kitchen was inconveniently located in the corridor and teachers from both play rooms needed to take detour to enter the kitchen for cooking (see Figure 4.16, detailed drawing can be found in the appendices).

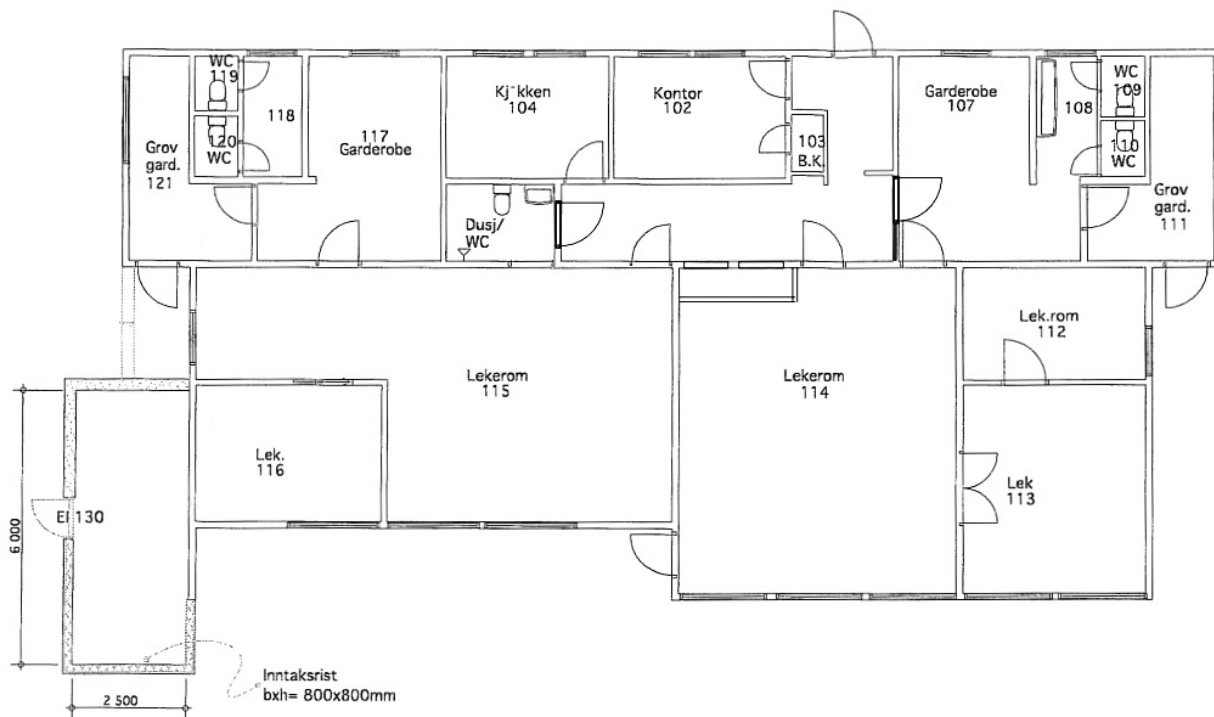


Figure 4.16: The kindergarten's original floorplan (Hol (2014))

So the kindergarten was asking the architect to design a new spatial arrangement in which there would be one small kitchen in each side of the premises so that teachers from either play room could stay in their own side of the building and cook in their own kitchen. Although it was a demand proposed by the kindergarten as a client, the architect suspected if it was the optimal solution by questioning the opportunity for communication and linkage. The architect was convinced that two identical kitchens will not only hinder the effective use of space, but also discourage the communication from both sides. Therefore, the architect decided to keep the one-kitchen design but relocated the kitchen to the center of the floor plan, and made it into a big kitchen with two slide doors connecting each side

(see Figure 4.17, detailed drawing can be found in the appendices). Such plan not only made the kitchen more accessible by teachers from both play rooms, but also created a social space during work break. Yet, if it was not for the original imperfect design with passable user experience, the architect might not be inspired to come up with final and optimal design.

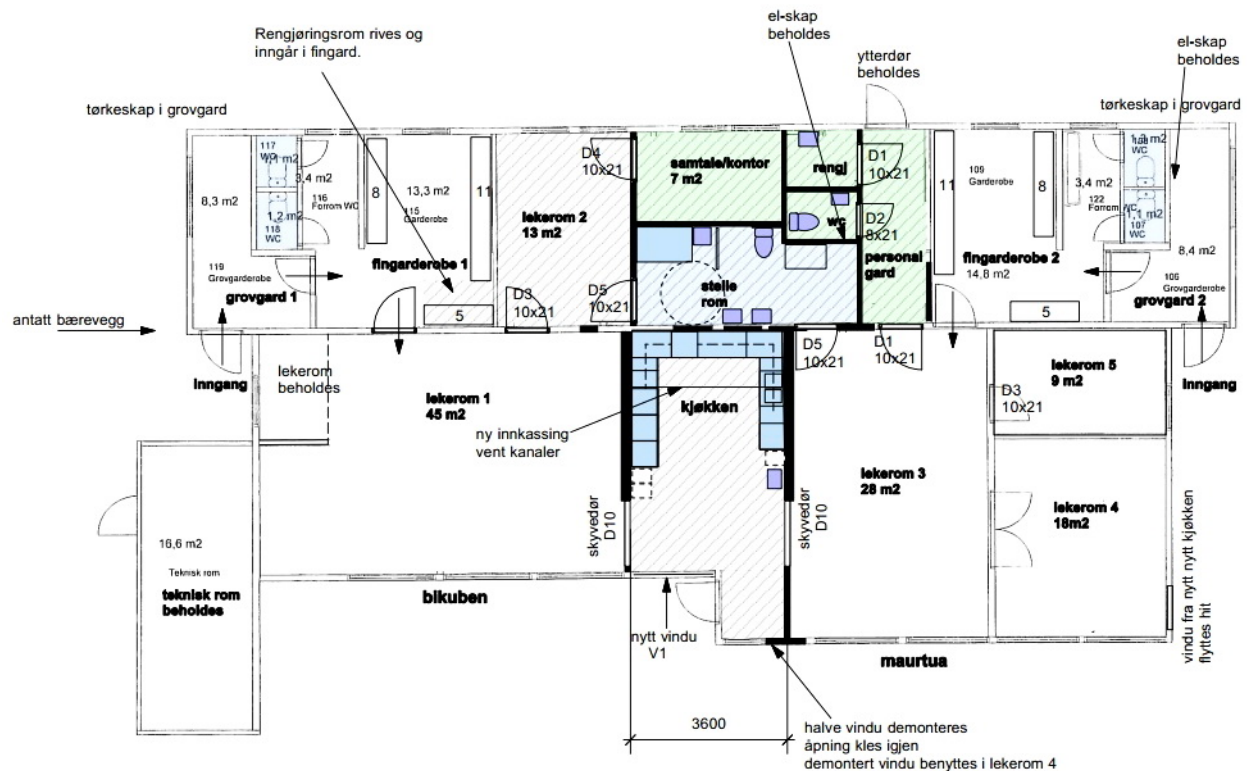


Figure 4.17: The optimal floorplan proposed by the architect (Hol (2014))

From a planner's perspective on user engagement

When it comes to users' influence over a project, it is believed that such influence is strongest at the programming phase. However, users don't have that much saying later on in the process simply because they are not given enough opportunities to involve that much, due to a concern that the budget will keep rising and exceed its limit thanks to the endless new demands coming from them. Nonetheless, users are, as believed by the interviewee as a planner to be more involved in projects from public sector than private sector, since they all have diverse demand,

and a non-profit public project is meant to accommodate those demands, whereas in a private project, the demands are less diverse under the for-profit guideline.

To sum up, in public projects featured by the construction or major upgrading of schools or kindergartens, user experience is always given enough attention, it has tremendous influence during the early design phase and is playing an important role in shaping the eventual output of the project, in spite of the fact that users are not involved that much in the later phases of the design process.

"It's important to remember that the users are the ones we are building for, on the other hand, they are not the ones who are qualified to perform the building projects. The current approach of engaging the users is doing a good job, actually, sometimes I'm afraid they are involving too much."

4.3.3 User engagement in the private sector - Rambøll

Rambøll

Founded in Copenhagen of Denmark in 1945, Rambøll Group A/S (also known as just "Rambøll") is a consulting engineering group with worldwide operations. In 2003 the company merged with Swedish Scandiaconsult making it the largest consulting engineering business in the Nordics (Rambøll (2008)). Rambøll is also expanding its operation in Norway, as a result, the planning of a new office building with an area of 5000 m^2 in Trondheim for 250 employees is underway, the building is expected to be finished in 2017 or 2018. As a senior procurement manager from Rambøll, Mr. Hallgrim Hjelmbrække, the interviewee, was using this case as an example of Rambøll's design philosophy, which in a way reflects the private sector's opinion and practice on user engagement. However, due to commercial confidentiality, detailed information regarding the new Rambøll premises such as design process or architectural drawings was not provided during this interview.

Rambøll's new office building in Trondheim

As an engineering consultancy with a strong architecture division, Rambøll is designing its new company premises in Trondheim without owning it, when the construction is finished, the

company will start its first leasing contract for this premises with the property company for the coming 10 years. During the design stage, requirement framework for the new space is made, together with architectural drawings for preferred space arrangement, are all part of an "overview". The overview phase is considered the most important phase in the design process, for many decisions made in this phase will directly influence the company's productivity during occupancy in the long run. The overview is then handed over to the property company, who will deliver the construction.

At the moment, Rambøll is proposing the requirement of a new space in both quality (human well-being inside the building) and quantity (cost). The new space will have an area of 5000 m^2 for 250 employees with the flexibility of accommodating up to 310 employees, as the intended range of average assigned area per person is between 15 m^2 and 20 m^2 . The requirement for flexibility should not only present in the area, but also in spatial arrangement. Normally Rambøll employees work in team, but sometimes also work alone on specific aspect of a project. Such flexibility in spatial arrangement of switching between group space and personal space also helps the company in the long run, since Rambøll will rent this space for the next 10 years, by which time many current old employees will be replaced by young ones who like to work together. Rambøll will rent this new space to increase its competence in attracting more good employees as well as helping with its own branding. It is believed that the new space will help employees better communicate inside an interdisciplinary team with its 'landscape' (open space) arrangement. A property company is hence responsible for delivering the optimal solution in space so that future Rambøll employees will have a higher productivity.

Rambøll is very cautious about all the decisions made for the future that each requirement is validated in terms of its benefit before it can be formally proposed. For example, among other requirements from Rambøll regarding the new space there is building-integrated ICT solution. The ICT solution in the new space is supposed to facilitate the efficient communication not only within the space but also remotely with other Rambøll operations globally. The benefit of having a good ICT solution is already prominent today as 30% of the design work for the new space is actually carried out in India, which contributes to a big saving in budget.

