Master's thesis

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Procurement for Zero Emission Neighborhoods

Master's thesis in MSc Global Manufacturing Management
Supervisor: Luitzen de Boer
Co-supervisor: Hasan A. M. Hamdan & Raymond Andreas Stokke
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Preface

This master's thesis has been written as a part of a finalizing course IØ3911 in MSc Global Manufacturing Management at Norwegian University of Science and Technology (NTNU). The subject of this thesis is related to Energy Performance Contracting. Public procurement and buyer-supplier relationships are considered key concepts relevant for this thesis. This project has been a challenging and an educational experience. I would like to express my gratitude to several individuals who have made the completion of this project possible.

First of all, I would like to thank my project supervisor, Luitzen de Boer. Your guidance and recommendations have been a big contributor for this thesis. I am thankful that you have shared your ideas, suggestions and constructive feedback, while always being available to lend a helping hand when needed. I will remember our meetings and discussions fondly. I would also like to thank the project participants for this project, who have provided data and information which has been researched in this thesis. Furthermore, the assistance provided by the co-supervisors for this project Hasan A. M. Hamdan & Raymond Andreas Stokke has been an important enabler for this thesis, who gave important suggestions and insights. Lastly, I would like to thank my family & friends, for their continuous support and encouragement throughout this project.

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Abstract

In order to reach the ambitious goals set by the European Commission, there exists a strong need to increase the number of energy-efficiency projects. The increased use of energy-saving projects can help public entities in reducing their carbon footprint and reaching their sustainable goals. Energy Performance Contracting (EPC) is a method of conducting energy efficiency projects which can be a facilitator for energy-saving projects for the building sector. EPC is a contracting arrangement between a host client and an Energy Service Company (ESCO), where the service provider implements energy efficiency initiatives which lead to cost reductions and energy savings. This master's thesis has aimed to provide an understanding of the challenges and opportunities that are evident within this field. Empirical indications and a decreasing interest in recent years, point to challenges and risk-factors evident in these projects. As there still exists significant potential for energy efficiency and sustainable contribution through EPC proceedings, necessary steps should be taken to mitigate these challenges. To strengthen the basis for our findings, data has been gathered for both theoretical and empirical aspects. As the majority of EPC projects are completed in the public sector, a strong linkage between EPC & Green Public Procurement (GPP) is evident which directs our search for data.

By combining findings from literature review, interview sessions with EPC participators and additional empirical data, several challenges & opportunities are found for EPC. The main challenges identified are related to the interpretation of energy levels, where a lack of transparency between the actors can create complexities for the projects. Additionally, poor mapping processes, smaller scales of project and deviations from the original NS6430:2014 standard are other factors that increase the challenges for EPC. To mitigate the challenges identified, various opportunities and enablers are shared. These enablers are described according to the different processes that occur during EPC projects. For initial phases, an increased emphasis should be placed on finding partners with a shared understanding of project and expectations, where a interactive/translative supplier interface can be a facilitator towards this step. Increased cooperation is also emphasised in the new templates and documents launched, which can help reduce the challenges associated with interpretations of energy levels. As a smaller scales of projects reduce incentives for ESCO in participating in such projects, clients should be aware that smaller scales may lead to lower willingness to participate by ESCOs. Economies of scale and higher potential for savings are factors for why larger projects are preferred by ESCOs. Lastly, as unexpected events/situations are bound to arise, responsiveness and feedback in the system should be evident as changes and adjustments are needed. This was especially evident during the COVID-19 pandemic, which caused a significant reduction for capacity in buildings. Inclusion of building operators/maintenance workers is seen as a beneficial inclusion, since increased understanding and competency of the project allows these workers to operate the building more efficiently. The enablers found are combined in a conceptual framework.

To further evaluate the findings from this master's thesis, the conceptual framework should be evaluated and trialed in other case studies. As this thesis has looked at a limited number of projects within the scope of public procurement in a specific region, a generalized consensus may be difficult to generate from the findings of this thesis. Similarly, as the emphasis in thesis has been placed on EPC and public procurement from a Norwegian context, studies from other regions may lead to other new interesting discoveries. Therefore, a larger case study may lead to new findings that shows that that framework developed in this thesis is subject to change.

Sammendrag

For å nå de ambisiøse målene satt av EU-kommisjonen, er det et sterkt behov for å øke antall energisparende prosjekter. Flere energisparende prosjekter kan hjelpe offentlige virksomheter med å redusere sitt karbonavtrykk og nå sine bærekraftige mål. Energy Performance Contracting (EPC) er en metode for å gjennomføre energisparendeprosjekter som kan være en tilrettelegger for bærekraftige prosjekter for byggesektoren. EPC er en kontraktsavtale mellom en vertsklient og en energitjenesteselskap (ESCO), der tjenesteleverandøren implementerer effektiviseringstiltak som fører til kostnadsreduksjoner og energibesparelser. Denne masteroppgaven har som mål å gi en forståelse av utfordringene og mulighetene som er å finne innenfor dette feltet. Empiriske indikasjoner og en avtagende interesse de siste årene peker på utfordringer og risikofaktorer som er tydelige i disse type prosjekter. Siden det fortsatt eksisterer et betydelig potensial for energieffektivitet og bærekraftig bidrag gjennom EPC-prosedyrer, bør nødvendige justeringer og initiativer tas for å redusere disse utfordringene. For å styrke grunnlaget for våre funn er det samlet inn data fra både teoretiske og empiriske aspekter. Ettersom flertallet av EPC-prosjekter fullføres i offentlig sektor, finnes det en sterk kobling mellom EPC & Green Public Procurement (GPP) tydelig som styrer søket etter data.

Ved å kombinere funn fra litteratur, intervjuer med EPC-deltakere og ytterligere empiri, finner man flere utfordringer & muligheter for EPC. Hovedutfordringene som er identifisert er knyttet til tolkning av energinivåer, hvor manglende åpenhet mellom aktørene kan skape kompleksitet for prosjektene. I tillegg er dårlige kartleggingsprosesser, mindre prosjektskalaer og avvik fra den opprinnelige NS6430:2014-standarden andre faktorer som øker utfordringene for EPC. For å redusere de identifiserte utfordringene deles ulike muligheter. Disse mulighetene er beskrevet i henhold til de forskjellige prosessene som skjer under EPC-prosjekter. For innledende faser bør det legges mer vekt på å finne samarbeidspartnere med en felles forståelse av prosjekt og forventninger, hvor et interaktivt/translativt fohold mellom parter kan være en tilrettelegger. Økt samarbeid er også vektlagt i de nye malene og dokumentene som har blitt lansert, noe som kan bidra til å redusere utfordringene knyttet til tolkninger av energinivåer. Ettersom en mindre skala av prosjekter reduserer insentiver for energitjenesteselskaper (ESCO) til å delta i slike prosjekter, bør kunder være klar over at mindre skalaer kan føre til lavere vilje til å delta fra ESCOer. Stordriftsfordeler og høyere potensial for besparelser er faktorer for hvorfor større prosjekter foretrekkes av ESCOer. Til slutt, ettersom uventede hendelser/situasjoner kan oppstå, bør respons og tilbakemeldinger i systemet være tydelige ettersom endringer er nødvendige. Dette var spesielt tydelig under COVID-19-pandemiet, som førte til en betydelig reduksjon av kapasiteten i bygninger. Inkludering av bygningsoperatører/vedlikeholdsarbeidere blir sett på som en fordelaktig inkludering, da økt forståelse og kompetanse for prosjektet gjør disse arbeiderne i stand til å drifte bygningen mer effektivt. De forskjellige mulighetene er samlet i et konseptuell rammeverk.

For ytterligere å evaluere funnene fra denne masteroppgaven, bør det konseptuelle rammeverket evalueres og prøves i andre studier. Siden denne oppgaven har sett på et begrenset antall prosjekter innenfor rammen av offentlige anskaffelser i en spesifikk region, kan det være vanskelig å oppnå en generell tolkning fra funnene i denne oppgaven. Tilsvarende, ettersom vekten i oppgaven er lagt på EPC og offentlige anskaffelser fra en norsk kontekst, kan studier fra andre regioner føre til andre nye interessante funn. Derfor kan en større forskning føre til nye funn som viser at det rammeverket utviklet i denne oppgaven kan endres.

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Acronyms

GPP Green public procurement.

GSS Green supplier selection.

IPMVP International Performance Measurement Verification Protocol.

KS Norwegian Association of Local and Regional Authorities.

LCA Life cycle assesment.

LCC Life cycle costing.

M&V Measuring & Verification.

NSD Norsk Senter for Dataforskning.

NTNU Norwegian University of Science and Technology.

PPM Purchasing process model.

TPF Third-Party Financing.

VGS Videregående skole.

ZEN Zero Emmission Neighbourhoods.

1 Introduction

1.1 Background

In order to overcome the challenges created by climate change and environmental issues, the European Commission presented a set of policy initiatives in 2019 called the European Green Deal. The European Green Deal aims to make Europe climate neutral by 2050, boost the economy through green technology, create sustainable industry, and cut pollution [2]. The need to improve energy efficiency is especially evident in building stock. According to findings by European Commission, buildings in EU are responsible for 40% of energy consumption and 36% of greenhouse gas emissions, where among these buildings around 75% are considered energy inefficient [2]. One important aspect of the Green Deal includes renovation and transforming buildings to be more energy efficient. Introducing new governmental regulations like the Green Deal provides increased pressure and new incentives for building owners to find innovative solutions to facilitate this green transition. Implementing such projects may result in benefits which include economic savings, waste reduction, new opportunities and reduced negative environmental impact [25]. To further encourage the transition towards sustainable energy solutions, the use of Energy performance contracting (EPC) provides a compelling alternative, which reduces energy consumption for building owners, and provides financial incentives for a energy service provider. EPC projects are able to contribute to this space by introducing an arrangement between a client and an energy service company (ESCO), where the service provider stands responsible for services and the actual energy performance delivered. This practice is a desirable mechanism to capture cost-effective energy-efficiency potentials with both the private & public sector's involvement [30].

1.1.1 EPC projects

EPC is a contracting mechanism between a host client/building owner and an ESCO. This contracting procedure is utilized in older and new building constructions in an effort to reduce energy consumption or increase energy production. These results are achieved by implementing more efficient solutions such as LED-lighting, productive HVAC system, adopting renewable practices. Alternatively, energy production can be increased by other measures such as installing solar panels, production of biogas and other smart solutions. This type of contracting arrangement emerged from US in 1980's and has gradually expanded to various countries [15]. The ESCO conducts various processes throughout the project ranging from the initial energy audit, implementation of energy-saving measurements, financing of project and monitoring energy savings. Unlike traditional contracting methods, where a service provider is compensated for the service provided, the success of the project is evaluated mainly based on the actual energy performance achieved. The ESCO is compensated based on the comparison of targets set and actual performance delivered. Reduction in energy consumption and better environmental performance are key factors, rather than solely focusing on lowest price. The duration of a EPC project can span over several years, including completing tasks such as ESCO selection, project implementation, and post project optimization. The financial savings that ensure due to the energy efficiency measures may be seen as a 'stream of income', which can then be shared between the client and the ESCO, or in other cases be used as a form of compensation for the initial investment required [57]. Since the savings in energy levels is guaranteed by the ESCO, the use of EPC reduces the amount of risk for the building owner, while simultaneously providing financial incentives for the ESCO.

1.1.2 Measuring & verification

A vital procedure for EPC projects is the process of measuring the specific energy levels at various stages in the project, called measuring and verification (M&V). For pre-existing buildings energy levels are taken before and after project implementation. In the case of new constructs specific targets are set, which are then compared to the actual results after project completion. Monitoring energy levels is considered essential, since these energy levels help determine the actual savings and to what degree the project can be considered successful. To collect this information, energy monitors are installed throughout the building which can identify the energy levels at specific points and sections, depending upon the number of monitors installed. However, the process of M&V can prove to be challenging and is always considered uncertain [40]. Energy levels may fluctuate vastly based on capacity, daily operations and maintenance of building, time duration of when facilities are used. Furthermore, energy levels may derive from different factors including, but not limited to: changes in weather, increased production level, operational errors. It is therefore difficult to understand if the changes in energy levels is given due to implementations made by the ESCO or other variables as recently mentioned mentioned. Furthermore, limited standardisation of protocols and routines for conducting this process may lead to different outcome, depending upon who or how this process has been completed. Lastly, interpretation of energy levels may differ amongst the project participants, where lack of trust between the partners can in some instances be seen and further cause complications for the project. Varying expectations and understanding of project can cause disputes amongst actors participating in this project.

1.2 Problem statement

Although the incorporation of EPC procedures has been increasingly used in building projects over recent years, theoretical and empirical indications points to complexities that may emerge in these projects. Indications from Zero Emission Neighborhoods (ZEN) research centre point to several risk-factors and challenges related to EPC projects. Furthermore, this claim is supported by a literature review conducted, which explains the decline in interest for participating in EPC projects. The challenges found are mainly related towards the process of M&V. As mentioned earlier, the process of M&V can in some cases be difficult to conduct which causes difficulties in understanding whether the project has been successful. Additionally the involvement of GPP in these projects can further increase complexities, where difference in competencies/understanding of project, adapting to a new purchasing approach and a lack of trust among actors can hinder a successful implementation of the project. Working selfishly & prioritizing personal gains over decisions that may otherwise benefit the overall project in general, can be a further source of problem since the level of success is depended upon the end performance achieved. This is especially important in EPC projects where the relationship between both actors depend upon trust and collaboration. These various factors can build up and provide challenges for the project. It is vital to mitigate these challenges surrounding EPC projects, to ensure the feasibility of these energy efficiency projects, especially considering the sustainable importance these projects can impart.

1.3 Research questions

To get a better understanding of what challenges and opportunities are evident, this thesis looks at previous literature, empirical evidence and past projects conducted in Norway. Interview sessions have been conducted with participants that have previous experience with EPC projects. Data from different sources will be used to provide a holistic overview of the field of EPC. By looking at EPC procedures both from the perspective of the client and the ESCO, this thesis will look to provide an answer for the following research questions:

- **RQ1:** What are the main drivers and barriers for EPC according to previous literature?
- **RQ2:** What additional challenges are found from empirical data?
- **RQ3:** How can these challenges be reduced for future EPC projects?

In order to provide a better foundation for answering the research questions, this thesis will gather information and data from theoretical and empirical sources. The basis of this thesis is provided by research articles of key concepts regarding EPC, and information from EPC projects completed in Norway. The next section will explain the methodology chosen for this thesis and the empirical perspective used. After this a literature review conducted on the topics of EPC, M&V, GPP and other relevant concepts found within will be further explained. The following section will present the empirical section, which contains information and experiences of different EPC cases in Norway and other relevant information. The findings from these cases will then be analysed thoroughly. Lastly, the findings will be presented in a conceptual framework before the concluding remarks will be shared.

2 Methodology

This section will explain the methodology used to complete this master's thesis, the origins and inspiration behind this thesis, in addition to the systematic combining approach which provides the basis for the methodology. This approach entails combining the theoretical, empirical, and a conceptual framework with a case that gradually evolves. The empirical evidence for this master's thesis is mainly provided from two independent organisations that have previously completed different EPC projects, where one of these organisations was involved as a client, while the other can be characterised as an ESCO. To support the empirical basis, information and data has been gathered from additional cases, standards/frameworks and other organisations that can influence the market space for EPC. After this, the research design for this thesis will be explained, which consists of an embedded single-case study. Lastly, an explanation will be given about how data has been gathered and analysed for this thesis, along with how research ethics decisions have been managed.

This thesis is written as a finalizing course part of a master's degree at the Norwegian University of Science and Technology (NTNU). The emphasis and central context of this study is considered EPC projects, and how the addition of green criteria and public procurement procedures can allow for both challenges and opportunities to arise. Previous literature and empirical indications point to several risk-factors and a decreasing interest for EPC in recent years. There is a belief that M&V processes are considered a crucial element and a potential pitfall for these projects. A literature review is completed, in order to find the relation and importance of the central concepts; EPC, M&V and GPP and the challenges found therein. This master's thesis will further build upon the findings from a preceding project with new empirical data. ZEN aims to contribute to the transition to a low carbon society by developing sustainable neighbourhoods with zero greenhouse gas emissions [57]. The research centre has initiated several pilot projects throughout Norway, as well as provided expertise to other projects that support their vision. ZEN is connected to several different stakeholders and partners from different backgrounds, ranging from municipalities, colleges & universities, and a diverse scope of different firms. Participants within the research centre are considered key participants for this master's thesis, where empirical foundation and evidence will be gathered from these sources.

2.1 Systematic combining

The interrelating and dynamic nature of this master's thesis leads us to a researching method developed by (Dubois & Gadde 2002) called 'systematic combining'. Their explanation of this approach is given as "a continuous movement between an empirical world and a model world" [22]. This approach consists of four different aspects: inspiration from practical scenarios/reality, existing literature, a developing framework and lastly, a case that gradually evolves. During this process, the research issues and the analytical framework are successively reoriented when they are confronted with the empirical world [22]. The framework evolves during the study, since new empirical observations change our view and understanding of theory. This is particularly useful for this thesis, where insights and experiences from the empirical perspective allows us to redevelop the framework according to new observations. In our case, a case that gradually evolves can be directly connected to this master's thesis. In systematic combining, the emphasis on verification, checking the accuracy of data is not the main issue [22]. The article by (Dubois & Gadde 2002) state that

multiple sources can contribute to reveal aspect of research topic and problems, previously unknown to the researcher. The article explains this method as an ongoing process of going back and forth between the framework, data sources, and analysis to expand our understanding of theory and practical problems that occur. This process is referred to as matching and redirection. The fourth aspect of the methodology, a case that gradually evolves shows a correspondence and similarity to this master's thesis. A further explanation of how the different aspects of the methodology are applied to this thesis will be given.

