Master's thesis

NTNU
Norwegian University of Science and Technology
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Identification Of Challenges Related To Impactful Success Criteria In Green Domestic Construction Projects – A Delphi Study

A case study of three Statsbygg projects

Master's thesis in Mechanical Engineering
Supervisor: Bjørn Andersen
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STATSBYGG

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Abstract

The public's awareness of climate change has increased steadily over the last decade, which affects the construction sector as we see a shift away from traditional construction strategies in favor of green construction. This thesis aims to identify challenges tied to specific success criteria that's identified using the Delphi method. The thesis provides an in-depth case study of three Statsbygg projects with high environmental ambition, where a panel of experts ranks success criteria and challenges identified through relevant literature, which is then used as an entry point for further discussion and theory building. A total of 48 papers were reviewed and a total of 45 success criteria were identified. From these 45 success criteria, 3 were singled out and a total of 24 challenges were identified, 8 for each success criteria. From these challenges three focus areas were identified; intra-organizational communication; organizational awareness; and internal and external relationship management, for project managers to improve on to increase project success rate. Future research should focus on impact of the project managers emotional intelligence skills and contractor relationship management.

Sammendrag

Vi har sett en endring i offentlighetens klimaengasjement det siste tiåret, som over tid har påvirket byggebransjen da man har sett et skifte fra tradisjonell byggeteknikk til fordel for «grønn» byggeteknikk. Denne oppgaven har til hensikt å identifisere utfordringer som kan knyttes opp mot spesifikke suksesskriterier som er identifissert ved hjelp av Delphi-metoden. Oppgaven tar for seg en eksempelstudie av tre byggeprosjekter med høy miljøambisjon i regi av Statsbygg, hvor et ekspertpanel rangerer suksesskriterier og utfordringer som er identifisert gjennom relevant faglitteratur. Dette brukes så videre som et utgangspunkt for videre diskusjon og teoribygging. Totalt ble 48 artikler anmeldt og vurdert, fra hvor 45 suksess kriterier ble identifisert. Av disse ble 3 suksesskriterier valgt ut og totalt 24 utfordringer identifisert, 8 utfordringer per suksesskriterie. Ut ifra disse utfordringene ble tre fokusområder som prosjektledere kan forbedre seg på og øke prosjekters suksessrate identifisert; inter-organisasjonell kommunikasjon; organisasjonsbevissthet; og intern og ekstern relasjonsstyring. Videre forskning bør fokusere på innvirkningen av prosjektlederens nivå av emosjonell intelligens samt kunderelasjonsstyring med fokus på entreprenøren.

Preface

This thesis was conceptualized after I'd written my specialization report on the subject of project complexity and environmental sustainability where the unique challenges faced in complex and green projects enticed me to delve deeper and see if I could identify specific challenges and the skills needed to overcome said challenges, as a way to improve myself as a project manager.

I want to extend massive gratitude and thank you towards my mentors in Statsbygg, Lars Petter Bingh and Elin Hansen for facilitating the research process and the supporting me with information ang high level of feedback. I'd like to thank my supervisor Bjørn Sørskot Andersen for the support and above and beyond dedication and help, even during the summer vacation. Thank you, this would not be possible without your help.

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Abbreviations/Symbols

EI	Emotional intelligence
W_i	Weighted score
CSF	Critical success factor
SCM	Supply chain management
LCA	Life cycle analysis/assessment

1 Introduction

The Brundtland commission presented in 1987 a report on sustainable development which perpetuated the idea of green construction as part of sustainable development (Brundtland, 1987). Today green construction is on the forefront in innovative design and environmentally sustainable solutions are becoming ubiquitous as the public is aware, now more than ever, and exerts pressure on governments and public figures to drive "green" changes. The result pressure is more buildings with high environmental ambition in the form of strict environmental certificates, i.e. BREEAM-NOR and FutureBuilt, both which requires the project manager to abide by strict rules and reference values. In this thesis three Statsbygg projects were used as the basis of the case study:

1. The new Government Quarter – BREEAM-NOR Excellent certificate
2. UiO Life Science Building – BREEAM-NOR Excellent certificate
3. The New National Museum – FutureBuilt certification

1.1 The problem

This identification of challenges faced by project managers of green construction projects, in the public sector, due to the increase in project complexity and heavy restrictions put in place by the strict environmental certificates. Two relevant research questions are:

1. Which critical success factors are the most important in green construction projects with environmental ambition on the level of BREEAM-NOR Excellent or FutureBuilt?
2. What challenges are the most impactful when dealing with the important success factors identified?

1.2 The solution

The thesis is comprised of 5 parts that together will try to solve the proposed problem. The first part is the background, which works as the theory foundation and is comprised of the reviewed and relevant literature explored in the 4-stage literature review. The literature reviewed can be classified into 4 main subjects, where the first subject is critical success factors identified in relation to green construction projects. The second subject covered is the impact of emotional intelligence has on project success, where Meng and Boyd (2017) explores the impact of internal and external relationship management and Wu et al. (2017) explores the impact of communication. The third subject is environmental sustainability and green construction where unique aspects around green construction is explored, e.g. the barriers for implementing environmentally sustainable solutions by contractors as explored by Hwang (2012), or alternative ways of measuring environmental sustainability as presented by Fernández-Sánchez and Rodríguez-López (2010). The different environmental certificates are also presented and how to obtain them. The final subject

covered by the literature review is project complexity where the interrelatedness of project complexity and green construction is explored.

The second part is an overview over the methodology used in this thesis, which is a 4-staged literature review and a Delphi Study, as well as an overview over its limitations and alternative methods that were considered, but ultimately discarded. The third part is a presentation of the weighted results from the Delphi Study and the limitations of the study. The fourth part is theory building through discussion of the different results by using reviewed and relevant literature. The final part is the conclusion where the study is summarized, focus areas based on the theory discussed for the project manager is presented together with final limitations and recommendations for future work.

2 Background

This chapter aims to give the reader a deeper understanding of the relevant literature reviewed for the study. The chapter starts by explaining Critical success factors, then emotional intelligence, followed by environmental sustainability and green construction, followed by an overview of the two environmental certificates BREEAM-NOR and FutureBuilt, and ends on the topic of project complexity.

2.1 Critical success factors

It's a wildly accepted practice to measure a project's success by utilizing the criteria time, cost and scope, otherwise known as the iron triangle of project management. This becomes very apparent on construction projects as the focus on cost and time management is higher than other sectors, with public construction projects heavily scrutinized as they use public funds. While the criteria of time, cost and scope are the basis for the evaluation of success in a project, we find many factors contributing to the overall assessment of project success, especially in the public's eye, which is a major stakeholder in public construction projects. These critical success factors are important to identify as they are key to attain the success approval of the public. Rockart (1979) defines critical success factors (CSF) as the limited number of areas in which positive results will ensure successful competitive performance. He further explains that if the results in the critical areas is negative, the total performance will suffer, thus making it clear the importance of continuously monitoring the critical areas.

Ambitious goals of environmental sustainability in public construction projects can lead to a shift from the standard CSF found in the construction sector. This is due to the limitations set by the ambitions as well as the expectations of the stakeholders invested in the project. Kang Youngcheol et al. (2013) explores the differences between the effect pre-project planning has on green construction projects compared to conventional construction projects. The findings show that green construction projects have a positive relationship between pre-project planning and cost performance, and that green construction projects with superior cost performance was more invested in pre-project planning than conventional construction projects. This notion is further supported by the findings of Son and Kim (2015) where the results showed that the cost and schedule performance of the green construction projects was dependent on the quality of definition in the pre-project planning phase.

Hwang and Leong (2013) concludes in their paper about schedule delay and casual factors in green construction projects that green projects in Singapore is completed behind schedule in 32% of the cases. They list five critical factors contributing to this delay in construction as:

1. Speed of decision making by clients
2. Speed of decision making involving all project teams
3. Communication/coordination between key parties
4. Level of experience of consultants
5. Difficulties in financing project by contractors

This list of five critical factors is being presented by Hwang and Leong (2013) as a possible focal point for project managers to expand upon to enhance the performance of the project.

Alzahrani and Emsley (2013) talks about the influence contractors has on project success and states that there are few literature works that highlights their importance. They further emphasize the close relations between contractors and project success by highlighting that the contractors often start their main duties when the construction project reaches its construction or execution stage, where the actual work is being done. The results presented shows that the CSFs of the contractors greatly impacts the success rate of the project and that safety and environment are criteria that are becoming a measurement for success in addition to the traditional iron triangle of time, cost and scope.

2.2 Emotional intelligence

A project manager deals with many different types of people in the span of a project and Meng and Boyd (2017) explores the project managers role in relationship management in construction projects and the effect this has on performance. The relationship management is divided into two parts, internal relationship management (IRM) and external relationship management (ERM), where IRM has a greater impact on project performance when measured in time, cost and quality, and ERM is more akin to stakeholder satisfaction. They further emphasize that IRM contributes to project team building and development, where ERM contributes more towards external stakeholder management and supply chain cooperation or collaboration. IRM is further explored by Wu et al. (2017) where they focus on the effect communication-conflict has on project success. The findings show that effective communication can in turn enhance the transparency of the information flow, thus resulting in better project team cohesion, which in turn results in the realization of the project. The biggest contributor identified by Wu et al. (2017) was communication willingness.

Zhang and Fan (2013) presents a strong positive correlation between project performance and the construction project managers level of emotional intelligence (EI). They state that project managers of small to medium projects can attain project success eventually through good use of technical knowledge and skill, but for larger and more complex projects, the project manager is more dependent on their EI levels as complexity levels moderates the correlation between EI and project performance. It's further specified that certain types of emotional intelligence are more suited for specific types of projects e.g. a project manager with high cultural understanding should be utilized on international projects; while project managers with high organizational awareness is best utilized on domestic projects. When seen in respect to contract type, they highlight inspirational leadership as a good trait to focus on when it's a unit price contract; while empathy is the best trait when dealing with a project with a cost plus contract.

The impact of a project managers leadership skill is explored by Zulkiffli and Latiffi (2019) and they conclude that the capabilities and leadership skill of the project manager clearly contribute positively to the overall performance of the project manager and to sustainable construction project development. The skills being highlighted are:

1. Communication skill
2. Motivation skill
3. Decision-making and problem-solving skill
4. Conflict management skill

5. Delegation skill
6. Planning and goal-setting skill
7. Team building skill
8. Negotiation skill

2.3 Environmental sustainability

Environmental sustainability is an ambiguous word with many different definitions. The most notable one is the one where it's part of the triple bottom line, which is part of the definition of sustainable development presented by Brundtland (1987, p.16) which states "Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs". Goodland and Daly (1996) defines environmental sustainability in their paper as a simple input-output rule where they focus on the distinction between renewable resources and non-renewable ones. The output rule presented states that waste emissions from a project should be within the environments assimilative capacity to absorb the waste without suffering any form of depredation. The input rule is split into two parts, one for renewable resources and one for non-renewable resources. The first input rule is for renewable resources and states that the harvest of a renewable resource must be done within the regenerative capacity of the resource as well as the system it's in. The second input rule is for non-renewable resources and states that the depletion rate of said resource should not exceed the rate new renewable substitutes can be made available.

2.4 Green project management

World Green Building Council (2020) explains green construction on their website as a building or construction that in its design, operation or construction reduces its negative impact on the environment while improving its positive impacts. They list up several features that can be utilized as focal points when improving a construction project or building, some of these are:

- Efficient use of energy resources
- Use of renewable energy
- Pollution and waste reduction
- Improvement of indoor climate
- Use of ethical and non-toxic materials

There is a good amount of literature tackling these features such as the study conducted by Morel et al. (2001) where they explored the impact using locally sourced materials had on the overall environmental impact of the project and concluded that using locally sourced materials had massive potential for reducing the environmental impact compared to industry standard materials. Shen and Tam (2002) explores the barriers found when implementing environmental sustainable solutions in Hong Kong construction seen from a contractors point of view while Hwang (2012) and Robichaud Lauren Bradley and Anantatmula Vittal S. (2011) explores the differences found when comparing traditional construction projects with green construction projects. They all highlight the fact that green

construction requires a higher degree of communication and a larger focus on planning as these two factors are important to ensure project success.

There are also several papers covering possible or alternative methods of measuring the environmental sustainability of a project. Fernández-Sánchez and Rodríguez-López (2010) explores different methodologies for identifying sustainability indicators for construction projects where they conclude that consulting with the stakeholders gives a certain consensus for a common standardized sustainability indicator. Tam et al. (2004) presents a tailor-made assessment tool for green construction in Hong Kong where the goal is to help assess construction activities and double up as a benchmarking tool for contractors' performance. While many focus on the indicators and the identification of these, some papers focus on the documentation process e.g. de Beer and Friend (2006) paper on environmental accounting where they present a management tool that allocates environmental costs to specific cost drivers, or Shen et al. (2004) paper that explores the benefits of implementing a waste management mapping model as an analysis tool for easy comparison between projects waste management systems. Raman (2013) explores the possible use of green supply chain management (Green SCM) to document and quality assure that the product is green and sustainable from a cradle to grave perspective, but specifies that the implementation of Green SCM is not an ad hoc solution as it usually requires massive organizational changes.

The inherent complexity of construction projects can make it hard to implement measuring systems which are of the type "one size fits all" which is a point Wei (2009) tries to tackle his paper on environmental sustainability metrics. Wei (2009) states in his paper that there is a need for unique and specified metrics to be able to properly assess the environmental sustainability levels of a construction project, and these metrics are focused in four groups: material usage, energy consumption, water usage and pollutant release levels.

Life cycle analysis/assessment (LCA) is a method where you look at the whole life cycle of the project, from cradle to grave. You start with the appropriation of raw materials (cradle) and end with the disposal of demolition waste (grave). Schroeder and Lemke (2015) explores the environmental sustainability of using dirt as building material by utilizing an LCA. They found that it's important to specify the system boundaries when applying the LCA as the choice of system boundaries could skew the results in a certain direction. This notion is also supported by the findings of Morita et al. (2011) who looked at the environmental impact a rail road construction project would have and found it necessary to conduct an extended LCA to also include the benefits of the new infrastructure on the usage of cars. The importance of good LCA boundaries is further cemented by the findings of Skele et al. (2011) which shows that the majority of harmful emissions from the production of construction materials stems from the outlines of the system boundaries, e.g. the energy consumption of the process of turning raw materials into building blocks.