Rambøll's perspective on user engagement

Since Rambøll is both the user and the tenant of the space, it thinks the users are the most important stakeholders to be engaged in the early design phase (sometimes also referred to as the strategic design phase). It is believed that early decision based on user experience will not only lead to a flexible solution, but also a more affordable one: if flexibility is not taken into consideration today, it will cost more money to make any change in the future. For example, there might be more employees 10 years from now, so the space should be able to accommodate from 250 people to up to 310 people. Rambøll reserves the option to demand the property company to provide more space with the same standard to those additional employees. However, if the number of total employees decrease in the future, the total area will not change unless otherwise negotiated. The new space will have an environment level of Excellent from BREEAM (Building Research Establishment Environmental Assessment Methodology), as required by Rambøll and factors such as air quality, lighting, canteen, bicycle storage, traffic connections are all considered important. Property companies paying more attention to the future stakeholders will have a better chance in winning the bid for providing Rambøll with the space.

In conclusion, Rambøll believes that the users are the only people who can make ROI (return of investment) for itself, the better the space can support users' work, the better it is for Rambøll's own interests. Such belief resonates with the PRUB (Project-Result-Use-Benefit) model proposed by [Driver \(2014\)](#) in which user experience goes backward and influences the planning of the entire project, which further results in the implementation of project that in turn benefits the user (see [Figure 4.18](#)). Rambøll's emphasis on flexibility is a demonstration of rigorous engagement of future users based on present observation since they are not currently approachable. Without such engagement, the project delivery will become an agreement between the supplier and the owner, leaving the users in a half-way excluded/partly included position ([Hjelmbrekke \(2015\)](#)). Although Rambøll is convinced that it has given enough attention to users, it is still trying to do even better, for it also believes that as a user, it is never too much to ask, and a company's ability to answer it will make a very competitive business.

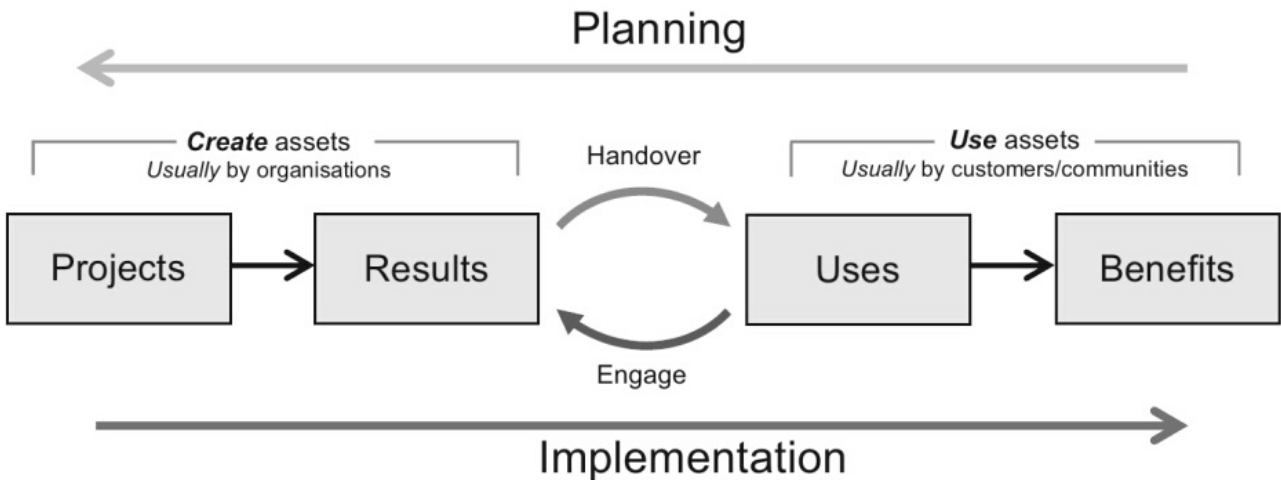


Figure 4.18: PRUB defines the core function of every organization as it interfaces with its customers and communities (Driver (2014))

4.4 Discussion

For each case study, the following observations are gained:

- Case Dar es Salaam: user engagement in sustainable urban development can create solutions which are socially positive, economically feasible, and environmentally friendly.
- Case Syracuse: user engagement can not only help optimize the final output, but also help reorganize the design team in achieving a much higher level of synergy.
- Case Trondheim: **it might be shocking as a fact that** the importance of user engagement is not always considered underappreciated, some sectors actually think quite the opposite at some point, while admitting its irreplaceable significance.

If all of the 3 cases studied in this chapter are compared in terms of social context, economy, project objectives, they will become more than uncomparable with each other. However, if these cases are generalized in terms of level of flexibility allowed in the project, level of user dominance, level of designer dominance, as well as time span of the project, some inner pattern can be discovered:

Assume there is a quantified measurement for the level of user dominance, designer dominance, and flexibility of project, and set the values to be 0-0.5 (low), 0.5-1.0 (medium), 1.0-2.0

(high), all 3 cases can be concluded in Table 4.1 below:

	Flexibility	User dominance	Designer dominance
DAR	1	0.5	2
SYR	0.5	2	0.5
TRD	2	1	1

Table 4.1: Level of flexibility/user dominance/designer dominance on different projects done in Dar es Salaam (DAR), Syracuse (SYR), and Trondheim (TRD)

If Table 4.1 is further converted into a radar chart (see Figure 4.19), three different triangles drawn with different colored lines can be observed, each representing one case study. Now consider the area of each triangle as the time span of project, it is not hard to tell that the time span in an order of long to short would be: TRD>DAR>SYR. Such result gained from the radar chart matches perfectly with the reality, where the projects discussed in case Trondheim will most likely span over 4 years, whereas case Dar es Salaam and case Syracuse's time span is 2 years, and less than 1 year, respectively. A possible explanation to this finding could be that the relation between user dominance and designer dominance is usually (if not always) mutually exclusive. In case Syracuse, the user dominance level was high, and the designer dominance level was low, the user had a very clear goal of what to be achieved in the project, thus led to a low level of flexibility, with that limited uncertainty, the time needed to complete the project was short. In case Dar es Salaam, the users had a need, but were not exactly sure about what they wanted, thus creating a medium level of flexibility while maintaining limited influence over the project as a whole, as a result, the designers had to take a strong lead in the project, and the time span of the project was reasonably long. In case Trondheim, both sides of the users and designers seemed to have reached a delicate balance, they both had a good but not dominant saying in the project, both knew what to expect/deliver, and the level of flexibility was also quite high. Given these factors, a project span of over 4 years seemed to be time well spent.

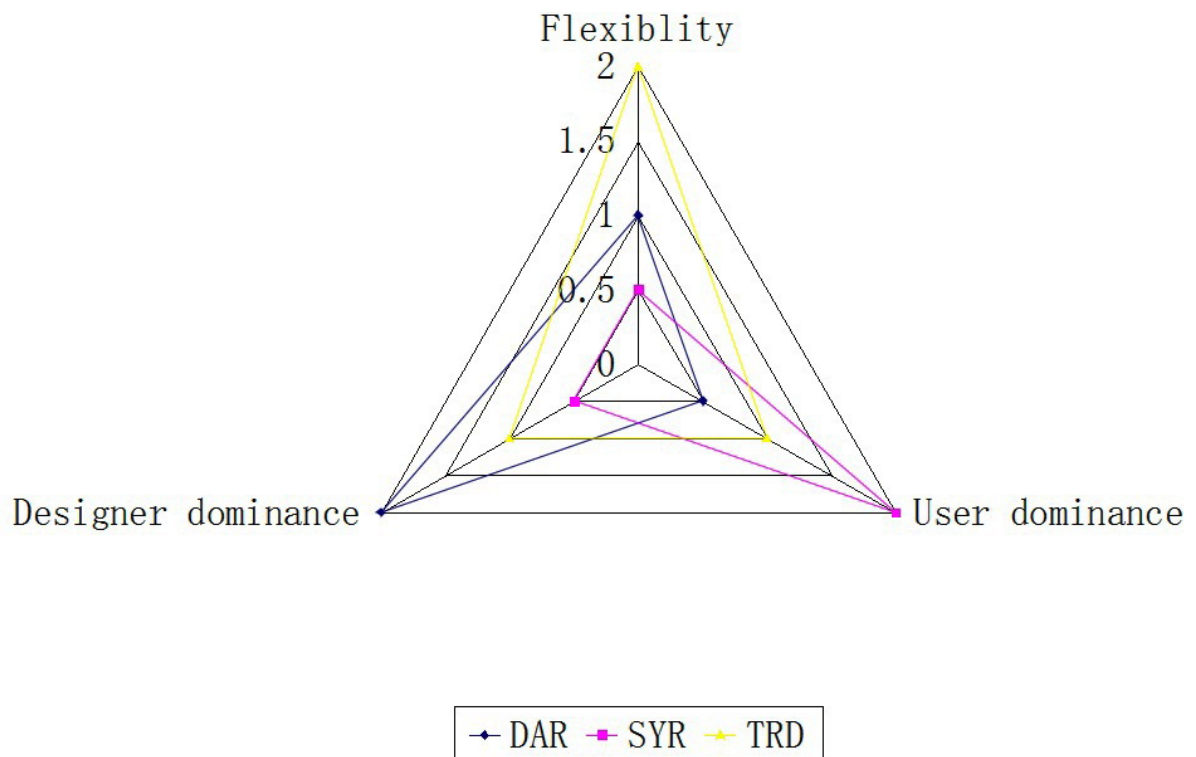


Figure 4.19: Level of flexibility/user dominance/designer dominance on different projects done in Dar es Salaam (DAR), Syracuse (SYR), and Trondheim (TRD)

Chapter 5

Conclusion

5.1 Talking cycles

From the scope of research introduced in Chapter 1 (see fig. 1.3), to the feedback (see fig. 3.1) and the feed forward model (see fig. 3.3) discussed in Chapter 3, and the dynamic within integrative design team and its interaction with the users (see fig. 4.15) described in Chapter 4, this entire thesis talks about the concept of different cycles and the importance of establishing these cycles. Although the topic of the thesis is more about user experience's influence over early phase building design, the purpose of having such topic is to find out design principles which can make buildings more sustainable, and it is at the core of being sustainable that things (including both physical materials, and intangible knowledge or information), while constantly absorbing new elements from the outside, circulate in a cycle. By influencing building design at the early stage with user experience from the later stages of a building's life cycle, the gap between a building's early stage and later stage is bridged (see also fig. 5.1), thus a life cycle is truly closed, opening up opportunities in the sustainable design, implementation, operation, and demolishing/reusing of a building. In nature adapted cyclical developments in the sense of a metamorphosis are quite common. Creatures that have to undergo a metamorphosis, for example, distinguish themselves at every stage by adjusting optimally to their environment. As the general conditions in our society, and consequently for our architectural surroundings, are constantly changing, our buildings must be convertible and adaptable to a certain extent. Only when this is the case does an architectural statement contain potential in the sustainability

sense, which makes it possible for the building to progress into a new life cycle, after finishing the intended life cycle, without the total loss of the energy previously put into it (Petzinka and Lenz (2008)).