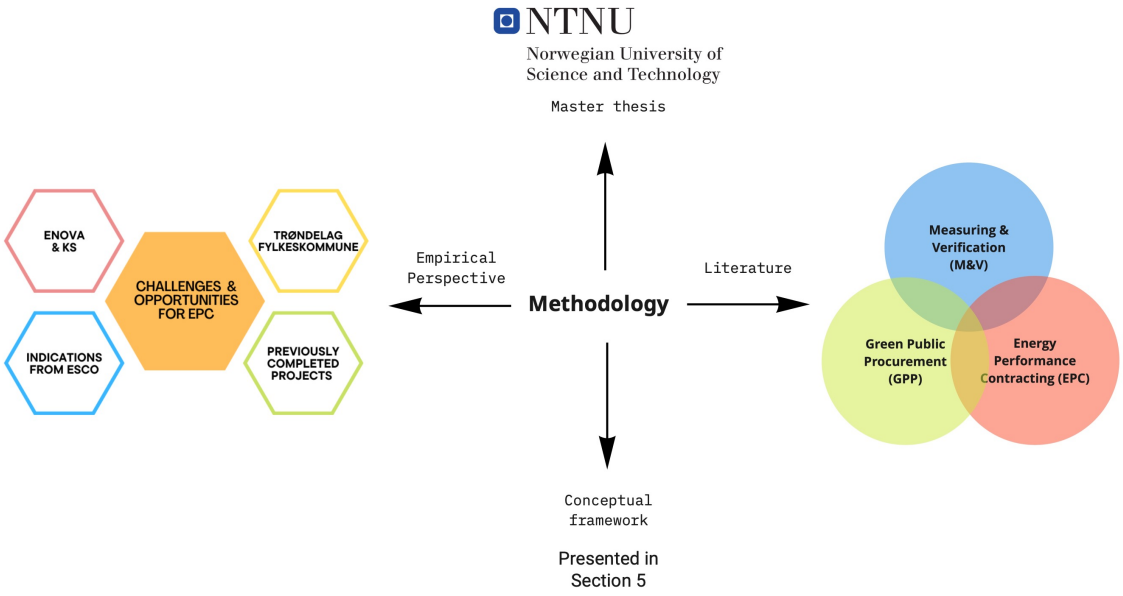

Figure 1: Systematic combining

2.1.1 Theoretical foundation

To get a better understanding of the field of energy efficiency, EPC projects and GPP, a literature review has been completed and is shared in Section 3. The aim of a literature review is to read and analyse previous literature and research articles on relevant topics, which provides the theoretical foundation for this thesis. A literature review is classified as either a systematic or narrative literature review [16]. The narrative review can be considered subjective to a certain degree, since the researchers assessment of which papers are considered relevant is taken into consideration. A systematic approach aims to minimise bias by conducting exhaustive literature searches. Systematic reviews of the literature are often seen as an accompaniment to evidence-based approaches, as their goal is to provide advice for clinicians and practitioners based on all available evidence [16]. A narrative approach has been used in this master's thesis, due to the extensive scope of this project thesis and time required to conduct a study using the systematic approach. Furthermore, as many of the findings in this thesis reflect upon the researchers observations and thoughts, a narrative analysis seems fitting. The articles found in the literature review were found using Google Scholar and Oria databases. Research papers that were considered relevant based on similarity to EPC market in Norway, ZEN project and relevant technical reports were included for the literature review.

Furthermore, specific websites and reports related to energy-efficiency topics were also used, from

European Commission, Energy Sector Management Assistance Program (ESMAP), Enova & ZEN. It should be mentioned that websites and reports are not always evaluated and critiqued in the same rigorous manner as research paper, and could therefore reflect biased opinion. Although, the emphasis on this paper is placed on the Norwegian EPC market, articles and cases from other countries were included in the literature review, assuming that certain concepts from those articles can be applicable for this thesis. Abstracts and conclusions were read to determine the relevancy of the article. The articles found were mainly read in a chronological order to give the researcher an understanding of how the EPC industry has changed and developed over time. In addition to these, several articles research papers were recommended by the project supervisors which were further read and analysed.

2.1.2 Empirical inspiration

The inspiration behind this master's thesis derives from two independent organisations, who have previous experience in completing EPC projects. The first organisation is a Scandinavian contractor/service partner providing a range of services including sustainable solutions for HVAC, building automation and other efficient solutions, that can be characterised as an typical ESCO. This organisation has chosen to remain anonymous, and therefore the name and details of projects the ESCO has participated in will not be shared. Instead of giving exact examples and details, indications of complications and risk-factors that the ESCO has experienced during previous projects will be shared. The second organisation is Trøndelag county authority who was involved in development of the new Heimdal VGS, where EPC proceedings where utilized to ensure the environmental targets set for the project are reached. Heimdal VGS was a pilot-project conducted in collaboration with ZEN, which aimed to provide a reference project and further increase the number of energy efficiency projects. This new school building was the first of its kind in Norway, which included the construction of a new school building with net zero emission. According to representatives from Trøndelag county authority, the county has initiated new school projects after the project of Heimdal VGS with the inclusion of EPC procedures. As there exists challenges & opportunities for both the client and ESCO, this master's thesis will look at factors and inspiration from both perspectives.

Additionally, to support the empirical fieldwork in this thesis, information from previously conducted EPC projects is obtained through a document analysis. Document analysis is an efficient way to obtain empirical data as part of a process that is unobtrusive and nonreactive [13]. The aim of this analysis was to gain further insight into EPC, by analysing documents and information regarding previously completed EPC projects in Norway. Information regarding these projects has been found from Doffin[1]. To gather additional empirical data, an effort has been made to gather information from important stakeholders within the field of EPC. Although the ESCO and the client can be considered the most important actors involved during these project, other participants and agencies are able to contribute to the field of EPC in a major way. This idea is supported by the important role played by governing and regulatory agencies such as Enova & Norwegian Association of Local and Regional Authorities (KS). By providing services similar to financial support or contractual agreements/frameworks for EPC, these agencies play a vital role in the development and operation of the entire EPC industry in Norway. Information has been gathered from these sources, where documents and other data posted by these vital agencies has been analysed, which

[1]Doffin: Norwegian national notification database for public procurement

draw connections to our problem statement.

2.1.3 Conceptual framework

Based on the literature review which was explained earlier, an initial conceptual framework was developed to mitigate the theoretical challenges found. The preliminary analytical framework consists of preconceptions based on previously read research articles, without any insight gained from empirical perspective. The initial framework is over time developed according to what is discovered through the empirical fieldwork, as well as through analysis and interpretation [22]. This framework is subject to change as new discoveries are made, since empirical observations may change or inspire the view on theory over the course of the study. The initial framework will be presented in the beginning of Section 3.3.3, following this, new empirical findings found from interviews and relevant information from document analysis will be presented. These findings are essential for the changes made to the revised framework presented later in Figure 14.

2.2 Qualitative research

In order to find answers for the research questions identified in Section 1.3, a qualitative research method has been used for this thesis. A qualitative research is used to understand people's beliefs, experiences, attitudes, behavior, and interactions [35]. Choosing a research method has implications for how data is gathered and analysed, what implications this has for this thesis will be further elaborated. Following this, the selection of an embedded single-case study will be explained. In this thesis, data has been gathered through interview sessions conducted with relevant organisations. This provides a platform which allows for in-depth questioning and better understanding of the motivations and ambitions of the participants. Furthermore, additional units of analysis are considered important sources, which will be explained.

2.2.1 Case study design

A case study can be explained as an in-depth study of a particular field or situation, which allows us to narrow down a very broad field of research into one easily researchable topic. While it may not answer a question completely, it will provide certain indications and give room for further elaboration and hypothesis creation on a subject [17]. The case study also provides an indication for the scope of this study, in terms of what boundaries and limitations are placed. (Yin 2003) explains four different case study designs, which are divided into single and multiple-case studies. These designs are further defined by consisting either of a holistic or a embedded unit of analysis [56]. If the case study only examines the global nature of an organization or field of study, a holistic study design is evident. Conversely, if a study includes different subunits of analyses a more complex/embedded study is developed. It is further explained, that both these variants have their own strengths and weaknesses, and should therefore be selected based on what type of analyses is required to answer our problem statement. The research design for this master's thesis consists of an embedded single-case design. According to (Yin 2003) the selection of a single-case design is justifiable, if the case fulfills one of the five rationales described. The indications regarding risk-factors and complexities, as explained by the ESCO for this master's thesis provides similarities to a unique case & the second rationale for case studies. Additionally, time constraint

placed on this master's thesis would not make a multiple-case study feasible. The central context of our study entails various challenges & opportunities that are evident in the field of EPC. To narrow down this broad field we take a deeper look at two specific organisations: Trøndelag county authority & a Norwegian ESCO, where their experiences regarding EPC projects provide the basis for the empirical findings in this thesis. However, since these projects are affected by other entities and other influencing factors, the addition of these sources is considered necessary. Triangulation, combines different theories, observations and experiences from these subunits and helps ensures that biases arising from a single source are overcome [44]. The figure below aims to explain the case study for this master's thesis, where relevant subunits are placed in the context of EPC.

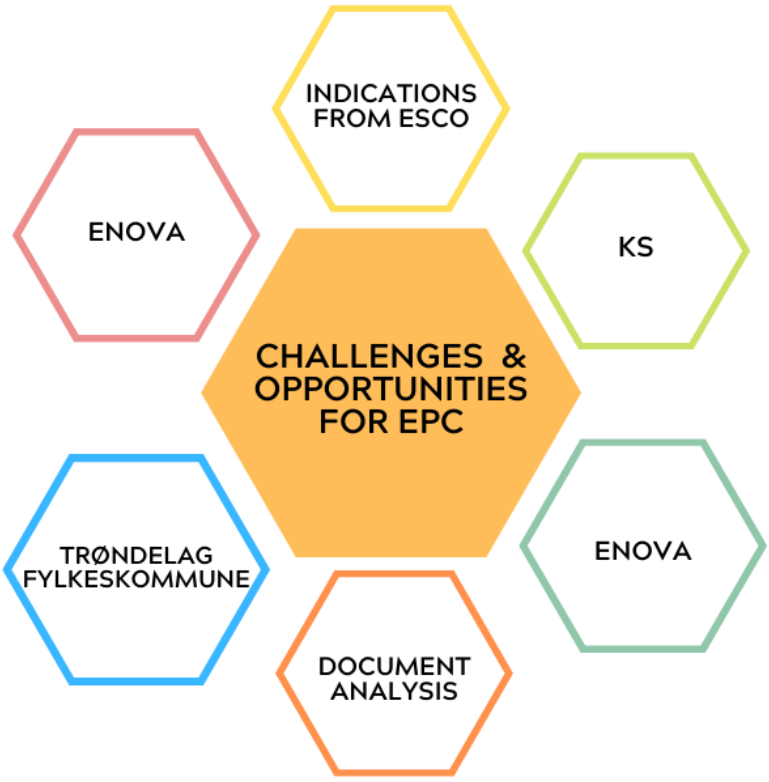

Figure 2: Subunits of analysis in the context of EPC

2.2.2 Interview sessions

To gain further insight into the practical dealings of EPC, a set of qualitative interviews were conducted with both the ESCO and Trøndelag county authority, in which, their experiences regarding various topics surrounding EPC proceedings were discussed. The purpose of these interviews was to find more practical data and reasoning behind various challenges and experiences of EPC that are dealt with both from the client (Trøndelag county authority) and the ESCOs perspective. ZEN research centre's extensive network and previous experience with with various organisations has provided opportunities to gather insights from these different sources. The representatives from Trøndelag county authority hold responsibilities as engineers and operations managers role within the county, while having vast experience regarding the role of EPC during development of Heimdal VGS. Similarly, the representative from the ESCO has extensive experience regarding the use of EPC, and has been involved in several EPC projects. The names of the representatives participat-

ing in the interview sessions will not be shared, as these participants will be treated anonymously. A list of the interviewees that participated and their roles are listed in the table below.

Interviewee	Organisation	Responsibility/Position
A	ESCO	Subject director
B	Trøndelag county authority	Engineer
C	Trøndelag county authority	Operations manager

Table 1: Interview participants

Trøndelag county authority first attended an introductory meeting with the researchers, followed by the main interview session. Meanwhile, a single meeting was arranged with the ESCO. To give an impression of the type of question that could be asked, two separate interview guides were sent to the participants before the interview, following the same structure but listing different topics and a selection of questions that were tailored for the specific meeting[2]. Examples of topics listed were: choosing energy consultant, relation between client & ESCO, basis for measurement. The interview sessions were conducted digitally over Microsoft Teams. Due to confidentiality reasons, the interview with the ESCO was not recorded, and only notes were taken during the interview. The second meeting conducted with Trøndelag county authority was recorded, where the recorded file was used for transcribing. These interviews were structured in a qualitative semi-structured manner, where the researcher has a list of questions or topics which provide an overview for the interview, however this approach of conducting interviews allows certain freedom in terms of determining the direction where the interview is heading, and asking followup questions that seem fitting. As explained by (Bryman 2016), in qualitative interviewing research ideas are more open-ended and there is an emphasis on interviewees' own perspectives [16]. The questions were asked in an open-ended way, which would allow for a elaborate free-flowing response from the interviewees. The interviews were conducted in Norwegian.

2.2.3 Document analysis

Document analysis can be used in combination with other qualitative research methods, as a means of triangulation [44]. This is evident in this thesis, where document analysis is used to triangulate more empirical data to support our systematic combining methodology. The previous cases have been found from various websites and databases, such as Doffin, Enova & Caverion[3]. The cases found from Enova and Caverion are examples of EPC projects, where the organisation has contributed as either an ESCO or through financial support. Doffin is the Norwegian national notification database for public procurement, where information and data is shared regarding public procurement tenders [1]. Data and information from recently completed EPC projects in Norway are further shared in Section 4.4, to provide real life examples of EPC cases in Norway. These cases were selected based on two main criterion's; recently published, to ensure that the cases represent the current state of the EPC market & based on whether the case contains relevant information and documents for our thesis. The keyword 'EPC' was used for searching articles on Doffin. It should be mentioned that since many cases from Doffin are notices for tender specifications, certain details or information may have changed since the posting of these tender specifications. The table below provides a list of the different cases found from Doffin.

[2]Interview guide for Trøndelag fylkeskommune is included as part of Appendix A
[3]Caverion ESCO is further described in Section 4

Case Nr.	Published by	Doffin reference	Publication date
1	Museene i Sør Trøndelag AS	2020-306531	28. April 2020
2	BaneNor SF	2020-325060	18. February 2020
3	Sunnmøre regionråd IKS	2018-360281	26. September 2018
4	Hedmark county authority	2018-324180	14. December 2018
5	Bergen municipality	2017-464478	14. August 2017
6	Alta municipality	2017-767547	26. Juni 2017
7	Modum municipality	2017-185828	2. October 2017
8	Oslo municipality	2017-639402	14. July 2017

Table 2: EPC projects from Doffin

2.2.4 Data analysis

Data analysis in qualitative research is defined as the process of systematically searching and arranging the interview transcripts, observation notes, or other non-textual materials that the researcher accumulates to increase the understanding of the phenomenon [12]. After the data was gathered from both interview sessions, the recorded audio of the interview with Trøndelag county authority was transcribed, while notes were taken during and after the meeting with the ESCO. Transcribing the interview was considered a more efficient solution rather than solely taking notes during the interview, as the transcribed file provides more detail and depth to statements made. Sentences and remarks that were considered especially relevant were further analyzed against the theoretical basis of this thesis, where parts of the theoretical framework was used to compare the different theories within each category with the findings. To analyse the data in a structural manner, the software NVivo was used to discover and evaluate findings from the interview conducted. NVivo provides tools which allows us to analyse data in a deeper and more rigorous procedure, where the transcribed file was imported and further studied. NVivo was used to create nodes within the program, where we can find similarities and connections for the interview and other notes, for specific topics including: Choosing third-party, monitoring energy levels, standards & contracts. It should be noted that analysis of data contains a certain level of subjective opinion, as to what findings or information is considered relevant.

2.3 Quality of research

The evaluation of a research study is often judged by the criterion's of reliability and validity [16]. Reliability applies to consistency, while validity is concerned with the accuracy of the research. These concepts are used to determine the quality of a study. However, the book by (Bryman 2016) mentions that these criterion's are mostly applied to quantitative research, and must therefore be adopted for a qualitative research. Therefore, the criterion's mentioned the book by (Bryman 2016) are used as guidelines for the research in this thesis. As the findings in this thesis is subject to personal opinion of importance and relevancy of different topics, replicating this study may be challenging. To avoid any potential harm to any participants, several ethical decisions have been made throughout this project, such as filling a notification form developed by 'Norsk Senter for Dataforskning' (NSD). These ethical decisions that have been taken to protect the gathered data will be further explained.

2.3.1 Reliability & validation

Reliability is defined as the ability to replicate the outcome of a study by using identical researching methods. It is often referred to as replicability of study, where same methodology will lead to corresponding result for the research. The reliability of a study is measured by these three factors: stability, inter-reliability and inter-rater reliability. The factors mentioned measure the level of consistency for indicators, to determine if indicators are stable or fluctuate over time. Additionally the level of subjective judgement is also considered relevant, due to subjective choices can result in different results. The methodology chosen for this thesis includes several subjective decision as to which research articles, information, organisations, questions are considered more relevant for our problem statement. As earlier mentioned, the development of the conceptual framework is reflected by the researchers discoveries and interpretations, which explains that although this research may be repeated in a similar manner, this may not necessarily result in the same results for other projects/researches. Another challenging aspect of replicating a similar outcome could derive from the subjective nature of this thesis, where research articles and literature has been chosen based on relevancy, according to subjective opinion. Similarly, by choosing different project participants to gather data from, could result in different findings/results.

