Frond-End Loading and its Impact on Cost Overruns in the Norwegian Public Sector

"Is the introduction of the Front-End loading scheme affecting cost overruns for the implementation of projects in the public sector of Norway?"

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”But you can't go back. For want of a nail, the war was lost, and all that.”

Stephan King

Preface and Acknowledgment

Five years ago, I started my studies in UiS after I had graduated from high school, I joined the BSc program in petroleum technology. At the time, I had no idea I would be completing my MSc studies within industrial economics, not to mention that my thesis would focus on a large scale economic and project management related problematic that is cost overruns.

The industrial economics program offers an abundance of interesting opportunities, which is what made it attractive to me as I was completing a bachelor degree in technical studies.

The report you are reading now is the result of the graduation project I have conducted for meeting the last requirement of 30 study points to complete a Master in Industrial Economics.

I would like to thank Finn Harald for the opportunity to work with him on this research and for constant follow up and valuable advice he has provided me throughout the writing process, the gathering of information and for critically discussing methods, processes and results on which the thesis is based. I also would like to thank Professor Kjell Hauge for the support.

Cost overruns in the implementation phase of projects are a familiar and common problem that is heavily researched within the field of project management. The issue this master thesis is one that is rather important, which the research community has newly started taking an interest in. It is namely the issue of the pre-planning phase or the Font-End Loading phase and its effect on cost overruns, with the Norwegian public sector as primary study subject.

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Abstract

Projects carried out in the public sector of Norway are often plagued with with large budget and schedule overruns. Not only that, the sector also struggles with delivering profitable projects, while delivering on the public service required.

Front-end loading, is a process designed to increase the value of an opportunity and to decrease the uncertainty that could arise during their implementation. The Norwegian public sector has incorporated this process in the early 2000s. Front-end loading can be quite demanding, and the expenses of carrying it out can vary from 1% to 7% of the total project expenditures. The process is supposed to decrease the cost overruns the projects might face, but does it really deliver on this promise?

Given these facts, this thesis aims to:

- Review the international literature to establish an understanding of what the front-end loading
- Answer the question of whether the introduction of the Front-End loading scheme really delivers on the promise of cost overrun reduction
- Provide the academic community and the public sector of Norway with

The process of exploring the Front-End loading related literature, yielded in the identification of the following crucial factors that are most essential for a successful FEL execution:

- The use of a structured stage-gated project
- Clearly defined project phases
- Thorough risk and uncertainty analysis
- Clearly defined decision gates
- Quality assured basis for the decisions by a third party
- Simplicity
- Proper understanding and management of cost overrun causes: under which stage they occur and how to mitigate or eliminate their effect on the continuity of the FEL process
- Standardization and common terminology

In order to answer the question of whether the Front-End loading scheme has had an impact, a portfolio of 91 projects executed post the introduction of the scheme were compared to a second portfolio of projects executed pre-the introduction of the scheme.

From the analysis, it appeared that some front-end Loading has had little impact on improving the cost overruns situation in the public sector of Norway. A set of projects were also reviewed individually, in order to identify the causes for cost overruns that are rooted in the Front-End loading scheme execution.

Based on the insights gained during the research project, a number of recommendations is given to the academic community and public sector of Norway.

To the Academic community of Norway:

- Research the development of cost estimation between K1 and K2
- Research to further document the effect of perverse incentives on the FEL practices
- Improved sharing of public sector project related data between the different academic institutions of Norway
- Research on how to improve the adaptation of the government FEL scheme by the different ministries, departments, municipalities and other governmental agents.
- Research the effect of understanding risk on the decision-making process specifically for project in the public sector of Norway

To the Public sector of Norway:

- Early involvement of the external consultancy services
- Increased transparency
- Cost estimates based on uncertainty analysis
- Improved attitude towards risk
- Availability of a Database for reference projects as recommended by Merrow: reports should be easily accessible for all departments, ministries and other governmental agencies for sharing experiences.

Table of Contents

1 INTRODUCTION 1
1.1 Statement of the Problem 3
1.2 Research Method 3
1.3 Limitations of the Study 4
1.4 Goal of the study 4
1.5 Relevance of the study 4

2 METHODOLOGY 7
2.1 Research Design 7
2.2 Literature study 7
2.3 FEL Models in the Norwegian public sector: 7
2.4 Actual practices: Data interpretation and case studies 8
2.5 Research Structure 8

3 ANSWERING THE QUESTION: WHAT IS FEL? 9
3.1 List of sources 10
3.2 The Cost Influence Curve 11
3.3 What is FEL? 14
3.4 FEL Models 14
3.4.1 IPA Model 15
3.4.2 CII Model 20
3.4.3 Gateway Model (UK) 22
3.4.4 Hydro: Capital Value Process 24
3.4.5 Other models 27
3.5 The importance of FEL 31
3.6 Cost and time Overruns: 33
3.6.1 FEL specific factors leading to cost overruns 36
3.7 The Norwegian Oil Industry FEL Model 37
3.8 The Norwegian Public Sector FEL Model 40
3.8.1 Quality assurance at KS1 41
3.8.2 Quality assurance at KS2 42
3.9 Discussion and summary 44

4 EXPERIENCES FORM THE NORWEGIAN PUBLIC SECTOR 48
4.1 How is the current FEL model working out for the Norwegian public-sector projects? 49
4.1.1 Sector specific conditions 54
4.1.2 Size and complexity of the project 54
4.1.3 Time for initiation and marked situation at the time 54
4.2 A correct approach? 55
4.3 Drastic cases from the Norwegian public sector: Can the causes of these cost overruns be traced back to the FEL phase? 56
4.3.1 The Oslo Opera building 56
4.3.2 New Holmenkollen ski jumping ramp 57
4.3.3 Transport projects 59
4.4 Perverse incentives and lack of competence: the leading causes of cost overruns? 60

5 CONCLUSION 64

6 RECOMMENDATIONS 66
6.1 To the academic community 66
6.2 To the Norwegian authorities 67

7 BIBLIOGRAPHY 68

List of Figures

Figure 1: Final cost Vs. Initial Estimate for a variety of public projects 2
Figure 2: Cost influence curve (Rocque, 2003) 12
Figure 3: Uncertainty versus available information I a project (Samset T. M., 2009) 13
Figure 4: FEL Stages according to (Merrow, 2011) 15
Figure 5: CII Front End Loading phase stages and activities (Construction Industry Institute , 2012) 21
Figure 6: Gateway review model (UK Government , 2017) 23
Figure 7: Hydro's Capital Value Process (Arne, 2017) 25
Figure 8: Activities in pre-project phase according to Robert G. Cooper (Trygg, 2002) 27
Figure 9: Sythesized input, activities, and output description of FEL (Trygg, 2002) 27
Figure 10: Barshop's FEL activities (Barshop, 2016) 29
Figure 11: The FEL process 29
Figure 12: FEL increases Likelihood of Success (Merrow, 2011) 32
Figure 13: Shell's Study of Cost Development throughout project cycle (Weijde, 2008) 32
Figure 14: Project Development Model for Oil/Gass Projects (Oil an Energy Department, 2010) 38
Figure 15: Project Development Model for the Norwegian Public Sector Projects (Samset, Andersen, & Austeng, 2013) 40
Figure 16: Stochastic Cost Estimation (Samset K. F., Volden, Olsson, & Kvalheim, 2015) .. 43
Figure 17: Deviation for p85 for 91 projects 2000-2014 50
Figure 18: Deviation from the initial estimate for projects in the 90s (In current Norwegian NOK) 51
Figure 19: Cost deviation relative to the P85 budget (percentages) (Volden, 2016) 52
Figure 20: Deviation for p50 for 88 projects 2000-2014 53
Figure 21: To what extent is there deviations from the agreements entered with consulting services regarding quality, cost and time (Revisjonen, 2016-2017) 61

List of Tables

Table 1: Literature sources 11
Table 2: FEL Stages: main focuses and activities (Merrow, 2011) 16
Table 3: Other FEL Models 27
Table 4: Three staged FEL models: main activities 30
Table 5: Cost and time overruns Literature Findings 33
Table 6: Cost overruns cause and FEL remedies 45

1 Introduction

At first glance, when the media generally reports about the execution of public projects, people can easily get the impression that these projects are responsible for the suction of considerable capital: cost estimates are exceeded, schedules are not met and the quality of the deliverables is questionable. The reporting, however, is perhaps fixated on the implementation phase of these projects, what contract term was not fulfilled? Which supplier or sub-suppliers didn't deliver in time...etc. This is why some of the more significant planning malpractices in the public sector are overlooked or not given proper attention. The research community on the other hand, recognizes indiscriminately that a real problem exists regarding achieving the goals set for projects regardless of the phase where the causes might occur.

It is established that cost overruns under the execution of projects are vastly studied and their occurrence is seen as normal and expected. A significant amount of recourses and personnel are mobilized to minimize the occurrence of such cost overruns under the project execution phase, where project management is the discipline concerning itself with achieving this. Cost overruns of this nature are also receiving a significant amount of media coverage. This study has for a purpose to try and highlight a persistent and reoccurring issue that has long managed to dodge the attention of researchers and the media alike. Namely, the issue of the introduction of a countermeasure in the form of a standardized pre-planning phase practice, the resources and effort put into this, and the effect it has had since the start of the practice.

This standardized pre-planning phase scheme, is the result of the Norwegian government decision to initiate a project to review the planning systems, implementation, and follow-up of major investment projects in the state (Berg, 1999).The reason for this was that large cost overruns were constantly incurred in project execution, along with delays and lack of realization investment project goals. Several ministries were involved and the final product is what we will come to call in this thesis: "The Norwegian Public Sector Front-End-Loading Model". Being a countermeasure for cost overruns, the expected result would obviously be a reduction in the cost overruns for the public sector.

An article on the e24 webpages (Lilleby, 2015) reports that the construction of the opera house in the capital city of Oslo which had an initial cost of 750 MNOK, ended up with a total cost of 4 300 MNOK. Similarly, the E18 Bjørvika project was authorized for 1 200 MNOK, upon closure the costs reached 7 100 MNOK. This is almost a 600% explosion of costs. A substantial percentage of the cost increases were incurred in the initial phase of these projects. The opera

house had a jump in costs of 224% solely in the early phase, which is acceptable to a certain degree, if we are to call this project for a complex one. The real issue is the additional 17% under the implementation phase. 33% jump in the implementation phase registered for the E18 Bjørvika (Morten, Knut, Bjørn, & Kjell, 2014). Take a look at some of the more significant projects that have been newly completed, and it becomes evident that the two initially mentioned cases are in no way a "one-time occurrence" (Figure 1).

In order to link the front-end loading practices or malpractices to the cost overruns occurring during the implementation phase, we will dive into the FEL scheme that the governmental institutions of Norway are currently using. This will aid in solidifying the relationship between the quality of the early phase project planning and the output of projects in the form of maintaining schedule and hitting close to the initial estimate.

It is worth mentioning that no scientific research has documented a quantitative correlation between early stage planning quality and the size of the project overruns. The underlying assumption in this thesis is: projects with a large focus on the planning phase, where the risks are extensively documented, with the cost estimate based on more elaborate calculations, and of which the scope is unchanged, will face less unexpected problems during its implementation phase.

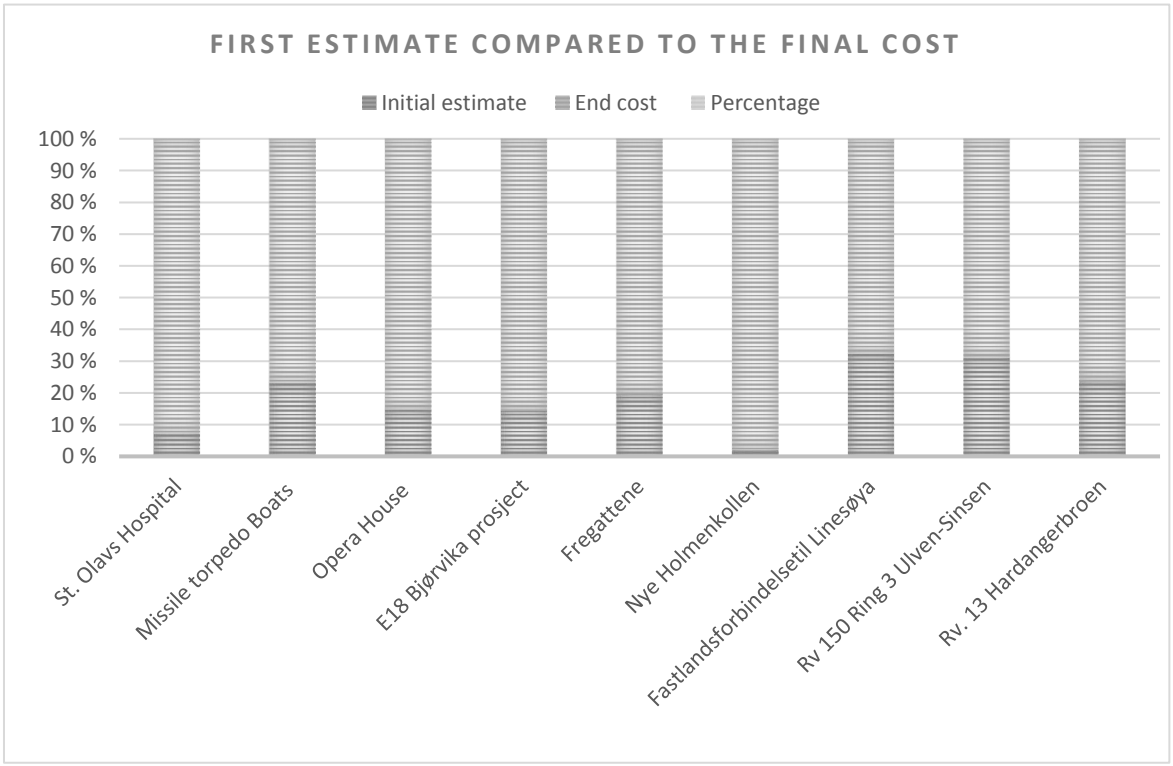

Figure 1: Final cost Vs. Initial Estimate for a variety of public projects

1.1 Statement of the Problem

This thesis will focus on the so-called front-end loading process (FEL), and the quality of it. For public projects that would be from the point where the feasibility study is initiated to the point where Stortinget (House of Parliament) authorizes the execution of the project. The front-end load phase is critical and therefore should be carried out with utmost thoroughness, especially for the more complicated and larger projects. The problems addressed in this study can be stated as follows:

"Is the introduction of the Front-End Loading scheme affecting cost overruns for the implementation of projects in the public sector of Norway?"

To answer this question, we will start by providing a literature basis for understanding and analyzing project cost overruns in the shadow of the FEL scheme used in the Norwegian public sector. This will be followed by establishing an overview of what the situation currently is with the continuous implementation of the FEL scheme throughout the last years. We will also include a study of some drastic cost overrun cases and their roots in FEL scheme.

A discussion of the factors involved in the determination of the FEL estimates for the public sector of Norway will be presented in order to study this problematic and reoccurring phenomenon and draw some lessons and recommendations for the overall execution of the FEL phase.

1.2 Research Method

The thesis will start with a systematic review that identifies, describes and appraises the literature describing "FEL implementation and its effect on cost overruns" necessitates itself, as it proves to be generally scarce compared to the topic of "cost overruns in the implementation phase". The fitted FEL schemes used by the Norwegian authorities will also be presented in chapter 3.

The gathered data consists of 91 projects executed in the period post the introduction of the FEL scheme to the public sector of Norway in the year of 2000. A qualitative approach will be used to map and assess the extent of cost overruns in the public sector, since the implementation of this new process. The aim being to identify how much these new practices have reduced cost overruns. Furthermore, an investigation into the reasons behind the increases will be carried out for some of the projects with a "drastically high" cost overrun, with the aim of isolating the

dominant factors for cost overruns rooted in FEL phase. These projects are picked based on their popularity in the media and the availability of data. The details of the analysis will be thoroughly explained later in chapter 2 of this thesis.

1.3 Limitations of the Study

The study limitation can be listed as follows:

- Terminology in project management literature is not standardized.
- The availability of data regarding cost estimates for public projects from KS1 to KS3 and the oil industry DG0 to DG3 was scarce. Any broader 'conclusions' drawn based on this analysis are treated as 'informed assertions'.
- The study of the relationship between the FEL estimate quality and the final cost, should not be done in isolation, it should include the execution phase's impact on study overruns as well.
- Interviewing some of the project leaders and managers involved in the chosen projects would have been helpful in supporting the conclusions drawn from the analysis. This was unfortunately not doable with the available resources at hand.

