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Identifying and Overcoming Inefficiencies in Substation Integration Project Execution

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ABSTRACT:
This thesis is written to address causes of inefficiencies and how to overcome such in small substation integration projects. This thesis investigates 29 small projects, which are comparable to small wind farm projects by their size and scope of supply. In addition to these, typical project key figures such as change in sales price, change of gross profit margin are studied against sold and booked hours. The relationships of these figures were also studied. Additionally, a complexity approach has been also considered by assessing a complexity factor rating based on scope of supply, project size and sold hours. The goal of these approaches was to evaluate whether there are relationships or correlation between these figures and use the results on reflecting the results of findings against those. The main theme of this thesis is the evaluation of hours. Additionally, the contribution of different functions for these types of projects is reviewed. This approach enabled the possibility to study the causes of inefficiencies of the projects.

This thesis was a mixture of a case study, qualitative research, and quantitative research. This thesis utilized both, quantitative with qualitative methods together, and had a case study type of approach throughout the thesis. This was due to a relatively small sample size combined with the nature of this study. An extensive literature review was conducted to study different perspectives of project management and which type of differences there potentially occurs in the project management literature. It showed that there is a lack of consensus in few topics, which required critical evaluation before drawing any conclusions. However, it showed that while reviewing project management literature, it is important to be aware of the context before. The literature review was a key in preparing managerial implications, which are presented at the end of this thesis.

This thesis shows that there are consistent and recurring inefficiencies in studied projects. The results of this thesis also proves that projects which had significant overruns in budgeted hours on average performed poorly. Additionally, those projects where actual hours stayed within sold hours performed generally well, and it was not unusual to these projects to ultimately improve their original gross profit margin. Interestingly, this is a contradicting finding to the results from performed chi-squared test and Fisher's exact test which proves that there is no relationship between hour overruns and gross profit margin change as such.

In conclusion, this thesis did not find a distinct method how to detect possible future inefficiencies during the remainder of the project. This is due to the evident fact that it is impossible to predict the future. However, this thesis found methods and practices which are apt to minimize the risk of such occurring. Whereas it is not possible to detect that an inefficiency is about to occur with certainty, there are factors which by identifying are possible to mitigate.

KEYWORDS: project management, inefficiency, project performance, small projects, time overruns, project phases.

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TIIVISTELMÄ:

Tämä diplomityö keskittyy pieniin sähköasemaprojekteihin, tutkien projektitoteutuksen aikana mahdollisesti ilmeneviä epätehokkuuksia, sekä syitä niiden ilmenemiselle että työkaluja niiden ratkaisemiseksi. Työssä tutkitaan 29 toimeksiantajan mittapuulla pientä projektia, jotka ovat kooltaan ja toimituslaajuudeltaan verrattavissa tyypillisiin pieniin tuulivoimaprojekteihin. Lisäksi työssä tarkastellaan tyypillisiä projektin avainlukuja, kuten myyntihinnan ja bruttokateprosentin muutoksia suhteessa myytyihin ja kirjattuihin tunteihin sekä tutkitaan näiden välisiä suhteita. Kompleksisuus on myös otettu huomioon arvioimalla projekteille kompleksisuustekijä, joka perustuu toimituslaajuuteen, projektin kokoon ja myytyihin tunteihin. Näiden lähestymistapojen tavoitteena oli arvioida, onko näiden lukujen välillä yhteyksiä ja peilata löydöksiä niitä vasten. Yksi työn pääteemoista on tuntien tutkiminen monesta eri näkökulmasta.

Tämä työ on yhdistelmä osallistuvaa tapaustutkimusta, kvalitatiivista tutkimusta sekä kvantitatiivista tutkimusta. Tämänkaltainen lähestymistapa valittiin suhteellisen pienestä otoskoosta ja tutkimuksen luonteesta johtuen. Laaja kirjallisuuskatsaus suoritettiin projektinhallinnan eri näkökulmien ja potentiaalisten eroavaisuuksien tarkastelemiseksi. Tulokset osoittivat, että projektinhallintakirjallisuudesta konsensus on vaikea tunnistaa, mikä vaati kriittistä arviointia ennen johtopäätösten arviointia. Kirjallisuuskatsaus oli avainasemassa johtopäätösten ja suositusten valmistelussa, jotka esitellään tämän työn lopussa.

Työ osoittaa, että tutkituissa projekteissa on jatkuvia ja toistuvia tehottomuuksia. Se myös todistaa, että ne projektit, joissa budjetoitu tuntimäärä ylittyi merkittävästi, suoriutuivat keskimäärin huonosti. Toisaalta projektit, joissa kirjatut tunnit pysyivät myytyjen tuntien rajoissa, suoriutuivat yleisesti ottaen hyvin, ja ei ollut epätavallista että näiden projektien bruttokateprosentti parani. Tämä on toisaalta pienessä ristiriidassa kahden hypoteesitestin - khiin neliö sekä Fisherin tarkan testin - tulosten kanssa, jotka puolestaan osoittavat, ettei tuntiylijäämien ja bruttokateprosentin muutoksen välillä ole suoraa yhteyttä.

Yhteenvetona diplomityössä ei tunnistettu selkeää vedenpitävää menetelmää, joilla olisi mahdollista tunnistaa tulevia tehottomuuksia projektitoteutuksen aikana. Työssä löydettiin kuitenkin menetelmiä ja käytäntöjä, jotka ovat omiaan minimoimaan tällaisten riskien toteutumista. Vaikka tehottomuuden tulevaa ilmenemistä ei voida varmuudella havaita, on olemassa tekijöitä, jotka tunnistamalla voidaan riskiä tehottomuuksien ilmenemisestä lieventää.

KEYWORDS: project management, inefficiency, project performance, small projects, time overruns, project phases.

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Abbreviations

CB	Circuit Breaker
CE	Civil Engineer / Engineering
CSF	Critical Success Factor
Doc	Document Controller / Controlling
DSO	Distribution System Operator
GP(-%)	Gross Profit (Margin)
HV	High Voltage
KPI	Key Performance Indicator
MV	Medium Voltage
PAC	Provisional Acceptance Certificate
PGGI	Hitachi Energy’s Power Grid – Grid Integration unit
PE	Primary Engineer / Engineering
PC	Project Controller / Controlling

P&L	Procurement & Logistics
PM	Project Manager / Management
PMI	Project Management Institute
PMBOK	Project Management Body of Knowledge
PP	Project Planner / Planning
SE	Secondary & System Engineer / Engineering
Site	Installation, Commissioning and Site Management
SP	Sales Price
TSO	Transmission System Operator
VL	Voltage Level

1 Introduction

1.1 Background of the study

The demand for this thesis initiated from client's review of their project portfolio's smaller size projects which seemed to not to be executed as well as anticipated. Client thus assumed that they might have inefficiencies, which they presume to appear due to a heavy structure and project organization. Client thus recognized a need for a study to detect in which phase of the project these presumed inefficiencies might lie, reasons for such and a solution to overcome such inefficiencies. There is also demand for an examination whether there are any convenient enhancement practices which could be implemented to their projects from project management literature and historical studies related to project execution.

A smaller size project in this context relates to a project which is under 2 million US dollars by its sales price. The vast majority of these types of projects are for wind power clients or a distribution system operator client.

1.2 Purpose and scope of the research

A project in general includes project management, engineering, procurement, logistics and in most cases, site works. Within the scope of this paper the projects naturally vary to some extent, but the sample size of and project selections are designed to be comparable to each other in order to find valid and comparable results. The core idea is to have similar enough projects in terms of their scopes of supply which enables the investigation of where presumed inefficiencies lie. This paper tries to identify whether there are in fact inefficiencies in the projects selected for this paper, provide tools how to prevent those from occurring and ultimately present recommendations how to overcome such.

A project timeline wise is considered in this paper starting from the date when sales teams handed over the project for project execution team, and ending for a *provisional acceptance certificate signature* date, also referred as *PAC*-date. PAC date is the point when warranty period for the delivery starts.

1.3 Problem statement and hypotheses

The problem that this study addresses is presumed high occurrence of inefficiencies during project execution phase regarding small projects. Client suspects that there might exist unknown inefficiencies which requires identification in order to enhance their small project execution performance across the business unit. The goal of this thesis is to provide answers and solutions for it by conducting a study with a labour-based approach.

Potential reasons might be design and engineering errors, non-lean processes, heavy project team structure, overuse or inapplicable use of high effort demanding project planning and risk management tools. The client's perspective to the definition of an inefficiency is not precise yet is related to excessive and unwanted usage of hours, time management, communication and the distribution of responsibilities and tasks which ultimately might lead to time and budget overruns and thus affect the project performance.

This study focuses on projects which falls into the category of small projects. Large projects can employ certain functions fulltime whereas small projects are a fraction of that, which means that one must make more out of a dedicated hour in small project compared to a large project. In other words, the use of hours might be more carefully used compared to large projects.

Since sample projects do not differ significantly by basic characteristics, the assumption is that possible overruns in hours is most likely due to changes in the scope during the project execution or notable and unforeseen challenges which eventually leads to higher workload what was initially anticipated.

One hypothesis is that if total hours have exceeded the sold hours by a fair margin the project is most likely to result in a negative gross profit. Another hypothesis is that if Secondary & System Engineering hours have gone over, the paper presumes that the hours will go over as well across the functions, meaning that Secondary Engineering has a heavy impact on all functions. This hypothesis bases on the fact that Secondary Engineering is likely to be the biggest contributor to project's success in terms of the use of project hours. Additionally, if there are overruns in Secondary or Primary Engineering in certain phase of the project, it might be a signal that there have been some unforeseen problems during the project which might have had a pivotal effect on the whole project such as a sudden change of scope of supply.

One suggestion for a mitigation practice on how to overcome labor related inefficiencies is by scaling down the utilization of many different functions by centralizing tasks and responsibilities to a smaller project organization, potentially even to one person, could potentially enhance the performance of these types of projects.

1.4 Research questions

The main research questions of this thesis are:

- Is it possible detect inefficiencies in small substation projects during their execution?
- Are there consistent or recurring inefficiencies in these types of projects?
- What are the causes of inefficiencies in poorly performing small projects?

Other research questions are:

- Can efficiency be enhanced by centralizing tasks and responsibilities to a smaller project team?
- How does general and administrative tasks such as meeting and reporting protocols affect the project performance?
- How does project size, scope, duration, and complexity affect the project financial performance?

- How budgeted hours have been typically met in sample projects?
- What are the typical reasons for hour overruns?
- Which functions contributes most to project performance?
- Which project phases are most crucial?
- How do projects, which have significant hour overruns compared to projects which have stayed within the budget, perform?
- Is there a relationship between hour overruns and gross profit margin change?
- What are the best practices from existing literature which client could utilize in their project execution to enhance their processes?

1.5 Objectives and significance of the study

The objectives of this thesis are from comparable set of projects to gather information about factors which affect project performance and conduct a study which answers to the research questions. The set of projects are examples of important base orders for PGGI unit where the competition is high and there is increasing pressure to execute projects as efficiently as possible. The key focus of this thesis is to identify whether there are some detectable inefficiencies which could be mitigated in early staged, harming as little as possible the project outcome. The journey to ultimately answering the research questions, this study will provide charts, graphs, and tables from unutilized information, which is likely to act as a stimulus for a constructive discussion for the project management organization.

This study may provide valuable information which could serve as a basis to change business processes and ultimately reduce or eradicate possible inefficiencies. As these types of small projects tend to fly under the radar, this study has potential to raise up and illustrate information which might have not been realized and utilized yet. It is reasonable for an organization to have a focus on larger projects as the risk of smaller projects to significantly harm the whole organization’s performance is limited comparing to larger projects. However, if organisation is able to prevent consistent inefficiencies from occurring, it is likely that the performance of the organization or unit enhances. On the contrary, if any consistent inefficiencies lie without being noticed, it is a continuous unidentified burden to the organization. Thus, this study has potential to provide an outcome which can be utilized to enhance the performance of the client organization long-term.

1.6 Justification for selected approach

To reach the objectives of this study, a rather pragmatic approach was selected by utilizing both quantitative and qualitative research methods by following the practices of a mixed methods research (Johnson & Onwuegbuzie, 2007). As the key objectives of this paper can be to some extent rather abstract matters (such as defining inefficiency in projects), utilizing only either quantitative or qualitative methods the objectives would not be easily reached and additionally would leave space for false interpretations as every project is unique by their nature. The need for selected approach lies in the fact that in order to reach these objectives, it is necessary utilize qualitative methods in addition to quantitative methods.

The key data collection and visualization, the structure of this paper, were done by following traditional quantitative research method practices. Since quantitative research practices forms this paper’s structure, this study can be defined in a similar manner as by Johnson & Onquegbuzie’s (2007) defines quantitative dominant mixed method research:

> *«Quantitative dominant mixed methods research is the type of mixed research in which one relies on a quantitative, postpositivist view of the research process, while concurrently recognizing that the addition of qualitative data and approaches are likely to benefit most research projects.»*

As the number of projects is low for a justified and valid quantitative research, yet high for traditional qualitative research, utilizing the best practices of each method is suitable for this type of research. The most contributing factors for the decision of selected approach are:

- Sample projects are unique by nature and thus requires a tailored approach.
- The amount of sample projects is relatively low.
- Project's financial result is not determined by labour effort, yet most likely affects to some extent.
- Sample projects have different clients, technical requirements, and scopes of supply.
- Presumably there does not occur inefficiencies in every sample project, which highlights the demand for more individual approach instead of quantitative approach.

The selected approach and the process of used mixed methods research practices in this paper are explained below. Qualitative methods were used in the beginning of this study in data sampling and later used in analysing and discussing the findings of this paper. The sampling of studied projects followed the original scope, which included projects smaller than 2 M USD project by sales price, which were fairly similar in terms of their scope of supply. As a rough reference the intention was to study projects which within the scope and in overall design and execution resembles typical wind farm projects. To clarify, sample projects include other client segments, meaning that studied projects were not limited to wind farm solutions only, but had in general similar characteristics as such.

Quantitative methods were the backbone of this study. It was utilized for data collection and visualization. Traditional quantitative methods were applied in gathering, filtering, and calculating the data such as as-sold figures, as-sold and booked hours, phasing project durations into different phases. This method provided an easy-to-approach and straightforward numbers and figures of each project and were thus easy to visualize. This formed the structure of this paper as the preliminary results of the data collection and visualization illustrates differences in the projects, which guided the research further.

Once the sample data was collected and visualized, the next step was to review the results and conduct the study further by focusing on the most differentiating projects to find out reasons behind the differentiating results comparing to other projects.

1.7 Company introduction

This thesis is made for Hitachi Energy Finland Oy. The Finnish unit of Hitachi Energy manufactures, designs, supplies and maintains transformers and reactors, provides power grid management guidance, builds automation and control systems, and executes projects in transmission and distribution network solutions as well as substations for energy and electricity companies, industry, transport, and infrastructure (Hitachi Energy, 2023). Hitachi Energy Finland has four units: Grid Automation, Grid Integration, Transformers and Functions & Services. The four units employed altogether over 500 employees in financial year 2022, and generated revenue of 214 million euros (Asiakastieto, 2023).

This thesis is made for the Grid Integration unit (PGGI), which offers among others i.e., air insulated (AIS) and gas insulated (GIS) substations, FACTS-systems, power quality enhancement solutions, turnkey and partial deliveries, maintenance and consulting services for substations and critical electricity distribution. Typical clients for the Finnish PGGI unit are major national transmission (TSO) and distribution system operators (DSO), wind farm developers and contractors and industrial and utility clients such as various factory and data center operators.

The approach of this thesis concerns the usual and well-known project constraints of meeting time, cost and scope requirements. This is due to the nature of the projects, which are directly tied to contracts. A typical project delivery is tied to project requirements and specifications, where a project needs to be delivered in an agreed time. If the pre-defined time and/or quality requirements are not met, the client is justified for a pre-determined fine payment. This is the basis for the selected approach. Projects are without exception fixed price contracts, which means that there are certain number of hours to complete a project. To put it another way, these projects cannot charge based on actual hours and material required, moreover, the budgeted hours must be sufficient to cover the costs. In general, the estimated number of hours bases on the best available current information which is expected to be sufficient for project completion.

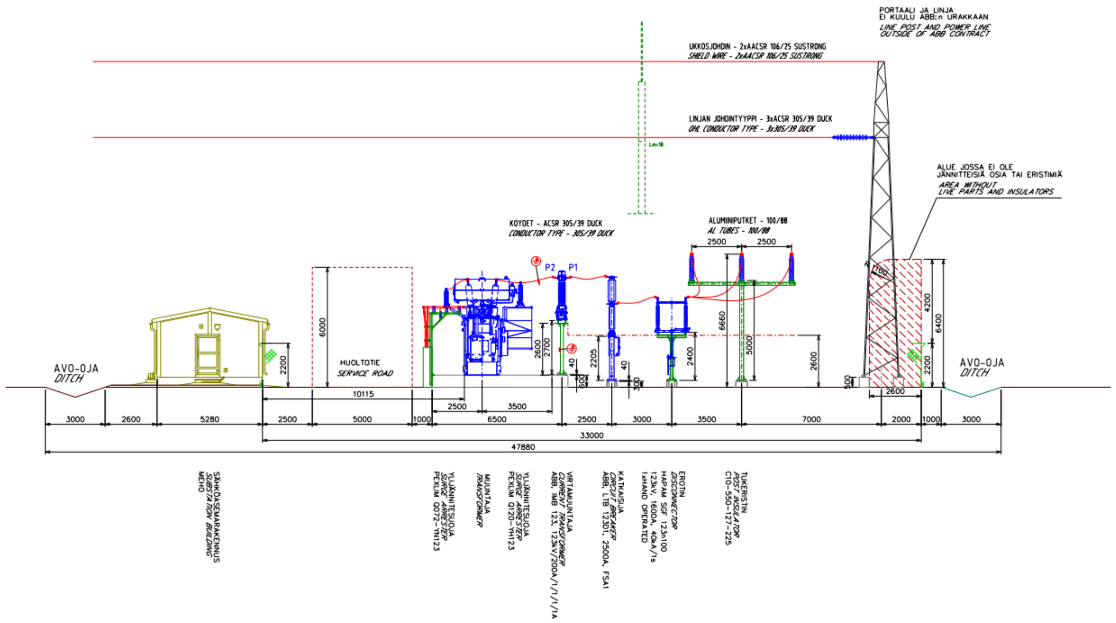


Image 1. Example of a project section drawing (Project 18)

To further set up the background for this thesis, a distribution of client's under 10 M USD projects from recent years can be seen in figure 1. It shows that the majority of projects are small (under 2,5 M USD), and thus amount-wise contributes the most. However, it is worth noting that the sum of the rest of the projects (2,4 to 10 M USD; 41 projects) are higher than the amount of the first basket (0,5 to 2,4 M USD), which indicates that sales-wise the contribution of small projects is limited compared to rest of the projects.

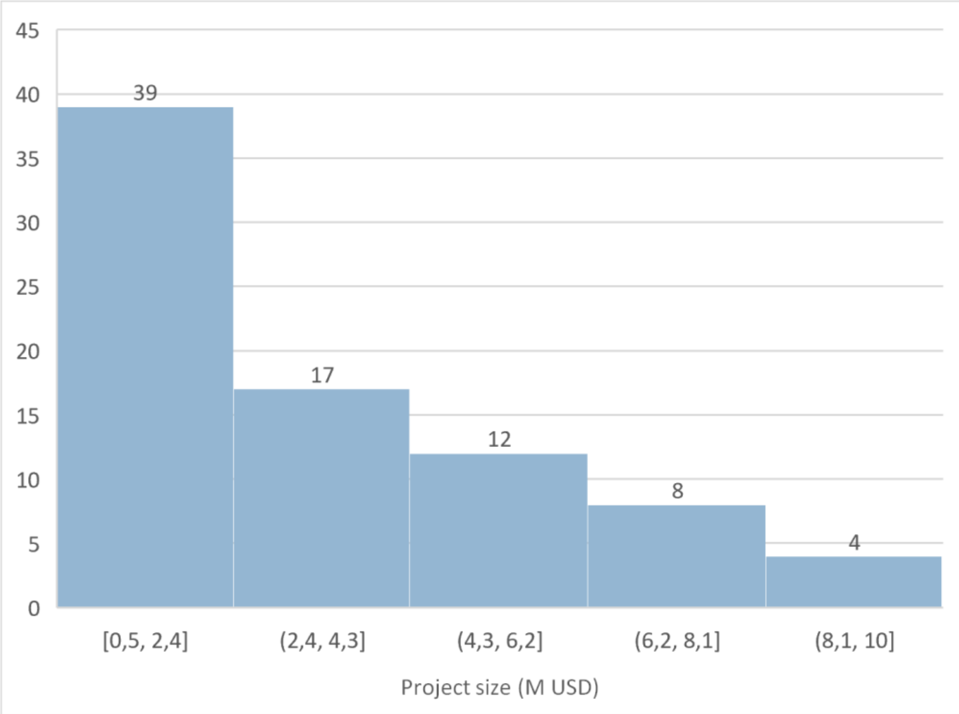


Figure 1. Distribution of client's projects from recent years (under 10 M USD)

In big picture, the scopes of small and large projects are roughly speaking not too different from one another. However, the size of project can vary greatly. Rough examples of typical differences and similarities of can be seen in table 1. Typically, project phases and overall progress follows similar pattern regardless of project size. Additionally, typically all functions contribute to a project regardless of which project is in question. The amount of contribution however varies greatly.

Table 1. Typical differences and similarities of client's projects

Typical differences	Typical similarities
Scope (i.e., number of substations, number of components, high voltage equipment)	Phases (design, procurement, installation, commissioning)
Location	Client
Amount of labour (due to larger or more complex scope)	Number of functions (teams) involved
Duration (1,5 to 4 years)	

More information regarding projects and project phases can be found in chapter 3.3.1. and 3.3.2.

2 Literature review

The purpose of this literature review is to provide a preview and framework for the reader about the type of research in question, establish the context for interpreting the results of the work, give examples of factors that influence project performance, offer the reader an understanding of what different stakeholders consider in a project, and present the general understanding and consensus prevailing in project management literature.

2.1 Defining success

There are three constraints which measures success, those being time, cost, and performance (Kerzner, 2017). These are also referred as the triple constraint triangle or the iron triangle. This triangle is considered as the basis of project management success since the starting points of project management research. However, even though these three attributes have had an important role and most likely will continue to have in the future, there are also other matters which should be considered in addition to the three established constraints. Even though cost, time and quality constraints would be met, the project might still be considered as a failure if there is no market demand for the product or service, the customer needs are not met, the deliverables lacks quality resulting in a unhappy customer, benefits of the business case were not met, the resulting financial value expected from the benefits was less than expected (Kerzner, 2017). Kerzner's findings shows that there is no unambiguous method to define project success as there are many other approaches in addition to the usual time, cost and quality, which can be utilized in defining whether a project has been successful or not.

Kerzner (2017) states also that the two metrics that takes two most attention and that needs continuous supervision are solely time and cost. What comes to project management, Kerzner's sees that the project management achieves its goal when it creates a continuous stream of successes within the project. The successes are not reality until agreed metrics which measures successes have been met. Simply put, to determine where a project can be considered as successful or not, there must be goals and objectives set before the start of the project. There must be something to reflect on. To put in another way, project success is dependent on its goals and objectives. This stresses the importance of goal setting process quality.

Shenhar (1998) has 4 measures for determining project success: meeting functional specifications, meeting technical specifications, meeting schedule, meeting planned budget. Hyväri (2006) on the other hand states that the project management literature lacks a clear and comprehensive definition of project success. Similarly, the term "failure" is often imprecise and poorly defined both in practice and in the literature, lacking substantial meaning. This illustrates well that the project success is not self-explanatory, and gives an example that project success can be defined only if there are defined goals and targets before the project start.

Hyväri (2006) suggests that there is a need for further research focusing on the connection between critical success factors and measurement techniques, as well as the human elements within project management. Furthermore, the author emphasizes the importance of directing increased research efforts towards studying the behavioral and organizational factors associated with project management. Hyväri's humane approach is unusual in project management literature. The humane approach in project management literature is yet to gain popularity among current project management literature.

In the study conducted by Hyväri (2006), it was found that the critical factors associated with project team members align with those identified by Belassi and Tukel (1996), which include communication, commitment, and technical background. Additionally, the study also identified critical factors pertaining to the environment, namely the client, technological environment, and economic environment, which were considered influential in determining project success or failure.

Dvir et al (2003) highlight the importance of project planning, stakeholder involvement, team experience, technical complexity, and client involvement in determining the success of a project. The authors found that project planning is a critical factor in determining project success. Better planning is associated with higher levels of project success. Authors suggest that involving key stakeholders in the planning process can improve the quality of project planning and increase the chances of project success.

According to White and Fortune's (2002) study, the key findings from respondents (236 project managers) indicated that clear goals/objectives, support from senior management, and adequate funds/resources were the most frequently mentioned critical success factors (CSFs). The research concludes that project team communication is a crucial CSF for larger companies, whereas the sufficiency of funds/resources is more critical for smaller companies. (Hyväri, 2006).

According to Hyväri (2006), the interviews conducted in her study indicate that the success or failure of a project is determined by the talent and experience of project management which aligns with Belassi and Tukel’s (1996) findings which identified commitment, coordination ability, and effective leadership as critical factors related to project management. A project manager who lacks talent and experience is not likely to be an effective leader or to be able to coordinate adequately.

A Hyväri’s (2006) survey on leadership ability found that good communication, motivation, and decisiveness were the top three characteristics of an effective project manager, followed by leadership by example, visionary thinking, and technical competence. These findings align with the study by Zimmerer and Yasin (1998) reviewed by Hyväri (2006), which highlighted leadership by example, visionary thinking, and technical competence as the most important factors in project management. Notably, managerial skills accounted for the majority of identified characteristics, with technical competence ranking sixth in this study compared to its previous ranking of third. Hyväri’s study underscores the significance of commitment, coordination ability, effective leadership, good communication, motivation, decisiveness, leadership by example, visionary thinking, and technical competence as critical factors in effective project management (Hyväri, 2006). Hyväri emphasized the importance of the project manager's overall project management ability and indicated that if project manager lacks ability to run a project, it is likely that the project performs poorly. Conversely to Dvir et al's (2003) finding where planning is the most important aspect of a project, Hyväri's study does not find planning to be as important.

Jani et al. (2012) conducted a study to examine the differences in opinions regarding the major factors influencing the successful completion of a project between the construction developer, and the contractor regarding construction industry. Despite Jani et al's (2012) study regards construction business, it does have many similarities to the scope of this thesis, which justifies its review. Jani at al's (2012) analysis revealed that the developer identified six sub-scales in order of priority that influenced project success: contractor's management problem, labor problem and experience, sub-contractor's problem, contractor's financial problem, machineries and material problem, and weather condition. On the other hand, the contractor's concerns were grouped into five subscales: contractor's financial status, material delivery, contractor's management skill and experience, labor, and availability of machineries.

Jani et al's (2012) findings highlight the varying perspectives of the project developer, usually the client, and the contractor on the factors contributing to project success. Thus, it is important to ensure that all stakeholders are on the same page and does have a consensus of how the project will be executed. This requires clear communication between all stakeholders. If stakeholders have significantly different perspectives of the project, it increases the risk of scope changes, especially if the contract or project requirements are poorly defined.

2.2 Defining efficiency

Sundqvist et al (2014) studied project efficiency in their paper and found out that the terms efficiency and effectiveness lack clear standards and is often used improperly without firm measures to follow. Streamlined interpretation of project efficiency would help project organizations. They state that in the field of project management efficiency as a concept and a term are often used yet seldom defined. However, the field of quality management differs – in quality management the concepts are used more appropriately. In quality management the term efficiency translates to perform tasks in the most convenient way given the current available resources (Sundqvist et al, 2014).

Sundqvist et al (2014) separates the terms efficiency and effectiveness in quality management by describing efficiency as a result of applying internal processes and effectiveness as customer satisfaction processes. Thus, the level of efficiency refers to the earned quality of an applied process which returns i.e. low unit costs and low cost of poor quality and the level of effectiveness is defined when the results, process outputs, achieves customer requirements. Whereas Sundqvist et al's (2014) definitions of efficiency and effectiveness are valid and exceptional in project management literature, this thesis paper approaches efficiency in a more traditional manner and does not measure effectiveness as per Sundqvist et al's (2014) principles.

Sundqvist et al (2014) finds that the literature in the field of project management includes discussion about efficiency and effectiveness, yet the use is often limited and typically hovers around executing certain activities. Their study highlights that due to time constraints and high workload, project focus tends to prioritize meeting time, cost, and scope requirements, leaving little room to consider alternative and potentially more effective approaches. Time constraints and high workload impact project focus, emphasizing the importance of meeting time, cost, and scope requirements (Sundqvist et al., 2014). Although Sundqvist et al (2014) presents alternative approaches, the approach of this thesis is based on the latter – meeting time, cost and scope requirements due to the nature of the projects.

Sundqvist et al (2014) emphasizes the significance of "doing things right the first time" in project management. They also find effectiveness in project management being defined as maximizing the utilization of allocated resources (Sundqvist et al., 2014).

According to Sundqvist et al. (2014), the current emphasis on measuring project performance primarily revolves around time and cost, restricting project departments to meet specific time and cost requirements for individual projects. The authors suggest that introducing new performance indicators would shift the focus towards other aspects represented by these indicators, thereby increasing the diversity of available performance measurements.

- The predominant focus on time and cost as project performance measures limits project departments to meeting set requirements in these areas.
- Need for alternative performance indicators to broaden the focus and incorporate other important aspects of project performance.
- Introducing new performance indicators would enhance diversity in measuring project performance. (Sundqvist et al., 2014).

2.3 Project size related studies

Payne & Turner (1998) states that people engaged in multiple projects within a program have been previously utilized a standardized project management approach, regardless of the specific characteristics of each project as it has been seen overall as good practice. This is in principle the client’s current situation. This approach offers has seen to have several noteworthy advantages. Firstly, a common project management approach enables the adoption of a consistent reporting mechanism, allowing for the generation of progress reports that can be compared across all projects within the program. This uniformity enhances transparency and facilitates effective communication and decision-making at the program level. Secondly, employing a uniform approach facilitates the calculation of resource requirements in a consistent manner.

This is particularly valuable when dealing with capacity constraints within the organization. By utilizing a standardized method for assessing resource needs, it becomes easier to allocate and manage resources effectively across different projects, ensuring that critical capacity constraints are addressed and mitigated efficiently. Moreover, a common project management approach allows individuals to move seamlessly between projects without the need to familiarize themselves with varying management styles or methodologies. This flexibility promotes knowledge sharing and enables the transfer of skills and expertise across the program.

Additionally, small projects have been seen as a training ground for future managers of larger projects, as the characteristics are more or less similar with this type of common project management approach. Payne & Turner (1998) recognize the upsides that a common project management approach offers but finds more tailored approach more suitable for many projects. They find that in many projects it is better to tailor project management procedures instead of using a "one-size-fits-all" approach. Payne & Turner's (1998) findings indicate that respondents reported higher levels of success, on average, when they customized their procedures based on the specific project type. Conversely, an increase in failure was observed when respondents employed common procedures for all projects. Based on this finding, it is reasonable to apply customized methods instead of a common management method.

Payne & Turner's (1998) finding is supported by PMI (2021) who suggest that tailoring project management methods for each project by their nature is also important, as they suggest that due to the fact that each project is unique, a project should have a process which is "just enough" to achieve the desired outcome while keeping costs minimum. This also refers to a need for a more tailored approach, as it is not reasonable to "over-manage" by applying for instance methods which are applicable for large projects but not small projects. A "just enough" process should be formed by assessing the context of the project and considering it as the backbone to make decisions and validations regarding project objectives, stakeholders, governance, and the environment (PMI, 2021).

Payne & Turner (1998) find the key differences on characteristics and project management matters based on the size of the project as follows:

1. For small to medium-sized projects, the primary focus lies in resource prioritization across multiple projects. These projects are not well-suited for bureaucratic procedures designed for larger and more complex projects. In other words, the resource allocation and availability are more important to small and medium-sized projects according to Payne and Turner (1998).
2. Large projects require the main emphasis to be on coordinating a complex sequence of activities and effectively balancing resources among these activities. It is crucial for the project manager to ensure critical activities occur on time and prevent resource constraints from hindering the bulk of the work.
3. Major projects necessitate coordinating the efforts of individuals across multiple sub-projects and managing substantial risks. The failure of a major project can have dire consequences for the parent organization.

Payne and Turner's (1998) findings underscore the significance of tailoring project management approaches to align with the specific characteristics and challenges posed by projects of different sizes. Small projects for instance require more attention to resource availability, whereas larger projects requires more focus on coordinating challenging tasks.

In conversations with project managers within the organization, Laporte et al (2013) discovered that project managers frequently faced the challenge of being overloaded with technical responsibilities alongside their project management duties. Consequently, this situation often hindered their effectiveness in carrying out management tasks, despite their expertise in project management. This finding highlights the potential strain on project managers who are expected to juggle both technical and managerial roles, which can potentially impact their overall performance and the successful execution of projects. Based on this finding, it is suggested to have a project manager whose responsibility is to manage the project without any burdens of technical tasks such as engineering. This finding also gives a reason to not centralize tasks and responsibilities to a one person or a smaller group. Centralization is unlikely to increase the efficiency in a project.

As part of the initiative to enhance project management practices, Laporte et al (2013) developed the following five checklists as they recognized a demand for such in their paper:

1. Small-project management process
2. Medium-project management process
3. Major-project management process
4. Drafting of service proposals
5. Detailed project planning

These checklists were designed within the framework of the program to provide guidance and structure for project managers in various project scenarios. The implementation of these checklists aims to enhance project management practices, ensuring consistent and systematic approaches across different project types and stages. (Laporte et al, 2013)

Laporte et al (2013) found also similarly to Payne and Turner (1998) that the number of projects running simultaneously significantly impacts the allocation of human resources and some project managers may not possess the comprehensive project management knowledge required. Resource allocation issues, and the dual role of project managers further emphasize the need for tailored approaches and support systems to effectively manage such projects and optimize their chances of success.

2.4 Resource management

Heagney (2012) argues that while it may be feasible for project managers to engage in project work in very small teams, typically consisting of three or four members, the situation changes as team sizes increase. As the team expands, the project manager faces increasing challenges in simultaneously working on project tasks and fulfilling managerial responsibilities. The demands and needs of team members constantly pull the project manager away from their own work (Heagney, 2012). Dvir et al (2003) found that team experience is also a factor that can influence project performance. Projects with more experienced teams tend to have higher levels of success. Based on these findings, it is reasonable to conclude that when a project team is a) small and b) experienced, and c) has clearly defined and non-overlapping responsibilities (Heagney, 2012) (Dvir et al, 2003) (Laporte et al (2013), the pursuit to achieve efficiency in project execution is likely to succeed.

Heagney (2012) emphasizes the inherent tension and trade-offs that project managers encounter when balancing their own tasks with managing the team. While smaller teams may allow for some degree of multitasking, the complexities and demands of larger teams make it impractical for project managers to effectively divide their attention between their individual tasks and team management responsibilities (Heagney, 2012).

An interesting finding by Heagney (2012) is that industrial engineers, which in this study can be seen as engineers of any functions, are available for work only 80 % of the time. The remainder typically consists of breaks, fatigue and delays caused by external factors. It is not untypical that the availability is in reality less than 80 %. It is worth noting that for instance if an engineer works for a same project the whole work day (7,5 hours), he or she is productive for 6 hours (Heagney, 2012) which again translates to a 1,5 hour loss for the project. Heagney (2012) suggests that even achieving 80% availability is uncommon as non-productive time is not untypical to be spent on meetings, non-project-related tasks and revisiting completed past work among various other demands.

Heagney's (2012) study shows that project management faces challenges associated with resource allocation and the reality that knowledge workers often have limited dedicated time and capacity for project-related tasks. It emphasizes the importance of considering these factors when planning and managing projects to ensure realistic expectations and effective resource utilization.

2.5 Project management tools

Westcott (2004) states that the project manager should be able to justify reasons for using project management tools and programmes as those should not be used solely for the sake of existence of such. Westcott (2004) sees that project managers who manages small or medium-sized projects, the recommendation leans towards not using such. Regarding whether such tools should be utilized or not, it is worth considering following aspects:

- Basic knowledge of project planning and management is necessary for effective use of project management software, which can be acquired through traditional tools.
- Acquired word processing and spreadsheet skills often prove adequate for most project tasks.
- The time and cost of learning the software may outweigh the benefits obtained.

Factors in a project, which supports the use of project management software:

- Many tasks and task interdependencies
- Involvement of diverse resources (people, facilities, equipment)
- Lengthy project life cycles
- Critical deadlines and milestones
- Potential for plan changes during project progression
- Significant expenditures
- Customer-mandated use of project management software. (Westcott, 2004).

The decision to adopt project management software depends on project size, complexity, available resources, and potential benefits. There is one correct answer whether to use project management tools or not. However, the decision on whether to not use or use should always be justified. The factors which Westcott (2004) presents are worth consideration when initiating a project. Many factors presented by Westcott (2004) are applicable for client projects regardless of project size due to the nature and structures of projects, meaning that tools should always be considered when initiating a project. His point regarding the learning time and cost of the software potentially outweighing the benefits obtained is especially important for small projects where sold hours are limited and has limited margin for hour slippages.

2.6 Project type & complexity

A key finding in Shenhar's (1998) research is the importance of properly categorizing projects to avoid costly mistakes. For example, overestimating the difficulty of a project can lead to overpriced bids, while underestimating the complexity of a project may result in problems beyond the competence or organizational framework of the project team. Figure 6 can be interpreted as a result which supports this finding.

Overall, Shenhar's typology of project management styles provide a useful framework for understanding how different approaches to project management can be used to effectively manage technological uncertainty in projects. By selecting the most appropriate project management style for a particular project, project managers can improve their chances of successfully completing their projects (Shenhar, 1998).

- Type A - low-tech projects are those projects that rely on existing, and well-established technologies.
- Type B - medium-tech projects use mainly existing technology; however, they incorporate some new technology or new feature that did not exist in the past.
- Type C - high-tech projects are typical in situations in which most of the technologies employed are new but exist.
- Type D - super high-tech projects are based on new technologies that do not exist at the time of project initiation.

Client delivers several projects which falls into Type C by Shenhar’s typology, but all projects studied in thesis are type A and type B projects. Shenhar (1998) asserts that different project types require different management styles. For instance, assembly and system projects (type A and B) require a more structured and focused management approach, while high-tech and superhigh-tech (type C and type D) projects demand a more flexible and adaptive management style.

This is in some respects contradicting to previous literature, as Shenhar's (1998) typology does not include project size. Small projects have been recognized to require flexible and tailored approach regarding project management style. However, Shenhar's (1998) typology does not include the size aspect. What if an organization has lots of type A and type B projects but which are small by size? This is the case in this thesis. In the context of this thesis, it is reasonable to propose that for small type A and type B projects the most suitable option is to have a structured foundation which applies to all projects but has possibilities for a more tailored approach based on project needs without overruling the main structure.

The projects studied in this thesis are similar to construction industry studied by Youker (2017); these are projects, which are in a contract-based industry and has typically well-defined scopes. Connecting factors are that cost is a crucial factor and the industry benefits from established processes and experienced personnel. These characteristics highlight the structured nature of construction projects, the importance of specialized labor, and the need for cost control. The presence of well-known processes contributes to the efficiency of construction projects. These findings support the proposition, which recommends applying tailored approaches if necessary to a fixed structure in case project is small, but by Shenhar's (1998) typology falls into type A and type B category.

Lump sum contracts, which all projects studied in thesis these are, requires effective labour hour management and active cost control (Youker, 2017). This highlights the significance of closely monitoring and managing labour hours and costs to ensure profitability and project success. Based on earlier findings and due to the fact that all projects in this thesis are based on fixed sum contracts, the main project management method structure should include monitoring methods regarding project progress and monitoring labour hours. Youker (2017) finds that equipment or system installation projects, which this thesis projects are, involve a well-defined scope and require efficient execution as well. He finds that speed is a crucial factor in these projects, which emphasizes the need for timely completion, meaning that close and structured monitoring method is reasonable. The author suggests that if the project is well-planned, the associated risk should be low. This highlights the importance of thorough planning and preparation to minimize potential risks and ensure a successful installation process.

Dvir et al (2004) found regarding project planning that unexpected changes to the original plan affect the project regardless of whether the plan has prepared carefully or not. They state that whereas plans are not unimportant, the capability to react to unforeseen changes in the projects is vital. This is an interesting point of view, as whereas it is not unusual to find claims in project management literature regarding the importance of project planning. However, Dvir et al's (2004) approach might have a great impact on minimizing risk and enhancing project performance, if applied adequately. If project has been planned by having this approach, it means that the project team has assessed possible risks and have evaluated the whole project lifecycle from beginning the end of the project. Naturally, contracts and client requirements dictate most of the overall project structure and progress, but for those parts which project team has any possibility to affect, it is crucial to have thought through all possible scenarios. In a way, it could be vital to have an "expect the unexpected" mindset when initiating and planning the project.

Youker (2017) lists factors which can be used when classifying a project. The factors mentioned by Youker are essential considerations in projects, regardless of their specific types. They include:

1. Size
2. Duration
3. Industrial sector
4. Geographical location
5. Number of workers involved
6. Cost
7. Complexity
8. Urgency

9. Organizational design

These factors provide a comprehensive overview of key elements that influence project management and planning. They help project stakeholders assess and address important aspects such as project scale, time frame, industry context, geographic considerations, workforce size, cost implications, project complexity, urgency, and organizational structure. Most of these points were utilized for sampling and defining the scope of this paper such as size, duration, industrial sector, geographical location, cost and complexity.

Kerzner (2017) defines complexity when comparing traditional projects to complex projects by reasons such as size, value, uncertain requirements, uncertain scope, uncertain deliverables, complex interactions, uncertain credentials of the labour pool, geographical separation across multiple time zones, use of large virtual teams and other differences. Kerzner's vision of complexity is somewhat different than what complexity means in this paper. He sees complexity more as a difficult project environment, whereas this paper defines complexity based on scope of supply, technical solutions, and client (technical) requirements, this is partly due to the fact that some of Kerzner's definitions (such as complexity of interactions and uncertainty of credential of the labour pool) are difficult to measure.

According to Dvir et al (2003), technical complexity of a project is a factor that can influence project success as more complex projects tend to have lower levels of success. Kerzner (2017) finds traditional projects have characteristics such as duration of 6 to 18 months (some variance between industries), assumptions are not expected to change over projects execution, technology is known and not expected to change soon, project team staying the same throughout the project, statement of work is well defined, target is stationary, few stakeholders and few metrics and KPIs. By this description, sample projects in this thesis are "traditional projects". Whereas Kerzner's (2017) findings on complexity do not necessarily apply to this paper, it is worth presenting that there are varying opinions on what the term complexity might cover.

Kerzner states that cost overruns and schedule slippages might occur but are limited compared to those which can take place on complex projects. When initiating long lasting, i.e. duration of 10 years complex projects, Kerzner says that the assumptions and expected outcomes of such projects will not probably be valid at the time when the project ends. The duration is not the only attribute that contributes for the assumptions to outdate, but it raises the probability of outdating.

According to Hyväri's (2006) research findings, no significant relationship was discovered between project type and critical success or failure factors. This can be seen as relatively strong statement by Hyväri. Her finding suggests that regardless of the project type, the factors contributing to project success or failure remain consistent. This result challenges the assumption that project type plays a pivotal role in determining critical factors. In other words, the critical success factors remain the same regardless of project type according to Hyväri (2006).

2.7 Design phase impact

As the design and engineering plays typically the biggest role in terms of resource hours in projects, it is important to review literature regarding the design phase and typical questions regarding the design.

Kuprenas' (2003) study on improving design phase costs focuses on assessing the impact of project management-based organizational structure, project manager training, frequency of design meetings, and frequency of design reports on design phase cost performance. He found that that having design team meetings more than once per month, as compared to less than once per month, statistically reduces design phase costs. He also found that reporting design phase progress more than once per month results in a lower mean design cost. This suggests it is worth considering having frequent design meetings combined with active reporting on the progress of design. An interesting finding was also that the application of project manager training and a project management-based organizational structure does not show a statistically significant lower mean design cost.

Table 2. Impact of design review and approval process (Williams et al, 1995)

TABLE 1. *Results of model runs*

(1) Average approval time	(2) Proportion comments	(3) Proportion extra work	Total man-hours used
Low	Low	Low	100.0
Low	Low	High	192.0
Low	High	Low	111.8
Low	High	High	267.9
High	Low	Low	100.4
High	Low	High	190.3
High	High	Low	113.1
High	High	High	325.7

Williams et al (1995) found that design review process has impacts on the efficiency of design process. The longer the review and commenting by the client took, the more it affected the used man-hours. All three variables (average approval time, proportion of client comments, and proportion of extra-contractual work) had notable impacts on the project's man-hours, leading to increased costs and potential delays. The three main factors contributing to the delay and disruption in the project were identified as: design changes requested by the purchaser without formal contractual approval, delays in document approval by the project client, and invalid comments on design documents that slowed down the design process (Williams et al, 1995). If all three variables were extremely high, simply meaning long review duration, large number of invalid and unjustified comments, and high workload due to consequences of the client feedback could result in more than three times the number of man-hours used when comparing to a fast and efficient review process. For this reason, it is important to try to minimize the opportunities for the client to disrupt the design process to avoid delays and extra work regarding the design phase. The possibility the affect the design process must be limited, well-defined and agreed by all stakeholders prior the start of the project. Especially the process for design review and approval must be clear to all project members.

2.7.1 Impact of design errors

Research by Muhamad and Mohammad (2018) concerning the impact of design changes in construction projects explored the factors contributing to time overruns and cost overruns in construction projects, with a particular focus on design changes. The findings revealed that design changes which originates from the owner's side are causing factors of project delays and increased costs. Design changes were defined as modifications made to the project design or requirements after the contract was awarded, resulting in a dynamic and unstable construction environment. These changes include regular additions, omissions, and adjustments to both design and construction work, affecting the contract provisions and work conditions. Notably, the study highlighted that design changes made by mistake could lead to subsequent changes during site works. Moreover, changes to the design after the contract was awarded created variations, which often became major sources of disruption, disputes, and claims during projects.

Burati et al. (1992) classified design changes into seven categories, encompassing design change/improvement, design change/construction, design change/field, design change/owner, design change/process, design change/fabrication, and design change/unknown. Another study by Chang et al. (2011) identified three categories of reasons for design changes: those under the owner's control, the designer's control, and beyond control. These studies regarding design error impacts shows that there are various reasons which could lead up to design changes.

The most common causes of design changes cited in research regarding design error impacts were changes in client requirements or specifications during the course of a project. Clients' evolving needs and project plans or scope changes initiated by clients after work had begun often necessitated reworking by the design team, impacting the design time and costs. Subsequently, research highlighted that lack of owner involvement in the design phase resulted in the addition or omission of scopes. Projects that commenced before finalizing the design were particularly prone to frequent design changes. Concurrent design and construction scenarios were identified as instances where such changes were prevalent. Design omissions were found to lead to productivity losses and project schedule delays, underscoring the importance of limiting any possibilities which could lead up to unwanted design changes after the project start.

Muhamad & Mohammad's (2018) study emphasizes the critical role of effectively managing and controlling design changes to mitigate time and cost overruns. However, as Williams et al (1995) demonstrate, it is important to have thoroughly set boundaries on design review process, to avoid unnecessary disruptions and inefficiencies during the design phase. Client should have limited possibilities to affect design changes during the project execution phase. If there are unclear boundaries, the risk of overruns in engineering hours increases, possibly even significantly. Williams et al (1995) challenges the statement of Muhamad & Mohammad (2018) regarding active collaboration between all stakeholders; whereas the collaboration between stakeholders is recommended to be active, the impact of this activeness itself on project performance must be thoroughly addressed. If active collaboration and discussion with the client means ultimately more design hours, it cannot be recommended. However, if the communication (i.e., regarding design review process method) is well planned, it is likely to be beneficial for all stakeholders.

2.8 Cost-affecting attributes

Doloi (2013) conducted comprehensive research on attributes which affects the cost performance of the projects in construction projects. According to his research two of the most crucial attributes are planning and scheduling deficiencies and effective monitoring and feedback processes. This supports previously concluded proposition which recommends utilizing a structured, yet tailorable project management approach with active monitoring regarding projects studied in this thesis.

Other important matters Doloi (2013) found are construction methods/techniques, complexity of design and construction, improper control over site resource allocations and mistakes and discrepancies in construction documentations. Client-initiated variations were also ranked high. Other relatively important attributes were design changes within development period, delays in work approval waiting for information and lack of communication between client and contractors. Less significant attributes in Doloi's research (2013) were scale and scope of the project, availability and supplies of labor and materials, lead times for delivery of materials, deficiencies in cost estimates prepared, size of the project team and project duration, the first mentioned being the highest ranked of this group.

2.9 Enhancement of project performance

Anantatmula (2015) highlights that, although crucial, project planning and control activities don't automatically lead to project success, suggesting the need for more adaptable and responsive project management strategies to better identify and navigate the unpredictability of project tasks. Therefore, according to Anantatmula (2015), to detect inefficiencies, project managers should focus not just on having planning and controlling measures, but on how adaptable these measures are in face of changing project circumstances. This is supported by Dvir et al's (2004) finding.

The influence of project size on the application of project management policies and procedures, as highlighted by Anantatmula (2015), provides another key insight for identifying inefficiencies. Recognizing that smaller projects may not require the full suite of policies and approvals that larger projects do can eliminate unnecessary bureaucracy, reducing time wastage and improving efficiency. Hence, project managers should tailor their management strategies to the project size, creating leaner processes for smaller projects and more detailed ones for larger projects.

Anantatmula (2015) also emphasizes the importance of senior management support for larger or high-priority projects that demand wide organizational involvement. This suggests that detecting and overcoming inefficiencies also hinges on ensuring the right level of management involvement. Therefore, it is essential to clearly define and communicate project size and priority to secure appropriate management support. Whereas

Anantatmula (2015) recommends frequent senior management meetings for larger projects, it can be concluded that it is to some extent applicable to smaller projects as well, as long as the meeting costs are adequate considering the smaller budget and it is considered to serve a purpose.

Dvir et al (2003) suggest that involving the client in the project planning process can improve the quality of project planning and increase the chances of project success and thus potentially enhancing the performance of the project. Clients can provide valuable input and feedback that can help to ensure that the project meets their needs and expectations.

2.10 Analysis of existing literature

A comprehensive summary of literature can be found in table 3. It includes author, context, themes and key findings of each study. A concluding analysis of the literature can be found below the table which includes most important findings of the literature and discussion of existing literature of this topic.

Table 3. Summary and analysis of literature review

Author	Context	Themes	Findings
Kerzner (2017)	Project performance factors	Time-cost-quality, alternative performance measurements, complexity definition, costs, duration	- Project successes are not reality until agreed metrics have been met. - The more uncertainty in project environment, the more complex project. - Complex project environment: uncertain requirements scope and deliverables, complex interactions, geographical location across multiple time zones, new and rapidly developing technology. - Noncomplex project less likely to lead to cost overruns and schedule slippages than complex projects
Shenhar (1998)	Project type	Project type and complexity-based project management style, project type categorization, project success	- Project types A (low-tech), B (medium-tech), C (high-tech) & D (super high-tech). - Types A & B require more structured and focused management approach - Type C & D projects demand a more flexible and adaptive management style

Dvir et al (2003)	Project success factors	Planning, team experience, stakeholder involvement, technical complexity	- Project planning is the most critical factor in determining project success. - Stakeholder involvement in planning increases the chances of project success. - More complex projects tend to have lower levels of success.
Hyväri (2006)	Project success & project type	Project success definition, success measurement, human/behavioral factors, talent & experience of project manager, PM attributes	- Project management literature and research to include more behavioral and organizational factors. - No significant relationship between project type and critical success or failure factors. - Need for further research on CSFs and measurement techniques. - Success or failure of a project is determined by the talent and experience of project management. - Critical success factors remain the same regardless of project type. - Good PM: technical competence, high commitment level, good communication, visionary thinking.
White & Fortune (2002)	Project success factors	Critical success factors, project goals & objectives, senior management support, adequate funds	- Most frequently mentioned critical success factors in project manager interviews (236 PMs): clear goals & objectives, senior management support, adequate funds & resources. - Crucial CSF for large project companies: project team communication. - Crucial CSF for small project companies: sufficiency of funds & resources.
Belassi & Tukel (1996)	Project success, Project Manager attributes	PM's technical competence, motivation, leadership, communication	- Important characteristics for project manager: technical competence, commitment, coordination ability, effective leadership, communication, motivation, decisiveness.
Jani et al (2012)	Project success	Contractor management, labor management, machineries and material management, weather condition	- Project stakeholders have varying aspects and focus points. - Developer/clients topics that influences project success: contractor and subcontractor management, labor management, machineries and materials, weather condition. - Contractor: contractors' financial status, material deliveries, contractor competence, labor and availability of machineries.
Sundqvist et al (2014)	Efficiency	Efficiency, effectiveness, quality management, internal processes,	- Efficiency is oftentimes not thoroughly defined, rather is used too loosely. - Efficiency: quality management; result of an applied internal process which returns good results, project management; performing tasks in

		alternative performance indicators,	the most convenient way given the current available resources. - Effectiveness: quality management; when process outputs achieve customer requirements, project management; maximizing the utilization of allocated resources. - High effectiveness can result efficient project execution.
Payne & Turner (1998)	Project management, size & type aspect	Project management approach based on project size, common project management vs. tailored project management,	- Higher level of success when used customized and tailored procedures based on project type and size. - Higher risk of failure when utilized common "one-size-fits-all" procedures - Process should be "just enough" to achieve desired outcome while keeping costs minimum (PMI, 2021). - In small projects, primary focus in resource prioritization across multiple projects, whereas in large projects the main emphasis lies in coordinating complex sequences of activities.
Laporte et al (2013)	Project size, project roles & responsibilities	Project manager's technical tasks, management process selection, project management practices,	- Project managers should not have technical tasks. - Resource availability and prioritization are a challenge especially in small projects. - Development of utilization of management process checklists based on project size.
Heagney (2012)	Resource management, project team size	PM's challenges concerning team size, resource availability, resource capacity, resource productiveness, time allocation	- The larger the project organization, the more demanding for the PM to fulfill managerial responsibilities. - PMs encounter trade-offs when balancing their own tasks with managing a team. - Small teams allows some degree of multitasking, whereas larger teams make it impractical - Individuals are not productive 100 % of their time, moreover, even 80 % productiveness is uncommon.
Westcott (2004)	Project management tools	Project management software, reasons to use PM software	- Use of project management tools should always be justified - Decision to adopt project management software depends on project size, complexity, available resources and potential benefits - For small projects not always justified to use, large projects typically benefit from using such
Youker (2017)	Project type, resource experience, project	Project characteristics, labor and cost management, typical factors, and characteristics of	- Planning and well-managed and active stakeholder communication is vital - Projects can be classified by size, duration, industrial sector, geographical location, number of workers involved, cost, complexity, urgency, and organizational design

	classification	construction project	
Kuprenas (2003)	Design phase	Design team meetings, design process reporting,	- Frequent team meetings reduce design phase costs - Frequent design phase progress reporting reduces design cost - PM training or organizational structure does not correlate to design costs
Williams et al (1995)	Design review process	Design review, design man-hours, design efficiency	- Design review process impacts the efficiency of design process - Approval time, quality and quantity of client comments and proportion of extra work affects the man-hours used - Long review times, high amount and invalidity of feedback which additionally causes lot of extra work can have significant negative impacts to the project design quality and efficiency.
Muhamad & Mohammad (2018)	Design changes, design errors	Design change definition, Impact of design changes and errors	- Design changes which originates from the owner's side are causing factors of project delays and increased costs - Design errors could lead to subsequent changes during construction phase - Design changes often became major sources of disruption, disputes, and claims - Most common causes of design changes: changes in client requirements or specifications during the project
Doloi (2013)	Project costs	Cost-affecting attributes	- Crucial attributes: planning and scheduling deficiencies and effective monitoring and feedback processes. - Other important attributes: complexity of design and construction, improper control over site resource allocations and mistakes in documentation
Anantatmula (2015)	Project performance enhancement strategies	Enhancement strategies for project performance	- Planning and control activities are crucial but do not automatically lead to project success - Adaptable, responsive, and tailored project management strategies are important to achieve efficiency - Small projects do not require same extent of bureaucracy than larger projects, risk of time wastage - Right level of senior management support must be considered based on project size and priority
Dvir et al (2004)	Project planning	Project planning, project changes, goal & objective changes	- Capability to react to unforeseen changes in the projects is more important than the original plan itself, regardless of whether the plan was carefully made

Based on Williams et al (1995) findings it is important to try to minimize the opportunities for the client to disrupt the design process to avoid delays and extra work regarding the design phase. The review process protocol must be clearly defined and organized, and project team should have possibilities to prepare beforehand by knowing what to expect and what kind of possibilities client or other stakeholders might have on the design. It is important to be hedged from unforeseen scope changes, client requirement and/or specifications (Muhamad & Mohammed, 2018) as these factors might have a critical impact firstly in the design phase and ultimately on the whole project performance.

The literature review shows that the suggestion on how to mitigate labor related inefficiencies by centralizing tasks to a smaller group is not a valid practice. Moreover, this practice is likely to increase the risk of inefficiency due to high workload and disturb the management of the project.

Project management literature contains extensive research indicating that close monitoring of projects, utilization of project management systems and cost tracking tools for project team and senior management information can improve project outcomes. However, the literature disregards the impact of amount of time spent on the monitoring itself including the maintenance and updating of these systems, and which type of impact this action has on the project performance. Theory found in literature leans more towards the argument that it's better to closely monitor and use such software even though it might consume work hours from the project. However, whereas progress reporting structures, project planning, and management software are not considered as crucial factors contributing to project failure in the literature in the first place, streamlining such processes would not do any harm.

Overall, based on literature, strategies to prevent inefficiencies to occur, and overcoming of such in case of occurring, could include:

- Implementing adaptable planning and control activities.
- Active, yet light monitoring of project progress
- Involving the client and other stakeholders in the project planning process.
- Limiting the possibilities of stakeholders and external factors to influence the project outside of agreed practices.
- Tailoring the use of policies to project size.
- Securing the appropriate level of management support.

Adaptable planning could be vital for two reasons. Firstly, it is the outcome of going through the whole project lifecycle in co-operation with the whole project team, which in other words means that the whole project has recognized the potential progress and potential risks that might occur i.e., during later stages of the project, meaning that they have more capability to react to unforeseen changes in the project. Secondly, it provides flexibility to the project schedule for those parts which are not dictated by client requirements. Another crucial factor is to limit any risks of changes in the agreed practices, as the most common causes of design changes are the changes in client requirements or specifications during the project.

The literature shows that the project management literature does have variance and differing opinions from each other. It demonstrates well the uniqueness of the field. Ironically, the subject of the field of study – projects – are unique by nature which are influenced by various factors all the way from industry, stakeholders, technology, environment, and complexity. As the field which project management literature is a part of is enormous, it is increasingly important to understand the context of each work. It is enormously important to draw conclusions from valid sources. For instance, whereas this thesis concerns project management, it does not validate to use for instance a medical drug development project funded by a government, which is significantly different by nature as the projects of this study, and thus not compatible. As the literature review of this thesis proves, even valid sources from similar industries might have relatively different approaches to certain topics.

3 Methodology

3.1 Research design & execution

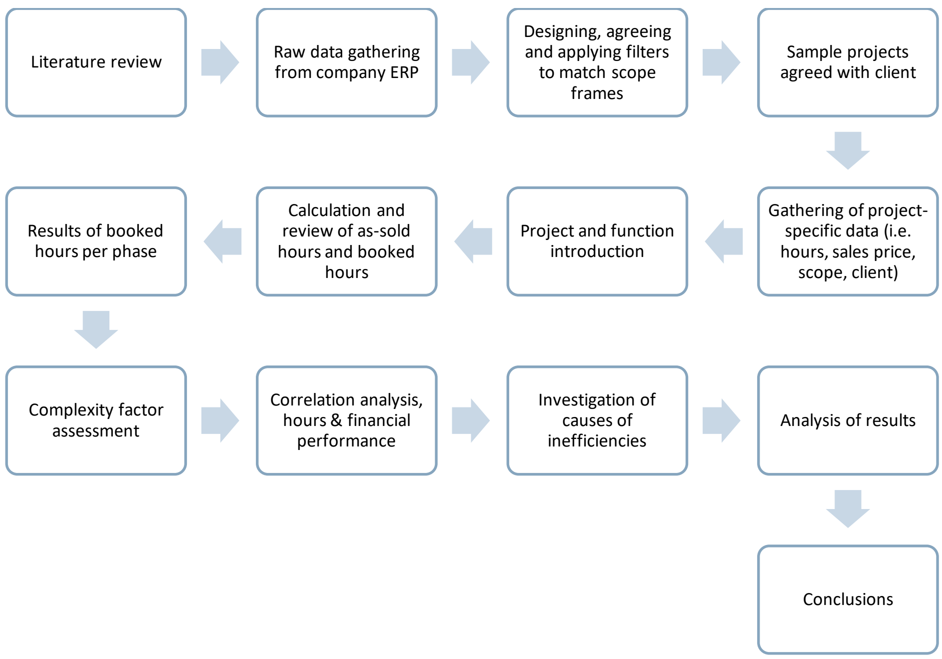


Figure 2. Research process timeline.

Figure 2 illustrates the process of how this thesis was conducted. Whereas the process was not in reality as simple and straightforward as the process graph indicates, it demonstrates well the overall structure and the progress of this thesis.

3.2 Data collection methods

Data was collected within the frames of the scope of this paper. For the project comparison data was collected from clients Enterprise Resource Planning software. It included all projects of the PGGI unit project start dates beginning from year 2010. I will refer to this project list as raw data. The data was extracted 23rd of January 2023. The project list included executed projects as well as ongoing projects. For instance, the newest project of the list had the start date of 15th of January 2023. The length of the projects, the time range between project start and finish dates, of the raw data varied from several months to several years.

The raw data included following information: project number, project name, project manager name, profit center, start date and finish date. 25 projects of the list did not have any project managers name listed. Total number of projects in the raw data was 235 projects without applying any filters. Profit center number is used to categorize projects industry or sector wise – thus profit center can be thought as a category type. However, after applying filters to the raw data according to the scope of study, the projects had variance in booked profit center numbers even though projects having similar scope, clients, and sales price. This proves that there are unclarities on which profit center numbers to be used in certain types of projects. The variance in used profit centers did not however influence the data collection, as projects were not filtered by profit center numbers.

Booked hours were collected project-by-project with a similar report from client ERP system, which allows the user to review how many hours at which specific date was booked. This report was used to calculate the actual hours and divide them into four phases introduced later in this paper. This required the information of the PAC-date, which was used as the cut-off date for the gathering of booked hours, and thus excluded hours which were booked after the PAC-date. It is worth noting that all the hour data collected concerns only internal labour, meaning that subcontractor hours are excluded from the figures of this thesis. Subcontractors are generally used for installation and civil works.

The data collection demanded heavy workload to obtain the additional information. The raw data lacked important information such as customer name, original sales price, original project cost, original gross profit amount and original gross profit margin percentage. This information was gathered manually project-by-project from client's project status report function in their ERP software. This report shows the original sales price, project cost, gross profit and gross profit margin, and the latest forecast, also referred as latest sales price, latest project cost, latest gross profit, and latest gross profit margin. The project status report can be retrieved from chosen month. This enables a possibility to investigate how these numbers have varied during a chosen project by comparing reports month by month. After the original sales price and customer name was retrieved from project status report, it was possible to sort and filter projects with these parameters. This enabled the investigation of sample projects by their sales price, change in sales prices (percentage) and change in gross profit margin (percentage).

The effort to detect inefficiencies and reasons behind them, the information was collected from document management systems, utilizing project progress reports, risk review materials, lessons learned documents, project schedules, project close-out reports and project quality reports. There was no clear structure to find any supporting documentation such as listed earlier, moreover all information had to be collected case-by-case. There was not any structured way to keep track on project progress, or, alternatively the document management process was poorly managed during the project execution. Some projects had very little documents saved in their dedicated document environment, which caused challenged during the evaluation of what factors caused inefficiencies to occur. Some projects had high-quality and comprehensive documentation regarding project reporting, on the other hand some projects' reporting documentation was virtually non-existent.

3.3 Sampling techniques & project introduction

3.3.1 Project introduction

The projects chosen for this study follows the scope introduced in chapter 1.2. The main idea behind the scope was to review small projects which resembles each other by their overall characteristics and scopes of supplies. Selection process included three levels which started from raw data gathering and filtering, continued with enhancing filters and lastly evaluating remaining list of projects case-by-case and hand-picking borderline cases in co-operation with the client. General information of sample projects with original sales price and as-sold hours included can be found in table 1. More detailed information of the scopes of supplies and technical information such as voltage levels, number of circuit breakers and civil work inclusion/exclusion, can be found in appendix 1.

There are following assumptions regarding general information of sample projects. The technical solutions employed in these projects are similar enough to make meaningful comparisons in terms of hours allocated to different roles. This study assumes that as-sold hours represent accurately the estimated effort required for each role in the projects and in addition actual booked hours reflect the real amount of work performed by each role in the projects. A project start is the moment when first hour has been booked and end date is the provisional acceptance certificate signature date, also referred as PAC-date. PAC date is the point when warranty period for the delivery starts and is in general the key ending milestone for all projects.

The average original sales price represents an approximate indication for project size and complexity. However, it's worth noting that the average original sales price of the projects does not have a direct correlation with the number of hours allocated to each role. Other factors, such as project complexity, specific client requirements, or technical challenges, influence the distribution of hours across roles presumably more than the sales price itself. Sales price does however give a preliminary indication of project complexity. All projects are located in Finland.

Table 4. Summary of project information

Project	Start Year	Customer Type	Original Sales Price	As-sold Hours	Dura-tion (m)
Project 1	2021	Infrastructure Contractor	876 000 €	1 764	13
Project 2	2021	Infrastructure Contractor	722 000 €	1 674	12
Project 3	2021	Wind Power Developer & Owner	335 000 €	930	7
Project 4	2021	Infrastructure Contractor	872 000 €	1 714	13
Project 5	2020	Infrastructure Contractor	1 045 000 €	1 480	17
Project 6	2020	Wind Power Developer & Owner	1 064 000 €	2 310	16
Project 7	2020	Infrastructure Contractor	1 057 000 €	1 537	17
Project 8	2020	Infrastructure Contractor	1 377 000 €	1 630	13
Project 9	2020	Wind Power Developer & Owner	841 000 €	1 400	13
Project 10	2019	Infrastructure Contractor	878 000 €	1 170	16
Project 11	2019	Infrastructure Contractor	937 000 €	1 290	18
Project 12	2021	Infrastructure Contractor	1 180 000 €	2 320	11
Project 13	2020	Infrastructure Contractor	659 000 €	1 570	12
Project 14	2018	Infrastructure Contractor	1 293 000 €	1 390	10
Project 15	2018	Infrastructure Contractor	1 961 000 €	1 800	9
Project 16	2018	Infrastructure Contractor	892 000 €	1 475	8
Project 17	2017	Infrastructure Contractor	236 000 €	788	5
Project 18	2016	Infrastructure Contractor	830 000 €	1 258	9
Project 19	2016	Wind Power Developer & Owner	1 835 000 €	2 591	7
Project 20	2015	Wind Power Developer & Owner	857 000 €	1 597	20
Project 21	2015	Infrastructure Contractor	850 000 €	1 463	7
Project 22	2015	DSO	1 241 000 €	1 972	8
Project 23	2014	Wind Power Developer & Owner	804 000 €	1 426	9
Project 24	2014	Wind Power Developer & Owner	807 000 €	1 490	9
Project 25	2014	Service & Automation Contractor	835 000 €	1 207	7
Project 26	2014	Wind Power Developer & Owner	1 050 000 €	1 125	8
Project 27	2013	Wind Power Developer & Owner	785 000 €	955	16
Project 28	2013	Energy Company	920 000 €	1 057	8
Project 29	2013	DSO	749 000 €	1 227	18
Average	-	-	*958 207 €*	*1 504*	*12*

In general, in terms of PMBOK Guide's (2017) process groups, all sample projects begin from the planning phase, followed by execution phase, moving on to monitoring and control phase and finally reaching project closure phase. Projects life cycle are similar to each other regardless of the project, but there are some differences depending on the scope of the project. Typical life cycle is as follows:

1. Project plan and schedule preparation
2. Design phase
3. Procurement of materials
4. Site mobilization and civil work
5. Equipment installation & commissioning
6. Project handover

This is the general structure of all sample projects. However, not all the above applies to all projects, as there are some projects which have for instance only engineering (design phase) and procurement of materials in their scope. By Shenhar's (1998) definitions, these projects are Type A and Type B projects.

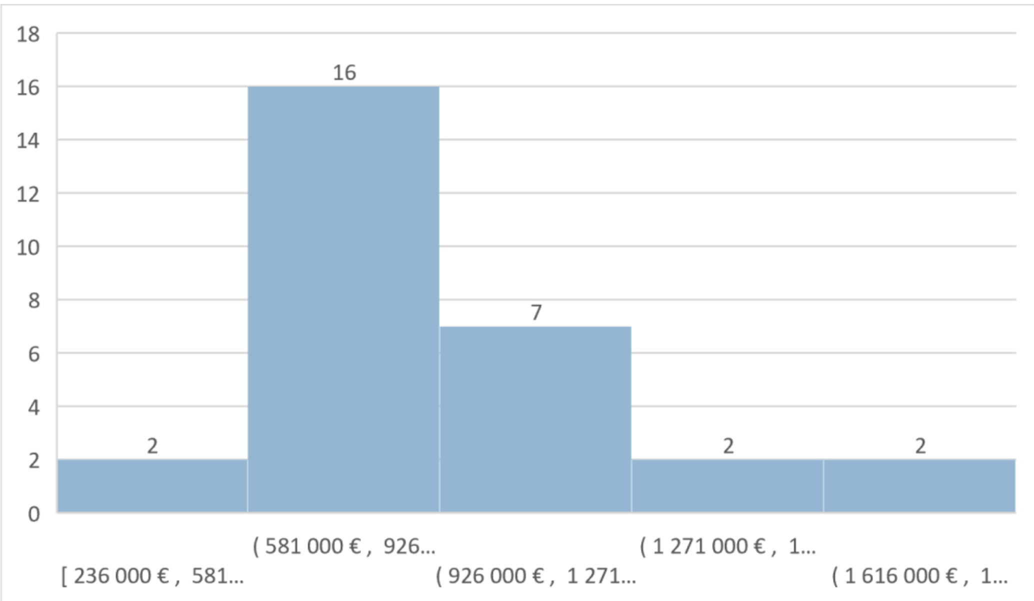


Figure 3. Distribution by project size.

Figure 3 illustrates the distribution of projects by their sales price, which can be interpreted as the size of the project. The biggest bin, projects from 581 000 € to 926 000 €, most of the projects (16) falls into that category. Second most populated bin is 926 000 € to 1 271 000 with seven projects represented. This visualizes well distribution of the typical project size. The average sales price of the projects is 958 207 €, as presented in table 5.

Figure 4 shows the distribution of projects based on durations. The duration of most project is between 5 to 10 months, whereas projects that takes 10 to 14 months and 14 to 19 months are not untypical. Commonly, the duration of these projects varies between 5 to 19 months, any longer than that is not usual. It is worth noting that the average duration of the projects of this thesis is 12 months as presented in table 5.

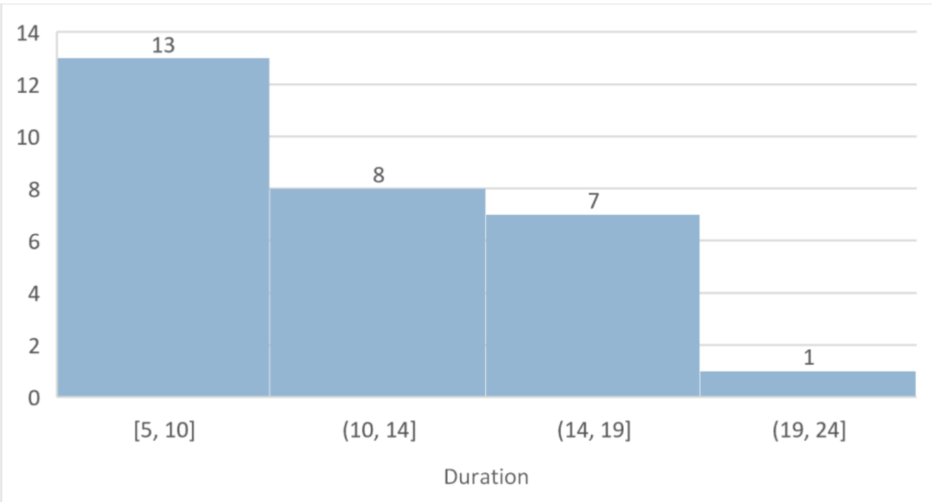


Figure 4. Distribution by project duration

3.3.2 Function introduction

Project organizations consists of following functions:

- Project Management
    - Manages the project with overall project responsibility and accountability.
- Secondary Engineering
    - Responsible for electrical design such switchyard, cabling, and auxiliary systems. Initiates request purchases according to own design. Designs and plans testing and commissioning protocols. Typically, in small projects

acts also as a Commissioning Engineer. This function can be generalized as Electrical Engineer, yet that would not be a precisely correct term.

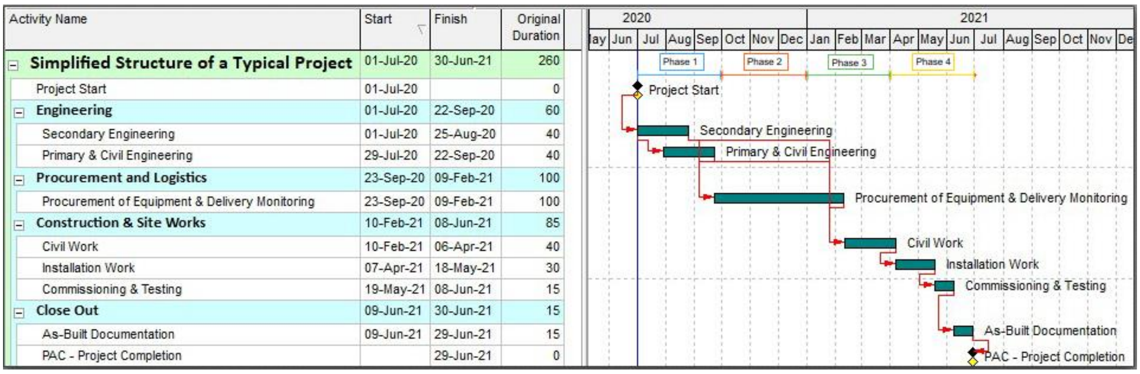
- Primary Engineering
    - Responsible for civil guidelines and the design of layout, steel structures, earthing, installation, to find optimal technical solutions. Initiates purchase request according to own design. Coordinates and co-operates with Civil Engineering. This function can be generalized as Structural Engineer, yet that would not be a precisely correct term.
- Civil Engineering
    - Designs foundations, air conditioning in buildings, and water and sewage systems. Prepares detailed calculations for foundations and steel structures. Prepares inquiries to civil contractors. Coordinates and co-operates with Primary Engineering.
- Procurement (Supply Management)
    - Responsible for procurement. Send inquiries and requests for quotations to suppliers. Reviews content of purchase requests. Issues purchase orders. Reviews and approves supplier invoices.
- Logistics
    - Responsible for logistics arrangements. Prepares packing, marking and documentation instructions. Inquires freights. Plans and coordinates transports. Follows up deliveries.
- Project Controlling
    - Responsible of project finance controls. Comprehensive management of ERP system for the project. Manages financial transactions and overall money traffic of the project. Maintains business risk management and reporting tool.
- Project Planning
    - Responsible for project planning. Prepares and develops baseline schedule for project and updates it during the project. Prepares reports of the

project schedule to stakeholders. Maintains risk management and reporting tool for schedule and milestone matters.

- Installation
    - Installation work is typically done by using contractors, but in some instances some internal installation work can be performed.
- Commissioning
    - Responsible for testing and commissioning. Prepares and executes commissioning plan. Co-operates with Secondary Engineer.
- Site Management
    - Responsible for site management and safety. Supervises all site work. Coordinates with project team, contractors, and customer at site. Receives goods when delivered at site. Typically, in small domestic projects, Project Manager acts as a Site Manager.

In this paper the following functions have been combined to one entity to:

- Procurement & Logistics to “Procurement & Logistics”
- Installation, Commissioning and Site Management to “Site work” or “Site” as these functions operates typically at site only.



Activity Name	Start	Finish	Original Duration
Simplified Structure of a Typical Project	01-Jul-20	30-Jun-21	260
Project Start	01-Jul-20		0
Engineering	01-Jul-20	22-Sep-20	60
Secondary Engineering	01-Jul-20	25-Aug-20	40
Primary & Civil Engineering	29-Jul-20	22-Sep-20	40
Procurement and Logistics	23-Sep-20	09-Feb-21	100
Procurement of Equipment & Delivery Monitoring	23-Sep-20	09-Feb-21	100
Construction & Site Works	10-Feb-21	08-Jun-21	85
Civil Work	10-Feb-21	06-Apr-21	40
Installation Work	07-Apr-21	18-May-21	30
Commissioning & Testing	19-May-21	08-Jun-21	15
Close Out	09-Jun-21	30-Jun-21	15
As-Built Documentation	09-Jun-21	29-Jun-21	15
PAC - Project Completion		29-Jun-21	0

Image 2. Simplified structure of a typical project

A simplified structure of a typical sample project is introduced in image 2 which gives a rough example of what project typically includes. It is worth noting that naturally, not every project follows same pattern as every project is unique and have different characteristics such as scopes and customer requirements. The overall structure however remains somewhat similar. Engineering typically includes design tasks such as layout and section drawings (Primary), single line diagrams (Secondary), earthing diagrams (Secondary), foundation drawings (Civil), and conducting the customer review process of the design. Customer approval is typically required in order to continue the project by for example purchasing equipment or send requests for quotations to subcontractors for civil or installation work based on the approved design.

Regarding contributions from each function phases 1 and 2 generally demands fairly plenty of effort from Engineering functions, as they prepare the design which is the foundation for the whole project. The design plays significant role in defining which equipment will be used and how those will be installed and commissioned. Thus, it is natural that engineering functions have the most hours dedicated to. The most hour and effort-consuming phases for Engineering functions are typically phases 1 and 2, where design activities and procurement typically occur.

Once equipment and material have been delivered site work has usually come to a stage which enables the start of installation work. Typically, these activities occur at phase 3. After installation work is completed, the commissioning and testing phase starts which is followed by close-out activities such as as-built documentation. These activities occur typically at phase 4.

3.4 Data analysis methods

3.4.1 Framework for data analysis methods

Even though there are various approaches on how to define whether a project has been successful or not, this study relies on the typical and well-known measures, which are time, cost and quality (Kerzner, 2017). Whereas this thesis does not focus primarily study whether these three constraints have been met, these three constraints are the main factors which affect the project performance of the sample projects. This means that the three usual constraints of time, cost and quality are the base to which inefficiency are being evaluated against. This study understand that a project has been successful and efficient when the actual gross profit margin is the same as sold. Thus, if a project has had to reduce the gross profit margin during the project, it is interpreted as not as successful project as was targeted. On the contrary, if the gross profit margin is increased during the project, project is considered as successful in terms of financial performance.

This thesis interprets satisfactory quality when the project is handed over to customer, which means PAC-date. The reason behind this is, that client will not accept any project if the quality requirements have been met. If the quality of the outcome of the project is poor, the PAC date would not be reality until the quality reaches satisfactory levels = client accepts the outcome of the project. Regarding the third constraint, time, this thesis studies the duration of these projects and studies whether there is any correlation between duration and project performance. However, this study does not focus on whether planned schedule have been met.

Concerning Shenhar's (1998) four measures for determining project success, this thesis evaluates two of such - meeting functional and technical specifications (in this case reaching PAC date), while disregards the other two - meeting schedule or meeting planned budget. Additionally, as opposed to Kerzner's (2017) definition of complexity, this study interprets complexity as mostly technical complexity. Whereas Kerzner (2017) describes complexity in project management as an environment with characteristics such as uncertain requirements, uncertain scope, uncertain deliverables and complex interactions, this thesis' definition of complexity differs from Kerzner's. In this study complexity translates to subjects such as technical solutions, technically demanding requirements, technical and broad scope of supply, project size and sold hours.

Regarding the analysis of efficiency or inefficiency in terms of resource efficiency, this study approaches and interprets efficiency as a combination of Sundqvist et al (2014) description of effectiveness and efficiency in quality management - to perform tasks in the most convenient way given the current available resources and maximizing the utilization of allocated resources. In other words, this thesis finds human resource to be efficient if a resource performs tasks by having a satisfactory and value adding outcome of dedicated effort without overrunning the planned schedule required for the task.

3.4.2 Financial comparison

Studying financial performance of sample projects, like studying overrun hours, it is relatively easy to find projects which are worth a deeper evaluation. Financial figures can be used to judge projects as successful or unsuccessful. The criteria of determining whether a project has been successful or not is naturally based on selected approach. In this case the comparison is done by comparing projects to each other and find out which differs the most and this way perceive projects which might have underlying inefficiencies. This thesis refers to financial success of a project as follows: a project has performed well financially when it has been able to keep or even increase their planned gross profit margin. On the contrary, a project is considered to perform poorly financially if a project has had to reduce its gross profit margin. In other words, this thesis does not take the actual or planned gross profit margin into account but evaluates only the change to the original margin.

Financial comparison of sample projects can be seen in table 5. The original sales price is the original amount paid for the project, Original GP% stands for the gross profit margin with which the project was sold. Actual sales price is the eventual sales price at the end of the project. In case the actual sales price is bigger than the original sales price there, it means that there have been variation/change orders which typically are buying options which have been offered with the original offer which are not included in the original scope of supply. Change in SP (%) is the change of sales price, Actual GP% is the actual gross profit margin at the end of the project and the Change in GP % indicates the difference between actual and original gross profit margins.

Table 5. Financial comparison of projects

Project	Original Sales Price	Change in SP (%)	Change in GP %
Project 1	€ 876 000	5,9 %	5,3 %
Project 2	€ 722 000	9,7 %	-4,7 %
Project 3	€ 335 000	3,0 %	-3,1 %
Project 4	€ 872 000	6,0 %	1,2 %
Project 5	€ 1 045 000	8,4 %	0,3 %
Project 6	€ 1 064 000	-0,4 %	-9,2 %
Project 7	€ 1 057 000	7,9 %	-0,6 %
Project 8	€ 1 377 000	13,7 %	-3,7 %
Project 9	€ 841 000	9,8 %	-24,2 %
Project 10	€ 878 000	16,7 %	2,5 %
Project 11	€ 937 000	1,0 %	1,2 %
Project 12	€ 1 180 000	10,8 %	-10,4 %
Project 13	€ 659 000	0,0 %	-11,4 %
Project 14	€ 1 293 000	1,5 %	2,8 %
Project 15	€ 1 961 000	-0,3 %	5,1 %
Project 16	€ 892 000	3,4 %	-7,7 %
Project 17	€ 236 000	7,2 %	-14,9 %
Project 18	€ 830 000	5,8 %	-1,5 %
Project 19	€ 1 835 000	0,5 %	4,8 %
Project 20	€ 857 000	21,4 %	-22,0 %
Project 21	€ 850 000	3,6 %	1,3 %
Project 22	€ 1 241 000	9,2 %	-7,4 %
Project 23	€ 804 000	-15,8 %	14,5 %
Project 24	€ 807 000	5,9 %	1,2 %
Project 25	€ 835 000	9,5 %	5,8 %
Project 26	€ 1 050 000	17,9 %	6,4 %
Project 27	€ 785 000	5,4 %	2,1 %
Project 28	€ 920 000	5,1 %	0,1 %
Project 29	€ 749 000	4,7 %	-6,9 %
Average	*€ 958 207*	*6,12 %*	*-2,5 %*

The relationship between change in the sales price-% and change in the gross profit margin-% is studied in figure 5.

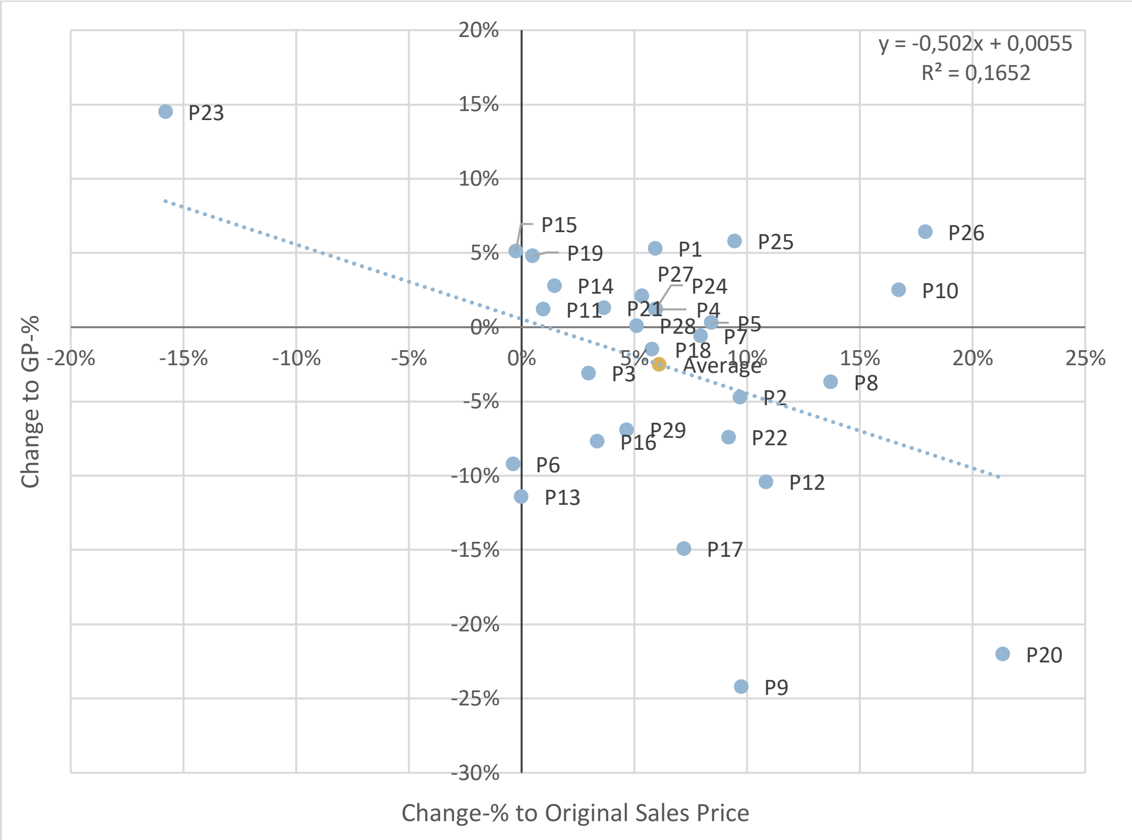


Figure 5. Correlation between Sales price change-% and GP change-%

Interestingly, the correlation between change orders and change in for profit margin is negative as shown in figure 5, meaning that projects which had more change orders were likely to result in a more negative gross profit than expected. Most notable project in figure 3 is project 23, in which firstly the sales price decreased by -15,8 % and secondly the gross profit margin increased significantly by 14,5 %. This is due to the fact that civil works were excluded from the original scope (see table 3). As P23 was notably different the same test was calculated which excluded the project in question. The result stayed virtually unchanged. Other notable project which differs from other are projects 9 and 20, which have resulted poorly financially (P9; – 24,2%, P20; -22 %) even though these projects had big sales price increases (P9; 9,8 % and P20; 21,4%). This breaks the assumption that big sales price increases cannot harm the gross profit margin significantly.

3.4.3 Scope comparison

Table 6. Comparison of project scopes

Project	VL 1 (kV)	VL 2 (kv)	CBs at VL 1	CBs at VL2	Inst. & Comm. Work	Civil Works	HV Eqmnt.	Main Transformers	MV Eqmnt.	Cont. & Prot.	Autom. Syst.	Auxiliaries	Complexity Factor
Project 1	110	33	2	9	x	-	x	0	x	x	x	x	**6,5**
Project 2	110	33	1	4	x	-	x	0	x	x	x	x	**4,5**
Project 3	33	10	8	1	-	-	-	0	x	x	-	x	**2,0**
Project 4	110	33	2	9	x	-	x	0	x	x	x	x	**6,5**
Project 5	110	33	1	4	x	-	x	1	-	x	x	x	**3,5**
Project 6	110	33	1	4	x	x	x	0	-	x	x	x	**6,5**
Project 7	110	33	1	4	x	-	x	1	-	x	x	x	**5**
Project 8	110	33	1	5	x	-	x	1	-	x	x	x	**6**
Project 9	110	20	1	8	x	x	x	1	x	x	x	x	**6,5**
Project 10	110	33	1	5	x	-	x	0	x	x	x	x	**3,5**
Project 11	110	33	1	4	x	-	x	0	x	x	x	x	**3,5**
Project 12	110	33	2	10	x	-	x	0	x	x	x	x	**3,5**
Project 13	110	33	1	4	x	-	x	1	-	x	x	x	**4,5**
Project 14	110	33	1	6	x	-	x	1	x	x	x	x	**5**
Project 15	110	33	2	10	x	-	x	2	x	x	x	x	**9**
Project 16	110	33	1	3	x	-	x	0	x	x	x	x	**3,5**
Project 17	20	0	1	0	x	-	-	0	-	-	-	-	**2,5**
Project 18	110	20	1	4	x	-	x	x	x	x	x	x	**3,5**
Project 19	110	33	2	8	-	x	x	0	-	x	x	x	**9**
Project 20	110	20	1	4	x	-	x	0	x	x	x	x	**5**
Project 21	110	20	1	4	x	-	x	1	x	x	x	x	**4**
Project 22	110	20	2	12	x	x	x	0	x	x	x	x	**9,5**
Project 23	110	33	1	4	x	**	x	0	x	x	x	x	**3,5**
Project 24	110	20	1	8	x	-	x	0	x	x	x	x	**4**
Project 25	110	20	1	4	x	-	x	1	x	x	x	x	**4**
Project 26	110	20	1	4	x	-	x	1	x	x	x	x	**4**
Project 27	110	20	1	5	x	-	x	1	x	x	x	x	**3,5**
Project 28	110	20	1	5	x	x	x	1	x	x	x	x	**6**
Project 29	110	20	1	15	x	x	x	0	*	*	*	*	**5**

*unknown, **originally included, later excluded

Table 6 introduces the scopes of the sample projects. Regarding the scopes it tells the following information:

- Voltage levels (1 & 2)

- The number of circuit breakers in each voltage level
- Installation and/or commissioning works in/out of scope
- Civil works in/out of scope
- HV equipment in/out of scope
- Number of main transformers in scope
- MV equipment in/out of scope
- Control & protection system in/out of scope
- Automation system in/out of scope
- Station auxiliaries in/out of scope

Additionally, the table includes a complexity factor, which is rating which estimates the complexity of each project based on earlier mentioned scopes and other factors such as sales price and sold hours. The factor emphasizes sales price, civil work and sold hours higher than other, as these are typically the characteristics of a complex project. Other information contributes as well, yet the contribution to complexity factor is less significant. The average of complexity factor is 5.03, minimum is 2 and maximum 9,5. Most of the projects (13) fell into bin with complexity factor between 2 and 4, meaning that most of the projects were non-complex. The number of projects with high complexity factor (6-11) were notably smaller than those with lower complexity factor. The distribution of complexity factor across project can be found in figure 6.

As figure 6 visualizes, the complexity factor of most project is relatively low. By reviewing this figure, a conclusion can be drawn that most of these projects should not cause too many issues as the complexity is not high, and thus not too demanding.

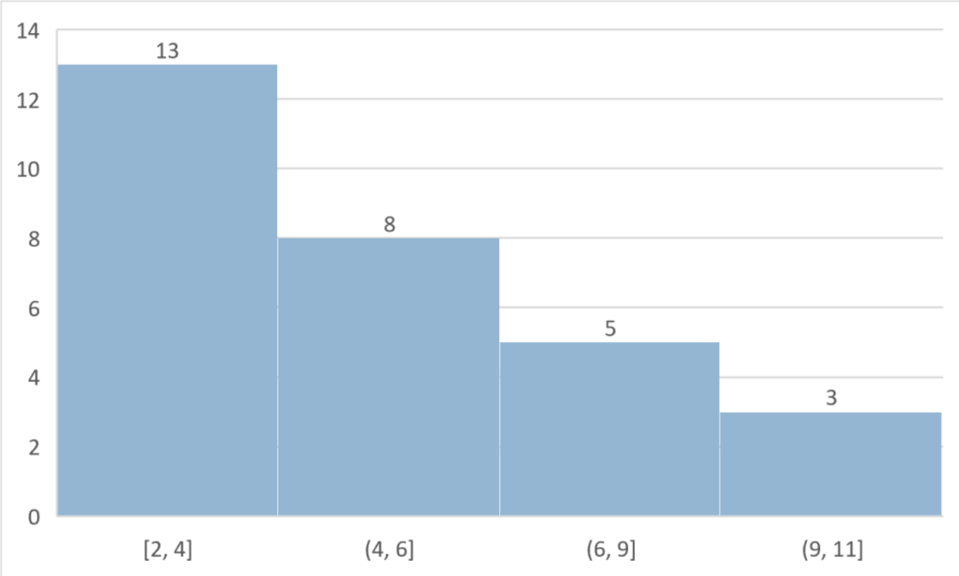


Figure 6. Complexity factor distribution.

To evaluate the correlation between project complexity and financial performance of the projects, a simple linear regression analysis is performed (figure 7). It shows that the more complex the project is based on the earlier introduced complexity factor, the more it affects negatively to the financial performance. The measure for financial performance in this test is the change in gross profit margin. The coefficient of -0,0028 represents the steepness of the line, which indicates the correlation between the variables. In this case, the coefficient shows that the more complex project in question, the more likely it is to result in a weaker financial performance than planned. Complexity factor is in x-axis and y-axis is the financial performance.

Figure 7 shows that there is quite a notable variance between these projects. It is safe to say that the performance of the projects is not very predictable, as there is plenty of variance in the performances of these projects. Moreover, this emphasizes the fact that every project is unique even though the premises should not differ significantly.

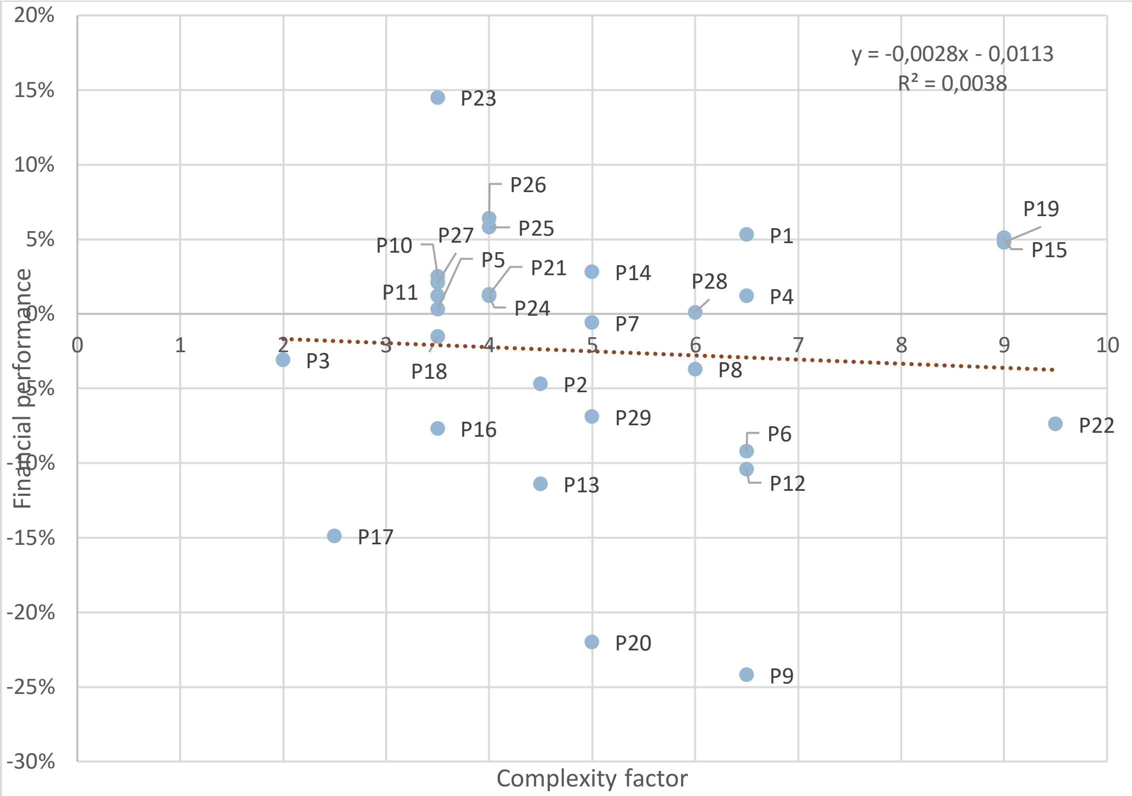


Figure 7. Correlation between project complexity and financial performance

As this thesis focuses on detecting and overcoming inefficiencies in project execution, projects which have performed poorly (financial performance under -5 %) are worth deeper evaluation. These projects sorting from lowest to highest in terms of complexity factor are Project 17, 16, 13, 20, 29, 6, 12, 9 & 22. The relationship between project complexity and the financial performance of the project in figure 7 shows, that higher complexity factor is likely to result in more negative financial performance than anticipated.

3.5 Limitations of the study

Due to the hour-evaluating approach how this study was conducted is not ideal for examining the smaller contributors' (Documentation, Civil Engineering, Project Planner and Project Controller) impact on projects. Since these functions books less hours than other functions, this paper interprets as insignificant which in reality is not the case. Even though their absolute number of hours the less significant functions are low, their impact on the projects should not be overlooked.

This paper does have only shallow insight on subcontract management and their impact to project performance, as all hour data of this thesis concerns only internal labour.

The actual impact of any cause of inefficiency is not considered in this thesis. Additionally, the discussion of potential compensation of overrun hours which change orders might cover is mostly disregarded in this paper nor does this study assess any possible financial impact what overrun hours may have induced.

4 Results & analysis

4.1 Findings

4.1.1 Hours

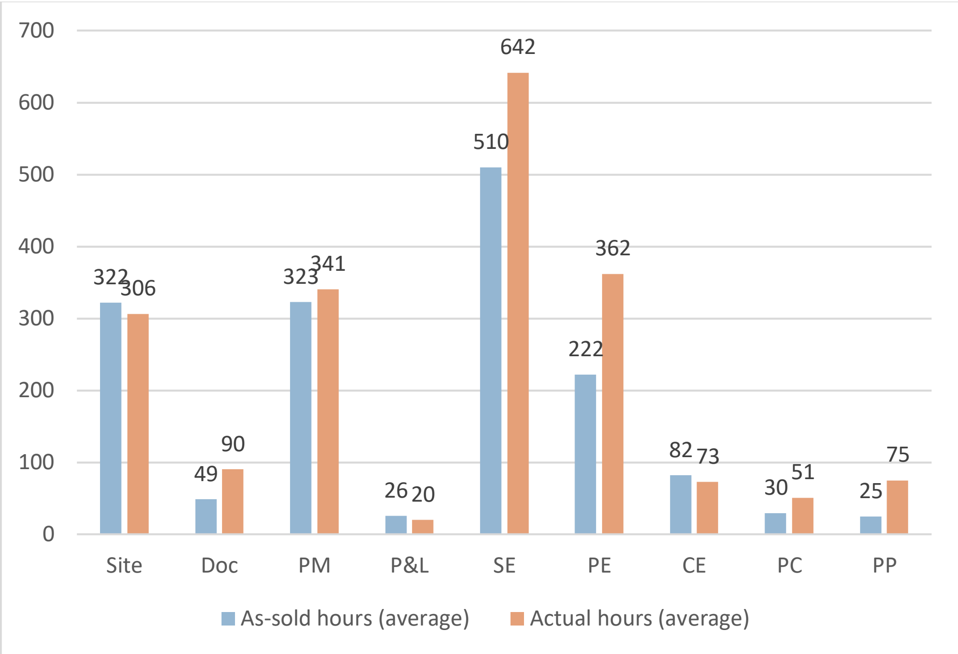


Figure 8. Comparison of average as-sold and average actual hours per function

Figure 8 contains the number of booked hours per function on average in sample projects compared to as-sold hours. This figure shows that there are two functions which draws attention by overrunning sold hours. Those being Secondary Engineering and Primary Engineering. Given the fact that Secondary Engineering has the most hours sold of all functions, the overrun is significant and is likely to contribute to the project performance. Despite Primary Engineering function has typically only fourth most sold hours, yet typically second most hours of all functions are something that requires attention.

Figure 8 overall gives the impression that might be consistent inefficiencies regarding Secondary and Primary Engineering functions. The big average overrun of Secondary Engineering combined with the fact that the Site hours stay on average below budget, might partly be explained by the fact that Secondary Engineering hours might include some Commissioning hours (which are included in Site hours in this study), because Secondary Engineers typically have a dual role as explained in chapter 3.3.2, but might not book hours precisely between the two.

The average was calculated from projects which a function had hours booked. There were few instances, where there were hours booked for some function despite not having budgeted hours at all. However, these instances were rare, and the contribution was minor. Figure 8 visualizes the average difference between each function within the sample projects. The differences between actual hours compared to as-sold hours in each function are:

- Site: 16 hours surplus (-5 % change compared to as-sold)
- Documentation: 41 hours overrun (85 %)
- Project Manager: 18 hours overrun (6 %)
- Procurement & Logistics: 6 hours surplus (-23 %)
- Secondary Engineering: 132 hours overrun (26 %)
- Primary Engineering: 140 hours overrun (63 %)
- Civil Engineering: 9 hours surplus (11 %)
- Project Controller: 21 hours overrun (72 %)
- Project Planner: 50 hours overrun (200 %)

Most notable hour overruns percentage-wise are Documentation, Project Controller and Project Planner hours. However, reflecting to the number of as-sold hours these hours are not as significant as four biggest contributing functions since the absolute number of hours does not contribute to the total hours as heavily as the most contributing functions. However, the hour overruns of these less-contributing functions should not be overlooked as although the absolute number of overrun hours are lower than the four key functions, they do contribute to the entity and additionally their influence on the project can be difficult to value. In addition, the figures of Project Planner and Project

Controller gives an impression of the demand of project managing and administration work is typically more demanding than anticipated.

Considering the four key functions – Project Manager, Secondary Engineering, Primary Engineering and Site work hours attention draws to Secondary Engineering and Primary Engineering. In proportion to the function's as-sold hours, Primary Engineering exceeds heavily (63 %) the sold hours on average. Hours-wise the overrun translates to a notable 140 hours. Secondary Engineering function's exceeding of 26 % sold hours translates to 132 hours.

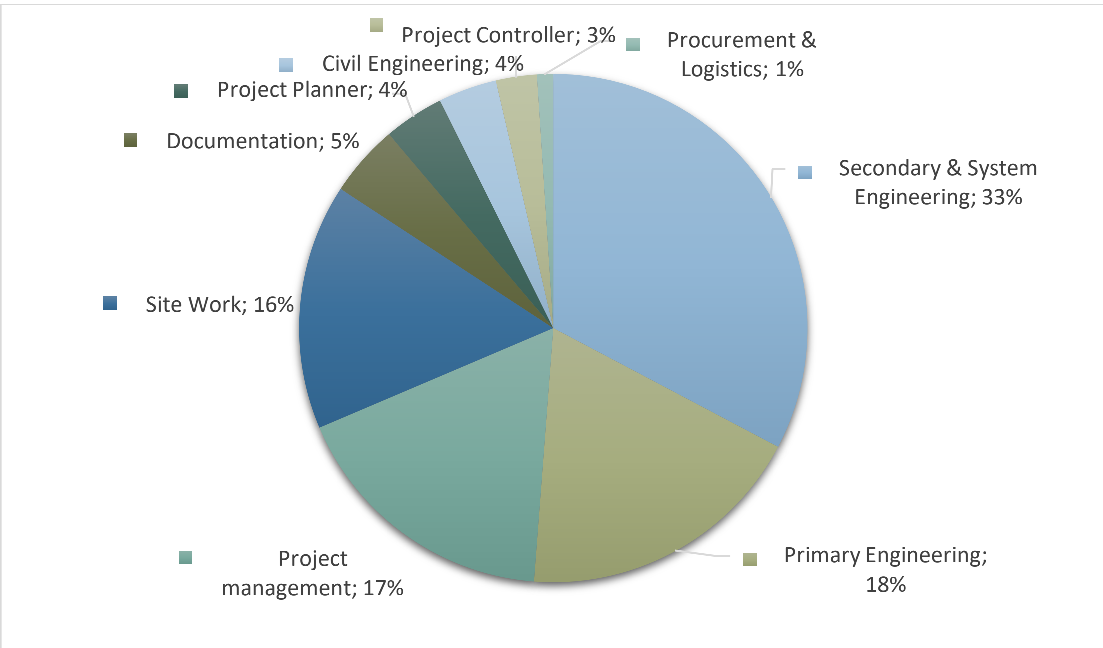


Figure 9. Share of average booked hours per function in projects

The share of average booked hours per function in sample projects can be found in figure 9. This figure visualizes the effort required in sample projects function-wise. The biggest contributors in these projects are secondary engineering with 33 % share, Primary Engineering with 19 % share, Project Manager with 18 % share and Installation, Site Management & Commissioning (Site work) with 16 % share of the total average booked hours. Other less contributing functions are Civil Engineering and Document Controlling with both 5 % share, Project Planner with 4 % share and Project Controller and Procurement & Logistics with 1 % share each.

It is safe to say that in terms of effort the project requires relies heavily to Secondary Engineering, Primary Engineering, Site work and Project Management. Alternatively, the projects are heavily dependent on the effort of these functions hours-wise. These four key functions altogether take an 85 % share of all booked hours. As the share of the other functions is low (15 %), it justifies focusing on these four core functions when studying the efficiencies and inefficiencies of the execution of sample projects.

A rather surprising finding is the relatively low share of Civil Engineering hours (5%) required of these projects. Finding suggests that there are either no significant technical matters which affects the civil design, and the design process is well established and streamlined and thus does not require significant number of hours. The variance in Civil Engineering hours is also relatively low which indicates that Civil Engineering topics are relatively predictable and encounter rarely issues which could lead up to big hour overruns.

Another relatively surprising finding is the relatively large share Primary Engineering (19%) takes. The fact that on average Primary Engineering books more hours than project managers in these types of projects, which should in general be somewhat similar in terms of technical solutions and scopes of supply. The fact that the amount of Primary Engineering is this significant suggests that the projects are not as similar technically as they are anticipated to be. The big effort might be caused by i.e. big variance of equipment used, varying suppliers and contractors which requires attention case-by-case.

The rather big discrepancy between Civil Engineering and Primary Engineering is something which could be important in the pursuit of detecting and addressing issues which causes unnecessary inefficiency. The number of hours Secondary and Primary Engineering books on average is significant comparing to the rest of the functions. Secondary

Engineering itself takes 33 % and together with Primary Engineering function together they take a 52 % share from the total average hours.

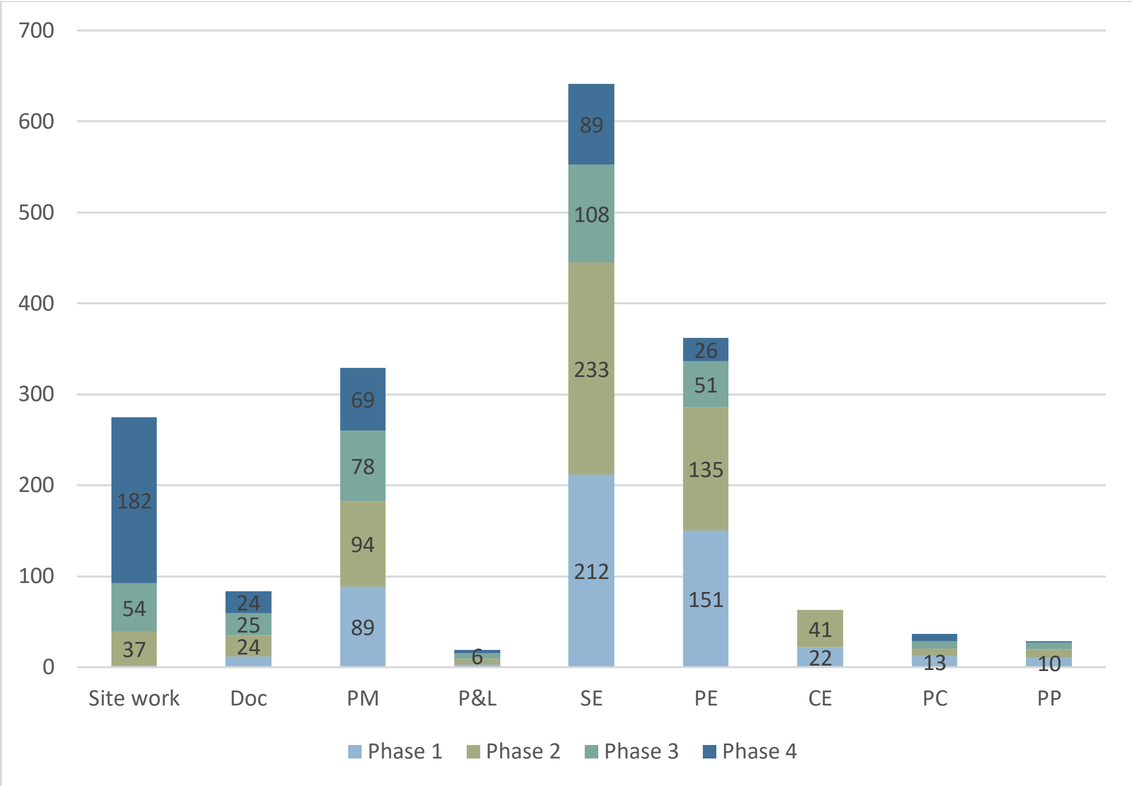


Figure 10. Phase averages per function

Figure 10 contains the average amount of each function books per phase. The numbers do not match with total actual hours as the averages were calculated by phase. It is worth noting that the total of these average is not equal to the total numbers in figure 8 due to the numbers of figure 10 are the averages of each phase and not the total numbers. However, this figure illustrates the hour usage and effort requires by each function in these projects. For instance, this figure indicates that Site work books most of its hours during phase 4 and that Secondary and Primary Engineers books most hours during phases 1 and 2, and typically not as much during other phases.

This further strengthens the significance of the roles of the four key functions, Site work, Project Management, Secondary Engineering and Primary Engineering. On the contrary, the role of other functions (Documentation, Procurement & Logistics, Civil Engineering, Project Controlling and Project Planning) can be concluded in booked hours wise as insignificant compared to the four key functions. However, even though the absolute number of hours the less significant functions are low, their impact on the projects should not be overlooked. The way this study was conducted is not ideal for examining their impact on projects, and thus this paper interprets their role as insignificant, even though in reality this might not be the case.

After evaluating the averages of each function and how each function books hours on average, the total sold hours and total actual hours of each project is presented. This information can be found in figure 11. Figure 11 illustrates that there are considerable variances firstly in the amounts of hours sold for each projects and secondly some exceptionally big differences in sold and actual hours. For instance, projects 6, 12, 20, 22, 24 and 29 stands out from others due to their total actual hours.

Conversely, projects 1 and 19 differs from others by showing that these stayed in the budgeted hours by a fairly notable margin. However, this is not usual, and it is in fact safe to draw conclusions based on this figure that the majority of the projects booked more hours than budgeted, in some cases even by somewhat significant margin.

Once the review and comparison of total as-sold hours and actual hours per project was studied, it was time to investigate how many hours were sold, or alternatively estimated, for each function and how many hours each function booked. These results can be found in image 3 and the variance between each function can be reviewed in table 7.

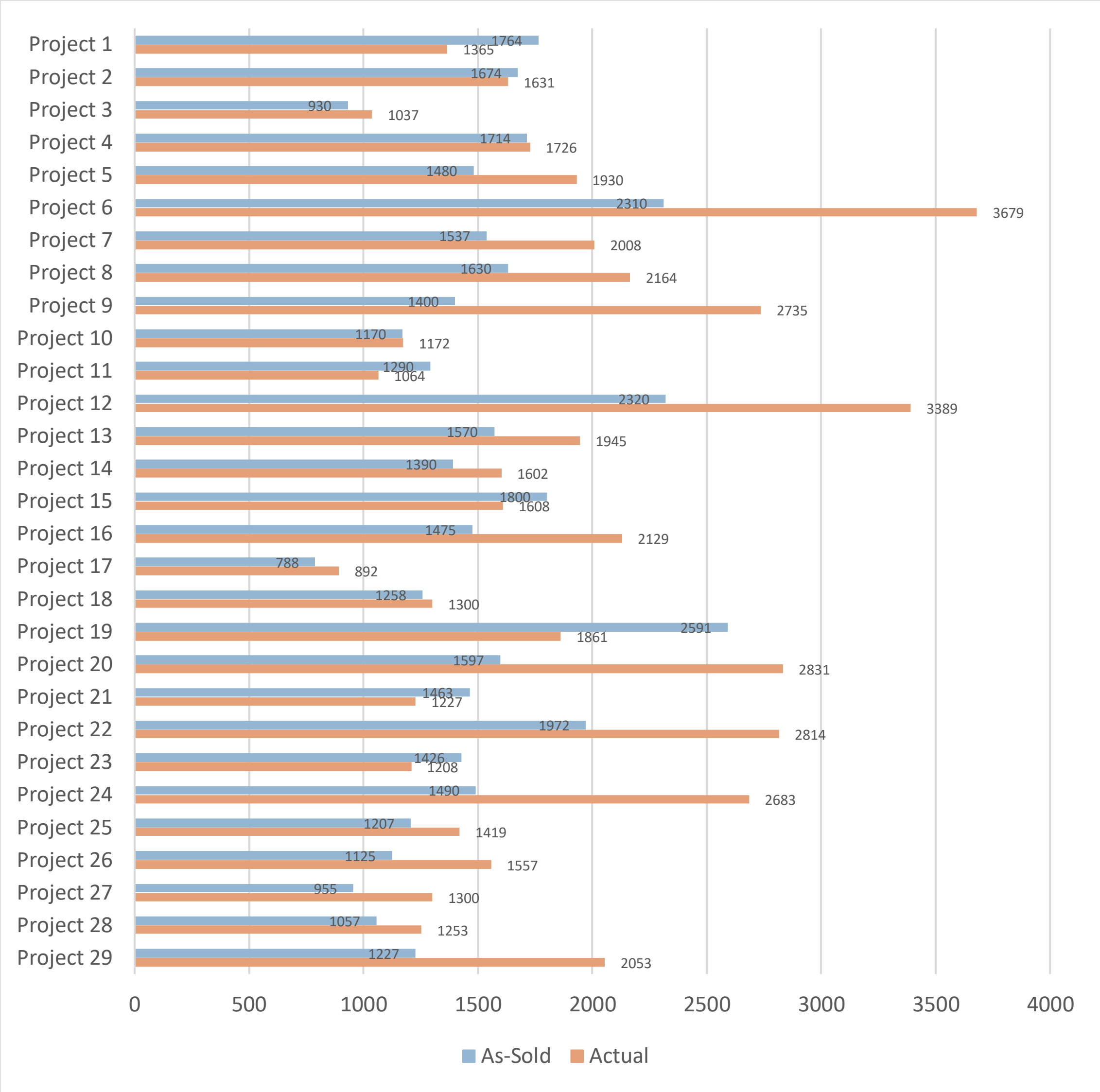


Figure 11. Total as-sold hours vs. actual hours per project

	PM		SE		PE		CE		Site		Doc		P&L		PP		PC		Tot.	
	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A
P1	400	312	450	250	300	475	114	31	370	0	50	171	40	34	20	40	20	53	**1764**	**1365**
P2	400	286	450	337	300	528	94	56	300	118	50	174	40	43	20	44	20	46	**1674**	**1631**
P3	280	131	360	757	100	47	80	33	0	0	40	35	70	30	0	0	0	5	**930**	**1037**
P4	400	338	400	308	300	408	114	34	370	282	50	193	40	66	20	41	20	58	**1714**	**1726**
P5	300	371	400	363	280	421	100	70	300	296	60	235	0	0	0	106	40	70	**1480**	**1930**
P6	500	745	600	1213	600	661	250	91	270	420	50	342	0	25	0	142	40	41	**2310**	**3679**
P7	315	363	430	385	280	496	100	80	312	322	60	199	0	0	0	94	40	71	**1537**	**2008**
P8	400	429	450	316	300	700	100	125	300	390	40	130	0	0	0	0	40	75	**1630**	**2164**
P9	300	623	400	707	250	558	120	174	250	308	40	88	0	21	0	73	40	184	**1400**	**2735**
P10	225	151	410	314	175	359	50	76	250	154	40	20	0	2	0	66	20	32	**1170**	**1172**
P11	225	157	410	226	275	280	50	124	270	127	40	40	0	2	0	68	20	42	**1290**	**1064**
P12	345	573	840	792	370	756	200	154	400	658	85	223	0	0	40	124	40	110	**2320**	**3389**
P13	400	340	450	745	250	253	120	204	250	208	60	98	0	0	0	30	40	68	**1570**	**1945**
P14	350	478	400	393	200	374	100	105	250	117	40	13	25	68	0	0	25	56	**1390**	**1602**
P15	400	320	600	490	300	363	120	56	300	268	60	3	0	50	0	0	20	60	**1800**	**1608**
P16	300	314	635	787	230	453	60	19	180	431	50	46	0	20	0	0	20	60	**1475**	**2129**
P17	214	180	328	481	40	61	20	0	166	92	0	51	20	20	0	0	0	8	**788**	**892**
P18	300	202	503	722	150	341	50	0	245	0	0	0	10	29	0	0	0	8	**1258**	**1300**
P19	541	397	770	638	250	323	50	0	960	434	20	2	0	51	0	0	0	16	**2591**	**1861**
P20	210	497	450	1246	50	256	0	8	887	725	0	79	0	21	0	0	0	0	**1597**	**2831**
P21	280	200	746	613	146	213	40	27	236	139	0	35	15	0	0	0	0	1	**1463**	**1227**
P22	374	377	852	1576	226	492	100	67	420	292	0	0	0	0	0	0	0	12	**1972**	**2814**
P23	430	304	504	490	146	172	40	40	286	197	0	5	20	0	0	0	0	0	**1426**	**1208**
P24	410	374	540	1265	146	527	40	128	344	362	0	27	10	1	0	0	0	0	**1490**	**2683**
P25	214	274	597	687	196	219	40	0	160	203	0	37	0	0	0	0	0	0	**1207**	**1419**
P26	164	371	587	630	146	391	40	27	178	122	0	16	10	0	0	0	0	0	**1125**	**1557**
P27	170	275	370	628	146	134	21	32	248	190	0	42	0	1	0	0	0	0	**955**	**1300**
P28	242	250	437	550	146	115	40	43	192	265	0	30	0	1	0	0	0	0	**1057**	**1253**
P29	275	252	418	705	130	126	40	22	314	848	40	99	10	2	0	0	0	0	**1227**	**2053**
*A**	*323*	*341*	*510*	*642*	*222*	*362*	*82*	*73*	*322*	*306*	*49*	*90*	*26*	*20*	*25*	*75*	*30*	*51*	***1504***	***1848***

Image 3. As-sold & actual hours per function per project.

Image 3 shows the hours used in different projects compared to the time that was budgeted for different functions. P represents the project, S stands for sold/budgeted hours and A stands for actual hours that were actually booked. A* shows the average calculated excluding 0 values, which is worth noting. The same data is used in table 7, which indicates the variance of the two. Whereas this image is not optimal to compare the figures, it shows the actual figures which have been estimated and what was the reality. Table 7 or more suitable for illustrating the differences in these figures.

Table 7. Variance in as-sold vs. actual hours of all projects by function

Project	PM	SE	PE	CE	Site	Doc	P&L	PP	PC	Total
Project 1	-88	-200	175	-83	-370	121	-7	20	33	-399
Project 2	-114	-114	228	-38	-182	124	3	24	26	-43
Project 3	-149	397	-54	-47	0	-5	-40	0	5	107
Project 4	-62	-93	108	-80	-88	143	26	21	38	12
Project 5	71	-38	141	-31	-4	175	0	106	30	450
Project 6	245	613	61	-159	150	292	25	142	1	1369
Project 7	48	-45	216	-21	10	139	0	94	31	471
Project 8	29	-135	400	25	90	90	0	0	35	534
Project 9	323	307	308	54	58	48	21	73	144	1335
Project 10	-74	-96	184	26	-97	-20	2	66	12	2
Project 11	-68	-185	5	74	-143	0	2	68	22	-226
Project 12	228	-49	386	-46	258	138	0	84	70	1069
Project 13	-60	295	3	84	-42	38	0	30	28	375
Project 14	128	-8	174	5	-134	-28	43	0	31	212
Project 15	-81	-110	63	-65	-32	-57	50	0	40	-192
Project 16	14	152	223	-41	251	-5	20	0	40	654
Project 17	-34	153	21	-20	-74	51	0	0	8	104
Project 18	-99	219	191	-50	-245	0	19	0	8	42
Project 19	-144	-132	73	-50	-526	-19	51	0	16	-730
Project 20	287	796	206	8	-162	79	21	0	0	1234
Project 21	-81	-133	67	-13	-98	35	-15	0	1	-236
Project 22	3	724	266	-33	-129	0	0	0	12	842
Project 23	-127	-14	26	0	-89	5	-20	0	0	-218
Project 24	-36	725	381	88	18	27	-9	0	0	1193
Project 25	60	90	23	-40	43	37	0	0	0	212
Project 26	207	43	245	-13	-56	16	-10	0	0	432
Project 27	105	258	-12	11	-58	42	1	0	0	345
Project 28	8	113	-31	3	73	30	1	0	0	196
Project 29	-23	287	-4	-18	534	59	-8	0	0	826
Average	*18*	*132*	*140*	*-16*	*-36*	*54*	*6*	*25*	*22*	*344*

The variance between as-sold and actual hours by functions can be seen in table 7. Positive numbers indicates the amount hours which exceeded budgeted hours and negative numbers indicates the amount of hours which was left in the budget. For example in project 5 the Project Manager actual hours was higher than as-sold (71 hours), meaning that Project Manager booked more hours than was sold for the project. On the contrary, in the same project booked Secondary Engineering hours stayed within the as-sold hours and thus the number is negative (-38 hours).

Overall, the actual booked hours for most roles are higher than the budgeted hours, indicating that the projects required more time and effort than initially estimated. The estimation of required effort can be interpreted to have poor conciseness, because ideally all figures in table 7 should be 0. An interesting finding is what bottom row, the average, shows; there are basically consistent overruns in every function excluding Civil Engineering and Site work. The total overrun of 344 is also notable and it is an indication that there are some recurring causes of inefficiency which results in an overrun of hours.

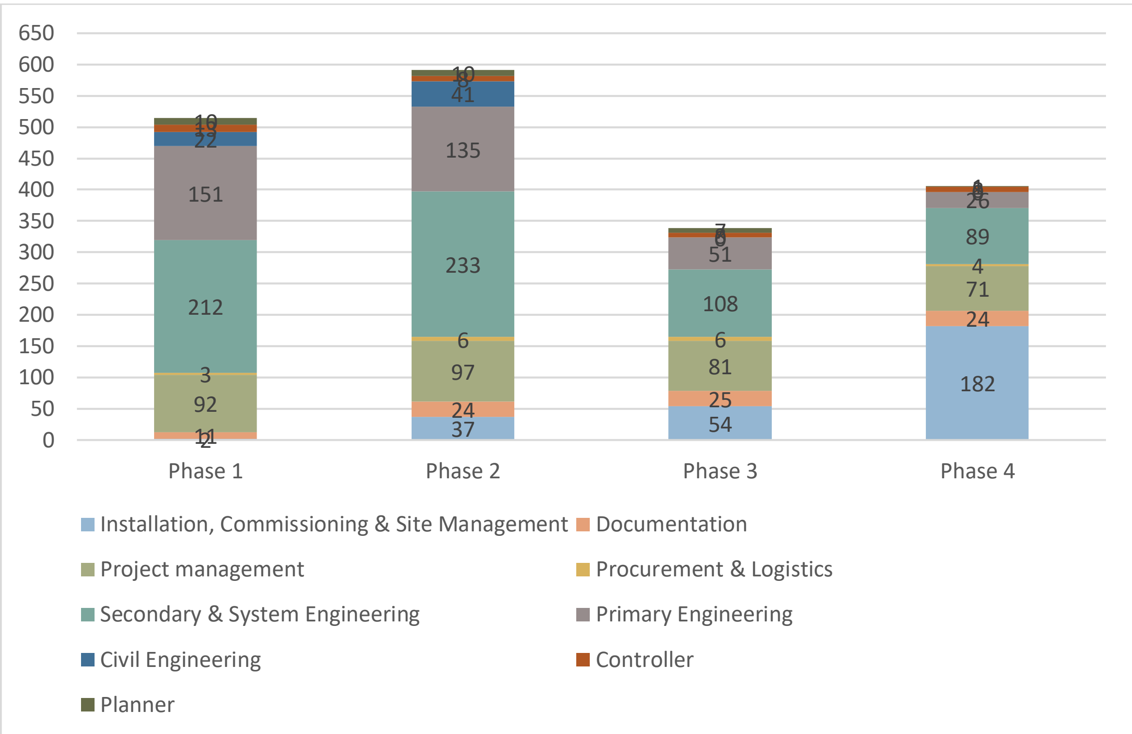


Figure 12. Phase-specific average booked hours per function.

Figure 12 illustrates the average effort required from each function during the project. The most hour-demanding phase of these projects is phase 2 with total hours booked on average being 591 hours. Second most demanding phase is phase 1 with 515 total hours, third most demanding phase is phase 4 with 406 total hours and the least demanding phase is phase 3 with 339 booked hours on average. This figure visualizes that effort-wise phases 1 and 2 are more demanding than phases 3 and 4. Notably, phase 2 requires almost double the number of hours on average than what phase 3 requires.

4.1.2 Relationship between hours & financial performance

Table 8. Dataset to run a Chi-squared and Fisher's exact test for sample projects.

	Projects, increased GP-%	Projects, decreased GP-%
Projects, actual hours > sold hours	9	13
Projects, actual hours < sold hours	6	1

Table 8 tells the amount of projects which has either increased or reduced gross profit margin to the original gross profit margin and which of those projects exceeds or stays within the sold hours. Additionally, this table is used to perform a chi-squared test and Fisher's exact test to investigate a possible relationship between hour overruns and change in gross profit margin. Projects which exceeded sold hours had more often gross profit margin reduced (13 projects) rather than increased (9 projects). Projects which stayed within sold hours were more likely to have an increase in gross profit margin (6 projects) rather than reduced margin (1 project).

To investigate the potential relationship between the projects with overrun hours and projects with change in gross profit margin, a chi-squared test was run with a simple python program (Programme 1) using SciPy library, which is commonly used in various fields of professionals in solving scientific problems (Weckesser & Haberland, 2019).

The null hypothesis H_0 for this test is that there is no relationship ($p \geq 0{,}05$) between project hour overruns and the change in gross profit margin. The alternative hypothesis H_a is that there is a relationship ($p < 0{,}05$) between them. The chosen significance level, p-value, of 0,05 (5 %) is commonly used (Majaniemi & Majaniemi, 2008) in hypothesis testing, and thus selected for this test. This significance level is interpreted as evidence to either reject or accept the null hypothesis.

$$H_0 : p \geq 0{,}05$$
$$H_a : p < 0{,}05$$

```
from scipy.stats import chi2_contingency

# Define the observed data
observed_data = [[9, 13], [6, 1]]

# Perform chi-squared test
chi2, p_value, dof, expected = chi2_contingency(observed_data)

# Print the results
print("Observed data", observed_data)
print("Chi-squared statistic:", chi2)
print("P-value:", p_value)
print("Degrees of freedom:", dof)
print("Expected frequencies:", expected)
```

Programme 1. Chi-squared test

The test run with above information as the dataset gives the following result for the p-value.

$$p \approx 0.103$$

As chi-squared test gives the result of $p \geq 0{,}05$, H_0 cannot be rejected. Thus, the result of performed chi-squared test shows that there is no relationship between project hour overruns and the change in gross profit margin. However, although chi-squared test is well-known and an established method for hypothesis testing, it is not ideal for small sample sizes (Bearden et al, 1982). Thus, a Fisher's exact test, which is more suitable for smaller sample sizes (Campbell & Freeman, 2007), is also performed to further validate the results. The same H_0 and H_a applies. The test is performed in python, similarly as chi-squared test (Programme 2).

```
from scipy.stats import fisher_exact

# Define the observed data
observed_data = [[9, 13], [6, 1]]

# Perform Fisher's exact test
odds_ratio, p_value = fisher_exact(observed_data)

# Print the results
print("Odds ratio:", odds_ratio)
print("P-value:", p_value)
```

Programme 2. Fisher's exact test

Fisher's exact test returns

$$p \approx \ 0.08$$

As $p \geq 0{,}05$, H_0 cannot be rejected with Fisher's exact test either. This further strengthens the same result as chi squared test that there is no relationship between project hour overruns and the change in gross profit margin in sample projects. This is an interesting finding, especially considering that the project complexity factor and gross profit margin change had a negative correlation, which means that the more complex project, the more likely the project is the result in a weaker than expected performance financially. In conclusion, hour overruns as such do not have a relationship to project performance, but complexity factor affects negatively to it.

4.1.3 Inefficiencies

To facilitate a deeper evaluation of sample projects the projects were grouped into three groups based on actual hour overrun/surplus compared to sold hours. Group A consists of projects which's actual hours stayed within sold/budgeted hours. Those projects are projects 1, 2, 11, 15, 19, 21 and 23. Group B consists of those projects where the hour overrun was less than the average overrun/surplus (24 % overrun) compared to sold hours in all projects. Group B projects are: 3, 4, 5, 7, 10, 13, 14, 17, 18, 25 and 28. Group C projects are those projects which had bigger overrun than average (24 %) compared to sold hours. Group C projects are: 6, 8, 9, 12, 16, 20, 22, 24, 26, 27 and 29. Generally summarizing Group A represents the projects which stayed in sold hours, Group B represents the projects which overrun sold hours by somewhat justifiable margin (=less than average) and Group C is the projects which overrun the sold hours by a significant margin. After projects were divided into these three groups based on the difference to sold hours, a comprehensively illustrative cluster graph was formed in figure 13.

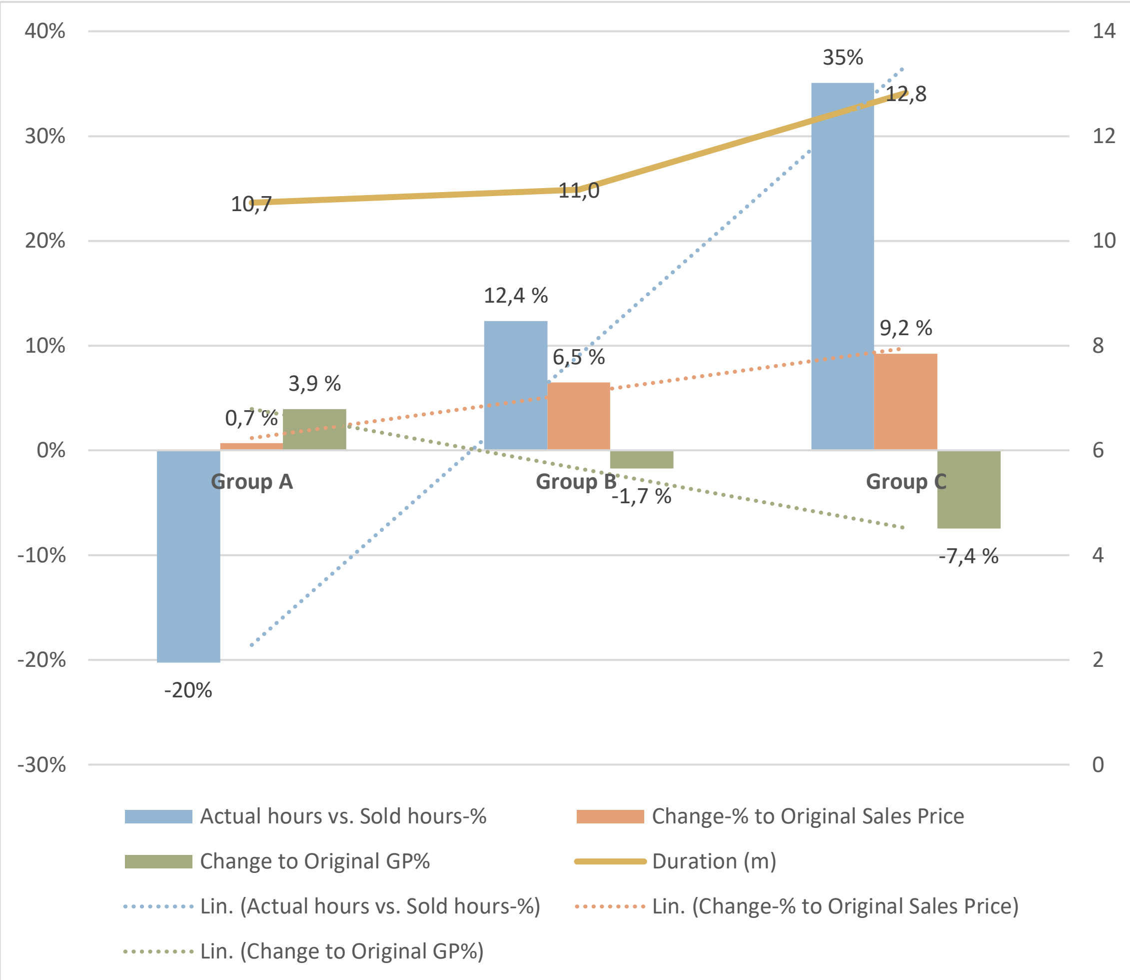


Figure 13. Comparison of projects by groups

Contrary to earlier chi squared and Fisher's exact tests, figure 13 demonstrates that there is an evident correlation between used hours and the performance. This is because this figure considers the amount of hour overruns and the increase/decrease of GP margin, whereas neither of the two test takes those into account. Those projects which stayed in the budgeted hours (Group A) were able to increase their gross profit margin on average 3,9 %, whereas Group B and C were not able to do. In fact, Group B and C projects had to decrease the gross profit margin, Group B by 1,7 % and Group C by 7,9 % on average.

Thus, it is fair to say that the more hours go over the budget, the more likely is the project to reduce the gross profit margin, resulting even in negative gross profit. This figure proves that the more hours are booked than sold, the longer project is likely to take, and the weaker financial performance is expected. Interestingly, this figure indicates that even though the amount of additional sales (variation orders) is higher, it is more likely to result a weaker outcome hours and gross profit wise rather than increasing the gross profit margin. To put another way, projects which had significant overruns in hours compared to what was sold, had bigger increase in their sales price, yet biggest decrease in gross profit margin. In addition, the duration of these projects where on average longer than the average of all projects combined.

Naturally, the possible outcome of ultimate result whether a project is unprofitable is dependent on the planned gross profit margin. An example for illustrative purposes; if an average Group C project has a planned gross profit margin of 10 %, the decrease of 7,9 % to the original 10 % gross profit margin would still result a gross profit for the project. This is however not the focus of this study, as sales-related matters are out of this thesis' scope.

Additionally, the commonly mentioned effect of project duration to project performance in project management literature can be also seen in figure 13. The durations are longer in those projects which had more actuals hours than sold hours, which suggests that prolongation of these projects might affect negatively to project performance although it is difficult to clearly separate if longer duration is the cause or consequence, both or neither. However, the investigation of causality of these subjects is not the focus of this thesis.

Figure 14 shows that the biggest contributors for hour overruns are likely to be Secondary Engineering and Site work. On average, Secondary Engineering booked in phase 1 nearly as much as Group A projects booked in first three phases combined. It is no surprise that group C projects stands out significantly compared to groups A and B.

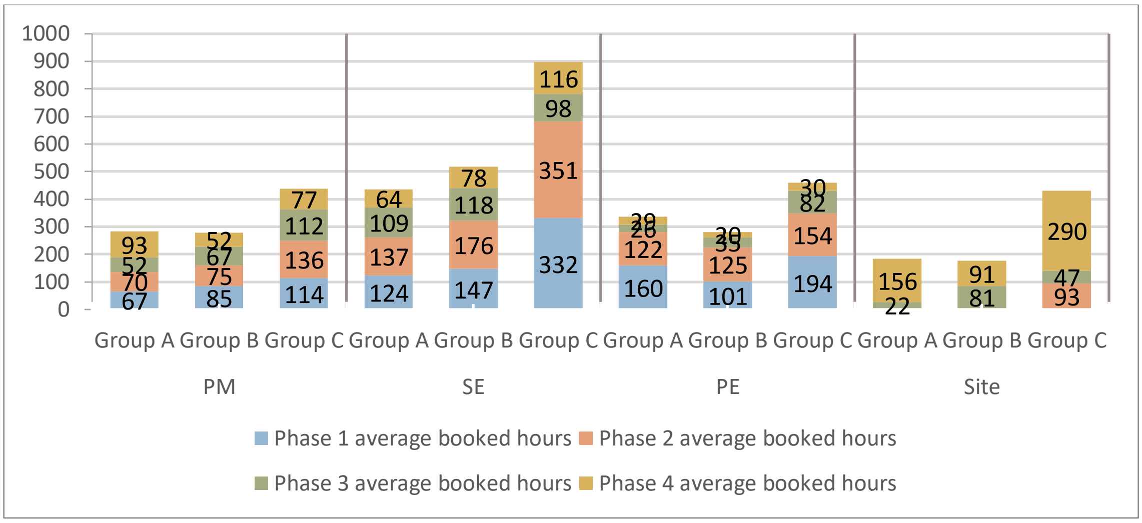


Figure 14. Group comparison, average booked hours per function

As figure 14 shows, there is a remarkable difference in hours from group C to group A and B. After comparing hours by group, it is worth to have a deeper look into group C projects to investigate are there any significant differences inside the group C projects in figure 15.

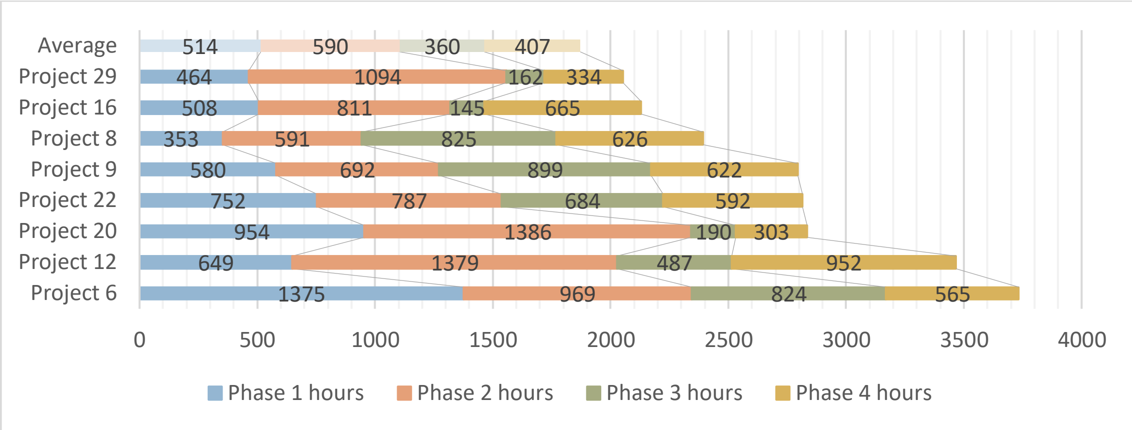


Figure 15. Group C projects, booked hours (all functions)

Figure 15 visualizes the differences of poorly performing projects (group C) hour-wise compared to the average of all sample projects. This figure contains hours from all functions combined. The figure 15 represents thus the projects from which it is possible to study whether there lie any inefficiencies. Projects 8, 9, 22 and 6 had notably higher hour bookings in the third phase compared to the average. From this figure, especially the following projects and phases stands out, considering the average structures, average hour usage of the projects and the weight of phases in proportion to other phases:

- Project 29: phase 2 – evidently most consuming phase
- Project 8: phase 3 – untypically demanding phase
- Project 9: phase 3 - untypically demanding phase
- Project 20: phase 2 – evidently most consuming phase
- Project 12: phase 2 and phase 4 – very high amount of hours
- Project 6: phase 1 – exceptionally high amount of hours

Projects 24, 26 and 27 from the Group C were excluded from figure 15, as those projects were able to cover overrun hours with change orders, and in fact resulted in an increased gross profit margin. The exclusion the three projects is a illustrative example of that if the original budgeted hours are not excepted to be sufficient, it is important to be able to cover the hours be change orders. It is very likely that if these three projects would have performed poorly if those would have not been able to cover the costs with change orders caused by unforeseen amount of labour.

Once the differences in phases were detected in figure 15, a more detailed review of how each function contributed to certain phases are presented in figure 16.

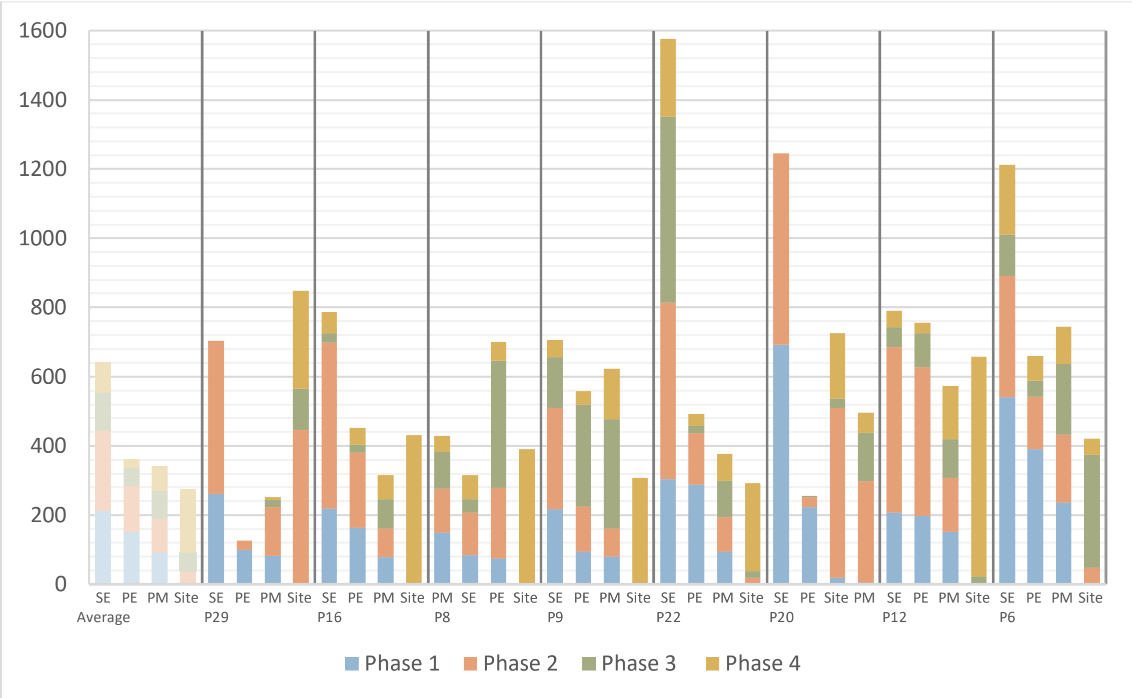


Figure 16. Key function phase-specific contribution to Group C projects

To compare the findings from figure 16 to figure 15:

- Project 29: phase 2: High contribution by SE and Site work (most likely commissioning)
- Project 8: phase 3: PE stands out, which is not typical.
- Project 9: phase 3: Untypically, PE and PM stand out.
- Project 20: phase 2: Notably high contribution by SE, Site and PM.
- Project 12: phase 2 and phase 4: Large number of hours by SE and PE during phase 2, exceptionally large number of hours consumed at site during phase 4.
- Project 6: phase 1: Considerably large number of hours required for SE, PE and PM.

Findings indicate that Secondary Engineering related issues are probable in Projects 29, 20, 12 and 6. Primary Engineering related issues are probable in Projects 8 and 9. Site issues are probable in Projects 29, 20 and 12, and Project Management related issues are likely in Projects 9, 20 and 6.

Interestingly, whereas Project 22 does not stand out in figure 15 in terms of how hours have distributed between phases, it certainly does stand out in figure 16 by quite a margin.

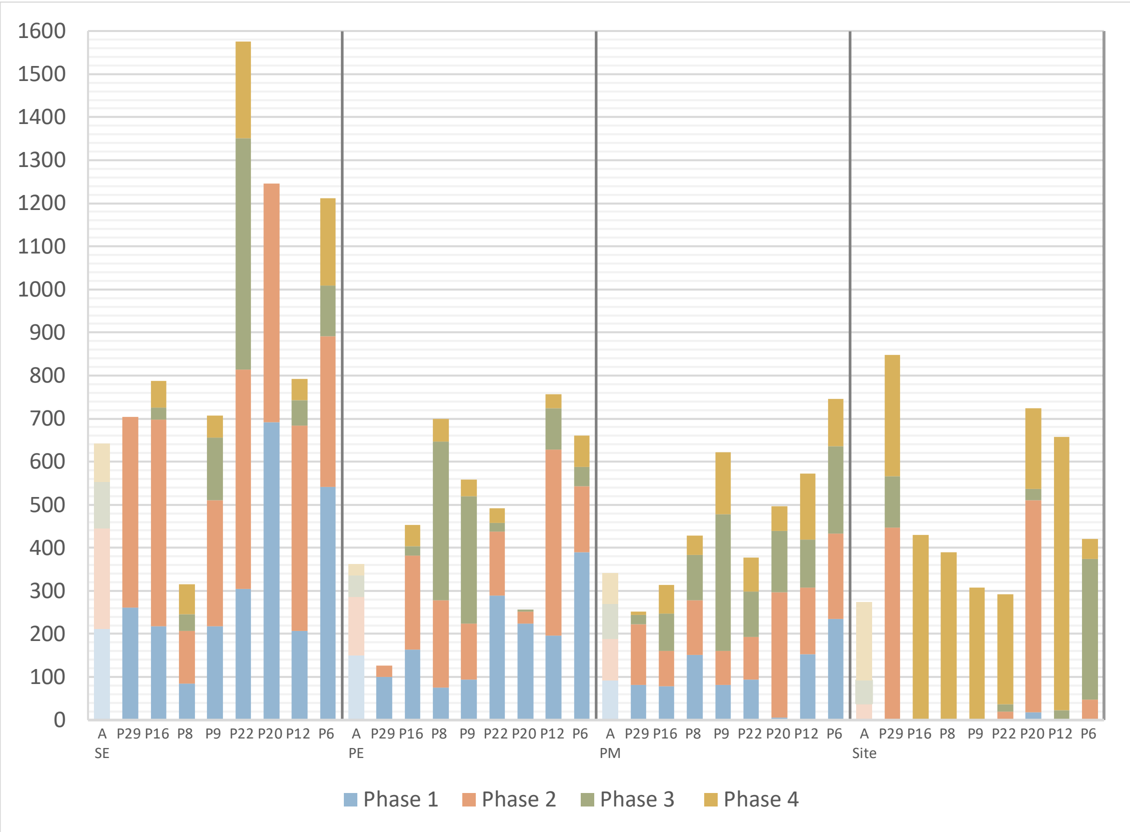


Figure 17. Comparison of key function phase-specific hour usage from poorly performed projects.

Project 29:

- Secondary Engineering: number of hours and timing reasonable. No hours booked in phases 3 and 4, which might be included in Site hours (commissioning).

- Primary Engineering: number of hours very low compared to average, timing reasonable.
- Project Management: number of hours relatively low, timing reasonable
- Site work: number of hours very high (over three times the average) and timing is atypical.

Project 16:

- Secondary Engineering: number of hours and timing reasonable
- Primary Engineering: number of hours and timing reasonable
- Project Management: number of hours and timing reasonable and below average
- Site work: number of hours reasonable, timing neutral.

Project 8:

- Secondary Engineering: number of hours very low (half the average), timing reasonable
- Primary Engineering: number of hours high, and timing atypical. In phase 3 the same number of hours than PE books on average in the whole project.
- Project Management: number of hours neutral, timing reasonable.
- Site work: number of hours somewhat higher than average, timing neutral.

Project 9:

- Secondary Engineering: Near average amount and timing wise.
- Primary Engineering: Higher than average by a notable margin, timing also atypical – heavy on phase 3.
- Project Management: Nearly two times the average, timing neutral, moderately heavy during phase 3.
- Site work: Neutral amount and timing wise

Project 22:

- Secondary Engineering: Significant overruns across all phases. Phase 1 most neutral, but remaining phases exceptionally high number of hours, timings atypical
- Primary Engineering: Phase 1 notably higher hours than average, otherwise more or less neutral.

- Project Management: Neutral amount and timing wise
- Site work: Neutral – near average

Project 20:

- Secondary Engineering: Exceptionally high amount wise. Phase 1 took more hours than an average project in total. Interestingly, all hours are timed in phase 1 and 2. The fact that SE did not have any hours booked in phases 3 & 4 indicates that all remaining hours were booked under Site work.
- Primary Engineering: Hours: less than average, abnormally most hours in phase 1.
- Project Management: Hours: notably higher than average, especially in phase 2. Timing: somewhat atypical, hours timed later than on average.
- Site work: Significantly higher than average due to phase 2, which is untypical.

Project 12:

- Secondary Engineering: Somewhat neutral overall, but phase 2 notably heavy (double the phase 2 average) compared to other phases.
- Primary Engineering: Significantly more hours than average due to phase 2. Overall, over two times the average. Timing-wise: heavy at phase 2, otherwise neutral.
- Project Management: Amount-wise fair overrun, whereas timing is neutral, slightly heavy at phase 4.
- Site work: Significantly higher than the average. Nearly three times the average. Timing-wise neutral, but hours are exceptionally high.

Project 6:

- Secondary Engineering: Significantly high number of hours (two times the average). Timing wise (or distribution of hours) somewhat neutral, yet phases 1 and 2 have drastically more hours than the average.
- Primary Engineering: Significantly higher than average. In phase 1 over two times the average.
- Project Management: Significantly higher than average (over two times the average), timing wise neutral
- Site work: Amount wise higher than average, most hours in phase 3, which is

untypical.

Following the analysis based on figures 16, 17 and 18, to set up the investigation of probable inefficiencies in these projects, a rating system is formed to estimate the probability of finding inefficiencies in table 9, which is the basis for reviewing each project individually. Rating scale from 1-5 is used, where 1 is unlikely (neutral) and 5 is very likely (high overruns and/or untypical timing). The probability ratings were assessed based on analysis of each project above.

Table 9. Probability rating assessment for detecting inefficiencies.

Project	SE	PE	PM	Site
P29	2	1	1	5
P16	2	2	1	3
P8	1	4	2	3
P9	1	3	4	2
P22	5	2	1	1
P20	5	1	3	5
P12	2	5	3	4
P6	5	4	4	3

Table 10. Distribution of all project hours between phases (% variance compared to average).

Project	Phase 1	Phase 2	Phase 3	Phase 4
P29	-5 %	22 %	-11 %	-5 %
P16	-4 %	7 %	-12 %	10 %
P8	-13 %	-7 %	15 %	4 %
P9	-7 %	-7 %	13 %	1 %
P22	-1 %	-4 %	5 %	-1 %
P20	6 %	17 %	-13 %	-11 %
P12	-9 %	8 %	-5 %	6 %
P6	9 %	-6 %	3 %	-7 %
Average distribution of total project hours	27 %	32 %	19 %	22 %

Whereas the probability ratings are assessed by focusing on individual functions and comparing each function to other projects, the overall hour distribution of all functions are not considered. Thus, to avoid drawing conclusions based on solely on focusing on individual functions, the bigger picture is important to consider as well. To evaluate notable differences and thus possible inefficiencies which the information from table 9 is not able to provide, the differences are studied in table 10. It indicates how hours distributes during the project and additionally highlights the variance between projects. A notable difference is considered in this case 10 % compared to average which is shown in bottom row. In this case, based on table 10, the projects which are likely to have inefficiencies in different phases are: projects 20 and 29 in phase 2, projects 9 and 8 in phase 3 and project 16 in phase 4.

After conducting analysis based on tables 9 and 10, supported by the findings from figures 16, 17 a more detailed investigation on project detail level was performed as described in chapter 3.2. Causes of inefficiencies can be found in table 12. However, before reviewing and analyzing the results of table 12, a short summary of findings is formed in table 11 to provide information of what are expected to be the causes of inefficiencies and to investigate whether those expectations align with the actual recognized causes of inefficiencies.

Table 11. Expected causes of inefficiencies

Project	P6	P12	P20	P22	P9	P8	P16	P29
Expectations	Heavy SE issues	PE related issues + notable site issues	Serious SE problems, Site issues	Serious SE problems	Some, yet not serious design issues	Untypical PE issues	No inefficiencies or minor issues at site	Notable issues
Phase	1 & 2	4	1, 2 & 4	All	3	3	(4)	4
Based on	Extremely high SE hours.	Lots of PE hours in general + high PE probability rating, lots of Site hours	Extremely high SE hours, probability rating	Sizable SE hours throughout whole project	Lots of hours from 3 functions	Untypically lots of PE hours, probability rating	No considerable signs of inefficiencies	Lots of site hours

The recognized and identified causes of inefficiencies can be found in table 12.

- X = confirmed cause of inefficiency
- / = unconfirmed but likely cause of inefficiency,

- (number) = phase(s) in which the cause of inefficiency emerged and/or had an impact to.

Table 12. Recognized and identified causes of inefficiencies.

Cause of inefficiency	P6	P12	P20	P22	P9	P8	P16	P29
Internal								
Design-related issues – Secondary	X	X			X			X(2)
Design-related issues - Primary & Civil	/			X (4)	X			
Installation & Commis-sioning-related issues	X (3/4)	X (4)		X	X (4)	/ (4)	X (4)	X (3/4)
Resource experience or competence		X (4)	X				X (1/2)	
Resource unavailability			X				X	
Underestimation of complexity			X					
Underestimation of re-quired effort		X (3-4)	X (3/4)	/ (1)	X			
External								
Supplier/subcontractor quality/competence							X (3/4)	
Supplier-originated is-sues	X (3/4)	X	X		X			
Component malfunction	X (3/4)				X			
Delay in receiving specifi-cations		X (1)						
Prolonged client design review		/ (1-2)						
Inadequate communica-tion by the client		X			/			
Both/unidentifiable								
Quality of documenta-tion							X (4)	
Unclear client or tech-nical requirements	X		X (1/2)					
Unclear or imprecisely defined scope		X (4)						

Project 6: Heavy SE issues were expected, were caused by external factors, where a component malfunctioned, which again explains the big overrun of SE hours.

Project 12: PE-related issues were expected as well as issues at site. Causes of inefficiencies were due to a combination of unclarity regarding scope, inadequate communication by the client and delays in receiving specifications. Underestimation of required effort and resource competence were also confirmed as causes of inefficiencies.

Project 20: Interestingly, serious problems were expected regarding especially Secondary design and Site work, it seems that instead of internal issues, external issues in form of supplier-related issues combined with unclear requirements were the confirmed causes of inefficiencies and the reasons for higher workload than estimated in this project.

Project 22: Serious SE problems were expected throughout the whole project. Turns out that there were issues detected regarding Primary Engineering design which might have somehow affected SE hours. However, the number of identified causes of inefficiency is low due to inadequate document management. There was very limited data to be found regarding this project. Underestimation of required effort is very likely, but it was not possible to confirm due to invalidity of the source used for this information.

Project 9: Some, yet not serious design issues were expected in phase 3, which proved to be true. These were caused by a component malfunction and underestimation of required effort.

Project 8: Exceptional project compared to others, as this project had relatively small amount of SE hours, yet PE hours were high. In fact, PE hours were double the average. There were very few inefficiencies detected in this project. This indicates that this project simply required more labor hours than estimated, which was the only factor contributing negatively to the project financial performance.

Project 16: No inefficiencies were expected, or if any, only minor issues at site. This was in fact correct, as the quality of documentation combined with supplier/subcontractor quality/competence caused inefficiency at site. Or, conversely, causes of inefficiencies did not have major impact which would have stood out when evaluating the booked hours of the project

Project 29: Very little hours in general in engineering might be one factor which caused a lot of hours required at site, as there were limited identified causes of inefficiencies confirmed. However, similarly to project 22, the documentation of this project was poor. Looking simply at the booked hours, the project might have had great success if site hours would have stayed as originally anticipated.

Interestingly, identified causes of inefficiencies have many similarities as Doloi (2013) found in his study such as complexity of design and construction (design-related issues), mistakes and discrepancies in construction documentations, client-initiated variations, design changes within development period, lack of communication between client and contractors, availability and supplies of labor and materials.

It is worth noting also that whereas there were many similarities, there were also topics which were not recognized as a cause of inefficiency in any of these projects. Those were for instance client-initiated variations and lead times for delivery of materials. Client-initiated variations might partly be included in unclear client requirements or unclear or imprecisely defined scope, but there was not any case in which described a client-initiated variation to be clearly identified as a cause of any inefficiency. Another inefficiency which is worth noting is that Doloi's (2013) mentioned factor, deficiencies in cost estimates prepared (i.e., subcontractor cost), was recognized in some projects but it is more related to sales process rather than project execution, and thus excluded from this table.

4.2 Analysis

Based on findings of this study regarding correlation between the effect on hour overruns, complexity factor and financial performance of the projects, interestingly no direct correlation exists between overrun hours and profit margin changes as chi-squared and Fisher's exact test demonstrates. Nevertheless, a high complexity factor is associated with a decline in profit margins. Simply put, while overrun of hours compared to sold hours do not independently influence the project's financial performance, their incorporation in the context of the influence of complexity factor presents a negative financial impact.

Chi-squared and Fisher's exact tests proves there is no relationship between overrun hours and profit margin changes as such. However, conversely to the tests, figure 13 demonstrates that there is an evident correlation between used hours and the performance since that considers the amount of hour overruns and the increase/decrease of GP margin, whereas neither of the two test takes those into account.

There was another interesting finding regarding the profit margin change - the correlation between change orders and profit margin change. Correlation between change orders and change in for profit margin is negative, meaning that projects which had more change orders (bigger increase to original sales price) were more likely to result in a negative gross profit than positive.

Whereas Primary Engineering function had the biggest overruns on average compared to what was sold, Primary Engineering related causes of inefficiencies were not as frequent that could have been anticipated. Only few directly Primary Engineering related causes were recognized as causes of inefficiency. This indicates that Primary Engineering simply requires more effort than estimated but is rarely a cause of any inefficiency.

The figures of Project Planner and Project Controller gives the impression that project managing and administration work is typically more demanding than anticipated. However, this aspect is challenging to study thoroughly and thus hard to validate.

The exclusion of the three projects from Group C in figure 15 underlines the importance of limiting any possibility to not be able to charge for extra work if there is a risk that there will be significantly more hours required than estimated. These three projects are great examples of projects which had notable overruns in hours, but were able to cover the costs of the unforeseen labour. As stated in the literature review, it is vital to “expect the unexpected”.

5 Conclusions

5.1 Discussion

The research questions are assessed in this chapter as the questions were significant guiding factor for this thesis. Questions are additionally good method to describe the study, discuss the findings and present additional thoughts which have risen during the preparation of this thesis. Research questions are listed as they were presented in the beginning of this paper.

- Is it possible detect inefficiencies in small substation projects during their execution?

This thesis did not find a distinct method how to detect that there might occur inefficiencies during the remainder of the project. This is due to the evident fact that it is impossible to predict the future. However, this thesis found methods and practices which are apt to minimize the risk of such occurring. Whereas it is not possible to detect that an inefficiency is about to occur with certainty, there are factors which by identifying are possible to mitigate. By identifying and taking actions on the factors which the project team have are able to have an influence during the project such as uncertainty of scope, the inefficiencies are less likely to occur.

- Are there consistent or recurring inefficiencies in these types of projects?

Yes. There are recurring inefficiencies in these types of projects. Design-related issues, installation & commissioning-related issues, resource experience or competence, underestimation of required effort and supplier-related issues.

- What are the causes of inefficiencies in poorly performing small projects?

Design-related issues, installation & commissioning-related issues, resource experience or competence, resource unavailability, underestimation of complexity, underestimation of required effort, supplier or subcontractor quality and/or competence, supplier-originated issues, component malfunction, delay in receiving specifications, prolonged client design review, inadequate communication by the client, quality of documentation, unclear client or technical requirements and unclear or imprecisely defined scope were identified and confirmed causes of inefficiencies. Surprisingly, client-initiated variations and lead times for delivery of materials were not identified as a cause of any inefficiency. Interestingly, a neglection of project management protocols such as project stage gate checklists were not recognized as a cause of inefficiency, even though it may be one reason behind some inefficiencies. However, the potential neglection of project management processes cannot be confirmed, and thus it is not viable to draw conclusions from.

- Can efficiency be enhanced by centralizing tasks and responsibilities to a smaller project team?

According to literature review, no. Also, considering that engineering functions are the biggest contributors hour-wise in these projects with their current areas of responsibility, their workload is likely to increase beneath tolerable levels.

- How does general and administrative tasks such as meeting and reporting protocols affect the project performance?

The impact of general and administrative tasks as such for the project is challenging to investigate. However, the fact that Project Planner and Project Controller books on average more hours than budgeted indicates that these types of tasks do have at least a minor impact on the project performance. However, as found in literature, there are more downside than upside in reducing general and administrative tasks such as project progress monitoring and reporting. Additionally, although Project Planner and Project

Controller hours typically overruns budgeted hours, the hours in relation to the whole portion of project is not significant and thus not a valid option to reduce these tasks.

- How does project size, scope, duration, and complexity affect the project financial performance?

Project size, scope and complexity were assessed as complexity factor, where the bigger the number was, the bigger, the larger and more complex the project was. Higher complexity factor is likely to result in more negative financial performance than originally planned. Meaning, that the larger the project is and the more complex scope the project has, the more likely it is to perform poorly in terms of financial performance.

- How budgeted hours have been typically met in sample projects?

In 7 out of 29 occasions the budgeted hours were not met. In other words, 22 projects overrun the budgeted hours. This indicates that it is not unusual to book more hours than was sold in these types of projects.

- What are the typical reasons for hour overruns?

Typical and identified reasons for hour overruns were due to supplier-originated issues and the underestimation of required effort. However, there might be other reasons as well from the table 12, but those are not directly identified as the causes of hour overruns as opposed to the two.

- Which functions contributes most to project performance?

There are four functions which contributes most in these projects. Secondary Engineering (by 33 % of the total project hours), Primary Engineering (18 %), Project Management

(17 %) and Site work (which includes Site Management, Installation and Commissioning) (16 %). These four functions take a total of 85 % share of the total project hours.

- Which project phases are most crucial?

Whereas it is impossible to provide an unambiguous answer to this question based on this thesis, in terms of effort required all functions combined the most important phases are phases 1 and 2. This statement is also supported by the findings of causes of inefficiencies, as there were instances where design issues in phase 1 and 2 caused more hours than anticipated at site (phase 4).

- How do projects, which have significant hour overruns compared to projects which have stayed within the budget, perform?

Generally, projects which had significant overruns performed poorly. However, there were some exceptions which had notable overruns, but had those covered by change orders, which improved their performance. Projects which sold hours were sufficient to complete the project performed generally well, and it was not unusual to these projects to ultimately improve their original gross profit margin.

- Is there a relationship between hour overruns and gross profit margin change?

Hypotheses tests proved that there is no relationship between overrun hours and profit margin changes as such. However, opposed to these tests, figure 13 demonstrates that there is an evident correlation between used hours and the gross profit margin change. This is because figure 13 takes the amount of hour overruns and the increase/decrease of GP margin into account, hypotheses tests are based on the number of projects, disregarding the weight of the changes.

- What are the best practices from existing literature which client could utilize in their project execution to enhance their processes?

Literature does not provide any straight answers to this question. However, there are many practices which are suitable for projects in the context of thesis. These are the most important findings of the literature review, which are important to consider in the pursuit of preventing inefficiencies to occur and additionally provide consistent enhancements to the project performance across the whole business unit.

1. Types A (low) and B (medium-tech) projects, which the projects of this thesis are, require more structured and focused management approach (Shenhar, 1998) (Youker, 2017).
2. Higher risk of failure when utilized common “one-size-fits-all” procedures for all projects regardless of their size (Payne & Turner, 1998).
3. Development and utilization of valid management process checklists based on project size (Laporte et al, 2013).
4. Capability to react to unforeseen changes in the projects is more important than the original plan itself, regardless of whether the plan was carefully made (Dvir et al, 2004)
5. Adaptable, responsive, and tailored project management strategies are important to achieve efficiency (Anantatmula, 2015).
6. It is vital to limit the possibility of any stakeholder to have any impact on the design after the project has started, because changes in client requirements or specifications during the project combined with long review times and invalid feedback impact negatively to project design quality and efficiency (Williams et al, 1995) (Muhamad & Muhammad, 2018).

These six key findings, in addition to findings of this study, serves as the basis for managerial implications presented later in the paper.

By recognizing and accommodating the unique aspects of different projects, organizations can mitigate risks and increase the chances of project success. Thus, continuous, and systematic evaluation of the project environment is highly recommended. The whole project team, together with all stakeholders, including senior management should keep “expecting the unexpected” throughout the whole project lifecycle.

Subsequently, research highlighted that lack of owner involvement in the design phase resulted in the addition or omission of scopes. Projects that commenced before finalizing the design were particularly prone to frequent design changes. Concurrent design and construction scenarios were identified as instances where such changes were prevalent. Design omissions were found to lead to productivity losses and project schedule delays, underscoring the importance of limiting any possibilities which could lead up to unwanted design changes after the project start.

It is justified to make conclusions that if a project is hypothetically highly prioritized project to the client, communication would most likely be active and constructive. Inactive communication is an indication that the client's project manager has more important projects to manage. This type of risk factor should be considered especially in these types of small projects when planning the project, and it is important to be hedged against it. Findings from the literature review supports this reflection. Anantatmula (2015) for instance emphasizes the importance of senior management support for larger or high-priority projects that demand wide organizational involvement, which strengthens the theory that larger projects draws the attention, while small projects might be overlooked, meaning, that if there is a situation in a small project where client’s project manager has large projects to manage in addition to the small one, larger projects draws a large proportion of the project manager’s capacity because larger project are more important to the client. This a view which should be considered regarding the execution of small projects.

Whereas a small project might not be important to the client, it can cause unwanted, and more importantly, uncontrollable inefficiencies. The lack of adequate communication has been proven to increase the risk of poor project performance, as the client's responses and approval of plans consumes time, and therefore the contractor cannot do their design on time, which again affects to the whole project by i.e., delaying the procurement of equipment.

This thesis was more demanding than I anticipated. The scope of this thesis proved to be relatively broad, although preliminary impressions were that the scope demands adequate amount of work. Especially gathering of raw and project-specific data, and the calculation of as-sold and booked hours proved to be highly demanding phases in terms of consumed hours of this thesis. Whereas the investigation of hours might not be directly presenting where the inefficiencies lie and why there were for instance more hours booked than planned, it has great information value of how projects do differ in terms of required effort in each phase of the project.

Although the literature review is relatively extensive and the results of this study may not be directly related to the used literature in all instances, the framework of this study required a deep review of existing literature. As the main objective, to identify and overcome inefficiencies in small substation integration projects, is quite broad, by reviewing literature comprehensively provided adequate readiness to start investigating the sample projects. As the literature and the results of this study shows, there are many factors that has an impact on the project and that project can be defined as successful by various measures.

5.2 Recommendations for future research

- A quantitative research with a bigger sample size using similar hypothesis tests and regression analysis to study how different types and sizes of projects correlates compared to what studied in this thesis.
- A research on what type of impact hour overruns or realized causes of inefficiencies may cause to the financial performance of the projects
- A research that studies the impact of smaller, less hours demanding, functions contribution to the project performance.

- A review of project success based on Kerzner's alternative measurement methods
- A research which evaluates correlation between the quality of document management and project financial performance. Some projects had high-quality and comprehensive documentation regarding project reporting, on the other hand some projects' reporting documentation was virtually non-existent. High-quality documentation simply meant that all meeting minutes and reports were held as supposed to, whereas there is no certainty whether all protocols were followed if there were no documents saved.
- A study which reviews exceptionally well-performing projects with a similar approach as how this thesis was conducted. In other words, a study to identify factors that have proven to enhance project performances and ensure how these could be maximized.

5.3 Managerial implications

This chapter presents recommended actions based on the results of this study and reasons behind them.

1. A structured, yet lightly modifiable management checklists based on project needs. Instead of a "one-size-fits-all" approach, lightly modifiable checklists which take the characteristics and unique needs of projects of this context into account, are recommended to support management of the project. The results of this study, combined with findings from the literature review indicates that these types of (to some extent non-complex) projects requires a structured project management approach. Small projects are however recommended to utilize more tailorable methods, which is contradictory to what is recommended for non-complex projects. Therefore, a mixture of these methods is recommended. This conclusion prioritized project type over project size, hence the structured approach been seen more valid for the foundation of the checklist.

2. Scope definition and boundaries. Importance of defining the scope clearly cannot be emphasized enough. The whole project team is highly recommended to be aware of what is included, what is excluded and what is expected from the project in general is important. This study shows that the unclarity of scope and requirements of the project

is not unusual cause of inefficiency. Additionally, as small projects do not typically employ project team members fulltime, meaning, that they are likely involved in multiple projects, which might obscure their recollection of the scope.

3. Clear guidelines and processes for stakeholder communication. It is vital to be able to prove that the project team has followed all the agreements. For instance, if a case where Secondary Engineer has submitted design drawings for client approval, without agreeing a cutoff date for design approval and the client does not respond, the project team is in an awkward position, which has great risk of affecting negatively to the project performance. This study shows that inadequate communication with the client were a cause of inefficiency. This method should not be too demanding to incorporate.

4. Minimize the opportunities for any stakeholder to disrupt the project. The implementation of this action requires a thorough understanding of the scope by all stakeholders and in addition, a clear communication plan and processes to apply this recommendation to reality. Hence, earlier recommended actions. A typical example of this is that client has great power to affect to the design changes during the project, which exposes the engineering team to rework and thus having an impact on the project performance. By minimizing the possibilities of any disruption, it is likely to have an enhancing effect.

5. “Expect the unexpected”. Dvir et al’s (2004) view might have a great impact on minimizing risk and enhancing project performance, if applied adequately. If a project has been planned by utilizing this approach, it means that the project team has assessed possible risks and have evaluated the whole project lifecycle potential obstacles from the beginning all the way to the end of the project. Naturally, contracts and client requirements dictate most of the overall project structure and progress, but for those parts which project team has any possibility to affect, it is crucial to have thought through all possible scenarios. Thus, it could be vital to have this type of “expect the unexpected” approach and mindset when initiating and planning the project, and carrying it throughout the project. Ideally client could be included in the planning process at least to some

extent, as a lack of owner involvement in the design phase have proved to cause changes in the scope during project execution.

6. Centralizing tasks is not recommended. Considering the findings in the literature review and the structure of the sample projects where the shares of project manager and engineering functions are significant (72 % of the whole project labour on average), it is important to keep the functions performing their core tasks which are critical to the project success. Any types of dual roles are not suggested. This study has proven that focusing on function's core tasks can be challenging as such, therefore adding any managerial tasks is likely to cause inefficiencies rather than overcoming such.

Overall, based on the findings of this study, a following checklist to prevent inefficiencies from occurring, and overcoming of such in case of occurrence, is recommended:

- Utilize a structured, yet modifiable gate checklist based on project needs as a tool to manage these types of projects.
- Increase of scope awareness across all stakeholders.
- Establish clear communication guidelines.
- Limit the possibilities of stakeholders and external factors to influence the project outside of agreed practices.
- Implementing adaptable planning - "expect the unexpected".
- Keep functions focusing on their core tasks.
- Maintain an active, yet light monitoring of project progress.
- Involve the client and other stakeholders in the project planning process.
- Tailor the use of policies based on project size or other project characteristics.
- Secure the appropriate level of management support.

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Appendices

Appendix 1. Descriptions of scope

Project	Description of scope
Project 1	110/33 kV Wind Farm grid connection
Project 2	110/33 kV Wind Farm grid connection
Project 3	33 kV Wind Farm grid connection and auxiliary 10 kV connection
Project 4	110/33 kV Wind Farm grid connection
Project 5	110/33 kV Wind Farm grid connection
Project 6	110/33 kV Wind Farm grid connection
Project 7	110/33 kV Wind Farm grid connection
Project 8	110/33 kV Wind Farm grid connection
Project 9	110/20 kV Wind Farm grid connection
Project 10	1 x 25/31,5 MVA Trafo 110/33kV Substa-tion
Project 11	1 x 25/31,5 MVA Trafo 110/33kV Substa-tion
Project 12	110/33 kV Wind Farm grid connection
Project 13	110/33 kV Wind Farm grid connection
Project 14	-
Project 15	Wind farm grid connection. 18 turbines, app. 80 MW
Project 16	110/33 kV Wind Farm grid connection
Project 17	Wind farm switching station
Project 18	
Project 19	110/33 kV substation
Project 20	
Project 21	9 turbine wind farm, same as project 25
Project 22	New station, 14 bays 1-bus, 2 x 110 fields.
Project 23	110/30kV wind farm, 9 turbines. Only substation part, transformer separate transaction with same delivery.
Project 24	110/20 kV substation - wind farm
Project 25	110/20 kV substation
Project 26	5 x 3 MW Wind Park Substation
Project 27	Wind farm SS, 16/25 PM, UniGear, Meho
Project 28	7 x 3 MW, new substation
Project 29	Extension for *** substation. One 110 kV bay + 15 bays 20 kV switchgear. New switchgerar building.