The validation of a study refers to the accuracy of what is indented to be researched. In an effort to provide an accurate representation of the topics analysed, multiple sources and literature have been reviewed. An effort has been made to select article with a acceptable level of citations, to ensure that the articles are well grounded and reliable. The theoretical framework developed is developed from information provided in the literature review. Additionally, to ensure the validity of this project thesis has been guided by professors and supervisors at Norwegian University of Science and Technology (NTNU), with vast experience and competencies regarding the subject discussed, mainly the topic regarding public procurement. The external validity defines to what extend a conclusion can be generalized [16]. A generalized conclusion for this study can be difficult to provide, due to this thesis being a single-case study and the dynamic nature of the subject. Similarly, as the field of public procurement is differentiated according to specific regulations and laws, a Norwegian context is taken into this thesis. The time-frame of this research and geographical importance must be taken into consideration, if this study must provide a generalized conclusion.

2.3.2 Limitations

As with all research studies, this master's thesis includes certain boundaries and limitations. Firstly, since this thesis looks into specific EPC cases in Norway, it would be challenging to find a generalized solution or consensus from this thesis since there exists a possibility that the findings in this thesis may not be applicable to other cases. Similarly, limited time availability also places a constraint on this thesis. As this thesis is part of a concluding course in MSc Global Manufacturing Management, the time designated was already decided upon. This thesis was completed during the spring semester of 2022, giving approximately 5 months of time to conduct this research. This provides a limitation regarding the finite number of sources and articles used in this thesis. Another limitation placed on this thesis is regarding the scope of study, where an emphasis placed on public sector limits the scope of research. The data collected for this thesis has been collected in relation to a specific case and during a limited time frame. Findings in this thesis can be considered subject to personal opinion, where importance of research articles and different findings is based

on subjective opinion. A broader/larger case study may find new discoveries, that wasn't possible during this thesis.

2.3.3 Research ethics

During a research study it is especially important to include questions regarding conducting research in an ethical manner, to avoid any risks or harms to the project participants. These questions are related to topics such as invasion of privacy, consent and deception for participants involved. To ensure the safety and privacy of the interviewees, determining how data would be stored and handled has been a critical factor during this thesis. All participants were informed regarding the interview sessions and that data would be gathered from the interview. This was informed by both oral and written communication. Additionally, a notification form was filled to NSD, which assists researchers and students in finding the legal basis in the legislation that enables high-quality research, while at the same time safeguarding privacy. NSD's aim is to regulate data or information regarding people and society which can be retrieved, processed, stored & shared safely and legally [45]. Information regarding participants, what information will be given about them, their role in this research and other relevant questions were filed in this form. The processing of personal data was assessed by NSD and deemed as legal, if it is carried out as described in the notification form.

3 Theory

This section will present a literature review of topics relevant for this thesis. First, a general explanation of EPC projects and their implementation in a Norwegian context will be given. Following this, the vital process of M&V will be further elaborated. Another important aspect of the literature review looks at the addition of procurement from public sector. As the field of GPP & EPC have several linkages and similarities, a look from public procurement perspective may find hidden drivers or barriers for EPC. Furthermore, other theoretical literature and research papers that are also considered relevant to our problem statement are also included. The last section consists of the main findings from theoretical literature. These findings provide the basis for the initial framework, which is presented in Section 3.3.3.

3.1 EPC Projects

EPC is a contracting arrangement between a host client and an ESCO, where the service provider implements energy efficiency initiatives which lead to cost reductions and energy savings. Although the first EPC projects emerged during late 1990's in Norway, interest significantly increased after 2008 [41]. This type of contracting arrangement aims to encourage sustainable projects, by providing incentives and benefits for both the client and ESCO. Building owners are able to increase energy efficiency in their facilities. Additionally, the possibility to upgrade ageing and inefficient assets while recovering capital required for the upgrade directly from the energy savings guaranteed by the ESCO, provides another incentive for the building owner to participate in these projects [41]. Between 2010 and 2019, over 80 EPC projects were completed in the Norwegian public sector [6].

3.1.1 The Norwegian EPC market

Public sector is an important enabler for EPC projects in Norway nearly all of the projects have been completed in the public sector, mainly in various public buildings, including schools, offices, and health care institutions [30]. Building sector and housing cooperatives are therefore considered important branches of EPC, with potential for increased adoption. Projects in housing cooperatives are often combined with refurbishment plans, which are prioritized by residents [30]. The majority of EPC projects completed in Norway usually include building refurbishment, energy management system, automation, and HVAC [11, 41]. According to (European Commission 2021) the rate of renovations for both the private and public sector needs to double, to reach the goals set by the commission. One way to increase this rate is by pooling or bundling of projects, which in turn reduces transaction costs by achieving economies of scale [30]. Examples of this method, from Germany has shown that pooling/bundling together public buildings can reduce transaction costs, minimise risk and act against cherry picking projects [10]. This approach is often evident in building refurbishment projects, where refurbishment is combined with energy-saving projects. (Aasen 2016) finds that municipality size is not a decisive factor for the uptake of EPCs, as long as the project seems worthwhile for the ESCO. Smaller municipalities are able to attract ESCOs by offering significant projects, that can interest the ESCO [3]. Smaller municipalities can perform complex EPC projects in the presence of two conditions: a good business case for the ESCO and a capable purchasing department [30]. Smaller projects provide limited potential for savings, thus

generating limited interest from ESCOs.

The article by (Lindseth 2015) mentions that the EPC market has been growing steadily in the last couple of years leading up to 2015. Initially low energy prices were the main reason for limited adoption of EPC projects. However, the ambitious sustainable goal of reducing emissions in Norway upwards to 55% by 2030, has required the need for increased adoption of energy efficiency projects [30]. Increased regulations on emissions, incentives for energy-saving projects and launch of a Norwegian EPC standards have been facilitators that have lead to increased number of projects. According to information shared by Enova the market for EPC in Norway was steadily growing between the period 2011-2017, however the adoption of these projects has remained stagnant in recent times [53]. The same statement is repeated by an article by (KS Energikommisjonen 2022) that explains that interest in EPC projects has decreased, due to complication with calculations [38]. Several reasons were given for this decline. An EPC-provider/ESCO declaring bankruptcy, cancellation of contract mid-project, smaller project sizes, difference in expectation and outcome are some of the reasons given [53]. The figure below shows number of public tenders listed per year for EPC in Norway.

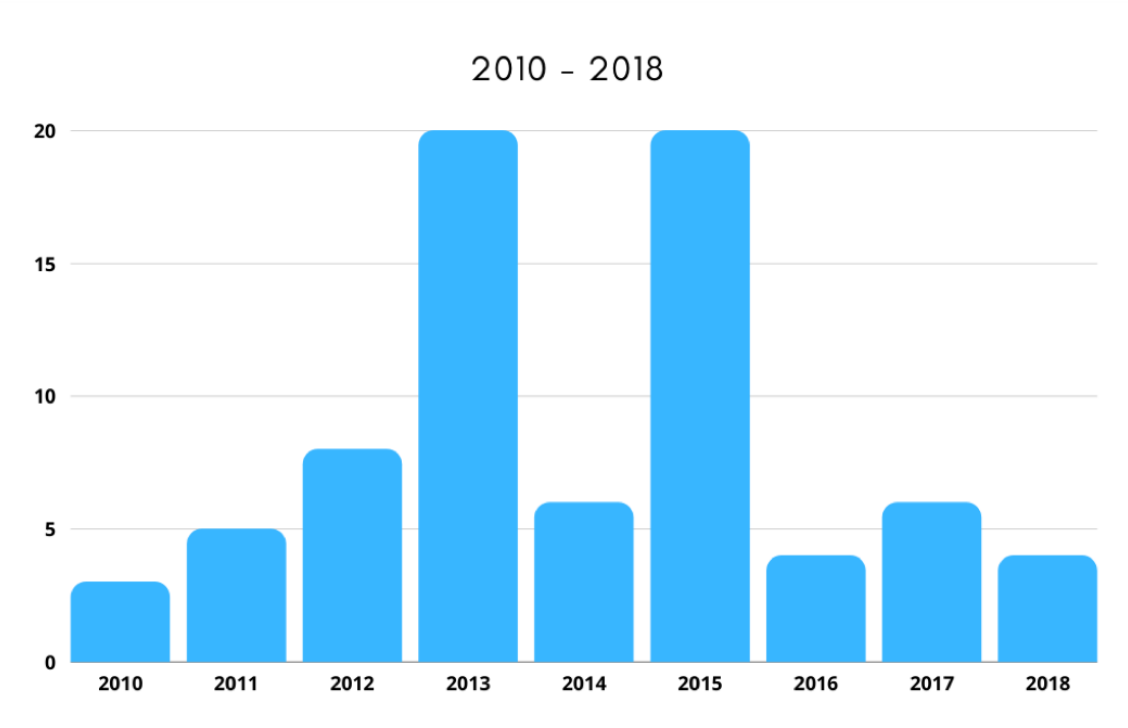

Figure 3: Public tenders listed in Norway (Data from EPC report 2019 to Enova)

3.1.2 Processes and financing

(Aasen 2016) explains how the EPC model used in Norway evolves over four phases. Although time required for projects may vary depending on the scale and complexity of project, a general timeline for a EPC project is explained as following. The first part (phase 0) which is completed within 3-5 months includes the establishment of project, selection of ESCO. Background data for energy use and other information is given to the ESCO that helps them in developing their proposal. The ESCO is contractually binded to the project after phase 0. In phase 1 (4-5 months) the selected ESCO completes energy audits that allows them to identify the savings potential for the project.

Phase 2 consists of implementing the project, where energy-saving initiatives are conducted by the ESCO and investments are made. The ESCO works as a project leader and conducts these processes in close cooperation with the client. Timeline for this phase depends on the scale and comprehensiveness of the project. The last part, phase 3 involves optimizing and monitoring, which is the period when guaranteed energy savings are realized, varies from 4 to 14 years depending on the type of measures [3].

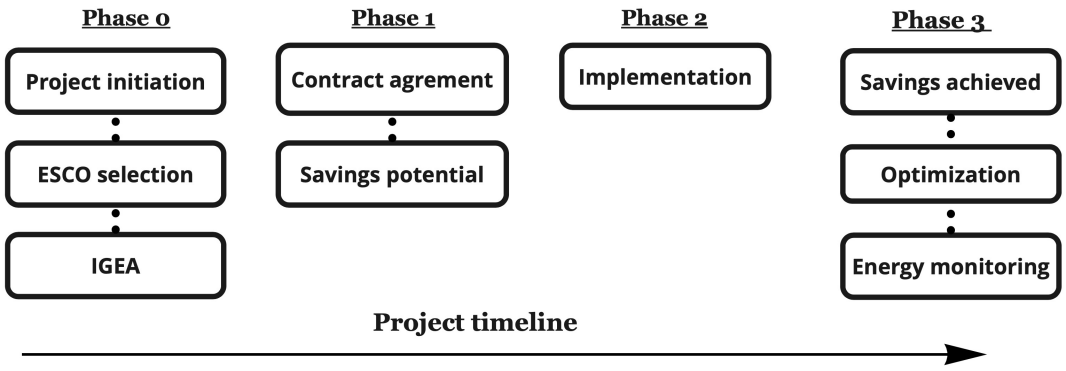

Figure 4: EPC Processes

EPC projects are often initiated with specific energy saving targets, and the success of these projects need to be determined by checking whether the relevant energy saving targets have been reached (Xia, Zhang 2013). An incorrect baseline energy audit can lead to difficulties in quantifying post project energy savings. Energy levels cannot simply be compared directly, considering changes can derive from numerous factors. An accurate estimation of expected energy saving is essential to mitigate the performance risk in EPC projects [40]. A balance of reliability and cost-effectiveness is important for the ideal results. After the project has been completed by the ESCO, the monitoring of energy is vital to determine the savings achieved. The article by (Lee 2015) distinguishes between three main approaches for energy estimations: simplified engineering method, regression analysis, building energy simulation. The regression method of measuring savings has been widely used in the residential and commercial building sectors [26]. The main differences in these methods lies within accuracy of model estimation, requirement on data quality and completeness, cost of model development as well as the ability of explanation in pre-set condition change. The cost of monitoring the energy levels is dependent on several factors, these include: the amount and complexity of the measurement equipment, sampling sizes, M&V options, quantity, complexity and interactions of energy efficiency measures, number and complexity of independent variables, accuracy requirement and the experience and qualifications of the M&V inspectors [55].

(Bertoldi 2006) mentions three main methods of project financing: ESCO financing, client financing or third party financing (TPF). When choosing either TPF or client financing a guarantee of energy savings is given by the ESCO, to warrant the return of investment and due to the higher risk associated for the client in either financing the project by themselves or borrowing money from a third party. (Aasen 2016) mentions how funding of projects in Norway is usually provided by Kommunalbanken, where favorable interests are given to energy efficiency projects. Neither the financial sector nor the ESCOs have been able to compete with this solution, which is used by all projects tendered over the last few years [41]. In addition to this, Enova SF provides grants to selected projects, which help promote EPC activity in Norway. As promoting energy efficiency

projects is of key importance for Enova, they are able to provide grants and other financial support to several projects The contribution by Enova has led to increased awareness and understanding for the concept of EPC in Norway.

3.1.3 Standards and protocols

Frameworks for contract agreements and general standards for EPC projects can be a large enabler in changing the consensus and increasing the number of projects in Norway. Having an official standard is important in the promotion of EPC as it counteracts many of the barriers related to trust, public procurement, and 'outsourcing' [41]. Having frameworks for contractual agreements will also remove the need to develop new agreements for every project, simplifying the process for both the client and ESCO. A standardised method for M&V is considered a key element, necessary for strengthening client and financiers' confidence in ESCOs and the energy services market in general [9, 48]. The use of guidelines and frameworks can simplify the process of conducting M&V activities. As the process of energy monitoring is directly related to the levels of profits and savings achieved, there exists a need for standardizing procedures to determine how risk and responsibilities will be shared. (ESCO report 2005) mentions how standardisation of M&V will help remove questionable results of unverified efficiency programs that place a cloud over the entire industry, and how it would be extremely beneficial to standardise savings M&V procedures to help users and the financial community better understand EPC and gain confidence in their return on investment [10]. The article by (Xia, Zhang 2013) mentions that M&V can be guided by protocols such as International Performance Measurement and Verification Protocol (IPMVP). The IPMVP provides general guidelines and standard terminology for crafting specific M&V plans [42]. Although IPMVP can prove to be useful in certain aspect, (Meyers & Kromer 2008) find that uncertainty regarding energy savings also apply to IPMVP.

As found by (Lindseth 2015) Norwegian standard NS-EN15221-3, guideline ISO 50007 and Norsk Standard - NS6430:2014 were launched in April 2014. The development of this standards has been a critical step towards a wider adoption of EPC in Norway. This will be explained further in Section 4.3.1. (ESCO report 2005) mentions how a number of companies are eager to call themselves ESCOs, without having the proper qualification or competency. The objective of an accreditation system is to enhance the quality and professionalism of service offered by the ESCO, which will increase the confidence in energy services sector and help promote the growth of the industry [28]. Therefore, the implementation of an accreditation system is considered an important tool for clients which ensures that the selected ESCO is reliable and qualified.

3.1.4 Enablers for EPC

The handbook by (FME HighEFF 2021) explains different enablers/opportunities for resource and energy collaborations, which may further increase the profitability and the likeliness for establishment for such energy collaborations. Even if the emphasis in this handbook is placed on energy collaborations in general and not EPC specifically, the enablers mentioned can still be considered highly relevant in the case for EPC, considering EPC is also a form of energy collaboration. Enablers listed are divided into four different stages that occur during such collaborations; determining opportunities & possibilities, finding potential stakeholders, negotiation, implementation & operation. The handbook explains that these enablers are also present before established contact,

where a common understanding of different parties' needs, aims, ambitions/intentions, visions, time-frames and general company values are considered important for the project. The search criteria for partners should include business with compatible cultures, shared values and long-term interests. Compatible parties reduce possible future conflict and are better able to handle risks in execution of the collaboration [25]. It is especially important to involve operators at existing facilities in early phases of the implementation planning, to reduce resistance. In addition to having procedures before and during project start the handbook also mentions that processes concerning feedback and follow-up. This can be especially relevant as optimizing and fine-tuning the implementations can have a significant impact on the results achieved.

M&V processes are usually completed by the ESCO carrying out the project, but the article by (Xia, Zhang 2013) also mentions independent third-party inspection body that can contribute to this process. The idea behind this conception is that, due to complexity surrounding M&V processes there could be a need to engage another additional stakeholder, who specializes in and can contribute to the uncertain processes of M&V while the ESCO conducts the remaining activities. Similarly, the report (ESMAP 2017) explains the possibility of engaging a third-party M&V expert to assist the development of a M&V plan by helping keeping costs limited and protecting key interests [48]. A real-life example of this method is mentioned in Montenegro energy efficiency project (2008-2014, ESMAP 2017), where the M&V activities were assigned to an independent third-party consultant [48]. M&V by a third-party gives unbiased and specialized evaluation of the system and energy performance of an energy efficiency project [48]. It is typically recommended that the M&V activities should be carried out by an independent third-party to ensure transparency in the M&V process [48]. The addition of this third-party can be referred in many different ways.