1.4 Goal of the study

The goals of this study are listed as follows:

1. This thesis gathers and provides an overview of the existing literature on the cost overrun problem and its relation to the FEL phase. Despite the restrictions put on the analysis part of it, the conclusions drawn in this thesis can form the basis for a more significant research to be carried out in the future.
2. Give an overview of the cost overrun situation in the public sector of Norway
3. The recommendations generated in the analysis process of this thesis will redound to the benefit of the key decision makers in both public sector and petroleum projects, considering that the problem presented is increasing in importance especially under the current economic situation, where both government and oil companies are increasingly worried about increased spending.

1.5 Relevance of the study

The relevance of the study results presented in this thesis resides in the following points:

- The gathering of literature on the subject present in existing scientific literature

- Exploring actual practices in the public sector of Norway
- Linking the quality of the FEL process to cost overruns for the projects at hand
- Comparing project governmental guidelines in the public sector and the real practices
- Comparing the FEL practice in the oil industry to that in the public sector, with the aim of isolating factors with specific relevance to cost overruns as an output.
- Draw attention to the FEL practice and encourage further academic research about the concept implementation in Norway.

The points mentioned above can serve as guidelines for future research with the aim of establishing a stronger correlation between FEL practice quality and the estimates accuracy and project overruns. This is especially relevant for the public sector of Norway, where cost overruns is a prevailing problem for a government that is decreasingly able to afford them.

2 Methodology

2.1 Research Design

This thesis is comprised of three sections, a literature review part, a part where FEL models from the public and petroleum sectors of Norway are explored, and finally an overview where a portfolio of projects is put to analysis in order to investigate the effect the implementation of the FEL scheme on the cost overrun situation in Norway.

The sub-sections below provide further details on what each of the different parts will focus on and how the findings put together will contribute to obtaining the study deliverables mentioned in chapter 1.

2.2 Literature study

Different FEL models were identified. Some major models were found to be exceptionally interesting. This interest stems mainly from the organizations that stand behind the development of the different models. These organizations are found to have large databases along with a long experience in the area of project management. Comparing these three major models, after listing the various individual procedures each of these follow, yields in a discussion of what the "best practice" is for the FEL process, along with the identification of the success factors reoccurring in each of the models.

Factors that may affect the decision-making in under FEL are also identified, categorized and discussed. A proper understanding of these factors is imperative for the sound implementation of FEL processes.

2.3 FEL Models in the Norwegian public sector:

The standards in an organization should reflect the way the company wants its employees to work. In this part of the thesis, the scope of work is limited to the FEL standards for both the public and petroleum sector, where the processes, the rules, and the constraints are extracted. These standards are governmentally set and regulated for both the public sector and the oil

industry, meaning that though the companies might have developed their own FEL practices, they should still abide by the regulations set by the Norwegian authorities.

Investigating poor FEL execution impact on cost overruns for projects in the public sector of Norway necessitates an in-depth knowledge of the FEL standards in the sector.

2.4 Actual practices: Data interpretation and case studies

The "actual practices" part of this thesis aims at investigating how FEL development phase has affected the resulting cost output for a selected set of projects for the Norwegian public sector. This is realized in reliance on secondary data gathered from different sources, in addition to newspaper articles, reports sourced in academic institutions, private and public organizations. Information was gathered about 91 projects in total.

The case studies are infamous examples of "drastic" cost overruns in the sectors. These will be presented and discussed in order see if some the cost overrun cause can be traced back to the FEL phase. The choice of the case study is not in itself a choice of method, but rather what will be studied.

The second aim for this part is to explore what factors did interfere with the proper implementation of the FEL for some of the "drastic" cases of overruns and whether these could have been hindered.

Flyvbjerg (Denzin & Lincoln, 2011) points out that "If you choose to do a case study, you are therefore not so much making a methodological choice as a choice of what is to be studied", regardless of method, the purpose here is to shine light on the FEL related problematics in the selected projects.

2.5 Research Structure

Chapter 3 is dedicated to listing the findings from the literature research. Concepts in the literature that exists regarding FEL, as well as the factors affecting the decision-making in this process are presented in the chapter. This is followed by a review of the FEL processes used in the Norwegian public sector of Norway. Chapters 4 is where the analysis is presented and discussed, along with looking at a diversity of projects, the cost overruns they incurred and the cause rooted in the FEL phase. This is then followed by a chapter where conclusions will be presented and discussed. Chapter 6 will list the recommendations given to the academic community of Norway and the public sector.

3 Answering the question: What is FEL?

Different industries use different designations to refer to the early stage of a project (Back, 2008):

- Front-End Loading (FEL)
- Pre-Project Planning (PPP)
- Feasibility analysis
- Conceptual planning
- Front-End Engineering Design (FEED)
- Front-End Decision Making (FEDM)

While at times, it is simply referred to as early project planning phase. The front-end loading phase (FEL) is the term reoccurring in this document to refer to this stage. FEL phase's impact on the increase of cost overruns for a project is a problem that does not get nearly enough attention in project literature as it deserves.

The resulting estimate from FEL for a project determines what conceptual solutions are to be selected, thus making it a prevalent guideline of the trajectory the project will be following. By considering the long-term effect of the entire project during the FEL phase, the project team can better predict potential future risks. This allows them to appropriately allocate risk and control the project's development trajectory. The forward-thinking company aims for a balance between risk allocation and cost control. If we are to employ the famous proverb of "For the want of a nail, the battle was lost", FEL phase is the nail in project planning, if neglected, it ultimately can result in a devastating loss for the project stakeholders in the form of cost overruns.

In order to better understand the front-end loading in the public as well as the petroleum sectors, in-depth knowledge of front-end loading literature general is necessary. In this chapter, the results of a review of this literature are stated, starting with information sourced in international project management literature, followed by a look at the public and petroleum sectors' guidelines and standards for the front-end loading process.

A summary of literature sources used in this study is listed in section 3.1 along with an introduction of the different institution and companies that the authors are affiliated with.

Section 3.3 starts by introducing a definition of the FEL concept in general. In section 3.4, concepts related to the execution of FEL phase are identified for different models. Section 3.6 discussed the specific factors occurring under the FEL phase that could result in cost overruns. Section 3.7 and 3.8 explore the FEL practice in the oil and gas industry of Norway and its public sector.

Under both sections 3.4 and 3.9 the FEL activities and deliverables, success factors, and implementation considerations are presented and discussed.

Conclusions attained based on this literature research are summarized and discussed in the last section of this chapter.

3.1 List of sources

In Table 1 below the databases and the books utilized in the literature study are listed. Many of the search results in the databases were not relevant. Conducting the research through the university internet access point allows access to some of the databases. Several articles and papers could not be retrieved because of this. A variety of search phrases were used, both in Norwegian and English. Unique content, directly relevant to the problem at hand, was relatively easy to retrieve when the search was conducted in Norwegian. The Norwegian governmental public databases were rich with relevant data, also easy to access. It is mentioned earlier that research in the area of FEL was scarce. Although the results were abundant when English search phrases were used, the content was repetitive and the relevant information was hard to locate.

In addition to searching the databases and the books mentioned above, a series of Google searches have also been performed. Many of the results lead back to the databases above. Some databases had restricted access, which was unfortunate as they seem to have had relevant information that would have made the research richer. References at the end of the thesis list the sources that were not included in the table above.

Table 1: Literature sources

Source	Type	Search phrase	Relevant Hits
NPD **(Norwegian Petroleum Directorate)**	Online database	"PUD veiledning"	3
Riksrevisjon **(Office of the Auditor General)**	Online database	The names of the projects selected as a part of the portfolio	12
Onepetro	Online database	"Front End Loading"	
BIBSYS Brage og Bragekonsortiet	Online database	"Front End Development" "Early stage project planning" "Early stage project planning" "Project definition phase"	3
Industrial Megaprojects: **Concepts, Strategies, and Practices for Success Edward W. Merrow John Wiley**	Book	-	-
Capital Projects: **What Every Executive Needs to Know to Avoid Costly Mistakes and Make Major Investments Pay Off**	Book	-	-
Project Management: **A Strategic Planning Approach**	Book	-	-

3.2 The Cost Influence Curve

Project literature, as far back as in the 70s (Boyd, 1976), shows that the earliest stages of the project are where one can influence the project outcome. Most project managers regard the Influence Curve, as shown in Figure 2, as the foundation of all the best practices associated with front-end loading. Few can argue with its basic premise that the ability to influence a project's final cost is greatest in the 'front-end' period, prior to final project authorization.

The basic assumption of the Influence Curve is simple: as the degree of project definition increases, the opportunity of influence over the project's outcomes decreases. This is what leads to the principle of front-end loading, namely the more completely a project is defined, the less likely it is to experience cost and schedule overruns (Gardiner P. D., 2005).

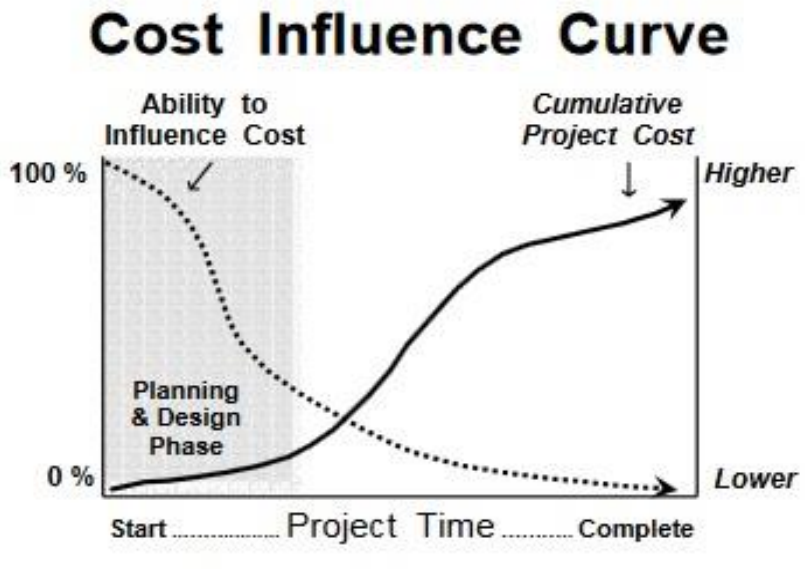

Figure 2: Cost influence curve (Rocque, 2003)

It is however important for the decision makers to consider the uncertainty factor parallel to the degree of influence. Projects experience a varying degree of uncertainty throughout their life cycle. It is widely recognized that the initial phase of a project is where uncertainty is highest due to scarcity information in this phase as it is indicated in Figure 2: Cost influence curve . As information continues to accumulate, the uncertainty is reduced. From the point of view of a decision makes, this would mean a larger flexibility to explore different solutions and concepts at the initial phase, but once the decisions are locked, this flexibility starts to diminish.

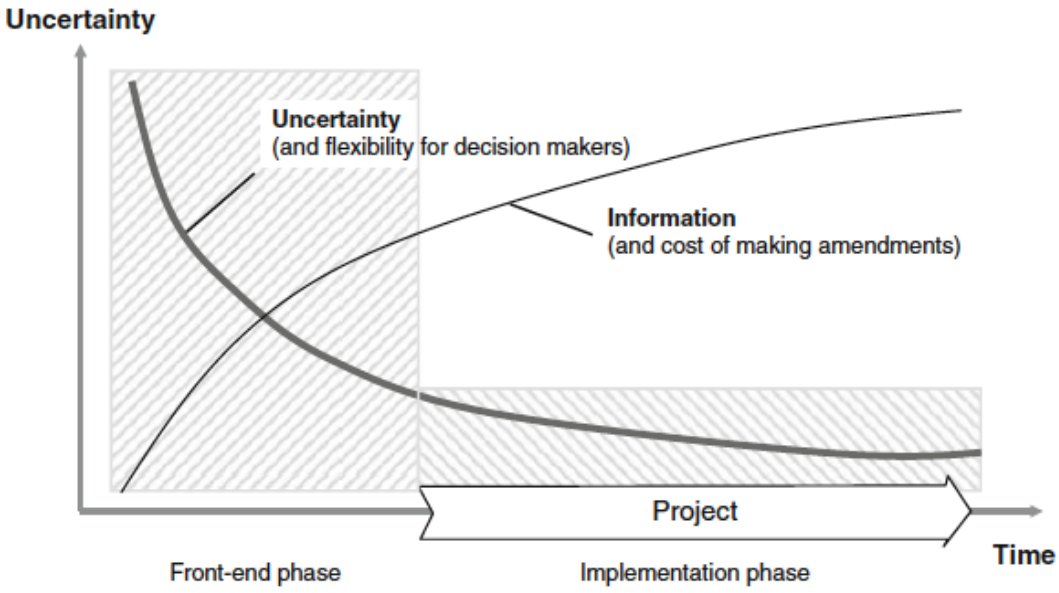

Figure 3: Uncertainty versus available information I a project (Samset T. M., 2009)

The distinction between FEL and the implementation phase is made to emphasize the point made from before. Higher uncertainty is associated with high influence levels in the FEL phase. Influence level starts then to diminish as we progress past concept definition into the implementation phase. The lack of and the nature of this paradoxical relationship between uncertainty and the degree of influence is what makes it what makes resource allocation tricky. Resources are usually poured into detailed planning and engineering while limited resources are put into getting the idea right from the beginning (Merrow, 2011).

Both Merrow (2011) and Samset (2009) argue that insufficient analysis of the problem along with not giving alternative solutions enough consideration are the main factors interfering with getting the Front-End-loading processes right. The decision makers are usually fixated on one solution, suggested by one individual, while it is all too rare that alternative concepts are identified and analyzed to the extent that they get a fair trial in the FEL phase.

The initial phase is when critical decisions are made when uncertainty is at its highest, the degree of influence is highest and available information is at its lower. Adding information, therefore, makes sense but only to a certain degree. A more thorough FEL process is, therefore, the key to achieving a successful implementation. Its thoroughness should not be restricted by the availability of the information at the start.

Information availability is recognized as a hinder to good project execution, but it is possible to overcome if FEL is done right. This will become more apparent as FEL models are presented and discussed in the sections below.

3.3 What is FEL?

According to Merrow (2011), FEL is "*the definition of a project, from the formation of the core team until full-funds authorization is achieved*". The Independent Project Analysis (IPA), a global consultancy in project evaluation and project system benchmarking, defines FEL as

> *"The process by which a company develops a detailed definition of a project that was initiated to enable the company to meet its business objectives".*

CII provides its own definition of the FEL process, calling it for Front End Planning:

> *"Front End Planning is the process through which owners develop sufficient strategic information to address risk and commit resources in order to maximize project success."*
> (Construction Industry Institute , 2012)

This thesis defines FEL as the entirety of work processes executed and decisions taken by key project stakeholders to carry the project through its life cycle yielding in a product, service, or process. Several other definitions were found under the search for FEL related literature.

3.4 FEL Models

While trying to accumulate information on the FEL process, several models were found. Each of these models found, created and adopted by academics, a variety of institutions and companies. These will be introduced and discussed in the upcoming sub-sections.

The majority of the literature that was accessible, was related to the area of New Product Development. These FEL models were therefore focused on the definition of concepts that should yield revenue and competitiveness for the business rather than on successfulness of the new products' technical development. Evidently, emphasis will be put on the IPA and CII models as they are most relevant to our discussion of the Norwegian FEL models in the public and the petroleum sector, where the successfulness of the project is the key performance index. The rest are mentioned in the section 3.4.3.

Factors imperative to the proper FEL process will be extracted while looking at the different models, and the main elements to be included in FEL will be listed at the end of this section.

3.4.1 IPA Model

Merrow (2011) is an affiliate of IPA or the Independent Project Analysis. IPA is a global consultancy in project evaluation and project system benchmarking established in 1987. IPA's database contains thousands of project data from around the globe (>15,000 projects). Their analysis is based on historical data, with the output being quantitative benchmarking, meaning IPA's output is purely empirical and statistical in nature. Its models are generally related to cost, schedule and performance issues (IPA , 2017).

Merrow (2011) divides the processes involved in FEL into three main stages with a halt for assessment and consideration at the end of each stage. The aim of the halts is determining whether to proceed or not. These halts are called for gates. The gate assessments should examine both the economic/business and technical grounds of the project so far as the point in question. The term gate is used when referring to the key decision point underway in a project initial phase. A basic rendition of the FEL phase is shown in Figure 4. The number of gates in a system is not crucial, although three gates in the minimum for a coherent process.