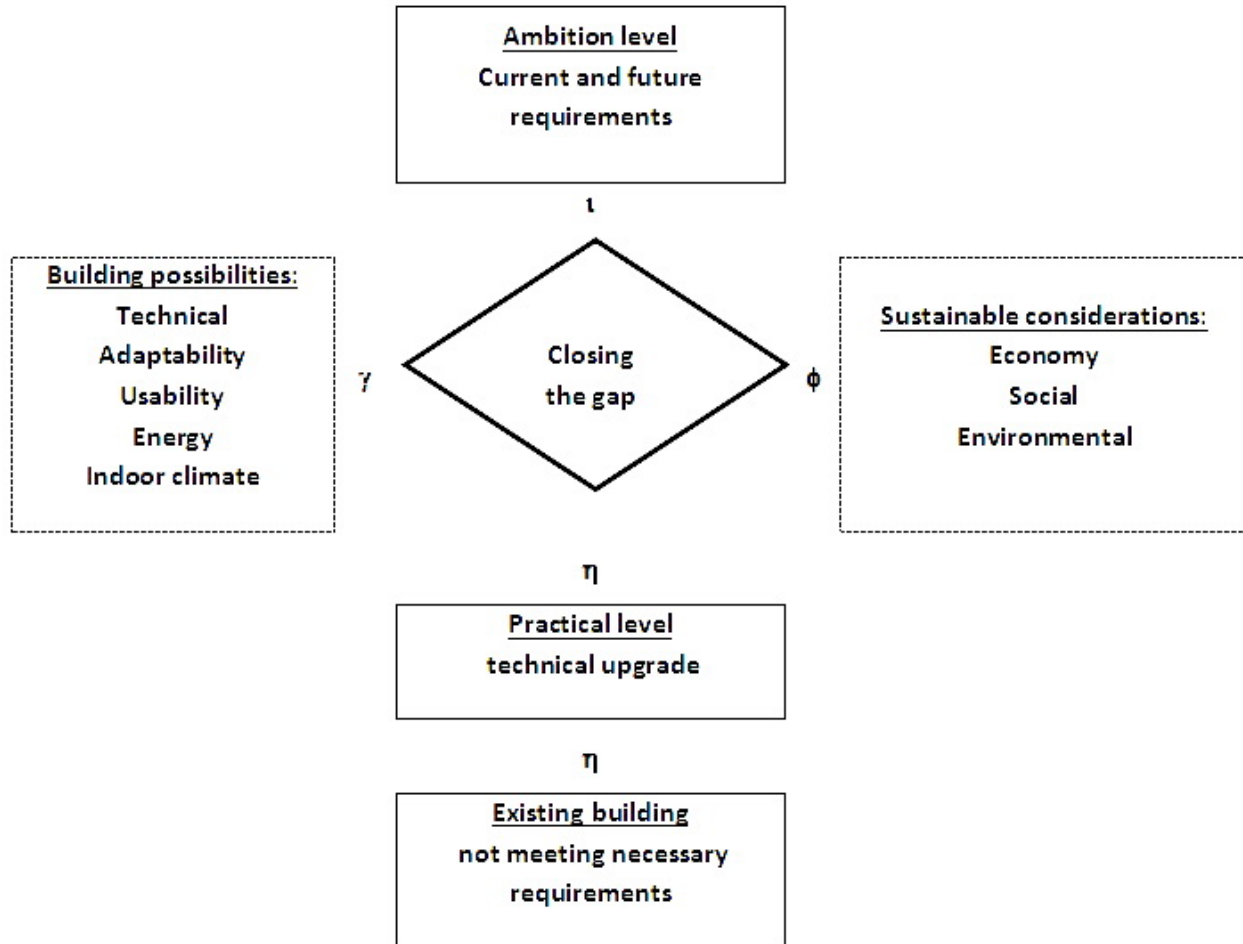


Figure 5.1: The aim of sustainable refurbishment is to close the gap between old buildings condition and new building requirements with a sustainable approach. [NordicInnovation \(2015\)](#)

In one of the unpublished work by [NordicInnovation \(2015\)](#) on sustainable refurbishment, a life cycle spiral of building was proposed, in which a building's life cycle is generalized into the following 6 steps (each corresponding to one number in fig. 5.2):

- Strategic decision: Sustainable refurbishment or only energy upgrading
- Evaluation of the building
- Planning and execution of sustainable demolition

- Planning and execution of sustainable rebuild
- Commissioning: hand-over and start of building
- In use evaluation of sustainability

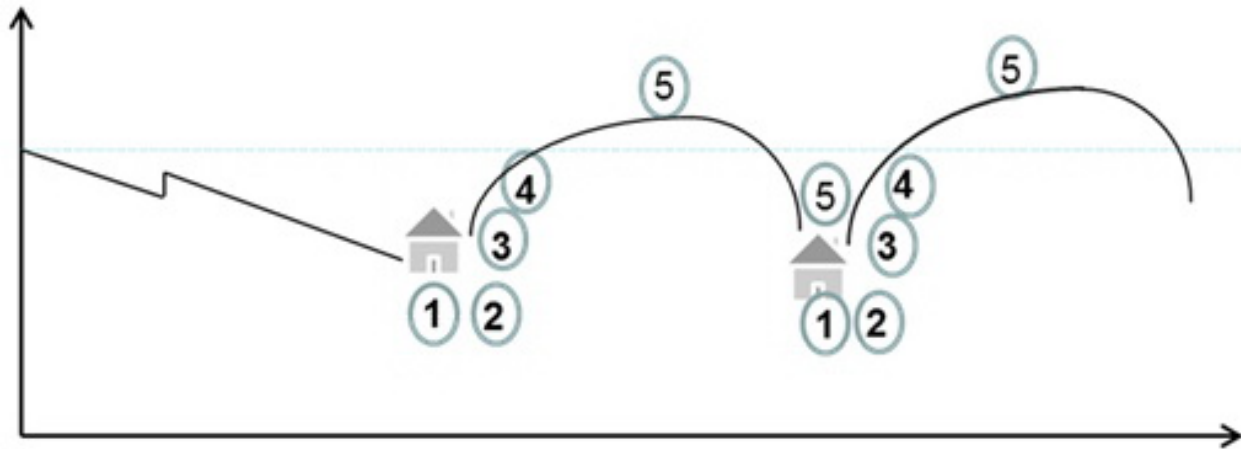


Figure 5.2: Life cycle spiral with 6 steps in each cycle (NordicInnovation (2015))

In fig. 5.2, it is assumed that the chronicle time line is denoted by the X-axis (horizontal), and the building's physical condition is denoted by the Y-axis (vertical). It can be observed that a building's physical soundness decreases with time almost linearly (note the abrupt rise on the straight line, which is caused by generic maintenance during the first life cycle), yet at some point, when evaluation and refurbishment get involved, the tide is turned, upon the implementation of sustainable refurbishment, the building's condition is improved dramatically (in some cases even better than the condition when it's initially completed), the building will continue its service life, or in other words, enter another life cycle instead of being demolished. Such model describes an ideal refurbishing process and provides food for thoughts which inspires the study on locating the spot (also known as the leverage point) on the curve where a minimum input will induce the maximum change. And judging from the curve, the best spot is within the strategic decision stage, namely the early design phase.

5.2 Stimulating stakeholders

The survey documented in Chapter 3 suggests an inconsistency in many building users' perception about building, on one hand, they think it is good for a building to have a sustainable profile in terms of efficient waste management, use of recycled material and so on, on the other had, they care less about the energy efficiency of the building and the GHG emission during the building's life cycle. In some other cases, such as the pilot study Quinta Monroy in Chapter 2, and the case study of Project Chamazi in Chapter 4 all indicate that stakeholders, especially users, can help develop sustainable building projects even under less favorable conditions - as long as they are motivated and believe that what they are doing is not solely out of a good cause such as sustainability, but also for their own good. When it comes to sustainability in the building sector, no goal can be achieved without motivating the stakeholders. Technical innovation alone, as argued by [Plessis and Wallbaum \(2010\)](#), has never been insufficient in keeping up with the demand of sustainability, while motivating the stakeholders to adopt these solutions on the other hand, is another story. The cause to such contradiction is complicated. The building sector for instance, has particularly diverse motives among various stakeholders, a network of interests based on a highly complex system which involves delicate process in design and construction. Such system is, though not intentionally by design, subject to retardation, or even resistance in accepting any radical but meaningful change. Many of the quantitative design metrics used today, which come as either carrots (subsidies, medals...) or sticks (taxes, fines...), are merely regulatory tools doing nothing better than containing the existing problems. Such tools, as described by [Meadows and Wright \(2009\)](#), are the least effective leverage points in a complex system. Changing the stakeholders' worldview, on the contrary, could be the most effective leverage points, and a genuinely sustainable solution. To do that, the building sector itself will have to go through fundamental change in the recognition of some of its "common sense":

- First, a new value system has to be established, which requires the incentives that expand the notion of enlightened self-interest from the individual to the individual as part of the whole world that is shaped by all the interconnected and interdependent systems.
- Secondly, empowering the stakeholders who are of vital importance, yet often underrepre-

sented (such as occupants) compare to other stakeholders (such as developers, architects)

Setting up the right value system and stimulating all the stakeholders by aligning the building's function with the users' core value will create the internal drive that continuously propel the building sector to self-organize and evolve. Take office building for example, in the model for identifying the added value of CREM, [Lindholm et al. \(2008\)](#) proposed 7 strategies (increase value of assets, promote marketing and sale, increase innovation, increase employee satisfaction, increase productivity, increase flexibility, reduce cost) that fall into the two categories of profitability growth and revenue growth, which eventually help to maximize wealth of shareholders. This can be viewed as a classical model which still largely focuses on the economical interests of shareholders. The model proposed by [Jensen et al. \(2013\)](#) on the other hand, allegedly to focus on the same core business value of maximizing wealth of shareholders, but in a more constructive way, which is from a view point more detached from business - by focusing on green FM (Facilities Management) influence. In this model, priorities are given to sustainable factors such as lower risks related to real estate, better indoor environmental conditions, less energy consumption/carbon footprints, and longer service life of buildings.

If the first model was to be adopted to an office building, there will hardly be anything sustainable about the building except for a good business for the company. However, the second model cannot be fully adopted either as users fear that implementing such model will only benefit the environment at the cost of reduced benefit for the company. In this case, the best way to motivate the users is to come up with an intermediate model that combines the two, namely, one that aligns the sustainability goal of the building with the core interests of the users, or in other words, one that adds value to the building, so that the users will practice a sustainable FM spontaneously (see [fig. 5.3](#)).