Enablers	Challenges
Development of standards/frameworks	Increased consumption after project
Transparency between actors	Uncertainty sorrounding savings
Involvement of third-party	Lack of trust
Financial support	Imbalance of information
Emphasis on sustainability	Smaller project sizes

Table 3: Enablers and challenges of EPC

3.1.5 Challenges

The article by (Backlund, Eidenskog 2013) explains how the relationship between ESCO and the client can be affected by insecurity surrounding M&V calculations. Energy performance is measured by calculations made by the ESCO, which requires specialized competency that the client does not necessarily have [7]. This creates an imbalance in information, since the client is not fully aware of how the technology is installed and how the calculations are completed. Similarly, the ESCO isn't fully aware how energy was previously used or how the changes implemented will by received by the client. This may provide challenges where the client may not fully trust the ESCOs calculations and believes that they are being taken advantage of. When firms do not trust the ESCOs calculations, this becomes a risk to the entire collaboration and the collaboration becomes unstable [7]. This can potentially lead to the termination of their contract agreement,

which creates financial losses for both parties, as long-term collaborations are seen more profitable for both actors. The article further mentions that long-term relationships reduce risks since this enhances trust between the partners and builds alliances.

According to the data collected in the article by (Lee 2015), it was found that "payment default of host after installation", "not sure if baseline measurement can be correctly established", and "costs of installation increase" were the top three key risk factors in EPC projects. Similarly the article by (Kissock, Eger 2007) mentions how uncertainty in expected savings reduces implementation of energy reduction measures. A lack of reliable energy consumption data from consumers makes it difficult to accurately quantify potential and actual energy savings delivered by ESCOs [32]. The savings generated by an energy-efficiency project is not directly measurable and, therefore, always uncertain [42]. Even in cases where cost savings are perceived to be significant and relevant to the decision, reliable data is rarely obtainable, leaving the assessment open to personal judgment [26]. This is because there are various extrinsic factors, such as change of occupancy and weather conditions, which leads to the project not achieving the expected amount of savings [40]. The scale of project can also increase the complexity of measuring energy savings, where energy changes might occur in a subsystem of a larger system or the entire system itself. Furthermore, defining a consumption baseline in the residential sector can be challenging since the energy consumption in this sector is much more dependent on individual needs and behaviors than other sectors [39]. In the residential sector, energy levels can vary immensely between each apartment, and is a dependent on the consumption levels of each resident. Monitoring levels over single components can yield in more accurate results, but proves to be a costlier option. Moreover, the energy use may also be a function of weather and/or production, which frequently changes between the pre and post- retrofit periods. In these cases, it is more difficult to measure energy savings and, as a consequence, savings are seldom verified [26]. The figure below summarizes the main enablers and challenges identified from the paragraphs above.

3.2 Role of GPP

Green public procurement (GPP) can be defined as conventional public procurement with the addition of green criteria's where goods are procured with reduced environmental impact. A demand for environmental friendly products from public actors may also set an example for the private sector and create markets for more sustainable products and services [43]. GPP is increasingly playing a significant role in the area of the sustainable built environment, including building projects [30]. As mentioned earlier, the majority of EPC projects in Norway, are completed by the public sector. Several correlations are seen between GPP and EPC during various processes, such as: identifying pre-requirements, tendering, supplier selection, awarding of contract, followed by the buyer-supplier relationship in the latter phases. To get a better understanding of the various processes inherent in procurement, frameworks for public procurement and various relating concepts will be further discussed.

3.2.1 GPP in Norway

As found by (OECD, 2000) the influence and impact of public procurement is significant, where public procurement represent 19% of GDP in Norway. The emphasis on greener practices is considered necessary, to ensure a sustainable future. The increase in importance given towards

sustainability challenges, is evident from governmental entities. An example of this is given in the Public Procurement Act states that all official bodies have a legal obligation to take environmental performance of products into consideration when new acquisitions are planned [43]. The inclusion of green criteria may indicate a costly addition project for many purchasing agents, which causes them to avoid green products as they would rather prioritize the financing of other projects instead [43]. Various grants and other financial support provided by Enova has been a mitigator for such challenges. The article by (Michelsen, de Boer 2009) examines the implementation of GPP at municipal and county level in Norway. The article finds that GPP is significantly more established in larger municipalities compared to smaller ones. Additionally, there exists a link between the municipality size and implementation of GPP practices, where smaller municipalities may lack the required competency or a dedicated purchasing department. A certain minimum size of the municipalities and counties seems to ensure the required amount and types of knowledge on purchasing processes; the ability to establish a purchasing department and the resources to develop a purchasing strategy [43]. This statement is corroborated by (EPC report 2019) which explains that due to the scale of projects significantly decreasing, this caused fewer ESCOs being interested in participating in these projects. However, as found by (Michelsen, de Boer 2009), one way to limit the challenge of municipal size is by collaborating/combining efforts, where smaller municipalities work together on a mutual project. Even though the lack of a purchasing department is considered an important barrier, there exists benefits of implementing GPP in local governments and entities, compared to national authorities. This is explained by the exploratory behaviour showcased by these local entities regarding procurement, where a national authority may be more risk averse [20].

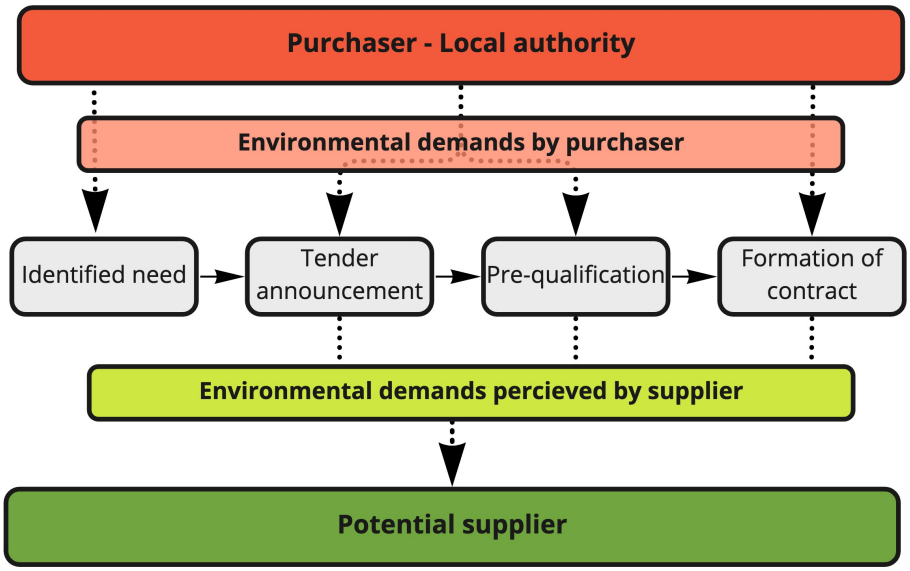

Figure 5: Stages in procurement process with environmental demands (Michelsen, de Boer 2009

3.2.2 GPP in building sector and LCA

The article by (Gonzalo, Bovea 2020) mentions how GPP can play an important role in reducing the environmental impacts from construction sector related products. In EU the construction sector is responsible for 10% of GDP and accounts for 7% of the workforce [14]. Even though

environmental considerations are taken into account during GPP processes in building projects, they are in many cases not weighed as important as factors like price and quality. There may also be a possibility where the buyer may choose to ignore this criteria, which would further complicate the buying procedure [14]. The article by (Gonzalo, Bovea 2020) explains that this belief stems from the fear of project delays, desire to simplify project and the risk of incurring in increased costs and limitations. There is found a linkage between GPP and Life cycle costing (LCC) which explains that higher initial costs may lead to lower costs during lifetime of project. This is achieved since the LCC method calculates a number of options with the objective of defining the optimum selection of goods taking into account all the significant costs involved in the service life of the goods [14]. The case study of procurement in building projects in Norwegian public sector by (Sparrevik 2018) mentions similar possibilities where integrating policy requirements into formal governance of project which allows for successful implementation of GPP. Policy requirements are integrated in procurement process through contextual activities. The contextual activities are explained as definable targets and functional requirements. The incorporation of definable targets (low or zero energy demands) from government into agencies allows the incorporation of tangible matters (i.e., Life cycle assessment (LCA)) in the procurement process [50]. Implementation of LCA in procurement activities therefore seems most successful when aligned with the strategy, aims and goals of organizations [34]. If there are no existing solutions, then functional requirements can prove to be effective in creating new solutions which improve environmental performance [50].

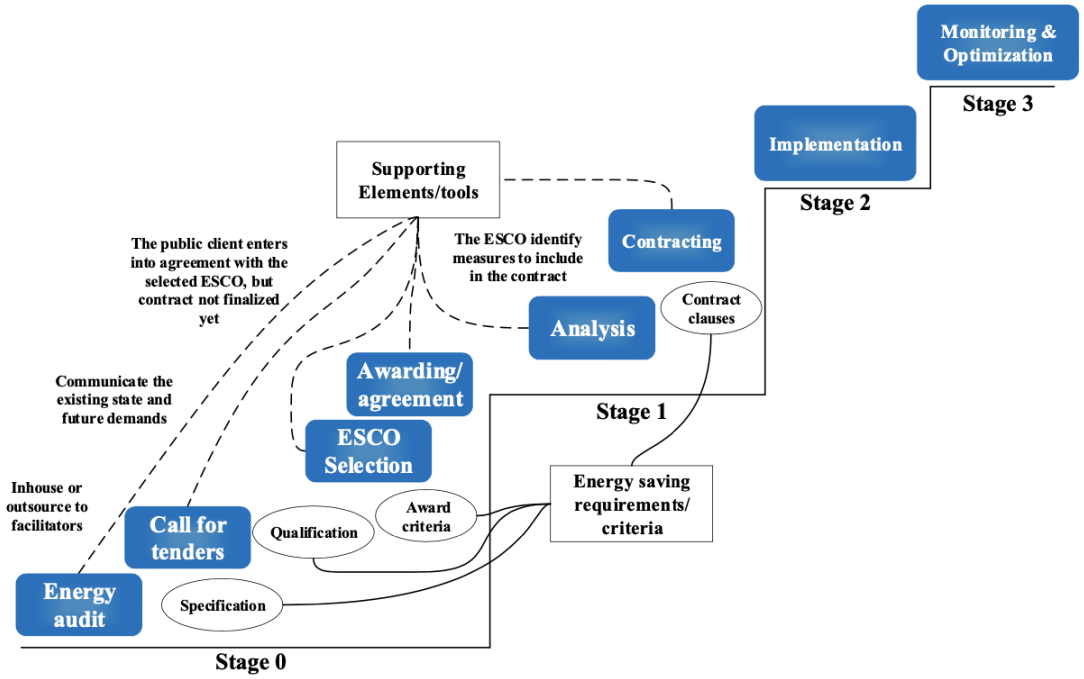

Figure 6: Aligning GPP process with EPC project

The (ZEN report 2020) mentions that there is reason to believe that GPP practices are not fully taken advantage of in EPC projects. GPP and public procurement can be considered the carrying vehicles of EPC, similarly EPC projects can help the advancement of GPP [30]. Regarding the environmental requirements and criteria, purchasers in EPC projects rely on different information about the building and current energy consumption to devise relevant competition criteria [30]. This step is considered vital since this determines what the guarantee for energy savings will entail. However, as evident in EPC processes, the analysis and evaluation is often dependent on

ESCO. Therefore clients may depend on external facilitators, who help clients in interpreting the current state of the building and potential for savings. The article further mentions that successful GPP needs to incorporate and adapt to appropriate and available supportive tools which include LCC and LCA. However, concepts as LCC or LCA cannot simply be required or stated, but the implementation of these tools requires specific, contextual knowledge and capabilities [34]. The (ZEN report 2020) presents a model which encompasses the various EPC processes with the advancement of GPP practices.

3.2.3 Purchasing process models

The article by (Bäckstrand et al. 2019) presents a number of different purchasing process models (PPM) showing the the sequence of activities that include purchasing and supply management [8]. Although these processes are considered important, they are often neglected in previous EPC literature. How the models differ and have evolved over time is also further explained in the article. The biggest difference between the models shared in this article is concerning the specific processes included in each model and whether the model follows a linear or cyclical process. An example of this is given in the article where a model developed by (Monczka 1999) follows a cyclical process and doesn't include the tactical processes, but focuses much more on the long-term process of designing purchasing policy, rather than conducting an actual purchase [8]. Similarly, a hybrid model developed by (Bäckstrand et al. 2019) is based on a 'Plan-Do-Check-Act' cyclical process which also includes a supplier exit strategy. Supplier exit entails how the procurement between a buyer and supplier is ended, following a purchasing process.

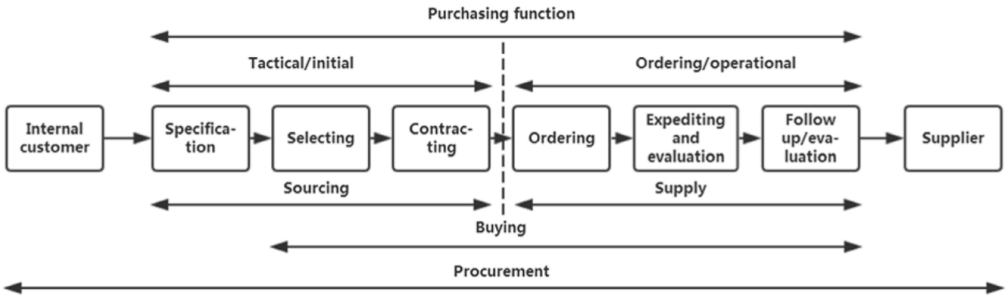

Figure 7: Linear PPM (van Weele 2018, Figure 1.2, p. 9)

Meanwhile the model developed van Weele proposes purchasing as a linear sequence of six steps, divided into a tactical part (specification, selection, and contracting) and an operational part (ordering, monitoring and evaluation) [8]. Since EPC projects are seen as a linear process where implementations by ESCO are initiated only once during lifetime of project, a cyclical PPM is not considered relevant since the processes of EPC aren't necessarily repeatable. Additionally, the inclusion of tactical processes (supplier selection, contracting) are important elements of a EPC project which the cyclical model by (Monczka 1999) excludes. Therefore, the PPM developed by van Weele is considered most suitable in the case of EPC projects. The process of evaluation/followup in the process model by van Weele, can be considered especially relevant for EPC, which can be referred to the stage where energy savings are calculated and the project's level of success is determined. It can be argued that the earnings and results obtained during this phase, is the reason and motivation behind why ESCOs and clients chose to participate in EPC activities. As explained by (Lee 2015) risks regarding M&V are all intrinsic, and both parties (the client

and ESCO) should equally bear them. This process can have several implications, as mentioned if the savings level are lower than expected, the ESCO may be liable to compensate for the limited savings.

3.2.4 Green supplier selection

The process of green supplier selection (GSS) is an important element of GPP, where suppliers are selected not only the basis of quality and price, but also the added criteria of green performance. (Igarashi 2015) mentions that the inclusion of green criteria and other environmental demands can increase the difficulty of decision-making for the purchaser. Certain purchasers may value price and quality factors higher compared to green criteria. Price and quality are still concepts closely related to contract awarding [19]. In addition to this, supplier selection is complicated by the need the confirm whether the selected supplier has necessary resources to complete the project. Since EPC projects are complex undertakings, replacing a supplier/ESCO with another may be difficult, since the number of service providers in this field are assumed to be limited. The article by (Michelsen, de Boer 2009) also mentions how municipalities and counties need to attach more weight to environmental aspects in supplier selection, in the prequalification phase or in the final selection of suppliers.

(Igarashi 2013) presents a framework consisting of the four key dimensions of GSS: alignment of supplier selection according to the company's sustainable goals, the role of decision-making tools and models in GSS, information processing activities and interrelated decisions, and lastly the wider supply chain context in GSS. The first dimension (alignment) concerns choosing a green strategy according to the company's overall strategy. To be useful, the environmental criteria cannot be chosen randomly without relation to the organization's long-term goals, for example, stimulate product innovation or cost-efficiency [30]. The second dimension entails the role of decision-making tools and models required for a specific supplier selection situations. The third dimensions deals with the different decisions and information processing activities conducted, where the different decisions taken must be coordinated and aligned throughout the process. Lastly, the fourth dimension deals with GSS as part of a broader supply chain context, as most organizations are both suppliers and customers, and therefore addressing environmental requirements through supplier selection can occur on the broader supply chain context of each organization [30].

Existing procurement policies have caused most public procurers to simply incorporate the environmental requirements in the call for tenders, rather than involving them in the selection process. [19]. The article by (Wondimu et al. 2016) explains how early contractor involvement can be a positive factor in public procurement projects. The article identifies six main success factors based on data from the case: timing of involvement, risk distribution, proper compensation, establishing trust, clients' competencies, and contractors' qualifications [54]. Similarly the article by (H. A. M. Hamdan & de Boer, 2019) explains that conducting a dialogue with market players (i.e., contractors and suppliers) before the formal tendering process offers various benefits that could potentially be used to reduce some of the structural complexity and uncertainty imposed on complex projects [31].