The materials used within a construction project has a big impact on the total amount of greenhouse gas emission due to the inherent emission of making said material, as well as the transport and disposal of it (Skele et al., 2011). Esin and Cosgun (2007) states in their paper that the construction industry is responsible for large percentages of the total waste generated by different countries and Bergsdal et al. (2007) states that waste generated from construction in Norway is estimated to be around 1.25 million tonne. Morel et al. (2001) explores the positive benefits of using locally sourced materials when looking at the energy consumption and transportation emission. They found that utilizing locally sourced materials yielded an energy usage reduction of 215% and a reduction in transport emission

by 453%. This positive impact is further backed up by the findings of Harris (1999) who found that imported softwood timber has close to 70 times larger environmental impact compared to locally sourced timber when measuring embodied energy. The benefits of utilizing soil as a construction material is highlighted by Morel et al. (2001) as it has an expected lifetime of 200 years compared to concretes less than 100 years, and they highlight the fact that research has made it relevant again as new knowledge and technology helps tackling the natural variances found in the materials when using inorganic subsoil that's procured onsite.

An important point in the LCA presented by Schroeder and Lemke (2015) is the "closing" of the cycle where you reuse recycled soil-based materials and thus making the life cycle self-sustaining (see figure 2.1) This idea of reuse and recycle and its importance is highlighted by Kaziolas et al. (2013) where the use of traditional building materials and the fact that many construction projects end pre-maturely due to rapid economic transformation is highlighted as important focal points. Kaziolas et al. (2013) highlights that the use of low recyclable traditional materials like concrete or bricks have a large negative environmental impact when ending a construction project pre-maturely because of the non-recyclable and non-reusable waste generated.

Figure 2.1: Life cycle of earth as a building material (Schroeder and Lemke, 2015)

2.5 Environmental certifications

As sustainable development can be defined differently depending on the country and culture, it's important to have an internationally acknowledged standard that you can turn to when you want to build environmentally sustainable buildings that can be modelled and compared to similar buildings with the same standard. It's important to note that having access to an international standard does not mean that domestic or local standards should be forgone as they are often more specialized due to the lack of restraints, where an international standard must abide by many restraints to be applicable to all.

In this case study we have two types of environmental certificates; BREEAM NOR and FutureBuilt where BREEAM NOR is the BREEAM standard amended by Grønn Byggallianse to fit Norwegian construction (Byggalliansen, 2019), and FutureBuilt is the local Oslo region certificate for environmental showcase projects in the local region (futurebuilt.no, 2020).

2.5.1 BREEAM-NOR

Building Research Establishment Environmental Assessment Methodology (BREEAM) is an internationally recognized certificate that measures a buildings sustainable qualities and was first used in 1990. Since then it's been used as a certificate for over 530.000 buildings and used in over 70 different countries and aims to raise awareness of the benefits of taking a life cycle approach to sustainability. Projects utilizing BREEAM standards are assessed by independent, licensed assessors, who gives the project or building a rating and certificate based on the scale; Pass, Good, Very Good, Excellent, Outstanding. This type of rating enables stakeholders to compare project or building performance with similar projects or buildings that uses BREEAM standards. The different scores relate to different practices and performance levels where:

- Pass: Top 75% of new buildings (Standard good practice)
- Good: Top 50% of new buildings (intermediate good practice)
- Very Good: Top 25% of new buildings (advanced good practice)
- Excellent: Top 10% of new buildings (best practice)
- Outstanding: Less than top 1% of new buildings (pioneer/innovator)

If you fail to meet the minimum requirements of the BREEAM standard or the performance measured is non-compliant to the BREAAM standard, then you get the rating of Unclassified (Byggalliansen, 2019).

BREEAM Rating	% score
OUTSTANDING	≥ 85
EXCELLENT	≥ 70
VERY GOOD	≥ 55
GOOD	≥ 45
PASS	≥ 30
UNCLASSIFIED	< 30

Figure 2.2: BREEAM-NOR Rating Benchmark (Byggalliansen, 2019, table 3, p.10)

When you're rating the different projects you utilize different criteria, but these are not necessarily equal in terms of environmental and sustainable impact, so BREEAM NOR utilizes a weighted ranking system to find the relative impact of technical sections found in BREEAM-NOR. The scores or credits awarded to the different sections can be traded to achieve a certain total rating, but to ensure that no fundamental sustainability issues are overlooked BREEAM-NOR operates with certain minimum standards in each of the sections. An overview of these minimum standards as well as an example of BREEM-NOR rating calculation can be seen in Appendix A.

The aim of BREEAM is presented in the BREEAM-NOR 2016 Technical Manual v1.2 (Byggalliansen, 2019) as:

- To mitigate the life cycle impacts of buildings on the environment
- To enable buildings to be recognized according to their environmental benefits
- To provide a credible, environmental label for buildings
- To stimulate demand and create value for sustainable buildings, building products and supply chains

The BREEAM New Construction scheme which aims to mitigate the negative environmental impact of new buildings whilst improving the positive social and economic impacts. The importance of careful timing is emphasized as key to cost effective optimizing when trying to achieve a certain BREEAM-NOR rating. It's advised that the project owner engage with a BREEAM-NOR assessor no later than the BREEAM Pre-Assessment Stage which goes through step 2 in figure 2.3 which covers the project definition and programming phase of the construction project.

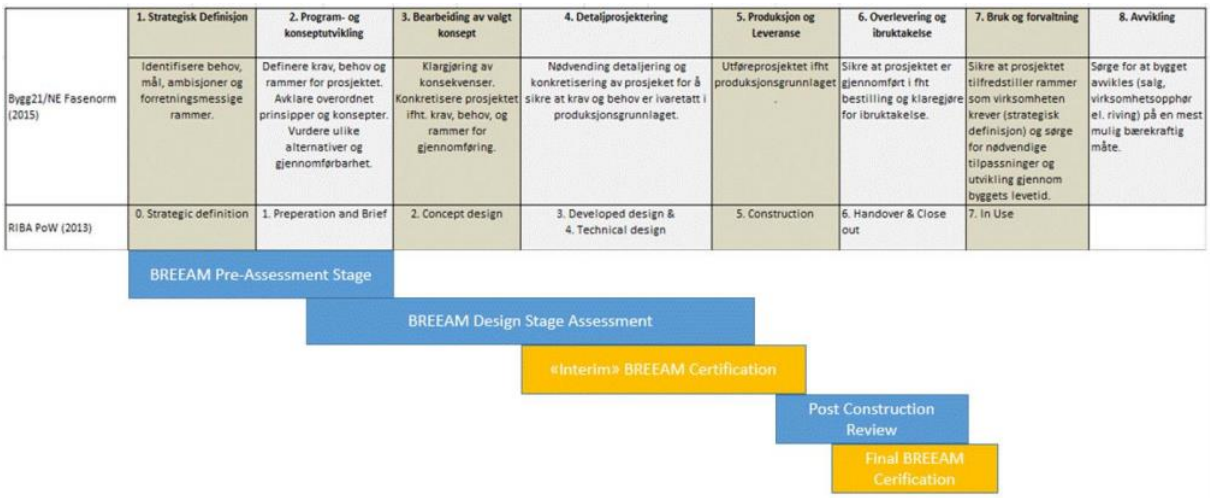

Figure 2.3: BREEAM-NOR Assessment and certification stages in relation to the project work stages (Byggalliansen, 2019, figure 2, p. 4)

Appendix B contains further information about the verification process and BREEAM New Construction and BREEAM scheme breakdowns.

2.5.2 FutureBuilt

FutureBuilt is a collaborative initiative between 10 partners that started in 2009 and aim to support climate-friendly urban development. The goal was to complete 50 pilot projects in the Oslo region where the projects aimed to reduce greenhouse gas emissions from transport, energy and materials by a minimum of 50 percent as set by the Paris Agreement and the UN Sustainable Development Goals (FutureBuilt, 2019).

The partners of FutureBuilt is:

- The municipal of Oslo
- The municipal of Bærum
- The municipal of Asker
- The municipal of Drammen
- The Ministry of Local Government and Modernization
- The Norwegian State Housing Bank
- Enova
- The National Agency for Building Regulations
- The Norwegian Green Building Council
- The National Association of Norwegian Architects

FutureBuilt projects are meant to inspire changes in common practice in the construction sector, which is done by fulfilling certain criteria. The most prominent one is the reduction of the carbon footprint must be 50% or greater, and the calculation of this is done by utilizing a green house accounting tool for buildings. The project must also reduce the emission stemming from transport, energy consumption and materials, have the construction site close to a major transport hub, be of high architectural and urban quality, and finally be innovative and have showcase qualities (FutureBuilt, 2019).

The reduction in emission from energy usage showcase the steep criteria for becoming a FutureBuilt project as the minimum requirement is close to a net-zero building, where you're supposed to strive for energy positive buildings. Fossil free construction site is as of 2017 the new minimum standard for FutureBuillt projects. To be able to meet these energy standards FutureBuilt projects must use materials that are tied to low greenhouse gas emission levels like wood or low-carbon concrete. There is also expected a heavy focus on a circular design where the use of recycling and reuse are prominent. Architectural and urban qualities entail that the project has qualities like walkability, universal design, biodiversity, and works as a meeting place that has a relationship to the city structure. This ties well into the criteria that the project must be located close to a major transportation hub as the project should focus heavily on green mobility and the amount of parking spaces should be reduced by half. Finally, the project has to illustrate how it contributes with innovative and forward-thinking solutions to be able to call itself a FutureBuilt Project (FutureBuilt, 2019).

To document these changes FutureBuilt recommends using some sort of climate gas accounting or utilizing known and established environmental certificate systems like BREEAM-NOR.

2.6 Project complexity

The Merriam-Webster Online Dictionary (2019) defines complex as *"a whole made up of complicated or interrelated parts"* which translates well to the notion that construction projects are complex projects due to the amount of moving parts and the level of uniqueness. Luo Lan et al. (2017) states in their paper that while there might not be a fitting overall definition of project complexity, there are fitting definitions of complexity for different areas of the project, such as technical complexity, environmental complexity and organizational complexity. This idea is in line with the findings of Lu et al. (2015) which states that project complexity is hard to define, and even harder to quantify, which often leads to a definition of project complexity that's based on a persons field of expertise instead of a definition which is concise and wildly applicable.

Some efforts has been made to try to make a clear cut definition, most notably by Baccarini (1996) and Gidado (1996) where Baccarini (1996) takes the dictionary definition and elaborates further where he operationalizes the definition in terms of differentiation, the number of varied elements and parts in the project, and interdependence, the degree of interrelatedness of the different elements and parts. Baccarini also notes the similarities between the dictionary definition of project complexity and systems theory where complex systems are defined in terms of differentiation and connectivity. Gidado (1996) on the other hand divides project complexity into two main perspectives, the managerial perspective which focuses on the planning and facilitation of the workflow, and the operative and technological perspective, which focuses on the technical intricacies and difficulties with executing individual pieces of work e.g. resource usage or environmental factors. Wood and Gidado (2008) further explores the findings of Baccarini (1996) and Gidado (1996) and concludes that project complexity should refer to the projects interactions, interdependencies and interrelations. They also state that it's important to identify this early as it's a way to understand the project, and subsequently reduce the inherent risk.

2.6.1 Influencing factors on project complexity

Lu et al. (2015) highlights the nonlinear complex interactions between tasks from different fields found in the project, be it engineering, technology, finance, organizational management, ecological or social. These complex interactions lend itself to greater project complexity and the degree of influence is defined by the difference between these tasks as the project manager must adopt different strategies to tackle the unique challenges presented. Some of the different task complexities presented by Lu et al. (2015) are technological complexity, goal uncertainty, environmental complexity and resource availability. Technological task complexity is referred to as the knowledge and skill requirement of the implemented or chosen technology and/or strategy. Goal uncertainty is referred to as the interrelatedness of the multiple sub-projects found in large-scale projects since large-scale projects not only achieves managerial goals; i.e., quality, cost and time, but also technological and economical goals, which in turn increases project complexity. Lu et al. (2015) defines environmental complexity as the complexity influence found in the environment the project operates in and the project stakeholders, while resource availability is defined as the complexity influence of the need of mutual coordination of the resource utilization. These tasks complexities represent the hidden dynamic workflow of the project and is according to Lu et al. (2015) the largest influencing factor on project complexity.

Kermanshachi et al. (2016) on the other hand focuses on utilizing Subject Matter Experts to identify complexity indicators, where the top three indicators identified are: Peak number of participants on project management team; the magnitude of change orders; the frequency of workarounds due to lack of materials. Dao Bac et al. (2017) provided in their paper a constructive approach in identifying project complexity indicators in high and low complexity projects where knowing the true complexity contributor helps the project manager to focus its efforts in minimizing its effects.

2.7 Statsbygg projects

Statsbygg is a public enterprise controlled by the Ministry of Local Government and Modernization and its main purpose is to carry out the Governments construction and real estate policies. Three green construction projects with close to the same environmental ambition has been chosen as the focus for this case study. The following paragraphs will present key numbers connected to each of the projects and provide a small overview of the function of the project.

2.7.1 New Government Quarter

The environmental ambitions of the construction of the new Government Quarter is rooted in the centrally prepared zoning plan. The government demands that the project maintains a high environmental standard and is subsequently mirrored by Statsbyggs' ambition of Breeam-Nor Excellent certification. The project is a direct consequence of the bombing of the old government quarter on 22nd of July 2011.

Principal	Ministry of Local Government and Modernization
Gross Building Area	TBD, estimated to be close to 162.000 m^2
Time frame	2020 – 2020 Feasibility study 2020 – 2021 Demolition of R4 and Y-block 2020 – 2029 Design planning and construction 2024 – 2029 Relocating to new buildings as they finish
Current status	Feasibility study
Cost	TBD
Environmental certificate	BREEAM-NOR Excellent

Table 2.1: Key figures, adapted from: (https://www.statsbygg.no/Prosjekter-og-eiendommer/Byggeprosjekter/Regjeringskvartal-nytt/, 2020)

2.7.2 New National Museum

The construction of the new National Museum is classified as a FutureBuilt pilot project where the goal is to reduce the total emission by 50%. This was done by implementing the use of heat pumps that utilize the water in the harbor basin to reduce energy consumption as well as using low emission cost materials with long life expectancy.

Principal	Ministry of Culture
Gross Building Area	54.600 m^2
Time frame	2012 – Feasibility study concludes 2013 – Oslo City Council adopts the zoning plan 2013 – Third-party quality assurance cleared (KS2) 2014 – Construction start 2018 – Topping out (kranselag) 2019 – Employees of the National museum relocates to the new offices 2020 – Construction completion 2021 – Open for the public
Current status	Under construction
Cost	619 MNOK
Environmental certificate	FutureBuilt

Table 2.2: Key figures, adapted from: (https://www.statsbygg.no/Prosjekter-og-eiendommer/Byggeprosjekter/Nasjonalmuseum/, 2020)

2.7.3 UiO Life Science Building

The new life science building at University of Oslo will work as a workspace to facilitate interdisciplinary cooperation and closer collaboration between health enterprises, local government and the private sector to enhance quality and relevance of research and studies, as well as solving major challenges tied to health and environment (UiO, 2020).

Principal	Ministry of Education and Research
Gross Building Area	66.700 m^2
Time frame	1st quarter 2014 - Tendering 3rd quarter 2016 – Feasibility study concludes 3rd quarter 2016 – Third-party quality assurance cleared (KS2) 1st quarter 2019 – Construction start 4th quarter 2024 – Construction finish
Current status	Under construction
Cost	680 MNOK
Environmental certificate	BREEAM-NOR Excellent

Table 2.3: Key figures, adapted from: (https://www.statsbygg.no/Prosjekter-og-eiendommer/Byggeprosjekter/UiO-Livsvitenskap/, 2020)

3 Method

The methodology that was applied to the research was chosen based on previous experiences and through conversations and inputs from my supervisor and my mentors at Statsbygg. This chapter will provide an overview of the chosen and applied methodology as well as highlight other options that were considered but ultimately discarded. Limitations, validity, reliability and transferability will be covered in the end of the chapter.

3.1 Data collection and database search

A four-staged literature review was conducted on the topics of:

- Green construction
- Waste disposal and waste management
- Project success criteria
- Project complexity
- Environmental sustainability
- Soft factors in project management

3.1.1 Stage 1 – Search for relevant literature

The search for relevant literature was done by using databases like Google Scholar and Oria where keywords, title and abstract were the filters used. An overview over search word combinations and total number of hits in Oria can be seen in table 3.1. The review of references of relevant literature was also done to supplement the search for relevant literature.

Search word	Oria
Environmental sustainability + construction	18.775
Waste disposal + construction	22.189
Project success + critical success factor	1.830
Project complexity	2.157
Project complexity + construction	1.334
Emotional intelligence + project manager	583
Green construction + project management	226
Green project management + early phase	24

Table 3.1: Overview over search word combinations for stage 1 of the literature review

3.1.2 Stage 2 – Selection process

Stage 2 is reviewing the selected papers found in stage 1. The papers were chosen based on the criteria:

1. Papers related directly to green construction, environmental sustainability, project complexity and green project management were selected, as well as any papers that were applicable to the chosen Statsbygg projects.
2. Duplicate findings i.e. article and conference papers were eliminated and the article was chosen.

This resulted in a total of 48 papers that were chosen for further review and analysis.

3.1.3 Stage 3 – Content analysis

An analysis of the 48 papers was done where the analysis focused on identifying core principles and possible correlations and interdependencies between the different subjects. The result of the analysis was organized into sub-chapters in the Background chapter that gives an overview of the current and relevant theories on the subjects.

3.1.4 Stage 4 – Application of findings and disscussion

The findings of stage 3 is used as the basis for the first survey of the Delphi Method and as the theory basis for the discussion of the results of the Delphi Method. The theory is also used as the fundament for new theory building and the final proposed focus areas.

3.2 The Delphi Method

The Delphi method is a research method that aims to find a reliable consensus of a group of experts. This is accomplished by utilizing structured communication without direct confrontation though a series of surveys or controlled opinion feedback (Okoli and Pawlowski, 2004).

The fact that the projects from Statsbygg all have close to the same level of environmental ambition, and they are all three public-space projects, it's natural to utilize a method that can find a common ground between these projects and answer the two research questions:

1. Which critical success factors are the most important in green construction projects with environmental ambition on the level of BREEAM-NOR Excellent or FutureBuilt?
2. What challenges are the most impactful when dealing with the important success factors identified?

The Delphi method does this by developing a ranked list of common challenges faced by the project manager in green construction projects by finding a consensus between experts from all three projects. This consensus was then to be used as a foundation and talking point when discussing project management in green construction projects with high environmental ambition.

3.2.1 The invitation and the panel of experts

To start off the Delphi method I first made generic invitations (Appendix C) that outlined the premise of the Delphi method, informing the possible participants of the plan and the goal of the research, how it's conducted, the estimated time of completion and why I wanted said participant to join. The next page detailed the setup of the whole Delphi method with overview over what the different surveys would be about as well as a link to the first survey.

The invitation was then sent to my mentors in Statsbygg, Lars Petter Bingh and Elin Hansen, as a written email as well as a pdf attachment. The invitation was then quality assured and sent to a third person for a final quality assurance. This was then forwarded to persons of interest that fit the criteria that were set for the experts which were; project managers, contracted advisors or someone with great understanding of the project and/or project organization.

3.2.2 The survey tool

Manually making a survey from the bottom up would take too much time and would be ineffective use of resources. The choice was made to utilize already existing survey making tools available for free on the internet. The final choice landed on surveymonkey.com as the platform and tool of choice, as I had previous experience with the survey and analysis tool that's available for the survey maker.

3.2.3 Delphi survey #1

The first part of the Delphi method was a survey aimed at ranking different success criteria for green construction projects that's been identified through the literature review process. The different success criteria identified were:

Author	Success criteria of note
(Meng and Boyd, 2017)	• Clear and systematic criteria • Good internal relationship management • Good external relationship management (stakeholder management)
(Alzahrani and Emsley, 2013)	• Turn over history • Staff qualification • Site organization • Documentation • Prior knowledge of construction strategy • Past experiences • Waste disposal • Environmental plans and goals • Quality control and assurance • Material usage
(Tabish Syed Zafar Shahid and Jha Kumar Neeraj, 2012)	• Project managers competence • Commitment of all project participants • Coordination between project participants • Regular budget updates
(Lindebaum and Jordan, 2012)	• Management of owns emotions
	• Stakeholder management • Conflict and dispute management

(Hwang and Ng, 2013)	• Risk management • Delegation • Public relation • Site layout and mobilization
(Tabassi et al., 2016)	• Innovation levels • Energy efficiency • Sustainable site management and planning • Strategic perspective • Inspire followers to go beyond own interests
(Zhang and Fan, 2013)	• Adaptability • Emotional self-control • Team management • Organizational awareness • Cultural understanding • empathy
(Robichaud Lauren Bradley and Anantatmula Vittal S., 2011)	• Early planning • Communication and coordination of multidisciplinary team • Early involvement of stakeholders • Clear environmental goals
(Son and Kim, 2015)	• Early involvement of contractor • Detailer pre-project planning phase • Clear definition of strategy
(Garbharran et al., 2012)	• Involvement of stakeholders • Competent project manager • Resource availability • Comprehensive contract documentation • Competent project team • Top management support • Political support • Clear objectives • Shared project vision • Local stakeholder involvement
(Banihashemi et al., 2017)	• Cleary defined goals • Comprehensive contractors' portfolio investigation
(Ajayi and Oyedele, 2018)	• Design flexibility • Early involvement of stakeholders and contractors
(Molenaar Keith R. et al., 2013)	• Effective use of schedule management • Timeliness of submittals by contractor
(Hwang and Leong, 2013)	• Quality assure the documentation • Documentation produced on time • Minimizing amount of variation orders
(Kang Youngcheol et al., 2013)	• Extensive pre project planning • Early identification of long lead/critical materials • Site layout • Project design criteria • Future expansion plans • Waste treatment plan
(Gunduz and Yahya, 2018)	• Completion of design at the construction start • Clear scope definition • Adequate risk analysis • Personnel selection and training • Effective tendering methods
	• Project complexity levels

(Chan et al., 2004)	• Control of sub-contractor's works • Appropriate organizational structure
(Luo Lan et al., 2017b)	• Trust among project teams • Cultural differences • Knowledge of new technology • Influence of external stakeholders
(Hussein, 2016, p. 59)	• Experience from similar projects • Clear project mandate • Clarity around project managers authority • Realistic scope definition and plans • Fostering trust between project teams

Table 3.2: Success criteria identified through relevant literature

These success criteria were then adopted to the final questions for the first Delphi survey where the participants had to rank the top 15 success criteria from 1 through 15 where 1 was the most impactful. The answers would then be given a weighted average ranking that was calculated using:

$$\frac{x_1w_1 + x_2w_2 + x_3w_3 \ldots + x_{15}w_{15}}{Total\ response\ count} \mid \begin{matrix} x = response\ count\ for\ answer \\ w = weight\ of\ ranked\ position \end{matrix}$$

The weights were applied in reverse, so the first choice had the heaviest weight, e.g. the survey had 15 rankings, which in turn gave the #1 choice a weight of 15, while the #15 choice was given a weight of 1. This way the more popular a choice was, the higher weighted score it got. The choice of making the participants rank only 15 of the success criteria were based on wanting to eliminate outliers or non-important success factors, as well as speed up the completion time as to not deter any participants to not answer due to the need of heavy time commitment. This was possible because the choices not ranked got a weighted score of 0 points. The choice of a ranking survey was because the survey would consist of a vast amount of success criteria and that using a different type of survey would lead to long completion time which in turn could lead to less responses within the execution window. Another factor was that it would be hard to utilize a Likert scale of any type and find a clear consensus when comparing so many entries. The anonymized results of the first survey was sent to all the participants together with the link to the second Delphi survey. The first survey can be seen in full in Appendix D.

3.2.4 Delphi survey #2

The second Delphi survey used the weighted results from part 1 as its focus. The participants were to rank eight challenges that are associated with the success criteria that was identified in the first survey where 1 is the most challenging and 8 is the most trivial challenge. The aim was to identify the greatest challenges that were associated with the given success criteria to further discuss how to best handle those challenges. The survey contained three ranking questions with eight challenges tied to each. After each ranking question came a comment box if the participants wanted to comment on the presented challenges, i.e. there was an obvious challenge missing. The challenges were identified through the papers that were reviewed in the literature review as well as using any prior

knowledge about the given success criteria if any. The three success criteria and associated challenges were:

Clear environmental goals: Clear goals and clear reference values for easy measurement
- Anchoring the current goals and reference values to the project – Being able to understand the goal and reference values in the context of the project. - Conveying the importance of the environmental goals to the members of the project organization. - Adapting the reference values to fit with the project when you're lacking experience from similar projects. - Identifying proper performance indicators that reflects the environmental goals of the project. - High project complexity - The implementation of good communication and documentation protocols within the project organization - Changes in the environmental standards over time due to the large time scope of the project - Implementation of new technology that voids previous reference values

Table 3.3: Challenges identified for the success criteria "Clear environmental goals"

Staff qualifications: The knowledge level of the employees when it comes to the used technology and strategy
- Training of project organization members - Wide difference between project organization members skill level - Lack of prior knowledge when utilizing state of the art technology - The lack of acceptance of the implemented strategy - A shift of power dynamics due to difference in knowledge of chosen technology and strategy - Implementation of new technology that leads to new training requirements - Anchoring the strategy in all levels of the project organization - Cost overruns due to lack of knowledge of chosen technology or strategy

Table 3.4: Challenges identified for the success criteria "Staff qualifications"

Documentation: The level of documentation available from the contractor for easy quality assurance
- Slow presentation of required documentation - Difference in the documentation format for the contractor compared to the project organization - Low levels of cooperation and willingness to facilitate quality assurance protocols - Noncompatible documentation systems - High levels of documentation required reduces the pool of possible contractors - Maintaining good working relations while also doing extensive quality assurance - Time delays due to complex project organization - Quality assuring the supply chain of the contractor due to lacking documentation

Table 3.5: Challenges identified for the success criteria "Documentation"

3.2.5 Choice of survey type

When designing and planning your Delphi method it's important to remember the end goal and what we want to accomplish with the survey. With the goal; to be able to compare and find a consensus between the three different projects, the ranking system was the most logical one, especially for the first survey where we wanted to identify as many success criteria as possible and then make them rank close to 1/3 of the possible criteria. This makes it easier to spot outliers and trends which makes the ranking survey the best option for survey 1.

Survey number two consisted of 3 main success criteria and the participants should rank 8 challenges from the most challenging to the most trivial one. The choice of ranking survey for survey number 2 was not as clear cut as for number 1 due to less questions and the applicability of a Likert or semantic differential scale which are scales where the user rate their level of agreement (Tullis and Albert, 2013). The implementation of a Likert or semantic differential scale would make sense if the goal was to gain more detailed knowledge of how each of the expert felt, but the main point of this survey was to find a consensus for all the projects, thus making a ranking survey more beneficial to use as the different projects vary in size, political pressure and environmental certificate type.

3.2.6 Optional interviews

The final part of the Delphi Study is optional interviews of the participants in regards of the results from the second Delphi survey. The idea behind this is to gain further knowledge into the experts' thoughts and feelings of the final results, as well as facilitate further discussion and reasoning. This can be done through email correspondence, phone or a physical meeting.

3.2.7 Limitations

The Delphi method is used to find a consensus between different experts on a certain subject. The nature of the Delphi method makes it very disconnected with the participants

as there are little to no interaction in the form of an open and live discussion, which in some cases can lead to a better consensus if the discussion is facilitated well. The Delphi method is also reliant on survey responses which can lead to delays, which in turn can lead to the participant disconnecting with the study. Time constraints is also a limiting factor as it was not possible to have organized controlled opinion feedback sessions in between the two surveys, which could have led to feedback of higher value than just the initial responses from survey 1. The identification of experts were also done through the help of my mentors in Statsbygg, which breaks with normal routine of using a knowledge resource nomination worksheet (KRNW) (Okoli and Pawlowski, 2004).

3.3 Alternative methods

3.3.1 Interviews

Interviews were another research option when trying to identify and map challenges associated with green construction project management. The problem was twofold, where the first part of the problem was the sheer complexity of the current selection of projects. Interviews would have been a better fit if only one project were looked at, but the whole point was to find challenges that span different projects and that doesn't stem from the uniqueness of a given project. The number of interviews would have had to be very high to get any real sense of consensus, as well as the fact that the questions would have been thoroughly thought through to have the experts agree on it. This reasoning, combined with the estimated time usage that interviews would take, was a deciding factor when disregarding interview as a valid option.

3.3.2 Regular survey

The use of a regular survey to gather quantitative data was considered as it's a "send and forget" method, which could have generated interesting data if it was done early and the survey had a long lifespan. A possible problem with quantitative data survey is the wide range of data generated due to the differences of the three projects used in the case study. The goal of the research was to identify challenges the project manager faces in green construction projects with high environmental ambition, which can be hard to do when using an anonymous survey sent out to the whole project organization. One could just send it to specific persons, but that's the same as the Delphi method without the tested framework of that method, thus regular survey was disregarded as a valid option.

3.4 Validity, reliability and transferability

3.4.1 Validity of the research

The Delphi method validity is based upon good consideration of the development of the surveys, the population that the hypothesis applies to and the sample of respondents (in this case the expert panel). The iterative process of the Delphi method continues until a satisfactory consensus is reached. Construct validity can be assured by asking experts to validate the variables chosen (Okoli and Pawlowski, 2004).

For this research the initial literature review formed the selection of success criteria presented in the first Delphi survey. This selection was first vetted by members of the

expert panel, which in turn validates the selection as relevant success criteria that are applicable to the case study projects. The goal of the research is to identify challenges that are prevalent in green construction by using case study projects and the Delphi Method is a good way of reaching the end goal. The low number of experts available and participating could lower the validity of the Delphi method, but the magnitude of the impact it has on the studies validity is hard to measure due to the use of case study projects which makes the choice of expert important as well, not just total number of participants.

3.4.2 Reliability of the research

The research methodology is extensively documented in this chapter which makes the study easy to repeat. The Delphi Study follows a clear path and the choices were based heavily upon the works of Okoli and Pawlowski (2004). It's believed that the consensus reached by the experts is replicable and will not change drastically by introducing more experts. It's important to note that the Delphi Study employed produces qualitative and quantitative data, where the process of conducting the research is easily replicable, the results may differ in richness depending on the projects reviewed due to the uniqueness of green construction projects with high levels of environmental ambition.

3.4.3 Transferability of the research

This research is specific to the three Statsbygg projects; New Government Quarter; New National Museum; and UiO Life Science Building; who all have an environmental certificate at the level of BREEAM-NOR Excellent or FutureBuilt. The study is biased towards challenges faced by project managers that operate within the organizational structure of Statsbygg, which skews the perception of what success criteria are important, and the challenges linked to said success criteria. The study can be applicable to project managers of projects of similar size and environmental ambition, but the success criteria presented should be reviewed by considering the organizational structure and size for best result when applied beyond the boundaries of this thesis.

4 Results

In this chapter the results from the Delphi Study will be presented in an orderly fashion with clear overview over the answers, limitations and any custom feedback from the participants.

4.1 Final panel of experts

After the initial invitation email, the final panel consisted of experts from all three projects where only one of the participants declined the invitation. The distribution of the final panel of experts looked like:

Project	Number of experts
The new Government Quarter	4
New National Museum	3
UiO life science building	2

4.2 Delphi survey #1

The first Delphi survey was active for 3 weeks, where a total of 6 responses were submitted by the participants. All three projects had 2 submissions each and the average time spent on the survey was roughly 23 minutes according to the analysis tool on SurveyMonkey. This is well within the time limit set in the mail at 30 minutes, and close to the estimated time of completion, which was set in the mail to be 20 minutes. Normally you would use the built-in survey analysis tool on SurveyMonkey to get an overview over the weighted rankings from the survey, but the rating was skewed due to the inclusion of N/A answer alternative. This was expected so all the answers were exported into an Excel file and handled there instead. Two answers stood out from the rest with a heavily favored weighted score, namely "Staff qualifications" at 8.33 and "Clear environmental goals" at 10.33. These two success criteria were the ones with the highest grade of consensus between the experts. The top 10 weighted success criteria can be seen in figure 4.1

Figure 4.1: Top 10 weighted success criteria from Delphi survey #1

There was also a consensus on the other end of the scale, where there were some success criteria that were not chosen by any expert, thus getting a weighted score of 0. The success criteria with 0 score were:

- Identification of long lead/critical materials
- Alternative procurement method and plans
- Local stakeholder management
- Number of external stakeholders
- Low total number of executives with decision-making authority
- Magnitude of change orders
- No late change orders
- No supply chain change

The low end of the weighted score list featured success criterias that could be classified as heavy outliers in the sense that most of them were chosen by only one expert as a success criteria of some note. This means that one expert valued this success criteria highly, but the other experts found the success critera not important to make it on their top 15 list. The only exception to this when looking at the low 13 scores above 0 is risk management, with 3 experts rating it as part of their top 15, and public media relations, where 2 experts agreed that it should be part of the top 15 success criteria found in green construction. Another outlier of note is the handling of government policies and regulations which had a weighted score of 4.67, but is classified as an outlier due to beeing relevant to only 1 of the 3 projects as both experts on the New Government Quarter project valued this heavily, where the other experts did not.

Outliers were defined in this instance as answers which were not supported by at least half or by a simple majority of the experts and if they didn't have experts from each project endorsing it. This rule made it easier to get an overview over which success factors had some sort of consensus that they were important. Figure 4.2 showcases all of the weighted scores from Delphi survey #1 while figure 4.3 is adjusted to only show the success factors that had at least half of the experts agreeing. The total number of valid entries after adjusting for the outliers were 15 total entries. This is in stark contrast of the total number of entries, which were 45.

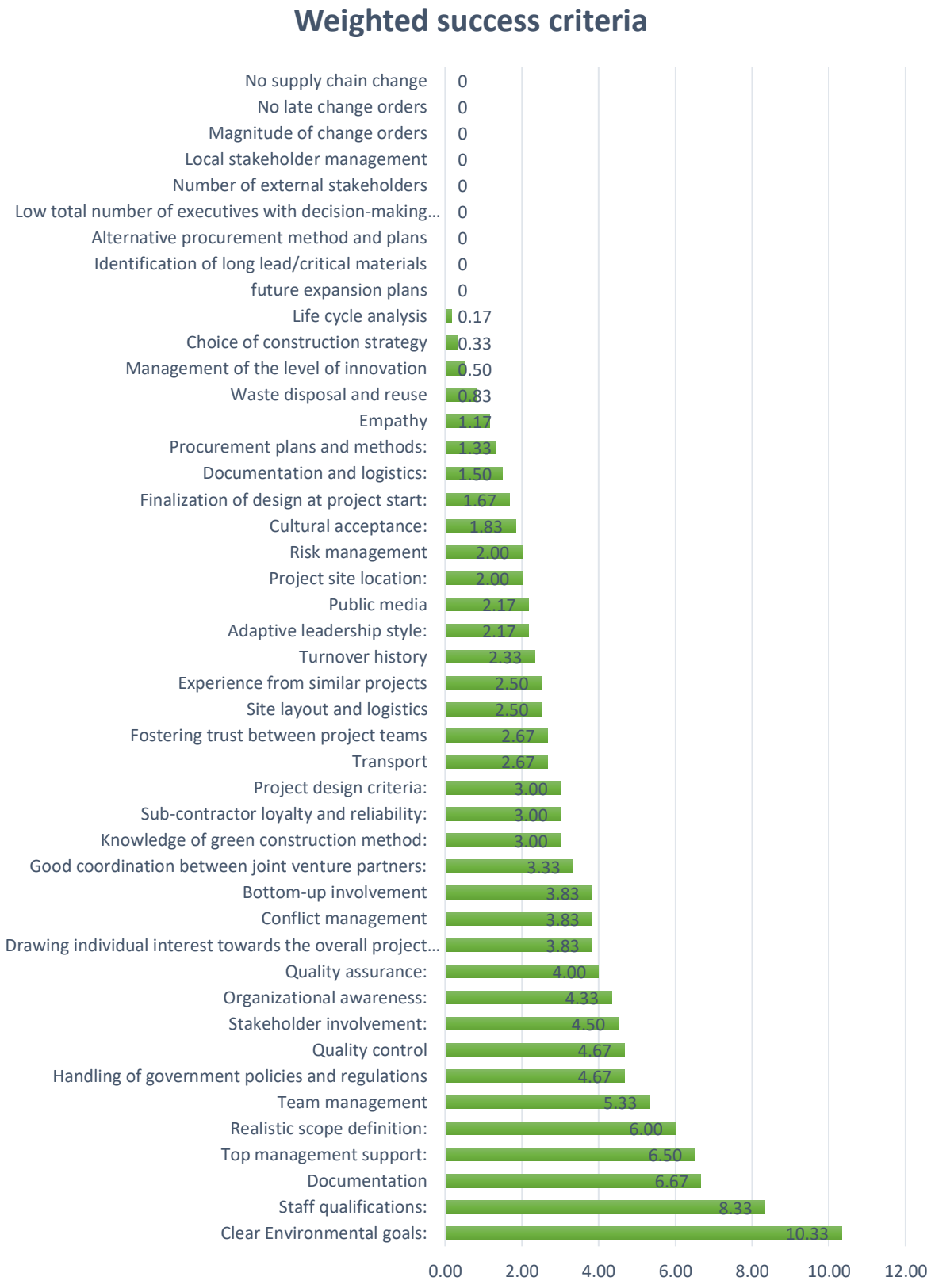

Figure 4.2: All weighted success criteria

Figure 4.3: Weighted success criteria adjusted for outliers

4.2.1 Limitations

One limitation with Delphi survey #1 was the fact that the responses got staggered as someone answered quickly while others answered late. This could lead to a deterioration of the quality of the answers because the participants answering early could feel disconnected to the study due to long intermissions between the two surveys. This was mostly because some participants had taken out summer holiday, as well as not being able to coordinate the responses between the three projects properly.

4.3 Delphi survey #2

The second Delphi survey was active for two weeks, where a total of 5 responses were submitted by the participants. This was an overall decrease of total submissions compared to the first survey and was due to participants taking summer vacation. The expert dropping out were part of the New Governmental Quartal project, so that project was only represented by one expert in the second survey, but all projects were represented by at least one expert. The average total completion time of the survey was 9 minutes which corresponds well with the time estimate presented in the second invitation email that were sent to all the participants. All three questions produced one answer each that stood out from the rest, while the second highest weighted answers had a bit more contention in the question of clear environmental goals and staff qualifications.

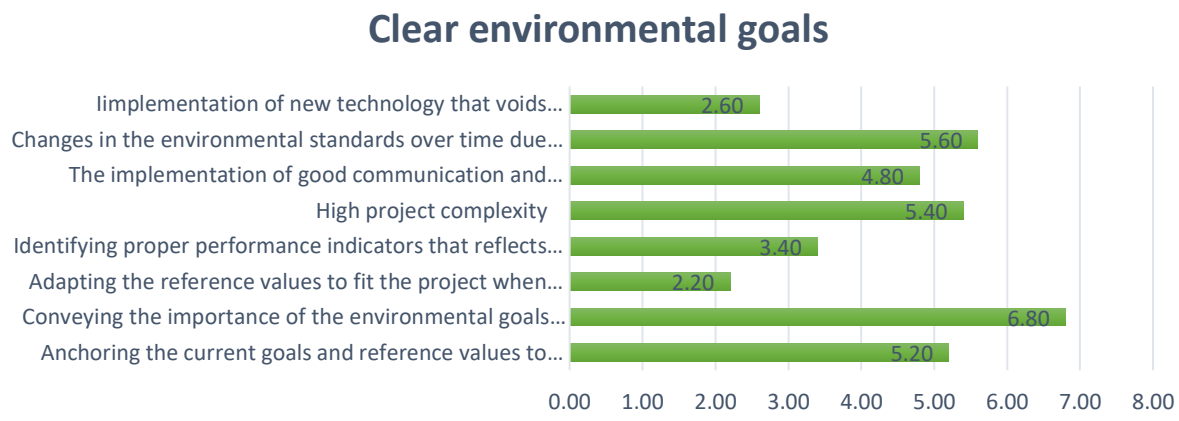

Figure 4.4: Weighted results of challenges with clear environmental goals

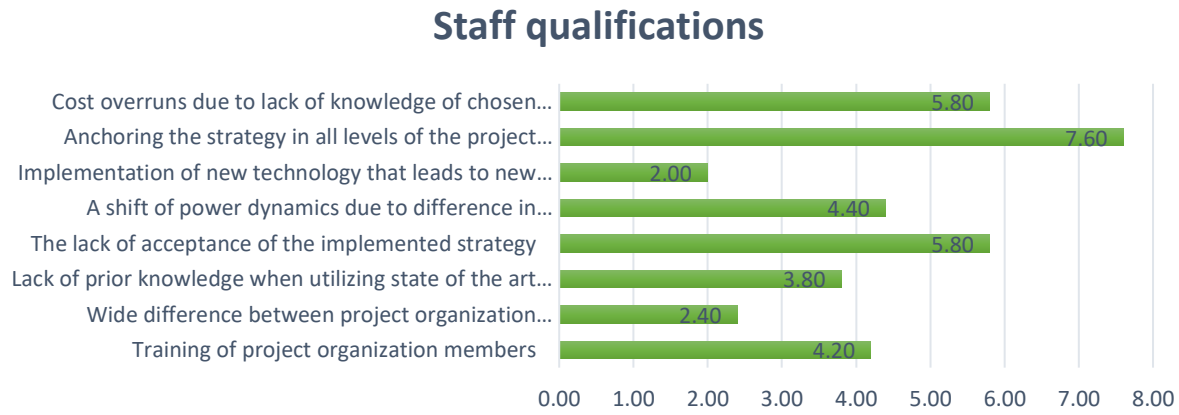

Figure 4.5: Weighted results of challenges found with staff qualifications

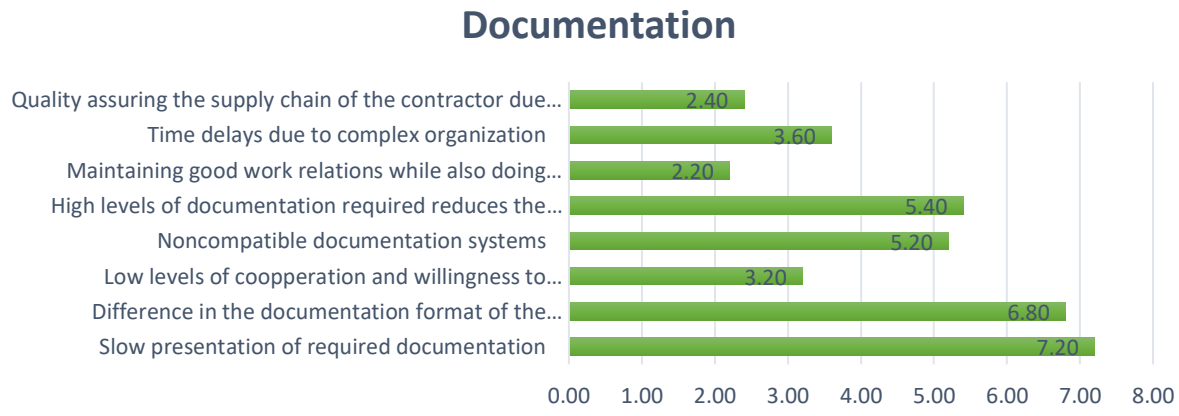

Figure 4.6: Weighted results of challenges found with documentation

There was a clear consensus for the most challenging aspects found when examining clear environmental goals and staff qualifications, while a lot closer when examining challenges found with documentation as the two top answers have a delta of 0.40 points. Those two answers on the other hand have a large delta of 1.40 down to the next challenges so it seems that the consensus is that "slow presentation of documentation" and "difference in documentation format of the contractor compared to the project organization" are the two biggest challenges faced by project managers when dealing with documentation as a success criteria. A trend can also be seen with the low scoring challenges as all three questions have two challenges each that are rated with a weighted score between 2.0 – 3.0. This shows that the experts agreed that these challenges were the most trivial ones. The question with the most contention was the one concerning clear environmental goals as a success factor, where the delta between the second highest score and the fifth highest score is only 0.80 points, which indicates that this was a question where the experts opinion differed compared to the trends seen in the other questions.

By adjusting out the low scoring challenges, which were found by the expert consensus to be the most trivial ones, we're left with a total of 12 challenges that should be used as the basis for discussion and theory building, where the allocation of said challenges looks like this:

Clear environmental goals

• Conveying the importance of the environmental goals to the members of the project organization • Changes in the environmental standards over time due to the large time scope of the project	• High project complexity • Anchoring the current goal and reference values to the project • The implementation of good communication and documentation protocols within the project organization

Staff qualifications

• Anchoring the strategy in all levels of the project organization • The lack of acceptance of the implemented strategy	• Cost overruns due to lack of knowledge of chosen technology or strategy

Documentation

• Slow presentation of required documentation • High levels of documentation required reduces the pool of possible contractors	• Difference in documentation format of the contractor compared to the project organization • Noncompatible documentation systems

4.3.1 Limitations

A big limiting factor for the Delphi survey #2 was the reduced run time of the survey, which was a bleed over effect from the time delays experienced with the first survey due to summer vacation. This reduction in time scope, combined with the summer vacation problem encountered with the first survey, reduced the total responses which lowers the validity of the study. All projects were fortunately represented, but the new Government Quarter project got reduced to only one expert that responded. The summer vacation also made it hard to organize final interviews as many of the experts were unavailable for further comment until the beginning of August, which were well after the final date of the study.

5 Discussion

In this chapter the method and results will be discussed up against relevant literature to establish the best way of tackling the challenges identified and the best practice for project managers going forward.

5.1 The expert panel

The process of choosing the members of expert panels was not done by utilizing a knowledge resource nomination worksheet (KRNW), but with the help of my mentors at Statsbygg, Lars Petter Bingh and Elin Hansen. In hindsight this was a mistake as I should have made contact earlier with potential experts to be able to better collect initial project success factors that were aligned with the different projects. The project success factors presented in survey 1 were based off of the extensive background information for the projects that were presented to me by my mentors in combination with the literature review, but it would have enhanced the survey if an initial collection of factors had been done prior to the first survey. The size of the expert panels is also an important point to note, where the final expert panel was made up of 9 experts divided over 3 projects. The number of experts in a Delphi panel can be modest and vary in size due to the group not depending on statistical power, but rather on group dynamics (Okoli and Pawlowski, 2004), which in turn makes the chosen expert panel valid, but in hindsight not ideal due to the amount of attrition that came with the summer vacation.

5.2 Delphi survey #1

5.2.1 Outliers

While it's interesting to identify success factors that the expert agrees on it's also interesting to look at the success factors that were not chosen, where the experts agreed that they were not important enough to be in the top 15 project success factors for green construction projects. The outliers can be classified into two groups, where the first group are the outliers that didn't receive any ranking whatsoever and the second group are the ones who received a ranking, but didn't pass the requirement of having at least 50% representation, and having at least one expert from each project rank it. The critical success factors that didn't receive any ranking were presented by these authors in the literature review.

Authors	Critical success factor
Kang Youngcheol et al. (2013)	• Identification of long lead/critical materials • Alternative procurement method and plans
Garbharran et al. (2012)	• Local stakeholder management
Meng and Boyd (2017)	• Number of external stakeholders
Kermanshachi et al. (2016)	• Low total number of executives with decision-making authority • Magnitude of change orders • No late change orders
Raman (2013)	• No supply chain change

Kermanshachi et al. (2016) explores in their study the different project complexity indicators and their impact, and the conclusion is that changes in general is a driving force behind increased project complexity, which in turn has a negative correlation with project performance which is confirmed by the findings of Luo Lan et al. (2017a); Luo Lan et al. (2017b); Wood and Gidado (2008); and Gidado (1996). Then the question becomes why the agreed consensus between the experts is that the success factors presented by Kermanshachi et al. (2016) is not valid for our case study projects. Low number of executives with decision making authority, magnitude of change orders and no late change orders are all project success factors that implies a volatile project organization, which is not necessarily applicable to Statsbygg as an organization or as a project owner. A parallel can be drawn to the "no supply chain change" which was presented by Raman (2013) where some of the biggest challenges with an environmentally sustainable supply chain was that a change in the supply chain would lead to an increase in both connected cost and complexity. Both Kermanshachi et al. (2016) and Raman (2013) presented success factors that where tied to an increase in project complexity, which in itself can be good project success factors, but the factors seem to be more suited for projects and project organizations that are more volatile in nature compared to Statsbygg.

While a lack of focus on project complexity dependent success factors can be attributed to Statsbygg low volatility and experience as project manager and project organization, the success factors presented by Kang Youngcheol et al. (2013) focus on redundancies. The success factors identified is the identification of long lead/critical materials and alternative procurement method and plans, which in isolation sounds like good success factors for construction projects as time is part of the traditional iron triangle; time, cost and scope. Kang Youngcheol et al. (2013) did say that the need for these redundancies go down with

an increase of focus on the pre-project planning phase, which is supported by Morel et al. (2001); Shen and Tam (2002); Hwang (2012); and Robichaud Lauren Bradley and Anantatmula Vittal S. (2011) who all stresses the importance of good planning and good communication to ensure project success in green construction projects. The projects in this case study are all projects with high environmental ambition in the form of BREEAM NOR Excellent or FutureBuilt standards, which forces Statsbygg to do extensive pre-project planning, which in turn reduces the need for these redundancies, or that these redundancies are part of best practice anyways, thus making the success factor obsolete.

Garbharran et al. (2012) and Meng and Boyd (2017) both highlights the stakeholders as critical success factors which is not strange when it seems like it's widely accepted that stakeholders have a large influence on a construction projects success rate, be it through direct impact in the form of forced changes, or indirect impact in the form dissatisfaction. This notion of importance is supported by the findings of Banihashemi et al. (2017); Hwang and Ng (2013); and Robichaud Lauren Bradley and Anantatmula Vittal S. (2011) who all highlight the importance of the stakeholder in green project management. One thing to note is the fact that Statsbygg is a publicly owned company governed by The Ministry of Local Government and Modernization and is dependent on the approval of a third-party quality assurance (KS1 and KS2) to be able to continue the project (Finansdepartementet, 2019). This will anchor the project in the public eye and helps alleviate the impact local or external stakeholders might have on the project. If the public is discontent with the project and voices their concern, it's usually up to the government to handle the public as a stakeholder for large public projects. Heavy involvement of local stakeholders can have a negative impact on project success which is highlighted in a case study of the construction of a Norwegian high school where high levels of user involvement had some detrimental effects (Hussein, 2016, pp. 223–233)

There are three success criteria that are interesting, which had a weighted score, but ended up being cut; Life cycle analysis; Waste disposal and reuse; and Handling of governmental policies and regulations. From figure 5.1 we see that life cycle analysis (LCA) and waste disposal and reuse both had a weighted score below 1 and LCA with the lowest score of 0.17, which is strange when it's heeded as an important success factor by Skele et al. (2011); Morita et al. (2011); and as one of the main principles of BREEAM-NOR in the technical manual by Byggalliansen (2019). One reason behind the low score and outlier status could be that LCA has become ubiquitous in Norwegian green construction practices which in turn will reduce the importance to specify LCA as its own success factor, much like the redundancies factors presented by Kang Youngcheol et al. (2013). Waste disposal and reuse as a critical success factor is highlighted by Banihashemi et al. (2017); Robichaud Lauren Bradley and Anantatmula Vittal S. (2011); and Shen et al. (2004) and they all agree that good waste disposal and the reuse of materials are paramount for the success for a green construction project. Waste disposal and reuse got a weighted score of 0.83, which would contradict that statement, but there is a caveat here; the TEK 17 "regulations on technical requirements for construction works" by the Norwegian Building Authority (Direktoratet for byggkvalitet, 2020). This building act and regulation sets strict rules for how waste is to be disposed, as well as requirements for the recyclability and reusability of materials used. This could be a driving factor for why waste disposal and reuse is so little valued as a success factor by the expert panel compared to the value relevant literature gives it, as the literature is giving general views on its importance instead of country specific, where the experts are ranking it within the knowledge that the project has to operate within TEK 17 requirements.

When looking at the other end of the spectrum of the outliers we have the handling of government policies and regulations, which got a weighted score 4.67. This score is higher than the majority of the success factors that had at least half of the experts and at least one from each project ranking it. The inflated score stems from the ranking from the two experts from The New Government Quarter project which ranked this success trait highly were the other experts didn't include it. This didn't come as a surprise as that project is under heavy public scrutiny and is subject to change due to shifts in political powers and public opinion.

Figure 5.1: Weighted score of success criteria outliers

5.2.2 Consensus

The top 3 critical project success factors were chosen as the basis for the second Delphi survey, but that doesn't mean that the other success factors identified are of no significance. Figure 5.2 shows the ranking when the top 3 factors are removed, which shows that the remaining success factors are close to each other when comparing weighted scores.

First thing that is notable is the amount of success factors relating to emotional intelligence (EI) of the project manager. Fostering trust between project teams; drawing individual interest towards the overall project objective; bottom-up involvement; conflict management; stakeholder involvement; and team management are all soft skills the project manager can inherit to increase the chance of project success. The impact EI has on project performance is debated in relevant literature and the consensus seems to be that it's hard to quantify its impact, but in general a positive correlation between the project managers EI and project success is observed (Hwang and Ng, 2013; Meng and Boyd, 2017; Tabassi et al., 2016; Zhang and Fan, 2013). Lindebaum and Jordan (2012) on the other hand states that the positive correlation found between EI and project success is dependent on the context and task found in the projects. One of the identified problems were the time-sensitivity of many projects which led to less focus on fostering interpersonal relationships and developing quality personal contacts. The fact that the experts seems to agree on the importance of EI factors is aligned with the fact that these projects are big in size and in time scope, which would make the findings of Lindebaum and Jordan (2012) not applicable in this situation.

Figure 5.2: Weighted success criteria when top 3 removed

The success criteria that just missed the top 3 was top management support, which according to Hussein and Klakegg (2014) is tied to project success in the way that the lack of top management support is statistically correlated to risk factors in the project and is tied to the identification process of project success criteria. The fact that Statsbygg is a publicly owned company is also affecting the relevance of top management support as a project success factor, as public projects are under heavy public scrutiny when measured with the traditional project success indicators of time, cost and scope. The need of top management support is apparent when implementing changes that could lead to public outcry due to cost overruns or changes in the scope.

5.3 Delphi survey#2

5.3.1 Challenges identified with clear environmental goals

Clear environmental goals

• Conveying the importance of the environmental goals to the members of the project organization • Changes in the environmental standards over time due to the large time scope of the project	• High project complexity • Anchoring the current goal and reference values to the project • The implementation of good communication and documentation protocols within the project organization

The challenge with the highest weighted score was the challenge of conveying the importance of the environmental goals to the members of the project organization, with a weighted score of 6.80, which has a delta of 1.20 points down to the next challenge. This cements the importance of intra-organizational communication as means to attain project success as presented by Meng and Boyd (2017). They rank intra-organizational communications and trust as the first among six components for internal relationships and highlights the impact internal relationship management has on project success. The ability to communicate well within the project organization will help conveying the importance of the environmental goals to all the members of the project organization. According to Wu et al. (2017) the type of communication between project teams within the same project organization is important as formal communication were positively associated with project success, while informal communication were negatively associated with project success. Communication could also be an entry point when tackling two other challenges that were rated high by the experts; the implementation of good communication and documentation protocols within the project organization; and anchoring the current goal and reference values to the project. Both challenges can be solved by good intra-organizational communication, where the anchoring of current goal and reference values to the project is the one that benefits the most from experience sharing within the project organization. The challenge with the implementation of good communication and documentation protocols within the project organization is that it's dependent on wide acceptance of the

proposed system. Zhang and Fan (2013) states in their paper that organizational awareness is the best trait for a project manager for domestic construction projects. Greater organizational awareness by the project manager could make it easier to propose good communication and documentation protocols that would be widely accepted by the project organization as the project manager is more "in sync" with the project organization.

The last two highlighted challenges related to clear environmental goals are; changes in the environmental standards over time due to the large time scope of the project; and high project complexity. These two challenges are interrelated as an increase in project complexity usually leads to time increase (Baccarini, 1996; Gidado, 1996; Luo Lan et al., 2017a) and changes in environmental standards, large changes of the project premise in general, or changes to the project over time, will increase project complexity (Dao Bac et al., 2017; Lu et al., 2015). This can create a negative feedback loop where the project complexity keeps increasing, making it harder to present clear environmental goals for the members of the project organization. The best way to handle these two challenges would be to focus on minimizing project complexity as that is the one thing the project manager can directly influence. The reduction of project complexity can be done through the identification of the type of project complexity (Lu et al., 2015) and then implementing changes that reduce that type of complexity. Increased organizational awareness will make this process easier (Lu et al., 2015; Zhang and Fan, 2013).

5.3.2 Challenges identified with staff qualifications

Staff qualifications	
• Anchoring the strategy in all levels of the project organization • The lack of acceptance of the implemented strategy	• Cost overruns due to lack of knowledge of chosen technology or strategy

The members of a project organization are the cogs that run the machine, and the quality of these cogs can be seen as the qualification level of its members. Green construction projects often employ new technologies and innovative strategies (Kang Youngcheol et al., 2013) which leads to a greater emphasis on the members qualifications. The experts all agreed that anchoring the chosen strategy in all levels of the project organization were the most impactful challenge. The implementation of a given strategy is the most crucial phase where strong leadership, motivation of the staff, organizational awareness and identification of internal forces are all important factors that affect the degree of success in implementing the new strategy (Göran Roos et al., 2015, chap. 6). The challenge of anchoring the chosen strategy in all levels of the project organization can be tied to the project managers organizational awareness levels and the communication levels within the project organization. As an implementation of a strategy inherently requires a change as you go from one strategy to another, the natural response is to resist the initial change. Good intra-organizational communication helps align the project organization members,

which in turn will reduce friction and animosity towards the changes that follow the implementation of the strategy, thus anchoring the strategy with the project organization members (Meng and Boyd, 2017; Wu et al., 2017; Zhang and Fan, 2013). This will also tackle the challenge of lack of acceptance of the implemented strategy, but here organizational awareness will play a big role as it's important to identify the internal forces within the project organization. By identifying internal negative forces and the corresponding internal barriers, the success rate of implementing the strategy goes up as the project manager can adapt its approach. The level of compliance, conformity, assumptions and heuristics are all correlated to the implementation barriers when advocating change (Hussein, 2016, pp. 70–73).

There is an inherent risk in utilizing new state of the art technology or new strategies as it's dependent on the skill levels of all the members of the project organization. The upsides can be massive, but it can also lead to cost overruns and/or time delays as the project staff doesn't have any prior experience with the given technology or strategy. This challenge of avoiding cost overruns due to lack of knowledge can be divided into two parts, where the first part is the use of new technology. The project manager should weigh the pros and cons of implementing said technology, but sometimes this is not necessarily an option as some projects require the use of innovative technologies, like projects with FutureBuilt environmental certificate (FutureBuilt, 2019). The second part of the challenge is the chosen strategy, which ties back to the project managers organizational awareness and communication skill (Meng and Boyd, 2017; Wu et al., 2017), as well as the project managers self-awareness of own limitations and ability (Zhang and Fan, 2013).

5.3.3 Challenges identified with documentation

Documentation	
• Slow presentation of required documentation • High levels of documentation required reduces the pool of possible contractors	• Difference in documentation format of the contractor compared to the project organization • Noncompatible documentation systems

Green construction projects require extensive documentation in all parts of the project organization when environmental certification is part of the project goal (Hwang and Leong, 2013; Robichaud Lauren Bradley and Anantatmula Vittal S., 2011; Zulkiffli and Latiffi, 2019). This extensive documentation can also lead to long lead times as the documentation is not presented in a timely and orderly fashion. This challenge is twofold as one part is the internal documentation process within the core project organization, while another part is the documentation from external partners such as sub-contractors that would be outside of the project organization or enterprise boundaries. The two challenges with the highest score were slow presentation of required documentation and difference in documentation format of the contractor compared to the project organization, with the weighted scores of

7.20 and 6.80 respectively. One thing to note is the possible one-way dependency that slow presentation of required documentation has on the other challenge as a difference in documentation protocols can lead to long lead times for documentation. The delta between the two challenges is only 0.4 points which lends itself to focusing on the challenge of different documentation formats as the other challenge has some degree of dependency on it. The challenge of different documentation formats can be tied back to the structure of the project organization and the level of organizational complexity (Lu et al., 2015), as well as the project managers organizational awareness and external relationship management (Meng and Boyd, 2017; Wu et al., 2017). Early contractor involvement (ECI) can be used as a positive factor to external relationship management and will help align the contractor with the project organization. ECI is extensively used in private sector and is underrepresented in public projects due to the many legal barriers (Wondimu et al., 2018), but this does not mean it's not applicable as an approach to reduce the challenge of different documentation formats. This is also a solution to the challenge of noncompatible documentation systems as that challenge is dependent on a timing factor. If this challenge is identified late, then the implications are large for the project, but if it's identified early the project manager can then start up a dialog with the contractor to align them with the rest of the project organization.

High levels of documentation required reduces the pool of possible contractors available for the tendering process, which in turn can affect the cost and time aspects of the project due to lack of competition. The strict documentation requirements found in the environmental certificates BREEAM-NOR and FutureBuilt (Byggalliansen, 2019; futurebuilt.no, 2020) is non-negotiable, thus making it hard to alleviate the impact of the high levels of documentation has on possible contractors. The only viable option is to facilitate good intra-organizational cooperation (Meng and Boyd, 2017), early contractor involvement (Wondimu et al., 2018), and fostering the relationship and trust between contractor and project manager (Meng and Boyd, 2017; Molenaar Keith R. et al., 2013)

5.3.4 Challenge interrelatedness

The three success criteria all had challenges that had either links to organizational awareness, management of project complexity, intra-organizational communication, external relationship management and strong leadership. These answers to the challenges faced within the three success criteria can also be applied, to some degree, to the other success criteria identified by Delphi survey #1. The success criteria fostering trust between project teams; conflict management; and team management can all draw parallels to intra-organizational communication (Hwang and Leong, 2013; Meng and Boyd, 2017; Robichaud Lauren Bradley and Anantatmula Vittal S., 2011), while bottom-up involvement and drawing individual interest towards the overall project goal can be attributed to strong leadership skills (Göran Roos et al., 2015, chap. 6; Zulkiffli and Latiffi, 2019). Quality control, top management support, realistic scope definition and risk management on the other hand can be tackled with proper project complexity management (Dao Bac et al., 2017; Kermanshachi et al., 2016; Luo Lan et al., 2017a; Wondimu et al., 2018).

The difference between the project managers experience levels is also a point worth exploring, where the focus points will differ depending in the experience of the project manager. A project manager with prior experience with the project organization usually have a greater initial understanding of the project organization and its inner workings, which shifts the focus over to managing the internal relationships within the organization

as well as communication. A new project manager would on the other hand have little to no experience with the project organization so the initial focus would be working on the organizational awareness. This difference highlights two fundamental different ways of approaching green construction depending on the project managers prior experiences. It's important to note that while the experienced project manager can focus on managing internal relationships and communication, it should not ignore organizational awareness as experienced project managers can have heuristics and assumptions (Hussein, 2016, pp. 70–73) that can work as a limiting factor.

6 Conclusion

The goal of this thesis was to conduct a case study based empirical investigation to identify specific challenges faced by project managers in green construction projects with high environmental ambitions and to use these challenges as a foundation for theory building about project management in green construction projects and how project managers can improve. 45 project success criteria were identified based on a literature review and were the basis for the first survey of the Delphi Study. The panel of experts then ranked their top 15 project success factors and the factors were then given a weighted rating. For a success factor to be eligible it had to have at least half of the experts rank it, and at least one expert representing each project rank it. This produced a list of 15 success factors and the top three success factors were chosen for further investigation.

Success criteria	W_i
Clear environmental goals	10.33
Staff qualifications	8.33
Documentation	6.67
Top management support	6.50
Realistic scope definition	6.00
Team management	5.33
Quality control	4.67
Stakeholder involvement	4.50
Quality assurance	4.00
Conflict management	3.83
Bottom-up involvement	3.83
Drawing individual interest towards the overall project objective	3.83
Fostering trust between project teams	2.67
Experience from similar projects	2.50
Risk management	2.00

Table 6.1: Weighted top 15 success criteria

These factors were further broken down into specific challenges correlating to the specific success criteria based on the literature review and ranked by the expert panel. 12 challenges were identified as challenging for the project manager:

- Anchoring the strategy in all levels of the project organization
- The lack of acceptance of the implemented strategy
- Difference in documentation format of the contractor compared to the project organization
- Noncompatible documentation systems

- Cost overruns due to lack of knowledge of chosen technology or strategy
- Slow presentation of required documentation
- High levels of documentation required reduces the pool of possible contractors

- The implementation of good communication and documentation protocols within the project organization

- Conveying the importance of the environmental goals to the members of the project organization
- Changes in the environmental standards over time due to the large time scope of the project

- High project complexity
- Anchoring the current goal and reference values to the project

These challenges were then used as the origin point for theory building where possible solutions were discussed and proposed based on reviewed and relevant literature. The result suggests that the project managers emotional intelligence (EI), i.e. the ability to communicate, inspire and manage relationships, is interrelated to many of the challenges identified by the study. The project managers organizational awareness is also identified as a skill that is heavily interrelated with the challenges presented as well as the ability to handle external factors like contractors, be it through external relationship management or early contractor involvement.

Different focus points were presented depending on the experience level of the project manager, where an experienced project manager should focus on different aspects of the identified skills compared to an unexperienced project manager who has little to no prior knowledge of the project organization. The focus areas proposed are:

Experienced project manager	Unexperienced project manager
1. Intra-organizational communication	1. Organizational awareness
2. Internal and external relationship management	2. Intra-organizational communication
3. Organizational awareness	3. Internal and external relationship management

Where the main difference is whether the project manager should prioritize organizational awareness or not, where the unexperienced project manager should focus on gaining organizational awareness to reduce the perceived project complexity as well as making it easier to develop the other two skills; intra-organizational communication; and internal and external relationship management.

The skill presented covers large areas concerning the project managers EI but is adequate as a reference guide for further improvement. The proposed skills also cover a large quantity of the success factors that were not classified as outliers as many of these were success factors directly connected to the project managers EI skills. The heavy outliers from the results of Delphi survey #1 are also of note and speaks of the organizational robustness of Statsbygg as a project organization, where usual critical success factors for green construction projects were trivialized by the expert panel.

While one could argue that hard analytical and technological skills are important traits for a project manager, while true, it's not ideal skills to improve as a project manager for green construction projects with high environmental ambition. The reasoning behind this is the fact that green construction pushes the boundaries when implementing state of the art technology and construction strategy to continually innovate, which in turn can make hard skills obsolete or lacking. The increase in project complexity and the dependence on an increasing number of parts, favors a focus on emotional intelligence or soft skills due to the constant nature of people and is the reasoning behind the focus on the three skills; Organizational awareness; intra-organizational communications; and internal and external relationship management.

6.1.1 Limitations and force majeure

This study is a case-study so the results will be affected by factors that could be unique to Statsbygg. The attrition of experts, as well as the delays due to summer vacation reduced the quality of the Delphi Study, making the consensus less robust. The lack of final interviews due to summer vacation and experts not being available for further comment denied further insight into the reasoning behind the results of Delphi survey #2. Two events of force majeure impacted the study, the first one was the outbreak of COVID-19 which led to a full shutdown of Norway, subsequently causing delays as participants had to adjust to the new situation of home office. The second event were the legal action taken against the project "New Governmental Quarter" as that led to a shift of focus for some of the participants.

6.1.2 Future works and application

The results of the study can be used as a guide for project managers when deciding what skills should be expanded to the benefit of project success in green construction projects. The use of the Delphi method has proven an effective tool to identify challenges faced by project managers and external advisors in large domestic construction projects and is applicable on similar projects. The impact of emotional intelligence should be explored further, with a special focus on communication and organizational awareness. The project managers ability to manage external relationships e.g. external contractors, should be explored further as the three success criteria and the challenges identified are mostly applicable to the management of said relationship.

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Appendix

Appendix A: BREEAM-NOR score and rating calculations

Appendix B: BREEAM-NOR verfification process

Appendix C: Invitation to Delphi Study and survey #1 appendix

Appendix D: Delphi survey #1 design

Appendix A – BREEAM-NOR Score and rating calculations

Assessment of shell and core/speculative buildings

Non fitted-out 'speculative' new buildings, often referred to as shell and core buildings, can be assessed using BREEAM-NOR NC. Further details on the application of the scheme to these types of building can be found in Appendix D.

Outside the scope of BREEAM NOR New Construction Schemes

BREEAM-NOR NC is not designed to assess infrastructure projects, community level masterplanning projects, or the refurbishment, fit-out, operation and deconstruction of existing building.

Information on assessing refurbishment and/or fit out projects can be found in Appendix C.

Existing buildings (occupied/unoccupied) can be assessed and certified using the BREEAM In-Use scheme. See www.byggalliansen.no for more details.

Scoring and rating BREEAM NOR assessed buildings

The elements that determine the overall performance of a new construction project assessed using BREEAM-NOR are as follows:

1. BREEAM-NOR rating benchmarks
2. Minimum BREEAM-NOR standards
3. Section weightings
4. BREEAM-NOR assessment issues and credits

How these elements combine to produce a BREEAM-NOR rating is summarised in the following pages, followed by a description and example of the method of calculating a rating.

BREEAM rating benchmarks

The BREEAM rating benchmarks for new construction projects are as follows:

Table 3: BREEAM rating benchmarks

BREEAM Rating	% score
OUTSTANDING	≥ 85
EXCELLENT	≥ 70
VERY GOOD	≥ 55
GOOD	≥ 45
PASS	≥ 30
UNCLASSIFIED	< 30

A BREEAM-rating enables clients and other stakeholder to compare a building's performance with other buildings BREEAM rated at the same life cycle stage of assessment. In this respect each BREEAM rating broadly represents performance equivalent to:

1. Outstanding: Less than top 1% of new buildings (innovator)
2. Excellent: Top 10% of new buildings (best practice)
3. Very Good: Top 25% of new buildings (advanced good practice)
4. Good: Top 50% of new buildings (intermediate good practice)
5. Pass: Top 75% of new buildings (standard good practice)

An unclassified BREEAM-rating represents performance that is non-compliant with BREEAM, failing to meet either the BREEAM minimum standards for key environmental issues or the overall threshold score required for formal BREEAM certification.

Minimum standards

To ensure flexibility, most BREEAM-NOR credits can be traded to achieve the target BREEAM-NOR rating i.e.non-compliance in one area can be off-set through compliance in another.

However, to ensure that performance against fundamental sustainability issues is not over-looked in pursuit of a particular rating, BREEAM-NOR sets minimum standards of performance in key areas, e.g. energy, water and waste. It is important to bear in mind that these are minimum acceptable levels of performance and should not necessarily be viewed as levels that represent best practice for a BREEAM –NOR rating level.

To achieve a particular BREEAM-NOR rating, the minimum overall percentage score (given in Table 3) must be achieved, and the minimum standards applicable to that rating level complied with – these are detailed in Table 4.

Table 4: Minimum BREEAM NOR standards by rating level

BREEAM issue	Comment	Pass	Good	Very Good	Excellent	Outstanding
Man 03: Responsible construction practices	*Crit 7/8				1 credit*	2 credits*
Man 04: Commissioning and handover	*Crit 1-4 **Crit 1-4+7	1 credit*	1 credit*	2 credits**	2 credits**	3 credits**
Man 05: Aftercare	*Crit 3				1 credit*	1 credit*
Hea 01: Visual comfort		Criterion 1	Criterion 1	Criterion 1	Criterion 1	Criterion 1
Hea 02: Indoor air quality	*Crit 1+7 **Crit 1+9			2 credits*	3 credits**	3 credits**
Hea 08: Private space	Residential only					1 credit
Hea 09: Moisture protection				1 credit	1 credit	1 credit
Ene 01: Energy efficiency					6 credits	8 credits
Ene 02a: Energy monitoring	Non residential only			1 credit	1 credit	1 credit
Ene 04: Low or zero carbon technologies					1 credit	1 credit
Ene 23: Energy performance of building structure and installations						2 credits
Wat 01: Water consumption					1 credit	2 credits
Mat 01: Life cycle impacts		Criterion 1	Criterion 1	Criterion 1	Criterion 1	Criterion 1
Mat 03: Responsible Sourcing		Criterion 1	Criterion 1	Criterion 1	Criterion 1	Criterion 1
Wst 01: Construction waste management						1 credit
Wst 03a&b: Operational waste					1 credit	1 credit

Section weightings

Each of the technical sections within BREEAM-NOR has an associated weighting. Weightings provide a means of defining, and therefore ranking, the relative impact of the sustainability issues covered in BREEAM-NOR. BREEAM-NOR uses a weighting system derived from a combination of consensus-based weightings, ranking by a panel of experts. These are used to determine the relative values of the sections used in BREEAM-NOR, and their contributions to an overall BREEAM-NOR score.

Table 5: Category weightings in BREEAM-NOR NC 2016

CATEGORY	Weighting (%)
MANAGEMENT	12
HEALTH AND WELLBEING	15
ENERGY	19
TRANSPORT	10
WATER	5
MATERIALS	13,5
WASTE	7,5
LAND USE AND ECOLOGY	10
POLLUTION	8
INNOVATION	10

BREEAM-NOR assessment issues and credits

BREEAM-NOR NC consists of a range of assessment issues spanning the ten technical sections.

Each issue addresses a specific building related environmental impact or occupant-related factor, and has a number of 'credits' assigned to it. BREEAM-NOR credits are awarded when a building meets the best practice performance levels defined for that issue i.e. it has mitigated an environmental impact or, in the case of the health and wellbeing section, addressed an occupant-related issue, such as thermal comfort, access to daylight or quality of acoustics.

The number of credits available for an individual assessment issue will vary. Generally, the higher the number of credits on offer, the more important that issue is to mitigating a building's impact. Where there are multiple credits available, the number awarded is usually based on a sliding scale, where progressively higher standards of building performance are rewarded with a higher number of credits.

It is worth noting that assessing a building's performance against the BREEAM-NOR issues also provides users with a credible set of key building performance indicators for a range of embodied, operational and construction impacts. They can be used to define performance levels in support of specific organisational policy objectives for individual environmental issues. However, care should be taken when setting design targets using individual issues, as it can limit design flexibility and have an impact on project costs.

Awarding credits for innovation

One of BREEAM-NOR's aims is to support innovation in the construction industry. The scheme does this by making additional credits available to recognise sustainability related benefits or performance levels that are currently not recognised by standard BREEAM-NOR assessment issues.

In this way BREEAM-NOR rewards buildings that go beyond best practice in terms of a particular aspect of sustainability, i.e. where the building or its procurement has demonstrated innovation.

Awarding credits for innovation enables clients and design teams to boost their buildings' BREEAM-NOR performance and, in addition, helps to support the market for new innovative technologies and design or construction practices.

There are two ways in which BREEAM-NOR awards innovation credits to recognise innovation in building design and procurement.

Exemplary level

The first is by meeting exemplary performance criteria defined in an existing BREEAM-NOR issue, i.e. going beyond the standard BREEAM-NOR assessment criteria and therefore best practice.

Note: not all assessment issues have exemplary performance criteria.

Innovative

The second route is where an application is made to Grønn Byggallianse by the BREEAM-NOR Assessor to have a particular building technology or feature, design or construction method or process recognised as 'innovative'. If the application is successful and building compliance is subsequently verified, an Innovation credit can be awarded.

An additional 1% can be added to a building's overall score for each innovation credit achieved. The maximum number of innovation credits that can be awarded for any one building is ten. Innovation credits can be awarded regardless of the building's final BREEAM-NOR rating, i.e. they are awardable at any BREEAM-NOR rating level.

Calculating a building's BREEAM NOR rating

A BREEAM-NOR Assessor must determine the BREEAM-NOR rating using the appropriate assessment tools and calculators. An indication of performance against the BREEAM-NOR scheme can also be determined using a BREEAM-NOR Pre-Assessment Estimator. The Pre-Assessment Estimator is available from the Grønn Byggallianse website www.byggalliansen.no.

The process of determining a BREEAM-NOR rating is outlined below and an example calculation included in Table 6:

1. For each environmental section the number of 'credits' awarded must be determined by the assessor in accordance with the criteria of each assessment issue (as detailed in the technical sections of this document).
2. The percentage of 'credits' achieved is then calculated for each section.
3. The percentage of 'credits' achieved in each section is then multiplied by the corresponding section weighting. This gives the overall environmental section score.
4. The section scores are then added together to give the overall BREEAM-NOR score. The overall score is then compared to the BREEAM-NOR rating benchmark levels and, provided all minimum standards have been met (refer to Table 6, the relevant BREEAM-NOR rating is achieved.
5. An additional 1% can be added to the final BREEAM-NOR score for each 'innovation credit' achieved (up to a maximum of 10%).

Table 6: Example BREEAM-NOR score and rating calculation

BREEAM-NOR Section	Credits Achieved	Credits Available*	% of Credits Achieved	Section Weighting*	Section score
Management	10	20	50%	0.12	6%
Health and wellbeing	11	22	50%	0.15	8%
Energy	15	32	47%	0.19	9%
Transport	6	9	67%	0.10	7%
Water	6	9	67%	0.05	3%
Materials	6	11	55%	0.135	7%
Waste	2	6	33%	0.075	3%
Land use & Ecology	1	10	10%	0.10	1%
Pollution	5	14	36%	0.08	3%
Innovation	0	0	0%	0.10	0%
Final BREEAM-NOR score					46,1 %
BREEAM-NOR rating					GOOD
*This will vary depending on building type and location.					

Table 7: Minimum standards for BREEAM NOR 'Good' rating achieved?

Minimum Standards for BREEAM NOR 'Very Good' rating Achieved?	Achieved?
Man 04 Commissioning and handover	Y
Hea 01: Visual comfort	Y
Mat 01 Life cycle impacts	Y
Mat 03 Responsibel Sourcing	Y

Producing case studies for BREEAM NOR 'Excellent and Outstanding' rated buildings

Projects certified to the BREEAM-NOR 'Excellent' and 'Outstanding' rating should act as exemplars for the industry. If they are to do this, case studies of these projects are needed so that other project teams and clients can refer to them.

Prior to Final Certification the design team and client for BREEAM-NOR 'Excellent' and 'Outstanding' rated projects are asked to provide either a case study of the building or information to allow Grønn Byggallianse to produce a case study. This information will be requested at the final post construction stage and should be provided with the BREEAM-NOR assessor's Final Certification Report.

Grønn Byggallianse will publish the case study on their websites, and share this with BRE Global to post on the Green Book Live website and in other BRE/BREEAM-related publications.

Appendix B – BREEAM-NOR verification process

Who is behind BREEAM and BREEAM NOR?

BREEAM is managed and continually developed by BRE Global and supported in certain countries by a number of National Scheme Operators (NSOs). NSO's (like Grønn Byggallianse) are independent organisations who develop and own country specific 'local' schemes that are affiliated to BREEAM.

The founder and owner of the BREEAM brand, BRE Global, is the NSO for the UK. BRE Global also develops and manages the pan-country scheme, BREEAM International. BRE Global is an independent, third-party approvals and certification organisation that is part of the BRE Group. The BRE Group is owned by the BRE Trust, a UK registered research and education charity that works to advance knowledge, innovation and communication in the built environment. The Trust uses all profits made by the Group to fund new research and education programmes.

The operation of BREEAM is overseen by an independent Governing Body and a Standing Panel for Peer & Market Review. The Governing Body represents stakeholders to ensure that BRE Global acts correctly and impartially, and treats customers fairly. The Standing Panel provides access to a range of experts that ensure scientific, technical and market robustness, and that BREEAM's development is open to external and independent scrutiny.

The United Kingdom Accreditation Service (UKAS) have accredited BRE Global Ltd against ISO/IEC 17065 'Conformity assessment - Requirements for bodies certifying products, processes and services'. This can be verified on the UKAS website, and includes BREEAM Scheme SD123 'Environmental assessments of the built environment – certification of the process'.

BRE Global Ltd is also certified to ISO 9001 'Quality management systems – Requirements' for all its BREEAM related activities. BREEAM-NOR is developed by Grønn Byggallianse. Grønn Byggallianse is currently operating BREEAM-NOR under license from BRE Global Ltd. Grønn Byggallianse has developed its own management system to be in line with BRE requirements and in accordance with the framework agreement with BRE.

The BREEAM family

BREEAM has expanded from a single scheme focusing on individual, UK buildings at the design stage, to a family of international schemes that encompass the whole life cycle of buildings from masterplanning of communities to new constructions, through to in-use and refurbishment of existing buildings.

All BREEAM schemes have affiliation to the 'BRE Global Code for a Sustainable Built Environment' in common. The Code is a set of strategic principles and requirements that define an integrated approach to designing, managing, evaluating and certifying the environmental, social and economic impacts of the built environment. It ensures that while BREEAM remains a highly flexible approach, all of the individual schemes share a robust scientific and performance basis (see Figure 1).

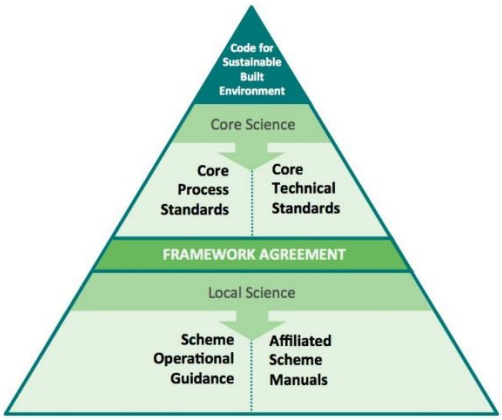

Figure 1: Diagram illustrating the relationship between the Code for a Sustainable Built Environment framework, the BREEAM Core Standards and the National Scheme Operator Scheme Documents.

BREEAM New Construction

The primary aim of the New Construction scheme is to mitigate the negative impacts of new buildings on the environment, and improve the positive social and economic impacts of the building over its lifetime. The BREEAM-NOR process allows this to be done in a cost effective, independent and scientifically authoritative manner.

How to apply the New Construction schemes

Careful timing of the use of BREEAM-NOR is key to cost effectively optimising the building's environmental performance and achieving the desired rating.

A BREEAM-NOR rating reflects the overall performance of the building. This means that the client, design team, principal contractor and BREEAM-NOR Assessor, as well as other specialist disciplines, all have an important role to play in achieving the desired performance level. However, orientating the brief towards sustainability needs to primarily come from the client. To facilitate this, clients and their project teams should preferably engage with a BREEAM Assessor (and/or BREEAM AP) no later than the BREEAM Pre-Assessment Stage (Step 2 in Figure 2) – and ideally sooner.

Appointing a BREEAM-NOR Assessor or Accredited Professional early in the project will make it much easier to gain the target rating, whilst retaining the flexibility of design decisions, budgets and potential solutions. Clients can find a list of assessors and Accredited Professionals on the www.byggalliansen.no and on the Green Book Live website www.greenbooklive.com[3] Once an assessor is appointed they can register the project with Grønn Byggallianse at www.byggalliansen.no .

It is worth noting that some BREEAM-NOR credits cannot be achieved if they are not addressed in accordance with specified project work stages. The applicable Bygg 21/Fasenorm work stage requirement is specified within each of the relevant BREEAM-NOR issues.

Figure 2 serves to highlight the link between the BREEAM-NOR 2016 assessment and certification stages, the RIBA Outline Plan of Work 2013 and the phase norm from Bygg 21/NE Fasenorm[4].

	1. Strategisk Definisjon	2. Program- og konseptutvikling	3. Bearbeiding av valgt konsept	4. Detaljprosjektering	5. Produksjon og Leveranse	6. Overlevering og ibruktakelse	7. Bruk og forvaltning	8. Avvikling
Bygg21/NE Fasenorm (2015)	Identifisere behov, mål, ambisjoner og forretningsmessige rammer.	Definere krav, behov og rammer for prosjektet. Avklare overordnet prinsipper og konsepter. Vurdere ulike alternativer og gjennomførbarhet.	Klargjøring av konsekvenser. Konkretisere prosjektet ifht. krav, behov, og rammer for gjennomføring.	Nødvending detaljering og konkretisering av prosjeket for å sikre at krav og behov er ivaretatt i produksjonsgrunnlaget.	Utføreprosjektet ifht produksjonsgrunnlaget	Sikre at prosjektet er gjennomført i fht bestilling og klaregjøre for ibruktakelse.	Sikre at prosjektet tilfredstiller rammer som virksomheten krever (strategisk definisjon) og sørge for nødvendige tilpassninger og utvikling gjennom byggets levetid.	Sørge for at bygget avvikles (salg, virksomhetsopphør el. riving) på en mest mulig bærekraftig måte.
RIBA PoW (2013)	0. Strategic definition	1. Preperation and Brief	2. Concept design	3. Developed design & 4. Technical design	5. Construction	6. Handover & Close out	7. In Use	

Figure 2: BREEAM-NOR assessment and certification stages in relation to the project work stages.

Verifying a building's certified BREEAM-NOR rating

The BREEAM-NOR certificate provides formal verification that the assessor has assessed a building in accordance with the scheme's requirements, and its quality standards and procedures. A BREEAM-NOR certificate therefore provides assurance to any interested party that a building's BREEAM-NOR rating, at the time of certification, accurately reflects its performance against the BREEAM-NOR standard.

3 Green Book Live is a free-to-use, publicly available online database designed to help specifiers and end users identify products and services that can help to reduce their impact on the environment .
4 Further detailed guidance and recommendations on the use and integration of BREEAM-NOR in the design and construction process and the use of Neste steg can be found on the following website:
http://www.bygg21.no/contentassets/ac0c77e4ec904c7a955525528b474b6c/veileder-for-fasenormen-neste-steg.pdf / (short version: http://www.bygg21.no/contentassets/974fd13545354595954fed799d1627b4/nestesteg_kortversjon.pdf). Also a more general description of integration BREEAM can be found in, 'Integrating BREEAM throughout the Design Process'. Cinquemani and Prior, BRE Press2010

All BREEAM-NOR certified buildings are listed on www.byggalliansen.no and Green Book Live at www.greenbooklive.com (along with a directory of licensed BREEAM-NOR Assessors/Accredited Professionals).

Anyone wishing to verify the BREEAM-NOR rating of a building can do so by either checking a building's BREEAM-NOR certificate, which will contain the certification mark (see Figure 3 below), or by searching Green Book Live for a specific listing.

Figure 3: BREEAM-NOR Certification mark

Maintaining a certified building's performance in use

To maintain the building's performance in use, and to help building managers and users reduce the running costs of their building, regular auditing against BREEAM In-Use Part 1 (Asset), Part 2 (Building Management) and Part 3 (Occupier Management) are recommended in the first three years of occupation (with regular reviews to maintain the 'In-Use' rating).

The certified performance of all BREEAM assessed buildings are listed by life cycle stage on the Green Book Live listing website. This is to provide evidence and assurance to the market of the business benefits of building, operating and maintaining buildings to high environmental standards and, it is envisaged, support the drivers for change in the way buildings are procured and operated. This in turn will help meet international obligations and targets on climate change.

Details of the BREEAM In-Use scheme can be found at www.breeam.org/inuse and a list of BREEAM In-Use Auditors is available from www.greenbooklive.com.

Using BREEAM NOR Scheme Documents

Scheme documents are produced to enable qualified and licensed BREEAM-NOR Assessors to complete assessments in a quality controlled, rigorous manner.

They will also help BREEAM-NOR Accredited Professionals (AP) to undertake project team facilitation, in terms of defining, monitoring and achieving the desired BREEAM-NOR rating. In addition, it is a reference guide for clients and members of the project team whose proposed building is being BREEAM-NOR assessed.

Note: BREEAM-NOR Scheme Documents are controlled documents and they are only valid on the day they are printed.

Scheme Documents are split in to six parts:
1. Introduction to BREEAM and BREEAM-NOR
2. Scope of the BREEAM-NOR Scheme Document
3. Scoring and rating
4. Assessment criteria
5. Checklists
6. Appendices (A-G)

Scope

The Scope section describes the types of building and stages of assessment that each version of the scheme can be applied to. The scope section can be used by clients and BREEAM-NOR Assessors to check whether it is the correct BREEAM-NOR Scheme Document to use for their project.

Scoring and rating

The Scoring and rating section outlines the BREEAM-NOR rating benchmarks, the process of establishing national environmental weightings and minimum BREEAM-NOR standards. It also describes how performance and BREEAM-NOR ratings are calculated from the individual BREEAM-NOR assessment issues and 'credits', including 'Innovation credits'.

Appendix C – Invitation to Delphi study and survey #1 appendix

DELPHI STUDY for Project Management of Green Construction Projects

Dear member of the project team

I am inviting you to participate in a Delphi Study to support my master thesis and research for Statsbygg (with Lars Petter Bingh and Elin Hansen as my counselors) into the challenges faced by a project manager in a projects early phases when the environmental ambition is set at a level like BREEAM NOR Excellent or FUTURE BUILT.

The aim of the thesis is to identify unique challenges faced by the project manager when managing green construction projects with high environmental ambitions, and how to handle said unique challenges in an optimal way.

As an expert in this field I am interested in your opinion on this matter and would ask you to first complete a ranking survey of different project manager skills and projects success factors. After confirming the important skills and factors you will then receive a second ranking survey. It is envisioned that the surveys should take up to 20 minutes to complete. Further details are provided on the next page.

Thanks in advance for participating and helping me with this Delphi Study

Yours Sincerely

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Information about the Delphi Study

The Delphi Study will be conducted over the course of two or three surveys, which aims to narrow down the challenges faced by a project manager when managing green construction projects with high environmental ambition. After each round the participants will receive the average and weighted result of the total for review and contemplation. All written answers can be answered in either Norwegian (bokmål/nynorsk) or English.

Survey 1

The first survey aims to isolate the project manager skills and project success factors that are important in green construction projects. The way this is done is by ranking the project manager skills and success factors in a top 15, where 1 is the most important factor / skill. This is done so we can gain a weighted rating of the different factors and skills to base the second survey on. An extra overview of the factors and skill covered in survey one is presented in the file: Delphi appendix 1.docx

Link to first survey:
https://www.surveymonkey.com/r/VXQRN9B

Survey 2

The second survey will be based on the weighted rating of the answers from survey one and will aim to uncover the challenges connected to the skills and success factors found from survey 1. The format of survey 2 is the same as survey 1, where you will rank the different challenges associated with the project success factors and skills found in survey 1.

Survey 3 (optional)

The final survey will be asking for comments on the results and weights found in survey 2.

Contractor Attributes
Turnover history: High turnover rate leads to novice employees with no to little knowledge of the current project
Staff qualifications: The knowledge level of the employees when it comes to the used technology, strategy and method.
Documentation: The level of documentation available from the contractor for easier quality control
Knowledge of green construction method: The contractor's expertise on green construction
Experience from similar project Similar projects can be other green projects, same certificate rating (BREEM NOR Excellence, FUTURE BUILT) or projects facing similar challenges
Waste disposal and reuse: Plans and practices of waste disposal and the plans for possible reuse of materials
Sub-contractor loyalty and reliability: The stability of sub-contractors and the quality of their documentation.
Quality assurance: Systems put in place to uncover documentation fraud, quality assure their supply chain and so on.
Quality control: Frequency and method for quality control

Pre-Project planning
Finalization of design at project start: Final design is ready and agreed upon before the construction project starts
Life cycle analysis/assessment: Impact of life cycle analysis, be it cradle to grave or cradle to cradle.
Future expansion plans: Flushed out future expansion plans to avoid possible changes later down the line
Project design criteria: Clear and defined project design criteria
Procurement plans and methods: Clear plans on how materials and contractors are being procured
Identification of long lead/critical materials: Early identification of long lead time supply chains and the materials associated with those supply chains.
Risk management: Identification of risk attributes and indicators of the project
Alternative procurement methods and plans: Redundancy plans in case of supply chain failure
Clear Environmental goals: Clear goals and clear reference values for easy measurement
Stakeholder involvement: Early involvement of critical stakeholders as a way to hedge future disputes
Choice of construction strategy: Early confirmation and commitment to the chosen construction strategy, e.g. lean construction, Porche TAKT and so on.

Management of the level of innovation: Proper management of the projects level of uniqueness and innovation required to meet the project design criteria

Governance
Top management support: Support and the trust of top management in the success of the project
Good coordination between joint venture partners: Level of communication, trust and coordination between joint venture partners
Low total number of executives with decision-making authority: Total number of persons with the power to alter the project plan in an aspect that affects the success of the project
Handling of government policies and regulations: The impact government policies and regulations have on the project and how it's handled
Documentation and logistics: Choice of method and plans for thorough documentation of the project and the following logistical requirements
Number of critical external stakeholders: External stakeholders which the project manager needs to gain authorization to implement certain solutions.

Location
Project site location: Impact of site location choice. New stakeholders, bad existing infrastructure, extra costs due to location and so on.
Site layout and logistics: Impact on e.g. waste disposal, security and transportation
Local stakeholder management: Management of local stakeholders, management of discontent stakeholders due to project location.
Transport logistics: Transport plan and optimization for chosen site location

Project scope
Realistic scope definition: Realistic scope definition that can be achieved
Magnitude of change orders: The number and size of the change orders
No late change orders: Timing of change orders is centered around the beginning of the project
No Supply chain changes: No major changes to the supply chain or change in suppliers

Emotional intelligence
Cultural acceptance: No cultural disconnect between project manager, project teams and contractor
Organizational awareness: Ability to identify the power currents, influencers, networks and group dynamic in the project organization
Conflict management: The ability to swiftly resolve conflict in the project team
Adaptive leadership style: The ability to adapt the leadership style to fit the needs of the project team members
Team management: The ability to properly manage the project team(s)
Empathy: Empathic skills needed to connect to the other members of the project organization and/or stakeholders
Bottom-up involvement and transparency: Involvement of project members and transparency of choices made
Fostering trust between project teams: The skill of connecting groups with different backgrounds together
Drawing individual interest towards the overall project objective: The skill of unifying people behind one goal
Public media management: The skill of tempering expectations and clearly communicate to the public media

Appendix D – Delphi survey #1 design

Delphi Survey #1 - Ranking of project manager traits and success factors

1. **Rank PM traits and project success factors based on their level of significance in performance for the early phases of the project when the environmental ambition is set to BREEAM NOR Excellent or FutureBuilt levels.**

Turn over history High turnover rate leads to novice employees with no to little knowledge of the current project		☐ N/A - Check if not in top 15
Staff qualifications The knowledge level of the employees when it comes to the used technology, strategy and method		☐ N/A - Check if not in top 15
Documentation The level of documentation available from the contractor for easier quality control		☐ N/A - Check if not in top 15
Knowledge of green construction method The contractor's expertise on green construction		☐ N/A - Check if not in top 15
Experience from similar projects Similar projects can be other green projects, same certificate rating (BREEM NOR Excellence, FUTURE BUILT) or projects facing similar challenges		☐ N/A - Check if not in top 15
Waste disposal and reuse Plans and practices of waste disposal and the plans for possible reuse of materials		☐ N/A - Check if not in top 15
Sub-contractor loyalty and reliability The stability of sub-contractors and the quality of their documentation		☐ N/A - Check if not in top 15
Quality assurance Systems put in place to uncover documentation fraud, quality assure their supply chain and so on		☐ N/A - Check if not in top 15
Quality control Frequency and method for quality control		☐ N/A - Check if not in top 15
Finalization of design at project start Final design is ready and agreed upon before the construction project starts		☐ N/A - Check if not in top 15
Life cycle analysis/assessment Impact of life cycle analysis, be it cradle to grave or cradle to cradle		☐ N/A - Check if not in top 15
Future expansion plans Flushed out future expansion plans to avoid possible changes later down the line		☐ N/A - Check if not in top 15
Project design criteria Clear and defined project design criteria		☐ N/A - Check if not in top 15
Procurement plans and methods Clear plans on how materials and contractors are being procured		☐ N/A - Check if not in top 15
Identification of long lead/critical materials Early identification of long lead time supply chains and the materials associated with those supply chains		☐ N/A - Check if not in top 15

	Risk management Identification of risk attributes and indicators of the project	☐ N/A - Check if not in top 15
	Alternative procurement method and plans Redundancy plans in case of supply chain failure	☐ N/A - Check if not in top 15
	Clear environmental goals Clear goals and clear reference values for easy measurement	☐ N/A - Check if not in top 15
	Stakeholder involvement Early involvement of critical stakeholders as a way to hedge future disputes	☐ N/A - Check if not in top 15
	Choice of construction strategy Early confirmation and commitment to the chosen construction strategy, e.g. lean construction, Porche TAKT and so on.	☐ N/A - Check if not in top 15
	Management of the level of innovation Proper management of the projects level of uniqueness and innovation required to meet the project design criteria	☐ N/A - Check if not in top 15
	Top management support Support and the trust of top management in the success of the project	☐ N/A - Check if not in top 15
	Good coordination between joint venture partners Level of communication, trust and coordination between joint venture partners	☐ N/A - Check if not in top 15
	Low total number of executives with decision-making authority Total number of persons with the power to alter the project plan in an aspect that affects the success of the project	☐ N/A - Check if not in top 15
	Handling of government policies and regulations The impact government policies and regulations have on the project and how it's handled	☐ N/A - Check if not in top 15
	Documentation and logistics Choice of method and plans for thorough documentation of the project and the following logistical requirements	☐ N/A - Check if not in top 15
	Number of critical external stakeholders External stakeholders which the project manager needs to gain authorization to implement certain solutions	☐ N/A - Check if not in top 15
	Project site location Impact of site location choice. New stakeholders, bad existing infrastructure, extra costs due to location and so on	☐ N/A - Check if not in top 15
	Site layout and logistics Impact on e.g. waste disposal, security and transportation	☐ N/A - Check if not in top 15
	Local stakeholder management Management of local stakeholders, management of discontent stakeholders due to project location.	☐ N/A - Check if not in top 15

	Transport logistics Transport plan and optimization for chosen site location	☐ N/A - Check if not in top 15
	Realistic scope definition Realistic scope definition that can be achieved	☐ N/A - Check if not in top 15
	Magnitude of change orders The number and size of the change orders	☐ N/A - Check if not in top 15
	No late change orders Timing of change orders is centered around the beginning of the project	☐ N/A - Check if not in top 15
	No supply chain changes No major changes to the supply chain or change in suppliers	☐ N/A - Check if not in top 15
	Cultural acceptance No cultural disconnect between project manager, project teams and contractor	☐ N/A - Check if not in top 15
	Organizational awareness Ability to identify the power currents, influencers, networks and group dynamic in the project organization	☐ N/A - Check if not in top 15
	Conflict management The ability to swiftly resolve conflict in the project team	☐ N/A - Check if not in top 15
	Adaptive leadership style The ability to adapt the leadership style to fit the needs of the project team members	☐ N/A - Check if not in top 15
	Team management The ability to properly manage the project team(s)	☐ N/A - Check if not in top 15
	Empathy Empathic skills needed to connect to the other members of the project organization and/or stakeholders	☐ N/A - Check if not in top 15
	Bottom-up involvement and transparency Involvement of project members and transparency of choices made	☐ N/A - Check if not in top 15
	Fostering trust between project teams The skill of connecting groups with different backgrounds together	☐ N/A - Check if not in top 15
	Drawing individual interest towards the overall project objective The skill of unifying people behind one goal	☐ N/A - Check if not in top 15
	Public media management The skill of tempering expectations and clearly communicate to the public media	☐ N/A - Check if not in top 15

2. **Please share any comments you have on your answers below:**

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