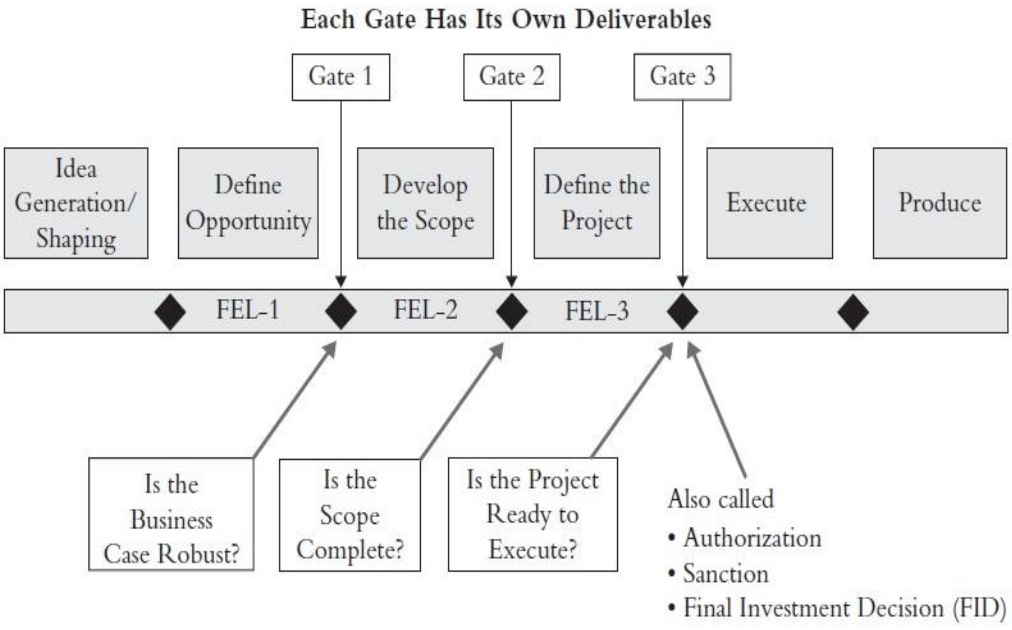

Figure 4: FEL Stages according to (Merrow, 2011)

There needs to be at least one gate at which the business case can be assessed, a gate when the scope is closed and the implications of the scope can be evaluated, and finally, a gate that triggers the full commitment of funds.

Furthermore, Merrow (2011) points out that an important misunderstanding concerning the purpose of the gates in the work process is that most business professionals might think that because the engineering and project management organization is the steward for the stage-gated process, the process is structured to meet an engineering purpose. Merrow (2011) refutes this and asserts that the gates' are to serve not an engineering purpose but a business purpose. The business purpose is to allow points in the development process to make decisions to stop, recycle, or proceed.

Table 2 provides a detailed overview of the processes involved in each of the stages named Figure 4. FEL 1 is the stage where the credibility of the business case is assessed. The IPA approach is to assign a score to each of the elements in consideration under each focus area. There are then summed up for each focus area. The score for each focus area is then weighted and summed to produce a so-called FEL index for Gate 1. This index, according to Merrow (2011), is supposed to represent a good indicator for the ratio of the actual NPV achieved in 30 months to NPV promised at full-funds authorization. Merrow (2011) notes that the initial FEL stage implementation should involve more elements than the ones mentioned in Table 4 for a more accurate index to be attained.

Cost estimates produced at gate 1 for most organizations have little or no meaning, as the physical scope is yet to be defined. These estimated are usually very low and the amount of their inaccuracy is completely unknown. This estimate can be anywhere from 80% to 30% lower than the eventual project cost. Merrow (2011) has therefore characterized this stage as the weakest in most organizations, resulting in many "unrealistic" projects slipping through to FEL 2 where they consume much of the organization's creative and technical resources to a non-satisfactory end.

Table 2: FEL Stages: main focuses and activities (Merrow, 2011)

Stage	Focus areas	Elements considered
FEL 1	Business Case	**• Market Experience** **• Competitive Analysis** **• Raw Material/Feedstock Costs** **• Investment and Economic Life** **• Legal/Regulatory Framework** **• Completeness of Business Plan**
	Team Dynamics	**• Sponsorship and Leadership** **• Clear Authorization and Resourcing Process** **• Multifunctional Project Team** **• Clear Team Goals and Expectations** **• Clear, Timely, Effective Communication** **• Effective Decision-Making Processes** **• Team Stability**
	Alternatives Analysis	**• Competitive Technology Selection** **• Business Objectives Statement and Charter to Team** **• Capacity Recommendation** **• Technical Plan**

FEL 2	Site Factors	**• Site Determined** **• Equipment Block Layout Identified** **• Preliminary Soils and Hydrology Report** **• Environmental Permitting Requirements and Strategy Identified** **• Health and Safety Requirements and Strategy Identified** **• Labor Survey** **• Local Content:**
	Design Status	**• Basic Process Data** – Feedstock/Product Properties – H&MBs **• Engineering Tasks** – Written Scopes – Sized Major Eqp. List – Utility, Infrastructure and Off-Site Requirements – Analysis of Existing Eqp. – Full Factored Cost Estimate **• Clear Business Objectives** **• Participation and Buy-In of:** – Operations – Maintenance/Turnaround – Business
	Project Execution Plan	**• Execution Strategies (Not Plans)** – Design – Procurement – Construction (Mod or Stick) – Turnover Sequences – Contracting – Team Participants and Roles **• Integrated CPM Schedule** – FEL-3 – Engineering – Procurement – Construction **• FEL-3 Plans (Not Strategies)** – Contracting – Long-Lead Procurement – Resource Requirements **• Clear Project Objectives**

FEL 3	Site Factors	• **Labor** – Availability – Cost – Productivity • **Local Materials Availability** • **Plot Plans and Arrangements** • **Environmental Requirements** • **Health and Safety Requirements**
	Design Status	• **Engineering Tasks** – Detailed Scopes – Feedstock/Product Properties – License Packages – Electric Single-Line Diagrams – Take-off based estimate • **Full Agreement/ Buy-In of:** – Operations – Maintenance – Business – Other Stakeholders
	Project Execution Plan	• **Contracting Strategy** • **Project Environment:** – Community relations – Regulatory liaison – Local content providers • **Project Organization/Resources** • **Team Participants and Roles** • **Interface management and communication plan** • **Critical Path Items** – Identification of Shutdowns for Tie-Ins – Overtime requirements • **Plans** – Commissioning – Startup – Operation – Manpower – Quality assurance • **Cost/Schedule Controls**

Little focus on the business case results in the consequences listed below:

- The project enters FEL-2 (scope development) with two or more possible scope options which, according to research, results in the discontinuation of FEL-2.
- Project coming under intense pressure to cut costs in FEL-3, which can potentially result in project termination
- Over optimistic and aggressive schedules to improve cash flow image.

The second stage, FEL-2, is where the scope is articulated in a detailed fashion, where all scope elements identified and are accounted for. Special emphasis should be put on the project's technical requirements and the project's sensitivity to the elements present at the execution site (country, region, commune ... etc.). The listed elements to consider in Table 2 are fitted for process facilities, other analogous elements are to be added for other projects.

According to Merrow (2011), comprehensibility is the most important characteristic this stage should possess. When a scope alternative must be singled out, scope details must be defined with utmost accuracy, with every piece of equipment to be used accounted for in order to obtain the best cost estimate and schedule forecast. Process Flow Diagrams or PFDs are asserted as an important tool for scope definition, failure to complete these will increase probability for project failure.

Merrow (2011) insists that this point should be where the go/no-go decision is made, and that the third stage FEL 3 should be dedicated to the final preparations for implementation, it's about addressing any minor lack of details in the previous to stages.

FEL 3 is where any uncertainty from FEL 2 is tackled, such that it becomes a certainty. The design tasks for this stage should be straightforward but demanding in terms of effort and resources. Merrow (2011) isolates engineering costs as being the most probable to overrun. In some cases some engineering tasks can be way more advanced than others, resulting in what should sound like a reasonable estimate. It is therefore that Merrow (2011), stresses the importance of categorizing the tasks at hand prior to the assessment.

The FEL 3 stage is also where any inadequacies or lack in the project execution plan should be addressed with special attention paid to the quality of schedule, such that the project is fully ready for sanction.

In conclusion, the IPA model encourages more emphasis to be put on FEL 1. FEL 2 is best executed when the scope development is "complete", all details are gathered, technological solution(s) are identified, and the of the execution plan necessary for the transition to FEL 3, including the implementation strategy and the overall contracting strategy, have been settled. FEL 3 should fill in the blanks left out in FEL 2. Work from FEL 2 should not be postponed to be carried out in FEL3. Without the project passing the third decision gate, the level of definition in FEL 3 should be carefully assessed, such that a transition into execution phase without it receiving full fund authorization.

3.4.2 CII Model

CII stands for the Construction Industry Institute, based at The University of Texas at Austin, is a consortium of leading owners, engineering-contractor, supplier firms, and academics. CII research efforts indulge many areas including Front-End Loading. The aim of the institute to measurably improve the cost effectiveness of capital projects, front end planning through completion and commissioning (Construction Industry Institute , 2012).

Similar to IPA model, the CII model divides the FEL process into three main phases as it is shown in Figure 5.

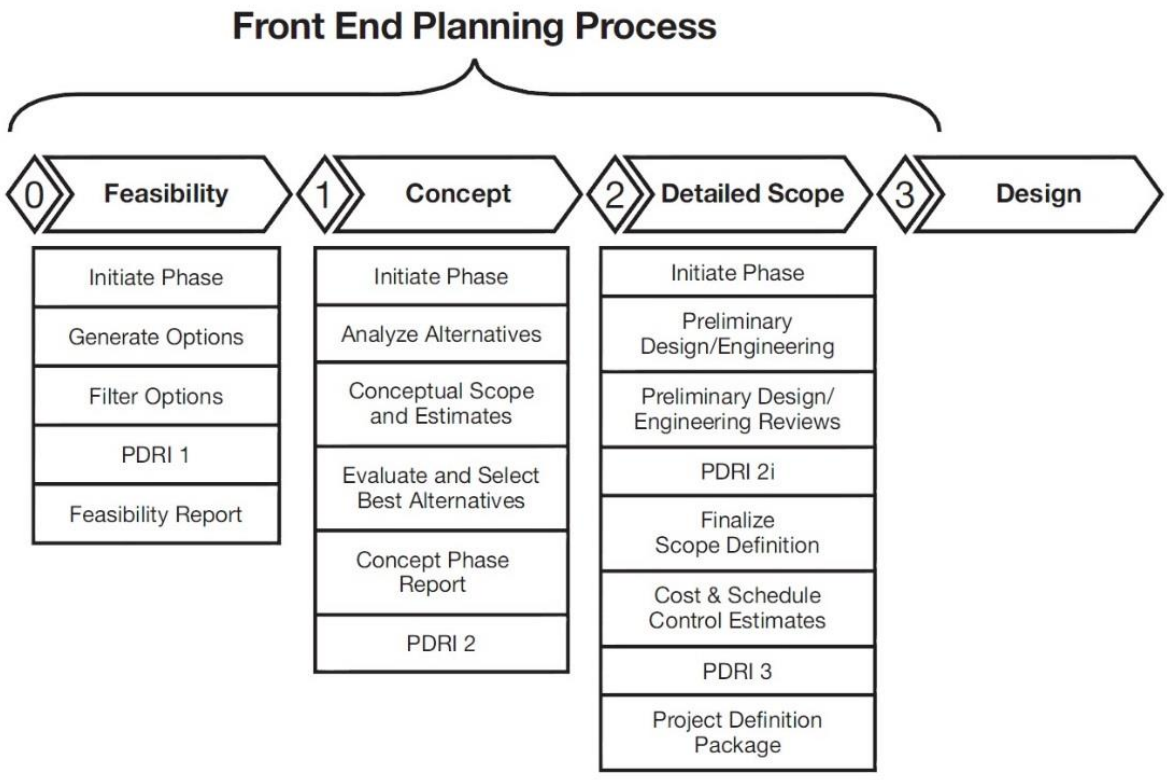

Figure 5: CII Front End Loading phase stages and activities (Construction Industry Institute , 2012)

The Project Definition Rating Index (PDRI) is a reoccurring expression in the table above. It is a checklist scoring system developed by CII that provides users a numerical score that reflects how well a project's scope has been defined. A total score of less than 200 is highly desirable.

The CII model is mainly designated for construction projects application and so are the activities involved, but it can also be fitted to other types of projects with the inclusion of the necessary elements. Construction Industry Institute (2012) lists the following activities as part of its FEL process, these are not stage-specific as it is the case for the IPA Model:

- Options Analysis
- Scope definition
- Life-Cycle Cost analysis
- Cost and schedule estimate
- Site investigation
- Environmental analysis
- Process design basis
- Initial engineering design
- Space planning, including room data sheets and stacking diagrams
- Site layout
- Project execution approach, including project control plan
- Procurement plan
- Architectural renderings
- Appropriation submittal pack

CII does also define certain rules that it regards as critical in the implementation Front End Planning. These are listed below:

- Develop and consistently follow a defined front end planning process.
- Ensure adequate scope definition prior to moving forward with design and construction.
- Use Front-End planning tools.
- Define existing conditions thoroughly.
- Select the proper contracting strategy early.
- Align the project team, including key stakeholders.
- Build the project team, including owner stakeholders and consultants.
- Include involvement from both owners and contractors.
- Staff critical project scoping and design areas with capable and experienced personnel.
- Identify and understand risks of new project types, technologies, or locations.
- Address labor force skill and availability during planning.
- Provide leadership at all levels for the Front-End planning process, including executive and project, owner and contractor.

These rules were outlined as the result of a study CII's Support for Pre-Project Planning Research Team had performed. The research team compiled 17 case studies from projects worth over $1.5 billion and analyzed project data in excess of $35 billion.

In contrast to IPA's model, access to more detailed literature on the CII model was restricted. But with these available details on CII, clear parallels can be drawn to the IPA model, as both models put emphasis on the same elements under each of the stages.

3.4.3 Gateway Model (UK)

The Office of Government Commerce (OGC) in the UK is a part of the finance ministry and report directly to the minister of finance. The OGC has developed the Gateway model, which constitutes their best practice for the execution of governmental investments projects (UK Government , 2017).

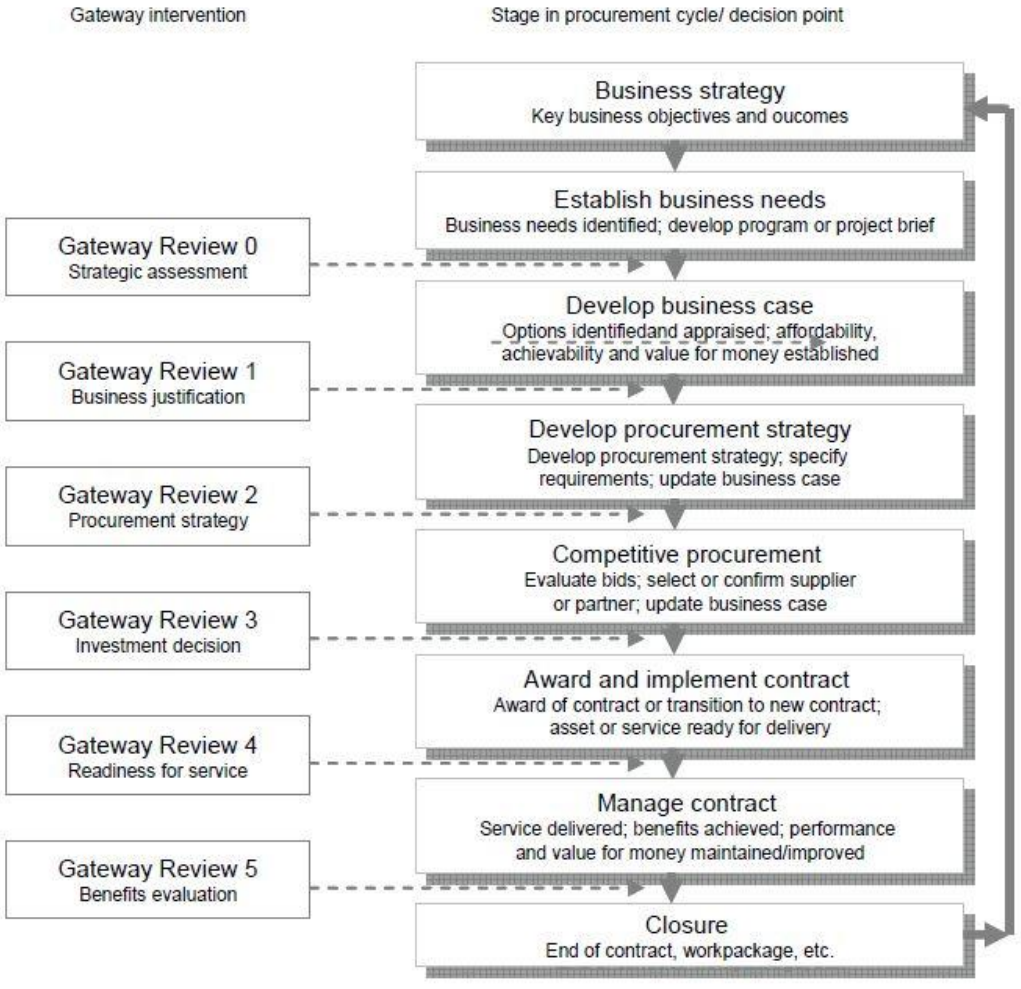

Figure 6: Gateway review model (UK Government , 2017)

Figure 6 is a visual representation of the model. The model is focused on revisions before decision points in the model where an audit is conducted by actors who are independent of the project to strengthen the basis that is submitted to decision makers before the overall decision.