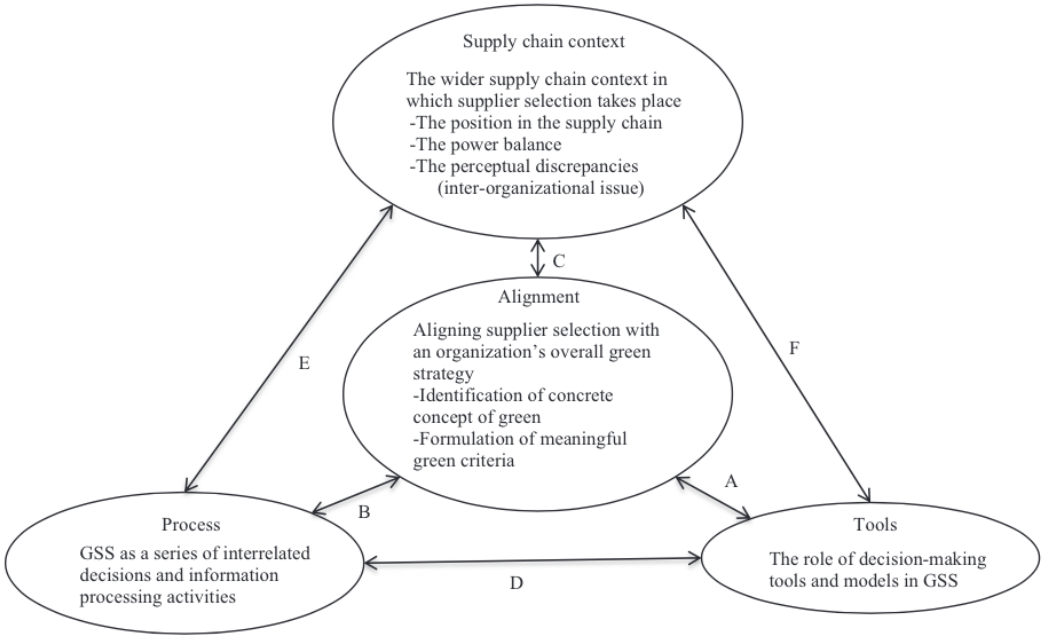

Figure 8: Conceptual model of GSS (Igarashi 2013))

3.2.5 Supplier interfaces

The article by (Araujo, Dubois and Gadde 1999) describes how buyer-supplier interfaces can have implications for their productivity, efficiency and innovativity. A change in relationship is evident with increased emphasis on creating a collaborative relationship, from which benefits can be attained [5]. Four different categories for interfaces are identified by the authors: standardised, specialized, translation, and lastly interactive. Each of these interfaces have different characteristics and are partly defined by the client's requirements regarding product specifications. Buying standardized products will not require a engaging interface, in contrast to products that are made according specific instructions. If we apply these different interfaces for the ESCO-client relationship in EPC projects where energy targets are given to ESCO, the translation and interactive interface shows certain resemblance where the link between these actors are more fluid & collaborative. The article further mentions that each interfaces has its' own pros and cons, and the benefits are determined by the context in which they are applied [5]. An example would be interactive interfaces which provide opportunities for productivity and innovation, however they are more complex to handle and require more investment. Choosing a translative or interactive interface can give room for a cooperative relationship between the client and ESCO.

3.2.6 Public procurement system

The article by (Edquist 2010) explains the emergence of national, regional and sectoral systems of innovation. Innovation may not solely apply to any specific product, but may for instance also include the innovation of a process. The author explains that firms normally don't innovate in isolation, but in interaction with other partners, suppliers, organizations through complex relations [23]. A relation between EPC proceedings and innovation procurement can be clearly seen, where the procuring organization specifies the requirements/specifications according to environmental goals set. The implementations and changes must constitute solutions to the challenges, but at the

same time they must be achievable given the state of the art at the time [24]. A national system of innovation may include different organizations that influence the use and development of innovations. Furthermore it emphasised that any given organization is influenced by other institutions or guidelines, such as: laws, rules norms and routines. Governing and regulatory agencies such as Enova, KS are examples of such influences for EPC (further elaborated in Section 4.3).

A research paper written by (Thai 2000) re-examines the scope of public procurement. The author develops a framework encompassing five core elements: policy making and management, procurement regulations, procurement authorization and appropriations, public procurement function in operations, and lastly feedback [51]. The first element: policy making and management, deals with policy makers and management executives who influence public procurement systems through laws and policies. The second element, procurement regulations can be seen as the institutional framework established by the policy makers, within which public procurement professionals implement their authorized and funded procurement programs or projects [51]. Given the importance and complexity surrounding public procurement, there exists a need for sound procurement regulations to provide clearly defined procurement goals, transparency in decisions & procedures, and equal treatment of all actors. Authorization and appropriations, the third element entails the funding or procurement budget which is considered a major element of public procurement, where many projects have faced delays due to insufficient investment. The article further mentions that procurement professionals can provide policy makers with valuable information in the pre-procurement cycle phases, including needs assessment, and procurement program authorization and appropriations. By doing this, new policies can be developed which potentially provide financial incentives for either on of the participants, reducing the possibility of a financing problem occurring.

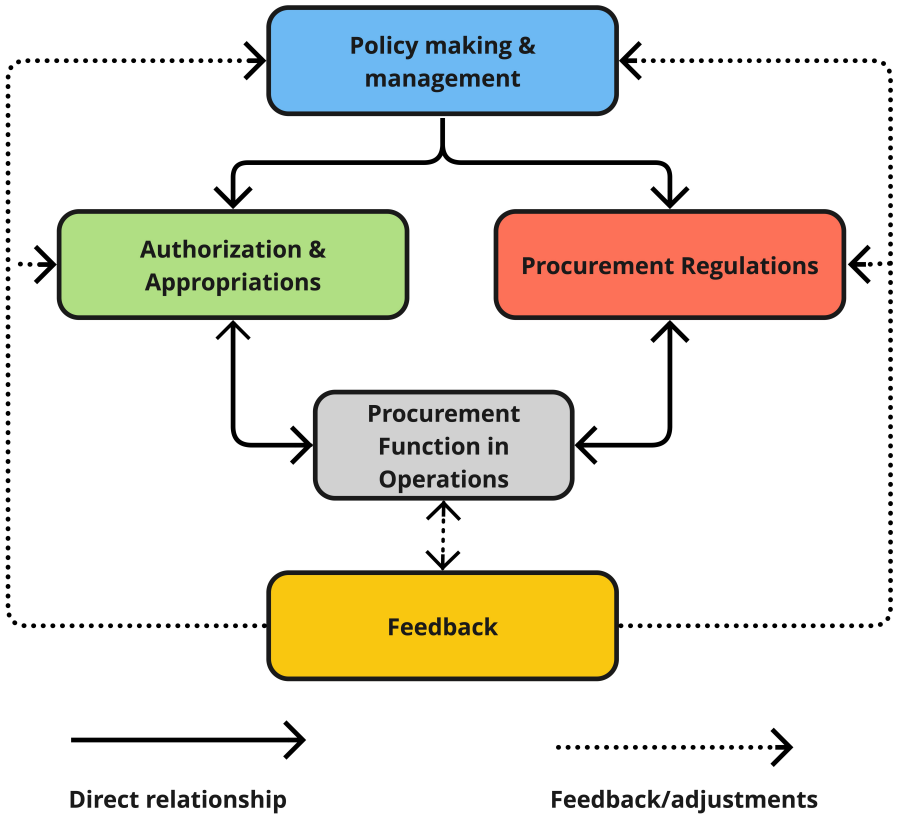

Figure 9: Public procurement system framework (Thai 2001)

The fourth element deals with public procurement function in operations, which represents managers/procurement officers, procurement process, organizational structure and different techniques or methods. This element is widely covered in previous literature and is considered as a critical and complicated element of the public procurement system [51]. Lastly, the fifth element concerns the feedback aspect of the procurement system, where a continuous evaluation to make required adjustments or reforms where they are needed. Feedback can derive from all parts of the system, ranging from procurement professionals to external governmental organizations. A lack of feedback can hide the potential challenges or problems within the procurement system. Feedback may indicate that procurement regulations, policies or agency procurement standards are no longer current or suitable, and adjustments or reforms are necessary [51]. The article also mentions how procurement system is influenced by environmental factors such as legal, political, internal, foreign policy, and social- economic. The author also explains that all the different elements and factors influencing the procurement system is dynamic and interrelated, where changes to one aspect will lead to change in another since there are conflicting forces present.

The various elements described in the article by (Thai 2001) can also be applied to the case of EPC. The first element, (policy making & management) influence over the market through laws and regulations showcases certain similarities to the role played by various governmental agencies and departments. Stating legal obligations to take environmental consideration during procurement is an example what role this element has in the context for EPC. The second element, procurement regulations have linkages to KS, Standard Norge and more, who provide procedures and policies for the manner in which procurement is conducted. Kommunalbanken and Enova are major forces who both have contributed to the field of EPC by providing loans and grants, showcasing similarity to the third element, authorization and appropriations. The fourth and fifth element are directly linked to the different procurement participators and the emphasis on feedback that is surrounded in these EPC projects.

3.3 Findings

As mentioned earlier, the main challenges for EPC projects stem from M&V processes, however the linkage of GPP has also several implications for these projects. These factors are further explained in depth, together with the opportunities that can potentially limit these challenges. The initial framework is developed based on these findings found from the literature review completed. These opportunities entails the addition of a third-party organisation which can contribute to M&V processes, whilst being a mediator between the ESCO and client. Additional factors such as development of new standards/frameworks and standardization of processes can also help mitigate these issues. The forthcoming paragraphs aims to answer the first research question **RQ1: What are the main drivers and barriers for EPC according to previous literature?**

3.3.1 Theoretical challenges

The main challenges found from the literature review are connected to: uncertainty surrounding M&V processes where changes in energy levels may derive from numerous factors, imbalance in information which can lead to a lack of trust, and other challenges that arise from changes in responsibility. As mentioned by (Meyers, Kromer 2008) since savings generated by an energy-efficiency project is not directly measurable and, therefore, always uncertain [42]. Weather changes,

change of occupancy, varying production levels can be reasons for differing energy levels. Varying factors mean that it can be hard to establish with certainty the effects of an energy efficiency improvement and therefore clauses and terms must be carefully negotiated in contracts, especially if the remuneration is performance based (Goldman et al. 2005). Another potential pitfall could be where the client's energy consumption level increases after project is implemented. This can create complexity and potential disputes, where it is difficult to determine if savings are low due to poor performance by ESCO, or as a result of increased energy consumption by client. In addition to this, the ESCO and the client may have different methods of calculating or interpreting energy levels, which creates potential misunderstandings.

The role of information can be considered vital in EPC projects. Imbalance of information can be evident between the ESCO and client during an EPC project, where the client may not understand the technological implementations, and the ESCO may not be fully aware of energy consumption from client after project implementation [7]. Similarly, the lack of knowledge regarding EPC projects and the processes involved might limit the understanding from the clients perspective. Since the ESCO covers aspects ranging from investments, project implementation and profits measuring, this could create a potential scenario where the client feels that it is loosing control over the project. The imbalance of information is evident from both the ESCO and the client's perspective. The level of transparency regarding information related to monitoring of energy levels between both actors can vary from case to case. This could eventually create a lack of trust where the client isn't certain if the savings provided by the ESCO are in fact certain or not. There is a possibility where the client may believe that it is being taken advantage of [7]. This is considered a major pitfall to the project. Likewise, the imbalance of information also applies for the ESCO, where the client may not be entirely transparent with sharing information. In conventional contracting methods, the service providers earnings are not necessarily connected to the the performance provided, and therefore the risk associated to the project may be considered less compared to a EPC project. Although the transfer of risk from the client to the ESCO is beneficiary from the client's perspective, we assume that the added responsibility of the project and return of investment hinging on the performance are factors that shouldn't be neglected from the ESCOs perspective.

3.3.2 Opportunities

To overcome the challenges found above, several enablers are found within previous literature that can be considered relevant for EPC projects; the inclusion of a specialized third-party and development of standards and protocols for EPC processes. The involvement of third-parties are considered a potential solution to overcome challenges connected to M&V and a way to increase trust among actors collaborating in the project. As mentioned in Section 3.1.4 this approach was earlier implemented in the Montenegro energy efficiency project. The third-party will contribute with competency required to complete the complex task of M&V processes where uncertainty is a large factor [48]. The article by (Igarashi 2013) explains the fourth dimension of Figure 8 the importance of the wider supply chain context in GSS processes. The element of power balance between buyer and supplier can be considered especially relevant for EPC, where as mentioned in Section 3.2.2 there may exists significant differences between the client and ESCO. Although, the client is considered the 'buying' company the ESCO conducts and is involved in all processes, which can create imbalance in power. The inclusion of a third-party can be justified, which can

lead to power balance among all collaborators. This can be explained due to the neutral position of the third-party where unlike the ESCO, their earnings may not be dependent upon the efficiency and results of the EPC project. Additionally, since the third-party acts as an mediator between both the ESCO and client, it can also contribute to conveying information between them, which would reduce the existing imbalance of information. This will in turn lead to increased trust among the project participants.

Additionally, developments within the field of EPC, will further influence the competitive landscape and reduce these challenges. These factors are not connected to the involvement of this third-party, but is rather dependent on increased regulations and continuing development of EPC practices. The dimension of decision making tools and models in GSS (Figure 8), explains how the consideration of environmental aspects further complicates supplier selection in the sense that more criteria must be evaluated and possibly traded off against each other [33]. The role of supplier selection is especially important during a EPC project, due to the long-lasting duration of the project. As mentioned earlier, the introduction of an accreditation system for ESCOs can be seen as a tool, which assures clients that the service provider is reliable and qualified. Similarly, the dimension of aligning entails how green criteria is related to the firms overall strategy. Although this is important for both the client and the supplier this criteria is considered a prerequisite in EPC, where the addition of green criteria is embedded within the selection process.

A logical response to the apparent lack of environmental competence is a call for national standards and templates for green procurement [43]. Similarly, newer and better protocols can help simplify the challenging process of M&V processes. Standardizing can predetermine specific risk or profit sharing levels, which reduce the possibilities of disputes occurring. Varying factors means that it can be hard to establish with certainty the effects of an energy efficiency improvement and therefore clauses and terms must be carefully negotiated in contracts, especially if the remuneration is performance based according to (Goldman et al. 2005). Contract standardisation will remove the need to develop new contracts for each new project, determine risk division, and decide how savings will be shared. Additionally, contractual frameworks/agreements can help the client in better understanding and trusting the project, [10]. Standardisation of processes and contracts can therefore be an important factor in reducing some of the challenges identified.

3.3.3 Initial framework

The initial framework presented uses the processes explained in Section 3.1.2 and is explained as following: The project is initiated by the client, where a qualified ESCO is selected. Choosing the ESCO is considered a simpler task due to the inclusion of one of the external factors, an accreditation system which simplifies the task of choosing a qualified and reliable ESCO. The ESCO conducts its usual practices during the project, however the processes concerning M&V are either partially or fully conducted by a specialized third-party/consultant. The third-party is able to contribute to this project by either finding or verifying specific energy levels. Additionally, the third-party also works as a mediator of information between the client and the ESCO to convey relevant information, which reduces the imbalance of information and increases the trust among all participants. The external factors of contract standardisation and M&V protocols are dependent on the future developments of EPC, but are considered to further reduce the complexity surrounding a EPC project.

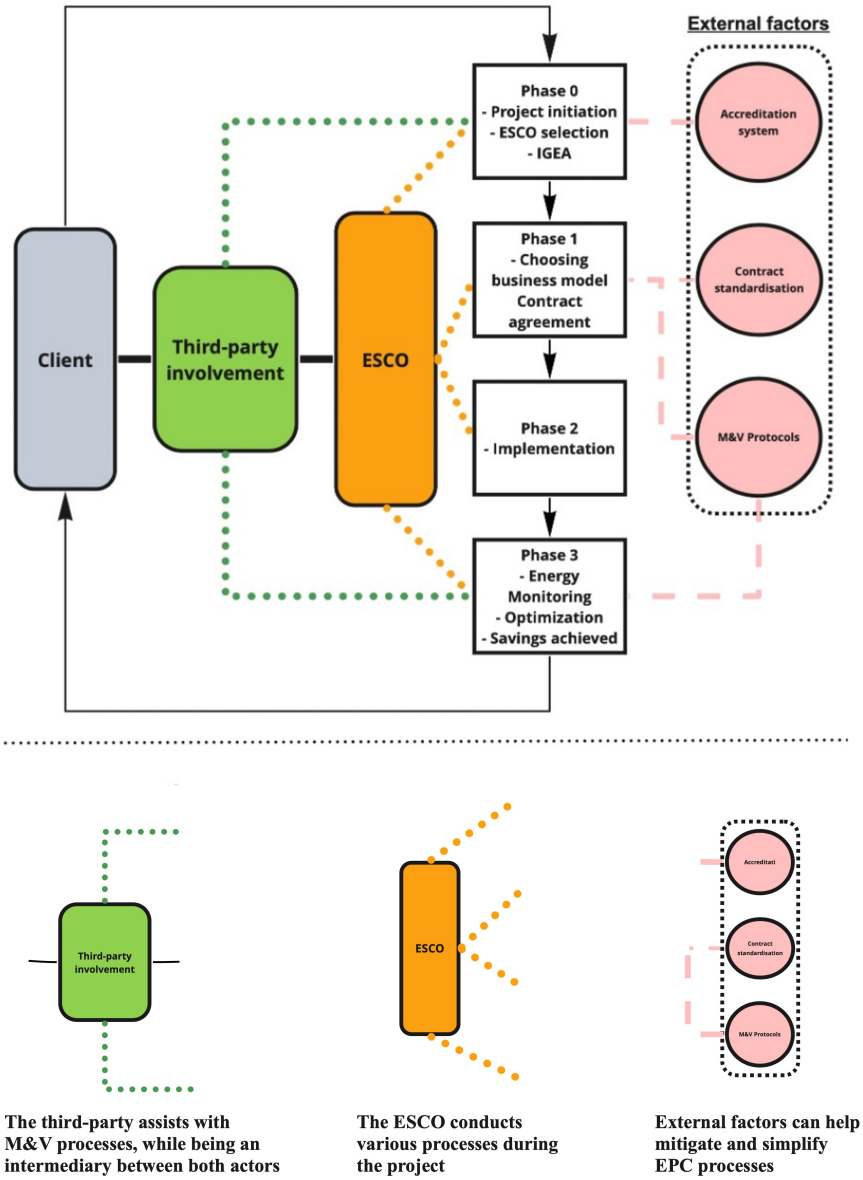

Figure 10: Initial framework

The benefits of a specialized third-party inclusion and external factors can be summarized in the following points:

- Providing competence and assisting ESCO in uncertain and challenging M&V processes
- Work as a mediator between the ESCO and client, to reduce imbalance of information
- External factors as accreditation system, standardizing contracts and protocols for M&V processes will further help mitigate the challenges found, as a factor of increased adoption of EPC

4 Empirical perspective

In this section we will look into the empirical data found from the interview sessions with the ESCO & Trøndelag county authority. First, the ESCOs previous experiences with EPC will be further elaborated, in addition to the challenges and risk-factors that are evident in their case. Thereafter, general information will be given about the Heimdal VGS project, regarding the different project phases, challenges and results obtained. Thereafter, the important roles and responsibilities of agencies Enova & KS will be shared. Lastly, empirical information from previous EPC projects completed in Norway will provide realistic examples, where data and information is gathered from public databases such as: Doffin, Statsforvalteren. The information provided in this section derives either directly from the interview sessions conducted, online databases, or other digitally available information regarding the entities and their projects.

