YRKESHÖGSKOLAN NOVIA

Emergency Diesel Generating Set Delivery Project for a Nuclear Power Plant

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BACHELOR'S THESIS

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Abstract

This thesis is made for Wärtsilä Energy Business. The purpose with this thesis was to document project team members' experiences, recommendations and improvement suggestions regarding the way of working and execution of an EDG replacement project.

Wärtsilä is supplying and replacing emergency diesel generators for a nuclear power plant. The emergency diesel generators are intended for back-up use to secure the power supply for the nuclear power plant. As a failure of these emergency diesel generators can result in very serious consequences they are required to follow and fulfil a number of strict requirements. This makes EDG replacement projects challenging and different from 'standard' projects.

All information presented in the result was gathered with a questionnaire which was sent out to 33 – both current and former – project team members. The questionnaire contained 74 open questions and the respondents were asked to answer all questions they were familiar with and involved in.

The result of this thesis consists of the respondents' answers which cover their experiences, improvement suggestions and recommendations for the following categories: Organisation & project management, procurement of equipment, budget, schedule, document management, documentation, manufacturing and its control, site work, systems and lastly the most important lessons learnt.

Language: English Key words: lessons learnt, project review, EDG replacement project

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EXAMENSARBETE

Författare: Victor Ekman
Utbildning och ort: Produktionsekonomi, Vasa
Handledare: Mikael Ehrs
Title: Reservkraftsdieselgenerator Leveransprojekt För Ett Kärnkraftverk

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Datum 11.11.2019 Sidantal 22 Bilagor 1

Abstrakt

Detta slutarbete är gjort för Wärtsilä Energy Business. Syftet med detta examensarbete var att dokumentera projektmedlemmars erfarenheter, rekommendationer och förbättringsförslag angående arbetssättet och utförandet av ett EDG projekt.

Wärtsilä levererar och ersätter reservkraftsdieselgeneratorer för ett kärnkraftverk. Reservkraftsdieselgeneratorernas uppgift är att säkerställa eltillförelsen för kärnkraftverket. Eftersom möjliga brister i reservkraftsdieselgeneratorerna kan ha ytterst allvarliga följder är det väldigt stränga krav som måste följas och uppfyllas av dessa. Detta gör att kärnkraftverksprojekt är mycket krävande och annorlunda jämfört med 'standard' projekt.

All information samlades in med ett frågeformulär som skickades ut till totalt 33 stycken nuvarande och föredetta projektmedlemmar. Frågeformuläret innehöll 74 stycken öppna frågor och projektmedlemmarna bads att svara på alla frågor de var bekanta med eller involverade i.

Resultatet består av en sammansättning av alla mottagna svar, vilket består av erfarenheter, förbättringsförslag och rekommendationer för följande kategorier: Organisation & projekthantering, inköp av utrustning, budget, tidsplan, dokumenthantering, dokumentation, tillverkning och dess kontroll, anläggningsarbete, system och till sist de viktigaste erfarenheterna.

Språk: Engelska Nyckelord: projektutvärdering,

Contents

1 Introduction

This chapter introduces the thesis to the reader, covering the background, purpose and delimitation of the thesis along with a disposition giving an overview of the chapters.

1.1 Background

Wärtsilä is supplying and replacing emergency diesel generators (EDG's) to a nuclear power plant. The emergency diesel generators' purpose is to supply electricity to the nuclear power plant in case the normal supply of electrical power from the electrical grid or main generator is cut off and lost. As a failure of these emergency diesel generators can result in a disaster, there are a lot of regulations and requirements to follow. This particular project is regulated by the radiation and nuclear safety authority of Finland (STUK), whose duty is to ensure radiation safety in Finland. This makes EDG replacement projects much more challenging and requires a different way of working than 'standard' projects which is why a project evaluation was chosen as subject for this thesis.

1.2 Purpose

The purpose with this thesis is to document project team members' experiences, recommendations and improvement suggestions regarding the way of working and execution of an EDG replacement project. By identifying good and bad practices you can avoid repeating mistakes but also keep the good practices in place in future projects. This will help to identify weaknesses as well as possible improvement areas in the project processes and the way of working.

The result of this thesis will consist of findings and recommendations which will help to identify improvement areas and weaknesses in the way of working but it also functions as a good base and introduction to people who eventually will work with similar projects in the future.

1.3 Delimitation

This thesis will only focus on Wärtsilä's project team and personnel, therefore not taking any sub-suppliers, customers or other parties involved into account. The data will be collected only from one project as well as a limited number of disciplines. Only key personnel will be interviewed. These limitations are set due to the time-limit.

1.4 Disposition

This thesis is divided into six different chapters as presented below.

The first chapter is an introduction to the thesis covering the background, purpose and delimitation.

