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Project management man-hour cost analysis

Case: Wärtsilä Energy Solutions

Jonatan Sandvik

Degree Thesis for Bachelor of Engineering

Degree Programme in Industrial Management and Engineering

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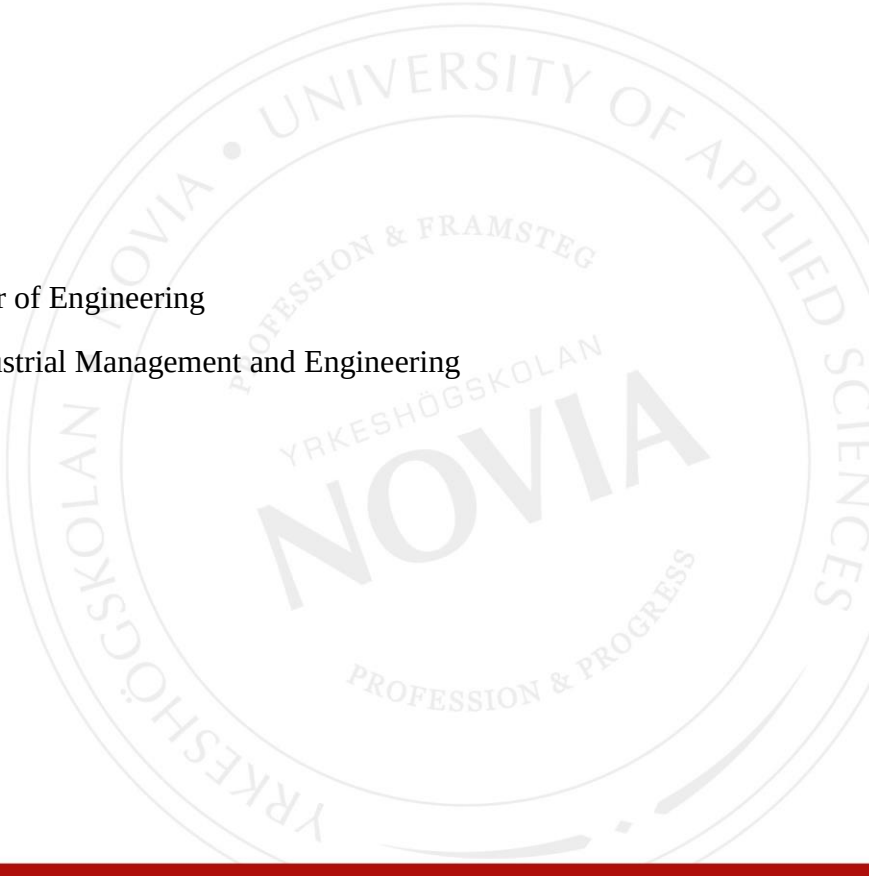

BACHELOR'S THESIS

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Abstract

This is the official version of the thesis that exclude method and result chapter. The classified parts can only be studied within Wärtsilä.

This thesis is made for Wärtsilä Energy Solutions, Project Management Development & Tools department. The objectives of this thesis were to analyse how well project management man-hour costs have been budgeted in power plant projects and to suggest improvements to the cost estimation-tool in CRM and to the budgeting process.

The execution of this thesis was made in different steps. First, historical projects' data was collected and analysed to answer how well man-hour costs have been budgeted compared to actual costs. Then, the estimation-tool was analysed and tested to be able to see how accurate the tool's man-hour estimations are. Lastly, interviews were held to collect expertise advice and qualitative data.

The results of the thesis are a deeper analyse of man-hour costs and improvement suggestions to the estimation-tool and to the budgeting process. During the process of making this thesis, a lot of relevant side findings have been noted and those are also presented as results.

Language: English Key words: project management, budget, man-hours, data, analysis

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EXAMENSARBETE

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Datum 10.4.2018 Sidantal 25 Bilagor 0

Abstrakt

Detta är den officiella versionen av examensarbetet som exkluderar både metod och resultat kapitlen. De sekretessbelagda delarna kan endast studeras inom Wärtsilä.

Detta examensarbete är gjort för Wärtsilä Energy Solutions, avdelningen Project Management Development & Tools. Syftet med examensarbetet var att analysera hur väl projektledningens arbetstimmar har blivit budgeterade i kraftverksprojekt samt att föreslå förbättringar på kostnadsberäkningsverktyget i CRM och på budgeteringsprocessen.

Utförandet av detta examensarbete har gjorts i olika steg. Först blev historiska projekts data insamlat och analyserat för att svara på hur väl kostnaderna för arbetstimmar har blivit budgeterade jämfört med de verkliga kostnaderna. Därefter testades och analyserades kostnadsberäkningsverktyget för att kunna se hur exakt verktygets uppskattningar är. Till sist hölls intervjuer för att samla in expertråd och kvalitativ data.

Resultatet av detta examensarbete är en djupare analys av kostnaderna för arbetstimmarna samt förbättringsförslag till kostnadsberäkningsverktyget och till budgeteringsprocessen. Under utförandeprocessen av detta examensarbete har många relevanta sidoupptäcker gjorts och dessa är också presenterade som resultat.

Språk: Engelska Nyckelord: projektledning, budgetera, arbetstimmar, data, analys

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TERMS AND ABBREVIATIONS

EPC	Engineering, Procurement and Construction
Process EPC	EPC above floor level
EEQ	Engineered equipment delivery
Basic EEQ	Basic engineering, procurement (equipment delivery, logistics)
Extended EEQ	Detailed engineering, procurement (equipment and material delivery, logistics)
CD	Customer Delivery
CFU	Cost Follow Up
WBS	Work Breakdown Structure
WES	Wärtsilä Energy Solutions
PMDT	Project Management Development & Tools
PMST	Project Management Service Team
Man-hours	Work amount needed to perform a task (in this thesis; project management work to execute a project)
Special projects	Explained more detailed in the internal version

FOREWORD

I would like to thank Wärtsilä for giving me the opportunity to write my Bachelor Thesis for the company and to all the people who have participated in interviews or otherwise tried to answer my questions. A special thanks to Mats Bystedt and Jonas Lindholm who have helped and supported me throughout this process.

I would also like to thank Novia UAS and Roger Nylund for supporting and supervising me in the writing process.

1 INTRODUCTION

Customers today are expecting more flexible providers that can make custom-made solutions for them. This leads to companies having to adjust their business depending on the customers demand to be able to compete with rivals on the market. Because of this, a lot of companies have changed from being a product-based company to becoming a project-based company. Project-based companies have a lot of advantages compared to product-based companies, but they also have a lot of challenges that product-based companies do not have.

To be able to sell something and be sure to make profit, the costs of the product or service needs to be known. The better cost knowledge a company has, the safer profit margins. For companies that only sell products, a cost calculation can often be done quite easily. For project-based companies it can be very difficult and especially time consuming to be able to predict accurate project costs. Still, for any company that wants to remain successful and profitable it is a must to continuously improve its estimating and pricing methodologies (Kerzner, 2017).