4.1 The ESCO

A Norwegian ESCO has provided empirical data for this thesis, by explaining risk factors & challenges it has faced during EPC projects. The ESCO describes itself as an end to end contractor. Examples of previous projects the company has conducted include such as hospitals, hotels, data centers, airports, large office buildings and more. The company's specialized competency within the field of HVAC, smart solutions, automation provides the necessary tools for the company to conduct EPC projects, explaining its role as an ESCO during these projects. The organisation has prior experience with EPC, where a number of projects have previously been completed. Although, the majority of these projects can be considered successful, the company explained certain barriers and risk factors it faced during some of these projects. The representative from the ESCO refrained from mentioning any details about any specific projects. Instead, broad examples of challenges and other indications perceived from their perspective, were shared based on their prior experience in a general sense.

4.1.1 Increasing energy levels post-project

One important challenge identified involved the interpretation of energy levels and cooperation with client. According to the ESCO, after the project has been completed the client may initiate new changes that may increase energy levels which are not accounted for. Since the energy levels may be significantly higher than expected, this can potentially lead to a dispute between the client & ESCO. The client may argue that the implementations made by the ESCO have not been successful, while the ESCO may argue that the client is responsible for increased energy consumption. Whether the client informs the ESCO about new initiatives made, may also vary for each case. An example of such an initiative was given, where a building owner installed charging stations for electric vehicles, as a factor of increasing governmental pressure for introducing more sustainable practices. If such an initiative is not taken into account during calculations for energy levels, it may lead to significant deviations between estimated and actual results. It was further asserted that requirements and usage may significantly increase over time. Similarly, the initial baseline measurement, which is often used for compare energy levels before and after may also be inaccurate. To address this issue, the representative emphasises the need to measure energy levels based on the implementations made by the ESCO, instead of simply comparing energy levels

before and after. According to representative, this would give a more accurate description, to what degree the implementation have been successful.

4.1.2 Selection of third-party organisation

In addition to the misunderstanding regarding monitoring energy levels, the company claims that the choice of a third-party or energy consultant can have severe implications, which further complicates the cooperation within EPC projects. According to the representative, the selection of third-party is either entirely or heavily influenced by the client. Instead of working as a mediator amongst both actors, the third-party/consultant may work on behalf of the client. Originally, the addition of a third-party is considered to favor all actors as they will be able to assist in various processes and solve disputes or other disagreements from a neutral standpoint. However, the influence from the client during the selection of this third-party/consultant may be problematic for the overall project. The third-party may be biased to favour decision that benefit the building owner. Additionally, it was also mentioned that the third-party/consultant may benefit from disputes that transpire between project participants, as this leads to additional work for this third-party. It was also indicated that the client may be aware of these potential pitfalls and risk-factors for the ESCO, and may take advantage of this situation if this provides incentives for themselves. Additionally, it was further mentioned that the portrayal of a win-win situation that may be attached to EPC projects, may in fact contain several risk-factors for the ESCO which are not highlighted. The representative pointed out that that to facilitate EPC proceedings, general framework & contract standards (NS6430:2014) developed by Enova and (KS) were utilized. According to the representative, the first EPC projects which the ESCO participated in, involved many risk-factors. This challenge has been reduced since the introduction of NS6430:2014. The development of a next-generation standard or contract framework could be an important improvement in an effort to reduce additional risk-factors and potential pitfalls the company faces. Lastly, the representative emphasises that even if EPC project are characterised as a cooperative partnership these agreements may not entirely reflect that, considering the client has the possibility the end the agreement mid-project, which the ESCO doesn't have.

4.2 Heimdal VGS

Heimdal videregående skole VGS is one of the largest secondary schools within the Trøndelag region. In 2009 Trøndelag county authority approved a strategy to reduce its carbon emission by 50% within 2020, which has been the motivation for choosing ambitious environmental projects, new Heimdal VGS being one such example. The decision was made to build a new building which would replace the old school from the 1970's. A dialog with their cooperative partners ZEB/ZEN Sintef explored potential solutions with inclusion of environmental aspects [49]. To ensure that the project would deliver the required energy levels, EPC proceedings were utilized in this project. Although, using EPC for refurbishing/renovating has been evident in older buildings, this would be one of the earlier projects combining EPC for a partly new construct. The new school opened August 2018 achieving several important environmental milestones.

4.2.1 Background

During the initiation of this project, improvement in environmental results and other aspects was considered necessary. Initial requirements included reaching the minimum passive house requirement for energy efficiency, and delivering a climate neutral building. In addition, climate impact associated with material use must be 20% lower, compared to schools where climate-friendly materials aren't utilized [47]. The new Heimdal VGS is able to accommodate 1140 students and 200 staff members, housing a new multi-purpose gymnasium hall, while simultaneously being the country's first zero emission school. This has been achieved mainly through the implementation of solar panels, giothermal & biogas initiatives. In addition to this, other considerations such as electrochromic glass, LED-lightning, efficient ventilation system are factors that further reduce the energy consumption. Annual energy consumption for the building has been calculated at approximately 38 kWh/m2, where current regulations have a maximum requirement of 110 kWh/m2. The table below compares the energy consumption level for Heimdal VGS compared with average consumption for school buildings fulfilling passive house requirements in 2017. The consumption levels showcasing average consumption in 2017 is calculated by energy consumption per unit area.

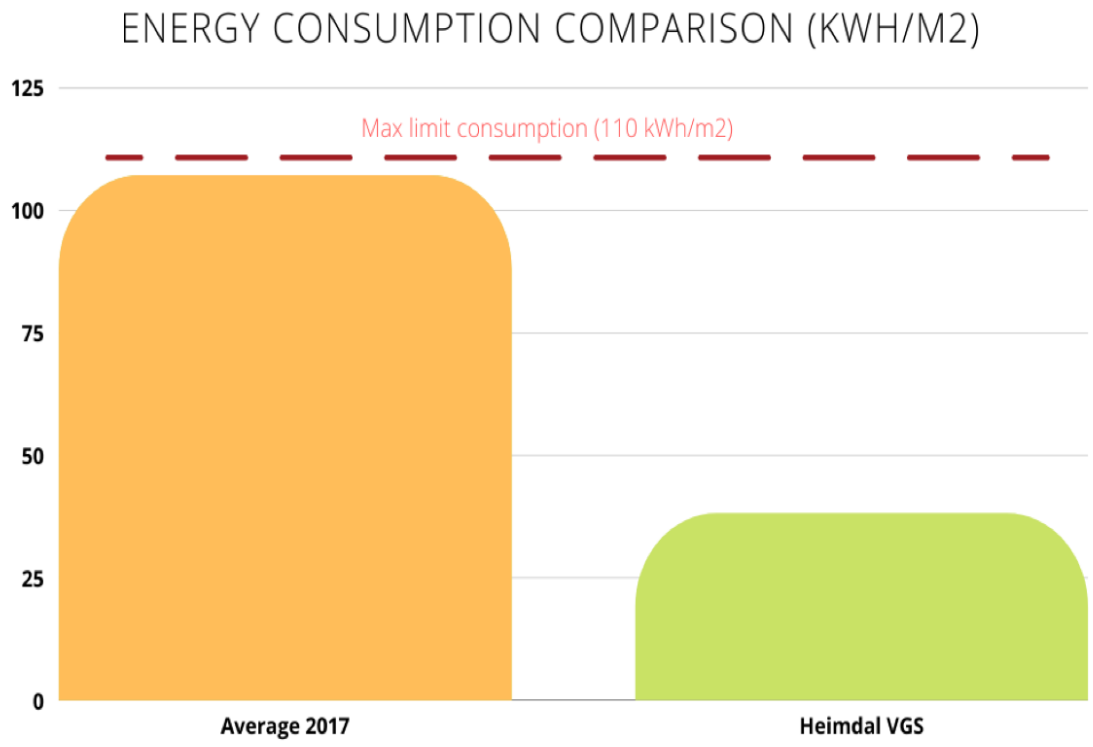

Figure 11: Energy consumption comparison (Enova building statistics - Appendix A)

Extensive focus was placed on the supplier selection aspect for this project which followed EPC guidelines. In 2013 the county authority prequalified eight different teams, where each of these teams received a grant of 200 000 NOK to participate in a conceptual phase lasting 3-4 months [47]. The teams consisted of entrepreneurs/ESCO and advisors (engineers/architects). ZEB/ZEN Sintef played a supporting role during the project by actively providing competency to the county authority and the teams. The client then proceeded to select three teams, who would each receive

additional support of 2 500 000 NOK to hand in a proposal based on intensive discussions with the client. Project leader from Trøndelag county authority, appraised this investment as beneficial, "influence is more prevalent in the earlier phases of the project, therefore placing resources in this phase can be considered reasonable" [47]. The county authority received a grant worth 21 500 000 NOK from Enova, due to this project being recognised as a pilot project and point of reference for future projects. The project was ultimately handed to Skanska as the main ESCO and Ramboll, as the architect and advisor.

4.2.2 Project implementation

During the first year of operation for the new building, energy consumption was significantly higher than expected results. This was a result of a number of different variables. Firstly, the initial operating hours decided for the school proved to be inaccurate, since the actual operating hours were notably longer to facilitate cleaners that arrive early morning and various sports teams and other groups that utilise Kolstad Arena until late evening. In addition to this, the COVID-19 pandemic provided several challenges where total capacity for number of students and workers present at school was reduced dramatically, which complicates the matter further. To reduce this challenge, representatives from Trøndelag county authority elaborated that the county authority and Skanska started to arrange monthly meetings to discuss operation, optimization and other changes to be made. Furthermore, the need to include building operators into these meetings was mentioned, since gaining insight into how these implementations and numbers are connected can benefit the operators in operating the building more efficiently. Previously, similar meetings were arranged however, those meeting were arranged more in regards to present energy levels and current numbers, not necessarily discuss potential changes or how adjustments can be made to better operate this new building. When discussing such possibilities with the ESCO to implement changes, usually the changes that lead to the biggest savings are implemented first. According to the representatives from the county authority, the ESCO is often willing to implementing these changes, since they are compensated for these services by the client.

In order to accurately determine energy levels, there have been installed over 200 energy monitors throughout the new Heimdal VGS school. These monitors are able to monitor the base load and other necessary information in different parts of the building. According to representatives from Trøndelag county authority these energy levels are listed in detail in a Microsoft Excel spreadsheet developed by the ESCO. Since all parts of the building may necessarily not be included within the contract, this spreadsheet is further divided into different sections, for energy levels that are included in the EPC contract and energy levels that are excluded. It was further elaborated that the information in this spreadsheet is entirely transparent and available for both Skanska and county authority. The representatives mentioned the emphasis on trust as a vital factor between Skanska and Trøndelag county authority. All initiatives or changes that may lead to increased energy use is informed to the ESCO by the county authority. Besides trust, the relationship between both actors is defined by a collaborative nature, where issues that have significant impact on energy levels are in many instances solved in cooperation with Skanska. An example of this was given during the interview session, where a de-frosting solution installed in the parking facility was a large consumer of energy. Even though this parking facility is not a part of the EPC contract, Skanska has actively contributed to solve this challenge.

Besides Heimdal VGS, Trøndelag county authority are developing new schools with the addition

of EPC procedures. In contrast to Heimdal VGS, one of these schools consists of an entirely new school building, which according to representatives from the county authority can be considered a simpler task from a numerical point of view. The reasoning behind this is given by a lack of documentation and measurements for certain parts of an existing building can complicate matters, when determining potential for savings.

4.2.3 Results

Trøndelag county authority's involvement in FME ZEN center can be considered an important enabler, which has provided the necessary environmental expertise and competency, a factor which can be seen as vital for a project of this scale. The county authority has taken advantage of their buying power, in order to drive an innovative and new-thinking procurement process. This will increase the competency within industry, according to the county mayor [49]. Managers from the county authority supports the use of EPC, by explaining how using EPC not only provided a robust and innovative solution, but also provides the protection and guarantee which the client looks for [47]. The motivation for the ESCO is evident as explained by the manager, since the ESCO is committed to delivering on these solutions as they receive good incentives for reaching these levels. Similarly failing to reach that aim would result the ESCO compensating for the error. The project leader regards the emphasis placed on actual energy improvements in a EPC contract as a major factor behind this project, as it is believed that the end-result would not be possible to achieve by focusing solely on price. It is further added: "We sense that Skanska/ESCO are equally engaged in succeeding with this project" [47]. The representatives from the county authority described the Heimdal VGS as a successful pilot project, even if there exists room for improvement.

4.3 Enova & KS

As mentioned earlier, any given organization is influenced by other institutions or guidelines, such as: laws, rules norms and routines. For EPC, this role is clearly evident for entities as Enova and KS. Their importance for the EPC market is clearly seen, whether that is evident through financial contribution or development of contracts & frameworks. It should be noted that although there are several other organisations that play a similar influencing role, these have been excluded due to the time-constraint placed on this thesis. The responsibilities and contributions of Enova and KS will be further explained. The information provided in this section is found through a document analysis of the EPC cases found from Doffin, further information was found from articles available online.

4.3.1 Enova

Enova SF is owned by the Ministry of Climate and Environment in Norway. The organisation can be considered an important influencing factor within sustainable matters, where the organisation provides grants and other financial support for projects pursuing climate friendly and other sustainable goals. Enova's contribution can be considered vital, as completing sustainable energy projects and adopting climate-friendly technologies can be a financially demanding task. In 2021, Enova invested NOK 4.6 Billion of public resources to climate change solutions, where over 5500 projects were recipients of financial support through Enova [4]. The organisation is considered a

large facilitator for the development of EPC, where Enova has provided grants and resources to a range of different projects, as evident during the Heimdal VGS project. Furthermore, Enova has played a key role for spreading awareness and advice for EPC in Norway [3]. In September 2019 a new implementation model and other frameworks were launched by WSP Global, LinKon AS & Caverion ESCO. The development of new templates and agreements for EPC, was initiated as a factor of limited and stagnant growth of EPC in Norway, as mentioned in Section 3.1.1. It is further emphasised that although the concept and processes of EPC may be understood, the implementation of the project may deviate from from NS6430:2014 and vary for each case. Other challenges found with existing agreements were difference in expectations of end-results, increased risk for ESCO since baseline measurements can be inaccurate, limited cooperation between client & ESCO increases difficulty and misunderstandings. The organisations within the project group (WSP Global, Linkon AS, Caverion ESCO), all have prior experience from different roles regarding EPC such as: ESCO, consultant and client. Enova supported the development of this new agreement, with a grant worth NOK 1 million. The new implementation model is based on the Norwegian standard for EPC: NS6430:2014.

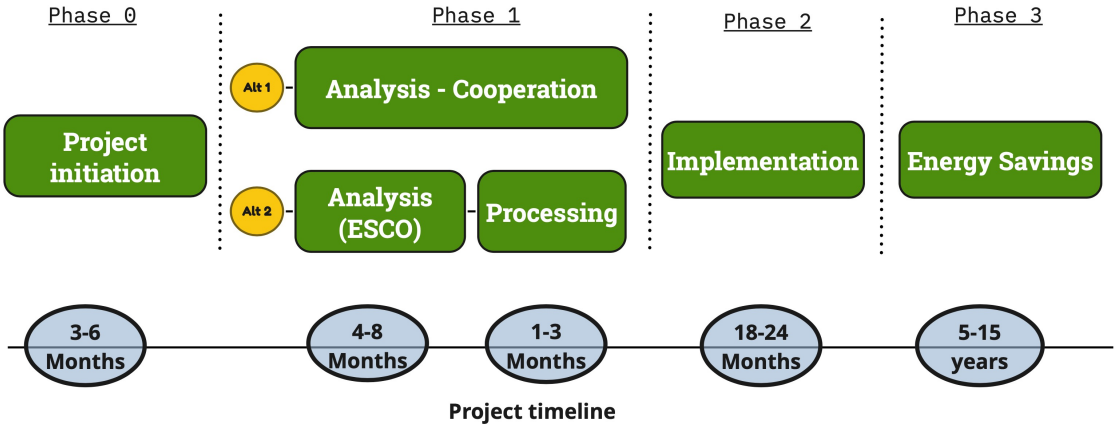

Figure 12: EPC phases/Implementation model (EPC report 2019)

The figure above shows an alternative way of conducting phase 1 which involves increased cooperation between the ESCO and client, as presented in (EPC report 2019). These new templates & agreements aim to ensure a good cooperation between customer and supplier and thus maintain a relationship of trust between the parties throughout the process [46]. One of the changes made in the new template is regarding the clients understanding of the project in terms of building material and resources included in the agreement, which will lead to the client having more clear expectations of the project. Another key adjustment made to the frameworks consists of contractual interaction for phase 1 of the project, providing more security for all partners [53]. Traditionally, the ESCO stands responsible for the initial analysis which is then processed and inspected. The new agreement places an emphasis on cooperation for this phase which follows an 'open-book' procedure for both investments & savings [46]. By having an emphasis on cooperation, this creates an open dialogue with both participants which aims to increase trust and understanding of both the client & ESCO. As the increased cooperation for phase 1 requires more attention, and in some cases increased competency for the client, it is further specified that not all cases may benefit from this alternative method. Certain projects may instead benefit from the traditional way of conducting phase 1, and therefore determining which method is considered suitable depends on each case.