The model consists of a total of six interventions from a group of project auditors, of which the first four applies to early phase or the FEL phase. The audit teams vary in size but are usually composed of three to five people. One revision takes from three to five days and is based on detailed control points regarding the decision-making basis or the maturity of the project. The audit team delivers its report at the end of the year of these 3-5 days. This ensures a fast process that does not delay the project process and decision-making process unnecessary (UK Government , 2017).

Particularly interesting conditions of the model are to be prepared by a separate organization under the responsibility of the Finance Minister, developing the model and carrying out project audits before decision-making. The model is audit-oriented, with audits performed by external personnel in advance of each decision gate. The model thus has a similarity to the Hydro model shown in Figure 7. The model specifies in plain text what to check in the decision base and what is expected by documentation and analysis prior to each revision. The scope of each revision, and what resources that are involved as auditors (their distance to the project) depends on the project Size and a rough assessment of whether the project has high or low risk. The early phase of the model has the following subdivision:

- Demand assessment
- Alternative assessment
- Pre-project and contract strategy
- Supplier selection

The model goes one-step further than what is today's practice in government investment projects In Norway because the basis for the decision on final allocation is obtaining offers from current suppliers. The downside of the strong audit focus is that it is resource-intensive both for the project and for the device that conducts the audit. In addition, this may in some cases delay the decision making process (UK Government , 2017).

3.4.4 Hydro: Capital Value Process

Hydro's Capital Value Process (CPV) is designed to ensure that Hydro's investment projects are predictable and competitive. The background for the creation of the model was an acknowledgment of the fact that Hydro's major projects towards the end of the 1990s were not delivered according to plan and that the decisions taken in the early phase were not taken on the correct basis. In addition, Hydro has become harder competition for the project funds, so there was a need for a controlled process that provided a better basis for comparing and selecting the best projects. In addition, Hydro had a need to address ownership of the projects more clearly than before. The model has a clear phase division with strict decision-making decisions (Decision Gates) (Arne, 2017).

The Figure 7 below illustrates Hydro's division into phases with corresponding decision points.

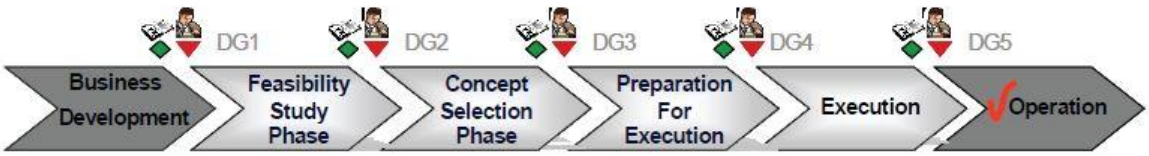

Figure 7: Hydro's Capital Value Process (Arne, 2017)

The model has been prepared with focus on the following conditions (Arne, 2017):

- Better quality of decisions
- Implement requirements from the company's investment directive
- Connect the various devices in Hydro through common terminology and communication arenas
- Early identification of drivers that can increase the value of the projects.

In the early phase or the FEL phase, which is up to the completion phase, the model contains four decision points:

DG1 Approval to start feasibility phase: Business opportunity identified and can be realized through different strategies. Initiate feasibility study.

DG2 Approval to start concept selection: Decision base is the feasibility study from the previous phase. Stop or Go is given at the decision gate: whether to initiate concept selection phase or not.

DG3 Concept Approval: Concept selection phase is completed, and the selected alternatives are up to evaluation. The decision gate at the end of this process determines whether to proceed to Pre-project phase or not.

DG4 Final Capital Expenditure Approval: This is also a Stop or Go decision gate. This is parallel to the parliament approval decision-gate that we will introduce later on for public projects.

Hydro's decision model has a strong focus on decision-making and activities immediately before and after the decision gates. The following activities are carried out in association with every decision taken (Arne, 2017):

- Maturity assessment
- Project audit
- Compilation of decision documents
- Decision-making process and decision
- Startup arena: for the next phase

Hydro's decision-making model is largely *a top-down model* focusing on the external evaluation of the decision basis at every decision gate. The model also focuses strongly on decision makers activities in advance, during and after each decision.

The model, as mentioned earlier has four decision points in the FEL phase, where the last decision gate is a "GO" /"No GO" decision for implementation.

The project audit is initiated by the responsible decision maker and is implemented in all projects above 50 MNOK. In Hydro's Decision-making model, the decision maker in charge is called for the gatekeeper. The same throughout the process. This leads to standardization the foundation and decision-making process becomes easier. Such a process with the same gatekeeper in all decision points will be very difficult to implement for public projects due to the management organization, number Investigations in the early stages, and because of the scope of the decision base then would be unmanageable for the deciding authority (Arne, 2017).

Hydro has adopted a methodology from the Construction Institute (CII), USA, to assess the project maturity. The process is called the Project Definition Rating Index (PDRI) which was mentioned under the CII section, and is a process in which the project is scored in an assessment of a total of 70 factors that affect the degree of success of the projects. The score indicates

maturity for the project, and Hydro's long experience with major projects provides a good basis for assessing what an acceptable score would be. A prerequisite for the use of the method is experience, without quantifiable experience, the outcome of the PDRI process cannot be assessed properly. Hydro has used this process for approx. 100 projects internally and externally.

This type of benchmarking of the projects reveals the degree of uncertainty upon completion of each phase and reveals where there is a gap in the decision base. This is done by comparison to industry standard, and with similar projects. The larger the project portfolio for the organization the more effective PDRI method is. This can be an interesting opportunity for governmental projects because of data availability and the large portfolio of projects the government has access to.

3.4.5 Other models

Other models are summarized below:

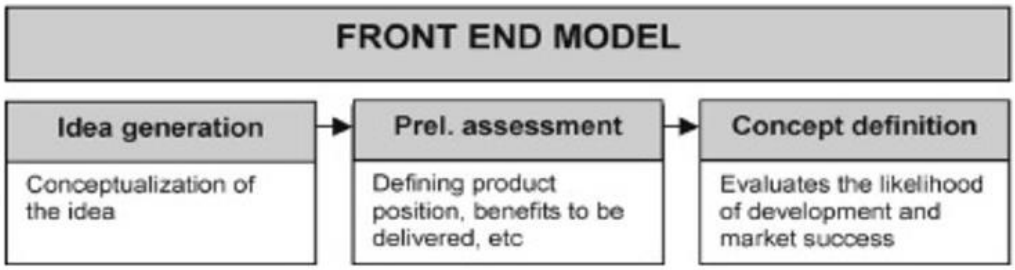

Figure 8: Activities in pre-project phase according to Robert G. Cooper (Trygg, 2002)

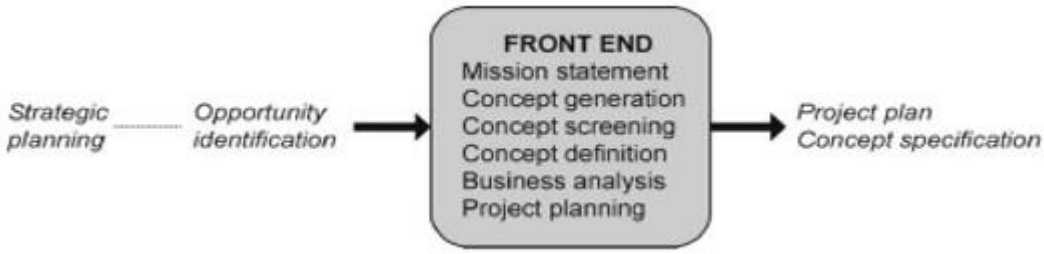

Figure 9: Sythesized input, activities, and output description of FEL (Trygg, 2002)

Table 3: Other FEL Models

Author(s)	Brief description and Reference
Robert G. Cooper	Often called "The Fuzzy Front End", is also divides the FEL process into three major steps in the FEL phase. (see Figure 8). (Trygg, 2002)

Nobelius and Trygg	**(Trygg, 2002)** Concluded their study with recommending that a Front End process applicable to all pre-project phases is inutile, that more managerial flexibility is necessary for a successful FEL execution. Figure 9 represents a synthesized model for FEL.
Paul Barshop	Barshop (2016) talks about the importance of a stage-gated process in his book, he defines the three first stages of his model as Front-End stage. These three stages are namely (Figure 10) - Assess Stage - Select Stage - Define Stage
Smith and Reinertsen	Authors identify the following pre-project activities (Trygg, 2002): - Opportunity identification - Idea generation and selection - Market acceptance - Business opportunity analysis - Product planning; Planning for financial and human resources.
Khurana And Rosenthal	Khurana differentiates between project specific elements and non-project-specific elements and their interaction and presents the Front End process as consisting of the following project-specific elements (Rosenthal, 1997): - Preliminary opportunity identification - Product concept and definition - Project planning.
Clark and Wheelwright	The model shows four FEL activities (Clark, 1993): 1. Technology Assessment and Forecasting 2. Market Assessment and Forecasting 3. Development of Goals and Objectives 4. The Aggregate Project Plan

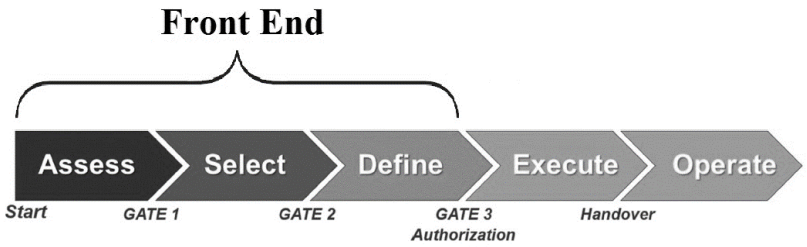

Figure 10: Barshop's FEL activities (Barshop, 2016)

For Barshop's model illustrated in Figure 10, each of the stages tries to produce an answer for the questions listed below:

Assess Gate:	Is this potentially a good investment?
Select Gate:	Is this a good investment?
Define Gate:	Is this still a good investment?

While the CII model is tailored to fit the needs of construction projects, Robert Cooper's and Trygg's synthesized models are built to satisfy the pre-project needs in the area of New Product Development. Barshop's and the IPA model on the other hand are fit for application in any project, as they include general guidelines that can be adopted to fit the execution of FEL for any type of projects.

There are factors that do reoccur in all the models, which can be characterized as success factors in the execution of FEL. It is found that all of the models adopt a stage-gated approach. For this stage gated approach to yield reliable results:

- it needs to be information and decision driven
- it should be supported by thorough analysis
- it should be structured, simple and easy to project fit

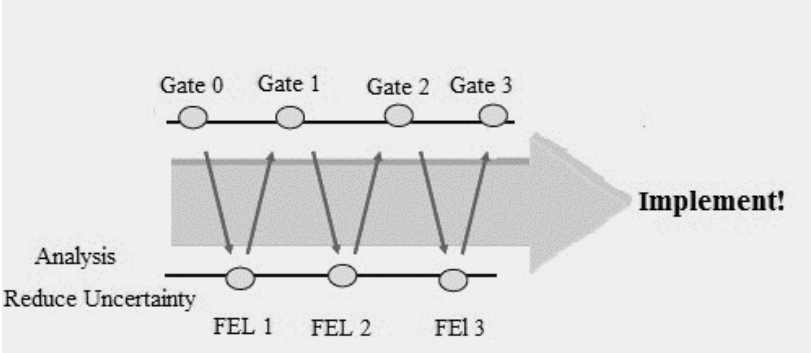

Figure 11: The FEL process

Table 4: Three staged FEL models: main activities

Model	FEL 1	FEL 2	FEL 3
CII	Feasibility	Concept	Detailed Scope
IPA's Merrow	Define opportunity	Develop Scope	Define the Project
Barshop	Assess	Select	Define
Robert G. Cooper	Idea generation	Preliminary assessment	Concept Definition
Khurana And Rosenthal	Preliminary opport-unity identification	Product concept and definition	Project planning

The Figure 11 above summarizes how the FEL should be carried out according to the findings in this chapter.

Some of the models mentioned in Table 4 contain more than three stages in their pre-project process. This is necessary when tailoring the process to a certain area, this is confirmed by Merrow. While the three-gated process is the minimum recommended, one can include additional stages if the needs of the project dictate this.

Studying these models yields in the identification of the following areas that should be included and analyzed in the FEL process:

- Project management
- Business
- Engineering
- Construction
- Maintenance
- Operations
- HSE
- Quality Control
- Human resources
- Contract strategy

3.5 The importance of FEL

The idea that a well-executed Front-End Loading phase is a critical indicator of the project's future performance, is becoming more recognized in project management literature. This idea represents the assumption underlying the increased focus on the FEL process.

As mentioned earlier it is not possible to completely eliminate uncertainty, therefore the correct approach would be to manage this uncertainty such that it is reduced to a minimum project is sanctioned. The front-end loading (FEL) stage of a project is defined as comprising all activities executed regarding that project up to project sanction. Merrow (2011) along with many other academics and industry veterans hypothesize that a thorough and detailed execution of FEL will significantly influence the eventual project performance, mainly leading to a reduction in the implementation overruns.

Merrow (2011) further argues for the importance of FEL by analyzing the effect varying quality of FEL has on the following project performance indicators individually:

- Cost performance: increased FEL quality yields in increased cost predictability
- Schedule performance: increased FEL quality yields in increased schedule predictability
- Production performance : increased FEL quality yields in reduced projects percentage with operability failures
- Safety performance: Projects with definitive or preliminary execution planning result in twice less injuries compared to poorly planned project (which shouldn't be a surprise)

Merrow concludes in his study that overall when the FEL quality is increased the success rate for projects improves dramatically, as illustrated in Figure 12 (Merrow, 2011).

CII provides further evidence supporting the importance of FEL. According to a survey executed in 2009 based on a sample of 609 projects worth $37 billion – owners with high FEL usage incurred 10% less costs than their counterparts with a low or no FEL usage, 7% shorter delivery time; 5% fewer changes (Construction Industry Institute , 2012).