1.1 Background

The study is made for Project Management Development & Tools (PMDT) – Wärtsilä Energy Solutions. The PMDT department's responsibilities are more deeply described in chapter 2.4. To develop project management processes and to control that the supporting tools are up to date, are some of the department's responsibilities.

To estimate how much time that will be consumed by the project team to finish a project can be very difficult. Wärtsilä, Energy Solutions (WES) builds power plants all around the world and there is no project that is exactly as another, which makes it even more difficult to estimate costs. Hence a man-hour estimation-tool has been created, to streamline the budgeting process. When streamlining the budgeting process, time consumption is reduced but the budget's costing accuracy might suffer.

The man-hour estimation tool that is in use today has been developed by the PMDT department in 2015 and no analysis or update has been done since that. Wärtsilä is continuously analyzing and improving the costing accuracy and when I asked to get a topic for my thesis a man-hour cost accuracy analysis was requested.

1.2 Problem Area

Companies are getting more digitized and businesses are changing more rapidly than ever before. This affects the way of working and also the costs for the company. To make good cost estimations are very essential for companies to be able to survive and that is why cost estimation methods needs to be updated and improved regularly.

Overpricing might sound less dramatic than underpricing, but both can be very hurtful for the company's net sales and profit. Underpricing generates lower profit than expected and sometimes also losses. Overpricing makes the company less competitive on the market and some possible sales might be lost.

As mentioned earlier, each power plant project is unique which makes it more difficult to estimate accurate man-hour costs. If a perfect estimation-tool would exist none of the projects' man-hours would be overbudgeted or underbudgeted. A perfect estimation-tool is utopia but by analyzing and updating the costing methodologies, the estimations can become more accurate.

1.3 Purpose

The main purpose of this thesis is to analyze how accurate WES has been at estimating man-hour costs for CD-projects and by analyzing historical data and theory, to suggest improvements on the estimation-tool and the budgeting process. By studying how WES budget man-hour costs today, valuable information can be gathered. This can be helpful when improving the budgeting process, but also for future cost analyses. The thesis will hopefully be an eye-opener for WES on how they sell and budget project management today and result in more accurate man-hour budgets in WES' projects in the future.

1.4 Delimitations

Through the years WES has delivered a wide range of projects within different energy markets. The thesis will only take into consideration customer delivery power plant projects with Basic EEQ (engineered equipment delivery), Extended EEQ, EPC (engineering, procurement, construction) and Process EPC scope types. *Special projects* will not be considered.

The thesis limits the analysis to only man-hour costs of the project team. When looking at a CFU, it is only the Project Management activity that is considered (see figure 7). Other costs for the project team, e.g. travel and meeting expenses, are not analyzed.

The thesis does not consider if projects have been over-resourced or if unexpected incidents have occurred during the project execution and therefore have higher actual costs than needed. The aim is only to see how large deviation it is between sales budget and actual costs and to suggest improvements on how to estimate a sales budget that corresponds to the actual costs.

1.5 Confidentiality

This is the official version of the thesis that can be studied freely by everyone. This thesis' internal version covers a lot of sensitive data that cannot be shown outside the company. Method and result chapters are therefore classified and can only be studied freely within Wärtsilä. Appendices that are included in the internal version are also removed from this official version.

1.6 Disposition

The disposition of the Bachelor's thesis is as follows:

Chapter 1 – Introduces the background, problem area and the purpose for the thesis.

Chapter 2 – Presents Wärtsilä and its organizations in brief. Project Management Development & Tools department is also presented.

Chapter 3 – Presents theory that is related to the thesis. This information helps the reader to get a basic knowledge of the subject and a more understanding of the thesis.

Chapter 4 – A final conclusion is presented and future research proposed.

2 WÄRTSILÄ IN BRIEF

Wärtsilä has grown from being a small sawmill to become a global leader in smart technologies and complete lifecycle solutions for the marine and energy markets. The company was established in 1834 in Wärstilä, Finland and has since that been into several industries before getting into the diesel engine market in 1938. Today Wärtsilä operates in more than 80 countries and has approximately 18 000 employees around the world. In 2017 Wärtsilä had a total net sales of 4.9 Billion euros. Wärtsilä was the 11th largest company by net sales and the 9th largest employer in Finland in 2016 (Largestcompanies, n.d.). (Wärtsilä, 2017a; Wärtsilä, 2018e)

The world is getting more climate conscious and the demand for clean and flexible energy is increasing. Wärtsilä has an integrated portfolio of services, systems and products that can respond to the demand for energy efficient and innovative solutions. The company is going through a digital transformation, that will increase the customer value by optimising installation performance throughout the lifecycle, using artificial intelligence and data analytics to support the customer's decisions. Wärtsilä is an innovative company that strives to be recognised by the customers to be a leading energy system integrator that can provide all essential technologies, services and solutions for sustainable and reliable power systems. All of this is mentioned in Wärtsilä's strategy and are visualized in figure 1 with the purpose stated as "Enabling sustainable societies with smart technology". (Wärtsilä, 2017c; Wärtsilä 2018e)

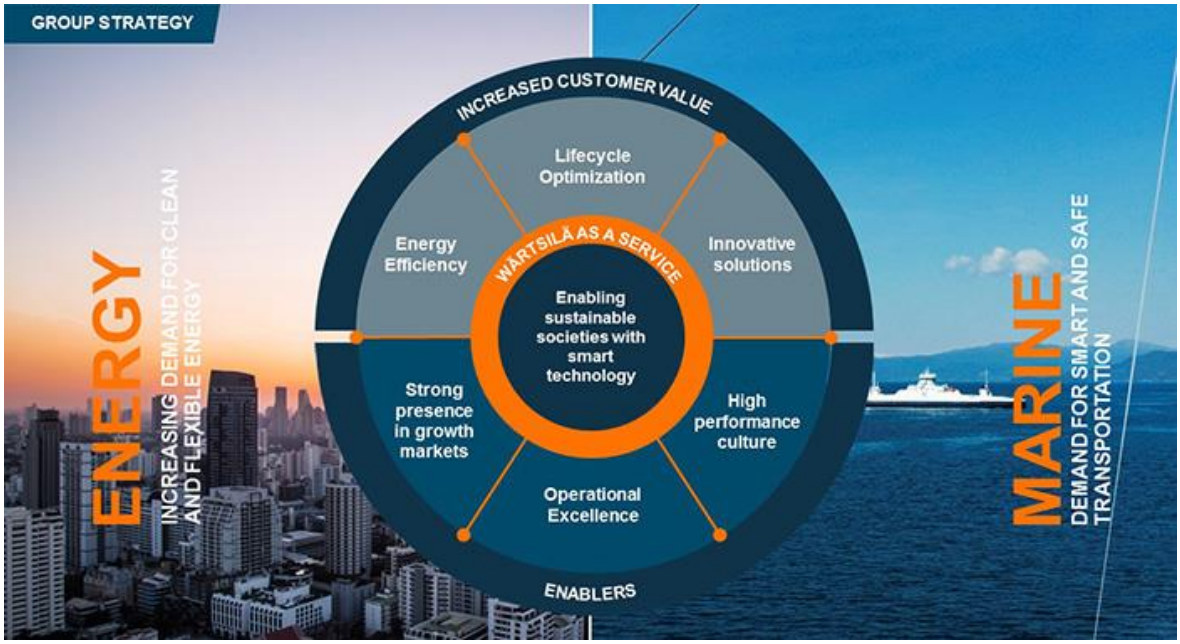


Figure 1 - Wärtsilä's strategy and purpose (Wärtsilä, 2017c)

Wärtsilä is divided into three main businesses; Energy Solutions, Marine Solutions and Services. More information about these business areas are shortly presented in sections 2.1, 2.2 and 2.3.