4.3.2 KS

The Norwegian Association of Local and Regional Authorities (KS) is an organisation for all local governments in Norway. KS is Norway's largest public employer organisation. The organisations has had a vital role for the development of EPC in Norway. KS has initiated the development of templates and contract documents for EPC, where the use of KS-templates is mentioned and evident in several different EPC cases from Doffin. As of April 2016, a total between 55-60 counties had utilized these templates to implement EPC projects, according to KS. A complete set of documents were developed to guide different EPC processes and proceedings[4]. An effort was made to contact KS, to get any insight on whether any new updated frameworks/templates were being developed. Unfortunately, the researcher was unable to establish any contact with any representatives. In a technical report released by KS in 2021 (Fit for '55' 2021) KS's support towards EU's 'Fit for 55' package was described. Fit for 55 refers to the EU's target of reducing net greenhouse gas emissions by at least 55% by 2030 [29]. The report also mentions the potential of EPC as a tool to increase energy efficiency in buildings. Moreover, KS describe Enova's and their own contributions towards the field of EPC. KS highlight that the templates and documents the organisation had developed for EPC has contributed to reduce energy consumption by over 30% within building sector for 68 counties [37]. The report acknowledges that the interest for EPC projects has decreased amongst ESCOs in recent years. The reason for this low interest is given due to examples of previous cases, where ESCOs have failed to reach the target level set [37]. This along with other factors has created skepticism amongst ESCO in participating in EPC projects. The report further encourages public entities in pursuing actions that mitigate these risk-factors, as the potential for EPC is considered immense.

4.4 Document analysis

The upcoming paragraphs gives examples of previous EPC project completed in Norway. The document analysis was completed to triangulate additional data and information, to strengthen the basis and findings of this thesis. The article by (Dubois & Gadde 2002) state that multiple sources can contribute to reveal aspect of research topic and problems, previously unknown to the researcher. As mentioned earlier, the information from these cases has been gathered mainly from public sources such as Doffin and Enova, however other articles are found from the website of Caverion. The documents found from Doffin mainly include various templates and models used to facilitate EPC proceedings, as well as target levels and other basic information concerning pre-project details. Meanwhile, the information gathered from Enova and Caverion for these cases derive from online articles published by the organisations mentioned.

4.4.1 Cases from Doffin

As all public procurement notices are listed on Doffin, a range of different cases are available for EPC. It should be mentioned that mainly tender notices/specifications are shared on Doffin, therefore information about post-project results is often not available. Similarly, as most cases are based on the same frameworks and standards, there are many similarities found in documents for these different cases. A limited number of these cases have sufficient documentation & other relevant

[4]List of various documents shared as an attachment in Appendix A

information that can be considered applicable for this thesis. Noteworthy findings and other relevant information is further shared. In Case 4 (Hedmark county authority), a similar project phase description to (Aasen 2016) is described in the tender specification. The case entails EPC proceedings used for 38 buildings, where phase 0 consisted of a tender offer dialogue phase with potential ESCOs, expected to last 6 months. Phase 1 is detailed as an analysing phase, where building analysis & calculations are completed jointly with a representative from the building owner. This phase is expected to last between 6-9 months. In the following phase the implementations will be initiated by the ESCO, where changes are expected to be complete in a 18+ month time-span. The tender specification specifies that operating hours are expected to continue as normal, and the ESCO is expected to work according to this. In the last phase when savings are realized, the project first enters a trial period of usually 6 months where additional support and fine-tuning of operation/equipment is provided by the ESCO. The overall savings period for this case is assumed to be 5 - 10 years. Case 3 (Sunnmøre regionråd IKS) had specified a similar timeline in their tender, where the county is looking at possibilities to reduce energy consumption and costs related by adopting EPC practices for three of their buildings. The tender specifies another responsibility for the ESCO, which entails the training of staff to ensure the optimal operation for the school. The tender specification for Case 7 (Modum municipality) provides a supplier selection process similar to Heimdal VGS, where three different ESCOs developed concepts and solutions based on further negotiations and evaluation upon which the preferred ESCO was selected.

Case 2 (BaneNor SF) describes Follobanen Delprosjekt Ski's pursuit of a senior employee that can fulfill the role as a quality advisor. Based on the information provided in the notice, an energy consultant is required by the county. Similarly, the Case 6 (Alta municipality) lists a requirement for an energy advisor that is expected to contribute with competency and know-how of these projects. The consultant is expected to take an active role in negotiation meetings, analysis reviews and otherwise in technical/economic/legal discussions. Contract between consultant and employer is only binding for the first phase of EPC, where an option to extend contract for the following phases can be possible. Furthermore, the client also requests the necessary training & education for operators & maintenance workers, to operate the various buildings in the most efficient way. The documents for Case 1 (Museene i Sør Trøndelag AS) include an Excel file sectioned into different parts, documenting the various energy levels for various buildings. The use of this Excel file is also mentioned in the contract proceedings for the case[5]. The challenge of finding documentation and information for pre-existing buildings is further supported in Case 5 (Bergen municipality), where the municipality has explained in the tender specification that documentation for pre-existing buildings may not be entirely complete. It should be noted that several of the cases listed on Doffin mention that the project mainly consists of three phases, where phases 2 and 3 are optional and dependent on political consideration. This is evident in Case 8 (Oslo municipality) where phase 2 & 3 are listed as optional extension of the original contract. Since phase 2 & 3 are not guaranteed as a part of the project, the contract duration for this project is set for only 30 months, compared to other projects which may last for 10 years or longer.

4.4.2 Cases from Enova & Caverion

Another example of a successful EPC project is given by the case of (Tingvoll municipality). During this project 86 energy efficiency implementations were initiated in 13 buildings [27]. The article

[5] An Excel spreadsheet used for energy monitoring is included in Appendix A

by Enova providing details for this project, mentions that this financially self sustaining project accounts to yearly savings of 1.5GWh, which saves the municipality a total of NOK 1.4 million each year. AF group was selected as the ESCO for the project and implemented several new initiatives such as isolating walls and roofs, installing heat pumps, updating/installing new systems. It is further mentioned that this project received NOK 1.8 million in grant from Enova. One important enabler has been described as training of operators and maintenance. According to a representative from the project, this increases understanding and ensures that savings are realized [27]. Similarly, the EPC project conducted in Skjervøy municipality was able to reach comparable results. The municipality is able to save 1.6 million kWh each year, while simultaneously being able to renovate and modernize their buildings [52]. The municipality is expected to save NOK 1.3 million on a yearly basis. Isolation, efficient ventilation system, new warming solutions were some of the implementations initiated. According to a representative from the municipality, an enabler for this project was the ESCO taking responsibility for the savings and implementations [52]. As the municipality is of a smaller size, it may lack certain competency or capacity to complete this project by themselves. This project was also the recipient of a grant worth NOK 1.3 million from Enova, and entered the guaranteed savings phase starting 2016. A third example of an EPC project is mentioned by Enova, for the project conducted in Kongsberg. An article shared by Enova explains the project which was initiated in 2012 which consisted of 32 buildings for the county. An EPC agreement was written with Norsk Enøk og Energi who was selected as the ESCO for the project, resulting in reduction for energy consumption levels by 36% [36]. Over 300 implementations were initiated by the ESCO, which saves the county upwards NOK 5.1 million yearly. According to a representative from the county, one important change was the installation of heat pumps in the largest buildings [36]. Like other cases, this project also received a grant worth NOK 5 million. The figure below lists the yearly savings (GWh) from different cases where EPC has been used.

Figure 13: Yearly savings from various cases (Data from Enova/Caverion)

Caverion ESCO, one of the companies part of the consortium behind the development of new EPC templates/documents, details the completion of three EPC projects where the company has parti-

cipated as an ESCO. As these articles are found from the ESCO involved in these projects, certain biases or subjective opinion may be evident. The first project was completed in Skien municipality and consisted of a large scale project where implementations were made in 11 kindergartens, 14 schools and 11 medical centers [21]. The ESCO developed and suggested 500 solutions/initiatives, of which 378 where approved by the municipality which were then implemented over 18 months. Skien municipality invested a total of NOK 37 million for this project, where a grant of NOK 8 million was given by Enova. An energy consultant contributed to different processes throughout this project, to assist the client in these processes. After four years of operation yearly savings are accounted to be 6 837 586 kWh which represents around 26%, saving the municipality approximately NOK 6-7 million yearly [21]. The second project completed by Caverion is increasing energy efficiency at the Norwegian headquarters for German company Würth Norge. Eight different buildings with varying level of consumption, accounts to a total area size of 26 000m^2 [18]. Since the project was only completed four months before the article was published, year by year comparisons are not provided[6]. However, it is mentioned that the energy consumption reduced by 500 000 kWh. This increase in efficiency is credited due to changing to new ventilation aggregates which provides higher efficiency [18].

[6]Figure 13 Only includes savings for first 4 months

5 Analysis

This section will look at the main findings and challenges found from empirical data. The addition of empirical perspective gives us new findings and shows that the initial framework is subject to change, as emphasised in the systematic combining methodology. The main differences from empirical data will be further examined to understand which challenges exists and what opportunities can help ensure the successful implementation of EPC projects. Thereafter, a revised conceptual framework will be presented which combines these factors in an effort to mitigate the challenges that are identified.

5.1 Empirical analysis

Although theoretical literature provides a rigid foundation, empirical perspective is needed to validate the hypotheses generated and look at the challenges & opportunities from a different perspective. In many cases, concepts deriving from a theoretical standpoint may not translate in a similar manner in a practical scenario. Findings from Section 4 illustrates hidden barriers and new challenges that may be evident within EPC projects. The data provided by the ESCO, Trøndelag county authority & the other projects will be further analysed. This section will aim to answer the second research question **RQ2: What additional challenges are found from empirical data?**

5.1.1 Use of third-party

The use of a third-party entity has been explored as a potential enabler to reduce the challenges identified earlier. In both the case for the ESCO & Trøndelag county authority, the involvement of such a third-party/energy consultant has been evident. During the development of Heimdal VGS, Trøndelag county authority involved an EPC advisor from an independent consultancy organisation, who assisted in various processes throughout the project. Discussing concepts & solutions, monitoring calculations & energy levels and involvement in meetings with the ESCO were some of the responsibilities of this consultant. During this project, the energy consultant didn't contribute Skanska with any specific M&V processes. According to representatives from Trøndelag county authority, this consultant has also been involved in other EPC projects which the county authority has initiated. The selection of this advisor is based on a framework agreement between Trøndelag county authority and the advisor. The inclusion of this third-party/consultant has proven to be beneficial for the county authority, considering that competency and expertise that the county authority otherwise may lack regarding these processes is provided by the consultant. Addition of an energy consultant or advisor is also evident in several cases from the document analysis, where a consultant is hired to contribute to EPC processes by the client.

Although the benefits for inclusion of this third-party consultants can be seen for the case of Trøndelag county authority, this may not necessarily be the case from the ESCOs perspective. As mentioned during the interview with the ESCO, the company has faced challenges in cooperation with a client and the third-party selected. Considering the selection of consultant is made by the client, this can create a potential conflict where the consultant is working on behalf and favoring decision towards one of the partners. This creates a situation where the third-party is biased towards one of the stakeholder, suppressing the role as a mediator between both actors as originally

imagined in Figure 10. This can be considered a major pitfall, if the third-party faces the tasks of solving any disagreements or disputes amongst both participants. The importance of selection for this consultant can be considered depended upon what role is required from this third-party. As mentioned in Section 3.3.2, the original thought behind the inclusion of a third-party/consultant is intended as a way to assist in various processes, while working as a mediator between the client and the ESCO to settle any disputes that may arise. However, as seen in the case for Heimdal VGS an energy consultant was selected by Trøndelag county authority, where the assistance of this third-party was only required by the county authority and therefore any role as a mediator was not evident. Therefore, if assistance is only required from the client's side, the selection from the client can be justified. Case 2 & Case 6 also mention the requirement for an advisor/consultant that is able to assist the counties/clients in various processes including but not limited to negotiation, concept development, calculations. This assumption is further strengthened in the case of Skien municipality who required the assistance of a consultant. By taking these different examples into consideration, we conclude that the involvement of a third-party/consultant in EPC project is mainly required to accommodate the client, rather than playing the role of a mediator.

5.1.2 Transparency of information

Another critical difference observed between these cases is regarding transparency of information between the client and ESCO. As mentioned earlier, Trøndelag county authority has described their relationship with Skanska as a collaborative partnership during the development of Heimdal VGS. Skanska has shown willingness to contribute their assistance to matters which extend beyond what is included in the EPC agreement. An example of such an issue was given regarding the defrosting solution, which was a significant energy consuming practice. The ESCO is compensated for contributing to processes which are not included in the agreement. It should be mentioned that although this may be possible in the case of Heimdal VGS, not all ESCOs may show a willingness or simply be able to prioritize such initiatives. The representatives from Trøndelag county authority also mentioned the use of an Excel spreadsheet which lists the energy levels for different parts of the building. According to the representatives, the information available in this spreadsheet is entirely transparent for both the client and the ESCO. All changes or increases in energy consumption are shared with Skanska, to avoid any misunderstandings. The use of a similar Excel spreadsheet is also evident in several cases analysed from Doffin. A template for such a spreadsheet is shared in Appendix A.

The representative from the ESCO emphasised the preference of measuring energy levels based on implementations made, rather than comparing total energy consumption before and after project completion. It was pointed out that the ESCO is often blamed for increased energy consumption post-project, even though the implementations made are legitimate. As the increase in consumption can derive from numerous variables, it may be problematic to determine whether the implementations made by the ESCO have been successful, given if the energy levels are simply compared pre and post-project. As a consequence of this, certain building owners may take advantage of this situation, where increased consumption is not informed to the ESCO since the client can not always be held liable for this increase. This presents a risk factor for the ESCO, where the ESCO may face consequences for the actions made by the building owner. Disputes and challenges may become evident as a factor of limited dialogue and refraining from sharing important information, that may have further implications for the project. Therefore, the importance of transparency and

trust between both actors can clearly be understood from both cases. As mentioned earlier, the document analysis conducted found several files from different cases which included documents resembling Excel spreadsheet. As explained in the case for Heimdal VGS, and further mentioned in other cases from document analysis, complex energy monitoring systems are able to provide extensive results and levels at various points in buildings. Coupling this with tools such as an Excel spreadsheet, provides many enablers for monitoring and control energy levels accurately and easily. Therefore, we assume that the process of monitoring energy levels isn't particularly challenging by itself, however the interpretation of these levels can be problematic. The occurrence of unexpected events can require adjustments or changes to be made for the energy distribution in different buildings. An example of this was evident during the COVID-19 pandemic, where capacity in buildings was dramatically reduced. To ensure that making these changes/adjustments is possible, the system should responsive where feedback is evident and adjustments can be made.

5.1.3 Challenges evident from other EPC projects

Empirical data and information gathered from document analysis provides additional challenges connected to EPC. (EPC report 2019) explains how increasing use of provisions and deviation from the original NS6430:2014 standard was one of the major reasons for a decrease in interest for conducting EPC projects. Increased deviation from the standard can prove to be problematic as it is difficult to see the consequences of these decisions until after the project is in phase 3 [6]. The challenge of finding documentation and information for pre-existing buildings as explained by representatives from Trøndelag county authority is further supported by the Case 5 (Bergen municipality). The municipality has explained in their tender specification that documentation for pre-existing buildings may not be entirely complete. This challenge was also highlighted by the representatives from Trøndelag county authority, as lack of documentation can be evident for pre-existing buildings. In the report (Consultation report 2021) KS provides an explanation for why the interest in EPC projects has decreased over the last years, and what the main factors behind this decreasing trend is ESCOs failing to reach target levels, poor mapping processes are cited as factors that have lead to this reduction in participation [37]. (EPC report 2019) supports these claims and further lists a poor tender specification as a problematic element, which often lacks any specifications or requirements for quality. Furthermore, the report explains that the ESCO faces several risk-factors regarding uncertainty surrounding baseline measurements [6]. The findings from this section provides inspirations and insight into how the initial framework can be improved. The main challenges found from empirical data can be summarized in the following points:

- Since the third-party/consultant involved in previous EPC projects has mainly assisted the client in different processes, therefore this third-party's role can not be considered as a mediator.
- Lack of transparency and cooperation between project participants produces uncertainty surrounding project expectations and interpretation of results.
- Progressive use of deviations from original NS6430:2014 gives uncertainty and can lead to misunderstandings during the project.