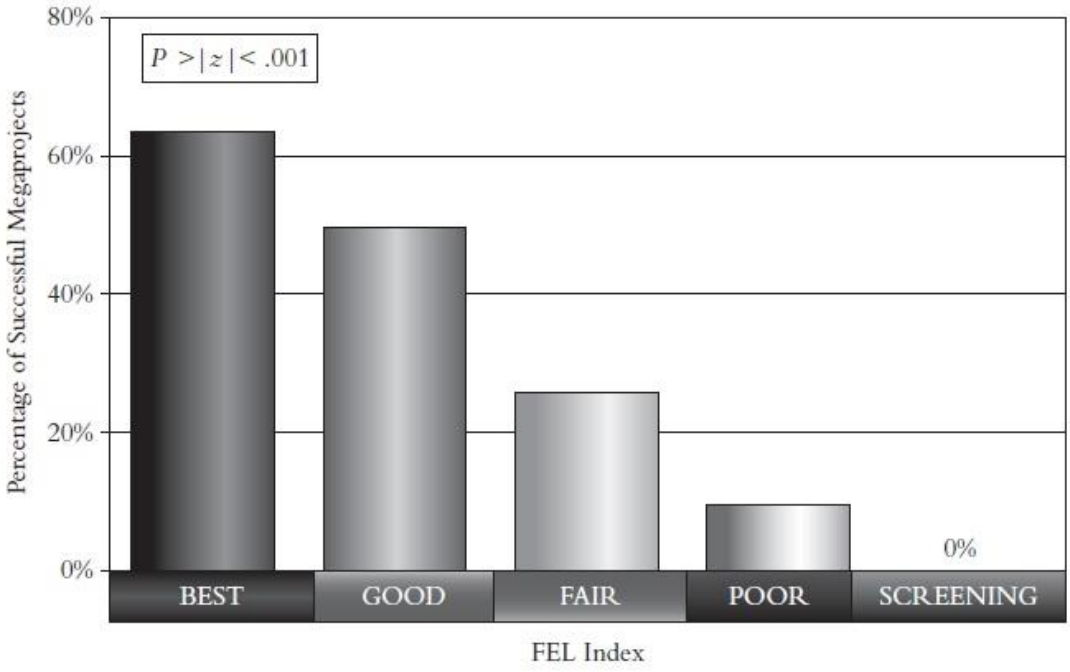

Figure 12: FEL increases Likelihood of Success (Merrow, 2011)

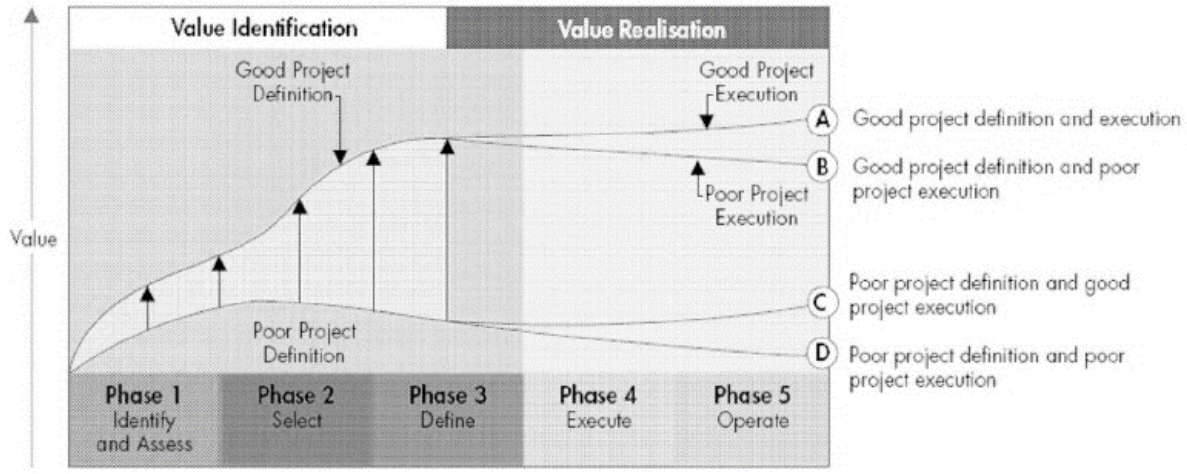

Figure 13: Shell's Study of Cost Development throughout project cycle (Weijde, 2008)

One of the major players in the oil and gas industry, Royal Dutch Shell has initiated a reevaluation of their project management processes, such that more efforts are put into early project work. The study was based on data acquired from 458 Shell global projects. Figure 13 illustrates clearly that the largest step in value creation can be made in the front-end loading of a project.

From an executive perspective, Barshsop (2016) lists the following benefits for FEL:

- Directing capital to the most attractive, most important investment opportunities
- Maximizing the value from each capital project that is funded
- Controlling the risk of financial loss or reputational damage

Barshop (2016) also emphasizes the importance of FEL, and that it has to be carried out such that it only allows projects that balance cost and benefit, risk and reward to be moved to the implementation phase, meaning only projects with a solid business case. FEL's importance here according to Merrow (2011) and Barshop (2016) resides in it being the tool to filter out projects that are not worth being realized. This issue will be taking up for discussion later in this thesis, especially when shedding light on the practices in the public sector.

The next section will be dedicated to identifying the factors leading to cost overruns generally and then isolating those specific the execution of the FEL process, and then touch upon what remedies are suggested in the literature as to how to manage these factors properly.

3.6 Cost and time Overruns

The aim of this section is to create a general understanding of how cost overruns occur in all project phases, before proceeding to identifying the factors specific to the FEL phase in sub-section 3.6.1. The literature presented in this section has investigated cost overruns in several sectors and countries.

Table 5: Cost and time overruns Literature Findings

Category	Source	Type of Project(s)	Identified Cause
	(Morris & Hough, 1987)	Oil and gas, Nuclear reactors, construction and IT projects	- Poor Project Design - Lack of Managerial Experience
	(Adisa & Ming, 2010)	Construction Projects	- Lack of Managerial Experience
	(Odeck, 2004)	Construction Projects	- Poor Cost Estimates
	(Love, Edwards, & Irani, 2010) (Gil & Lundrigan, 2012)	Construction Projects	- Scope Definition

Technical	(Arvan & Leite, 1990)	Public sector procurement projects	- Contract design and incentives
	(Berechman & Wu, 2006)	Transportation Infrastructure Investments	- Poor Risk Assessment
	(Flyvbjerg & Budzier, 2011)	IT Projects	- Poor Risk Assessment
Economical	(Berechman & Wu, 2006)	Transportation Infrastructure	- Shortage of Skilled Labor - Changes in Real Interest Rates or Exchange Rates - Rapid Economic Growth
	(Westney, 2017)	Oil and Gas Projects	- Market Conditions
Cognitive	(Khaneman & Lovallo, 1993) (Kahneman & Tversky, 1979) (Flyvbjerg B. , 2008) (Næs, Andersen, Nicolaisen, & Strand, 2015)	variety of projects	Cognitive Bias: - Optimism - Attitude towards risk - Zero alternative Bias
Political	(Welde, Samset, Andersen, & Austeng)	variety of projects	- Deliberate underestimation
	(Arvan & Leite, 1990)	Public sector procurement projects	- Hidden information
	(Næs, Andersen, Nicolaisen, & Strand, 2015)	Transportation projects	- Forecast bias - Strategic misrepresentation

Flyvbjerg et al. (2010) categorizes the causes of cost and time overruns into four main categories: (1) Technical causes, (2) Economical causes, (3) Psychological causes and (4) Political causes. This is a very suitable categorization which will be adopted to classify the causes identified in the literature. Table 5 summarizes the findings in the literature research conducted for this section.

Literature concerning the technical causes of cost overruns is most common. The imperfection of analysis methods and the lack of data are the easiest to identify and quantify post project execution. Most literature of technical nature aims to draw a link between project complexity and cost overruns. The prevailing hypothesis linking cost to project complexity states that increasing complexity leads to increased costs. Merrow (2011) goes as to characterize complexity as "The nemesis of Megaprojects".

Larger projects would mean higher price unpredictability, complex project design and implementation, and uncertain estimations. These are considered variables that influence cost overruns, and that do become more difficult to manage the larger the project is. Other causes include scope creep, unfit organizational structure, and lack of risk understanding, inadequate decision-making processes, and inadequate planning processes. One notices immediately that these causes relate to the FEL process, and the most challenging aspect of it, which is predicting future changes, but a good FEL process should increase the capability of adapting sufficiently well to changing circumstances, assign accountability and perform better when it comes to control, and planning.

When the economic theory of cost overruns is concerned, marked conditions and the uncertainty associated with it is also a potential cause of cost overruns in this category. Sudden plunges in real interest rates, for instance, will have implications on the project's execution and outcome. The personal involvement of project agents and the potential it represents in the shape of personal gain can be a cause to underestimate project costs in order to get the project sanctioned (Flyvbjerg B. , 2008).

The psychological theories look upon cost overruns as the effect of cognitive bias and faulty decision-making heuristics in the mind of the agent doing the estimating. The main causes in this category manifest themselves in the form of planning fallacies and optimism bias. The planning fallacies occur when a tendency to underestimate costs or risks of project related activities while bluntly overestimating the benefits. Certain project stakeholders might display

an overwhelming belief in the project's success, which might result in actions such deliberate disregard of potential red flags in the planning of risk and the estimation of costs.

Finally, the political explanation is that cost overruns are believed to be the result of deliberate deception motivated, as its designation implies, by political rather than economic reasoning, for the purpose of increasing the likelihood of sanctioning the projects.

3.6.1 FEL specific factors leading to cost overruns

It is apparent from the study of literature that many of the causes for cost overruns are situated in the pre-project phase or the FEL phase. A study performed by the Concept Rapport Research Group at NTNU aimed to investigate the underestimation of cost overruns in the early phase for some major public projects, concluded with identifying the following factors as "main reasons" for cost overruns (Morten, Knut, Bjørn, & Kjell, 2014):

- Initial underestimation of cost is politically motivated.
- Poor scope design
- Inadequate estimation techniques and use of expertise
- Risk is generally underestimated and benefits overestimated.
- Over-optimism

The study mentions that an intentional and biased approval of an unrealistically low estimation was necessary if some of the projects in the study were to get a green light. The decision makers with political stakes in the realization of such projects might be easily compelled to accept these low estimations.

Cost estimation increases can also occur because of technical reasons. For instance, the necessity for scope expansion, lack of expertise and adequate estimation techniques. While the predictable technical reasons for cost increase are somewhat easily manageable, the less familiar and the unpredictable technical factors can result in substantial cost increase if not given the proper attention. The study was able to document many of these technical reasons specific to the projects at hand, but overall poor planning and cost estimations are the reoccurring cause in all the projects scrutinized in the study.

Indications were found of risk sources being underestimated and/or overlooked, and the benefits being overestimated for some of the projects studied. Indications of over-optimism are especially dominant for the projects in included in the study. The report also mentions that these

kind of causes are especially prominent for projects that are promoted by local interest groups. (Morten, Knut, Bjørn, & Kjell, 2014).

3.7 The Norwegian Oil Industry FEL Model

In order for a company to be authorized to initiate a project on The Norwegian Continental Shelf (NCS), it has to first comply with the guidelines for plans for development and operation of a petroleum deposit (PDOs). Is some cases also called plans for installation and operation of facilities for transport and utilization of petroleum resources (PIOs). These guidelines are provided by The Ministry of Petroleum and Energy (MPE) and The Ministry of Labor (AD).

According to Oil and Energy Department (2010), the PDOs and PIOs consist of a development or installation section, and an impact assessment section. The guidelines provide information about how the authorities process development plans. They describe the requirements for documentation in the planning phase, the impact assessment process, the development section of a PDO and the installation section of a PIO.

To clarify the difference between PDO and PIO: A PDO is prepared by the licensees in the production license(s) where the deposit is located. PDOs must be approved by the MPE. A PIO is a permit given with regards to installation and operation, usually with the intent of transporting petroleum.

The purpose of the guidelines is to provide advice on how a PDO or PIO can be prepared in a manner which fulfills the authorities' requirements, as well as to explain the administrative processes and contribute to efficient cooperation between the licensees and the authorities.

The formulation of PDOs and PIOs is governed by the Act of 29 November 1996, No. 72. An Act relating to petroleum activities stipulated by Royal Decree of 27 June 1997, the Regulations relating to health, environment and safety in the petroleum activities stipulated by Royal Decree of 31 August 2001 with associated regulations, as well as the Temporary Regulations relating to safety and working environment for certain petroleum facilities on land and associated pipeline systems.

Although the guidelines are normative, i.e. the documentation must be adjusted to fit the specific development situation. They do provide an overview of what companies are obliged to include in the execution of the FEL phase for the projects they intend to start on NCS.

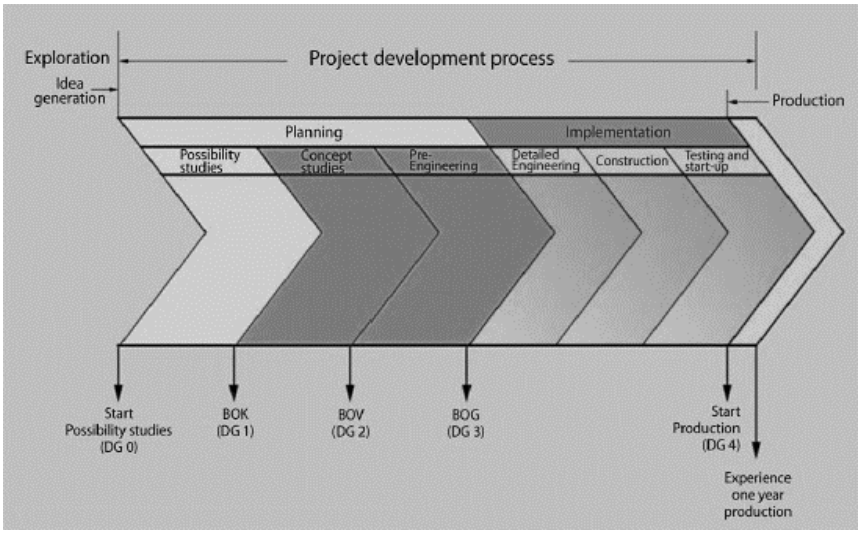

Figure 14: Project Development Model for Oil/Gass Projects (Oil and Energy Department, 2010)

The PDOs and PIOs guidelines draw a distinction between a planning phase and an implementation phase for all projects applying for authorization as shown in Figure 14:

- The planning phase: DG0 to DG3
- The implementation phase: DG3 to DG4.

The guidelines (Oil and Energy Department, 2010) do reflect the authorities' concern with the FEL phase. This is apparent in the early involvement of the authorities, already at the first decision gate1 when the feasibility study is conceived (BOK). BOK to BOV (where the conceptual study is initiated), the licenses meet up with Gassco, the Norwegian Petroleum Directorate (NPD), and The Petroleum Safety Authority (PSA) for an examination of the potential alternatives available and the potential problems that need special attention, along with the scope the BOV will assume.

The licensees in a production license POD should make the results from the conceptual studies available to the NPD, with a copy to the MPE. Gassco and PSA are also to be provided with this information.

The pre-engineering phase in Figure 14 is the equivalent of FEL 3 in Merrow's model, where further development of the basis for a business concept to such a level that a final "decision to implement" (BOG) can be made, and the PDO or PIO can be submitted to the authorities in order to initiate the implementation phase. This is constituted by the Petroleum Regulations, Section 22; the Planning and Building Act, Section 14-2, the Impact Assessment Regulations Section 6, cf. Section 2, third subsection (Oil and Energy Department, 2010).

During the planning phase, the licensees are required to include the following elements in their documentation:

- the resource base
- production strategy
- development solutions
- infrastructure
- unitization
- external environment
- energy efficiency
- profitability, with special emphasis on socio-economic profitability
- uncertainties
- expansion and extended use of existing infrastructure
- barriers against major accidents for the protection of personnel, the external environment and material assets, including regularity
- use of risk reduction principles
- working environment-related factors that can affect health and well-being
- reliability factors that affect operational regularity/robustness/ease of maintenance
- emergency preparedness, including the ability to control and limit loss if accidents should occur
- use of new technology and work to qualify such technology

The FEL Model designed by the Norwegian Government as a minimum requirement for oil and gas projects carried out on NCS carry many similarities to the models discussed in the sections above, especially to Merrow's model. The licensees are obliged to realize under certain core activities under the FEL phase, in order to be issued a consent. These are also very similar to the ones we have explored in earlier sections under the presentation of the FEL models. Overall it does seem that the Norwegian authorities do recognize the importance of FEL, and are therefore very particular about following up with the licensees FEL work since the start and aiding in the execution of a thorough and detailed FEL process.