2.1 Energy Solutions

Energy Solutions is the business area that focuses on the energy market. WES builds and designs power plants for industries, independent power producers and utilities. WES is a leading EPC contractor and lifecycle support provider. WES has broadened its portfolio the latest years and can today offer ultra-flexible internal combustion engine based power plants, energy storage systems, utility-scale solar photovoltaic power plants as well as LNG terminals and distribution systems. In 2017 WES had installed over 65 GW power plant capacity in 177 countries around the world. (Wärtsilä, 2018a; Wärtsilä, 2018e)

2.2 Marine Solutions

Marine Solutions focuses on the marine market and has a strong position in the marine and oil & gas industries. To underline how great positioned Wärtsilä is on the marine market it can be mentioned that every 3rd ship in the world runs with Wärtsilä technology. Wärtsilä Marine Solutions is operating in all the main vessel segments with a broad portfolio of products, services and solutions. (Wärtsilä, 2018b; Wärtsilä, 2018e)

2.3 Services

Services is the largest business area within Wärtsilä looking to net sales (45 % of Wärtsiläs total net sales 2017). Wärtsilä Services helps the customers to grow their business by supporting them throughout the lifecycle of the installations and optimising the efficiency of their operations. Wärtsilä Services has about 11 000 professionals in 160 locations around the globe and serves more than 12 000 customers per year. Services offering portfolio is the broadest in the industry and consists of spare parts, optimising customer operations and providing guarantee of performance, just to mention a few. (Wärtsilä, 2018d; Wärtsilä 2018e)

2.4 Project Management Development & Tools

PMDT is a department within WES and as mentioned in chapter 1 the thesis is made for them. PMDT department is doing a lot of things but some of the main responsibilities are to develop and deploy project management processes and supporting tools to areas and business lines within WES. The department is also monitoring and controlling that these processes and supporting tools are used consistently and correctly. PMDT does also provide inputs to Sales Development, Operational Development, Business Development, Product Development and other relevant areas and business lines from a project management perspective. The thesis falls into the category mentioned last. (Wärtsilä, 2018c)

3 THEORY

This chapter will present necessary theory to better understand the problem, the method and the results. The beginning of this chapter will present project management both in general and how it is done within WES. How projects and project management within WES is handled will be emphasized because it is more important in this thesis. Thereafter budgeting and estimating project costs will be discussed. At the end of this chapter theory about data will be presented, because it will be in great focus throughout the method and result chapters.

3.1 Project management theory

Project management was already introduced in the 1960s, but was for a long time seen as an ineffective way to run a company. A lot of executives had a strong belief about how a company should be run and were inflexible to changes. They could neither see nor admit the benefits project management would give their company. It was first after economic crises like recessions in 1990s, the housing crisis in 2008 and the economic downturns in 2013, 2014 and 2015 that executives started to reconsider how to manage their companies. These economic crises forced many companies to change their way of working and the need for having better control over existing resources was emphasized. Companies noticed the importance of project portfolios that would increase the value to the firm and also higher the percentage of project successes. Project management got great attention because it was seen to satisfy all these needs, both in good and bad economic conditions. Today project management is applied in almost all industries as well as in all different sizes of companies. (Kerzner, 2017)

3.1.1 Project definition

Project management is the practical work done by any leader to manage a project. Before going through project management, one must understand what a project is. Project definition can differ a bit from source to source but Kerzner (2017), PMBOK® (2013) and Nicholas & Steyn (2012) mentions some of a project's characteristics as follows:

- Temporary, which means that it has defined start and end dates
- Unique, in the way that it is not a routine operation
- Have specific goals and to be completed within certain specifications
- Consume both human and nonhuman resources
- Being somewhat or largely unfamiliar and risky.

3.1.2 Project management methodology

Project management is used to achieve a project's requirements by using necessary knowledge, skills and tools. It is very common that the knowledge, skills and tools are grouped into processes and activities. Kerzner (2017) and PMBOK® (2013) lists the project management processes and describe some of the activities that are done within the processes as follows:

1. Project initiation
    - Selecting the best projects and recognizing their benefits
    - Preparing documents to sanction the project
    - Selecting the project manager

2. Project planning
    - Defining requirements, quality, quantity and needed resources for the work
    - Scheduling the activities and evaluating various risks

3. Project execution
    - Negotiating for the project team members
    - Directing and managing the work

4. Project monitoring and control
    - Tracking progress by comparing actual results with predicted results
    - Analysing deviations and adjust if necessary

5. Project closure
    - Confirming that all work has been accomplished
    - Contractually, financially and administratively closing the project

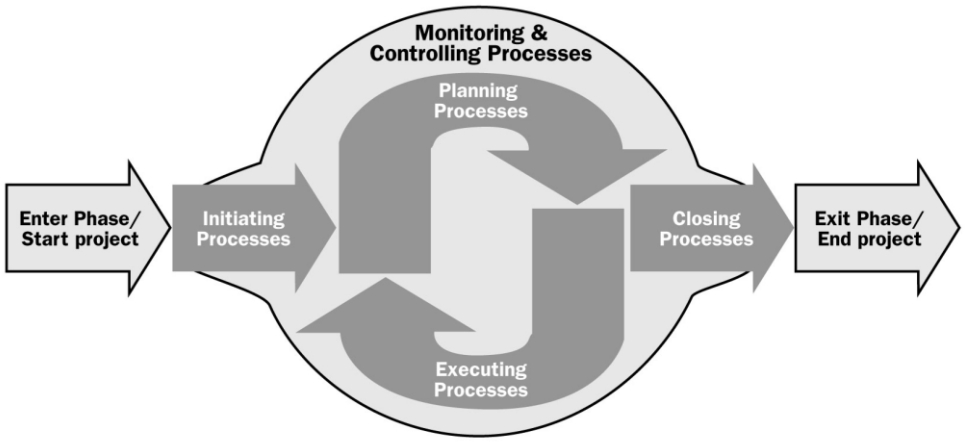


Figure 2 - Project Management Process Groups (PMBOK®, 2013)