5.2 Combining theoretical & empirical findings

As previous sections have looked at what challenges can be evident within EPC projects, this section will look at the opportunities and enablers that can reduce the challenges found. The findings are found by cross-checking various enablers from theoretical and empirical data. These main enablers are mainly related to increasing cooperation and transparency amongst both actors to reduce uncertainty and misunderstandings. Various other opportunities and enablers are further shared. These different factors are combined in the revised Figure 14, which takes inspiration from some of the findings from Section 3.3.3. Lastly, the third and final research question will be answered and further combined in a conceptual framework**RQ3: How can these challenges be reduced for future EPC projects?**

5.2.1 Importance of supplier selection

The role of supplier/ESCO selection is crucial for any EPC project, especially since the project can last over several years. This has implications for the participants and the project in general. As mentioned in (FME HighEFF 2021), developing a common understanding of a shared vision and understanding of the overall project between stakeholders is considered an important enabler for energy collaborations. This can be facilitated by having a collaborative interface with the supplier, as explained in Section 3.2.5. A change in relationship is evident with increased emphasis on creating a collaborative relationship, from which benefits can be attained [5]. This is also emphasised in the case of Heimdal VGS, where extensive focus was placed on the pre-qualification phase for ESCO selection, where numerous candidates were given financial support to develop concepts and tenders for the new Heimdal VGS. The representatives from Trøndelag county authority emphasised the importance of transparency between them and Skanska, where all changes & implementations are mutually shared. In addition to this, the information for various energy levels is available to both actors in an Excel spreadsheet. The need to develop an open collaborative and transparent relationship is clearly evident between the ESCO & the client, which can reduce misunderstandings and conflicts. This assumption is further strengthened by the statements by the representative from the ESCO, who explained how refraining from sharing information and changes has lead to misunderstandings and disputes, as mentioned in Section 5.1.2.

Several contractual documents found from the document analysis specify the need for previous EPC experience for project leaders/managers and the ESCO in general. The ESCO or workers are often asked to provide a reference of previous projects that they have participated in, either through EPC or other relating energy efficiency proceedings. This requirement has correlation with the concept of an accreditation system as explained in Section 3.3.2, which can be used to determine whether an ESCO has the necessary competence and resources to participate in a EPC project. The addition of this requirement provides an assurance for the client that the potential supplier has the necessary competency/know-how to complete a project with similar attributes. Although supplier selection may often place certain criterion's/requirements for the supplier the client can also take certain steps to increase the possibility for success. As mentioned in Section 3.2.1, a certain municipality size can be required to engage or interest an ESCO, considering project scale or competency may be required from the client. Furthermore, (EPC report 2019) also explained how one of the factors behind decreasing interest for EPC projects derived from smaller projects being offered. Examples are given where previous projects containing over 10 buildings were available, have been reduced

to projects containing only 3-4 buildings. These indications shows that larger scale projects are prioritized by the ESCO, as this provides more room for savings and economies of scale may be attainable. Projects that are small in scale can be pooled/bundled together, which in turn reduces transaction costs. [30].

Empirical research shows that the use of third-party has been more evident from the building owner/client's perspective, rather than as a mediator or M&V specialist. As evident during the case for Heimdal VGS energy consultants and advisors were involved in this project, however their role consisted of assisting the client in various procedures. Attending meetings, discussing solutions, controlling calculations were some of the tasks and responsibilities during this project. Similarly, Section 4.4.1 describes examples of cases for Alta municipality & BaneNor SF, where similar roles were required by these organisations. This confirms our assumption that the role of a consultant or third-party is mainly needed to assist the client/building owner in EPC procedures. Therefore, the role described as a mediator between both actors may not be suited for this consultant/third-party.

5.2.2 Standards and contracts

The importance of developing standards and other relevant documents for EPC cannot be underestimated. The contribution made by various organisations to develop templates, frameworks and other documents for EPC has been an important enabler for projects in Norway, as they are able to map and guide different processes. The use of Norwegian standard NS6430:2014 is evident in all the cases analysed for this thesis. Even though the cases analysed from Doffin are conducted using the the general EPC standard NS6430:2014, certain changes or provisions are often included. As Case 5 (Bergen municipality) points out, certain provision were included in the contracts which contained information regarding involvement of interns/trainees for the project. What specific provisions are included often varies for each case. To increase the interest for participating in EPC projects, new templates and EPC documents were released by the project group (WSP Global, Linkon AS, Caverion ESCO, Enova), as mentioned earlier in Section 4.3.1. These new updated documents were developed to increase the interest in EPC, while minimizing challenges and risk-factors found from previous projects. These templates have also an increased focus on transparency and conducting processes in a 'open-book' principle. The templates aim to solve many of the challenges that have been identified from various sources throughout this thesis. Cooperation between client and the ESCO in phase 1 of the Figure 12 supports the other theories which requires increased collaboration and transparency. However, references of projects utilizing these new documents and templates is needed to determine the impact these developments have had. As the market for EPC will continue to develop over the time, it should remain a priority to adapt templates and regulations according to current market trends.

5.2.3 Optimization & post-project changes

In certain cases the actual energy level can vary significantly for a building or a specific segment, and therefore changes or adjustments may be necessary. When implementing changes and new technologies it is vital to have a predetermined understanding between all participants concerning who will be financially responsible for financial cost for implementing these changes. An example of such a case was given by Trøndelag county authority, when a de-frosting solution was earlier installed. The ESCO for the project; Skanska, contributed to reducing this problem, even though

this solution was not a part of the EPC contractual agreements. It was mentioned by the representatives from Trøndelag county authority that the county authority were responsible for the investment required and the ESCO was further compensated for this task. If there exists a lack of mutual understanding regarding the interpretation of energy levels, disputes may occur between participants. The actors may refrain from taking responsibility, which then causes uncertainty for the project. According to the representative from the ESCO this has earlier been evident in previous cases where reaching target levels may be complicated, due to the client increasing energy consumption at their facility, and further being blamed by the client for not reaching target levels. Therefore, the need and importance of a collaborative cooperation between the ESCO and client is considered vital in EPC projects. This further strengthens the argument to adapt the new contract frameworks developed Section 4.3.1

(EPC report 2019) mentions that limited input from client during the project, can pose a potential challenge with EPC projects [6]. The benefit of including operation & maintenance workers early into EPC proceedings is further highlighted in (FME HighEFF 2021), as an enabler to reduce resistance [25]. Situations where operating time is not accurate may be avoided, as mentioned in Section 4.2.2. Considering these workers are responsible for the daily operations of a building, their presence in vital decisions and meetings seems sensible. This claim is further supported by the representatives from Trøndelag county authority. By gaining better insight into how different technologies and implementations can be utilized, these workers are better able to operate the building more efficiently. The need for a responsive system, where adjustments and changes could be made was especially evident during COVID-19 pandemic, when the capacity and attendance was significantly reduced. The representatives further explained that meetings conducted post-project should also have an emphasis on adjustments and fine-tuning of equipment, in addition to evaluating performance and presenting energy levels.

5.3 Revised framework

After identifying the various challenges associated with EPC projects from theoretical and empirical sources, various enablers are found that can help mitigate these challenges. The revised framework takes inspiration from the initial framework, which is developed around the four processes during an EPC project. The initial framework identified a third-party organisation that would work as a mediator between both participants, to reduce imbalance of information and uncertainty for M&V processes. However as mentioned earlier, since the assistance of a third-party/consultant is usually only required by the client, the role as a mediator may not be viable. The early phases of the project can benefit by having an increased emphasis on cooperation and transparency between both actors. In addition to this, feedback and responsiveness are vital elements for maximising potential savings. The revised framework has several linkages and similarities to to the purchasing process model developed by van Weele Figure 7. These various enablers are combined in this revised framework, which aims to answer the third research question: **RQ3: How can these challenges be reduced for future EPC projects?**

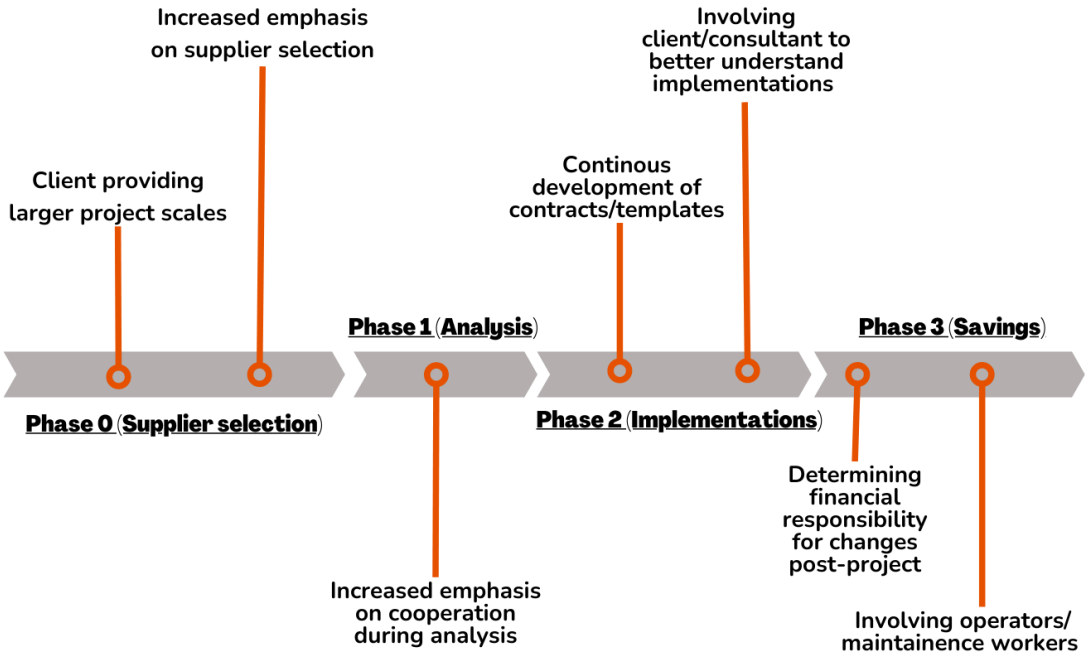

Figure 14: Revised framework

6 Conclusion

This master's thesis has aimed to provide an understanding of the field of EPC from a public procurement perspective, and the challenges and opportunities that are evident within. EPC projects can be seen as an important tool in enabling public entities and larger corporations to engage in energy efficiency projects, which increases their sustainable contribution. However, empirical indications and a decreasing interest in recent years point to challenges and risk-factors evident in these projects. As there still exists significant potential for energy efficiency and sustainable contribution through EPC proceedings, necessary steps should be taken to mitigate these challenges. To find these different challenges and enablers for EPC data has been gathered through theoretical and empirical sources. The challenges and opportunities identified are found from cross-checking theoretical and empirical findings. The main challenges identified are related to the interpretation of energy levels, where a lack of transparency between the actors and poor mapping processes create complexities & challenges for the projects. Furthermore, smaller project sizes/scale provide lower incentives and potential for savings for ESCOs, which may be the reason why ESCOs prioritize larger projects that allows economies of scale. Lastly, deviations from the original NS6430:2014 standard are other factors that increase the challenges for EPC. Although, certain deviations may be necessary to adapt agreements according to project ambitions and targets, progressively increasing changes from the original standard can lead to misunderstanding of responsibility and interpretation of savings.

As there still exists significant potential for energy efficiency and sustainable contribution through EPC proceedings, necessary steps should be taken to mitigate these challenges. To reduce the challenges found, several opportunities and enablers are suggested. These enablers are described according to the different processes that occur during EPC projects. For the initial phases of the project, an increased emphasis should be placed on finding partners with a shared understanding of project and expectations, where a interactive/translative supplier interface can facilitator. Theoretical findings regarding supplier selection in GPP literature shows several correlations for this statement. This concept is further supported by the new contract documents and frameworks launched (Section 5.2.2), which emphasises the need for increased cooperation between client and the ESCO. Continuous development of contract agreements and other documents is considered essential, to ensure that these documents are updated with the current trends and market developments in EPC market. Lastly, as unexpected events/situations are bound to arise, responsiveness and feedback in the system should be evident as changes adjustments are needed. This was especially evident during the COVID-19 pandemic, which caused a significant reduction for capacity in buildings. Inclusion of building operators/maintenance workers is seen as a beneficial inclusion, as increased understanding and competency of the project enables these workers to operate the building more efficiently. These different opportunities and suggestions are further combined in a conceptual framework, which lists these various enablers according to the four phases that occurs during an EPC project. The suggestions shared take inspiration from GPP concepts, to reduce the challenges associated with EPC. Reducing these challenges may lead to increase uptake of EPC and other energy-saving projects for the building sector, which is considered necessary towards a sustainable transition.

Further work

To further evaluate the conceptual framework developed, this framework should be trialed in new case studies. Considering this thesis has mainly studied EPC from a public procurement aspect in Norway, a generalized consensus may be difficult to generate. More research is needed on this subject to confirm whether the findings in this thesis can bed validated for several cases, or only limited to the cases analysed in this thesis. Therefore, conducting new case studies in different regions/context may either validate the findings of this thesis or influence/change the findings. The limitations mentioned earlier in Section 2.3.2 should be taken into account when conducting these new case studies. As the market for EPC is continuously developing, case studies completed in the future may find new answers and discoveries, that are not necessarily evident currently. This can also be applied to the research articles and theory that has been studied in this thesis. As older articles may mention details and information which may not be entirely relevant for future studies, it is vital that more research is conducted on this topic to guide future studies. This has similarities to the methodology chosen for this thesis, where new observations/findings influence the framework developed.

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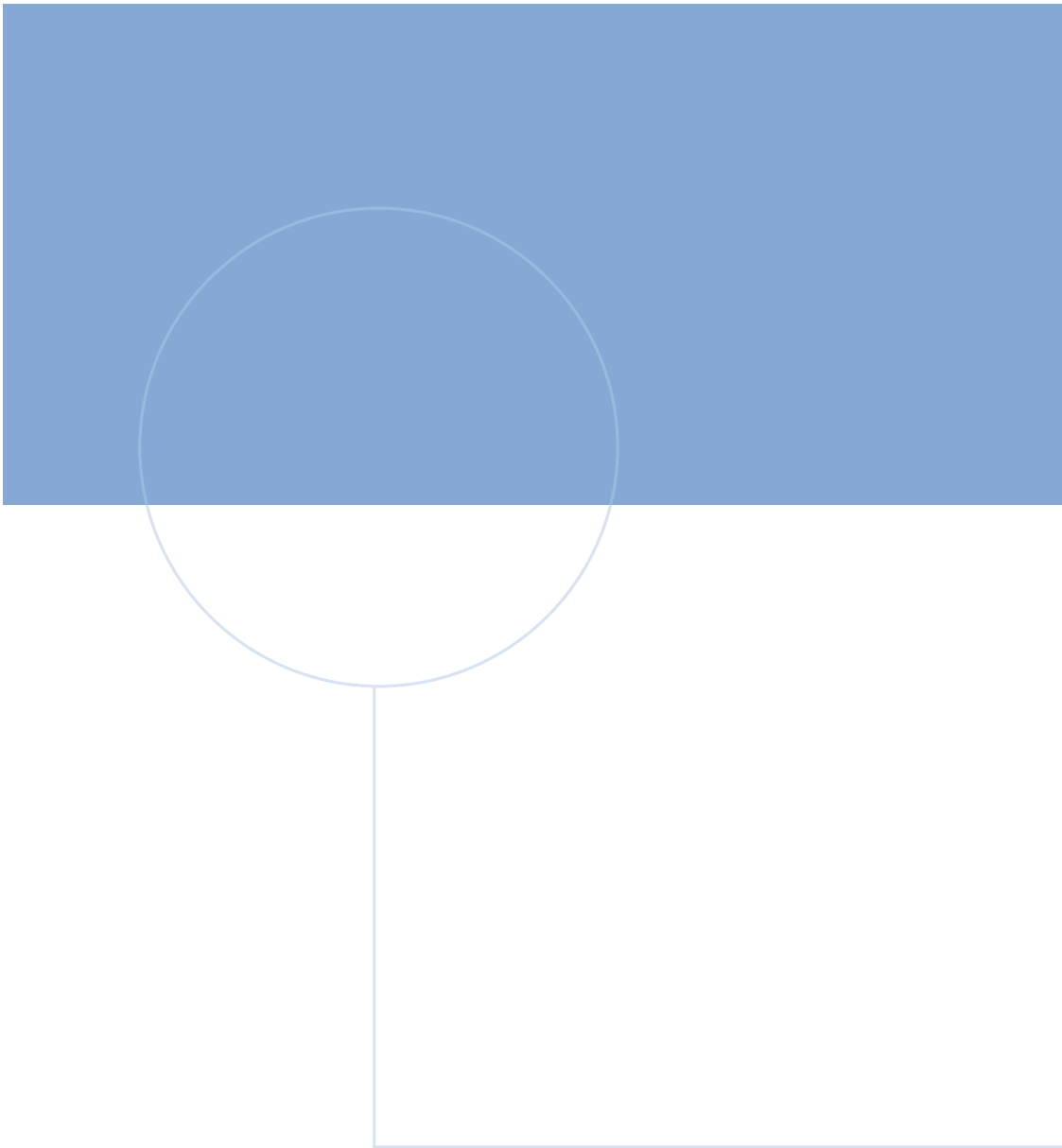
A Appendix

This thesis includes four attachments that are part of the appendix. These attachments are included as a separate ZIP file.

1. Interview guide sent to Trøndelag county authority for the interview sessions.
2. Building statistics for 2017 provided by Enova, which explains passive house energy requirements for various building types.
3. Report by KS, detailing various contract documents and frameworks it has provided to facilitate EPC proceedings.
4. Template for Excel spreadsheet used for monitoring energy levels (found from Doffin).



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