The second chapter will give a short presentation of Wärtsilä and their businesses.

The third chapter covers the theoretical framework of which this thesis has been based on.

The fourth chapter tells about the method used in order to get the result.

The fifth chapter presents the results of this thesis.

Lastly the sixth chapter concludes the thesis with a discussion and suggestions for further research.

2 Wärtsilä in brief

Wärtsilä was established in Tohmajärvi, Finland year 1834 as a sawmilling company and have now been at the leading edge of engineering innovation for over 180 years. Wärtsilä is a global leader in smart technologies and complete lifecycle solutions for both the marine and energy market. Wärtsiläs purpose is to enable sustainable societies with smart technology and their strategy is to increase customer value in the marine and energy markets through three key focus areas: Energy efficiency, lifecycle optimization and innovative solutions.

Wärtsilä operates in over 200 locations in more than 80 countries. In 2018 Wärtsilä had approximately 19000 employees and a net sale of EUR 5,2 billion. 20% of the employees was located in Finland, 40% elsewhere in Europe, 24% in Asia, 11% in the Americas and the remaining 4% in other countries.

Wärtsilä is divided into two businesses, Energy Business and Marine Business. Wärtsilä Services is as of January 2019 incorporated into both Marine and Energy business. (Wärtsilä, 2018)

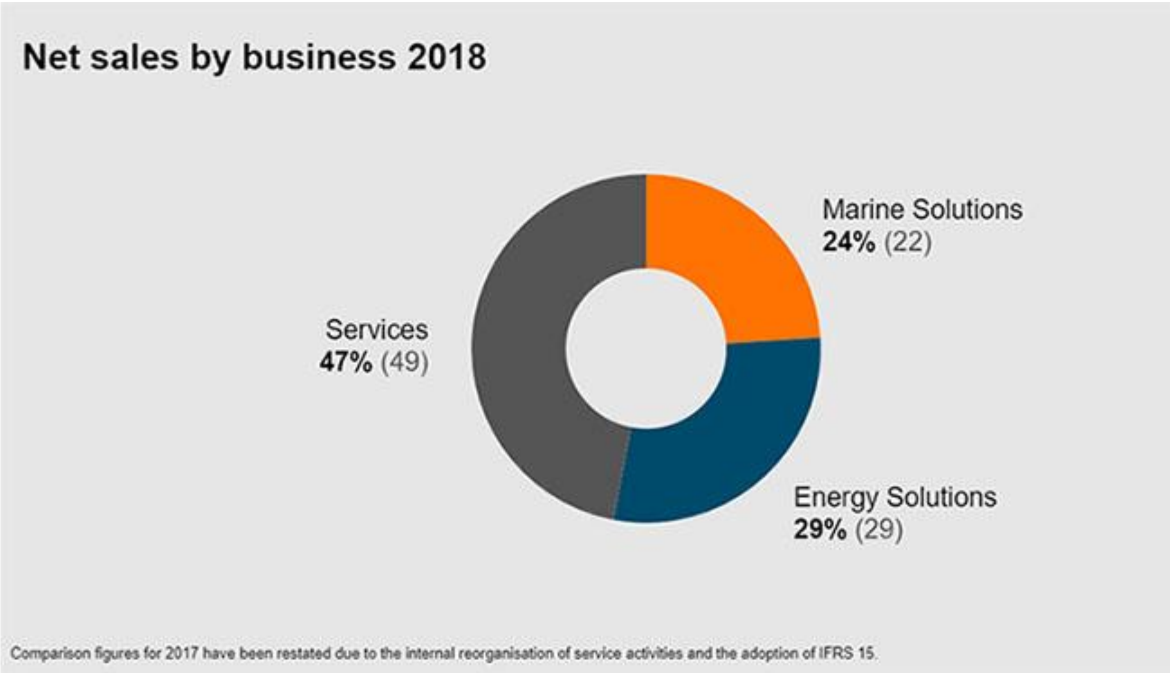

Figure 1: Net sales by business 2018 (Wärtsilä, 2018)

2.1.1 Wärtsilä Energy Business

Wärtsilä Energy Solutions design, build and serve power systems, such as engine-based flexible power plants, hybrid solar power plants, energy storages, integration solutions and LNG solutions. Wärtsilä has power plants in 177 different countries with a total capacity of 70 GW. Energy business had a net sale of 1,517 million euros year 2018 with approximately 1171 employees. (Wärtsilä, 2018)

2.1.2 Wärtsilä Marine Business

Wärtsilä Marine Business is a provider of ship machinery, propulsion and manoeuvring solutions. Products such as Engines and generating sets, reductions gears, propulsion equipment, control systems and sealing solutions are made for all kinds of vessels and offshore applications. Marine Business had a net sale of 1,232 million euros year 2018. (Wärtsilä, 2018)

3 Theory

This chapter will present relevant theory for this thesis. The topics covered are:

1. **The lessons learnt process**, which explains why it is beneficial to collect lessons learnt as well as how it should be done.

2. **The different research methods and the research method used in this thesis** – The different research methods have been studied to get an understanding of them and what they are used for in order to select a suitable research method for this thesis.

3. **Questionnaire as a data gathering technique –** The theory of the questionnaire as a research instrument and how it should be created have been studied as the information gathering for this thesis is done through a questionnaire.

4. **STUK Case Study – Olkiluoto 3 EDG Procurement Investigation** – This case have been studied as it covers an investigation regarding the purchasing process of emergency diesel generators for a nuclear power plant, therefore the same kind of project as the one covered in this thesis. This case helps to get a better understanding of what kind of problems that can occur in EDG replacement projects and it has also functioned as a source of inspiration for the questions in the questionnaire and the overall arrangement of the results. Furthermore will the findings in this thesis be compared to the findings in the case study to see if there are any similarities in the results.

3.1 Lessons Learnt

Lessons learnt is knowledge and experience gathered from a project, this includes both positive and negative experiences. By sharing lessons learnt you minimize the chances of repeating the same mistakes in upcoming projects and you also know which good practices to keep (Rowe & Sikes, 2006).

Lessons learnt can occur and be collected in any point of the project life cycle (Jugdev, 2012). Although, collecting them in the end of a project might result in losses because people tend to forget and project members might have left the project. (Milton, 2010)

Organizations naturally learn over time by doing activities repeatedly, but this learning can be speeded up by actively focusing on learning by using a lessons learnt system (Milton, 2010). Lessons learnt gives organizations the possibility to improve their processes, their future projects and upcoming steps in their ongoing projects (Rowe & Sikes, 2006).

The lessons learnt process consists of five steps; identify, document, analyse, store and retrieve. The lessons learnt process defines the required activities to carry out a successful lessons learnt review. (Rowe & Sikes, 2006)

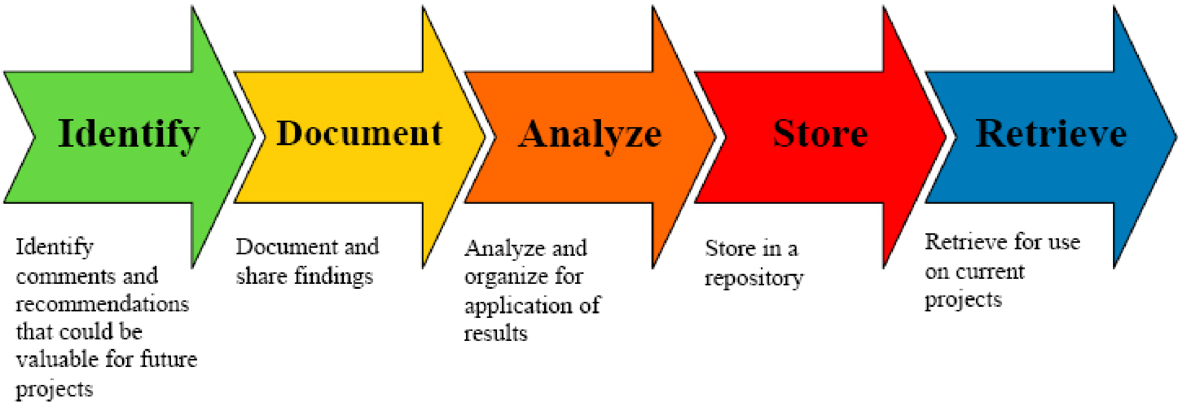

Figure 2: Lessons Learnt Process (Rowe & Sikes, 2006)

Step 1: Identify

The first step is to identify valuable comments and recommendations that could be used to improve future projects. To identify these, two activities is to be conducted; preparation for the lessons learnt session and conducting the lessons learnt session.

In preparation for the lessons learnt session, the participants should complete a project survey to be better prepared for the session and their responds. This will also give people who are unable to attend the session an opportunity to give their input. The survey should be categorized to focus the answers and discussion to specific areas, such as project management, design, technical and resources. Each of these areas should also have their own specific questions.

The second activity is to conduct the lessons learnt session. The main task is to identify the success and failures within the project and gather improvement recommendation for future projects. (Rowe & Sikes, 2006)

Step 2: Document

The second step in the process is to document and share discoveries. This is done by creating reports. The type of report depends on the audience. All who participated in the lessons learnt session or gave their input in the survey should be given a detailed report containing data captured during the session and in the survey. The participants must then approve the accuracy of the report before it is finalized. The final report shall be distributed to all project members and stored within project documentation. (Rowe & Sikes, 2006)

Step 3: Analyse

Step three is to analyse and organise the lessons learnt with the purpose to detect weak areas and identify actions to strengthen these. These actions can for example be improvements in the project management process, more training or other changes in procedures and processes. (Rowe & Sikes, 2006)

Step 4: Store

Step four is to store the lessons learnt. Depending on the size of the organization they may or may not have a dedicated system for lessons learnt storage. In smaller organizations lessons learnt are often stored along with other project documents whereas bigger organizations store lessons learnt in a dedicated database. (Rowe & Sikes, 2006)

Step 5: Retrieve

In smaller businesses, where the lessons are stored along with other project documentation, it can be hard to retrieve lessons learnt because the missing ability to search for key words. In organizations with a dedicated lessons learnt database, it is crucial to identify key words for easy retrieval. (Rowe & Sikes, 2006)

3.2 Research Method

The research method is chosen according to the research subject and purpose. The two research methods are quantitative and qualitative methodology.

The quantitative methodology is used when you want general knowledge, knowledge about quantities or find relationships between different factors. (Ekström & Larsson, 2010) The data in a quantitative research is information about quantities, and therefore numbers (McLeod, 2019).

The qualitative methodology is on the other hand preferred when you want to understand more complicated phenomena, their nature and characteristics, in one word – the phenomena's qualities, which cannot be measured, only observed. (Ekström & Larsson, 2010) (McLeod, 2019)

Furthermore do the two methods differ in the fact that the qualitative methodology usually develops a hypothesis whereas the quantitative methodology often tries or proves a hypothesis (Ryen & Torhell, 2004)

Qualitative Methodology

The qualitative methodology is a research method which creates descriptive data from people's own words, either spoken or written (Taylor, et al., 2015). It is a form of social study used to explore people's perspectives and experiences (Holloway, 1996). (McLeod, 2017) quotes Punch explaining it as "an empirical research where the data are not in the form of numbers". The data collection in a qualitative research can be done through a number of methods, these are for instance interviews, open-ended questionnaires, observations, document and text analysis (Ryen & Torhell, 2004). Photographs, videos and sound recordings can also be used as qualitative data (McLeod, 2019).

The result of a qualitative research consists of findings in the collected data - new insights and understandings (Saldana, et al., 2011). The data collected from the research can for example be used to diagnose organizational issues and create strategies to solve these (Herndon & Kreps, 1993). Qualitative researches are often based on case studies in order to get a better understanding on what is studied (Kvale, 2007).

3.3 Questionnaire as a data collection technique

A questionnaire is a research instrument that can be seen as a written interview with the purpose to gather information from the respondents. Questionnaires are preferred when you want to collect information from a larger sample of respondents in an efficient and quick manner. (McLeod, 2018)

There are usually two types of questions used in questionnaires, open-ended and closed-ended. Open-ended questions means that the respondent is given an answer-box where the respondent can answer freely using their own words. Closed-ended questions on the other hand gives the respondent a set of answers to choose from, for example "yes or "no" or ordinal data that can be ranked from 1-10, thus not giving respondents the possibility to answer with their own words. (Dillman, et al., 2009)

Closed-ended questions are most suitable for quantitative research, as closed questions easily can be converted to quantitative data by for example counting the amount of “yes” or “no” answers on a question, which allows for statistical analysis of the answers. (McLeod, 2018)

Open-ended questions are on the other hand preferred for more complex questions, when you want the respondent to answer the question freely with their own words without any limitations. When using open-ended questions you get rich and detailed qualitative data from the respondent. (Dillman, et al., 2009) Although, open-ended questions are more time consuming than closed-ended, both for the respondent answering the questions and the analyser. (McLeod, 2018)

To get even more in-depth answers to your open-ended questions, sub-questions can be created to your main questions. For example, a main question can be “What happened?” with the following sub-question “How did this affect you?” (Bhat, n.d.)

When sending out the questionnaires for a qualitative research it is important to first introduce the respondents to the research by mentioning the topic as well as the reason why the research is conducted. (Bhat, n.d.)

3.4 STUK Case Study – Olkiluoto 3 EDG Procurement Investigation

The Radiation and Nuclear Safety Authority of Finland (STUK) (Radiation and Nuclear Safety Authority of Finland, 2011) detected several low-quality design documents for the emergency diesel generators auxiliary system and its equipment for Olkiluoto 3. STUK started an investigation targeting the licensee TVO, the plant vendor Areva and the EDG auxiliary supplier Alstom.

This case has been studied as it covers an investigation regarding the purchasing process of emergency diesel generators for a nuclear power plant, therefore the same kind of project as the one covered in this thesis. This case helps to get a better understanding of what kind of problems that can occur in EDG replacement projects and it has also functioned as a source of inspiration for the questions in the questionnaire and the overall arrangement of the result in this thesis. Furthermore will the findings in this thesis be compared with the findings in the case study to see if there are any similarities in the results.

Here follows a brief explanation of some words and abbreviations found in the text. YVL guides refers to regulatory guides on nuclear safety and security (Ydinturvallisuusohjeet) set by STUK, which contains safety requirements for nuclear power plants. The nuclear plant systems, structures and components are grouped into different safety classes such as safety class 1, 2, 3 (SC 1, 2, 3) and EYT (non-nuclear safety) based on their safety significance. KTA (Kerntechnischer Ausschuss) are German nuclear safety standards.

The investigation resulted in several findings and recommendations which have been concluded and listed below.

Basic design and engineering before signing of the supply contract

The basic design was done in a short amount of time and technical details were not sufficiently addressed. TVO had a passive stance and did not follow the implementation of the basic design actively. YVL Guides and KTA standards were not written and explained clear enough.

Following recommendations were made:

1. Basic design and engineering should have enough time reserved and be made with care. The outcome of the basic design should be complete technical specifications, quality control specifications, specifications for the documents required for regulatory oversight, and specifications to demonstrate conformance.

2. The earlier mentioned specifications should be reviewed by the licensee (TVO). The licensee should prepare a quality control and regulatory oversight measures framework document already in the basic design phase.

Supply Contract

The supply contract had some weak areas. First off it was based on too limited and inadequate information and requirements regarding technology, quality management, demonstration of conformance, quality control and its documentation during manufacture, timely communications, final documentation, elucidation and clarification of YVL Guides.

The plant vendor Areva did not have the supplier Ahlstom as contracting party and furthermore did the EDG contract only cover the sub-assemblies for the EDG instead of the complete entirety which Areva was responsible for. This had a negative effect on the project progress and management.

The licensee had problems supervising the EDG supply chain as it became very long and complex. They were not aware of all the companies included and did not have procedures for managing suppliers who provided several different products.

Following recommendations were made:

1. When procuring equipment consisting of parts from several fields of technology, choose a supplier who can manage the entire supply and sub-suppliers.

2. Following things should be specified among other things in the contract with the supplier responsible for the complete assembly of equipment:

    - Technical requirements for complete assembly
    - A preliminary component-level technical breakdown of parts to serve as basis for classifications (safety, quality, seismic etc.) and quality specifications
    - Quality management requirements created in the basic design stage as well as quality management requirements for manufacturing stage.
    - Requirements regarding quality control results documentation
    - Exchange of information methods and timetable
    - Itemization of licensing documents according to YVL Guide requirements

3. When producing equipment containing components from multiple technology fields, there should be no shared responsibilities in the supply contract and the contractual relationships for the entire supply chain should be stated clearly.

4. The licensee should be familiar with all key suppliers and also evaluate their ability to deliver according to the safety significance of the parts to be delivered.

Organization and Project Management

Neither TVO nor STUK had a specific EDG project with specified duties, responsible persons, and communication and reporting procedures. This meant that responsibilities were spread out and no one was responsible for the entity. Areva had a project organization, although, because of people being changed out all the time it had a negative effect on the performance. The project was led by electrical engineers in all organizations which caused a big loss in mechanical expertise. “The role of experts in quality management and control has been small throughout the project”.

Following recommendations were made:

1. The licensee should be required to allocate enough resources and in-house personnel to key duties in order manage the procurement.

2. The planning and execution of a project with this broad technical field should be done by a working group/sub-project team with expertise in all the needed technical fields as well as quality management. The team should have clearly defined duties, responsibilities and communications.

3. In a project involving many technical fields it is important to have strong project management skills. The expertise demand and suitability should constantly be reviewed during the project and new resources added if needed.

4. If personnel are changed out, a proper induction process to the project and operating procedures are needed.

5. All key stakeholders should be introduced to the national legislations and regulations by the licensee. The plant vendor must ensure that all national requirements are understood and fulfilled regardless of country where the equipment are manufactured.

Design documents

Defining the requirements between the parties was a problem already in the initial phase. The requirements were never clarified in discussions between the parties which resulted in all parties having a different understanding of them. This led to inadequate design documents of poor quality.

The project specification prepared by the plant vendor Areva was not detailed enough. YVL requirements regarding individual pieces of equipment (valves, pumps, electric motors) were not considered. Furthermore was the project specification and system descriptions reviewed in the wrong order.

In the interviews it emerged that the YVL Guides regarding earlier mentioned pieces of equipment can be interpreted differently and are not well applicable for small equipment used in the EDG’s auxiliary system.

Following recommendations were made:

1. The design documents must be clear and well-defined.

2. Faults and inadequacies noticed in document reviews must be systematically followed up and their root causes identified.

3. The licensee or other regulatory body must require incomplete or faulty design documents to be improved before the detailed inspection.

4. When YVL guides are created, the clarity and potential for misinterpretation in the requirements must be reviewed.

5. If design documents which are not specified in the YVL Guides are submitted to STUK by the licensee, the purpose of that document needs to be clearly mentioned and explained.

Manufacturing and its oversight

The EDG project's controlling documents for the oversight of component manufacturing were not clear, especially the inspection groups 1 and 2 concerning safety class 2 caused confusion as they had not been used before in the OL3 project, neither had they been used in other deliveries by Alstrom and Areva.

According to the interviews there were no suppliers who could provide parts for the auxiliary system that met the requirements specified in the YVL Guides 5.3 and 5.7 as the requirements are much stricter than in other countries.

Following recommendations were made:

1. Components which are assembled from separately manufactured parts must have the functional importance of each part described in the technical itemization. The "functional importance" of a part depends on the consequences in case of a failure. Individual important components must fulfil the requirements set for the whole assembly, even if they are series-produced.

   If there are parts missing documented quality reports for the relevant manufacturing stages there needs to be a proper quality management system in place which proves both the quality of the product manufacturing series and that the requirements are met. The quality management system needs to be verified by audition.

2. In cases where series-produced parts or components will be used in safety-classed systems, the licensee must define a method to assure the quality of these.

3. If there are decisions that causes misinterpretations, STUK should use its right to revoke these, respond to any observed confusion and ensure that the decision is adjusted.

Quality Management

The EDG supplier chain became very long and complex. The EDG supplier, Alstrom, had approximately 30 subcontractors of which ten had even more subcontractors. The supply chain had insufficient understanding of both the national regulations and Olkiluoto 3. There was also lack of resources assigned to the quality management in the supply chain.

STUK's interviews showed that TVO was passive in supervising the supply chain and did not have a specific supply control plan for monitoring the EDG project. TVO conducted a few audits, although, these were neither timely nor effective. The quality management department had a small role in the supply chain control and there was also insufficient exchange of information and cooperation between the quality management department and plant technology department.

Following recommendations were made:

1. The licensee, TVO, should control the project delivery more actively and an oversight plan for the delivery should be prepared already in the planning stage. The plan should address project management issues, such as control of schedule, cost, progress, documentation, exchange of information and quality assurance/quality control measures. An oversight over regulations should also be included.

2. The licensee and main supplier should prepare quality management plans (project specific) for each sub-supplier to ensure that the requirements are met.

3. The supply chains quality management and implementation skills need to be assured.

Communication

The exchange of information in the supply chain was primarily done by official correspondence. This resulted in the information being interpreted differently in the different organizations. Because of the information being sent along the long supply chain some misunderstandings were never corrected while others were not even detected.

Submitted documentation was inadequate and did not fulfil the intended purpose defined by the YVL Guides regarding content and scope. TVO had problems defining what issues was to be approved by STUK whereas STUK had problems addressing what issues were approved by them and which ones were not. The processing time was also long and could be up to one year in some cases. This led to decisions being implemented differently from what was intended. The manufacturing process continued no matter if the approvals were received simultaneously or afterward.

Many of the inspectors, reviewers and consultants who were involved in the process only focused on small and specific parts and was not aware of other or earlier decisions. The reviews were also conducted by people with insufficient experience.

Following recommendations were made:

1. The licensee should ensure that applications and decisions are well defined and that the whole supply chain understand these and avoid misunderstandings through meetings and discussions.

2. Requirements should be justified by clear criteria and follow jointly-adopted guidelines.

3. New people joining the project should be introduced to earlier policy guidelines and documents.

4. All technical standards, YVL Guides and other regulatory decisions applied to the project must be available to all parties involved. This must be ensured by the licensee.

Safety Culture

Experts from TVO, Areva and Alstom agreed that the main problem was incomplete documentation. Without adequate quality assurance procedures, it became a problem to verify the required quality standard. Instead of having the quality control groups based on the safety significance of the components were they product-based.

Detected issues and problems were consistently postponed in order to continue with the project, for example were the problems found in the type test of the diesel generators not reported to STUK, nor were they repeated at the factory, instead they decided to perform complementary tests on site. The project was never paused even though the issues piled up and all the parties having different views on the issues.

TVO had a passive role in the document approval process and sent documents for approval to STUK without first ensuring that they met the requirements by inspecting them themselves. The issues they were seeking approval for were not specified clear enough and if there were deviations from the YVL guides in applications they were not sufficiently indicated.

The following recommendations were made:

1. Safety should be priority one even though there is time pressure and potential additional costs.

2. The equipment manufacturing quality control should be categorized by the equipment's safety significance.

3. Problems should be solved on time before they build up.

4 Method

This chapter will cover the method used to execute the practical part of the thesis, the information gathering.

A questionnaire made in excel was sent out by e-mail to all key personnel who are or have been involved in the project. The questionnaire consisted of 74 open-ended questions divided into different categories. The project team members were asked to answer all questions they had experience of or were involved in to get as many opinions as possible for each question. They were also asked to mark the questions they could not answer or were not involved in, this was only done so it would be easier to filter out the rows without answers.

The questionnaire was made with the help of a project team member and further feedback was given by the projects former project manager. Before the questionnaire was sent to the respondents, it was first tested by a project team member to ensure that questions were understood and could not be misinterpreted. The questionnaire was sent out to a total of 33 persons. An accompanying letter was sent out together with the questionnaire where I presented myself, explained the purpose of the thesis and the questionnaire along with the expected outcome. It was also mentioned that the answers were anonymous and that no names will be mentioned in the thesis. The deadline was stated and set one week and two days after it was sent to get the answers before people went on vacation. A final reminder was sent to the respondents who had not sent in their answers three days before the deadline.

The questionnaire method was chosen in order to get information from as many respondents as possible as interviews with everyone would have been too time consuming. The questionnaire was created in excel because it was easy to organize them in a structured way, it fits long answers and it is easy to retrieve the data from the sheets. Open-ended questions were used to let the respondents answer freely with their own words, giving as rich and detailed information as possible.

The total amount of received questionnaires were 15, which was around what I expected as it was sent out during vacation time. Most of the received answers were extensive and detailed and all respondents answered to a good amount of questions. The number of answered questions in the questionnaire were on average 36. Some questions were not included in the result as the amount or quality of the received answers for the particular questions were not sufficient enough to analyse and produce meaningful conclusions from. Some questions did not get any answers at all and did therefore not get included.

5 Result

This chapter has been removed from the public version of the thesis.

6 Discussion

The purpose with this thesis was to gather knowledge, experiences and lessons learnt from an EDG replacement project by interviewing current and former project team members. The result consists of the project personnel's thoughts, improvement suggestions and other recommendations for the following categories: Organisation & project management, procurement of equipment, budget, schedule, document management, documentation, manufacturing and its control, site work, systems and lastly the most important lessons learnt. The result fulfils the purpose of the thesis.

The data was gathered with a questionnaire that was sent out by email to 33 persons of which 15 answered. The number of responses were pretty expected as this questionnaire was sent out at vacation time. Most of the received answers were extensive and detailed which is good. Although, I would have liked to see more suggestions for improvements or solutions to the problems that were mentioned in the questionnaire. Looking back now, I should have designed the questionnaire a bit different asking more directly for potential solutions and improvements in a separate column in the questionnaire as it now only was written in the accompanying letter to include possible solutions or improvement suggestions.

Some of the questions were also interpreted differently by the respondents which resulted in some slightly unrelated answers, but most of them could be associated to other questions instead. This was most likely because of bad formulated questions on my part which could have been prevented by having the questionnaire tested out by a couple of more persons before sending it out.

6.1 Similarities with STUK case study

When comparing the findings presented in this thesis with the findings in the case study a number of similarities can be found.

In the case study it was said that the YVL guides and KTA standards were not written and explained clear enough and that they could be interpreted differently. The same problem is found in this thesis in a number of places, where it is said that there are difficulties understanding the YVL requirements and that experts are needed for this.

Furthermore it was said in the case study that the role of experts in quality management and control had been small throughout the project and to prevent this it was recommended to constantly review the expertise demand and add resources when needed. The lack of expertise in the project was also something that was found in the result of this thesis and the recommendation made in the case study, to constantly review the expertise demand and suitability during the project, can also be applied to this project.

In the case study it was also mentioned that based on the interviews there were no suppliers who could supply parts for the auxiliary system that met the applicable YVL guides, as they're much stricter than in other countries. This seems to have been a problem in this project too as it was many who pointed out that almost every, if not all, suppliers had problems fulfilling the requirements.

The main problems found in both this thesis and in the case study seems to be related to the requirements. They have proven to be both difficult to understand and to interpret correctly for all parties involved. This have led to low quality documents, delays, extra costs, etc., in both cases. One of the most common recommendations to counter this found in this thesis was to reserve enough time to study the requirements and ensure that they are correctly understood, with the help of experts, before proceeding with the project. In the case study it was also recommended that STUK should review their new requirements to minimize the risks for misinterpretations.

6.2 Further research

This thesis works as a good base for further research as it easily can be made a lot more complex and in-depth. The first step would be to carry out interviews with the participants to get more detailed answers. All problems and challenges mentioned in the result of this thesis could be investigated closer with possible solutions or improvements as a result. The same applies to the improvement suggestions and recommendations mentioned in the thesis which also could be further looked into and implemented if only possible. Additionally could sub-suppliers, customer and STUK be involved and interviewed in order to see things from their perspective and their thoughts on the project and the way of working.

6.3 Final words

I have learnt a lot from making this thesis and it has given me a lot better understanding of the way of working and what kind of challenges you can face in these kind of projects. I would like to thank everyone who took their time to answer the questionnaire and everyone who has helped out with the making of this thesis.

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Appendix

	Questions
Organisation and PM	How was the project team formed? (Based on skills, experiences?)
	Is there differences between a 'standard' project team and an EDG replacement project team?
	Have there been nuclear experts involved? More expertise needed?
	Have the team members roles and responsibilities been clear?
	Have there been enough resources allocated to the project?
	How was the recruitment of internal personnel to the project? Challenges?
	Have new project team members been inducted and informed good enough?
	When changing project team members, how have the project performance been affected?
	How have the cooperation with support functions been? (Supply Management, Finance & Control, WSSC, Legal, Services)
Procurement of equipment	Why couldn’t Wärtsiläs 'standard' suppliers supply all components/material
	Looking back, should Wärtsilä have chosen known suppliers even if they were more expensive?
	Which ones of the suppliers who have supplied to the project have met the requirements regarding: a) Quality b) Delivery time c) Costs
	Which ones of the suppliers who have supplied to the project have not met the requirements regarding: a) Quality b) Delivery time c) Costs
	Which ones of the suppliers who have supplied to the project will probably not deliver equipment to Wärtsilä in the future for EDG replacement projects or other demanding projects?

	Which ones of the suppliers who have supplied to the project should be avoided in future EDG replacement projects or other demanding projects? Why?
	How did the purchasing process work (RFQ, quotations, PO)? Major challenges?
Budget	Comments regarding the budget for the aux. equipment. Why is nuclear equipment much more expensive than 'standard' equipment?
Schedule	Which were/are the major challenges? How can they be avoided?
Document management	Which were/are the major challenges? How can they be avoided?
Documentation	**1. Requirement Specifications**
	What should Wärtsilä have done differently?
	Other comments?
	2. Construction Plans
	Estimated schedule vs. actual, big differences? Why?
	Why does it take a long time to finish them and get them approved by customer and STUK/Dekra?
	What should the suppliers have done differently?
	What should Wärtsilä have done differently?
	Other comments?
	3. Suitability Analysis
	Estimated schedule vs. actual, big differences? Why?
	Why does it take a long time to finish them and get them approved by customer and STUK/Dekra?
	What should the suppliers have done differently?
	What should Wärtsilä have done differently?
	Other comments?
	4. Checking of Readiness
	Did the suppliers understand what it meant?
	What should the suppliers have done differently?

	What should Wärtsilä have done differently?
	Other comments?
	5. Construction Inspection
	Did the suppliers understand what it meant?
	What should the suppliers have done differently?
	What should Wärtsilä have done differently?
	Other comments?
	6. PDQR
	Did the suppliers understand what it meant?
	What should the suppliers have done differently?
	What should Wärtsilä have done differently?
	Other comments?
Manufacturing and its control	What should Wärtsilä have done differently?
	What should the suppliers have done differently?
Site	What has been going well?
	What has been going bad / challenges?
Communication	Have the communication with support functions been working? (Supply Management, Finance & Control, WSSC, Legal, Services)
	Was it clear who to inform
	Was it clear what to inform
	Was it clear when to inform
	Was it clear where to inform
	Was it clear why to inform

	Was it clear how to inform
	How is the information flow within project team, suppliers, customer, governing bodies (STUK/Dekra)?
	Have it occurred gaps in information, knowledge and understanding between the people involved?
EDG set	Comments? (what is important to remember)
Fuel System	Comments? (what is important to remember)
Lube Oil System	Comments? (what is important to remember)
Compressed Air System	Comments? (what is important to remember)
Cooling System	Comments? (what is important to remember)
Intake Air System	Comments? (what is important to remember)
Exhaust Gas System	Comments? (what is important to remember)
Piping and ducting	Comments? (what is important to remember)
Ventilation	Comments? (what is important to remember)
Generator	Comments? (what is important to remember)
Control System	Comments? (what is important to remember)
LV System	Comments? (what is important to remember)
Cables	Comments? (what is important to remember)
Instruments	Comments? (what is important to remember)

Plant Electrification	Comments? (what is important to remember)
Civil (Steel Structures)	Comments? (what is important to remember)
Other	Comments? (what is important to remember)
Lessons learned	Mention the 3 most important lessons learned from this project