5.3 A Difficult Relationship

The relationship between building design and sustainability is never as easy as it seems to be. Imagine what kind of a plan would truly succeed, if the people making the plan is having doubt about it? Designing and building sustainable buildings nowadays seems trendy, yet neither the architects nor the public are genuinely enthusiastic about it. Peter Eisenman once said: "To talk

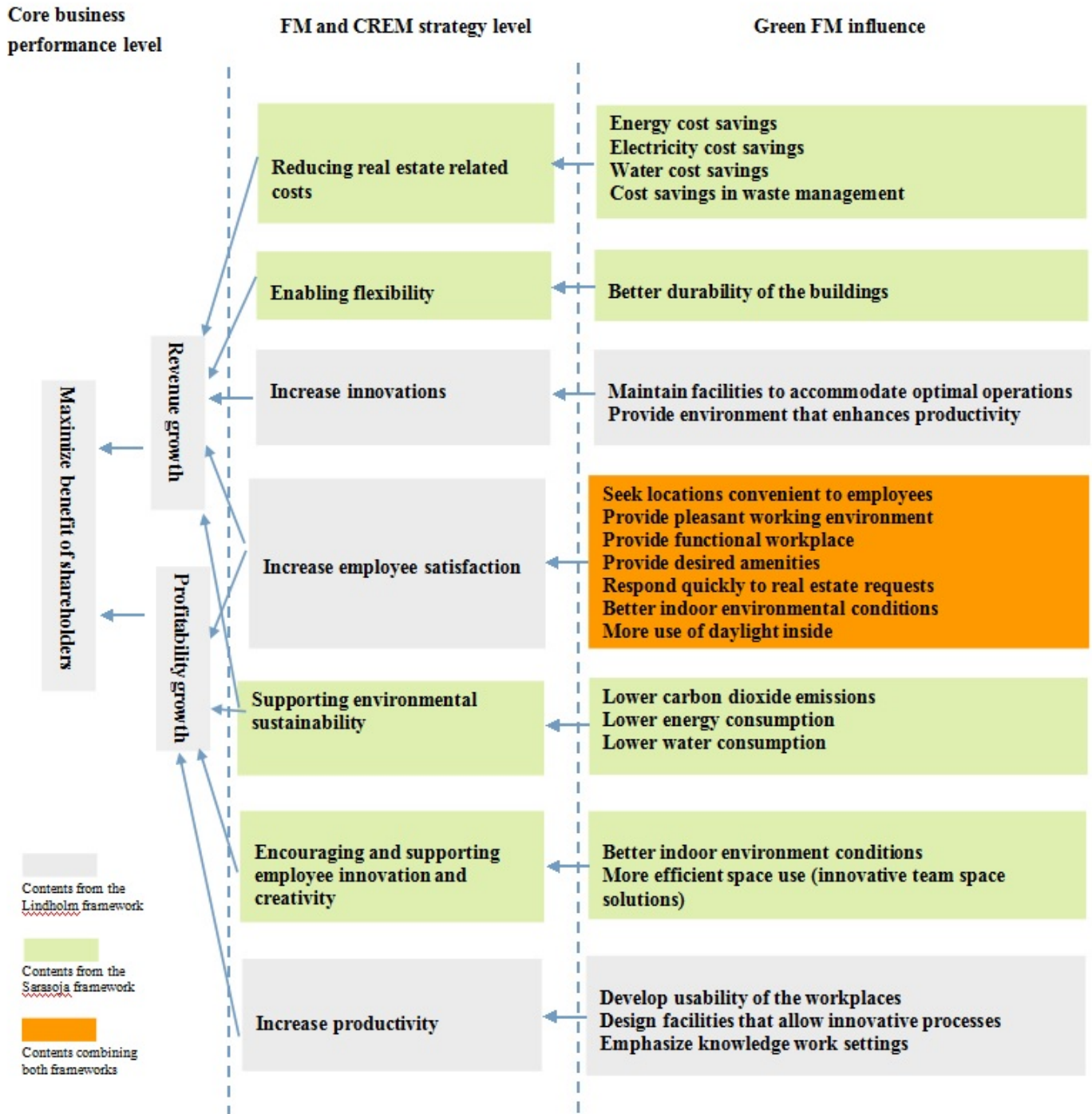


Figure 5.3: Added value of CREM. Jiang (2014)

to me about sustainability is like talking to me about giving birth. Am I against giving birth? No. But would I like to spend my time doing it? Not really. I'd rather go to a baseball game" (Hawthorne (2002)). If this entire thesis talks about how important it is to influence the early

phase of building design and how to do it in a rather rational and objective manner, the very last paragraph might have just broken the sugar coating of the message by bringing up the harsh reality against all the wishful thinking, since even architects don't care that much. But luckily, this also transcends the topic by proving that user experience's influence on the early phase of building design should not only be a technical intervention, but also the catalyst to a culture that is reluctant to change.

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Appendix A

Acronyms & Explanations

AOS average length of stay	GHG green house gas
BCO British Council for Offices	GJTA global job task analysis
BIM building information modelling	HAI hospital acquired infection
BREEAM Building Research Establishment Environmental Assessment Methodol- ogy	IFMA International Facility Management As- sociation
BSC balanced score card	IPD integrative project delivery
CASBEE Comprehensive Assessment System for Built Environment Efficiency	HVAC heating, ventilation, air conditioning
CCI The Center for Community Initiatives	HR human resource
CREM corporate real estate management	KPIs key performance indicators
EBD experience-based design	LCA life cycle assessment
EBCD experience-based co-design	LCC life cycle cost
FM facilities management	LEED Leadership in Energy and Environmen- tal Design
GC general contractor	MEP mechanical, electrical, and plumbing

Muda a Japanese word meaning "futility; uselessness; idleness; superfluity; waste; wastage; wastefulness", and is a key concept in the Toyota Production System (TPS)	ROI return of investment
NTNU acronym for Norwegian University of Science and Technology (Norges teknisk-naturvitenskapelige universitet)	SIA sustainable impact assessment
PFI private finance initiative	SURE sustainable refurbishment
POE post occupancy evaluation	SyracuseCoE the Syracuse Center of Excellence
REC real estate and construction	The Federation the Tanzania Urban Poor Federation
RFI request for information	TPS the Toyota Production System
	UNEP United Nations Environment Program
	UNFPA United Nations Population Fund
	VDS virtual design studio

Appendix B

Additional Information

B.1 Osterwalder Business Canvas

B.2 LEED v4 and Its Connection with USGBC and GBCI

B.3 Different Rating Systems within LEED v4 and the Scoring Scheme under Each Category

B.4 Major Questions from Project OSCAR Survey (original)