It is common to number the processes from 1 to 5 by starting with the project initiation and ending the project with the project closure. However, in practice the processes overlap and interact with each other. PMBOK® mentions also that some processes reoccur during the project, e.g. the planning and executing process (see figure 2). Figure 2 pictures the monitoring and controlling process as a background group that occurs at the same time as the other process groups. The processes are often linked so that one process's output becomes the input to another process. Figure 3 illustrates how process groups interact and shows the level of overlap at various times during the project. (PMBOK®, 2013)

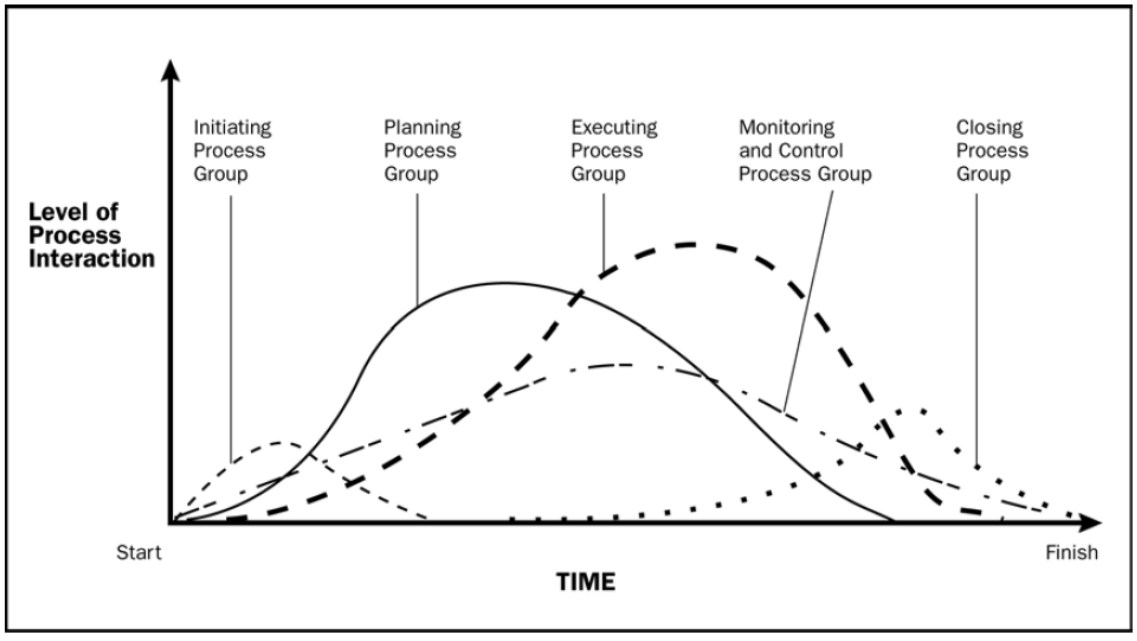


Figure 3 – Process Groups Interact in a Project (PMBOK®, 2013)

As already mentioned, each project is unique and the requirements from project to project and customer to customer often vary, which might lead to changes in the activities within the processes. Due to uniqueness of both companies and projects the project management processes and activities listed above are neither possible or meant to be used to the letter for all projects and industries. However, the project management model is a useful guide that can be customized and applied to a wide range of projects. If project management is emphasized and used effectively, it will bring a lot of benefits, e.g. improved estimating capability for future planning which is in great focus of this thesis. (Kerzner, 2017)

3.2 Project Management within Wärtsilä Energy Solutions

Each company has its own way of working and to only have a general understanding of projects and how they are managed will not be enough for the reader to be able to understand the entirety of this thesis. Hence it is necessary to clarify how projects are managed at WES.

3.2.1 Project types and classes

All projects within Wärtsilä can be divided into three categories; **CD** (Customer Delivery), **PSD (**Product and Solution Development**)** and **OD** (Operational Development). Every category has a couple of project types under them and in this thesis only the main WES' CD project types are considered and those can be seen in table 1. (Wärtsilä, 2017b)

Table 1 - CD project types

Project Type	Description
EPC	Engineering, procurement, construction
Process EPC	EPC above floor level
Basic EEQ	Basic engineering, procurement (equipment delivery, logistics)
Extended EEQ	Detailed engineering, procurement (equipment and material delivery, logistics)

Basic EEQ and Extended EEQ are both equipment delivery project types. Extended EEQ is a complete supply solution that contain detailed engineering and all the materials and equipment needed for power generation, including the main buildings and related equipment. Basic EEQ on the other hand is a scope of supply where only the main equipment, related auxiliary, process equipment and materials are engineered and supplied. In basic EEQ the customer needs to use its own resources or contract other parties for overall project management, detailed engineering, construction and installation. (Wärtsilä, 2010; Wärtsilä, 2015)

EPC is a project type where Wärtsilä takes responsibility for all aspects of the work, including engineering, procurement, construction and installation. EPC projects are often seen as an advantage for the customer since only one contractor is needed. Process EPC includes the same features as the full EPC, except that it relates only to installations above floor level. Subsoil and foundation works, the supply of underground materials, and site area works are not included. (Wärtsilä, 2010; Wärtsilä, 2015)

To be able to assure the right level of project management in demanding and complex projects and to avoid unnecessary bureaucracy in easier projects, a project classification has been implemented. By subdividing all projects into classes, it is expected to be easier to decide an appropriate level of management for each project. The classes have different criteria and every project is analysed during the initiate phase and put into one of these classes. A project's classification might change during plan phase when more information has been gathered. The projects are being classified as either A, B or C, where A is a very complex project, B is a normal project and C is a simple or straightforward project. (Wärtsilä 2017b)

3.2.2 Project lifecycle

In Wärtsilä Energy Solutions projects are divided into processes, phases and decision points (gates) and these can be seen in figure 3. The processes in CD projects are similar like the one presented in chapter 3.1.2, including initiating, planning, executing, closing and also monitoring and controlling that are done during the whole project. A project's lifecycle is divided into four main phases; initiate, plan, execute and close. In figure 4 can be seen that there are also two project-related phases outside the project; explore and evaluate benefits.

Each project phase starts and ends with decision points that are called gates. Gates are mandatory project management decision points where the project owner and/or project steering committee evaluates achieved results and decides if project should be continued (GO) or terminated (NO GO). For the project's management to be able to monitor the project's progress and its schedule, milestones are used. Milestones are significant points or events that are linked with specific project results, e.g. testing is finished, or some part of the delivery is ready. (Wärtsilä, 2017b)

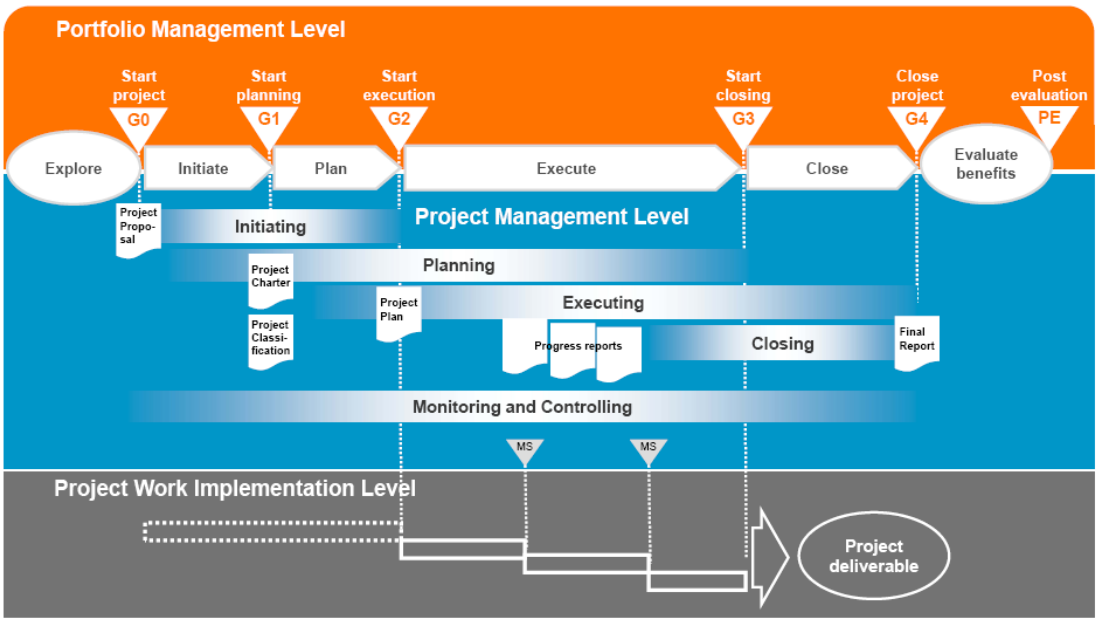


Figure 4 - Wärtsilä Project Model framework (Wärtsilä, 2017b)

3.2.3 Project organization

To be able to accomplish a project successfully, the project organization and its stakeholders need to be well organized. In figure 5 are the most common project roles in CD project organizations shown. All projects have a project owner and a steering committee with a business interest. The project owner is always someone from the sales organization (sales representative, account manager or equivalent). The owner is a member of the customer's project steering committee and the chairman of Wärtsilä's steering committee. The members in Wärtsilä's steering committee are typically the project's most important stakeholders. The steering committee has two main responsibilities; ensuring the business benefits and resource allocation. (Wärtsilä, 2017b)

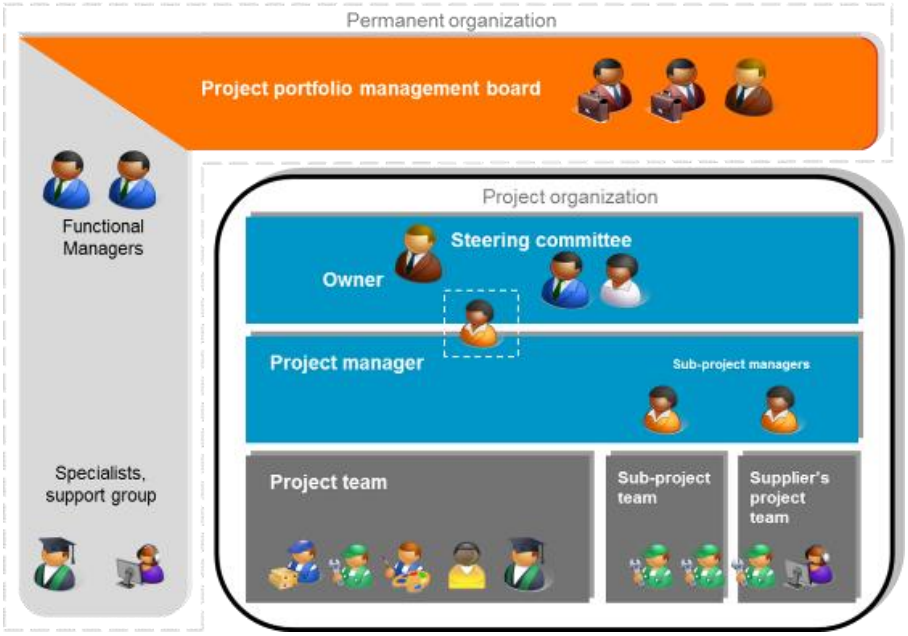


Figure 5 - Project organization (Wärtsilä, 2017b)

Every project has a project manager that is liable for the operational management of the project according to the project plan. The project manager has a project team that he is responsible for and a typical project team is shown in figure 6. Depending on the project's scope and complexity, the project team can look different, e.g. in EEQ projects there are no civil engineers within the project team. The project team and the work amount allocated for each member to the project are chosen after type and classification are decided. (Wärtsilä 2015; Wärtsilä 2017b)

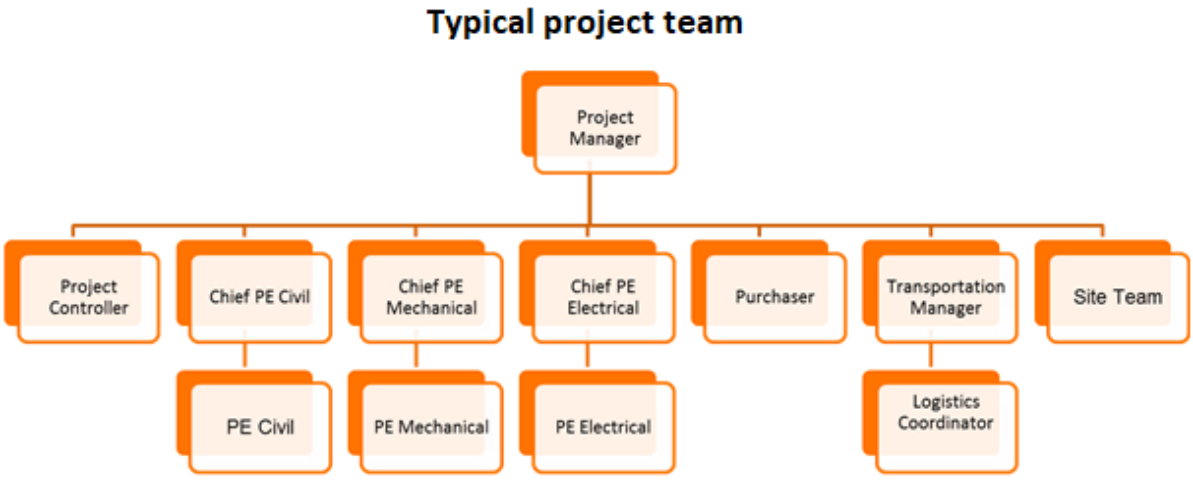
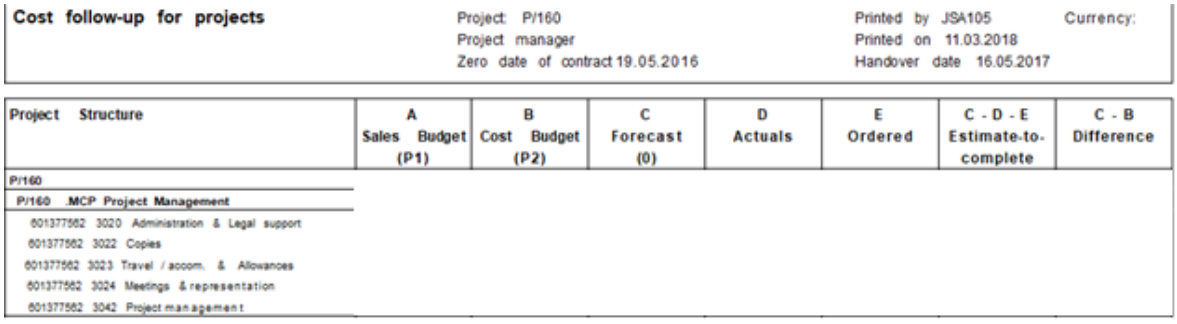


Figure 6 - Typical project team (Wärtsilä, 2015)

3.2.4 Budgeting and reporting in Wärtsilä Energy Solutions

Since this thesis is focusing on budgeting and estimating project management costs, it is suitable to shortly discuss the most relevant things about budgeting CD projects within WES. When gate 1 is accepted and the plan phase starts (see figure 4), one of the main activities is to prepare an offer. This is done within the sales organization, but with support from the project management organization. The sales organization goes through the contract and calculates how much work, material and time that is needed and estimates the project's total cost. (Wärtsilä, 2017b)

Depending on the project's scope and type the sales organization estimates the costs needed for the project team throughout the project. The site team's costs are estimated and budgeted separately as *Site Management*, whilst the rest of the project team's costs are budgeted as *Project Management*. The budget for Project Management (MCP) is split up into activities, e.g. travel (3023), meetings (3024) and project management (3042). The project management activity is only the project team's work hours spent on the project and that is called man-hours. If an offer is accepted by the customer, the budget is set to that contract. The budget is then put into a CFU (cost follow-up) where actual costs during the project are followed up and compared to the budget (see figure 7). The project team's man-hour cost is set to XX €/h and when the project team reports their work hours it is multiplied by XX € and put into the CFU's Actuals column. It is the comparison between the CFU's Actuals and Sales Budget that decides if the project's estimations have been good.



Cost follow-up for projects

Project: P/160
Project manager
Zero date of contract 19.05.2016

Printed by JSA105 Currency:
Printed on 11.03.2018
Handover date 16.05.2017

Project Structure	A Sales Budget (P1)	B Cost Budget (P2)	C Forecast (0)	D Actuals	E Ordered	C - D - E Estimate-to-complete	C - B Difference
P/160							
P/160 _MCP Project Management							
601377562 3020 Administration & Legal support							
601377562 3022 Copies							
601377562 3023 Travel / accom. & Allowances							
601377562 3024 Meetings & representation							
601377562 3042 Project management							

Figure 7 - Snip of the Project Management part from a CFU

3.3 Estimating project costs

Estimating products' costs is often quite straightforward, but Kerzner (2017) points out that many business managers consider estimating and pricing projects as an art. This is because every project is unique and that brings a lot of complexities. This thesis is focusing on project management costs. These are in most cases the most abstract costs to estimate in a project and therefore most uncertain. Hence it is needed to point out some of the main problems when estimating project costs and discuss how to overcome this obstacle in theory.

3.3.1 Cost estimation problems

Cobb (2015) points out two common problems when planning projects and estimating costs. The first one is called *Analysis paralysis* when the contractor is spending too much time attempting to make too detailed estimates on uncertain and unreliable information which often leads to commitment delays. The second problem, *Cavalier approach*, is the quite opposite and then the contractor is not worrying about managing uncertainty and risks at all and just starts to do the project with very little or no upfront planning or estimations. The best approach for a contractor would be somewhere in between those extremes.

Both over- and underestimating a project's costs can be devastating. When projects are overestimated, the risk to lose the job to a lower-bidding competitor increases. This can lead to missed sales and overcapacity within the company. Underestimations are, according to Kerzner (2017), still worse than overestimations. This is because a low fixed price bid can win the contract instead of a competitor and provide the company with jobs and higher net sales but when the costs later overrun the budget, the contractor will lose money and if they can finish the project it will end with negative margin. Underestimating is often accidental because the contractor is too optimistic when calculating the estimations. Underestimations can also be intentional, in a practice called *buy in*, and then the contractor reduces the costs of an initially realistic estimation to be able to win against competitors. The contractor then has the belief, that it might be possible to cut costs or to renegotiate the price with the customer. To do a *buy in* is relatively common but often seen as both risky and unethical. (Nicholas & Steyn, 2012)

According to Lock (2013) is it very difficult to put a general rule on how accurate estimations needs to be in fixed priced projects. He also points out that it is not possible to tell how crucial different grades of estimation errors are, because it is dependent on the company, the business and the specific project. If a company sells a project with a high intended profit

margin, a small cost estimation error is usually not that critical. Then again if a project is sold with a small margin, the estimation error can cause the project to end up unprofitable.

Lock (2013) also explains how the budget overrun is reacted to differently within the company. Consider a project was sold to a fixed price of 1 MEUR and the cost was estimated to 850 TEUR. Imagine that the actual cost ended at 910 TEUR, which is a 60 TEUR cost variance. Project managers and the estimators will often be quite satisfied with this result because the project ended profitable and with only a 7 % estimation error. On the other hand, the company's management and other stakeholders planned a 150 TEUR gross profit from the project and because of the estimation error lost 40 % of the estimated gross profit. Lock (2013) highlights that profits are vulnerable and therefore estimations and budgets need to be prioritized and good. He also mentions that managing an underestimated project can be soul-destroying. Those who have done it, would not wish to repeat that experience.

To do accurate cost estimations can and has shown to be very difficult because it is often done in the beginning and before much is known about the project. As a rule, the less well defined the project is, the greater the chances are that estimated costs will differ from actual costs. The amount that actual costs exceeds the initial estimations are called *cost escalation*. Cost escalations are relatively common and are often dependent on the project's complexity. The more complex a project is, the greater the chances are for cost escalation. Examples of this is nuclear power plants that usually exceeds the cost estimations by a factor of two or three and NASA spacecraft that often exceeds the estimations by a factor of four or five. (Nicholas & Steyn, 2012)

3.3.2 Methods to estimate project costs

As can be seen in chapter 3.3.1, there are a lot of difficulties to do accurate cost estimations and to estimate non-accurate can be very crucial for the contractor. Hence important knowledge and some methods needs to be known to be able to estimate more accurately. Cost estimations can be done in different ways and companies try to implement the most suitable methods for them.

Kerzner (2017) points out some information needs to be collected prior the start of calculating costs to be able to get an accurate estimation. This information could e.g. be recent experience in similar work, knowledge of the processes, estimating software and databases if possible and to interview experts. Each company often have their own unique approach to estimate costs but according to project management practices, a company should

start the estimation phase with a *parametric estimate*, *analytical estimate* or an *expert judgement*. A parametric estimate is based on statistical data. An analytical estimate is a comparison between the current project's features and a completed one's, where the costs to the current project is adjusted based upon the difficulty degree. An expert judgement is information and estimations from individuals or groups with expertise knowledges and experience from similar types of projects. (Kerzner, 2017)

PMBOK® (2013) explains the estimation process further by expressing the importance of having the knowledge of what the deliverables and the contract requirements are to be able to estimate accurately. To get this knowledge a WBS can be created. Creating a WBS is the process of subdividing the project deliverables and the whole project work into smaller and more manageable parts. By doing a WBS it is easier to estimate how much each part of the project will cost and that will result in a more accurate total cost estimation. Looking at project management and work efforts needed, to create a WBS is one way to estimate total time consumption of a project.

Lock (2013) and Kerzner (2017) are both mentioning that if possible, the estimating of project labour time should be obtained by the project manager or other senior individuals that are going to be responsible that project tasks will be managed. They also mean that it would be preferable if everyone responsible for something would estimate their parts, e.g. the chief design engineer provides estimations for the design etc. In many cases this is not possible but Lock (2013) points out that it is often very difficult for an estimator to make accurate estimations without help from expertise.

Kerzner (2017) mentions that a lot of companies today try to standardize the estimating process by creating and implementing an e*stimating manual*. The manual is made to save time on the estimation process and some companies have been able to reduce the time consumption of the estimation process by 90 percent. If standardizing processes and using estimating manuals, one need to understand that it will provide accuracy limitations. To estimate absolute accurate work amount (i.e. man-hours) required for a project is though impossible. That is because the factors that can impact the costs are so diversified and unpredictable. Kerzner (2017), Lock (2013), PMBOK® (2013) and Nicholas & Steyn (2012) are all however highlighting that increased effort on developing cost estimations most often improves cost estimation accuracy and therefore should be prioritized.

3.4 Data analytics

Data has been said to be the new oil – an abundant resource of huge value. The difference between data and oil is that everyone has access to data. Companies today are drowning in the amount of data that is collected and the amount of data created will only increase. IBM estimated that the world is generating 2.5 quintillion (10^{18}) bytes of data every day, which means that the last two years 90 percent of all data has been created. The data itself has often no value but by taking advantage of it, great value can be achieved. (Baesens, 2014)

3.4.1 Defining data

Peck, Olsen and Devore (2012) defines data as recordings of one variable or simultaneously of two or more variables. According to Baesens (2014) is data usually divided into two main forms; *qualitative* and *quantitative*. Quantitative data is numbers and qualitative data is words. Quantitative data is more often used for statistical analyses, but qualitative data is also becoming more common in similar analyses. The downside however with qualitative data is that it needs to be properly pre-processed before it can be analysed.

3.4.2 Data analytics process

According to Erl, Khattak and Buhler (2016) the terms *data analytics* and *data analysis* are often mixed together and therefore need to be clarified. Data analysis is only the process where data is studied to find relationships and patterns. Data analytics on the other hand is the whole data lifecycle discipline that includes collecting, cleansing, organizing, storing, analysing and governing data. To be able to do a good analysis, the whole data analytics process needs to be properly done. Good data analytics enables decision-making based on factual data instead of someone's intuition (Erl et al., 2016)

Baesens (2014) process model presented in figure 8 shows all the steps in the analytics process. The steps are as follows:

- **Step one** is a thorough definition of the problem that should be solved by the analytics.

- **Step two** is to identify and select all data that will be needed for the analytics. This step is very important because data is the key ingredient for a good result. All data is gathered and stored in a staging area, for example in a data warehouse or in a data mart.

- **Step three** is the pre-processing step where all the data gathered needs to be cleaned to get rid of all inconsistencies, such as missing values, outliers and duplicates. According to Baesens are step two and three the most time-consuming steps that usually takes up to 80 % of the total analytics process time.

- **Step four** can be applicable if the data needs to be further transformed from e.g. alphanumeric to numeric coding.

- **Step five** is when the analysis of the pre-processed and transformed data will be done. Different types of analyses can be made depending of what the analytics aims for.

- **Step six** is when the model is built and business experts interpret and evaluate the results. If the analytic model is good, usable patterns are found that can be used to support decision making.

(Baesens, 2014)

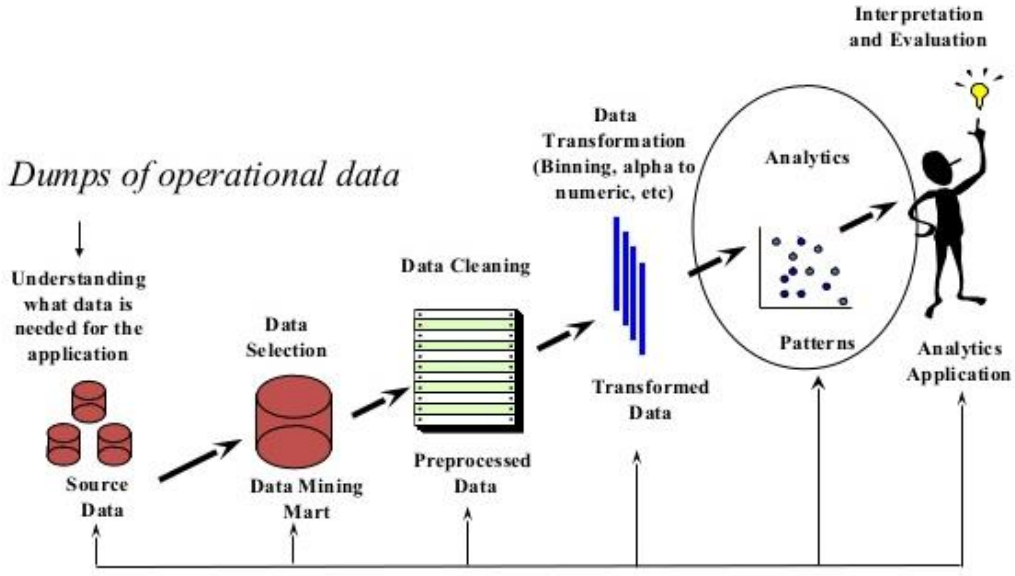


Figure 8 - The analytics process model (Baesens, 2014)

3.4.3 Analytics categories

Analytics can be divided into four categories depending on what results the analytics produce. Erl et al (2016) describe the categories as follows:

- **Descriptive analytics** is made to answer questions about things that already have occurred, e.g. “What was the order intake the last quartile?”. Descriptive analytics answer only the question what, not why.
- **Diagnostic analytics** is made to determine the reasons why a phenomenon occurred, e.g. answering the question “Why were Q2 sales less than Q1 sales?”. Diagnostic analytics require a more advanced skillset than descriptive analytics but bring more value.
- **Predictive analytics** is an attempt to predict future outcomes by finding patterns and trends based on historical and current data. Results of predictive analytics could e.g. try to answer the question “What are the chances that a person buys product C if they already purchased product A and B?”
- **Prescriptive analytics** is made based on the results of a predictive analytics by defining what actions should be taken. Instead of only deciding what option is the best, the results of prescriptive analytics answers why it is the best. An example of a question for prescriptive analytics could be “When is the best time to trade a particular stock?”.

About 80 % of the results generated from analytics is estimated to be descriptive because it is cheaper and easier to do than prescriptive analytics. Prescriptive analytics on the other hand brings a lot more value than a descriptive analysis. In figure 9 the categories value and complexity is visualized. A conclusion is that the more value analytics brings, the more complex and expensive will the analytic process be. (Erl et al., 2016)

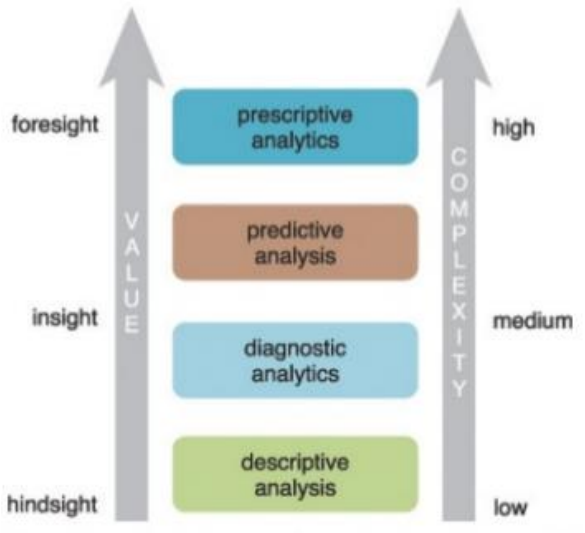


Figure 9 - Value and complexity depending on analytics category (Erl et al, 2016).

3.4.4 Data Quality

In analytics, data quality is the basis for trustworthy results. Data could be defined as high quality if it is fit for the intended use. To know if the data and the analytic’s results is reliable can be very difficult. A general rule when doing analytics is that the more data, the better results. (Baesens, 2014) According to Finlay (2014) are a couple of hundred cases needed to

be able to make a good predictive analytic model. He mentions if a company wants to predict who is likely to buy a new app and who is not, the company need information from at least 300 buyers and 300 non-buyers to be able to make a usable prediction model. Finlay (2014) are on the same line as Baesens (2014) that the more data, the better but also highlights the importance on using essential data. An example of this could be a comparison between men and women with a total data sample of 1000 persons. The total quantity of data is enough but if the sample include e.g. only four men it will make the men's results non-reliable.

According to Baesens (2014) is poor data quality experienced in everyday life and it is growing within companies because of the exponential increase in the size of databases. Data quality management is one of the most important business challenges for companies today. A well-known saying within data quality management is "garbage in, garbage out". He claims that decisions made based on poor data quality can be very harmful for a company. Peck et al (2012) have the same opinion and highlights that the quality of a company's decisions will completely depend on the information available. Baesens (2014) mentions a couple of data quality problems that should be known and therefore could be avoided;

- **Format problem** – If similar data is in different formats, e.g. *USA* and *America* or *01.02.2018* and *2018/02/01*. This can occur if there are no rules or the process is not standardized when data is recorded.
- **Consistency problem** – If same data needs to be filled into multiple sources it can result in duplicates or inconsistency. Baesens (2014) recommends using only one source for same data if possible.
- **Objectivity problem** – Subjective judgement should be avoided if possible because it can create data bias.
- **Accessibility problem** – If the amount of data is big, it can lead to high response times.

As Baesens (2014) said, data can generate great value but for a company to be able to take advantage of that value, the data need to be of good quality. The first step of bettering data quality is to understand what poor data quality is and know how to avoid it.

4 CONCLUSION

This chapter will conclude the thesis by first discuss if the purpose of the thesis was reached. Then discuss some of the thesis' challenges and last propose further research.

4.1 Was the purpose reached?

The purpose of this thesis was to analyse how man-hours are budgeted in WES and suggest improvements on the estimation-tool and the budgeting process. Before the purpose of the thesis was decided, it was well known that it will require a lot of time and effort to do the analyses and almost impossible to discover revolutionary findings that would lead to great improvements of the estimation-tool. Even if this was the starting point, it was clear that some findings can be discovered that would attract attention and hopefully some improvements can be made in the future.

So, what was the outcome of this thesis? Analyses of man-hour costs and the way they are budgeted was made, a lot of interviews were held and from all the results, improvement suggestions were given. A final estimation-tool was not made because it would have required so much time and therefore it was not possible to include in this thesis' scope. However, a lot of interesting information and valuable knowledges have been found and shared to WES thanks to this thesis. Looking at the results and all the findings, the thesis has well succeeded to fulfil its purpose.

4.2 Challenges of the thesis

The thesis has been challenging and demanding but I have gained a lot of knowledges about different processes and also made new connections in WES. Initially the work for the thesis seemed to be quite straight forward but after getting more knowledge of the problem, I realized how challenging it is. To retrieve data and sort it was quite easy but very time consuming. The most challenging has been to clean the data and to know if it is reliable. The number of projects and the data available per project is not much and that is a challenge for the analysis and its reliability. I have many times during the process hesitated if it is even possible to do reliable analyses and state something with the data available. Even if the data quality has been an issue, after properly cleaning and a lot of double checks, it can be stated that the analyses and the results of the thesis are fairly reliable.

4.3 Further research

There are a lot of further research that can be done for this topic. The suggestions in this thesis should be back-tested and checked with historical projects. More alternatives to the estimation-tool should be reviewed and tested also. Decisions if the project manager should be more involved in the sales phase and to what extent, should be taken.

The estimation-tool today is most suitable for standard projects and therefore it would be necessary to study how non-standard projects man-hour estimations could be improved. WES is going into new businesses like solar and batteries and to do accurate man-hour calculations in these businesses will most probably be more important than in the projects executed today. Therefore, it could be valuable to further research how the estimation-tool could be developed for projects in new businesses as well. The estimation-tool could also be developed further to be used as a tool for estimating budgets for site management in WES.

All in all, I would like to state that costing accuracy is very important and should continuously be analysed and improved in all different businesses and parts of projects within WES.

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