The FEL phase in Figure 14 starts at DG0 and ends at DG3. This is where the project is PDO or PIO approved. This thesis is mainly concerned with the quality of the FEL process, reflected in the developments taking place at DG0 through to DG3, where the pre-engineering work is done. The scope is therefore articulated in a detailed fashion, where all scope elements identified and are accounted for:

- The project's technical requirements
- The project's sensitivity to the elements present at the execution site are identified, and

- The engineering tasks are devised
- Business objectives are identified
- Overall execution strategy is in place

3.8 The Norwegian Public Sector FEL Model

Public Sector Projects are subject to governmental regulations, much like the oil sector, the authorities have built a standardized Project execution model that is to be used. There are currently six consultant consortiums that have been awarded an agreement with the Ministry of Finance to monitor the implementation of quality assurance policies (Samset, Andersen, & Austeng, 2013). These six consultant consortiums are namely:

- Atkins Norge AS, Promis AS, Oslo Economics AS
- DNV GL AS, ÅF Advansia AS, Menon Business Economics AS
- Dovre Group AS, Transportøkonomisk institutt
- Holte Consulting AS, Samfunns- og næringslivsforskning AS, Proba Samfunnsanalyse AS, A-2 Norge AS
- Metier AS, Møreforsking Molde AS
- PricewaterhouseCoopers AS, Teleplan Consulting AS, Concreto AS, Tyréns AB

The project model is partitioned into several stages each with a corresponding decision gate, as illustrated in Figure 15 below.

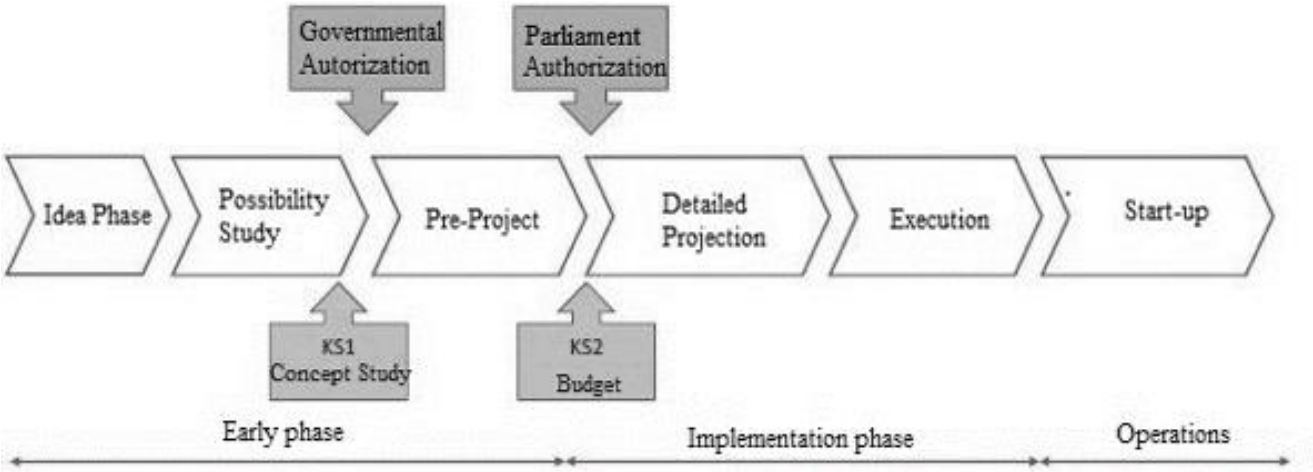

Figure 15: Project Development Model for the Norwegian Public Sector Projects (Samset, Andersen, & Austeng, 2013)

The first three stages are categorized as Early Project Phase, which will be referred to as the FEL phase throughout the rest of this section. The Detailed Projection and Execution stages are part of the implementation phase, whilst the startup stage is where operations are initiated.

The Norwegian FEL phase is quite simple compared to the previous models introduced. It only contains two decision-gates with the corresponding requirements. These two decision-gates, referred to in the figure as KS1 and KS2, are supposed to strengthen the quality of decision making in the FEL phase. A QA (Quality Assurance) agent is tasked with the control and the support of the departments involved throughout the project (Samset K. F., Volden, Olsson, & Kvalheim, 2015).

3.8.1 Quality assurance at KS1

KS1 is a decision-gate at the end of the possibility study phase, when the project has reached this gate, at least three conceptual solutions/alternatives, including the zero option, should be made available for evaluation. The process of choosing the concept, in this case, is purely political, this means that the agent tasked with quality assurance will not be involved in the decision making. The agent's role is limited to supporting and advising the department initiating the project (Samset K. F., Volden, Olsson, & Kvalheim, 2015).

The department/government agency is required to put the following documentation before the quality assurance agent for evaluation before the decision-making process is to be started for KS1 (Samset K. F., Volden, Olsson, & Kvalheim, 2015):

1. **Need analysis:** which will map stakeholders and evaluate normative (Political) guidelines and demand-based needs in the relevant area.
2. **Strategic capital:** shall define community goals and impact targets for the project.
3. **Overall requirements:** for example other community goals that form the framework conditions for the project.
4. **Feasibility study:** The needs, goals, and requirements must be defined and merged into an opportunity room. It is important that the approach to this does not get too narrow.
5. **Alternative analysis:** including the null option and at least two others conceptually different alternatives.
6. **Guides for the pre-project phase:** implementation strategy for the selected alternatives

The agent tasked with quality assurance shall review the documentation and evaluate them based on the level of consistency in and between the different elements named above. The agent then performs own uncertainty analysis in addition to a socioeconomic analysis. The agent then produces strategic recommendations as to how the decision should be made. The recommendations should include a ranking of the alternatives based on priced and unpriced effects in addition to flexibility and financing plan. The involvement of this quality QA agent is supposed to combat the deliberate cost underestimation (Samset K. F., Volden, Olsson, & Kvalheim, 2015).

The transition towards KS2 is initiated when the QA agent provides their recommendations on what elements from the KS1 should be included in the governing documentation for the project.

3.8.2 Quality assurance at KS2

A so-called Governing Document should be in place by the time the project has progressed as far as the decision gate KS2. The governing document has for a purpose to secure operational success, contains realistic budgets and assures that all deliverables are produced in a time and cost-effective manner (Samset K. F., Volden, Olsson, & Kvalheim, 2015).

The department or government agency should make the following documents available for the quality assurance agent before the decision is put on the table for the parliament (Samset K. F., Volden, Olsson, & Kvalheim, 2015):

1. **The central governing document:** this document provides a full overview of all the central elements in the project, its goal and framework, project strategy and project governing basis.
2. **A complete basis of estimate:** along with eventual income
3. A minimum of two different principle **contract strategies**.

The QA agent is to review and control the documentation above, as well as performing an analysis of the success factors/fall pits and the overall uncertainty and risk picture.

The cost uncertainty analysis should be based on the "basis of estimate" along with the expected additions in order to produce an expected cost and the associated uncertainty. The QA agent is then to give their recommendation on the matters of (Samset K. F., Volden, Olsson, & Kvalheim, 2015):

- If the cost estimate is taking into account all anticipated uncertainties.
- How the project is to be governed, so it stays within the ranges estimated.

The recommendations regarding the cost frame are essential to KS2 and are based on a stochastic cost estimation. Through mathematical analysis methods and simulation tools, a cumulative probability distribution is produced for the investment costs as it is shown in Figure 16.

The cost frame approved by the Norwegian parliament is normally the P85 minus the potential simplifications and reductions (reduction list) that are cut when the cost frame is compromised. The budget made available to department/agency is usually lower in order to avoid incentives to use contingency reserves and normally corresponds to the media P50 (Samset K. F., Volden, Olsson, & Kvalheim, 2015).

The difference between the P50 and P85 is the uncertainty reserve, if the agencies go over the P50, they must be allowed by the department to increase the budget. If they go over P85 then they are outside the departments' jurisdiction, they have then to answer to the Stortinget (House of Parliament).

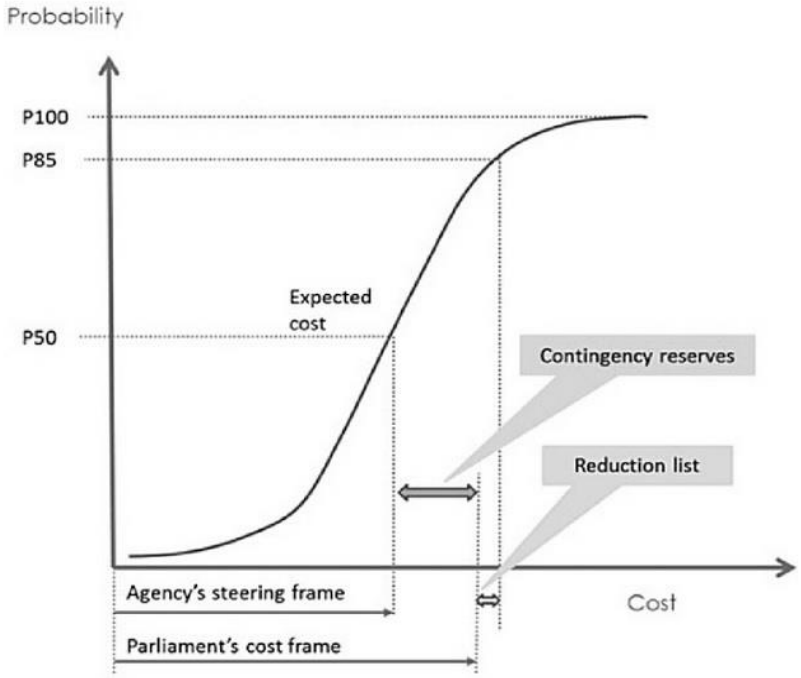

Figure 16: Stochastic Cost Estimation (Samset K. F., Volden, Olsson, & Kvalheim, 2015)

3.9 Discussion and summary

Alterations will still sometimes be required, as it is basically impossible to predict every single possible altercation given that every project is unique. These alterations should however not be for reasons that could have been hindered from occurring by better planning, it is here that the importance of FEL resides and why it should not be undermined.

Chapter 3 was a dive into literature concerning the FEL process, along with a review of the Norwegian FEL models for both the public and petroleum sectors. Based on the literature reviewed in this chapter, there seem to be a growing interest for the FEL process as a highly critical and important part of project governing and execution.

A detailed FEL is thought to result in a good understanding of the technical requirement and subsequently the development of a scope that delivers both on time, and cost efficiently. Furthermore, thorough FEL is suggested to lead to a well-defined scope and execution approach, reducing scope creep. A thoroughly executed FEL results in better documentation of risk and uncertainty thus making the implementation phase more predictable. This way, the need for drastic and complex design changes in the implementation phase is reduced.

The following factors are found to be the most essential for a successful FEL execution:

- The use of a structured stage-gated project: this is common for all the models that have been studied in this chapter, including the ones used by the Norwegian authorities.
- Clearly defined project phases
- Thorough risk and uncertainty analysis: The Norwegian FEL public sector model constitutes a reevaluation performed by a third part.
- Clearly defined decision gates
- Quality assured basis for the decisions by a third party
- Simplicity
- Proper understanding and management of cost overrun causes: under which stage they occur and how to mitigate or eliminate their effect on the continuity of the FEL process
- Standardization and common terminology

The literature sites the following outcomes as the results of good FEL practice (e.g Merrow, Barshop, CII):

- Increased cost predictability
- Increased schedule predictability

- Scope creep reduction
- Better HSE

Exploring the cost overruns' related literature reveals that many causes for cost overruns can be traced back to the FEL phase. Most of the causes can be hindered from affecting the project outcome when complying with the suggested activities in the FEL models presented previously.

Table 6: Cost overruns cause and FEL remedies

Cost Overrun cause	FEL remedy(s)
Scope Definition: Combatting Poor cost Estimates and poor project design	The entirety of FEL 2 is dedicated to project definition: - Thorough study of the potential solutions, including the zero option. - Define clear business objectives - Define engineering tasks - HSE consideration - The proper mapping for all stockholders and their influences (See Merrow's model for more on FEL 2)
Contract design and incentives	Carrying out FEL2 properly would result in the proper mapping of the project's needs and potential market suppliers, making it easier to compose purchasing and procurement strategies.-
Poor Risk Assessment	Assess Technology and use reliable analysis methods under FEL2
Market Conditions	Through market analysis under FEL2, using surveys, statistical methods, forecasting etc.
Cognitive Bias: - **Optimism** - **Attitude towards risk** - **Zero alternative Bias**	The involvement of a third party for Quality Assurance and provide additional input before the decision is made at gate.
Forecast bias **Deliberate cost underestimation** **Strategic misrepresentation**	The early involvement of a third party for Quality Assurance

Table 6 offers examples of the potential causes identified in the literature along with the remedial activities good FEL practice recommends to combat these. Several studies found under the search for FEL literature document the positive effect of complying with good FEL practice e.g (Weijde, 2008), (Merrow, 2011), (Construction Industry Institute , 2012).

Looking at all the number of FEL models found through this research, delivering high quality Front-End Loading process is considered highly important by both academics and organizations both public and private.

By looking at the research conducted by CCI and IPA, many pointers exist that a front-end loaded project will add value to project investments whether private or public and reduce unpredictability during project implementation. Front -end loading does not come without a bill: the cost of the FEL phase varies from 1% to even 7% of the total capital expenditure (Merrow, 2011). Considering the cost plus the time spent on front-end development, an optimum must be found at which FEL is performed in a way that fulfills the intended goals of the FEL phase (mentioned above), such that the final outcome is a project executed with minimal or totally absent cost overruns.

It is also important to point out that the FEL process as standardized as it can get, must leave room to customization, as it is necessary to *fit* the FEL process to the novel nature of every new project. This necessary as it is widely recognized by academics and managers alike that every new project is unique and must be treated as such (Gardiner P. J., 2005).

Finally, in exploring the Norwegian guidelines and regulations for project planning and execution, it appears that these do account for all the factors that make for a good FEL practice, both for in the public sector and for governing petroleum related projects on its territory, having to include all factors previously described as essential to good FEL practice. This indicates that the authorities do recognize the importance of the FEL process, and are aware of the benefits that can be harvested when FEL is properly implemented. Whether these guidelines are properly implemented remains a challenge to investigate. We will, however, examine the effect of not complying with good FEL practices on the cost overruns in the implementation phase for a variety of Norwegian projects.

4 Experiences form the Norwegian public sector

Autumn 1997, the Norwegian government decided to initiate a project to review the planning systems, implementation, and follow-up of major investment projects in the state. The reason for this was that large cost overruns were constantly incurred in project execution, along with delays and lack of realization investment project goals. The project included 11 concrete investment projects under the Ministry of Transport, the Ministry of Defense and Ministry of Labor and Administration, and was led by a managing group with participation from these ministries and the Ministry of Finance.

The study Berg (1999) focused on (1) whether the basis for the decision was sufficient when the projects were given a green light and (2) whether the project implementation was efficient. Of the 11 projects, only three remained within the designated cost frame. It was concluded that the decision basis was inadequate in several of the projects, and that failure in the initial phases of the projects, prior to giving the Go for implementation, was identified as the main reason for large cost overruns during implementation.

During the implementation of the projects. The project breakdown was also a continuous problem and one found that:

"*The goals bore more of a resemblance to wishes or wills that cannot be broken down to operative sizes that give a practical basis for management. No prioritization has been made between the goals. There are too many of them and all of them can bet fulfilled at the same time. The goals are shown by further analysis not to be goals, but work tasks. There was indeed no overall goals definition"* (Berg, 1999)

The 11 projects in the study had a total cost framework of around 5.5 billion. NOK. The cost overruns for the eight projects where one had numbers for final cost amounted to 84 per cent. The overruns were particularly large for three of these projects (70-500 %).

Another public inquiry into the development of investment took place for the Norwegian continental shelf (Investeringsutvalget Olje- og energidepartementet, 1999). This has also shown that in a selection of 13 projects had varying cost overruns between 17 and 107 percent, resulting in an average of 37 percent or about 30 billion NOK. For the entirety of the projects on the continental shelf, that have secured a PUD approval in the period 1994-98, cost overruns totaled for about 26 billion, 13% on average.

This was a lot of money "going to waste"; a situation that was of course not acceptable. The introduction the FEL scheme, immediately followed, alongside external quality assurance in the decision-making process for the larger project (Berg, 1999).

When the problem statement was set for this research project as mentioned and explained in section 1.1. Two main directions were mentioned: providing a literature basis for understanding and analyzing project cost overruns in the shadow of the FEL scheme used in the Norwegian public sector, and establish an overview of what the situation currently is with the implementation of the FEL scheme. After presenting the literature in the previous chapter, and analyzing the data available in the coming section 4.1, a study of some of the drastic cost overrun cases in the sector is presented in section 4.3. This is to identify the causes for such occurrences with regards to the implementation of the FEL scheme.

A summary of the findings will be provided in Chapter 5, along with a discussion. The goals of this research will also be revisited in this chapter, and the degree to which these have been achieved are discussed.