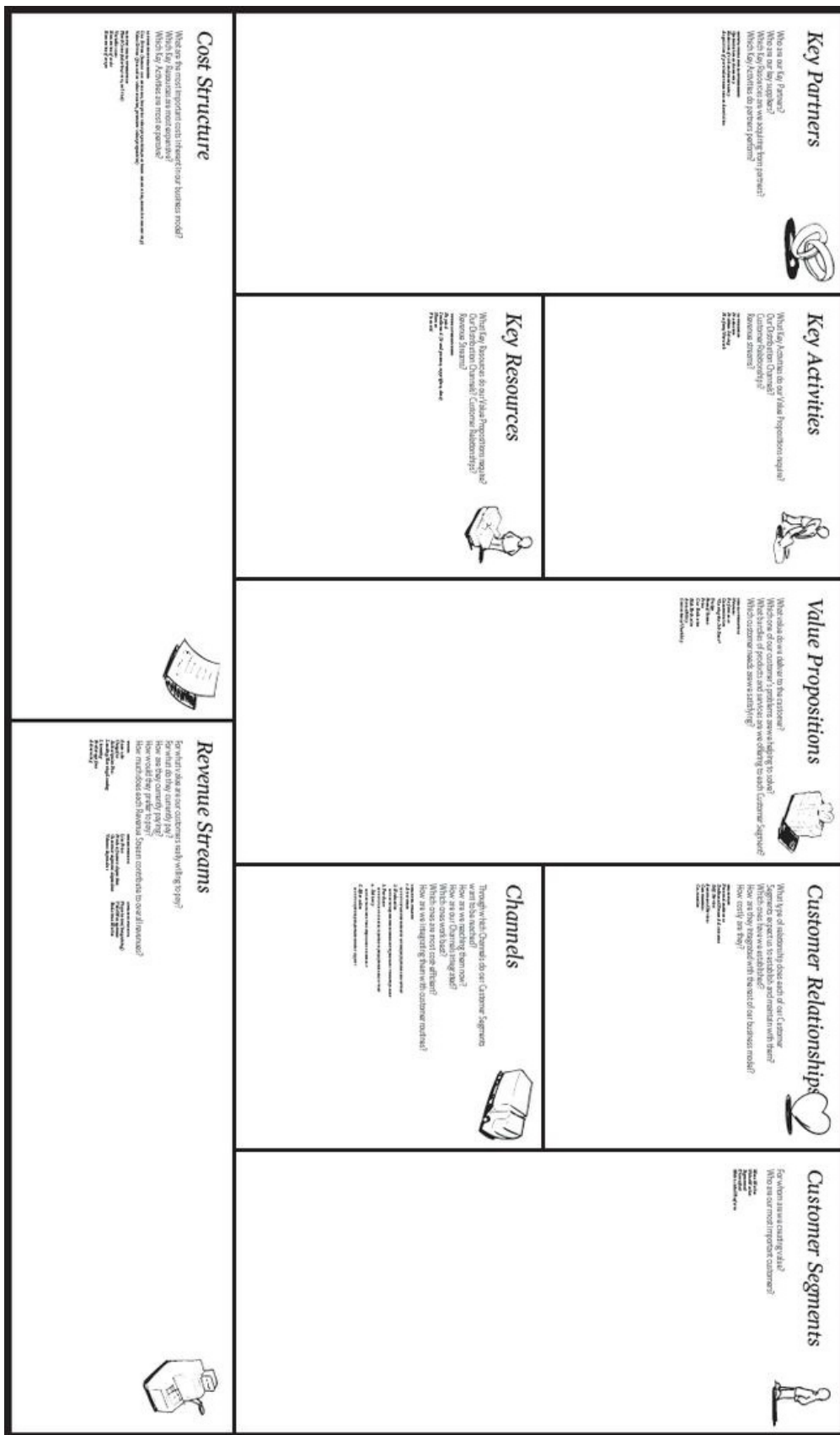


Figure B.1: Osterwalder Business Canvas

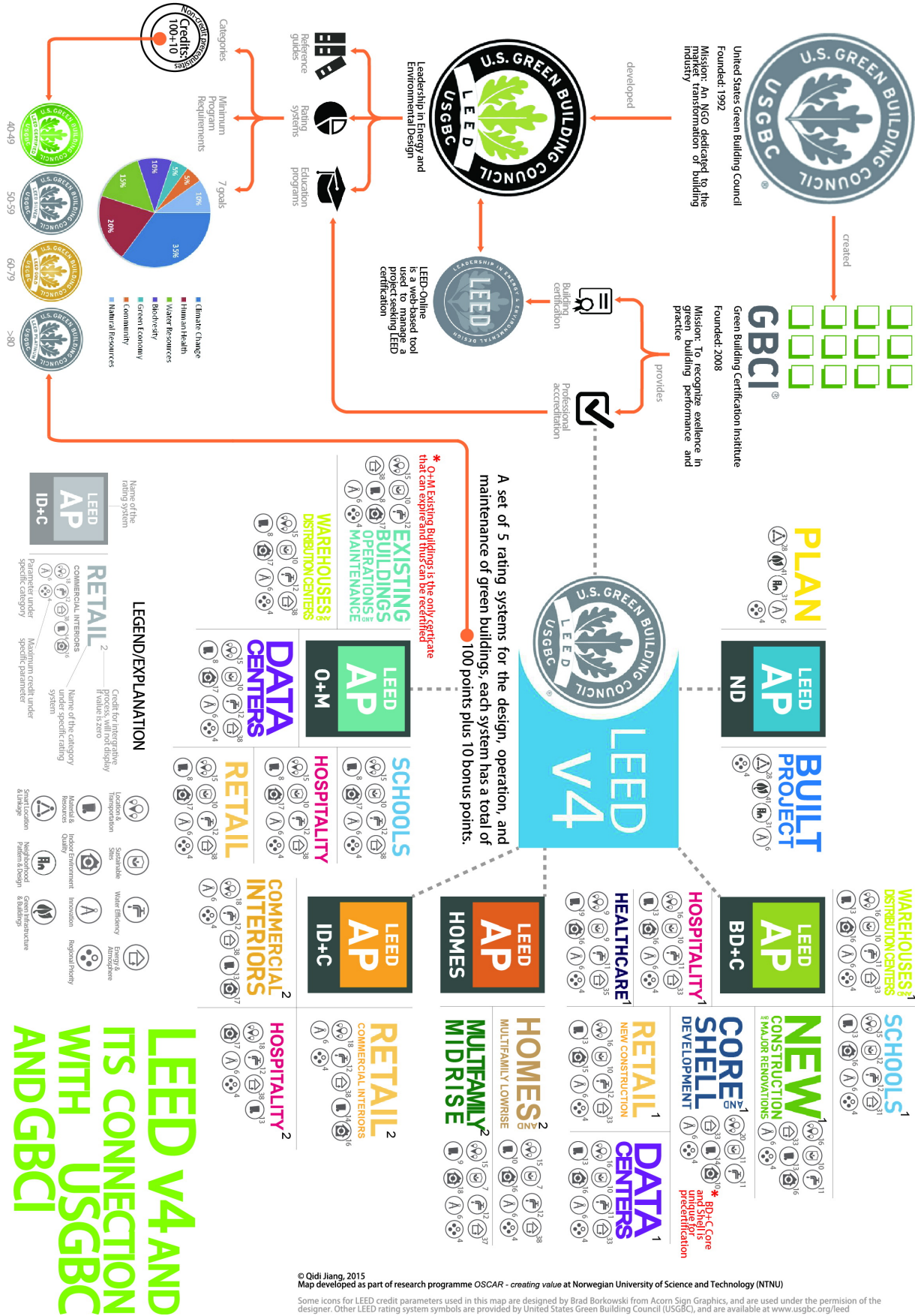


Figure B.2: LEED v4 and Its Connection with USGBC and GBCI

Different Rating Systems within LEED v4 and the Scoring Scheme under Each Category

Rating System	Category	Integrative Process	Location & Transportation	Sustainable Sites	Water Efficiency	Energy & Atmosphere	Material & Resources	Indoor Environmental Quality	Smart Location & Linkage	Neighborhood Pattern & Design	Green Infrastructure & Buildings	Innovation	Regional Priority	Total
Building Design and Construction	New Construction, & Major renovation, & Core & Shell	1	16	10	11	33	13	16	N/A	N/A	N/A	6	4	110
	Schools	1	15	12	12	31	13	16	N/A	N/A	N/A	6	4	110
	Retail	1	16	10	12	33	13	15	N/A	N/A	N/A	6	4	110
	Data Centers	1	16	10	11	33	13	16	N/A	N/A	N/A	6	4	110
	Warehouses & Distribution Centers	1	16	10	11	33	13	16	N/A	N/A	N/A	6	4	110
	Hospitality	1	16	10	11	33	13	16	N/A	N/A	N/A	6	4	110
	Healthcare	1	9	9	11	35	19	16	N/A	N/A	N/A	6	4	110
	Commercial Interiors	2	18	N/A	12	38	13	17	N/A	N/A	N/A	6	4	110
	Retail	2	18	N/A	12	38	14	16	N/A	N/A	N/A	6	4	110
	Hospitality	2	18	N/A	12	38	13	17	N/A	N/A	N/A	6	4	110
Building Operations & Maintenance	Existing Buildings	N/A	15	10	12	38	8	17	N/A	N/A	N/A	6	4	110
	Schools	N/A	15	10	12	38	8	17	N/A	N/A	N/A	6	4	110
	Retail	N/A	15	10	12	38	8	17	N/A	N/A	N/A	6	4	110
	Data Centers	N/A	15	10	12	38	8	17	N/A	N/A	N/A	6	4	110
	Hospitality	N/A	15	10	12	38	8	17	N/A	N/A	N/A	6	4	110
Neighborhood Development	Warehouses & Distribution Centers	N/A	15	10	12	38	8	17	N/A	N/A	N/A	6	4	110
	Plan	N/A	N/A	N/A	N/A	N/A	N/A	N/A	28	41	31	6	4	110
	Built Project	N/A	N/A	N/A	N/A	N/A	N/A	N/A	28	41	31	6	4	110
Homes	Homes & Multifamily	2	15	7	12	38	10	16	N/A	N/A	N/A	6	4	110
	Lowrise Multifamily/Midrise	2	15	7	12	37	9	18	N/A	N/A	N/A	6	4	110

Relationship between final score and certification:
 40-49: LEED Certified; 50-59: LEED Silver; 60-79: LEED Gold; >80: LEED Platinum

Figure B.3: Different Rating Systems within LEED v4 and the Scoring Scheme under Each Category

1. Hvem eier den virksomheten du er ansatt i?

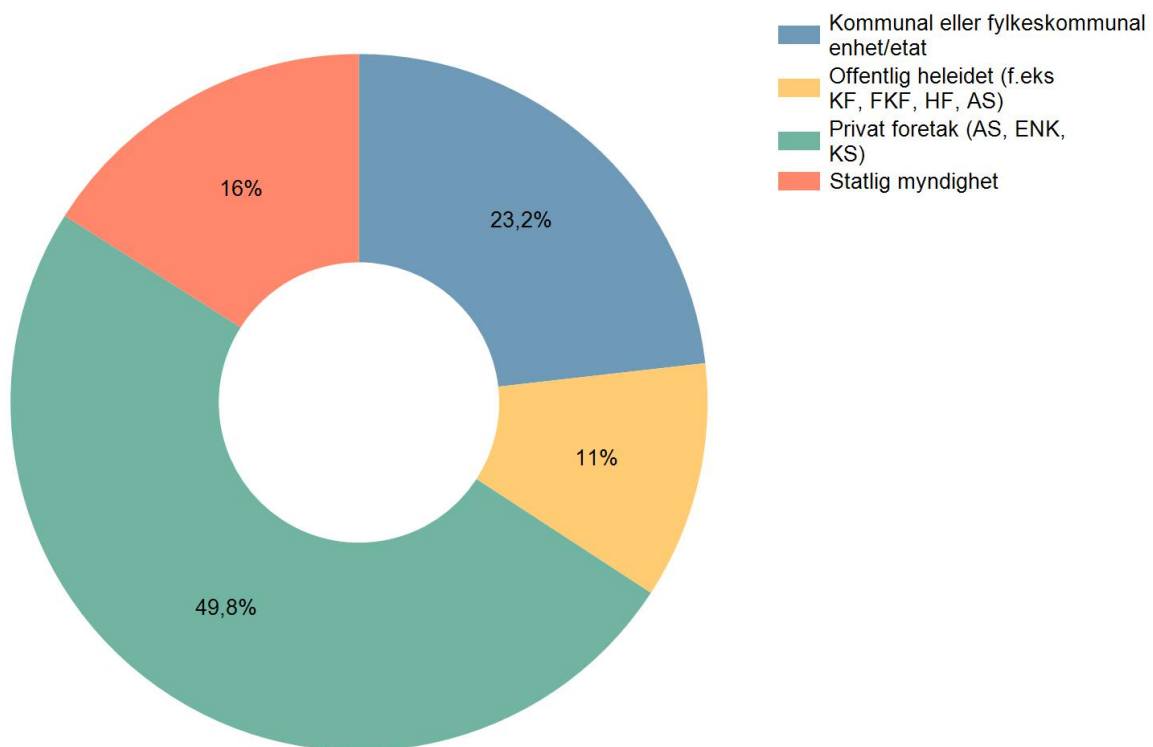


Figure B.4:

2. Kjønn

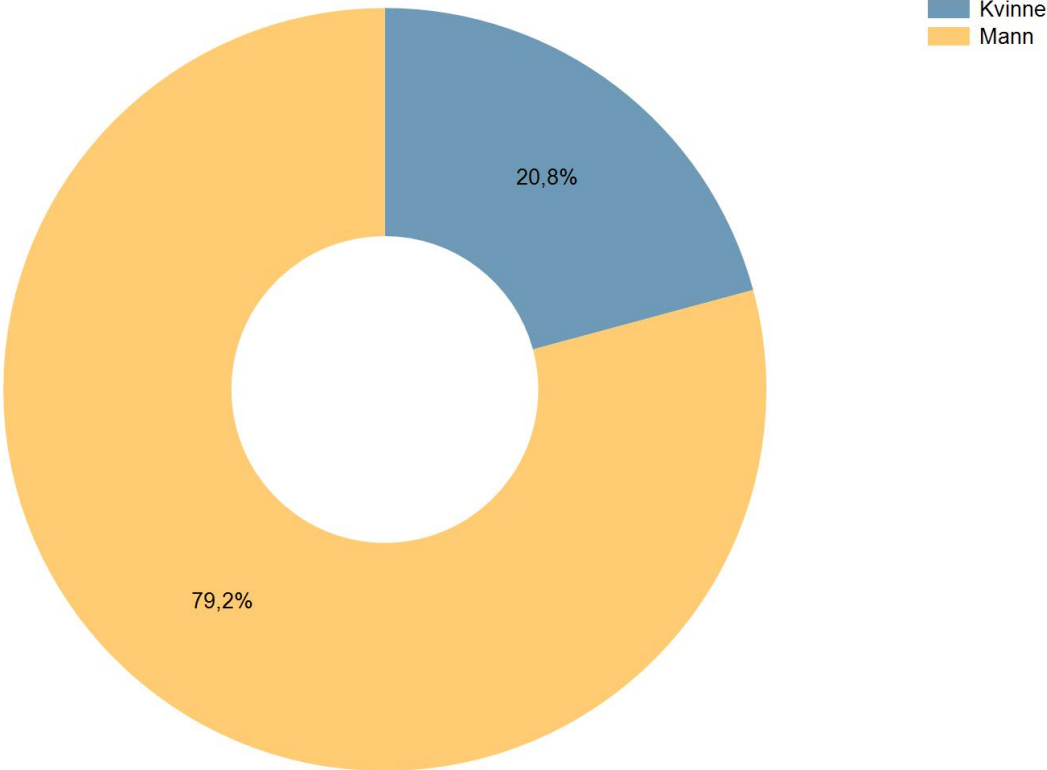


Figure B.5:

4. Hva er din utdanningsbakgrunn?

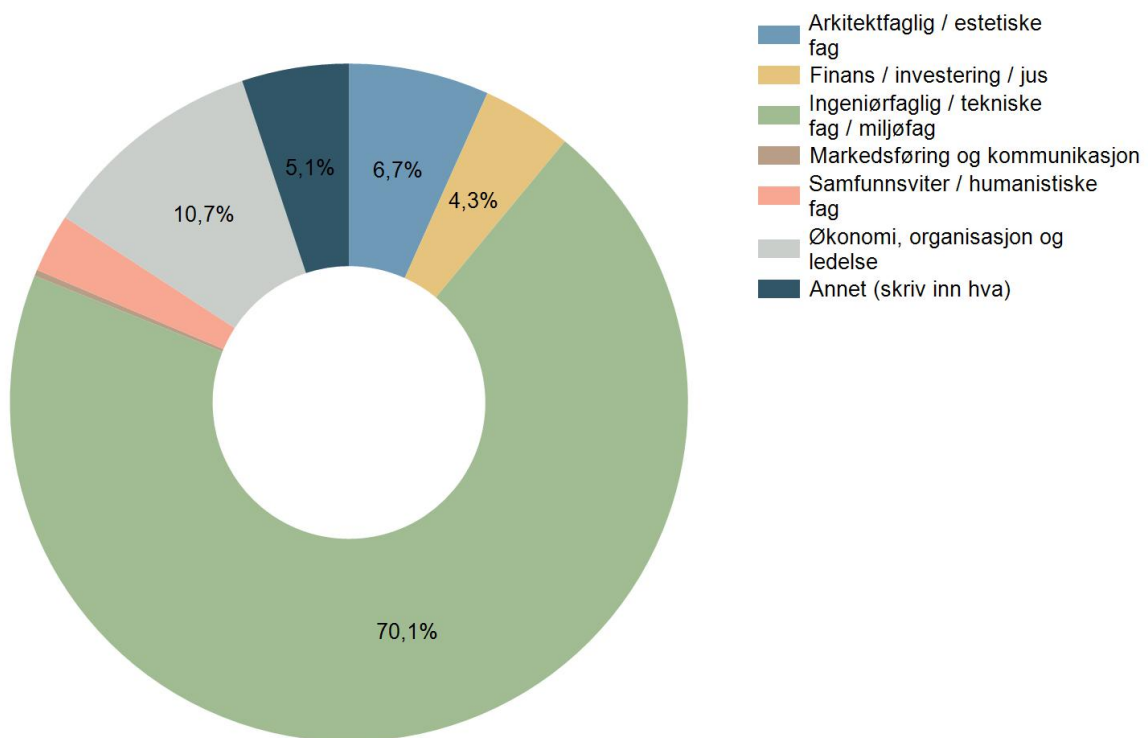


Figure B.6:

5. Hva er din hovedrolle i forhold til bygg- og eiendomsprosjekter?

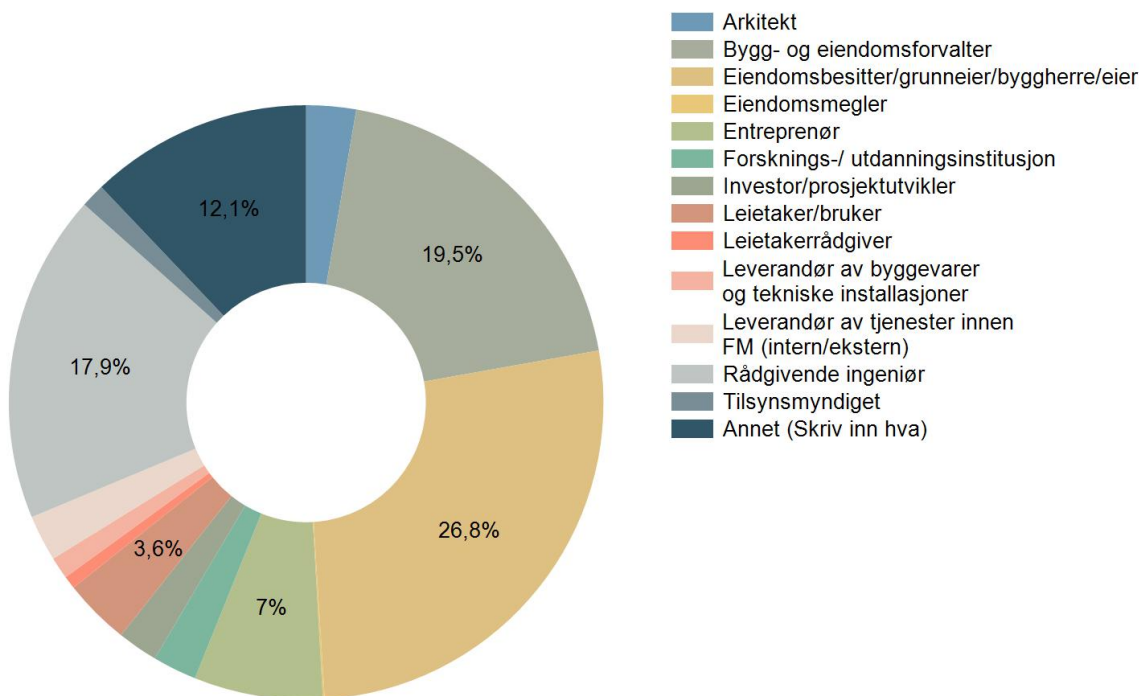


Figure B.7:

6. Hvilken fase(r) jobber du hovedsakelig i?

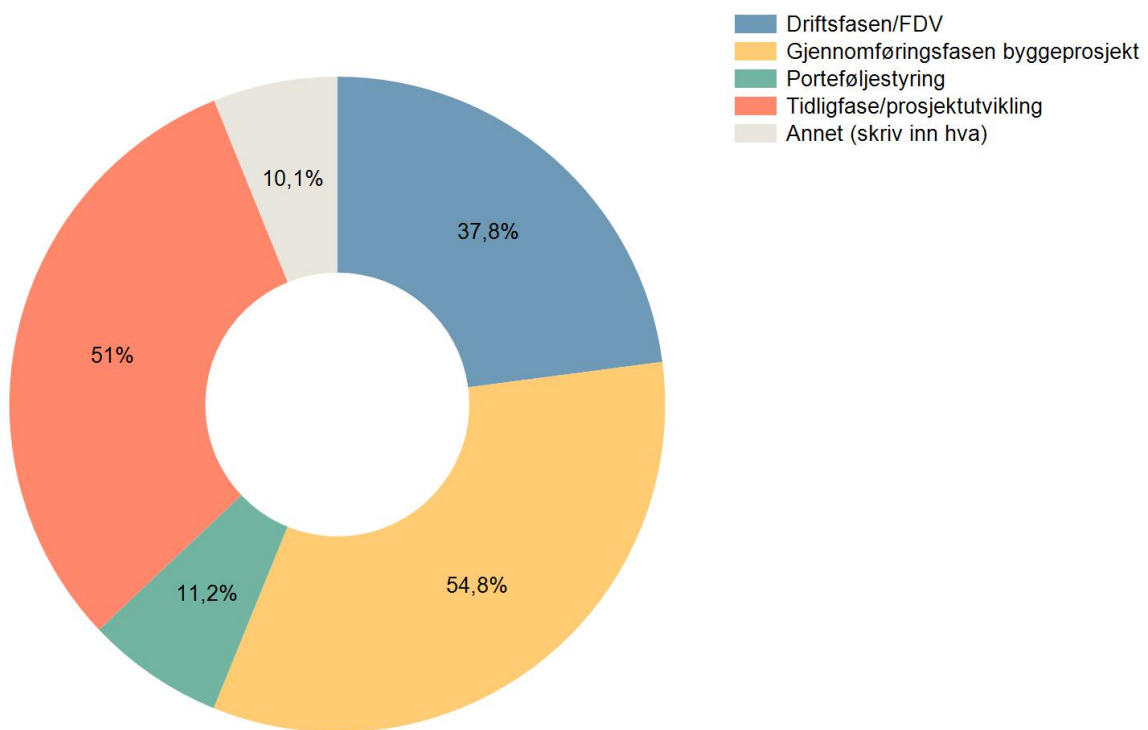


Figure B.8:

7. Hvilke(n) av bygningstypene/-segmentene listet opp under ønsker du å basere svarene dine på?

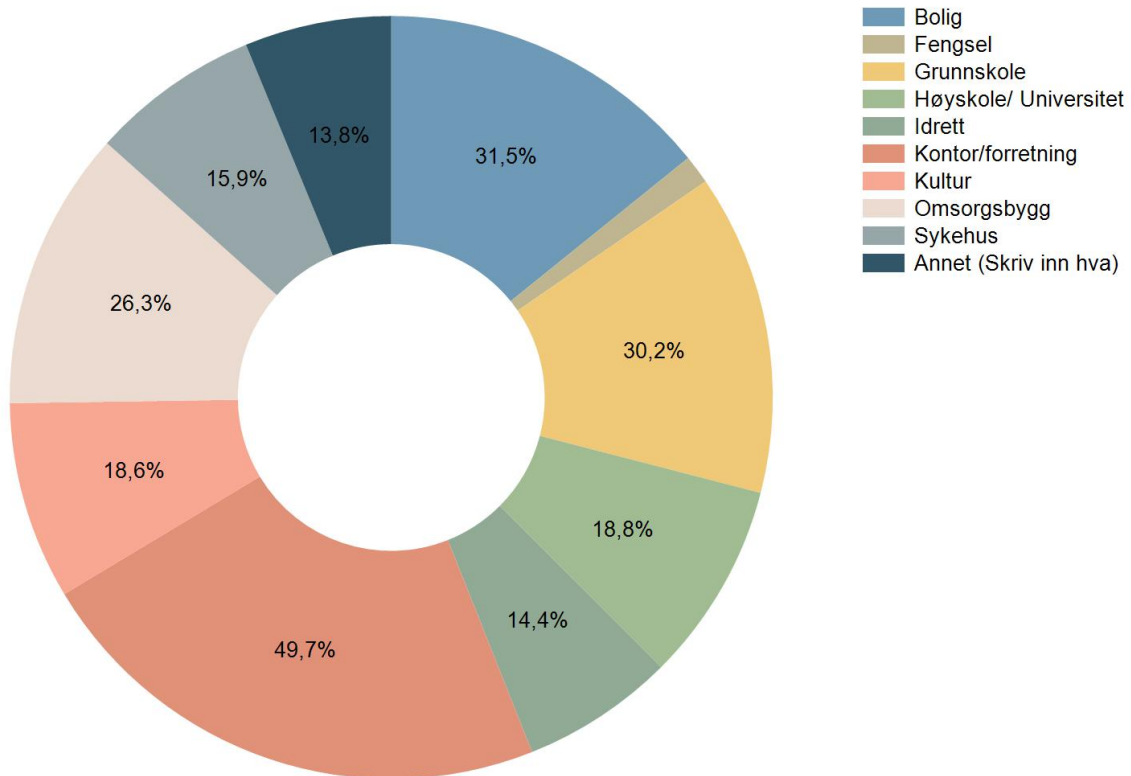


Figure B.9:

8. I spørreundersøkelsens del 1 vil vi ta for oss i hvor stor grad ulike aspekter er vektlagt ved planlegging av nye bygninger/eiendommer eller ved inngåelse av nye leieavtaler.