4.1 How is the current FEL model working out for the Norwegian public-sector projects?

The Norwegian FEL scheme along with quality assurance has first been adopted by the Norwegian government in the year 2000. The aim was to improve the decision-making processes and reduce cost overruns. The FEL process, as discussed earlier, entails that project managers first investigate all appropriate solutions according to a particular standard. This will then be quality assured by private consultants. Then a preliminary project is prepared, which in turn is quality assured by new consultants. Only after all steps have been taken can the project manager schedule a construction start. The quality assurance process takes several years, and a lot of thorough work, but has the implementation of such a process reduced cost overruns in the Norwegian public sector?

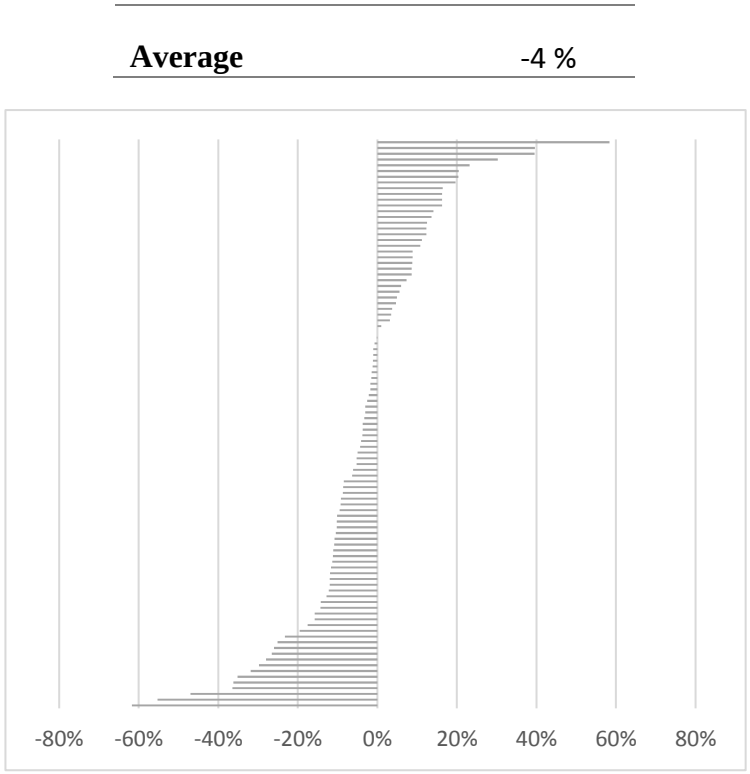

Figure 17: Deviation for p85 for 91 projects 2000-2014

Figure 17 shows deviations between end cost and cost frame for the parliament P85 at KS2 for 91 projects executed between the year 2000 and 2014. The data about these projects were gathered from multiple sources, but mainly Concept report project at NTNU (Norwegian University of Science and Technology) (Forskningsprogrammet Concept, 2017) and using the search engines to find KS2 values for the different projects. The data was revised and organized on an Excel sheet to generate Figure Figure 17

The projects are sorted from the largest negative to the largest positive deviation from the P85 value. There is a variety of project types amongst these 91 projects: Railroad projects, highway and road projects, defense projects and building projects. These projects have been through the KS2 decision gate, implemented and completed in the period between 2000 and 2014. 71% of the projects were executed within the P85 cost frame.

Cost overruns occur in 29 %. The overall average is -4%, which could be said to be the size of the cost savings. This is an overall a good result, especially compared to the rest of the world. This is said based on one of Flyvbjerg's studies encompassing 258 large transportation projects across 20 countries, where he concluded that as much as 90% of these projects went over budget (Flyvbjerg, Holm, & Buhl, 2002).

To put things in perspective, 29 projects, executed in the 90s before the introduction of the FEL process into the Norwegian sector, were organized in the same fashion as done in Figure 17, largest negative to the largest positive deviation from the initial estimate. An initial look at the diagram in Figure 18 leads us to conclude that far more projects ran over budget in this period. In fact, only 10 out of these 29 projects were finished within or below the planned budget.

A study performed by the Concept Rapport group at NTNU had a thorough study in 2013 of 78 projects that were subject to the new FEL standard, and were through KS1 and KS2 comes in support of the earlier conclusions. The group concluded that ca. 80% of the projects involved in the study ended up with cost savings relative to the P85 estimated budget, while only 17 projects exceeded the budget. The total net savings for these projects was estimated to be 6% of the total investment (Volden, 2016).

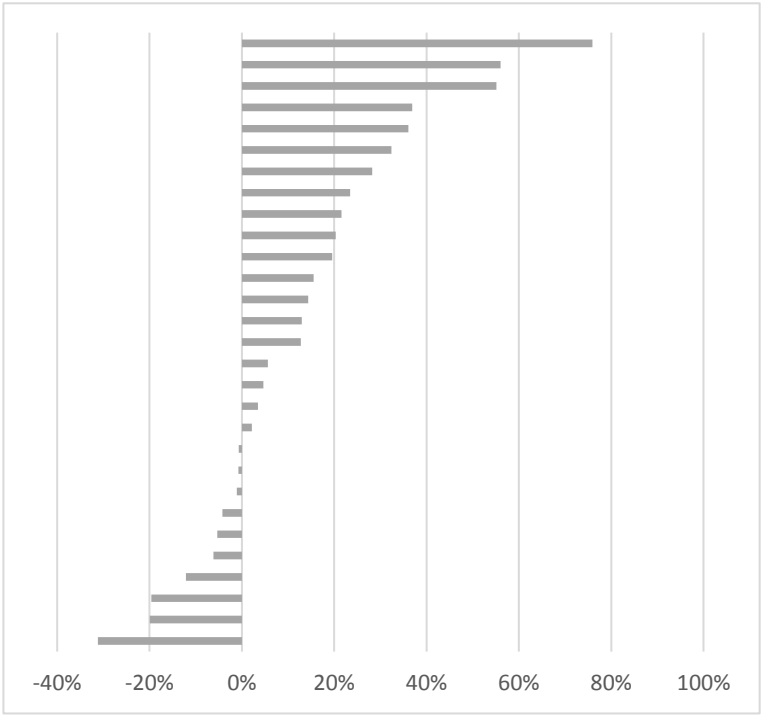

Figure 18: Deviation from the initial estimate for projects in the 90s (In current Norwegian NOK)

This is a surprisingly good result, which could be said to be indicative of the government having better and firmer control on their investment projects. Figure 19 illustrates the results obtained by the Concept research team.

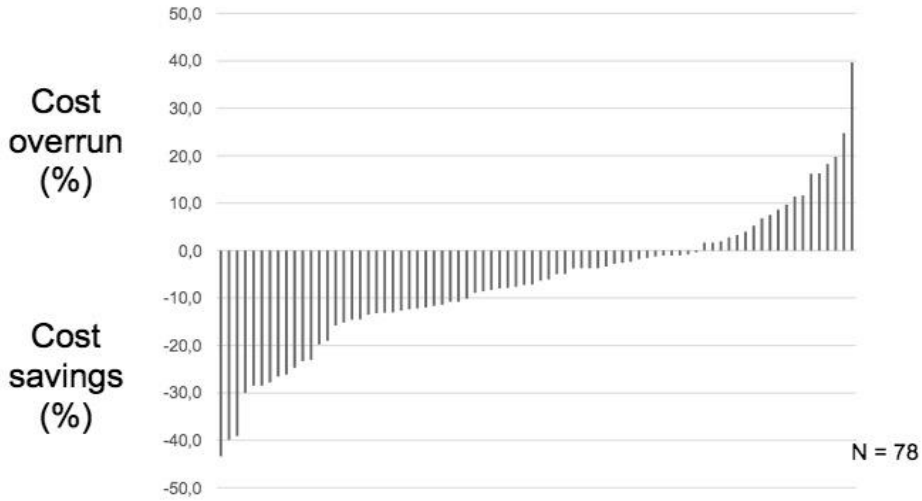

Figure 19: Cost deviation relative to the P85 budget (percentages) (Volden, 2016)

As mentioned earlier P50 is the expected value, that is, it is 50 percent probability that the cost will be within this number. The P85 is higher, as it is 85 per cent likely that the cost will be within this value. The parliamentary cost framework is more spacious than expected cost. The cost framework takes into account assumptions related to implementation and is usually close to the P85 value.

The executing party, meaning the department/ministry, on the other hand, should commit to cost frame that normally corresponds to the expected value P50. When reminded of this definition, it appears that the comparison to the 85 is not a fitting one. The correct way of comparing the situation pre-FEL and post-FEL would be to look at how much the projects have deviated from the P50 value. P50 values are more comparable to the estimated values used pre-FEL introduction. This is what was done, and the data was organized similarly to the figures above yielding in Figure 20. P50 values were not available for 7 of the projects, making the total of projects considered in Figure 20 N=81.

Figure 20 still maintains the symmetric shape of the previously introduced Figures 17, 18 and 19, but it tells somewhat of a different story. The analysis shows that only 28 projects out of 81 have succeeded in maintaining a cost lower or equal to the P50 value, which only 34% of the projects at hand have averted cost overruns, which is almost equal to the percentage found for projects executed in the 90s. The cost overruns average size is as large as 7%.

Average	**7 %**

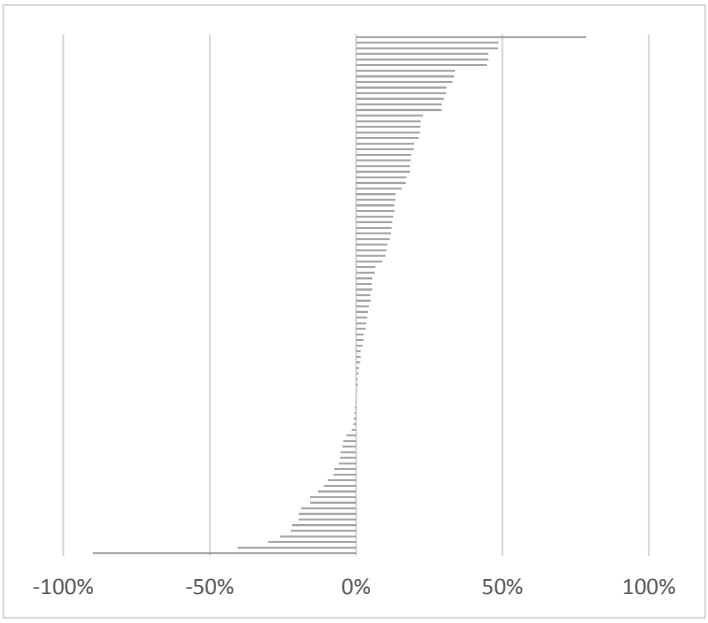

Figure 20: Deviation for p50 for 88 projects 2000-2014

Based on this second comparison and with the principle assumption being that P50 is more likely to resemble the budget estimates in the 90s, it appears that no considerable improvement has occurred with the introduction of the FEL scheme. This brings to mind a study by (Flyvbjerg et.al, 2003), which has similarly concluded that estimates did not improve and cost escalation has not decreased over the past 70 years. Although this was a first of its kind, statistically significant study of cost performance, with a sample covering 258 projects in 20 nations worth approximately US$90 billion. The focus, however, was on transport infrastructure projects only. This bring one to ask: are these results really reason enough to bring the futility of the FEL scheme into question? Are cost overruns the general case for projects rather than the exception?

Rather than completely dismissing the positive effect, the FEL scheme has had in the Norwegian public sector, one should be reminded that cost overruns problematic have persevered over a long time and that it will not simply and immediately go away by merely pointing out its existence and the introduction of a countermeasure. It is therefore suggested that the effect of the FEL scheme be studied in a different fashion, one where the development of cost overruns is observed as the experience with the FEL scheme application increases.

This comparison to the situation in the 90s and the global situation is also not very reliable, as it does not account for many important factors that will certainly affect the outcome, amongst which we mention:

- Sector specific conditions
- Size of the projects
- Complexity of the projects
- Time for initiation and the marked situation at the time

The effect of these on the comparison will be discussed in the subsections that follow.

4.1.1 Sector specific conditions

Calculation of final cost and comparison of this to estimate and frame are in initially unproblematic. In practice, however, it is the case that different agencies have different departments/agencies have different routines and a varying level of experience with the FEL scheme. One of the most important differences is which cost estimates are used as a reference, as it was found to be the case from the literature review of governmental documents. This will be a challenge when you want to compare results for projects from different sectors. Access to this type of information has also proven to be a challenge, as one has to scrap together information from different unaffiliated sources, which can bring the credibility of these into question.

4.1.2 Size and complexity of the project

To better document, the effect of the FEL scheme, the characteristics of projects should be as similar to each other as possible. This will make it easier to isolate the FEL specific conditions when the size and complexity of the projects subject to the analysis have a higher degree of resemblance. The difference in size and complexity will result in the usage of different cost estimation methods, a different approach to uncertainty, and a different attitude towards risk.

4.1.3 Time for initiation and marked situation at the time

Building costs per meter have increased by an average of 8.5% per year over the period 1991-2011 and 45% from 2008 to 2011. This corresponds to more than a fivefold increase in the cost of building a given project in the course of 20 years. Over the same period, the construction cost index has increased by just over 90% (Morten, 2016). It can explain some of the challenge of cost management in transport projects considering that building projects do last for several years.

Another case to point out is that of the recent oil crisis that hit the country. This has led to a wave of labor and economic cuts. These cuts do mean a reduction in access to competent labor

and limited access to critical economic resources. A direct relation has been established between these types of cuts and the rise in the number of setbacks and accidents faced in the workplace. A recent case was the Statoil's examination of the incident at the Stureterminal station in Hordaland where five people were exposed to hydrogen sulfide emissions (Breivik & Nysveen, 2012).

Understaffing was identified as the main reason the incident occurred. PTIL (The Petroleum Safety Authority) issued a report identifying understaffing caused by the crisis as a factor that raises the probability of accidents occurring offshore (Taraldsen & Andersen, 2015).

These types of marked developments should be taken in consideration when comparing projects, as the effects of such developments can strike at the heart of the organization's capability of carrying out the FEL scheme properly and executing the project in accordance with it, easily resulting in cost overruns.

4.2 A correct approach?

Earlier, in section 4.1, a suggestion was made that the development of cost overruns should be tracked as the level of experience with the FEL scheme rises. This is an approach that was the Concept research team has come to adopt.

The Concept research group continues to research the project overruns problematic in the public sector of Norway. The group has been very prolific in terms of producing reports documenting the repercussion of the government's investment policies since the introduction of the FEL scheme. The research team has been tracking the development of cost overruns in projects that underwent the FEL scheme, as they continue to be realized and concluded.

A recent report released in 2014 (Morten, 2016), presents an updated study of cost management in projects subject to external quality assurance, KS2. The background is Concept Report No. 35, which showed, among other things, that 80% of the projects had been carried out at a cost lower than the Parliament's cost framework. Since the previous data collection, which only went up to approx. autumn 2012, another 11 newly finished projects (2012-2013) were added to the analysis. The main relevant findings in the report were as follows:

- Out of the 51 completed projects, 38 have had an end cost on or within the cost frame. It accounts for 75% or 5 percentage points less than the situation in 2012.

- The total closing cost was NOK 2.9 billion lower than the cost frame, or 3.6% of the entire portfolio.

Based on this, we conclude that cost control in major Norwegian investment projects is still good and probably better than in many other countries. However, the question of whether it is getting better remains to be answered as more and more projects are concluded and analyzed.

4.3 Drastic cases from the Norwegian public sector: Can the causes of these cost overruns be traced back to the FEL phase?

4.3.1 The Oslo Opera building

About the project

The building was opened as planned in 2008 with a significant cost overrun. The Opera has been well received by the public and has become a tourist attraction, not least due to the proximity to the sea and because the public can walk free on the large sloping ceilings. The decision to build opera in Bjørvika was taken without taking into account the enormous costs that would entail the redevelopment of road systems in the area. This included the very costly lowering tunnel that was in place and was put into operation in spring 2010. The project has subsequently been strongly criticized by actors in the cultural sector. The operating budget has been multiplied and the public annual subsidy for operations is higher than the Culture Council overall allocates to all other cultural fields (Literature, visual arts, etc.). At the same time, there has not been much more opera for the money.

Where it went wrong

The opera was initially estimated to cost 750 Million NOK in 1989. The KS2 quality assurance estimate turned yielded in an estimate of 3.62 Billion NOK. The project implementation ended up costing an additional 1 Billion, raising the total cost to 4.352 Billion NOK (Lilleby, 2015).

FEL malpractices and the potential cause for this cost overrun (Welde, Samset, Andersen, & Austeng)

Welde and his research team reported the following, in their 39th report as part of the Concept project: The cost increases in the project were primarily due to (1)lack Information, (2)unclear assumptions and (3)unforeseen circumstances, as well as a good portion (4)strategic underestimation and (5)tactical breakdown. Factors (1), (2) and (4) clearly belong under FEL malpractices.

According to the same report, Vestbanen, Bjørvika and Folketeaterbygningen options, have received equal treatment through the early stages. Strategic underestimation seems to have happened under the evaluation of all the concepts.

The income from the project was never considered in all cases because it was established that future true revenues from the opera would in no way be able to cover up investment costs. The big strategic failure was the little concern the road system was given in the planning face. The opponents of project argued at an early stage for this to be as source of uncertainty around the final amount for the Bjørvika option.

Investigators and specialist communities with experience in this area, including Statsbygg, have made most estimates in this project. There has been considerable uncertainty in the earliest years, both with regard to what is being built and where it should be placed. A substantial source of uncertainty that appears to be overlooked on purpose, to generate a low estimate that would be more acceptable to the decision makers, even with Vestbanen alternative being more of a suitable one.

In this project, there were several parties who stood against each other: for and against Opera, for and against new construction, for and against Bjørvika. Therefore, there is no reason to believe that there has been some over-optimism or risk ignoring in this case.

4.3.2 New Holmenkollen ski jumping ramp

About the project

The Holmen ski jumping ramp and park for jumping and cross-country skiing is a national and International winter sports icon. It is a national facility for winter sports and not least, Norway's most visited tourist attraction with over 600,000 visitors each year. That was why there was little disagreement when the Oslo City Council decided to host the 2009 Skiing World Cup in 2003. In order to that, the entire facility for jumping and cross-country skiing had to be rebuilt and renovated. In addition to the actual jumping tray, the project contains a normal tray in midtstuen, a new arena and cross country tracks, technical infrastructure, snow production facilities and some temporary facilities for the World Cup. The hopper itself has space for approx. 20,000 spectators. With the other facilities, the capacity is considerably larger.

Where it went wrong

When the new about the new Holmenkollen ski jumping ramp broke out in the media, many political figures were quick to condemn the project turnout:

"I can not remember a bigger percentage of crack ever. This is a Norwegian record in cost overruns" said Group Manager for AP (Labor Party) in Oslo City Council, Rune Gerhardsen, to Dagbladet.no.

"This is the biggest overrun on a public construction project ever," said Minister of Culture Trond Giske on TV2 news.

The cost estimate in Oslo city council was increased from 600 to 900 million NOK, and in August 2009, it became clear that the actual final cost for the ski resort is estimated at 1.8 billion kroner, according to a report from the consulting company Metier, an external quality assurance agent. A cost explosion left both the political scene in the country and the public in shock.

FEL malpractices and the potential cause for this cost overrun (Welde, Samset, Andersen, & Austeng)

A cost overrun of this size obviously points to a completely unrealistic one perception of what a project of this size would cost. Even with the original plan to only upgrade Holmenkollbakken the cost estimate set (40 Million NOK) was unreasonably low. Then comes the tight progression plan that posed major challenges in terms decision-making, cooperation with users and stakeholders, implementation of procurement strategies, engineering processes and implementation of construction work. Many different contractors were going to work together in a limited geographical area and it was demanding in terms of coordination between the various subprojects.

New Holmenkollen was a large and complex project. The largest the Oslo municipality has ever completed. In an evaluation of the project, concluded that the one municipality was not in possession of the necessary capacity or competence to execute the project. The municipality audit team lists the following factors as potential causes for the cost overrun (Oslo, 2009):

1. The project had a short time to prepare the cost estimates in the decision base
2. No uncertainty analysis were made for the agreed concept and cost framework
3. There was insufficient capacity and came expertise
4. There was uncertainty about roles

All of these factors except for the first can be classified as FEL malpractices. The resulting consequences are rooted in the non-proper implementation of the FEL scheme.

Project managers in the municipality constantly felt a lot of pressure to find Cost-effective solutions to keep the management frame. The cost was slow progress, which in turn led to cost increases.

There was no uncertainty analysis and originally adopted "The cost framework" for the project was a purely deterministic estimate. Only in 2009, a year before the project was completed, that an external quality assurance was carried out for the project, which is very late. In the quality assurance report, it was pointed out that the project ever since the allocation of World Cup has been the subject of conceptual selection, alternative assessments, and changes. This was primarily due to the need to keep budgets, but also the requirements for alternative assessments and adjustments due to failure to fulfill the technical requirements. This has led to a dramatic increase in the workload of hired architects and compared to what that which was originally determined.

The costs increased dramatically as the concept became clear and the project slowed forward. This again led to reorganization and (partly unrealistic) political demands cost cuts. At the same time, as pointed out in the KS report, this was an extremely time-consuming and technically demanding project. Overall, this demanded a great deal project management and implementation. The latter was inadequate and especially in the project's first phase, which was characterized by a lack of capacity and competence. It was not untill June 2009 that the construction client position was a 100% occupied by someone.

It appears that an investigation of background and motive for the first estimates is necessary, as there seem to be indications that some kind of foul play was at hand, maybe deliberate underestimation.

4.3.3 Transport projects

Cost overruns in the transport projects are becoming an increasing focus for the authorities and the media alike. This mainly because of the huge amounts of money the government has been pouring into the sector lately.

Dokument 1 (2013–2014) (Riksrevisjonen, 2013), a report issued by the office of the Auditor of Norway (Riksrevisjonen) concluded that the Norwegian Public Roads Administration has

considerable costs overruns and delays in their road projects. For the controlled contracts, it was found that cost overruns on average were at over 20 per cent and 25 per cent of the contracts were delayed by a minimum of six months.

The office of the Auditor of Norway was especially critical of the Ministry of Transport's lack of attention aimed at the Norwegian Public Roads Administration to monitor road construction contracts in the early phase, which it has identified as a necessary measure for reducing both the risk of cost overruns and delays. Cost overruns on such contracts lead to the projects being more expensive, while delays in road projects lead to reduced accessibility and reduced road safety, which entails an associated cost toll. The report also mentions a lack of compliance with archiving and documentation requirements, which is also a necessary for good FEL practices.

A report issued by Norconsult AS (2016) aimed at investigating the cost overruns in the sector, also identifies several FEL scheme related factors as main causes for the cost overruns plaguing the transport sector. The report lists the following factors:

- Project creep
- Lack of competence within planning
- Deliberate underestimation and maintaining low estimates for political motivations

4.4 Perverse incentives and lack of competence: the leading causes of cost overruns?

For the projects and reports that were looked at in this study, there seems to be a set of project overrun causes that are predominantly present in the FEL phase. Deliberate cost underestimation and deliberately overlooking risk. These will be referred to as perverse incentives.

In the study (Welde, Samset, Andersen, & Austeng) that looked at 12 projects with dramatic overruns, several indications were found of initial underestimation of cost for political gain. This deliberate underestimation has yielded in scope increases, inadequate estimations of risk and poor allocation of expertise.

The report further concludes that that five of the twelve projects would not have been approved if the estimation under FEL was carried out transparently. Four of the projects had most likely been realized, while it is more uncertain with the last three.

This goes to show that underestimation of costs under the FEL phase has yielded in major implications for the projects in the public sector of Norway, and is probably a far more severe problem than cost overruns in the implementation phase. To prove this point however, large and more significant research should be carried out to investigate the extent of this problem, as the work done in this thesis and the reports reviewed are not ground enough to generalize this for the whole sector.

Another factor that was worth more attention is that of competence. It seems that several reports cite lack of competency as a reason why the proper execution of the FEL scheme fails. Although the departments/agencies do have access to external consultants, the involvement of these usually not change much of the outcome.

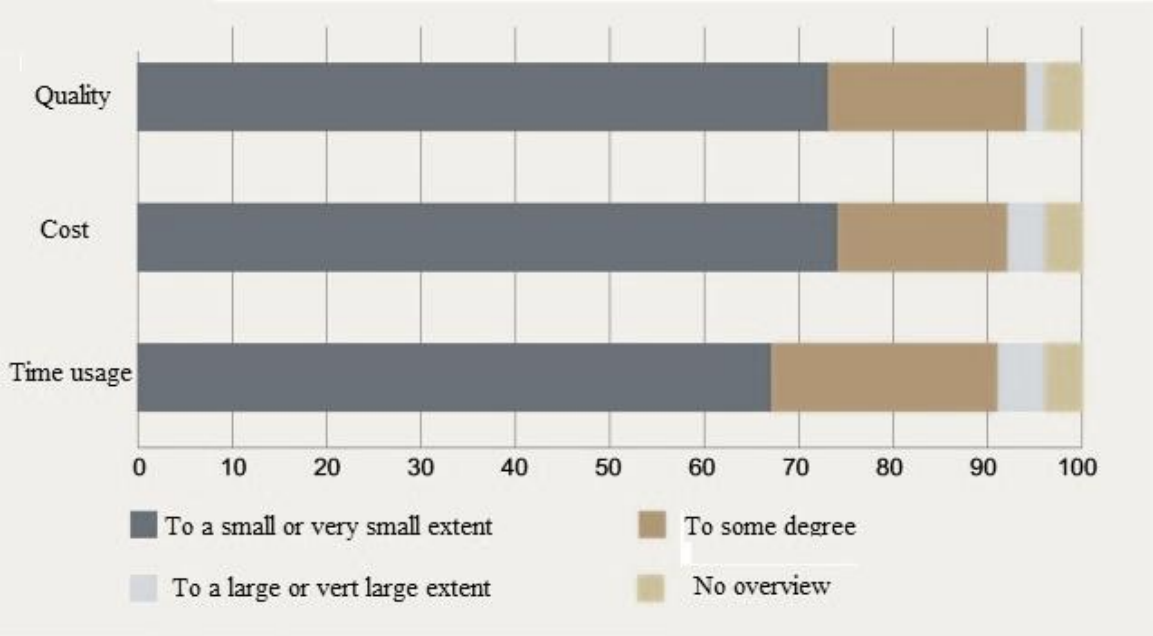

Figure 21: To what extent is there deviations from the agreements entered with consulting services regarding quality, cost and time (Revisjonen, 2016-2017)

Figure 21 taken from a study performed by the office of the auditor general of Norway (Revisjonen, 2016-2017), in which the usage of consulting services by governmental institutions was assessed. The Figure shows the extent of which consultancy services deviate from terms of the agreement with governmental institutions when it concerns quality, cost and time use in the period 2014-2015.

About 27 % of those who answered the survey indicate some or a large degree of deviations has occurred in quality and cost or that they do not have an overview of the quality of the consultancy services performed. Of the business types, the ministries are had the least deviation.

For the other business types, there were only minor variations. The deviation is greatest in terms of time spent. About 33 % of employees that have used consultancy services replied that in some or to a large extent, deviations occurred on time, or that they do not have an overview of time spent (Revisjonen, 2016-2017).

When it comes to time use it is ministries with least deviations. The survey shows that the proportion of businesses that responded to the existence of anomalies with regard to quality, cost or time use, is greater among the businesses that use a lot of consulting services, than among those who use little such services (Revisjonen, 2016-2017).

If we consider the quality and time the consultants deliver/use when it comes to completing their services, it seems that is not a pressing issue in the public sector. The reason might rather be that the involvement of the external consultants is usually late in the project-planning phase, and they are brought in to clean up the mess rather than contributing to upholding good FEL scheme practices.

5 Conclusion

The answer to the research statement is presented in this chapter, along with a concise summary of the results of the study.

The analysis from Section 4.1 shows what might be characterized as conflicting results. There are indications that the introduction of the FEL government scheme might have a positive impact resulting in the reduction of cost overruns in the public sector. This at least the case for the comparison between the past situation and the P85 cost frame of the FEL scheme era.

When looking at how cost control develops as experience with FEL scheme grows, it appears that it is under continuous improvement, this was discussed in section 4.2.

The comparison with the P50 values shows that no improvement has happened, which might be considered as an indication the cost overruns phenomenon, despite the FEL scheme measure, continue to persevere and is somehow normalized. The symmetry of in the data we attained in our analysis remains the same in all the figures, which goes to further support the claim that the situation remains relatively unchanged.

However, these conclusions cannot be ascertained as the data was not sufficient to perform a quantitative analysis and the limited number of individual case reviewed in this thesis. The number of projects subject to the FEL scheme and quality assurance process continues to grow, and with that, the number of data points for a future more significant research.

The individual drastic cases review shows that the perverse incentives are the leading cause the FEL scheme is not appropriately executed. Ways to combat these were introduced and discussed in Chapter 3. However, a more thorough investigation into why these keep persisting should be initiated on a larger scale, rather than individual cases.

Regarding the goals of this thesis, The first goal has been achieved by performing a thorough literature review of the FEL concept in Chapter 3, accompanied with a discussion and listing of concepts related to FEL phases that are characteristic of successful projects. The FEL scheme was found to have a positive influence on project success in the literature reviewed, but this effect was however not obvious in the overview of the reality of the Norwegian public sector practices.

Regarding the second goal, Chapter 4 provides a rather qualitative overview of the situation, the findings of which were discussed earlier in this chapter. The third goal is materialized in the following chapter, titled Recommendations.

6 Recommendations

Base on the insights gained from the research performed for this thesis, these recommendations are directed to both the academic community and the Norwegian authorities.

6.1 To the academic community

For the academic community, the following recommendations are given regarding improving the FEL scheme practices:

- K1 to K2 cost development research:

The cost development between KS1 and KS2 are not cost overruns, as the Stortinget (house of parliament) has neither decided to implement the projects nor set a final budget, but is still a challenge for several reasons. In order to do something about it, it is therefore important to first have knowledge of why this happens. To reveal the reasons why cost estimates have changed. It would have been very interesting to look at the cost development under the FEL phase between KS1 and KS2. However, this was unfortunately not attainable because of the unavailability of data about the KS1 estimates.

It would have been interesting to analyze:

1. How the deliberate underestimation "survives" the KVU / KS1 to KS2 evaluations.
2. The unexpected Changes and solutions that could not have been identified in KVU / KS1 and their effect on cost overruns.
3. The time and cost spent between KVU / KS1 and KS2 and its effect on the quality of implementation and consequently cost overruns.
4. The Timing of the involvement of the external quality assurance agents and its impact on the final cost outcome
    - Research to further document the effect of perverse incentives on the FEL practices
    - Better sharing of data between the academic institutions of Norway (common easy access database) and the expansion of the Concept Report project to include other universities. The alternative would be the initiation of similar investigative projects into cost overruns in the public sector, in other institutions other than NTNU.
    - Research on how to improve the adaptation of the government FEL scheme by the different ministries, departments, municipalities and other governmental agents.

- Research the effect of understanding risk on the decision-making process: it is our understanding that understanding of risks involved in executing projects can be the difference between failure and success, as it is apparent for the cases we have looked at. A number of techniques and software programs are being used to make educated speculations about future outcomes. From SWOT analyses to Risk registers to Formal risk mitigation plans and programs, all are put in place to give the impression that we can cope with any risk that may occur during the execution of a project. Large calculation programs based on the Monte Carlo method are being used to create the impression that we as project managers and executioners can deliver within certain strict boundaries. However, are these used sufficiently in the FEL phase? In addition to what effect do they have on the final project cost outcome?

6.2 To the Norwegian authorities

This thesis deals with a phenomenon that has been scarcely studied or problematized in the research literature. The review of project cases, along with the review of the cost overruns situation in the public sector of Norway was not very broad or significant. Nevertheless, we provide some suggestions for practices that can help improve the implementation of the FEL scheme:

- Early involvement of the external consultancy services: Perverse incentives and over-optimism can be held in check with the presence of a third objective party.
- Increased transparency: To combat the effect of perverse incentives and the resulting malpractices, thorough documentation should be maintained throughout the entirety of the FEL phase.
- Cost estimates based on uncertainty analysis: Already in KS1, uncertainty calculations of all alternatives should be thoroughly executed to avoid malpractices similar to the ones under the Opera project. The calculations should be updated through all phases of the project.
- Attitude toward risk: All decision makers should have a good understanding of risk and how to communicate risk to all project stakeholders.
- Availability of a Database for reference projects as recommended by Merrow: reports should be easily accessible for all departments, ministries, and other governmental agencies for the purpose of experience sharing.

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