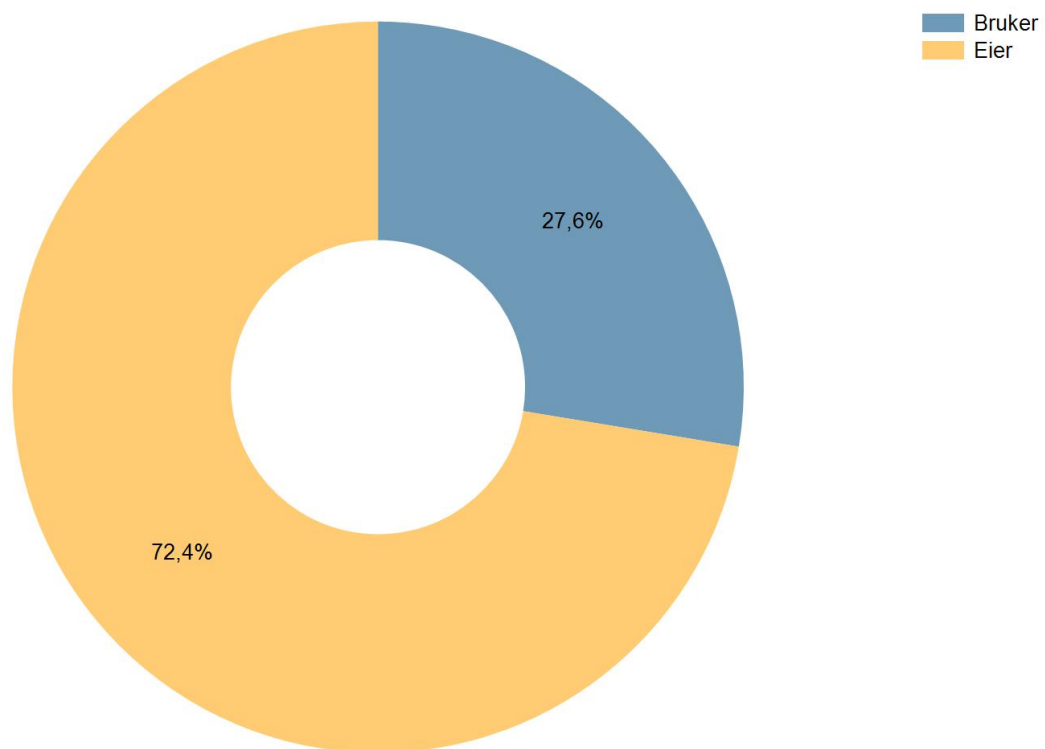


Figure B.10:

9. I hvor stor grad har følgende aspekter vært vektlagt?

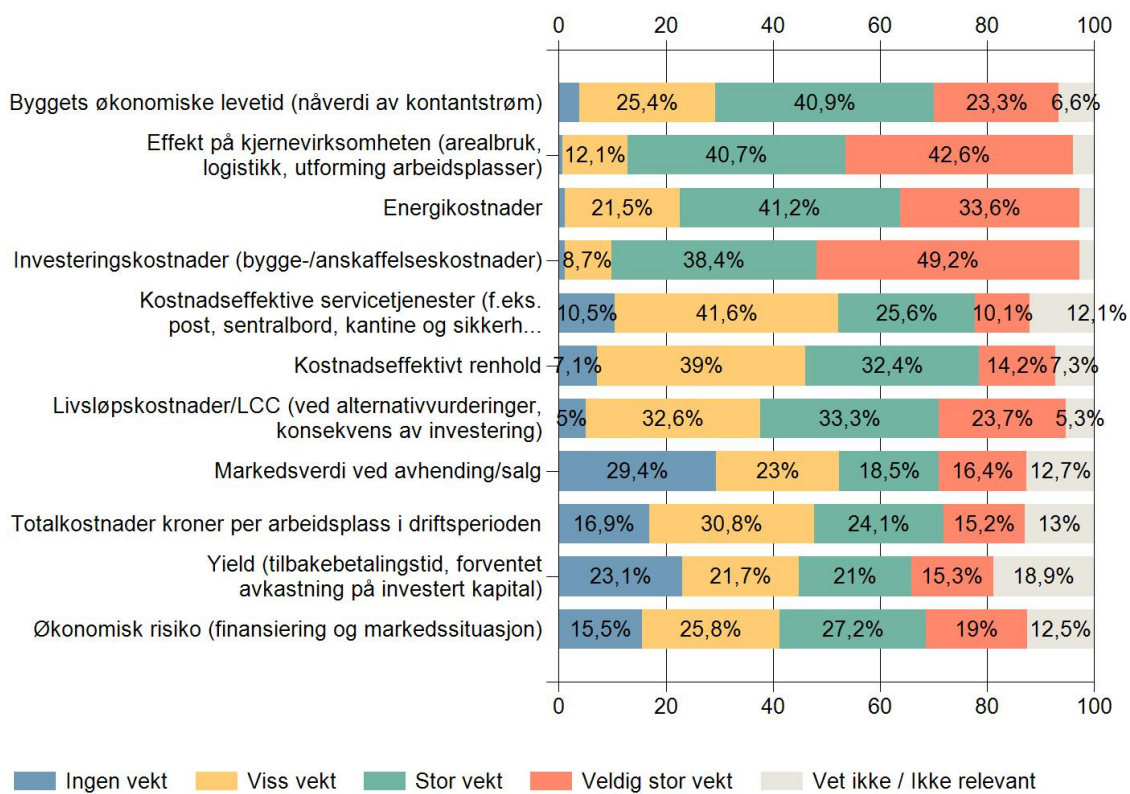


Figure B.11:

10. I hvor stor grad har følgende aspekter vært vektlagt?

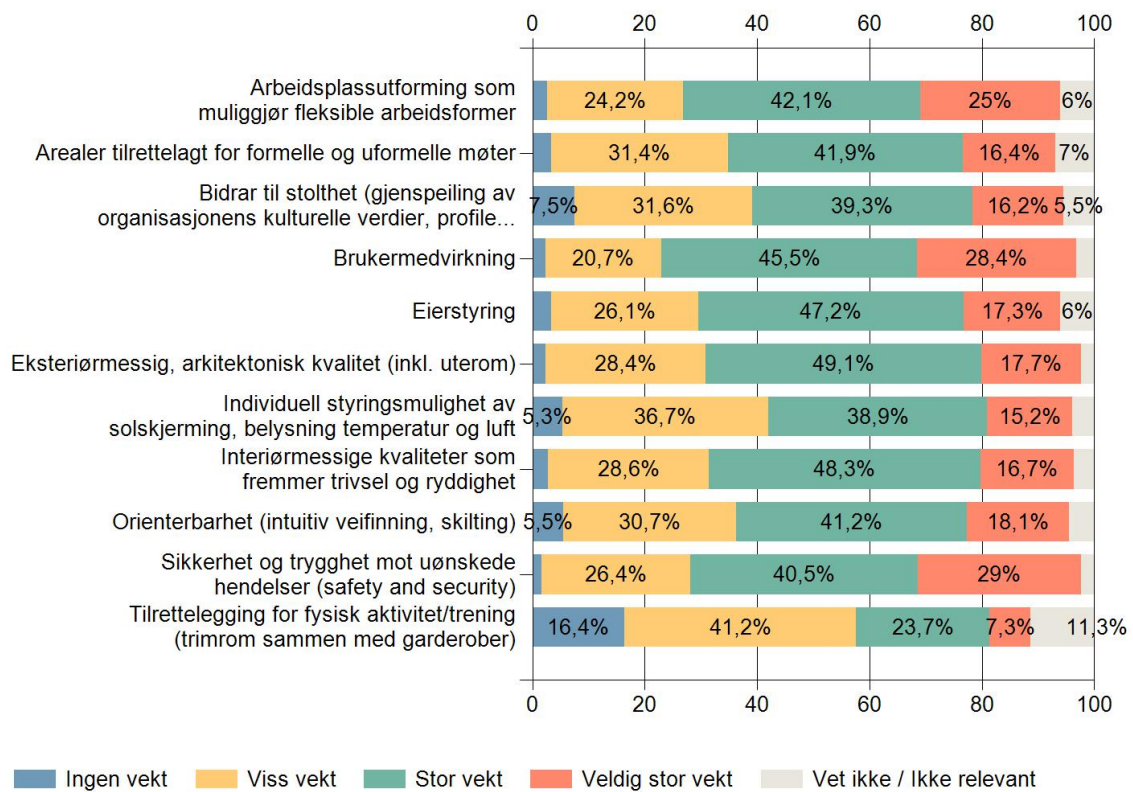


Figure B.12:

11. I hvor stor grad har følgende aspekter vært vektlagt?

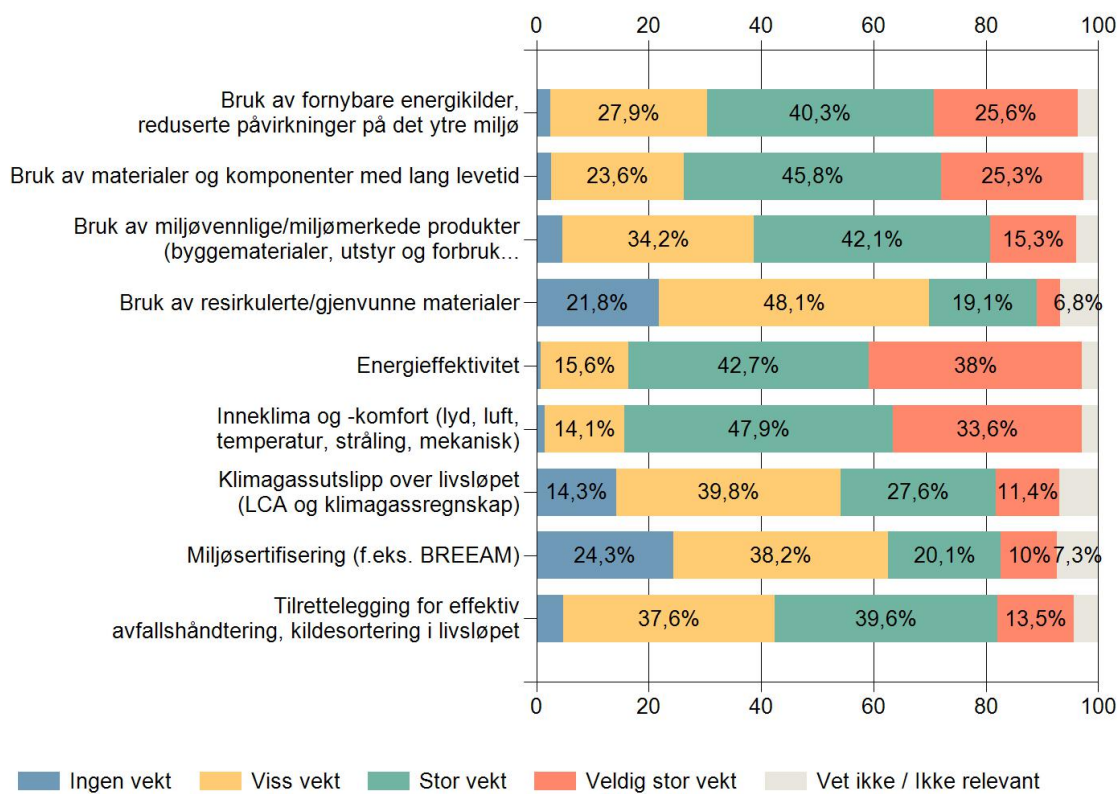


Figure B.13:

12. I hvor stor grad har følgende aspekter vært vektlagt?

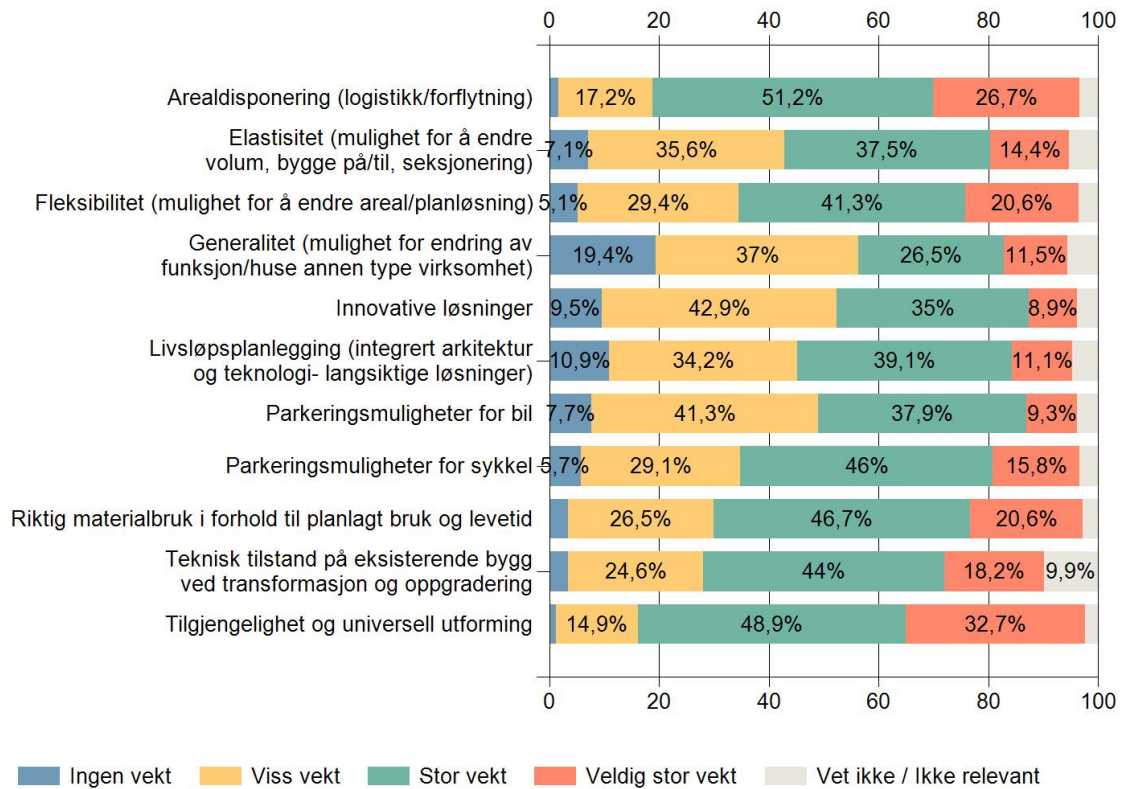


Figure B.14:

13. Tror du at brukere og eiere prioriterer ulikt med hensyn til verdiaspekter?

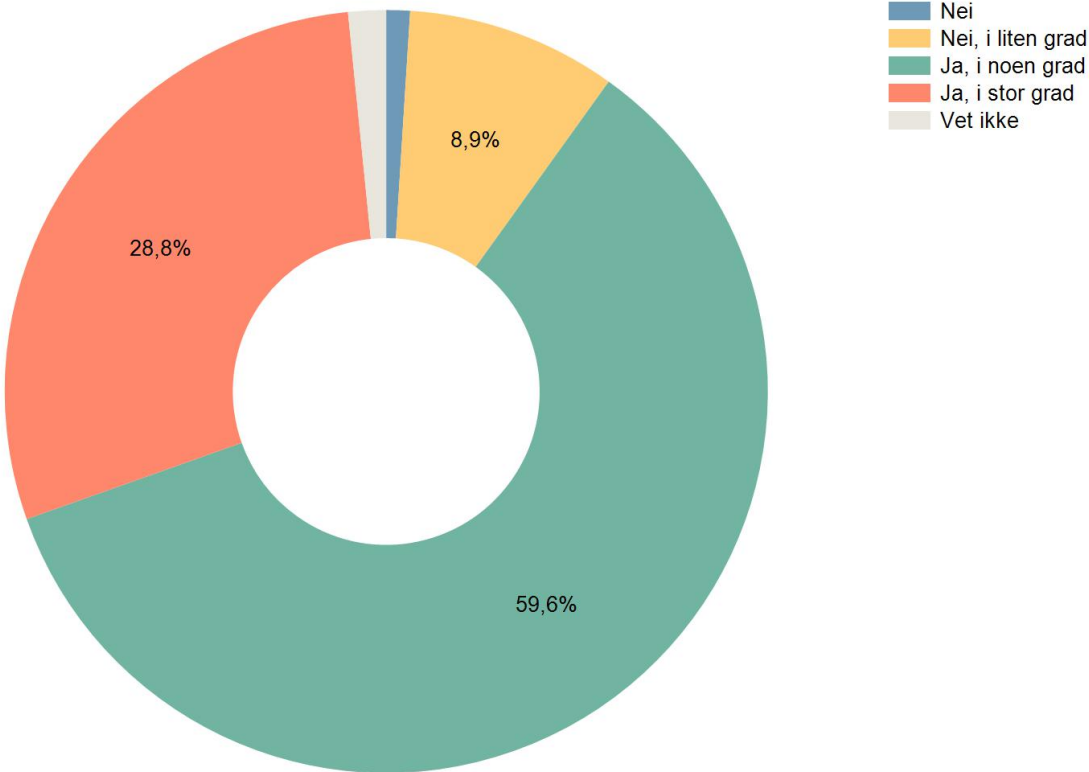


Figure B.15:

14. Hvilke av følgende områder har du vært involvert i mht. måling og rapportering?

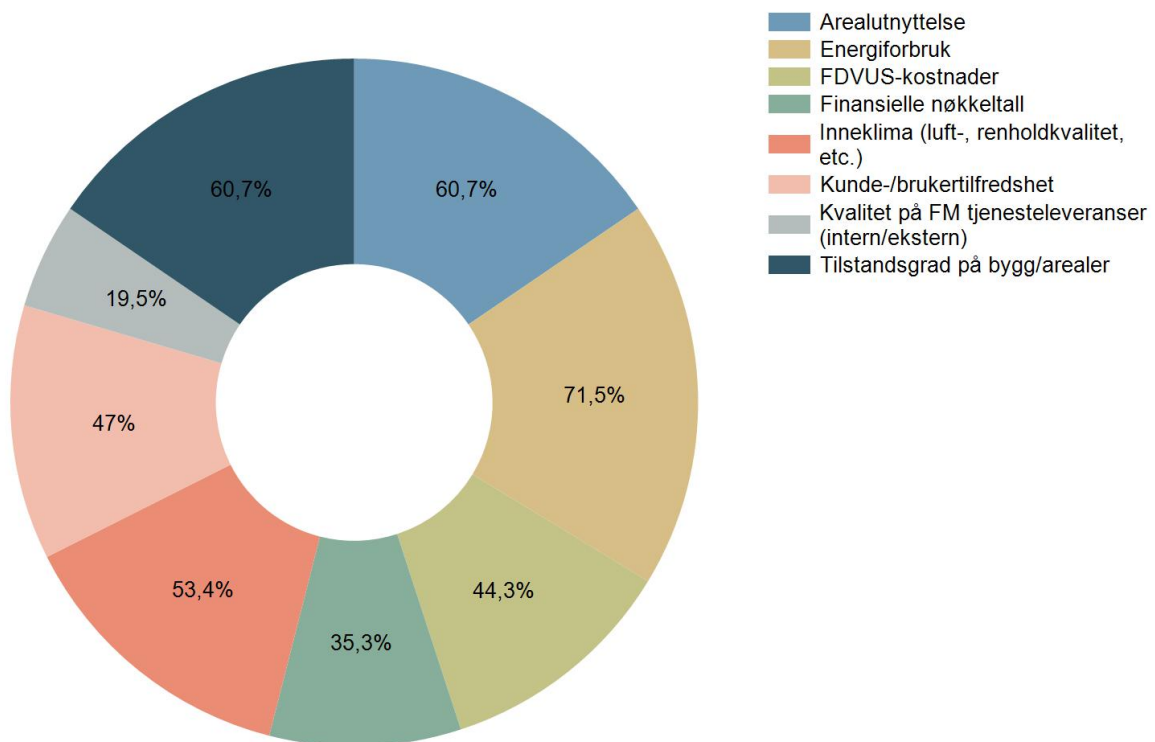


Figure B.16:

15. Basert på dine erfaringer fra planlegging av nye bygninger/eiendommer eller ved inngåelse av nye leieavtaler, hvor enig er du i at følgende kan være hindringer for verdiskaping for eier og bruker?

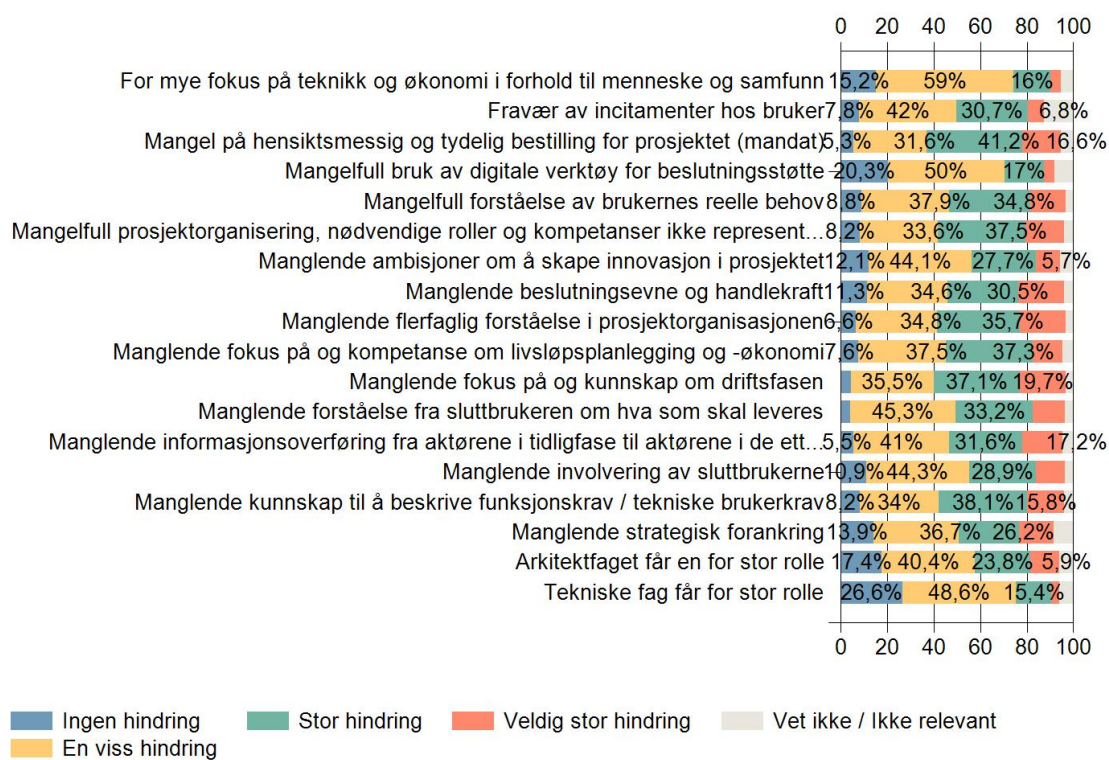


Figure B.17: