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Process Mapping the Journey of 4-Stroke Engines: From Sales to Reassembly

A Case Study on Analyzing Phases, Challenges, and Workflow Improvements in Engine Power Plant Disassembly and Reassembly Activities.

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Degree Thesis for Bachelor of Engineering

Degree Programme in Energy Technology

Vaasa, Finland, 2025

DEGREE THESIS

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Degree Programme and place of study: Energy Technology, Vaasa.

Specialization: Project Engineering

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Title: Process Mapping the Journey of 4-Stroke Engines: From Sales to Reassembly

Date: 2.5.2025 Number of pages: 50 Appendices: 12

Abstract

With growing energy market opportunities boosting engine power plant sales, transporting engines has become crucial for Company X. Due to route and destination constraints, 4-stroke engines often need disassembly and reassembly at the destination. This thesis aims to create a detailed process map and workflow to improve the disassembly and reassembly process.

The process mapping was achieved through interviews with internal and external stakeholders, supplemented by one-on-one interactions, document revision and 46TS engine disassembly participation. The process is structured into 3 distinct phases: sales, disassembly, and reassembly.

This thesis presents three detailed process maps for each phase, outlining the current workflow, identifying challenges, and highlighting impacts. It offers recommendations for improvement like investigating the impact of communication gaps between different functions, enabling visualization and enhancing the entire process. Consequently, Company X can maintain its commitment to performance excellence and continuous improvement.

Language: English
Key Words: process mapping, 4-stroke engines disassembly & reassembly, transportation, process flow, power plants.

ACKNOWLEDGEMENTS

I extend my deepest gratitude to my supervisor Philip Hollins, for their unwavering guidance, expertise, and patience throughout this research journey and my studies at Novia.

To my company supervisor Björn Nygård, and colleagues at Company X, thank you for your trust, collaboration, and access to invaluable insights and resources.

Lastly, to my late mother, Ibe Ijeoma Scholastica, whose values, resilience, and belief in my potential continue to inspire me every day-this achievement is yours as much as mine.

Table of Contents

List of Figures

List of Tables

Abbreviations and Terms

AMER	North, Central and South America
BDM	Business Development Manager
BOM	Bill of Materials
DAP	Delivered at Place
DDP	Delivered Duty Paid
EH	Engineering Drawings
EEQ	Engineered Equipment delivery projects
EPC	Engineering, Procurement, and Construction
FEMA	Failure Mode and Effects Analysis
FS	Field Service
GM	General Manager
GW	Giga Watts
ICE	Internal Combustion Engines
ICS	Installations Construction Services
IEA	International Energy Agency
IMO	International Maritime Organization
INCO	International Commercial
IOS	Internal Order Specification
MEA	Middle East and Africa
Mech. Eng	Mechanical Engineering
MW	Mega Watts
Nox	Nitric Oxide
NSR	Non-Standard Request
SPTM	Self-Propelled Modular Transporter
SRA	Smart Resource Allocation
SRR	Smart Resource Request
Twh	Terawatt hours

1 Introduction

It is projected that by 2025, that annual global electricity generation will reach approximately 12,000Twh according to IEA. Multiple factors are driving this demand, including population growth, urbanization, economic development, renewable energy integration etc. Power plants play a critical role in meeting the growing global energy demand. They are essential for generating electricity and driving the transition to more sustainable energy solutions. Power plants are facilities designed for converting primary energy into electrical power on an industrial scale. (Energy Education, 2018).

In power plants, the transportation of engines and equipment to the site is a critical aspect of the energy generation process. This involves the movement of large and heavy machinery, such as turbines, generators, and other essential components, from manufacturing facilities to the power plant location. Some engines are too large and heavy to be transported in one piece, hence they must be disassembled and reassembled at site.

The process of disassembly, the logistics of transportation and reassembly and commissioning of engines can be a challenge at different points in the process.

1.1 Background

Founded in 1834, Company X has evolved from a small sawmill in Tohmajärvi, Finland, to a global leader in sustainable technology and services. The company focuses on enhancing the environmental and economic performance of its customers by providing cutting-edge solutions such as engines, propulsion systems, hybrid solutions, and energy storage technologies (Company X,2024).

Company X is a global leader in the energy sector and a pioneer in decarbonization, offering cutting-edge propulsion systems, hybrid solutions, and energy storage technologies (Company X, 2024). The company delivers innovative technologies and comprehensive lifecycle solutions to the marine and energy markets, with a workforce of 17,800 employees across 79 countries. Company X boasts over 79 GW of installed engine power plant capacity and equips more than 41,500 vessels worldwide. In 2023, the company achieved net sales of approximately €6,015 million (Company X, 2024).

There are three Company X businesses which are:

- **Company X Energy**: Dedicated to advancing the transition to a 100% renewable energy future, this division offers cutting-edge technologies and services for decarbonization, including power plants, energy storage solutions, and optimization technologies.

- **Company X Marine**: This division specializes in providing innovative power, propulsion, and lifecycle solutions tailored to the maritime industry. It actively supports the industry's shift toward sustainable practices, including the adoption of alternative fuels and the integration of digital ecosystems.

- **Company X Portfolio Business**: Comprises independently run units like Automation, Navigation & Control Systems, Gas Solutions, Marine Electrical Systems, and Water & Waste. These units focus on performance improvement and unlocking value through strategic alternatives.

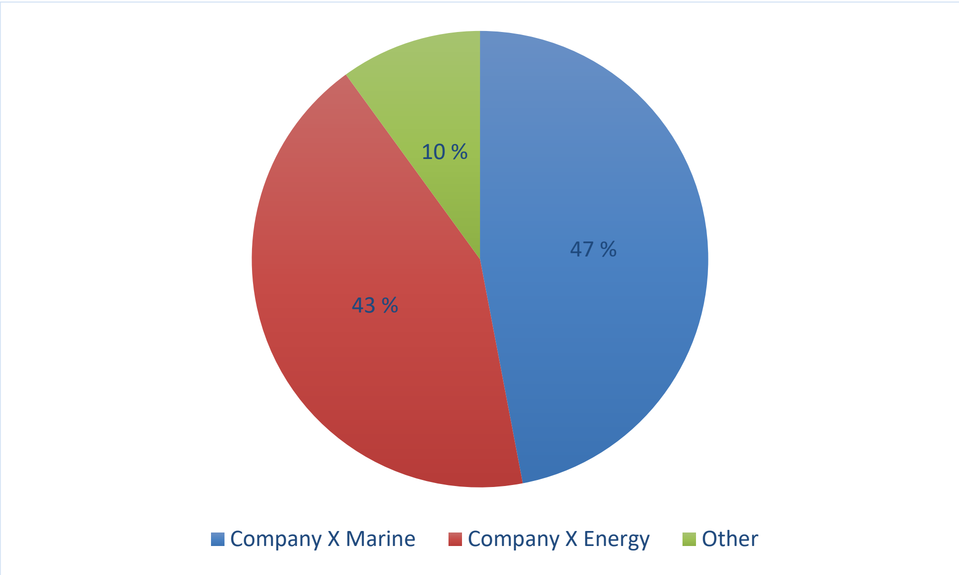

Figure 1. Group Net Sales by Business 2023 (Author's own). Adapted from Source: Company X

With Company X Energy business contributing 43% of net sales in 2023 (see figure 2). One of the main products of Company X energy is flexible engine power plants. The business provides a diverse array of flexible engine power plant solutions designed to ensure baseload availability and facilitate a smooth transition to renewable energy. These power plants can operate on 100% synthetic and carbon-neutral methane and can also utilize hydrogen/natural gas blends with up to 25% hydrogen. They support their customers with the production, transportation, installation of engines and development and service agreements for the power plants. Company X manufactures an extensive portfolio of four-stroke medium-speed engines, including diesel, gas, dual fuel, and multi-fuel options. These different engines are available in 4L to 16L cylinder configurations offering power out range of 0.7 and 2.0 MW with different weights ranging from 35 to 252 tons and height from 2295mm up to 4363mm. The engine portfolio is IMO NOx Tier II compliant and IMO NOx Tier III compliance achieved through Selective Catalytic Reduction (SCR) system, dual-fuel engines in gas mode, and pure gas engines (Company X, 2021).

According to Company X's annual report 2025, it shows order intake for power plants increased by 11% to EUR 3,366 million.

With transportation limitations, the large dimension and weight of engines have restricted deliveries to landlocked power plant sites. To adjust to this situation, the engine parts must be dismantled and reassembled. The decision is based on factors such as weight, dimensions, cost and site location.

The methods for disassembly and reassembly are project specific. The process involved many stakeholders across different sections in the company. In a bid to reduce challenges and unresolved operational bottle necks encountered by the several stakeholders and improve the process, a standard process map is needed to establish clear routines and activities on how this process is carried out.

This research will contribute to Company X’s ongoing efforts to deliver high-quality, reliable solutions in terms of engines to its customers worldwide and create an opportunity for process improvement.

1.2 Aim and Objectives

The aim of this thesis is the development of a process map for the disassembly and site reassembly of engines in power plant projects undertaken by Company X. To achieve this aim, these objectives were developed:

- Develop a process map of all essential activities from the sale phase to the reassembly phase for engine dismantling and site re assembly.
- Identify process flow and the key stakeholders in the process.
- Determine challenges and pain points encountered and propose solutions.
- Create supporting documentation

1.3 Scopes

The scopes / objectives were clearly defined at the beginning of the thesis after a series of meetings with the supervisor at the company, the scopes / objectives of this thesis were identified.

In this project it is important to note that this thesis will not delve into the following: technical specifications implementation of proposed solutions, creation of training programs, detailed financial analysis, and assessment of long-term impacts of the proposed changes.

1.4 Outline of the Report

The report will be divided into seven sections. The first section is an introduction to the background, aim, objectives and scope of the project. The next section is the literature review, which will be presented with the report's theory. The third section is research methodology, which encompasses the methods and processes used during the phases. These phases are exploratory and explanatory. The following fourth section is the result, and that chapter contains the execution of the project. This is followed by a fifth section discussion, where the findings will be discussed. And the final section, conclusion and further recommendations which will highlight the key findings and recommendations from the thesis.

2 Literature Review

This section constitutes the theoretical framework for this thesis and contains various theories, concepts, and criteria regarding the area of process, process mapping and engine disassembly & reassembly. The section aims to examine existing knowledge in the field to use well-chosen parts during the degree project.

2.1 Process

To understand process mapping, we need to understand what a process is. According to Baird (2014), a process is a series of actions or steps taken to achieve a particular goal or end. It can be found in various contexts, such as business, manufacturing, computing, and everyday activities as little as making someone's bed in the morning. Here are some key aspects of a process:

- **Sequence of Steps**: A process involves a specific sequence of steps or activities that need to be completed in a particular order.
- **Purpose**: Each process is designed to achieve a specific outcome or result.
- **Repetition**: Processes can be repeated multiple times to produce consistent results.
- **Inputs and Outputs**: Processes typically have inputs (resources, information, etc.) that are transformed into outputs (products, services, etc.).

2.2 Process Mapping

Process mapping is a method for graphically illustrating the sequence of steps within a process. It helps organizations understand workflows, identify inefficiencies, and improve processes. By creating a visual diagram, process mapping provides a clear understanding of how a process works from start to finish (Ruiz, 2023).

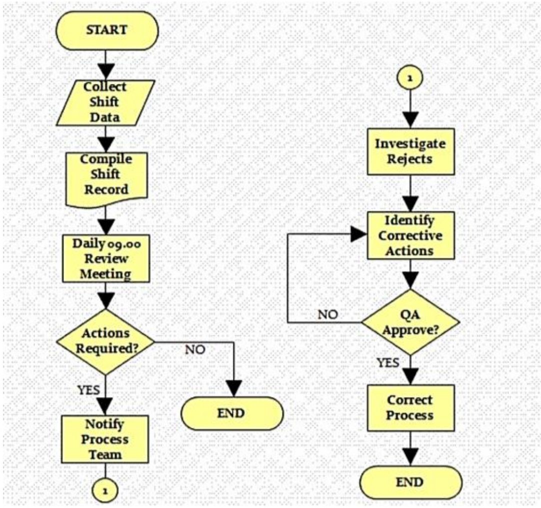

Figure 2. Process Mapping / Flowchart Sample. Source: https://discover.hubpages.com

2.3 Historical Development of Process Mapping

The need to increase productivity and clarity in workflows has significantly evolved process mapping over time. According to Shehu (2024), process mapping first emerged in the early 20th century. In 1921, industrial engineer Frank Gilbreth created process charts, the first organized technique for recording process flows. This became a fundamental tool in industrial engineering after being presented to the American Society of Mechanical Engineers (ASME). Other industrial engineers, including Allan H. Mogensen, adopted Gilbreth's idea and taught efficiency through work simplification conferences in the 1930s. The concept became more well-known after being incorporated into the works of Mogensen's students, Art Spinanger and Ben S. Graham. Graham integrated flow process charts into Standard Register Industrial's information processing system. The ASME standardized Gilbreth's original idea in its 1947 ASME Standard for Process Charts.

Technological advancements have transformed process mapping from basic flowcharts to complex tools and software solutions, enabling real-time collaboration, integration with other business systems, and thorough analysis (Eby, 2017). In recent decades, process mapping has become essential in approaches like Lean and Six Sigma, offering a visual depiction of workflows to identify areas for improvement, reduce waste, and enhance quality (ORS, n.d.).

2.4 Type of Process Mapping

There are numerous process flow models (e.g. flowchart or flow map, process flow diagram, Gantt chart) the ones documented here are commonly used by Company X.

2.4.1 Flow Map

The term "Flow map" originates from cartography and represents a blend of maps and flow diagrams. In these diagrams, the arrow width corresponds to the flow rate, often referred to as Sankey diagrams. Flow maps visually depict various movements, such as animal migrations, financial transactions, or the flow of goods and people. The arrows indicate direction, while their width reflects the quantity being represented (Flowmapp, n.d.).

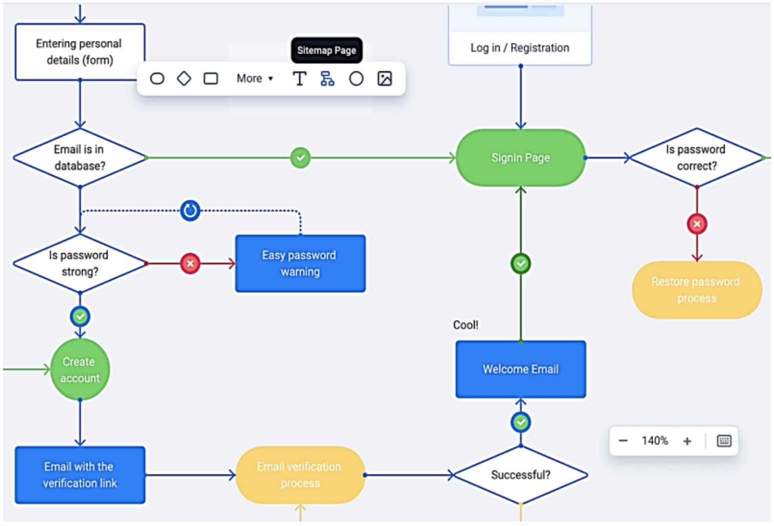

Figure 3. User Flow Map. Source: [Flowmapp]

When tailored a creative, decision or production process is called a process map, a flowsheet or a process flowchart.

2.4.2 Swimlane Map

Based on the nature of this thesis which involves multiple functions and teams, swimlane map, also known as a cross-functional or deployment flowchart will be used cos it is a suitable process map, it organizes process activities into “swim lanes” to designate who is responsible for each task (Team Asana, 2024). The map is divided into channels for each stakeholder, listing each activity in the appropriate stakeholder’s channel. This type of map highlights the different roles involved in the process and the interactions between stakeholders. It illustrates how a process transitions between various teams or departments. Each "lane" in the diagram represents a distinct department or role (Croft, 2023).

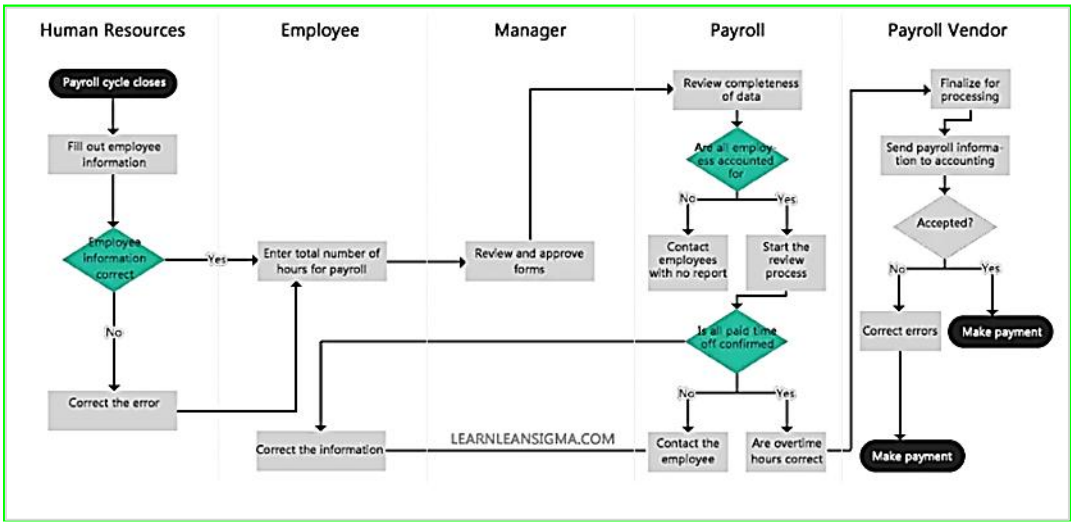

Figure 4. Cross Functional / Swimlane Process Map. Source: Learn lean sigma

Best for clarifying the roles of multiple stakeholders in a process and increasing accountability.

2.4.3 Value Stream Map

A value stream map is a lean management tool that visualizes the process of delivering a product or service to the customer. These maps use unique symbols to illustrate the flow of information and materials. By documenting data such as cycle time and the number of people involved in each step, value stream mapping helps identify areas to reduce waste and opportunities for future projects.

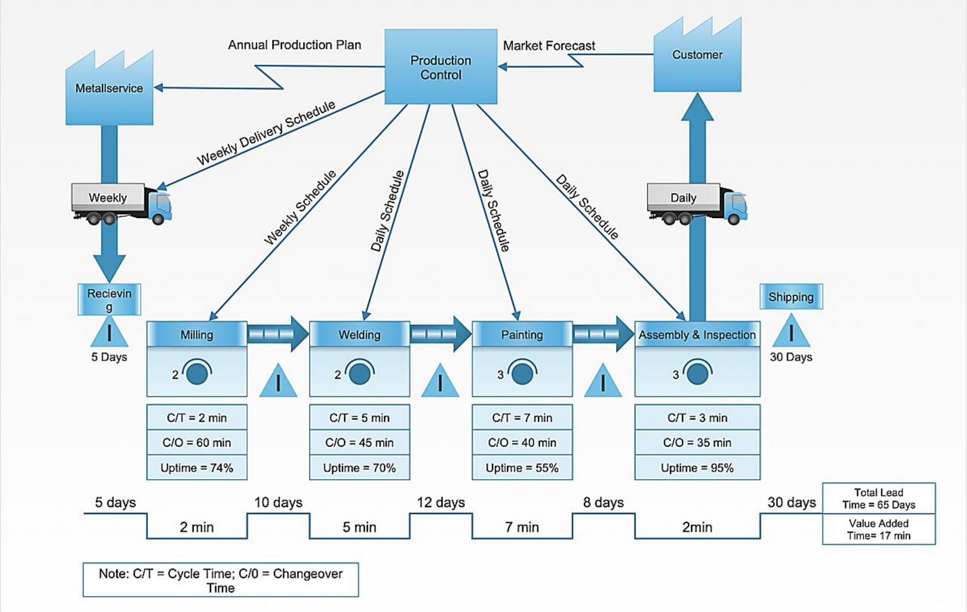

Figure 5. Value Stream Map. Source: Concept Draw

Best for describing the process of delivering a product to a customer and documenting quantitative data about the process.

2.5 Engine

An engine is a machine designed to convert one form of energy into mechanical energy (M, 2019). This mechanical energy is then used to perform work, such as moving a vehicle, generating electricity, or powering machinery. Engines are fundamental to many aspects of modern life, from transportation to industrial applications.

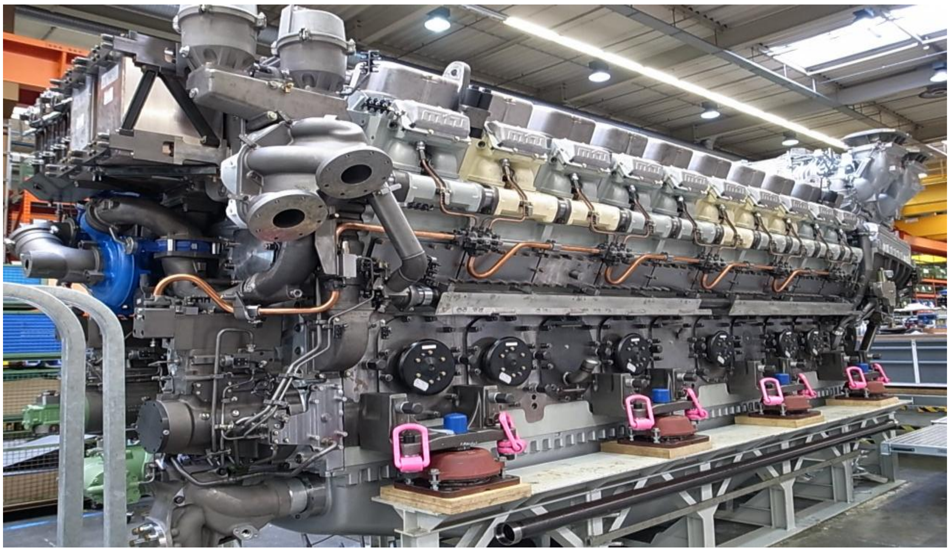

Figure 6. MTU Series 8000 FN Engine. Source: MPDS Marine

2.5.1 Internal Combustion Engines (ICE)

The company deals only with internal combustion engines. Internal combustion engines are types of engines where the combustion of fuel occurs within the engine itself, producing mechanical power. They are the most used type of engine, found in cars, trucks, and many industrial applications (M, 2019).

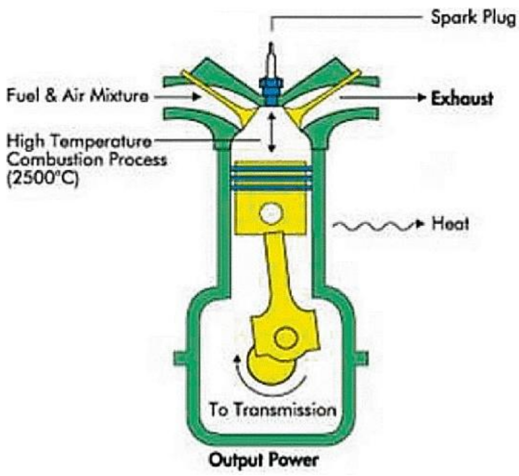

Figure 7. Single Cylinder IC Engine Diagram. Source: ResearchGate

There are two main types of ICE:

- **Gasoline Engines**: These engines use spark ignition to burn gasoline. They are known for their high-power output and are commonly used in passenger vehicles.

The air-petrol mixture is compressed and ignited by a spark plug, causing an explosion that drives the piston.

- **Diesel Engines**: Diesel engines use compression ignition to burn diesel fuel. They are more fuel-efficient and durable, making them ideal for heavy-duty vehicles and machinery. In these engines, only air is compressed, and diesel is injected at high pressure, igniting due to the heat of compression.

Company X offers a range of internal combustion engines, including diesel, gas, and dual fuel options, designed to meet stringent environmental regulations and reduce emissions.

2.5.2 Internal Combustion Engines in Power Plants

Power plants or power stations of all shapes and sizes use internal combustion engines and turbochargers, either as backup solutions or to generate power on a more permanent basis. It can be a nuclear plant running diesel engines as backup, peaking plants helping to balance fluctuating demand, or distributed power stations providing electricity in more remote locations, internal combustion engines offer plenty of benefits. As with other applications, turbochargers also play a big supporting role (Accelleron, 2023).

Power plants are constructed in diverse forms, utilizing a variety of energy sources such as nuclear power, wind, solar, ocean tides, natural gas, coal, and other fuels. Many use turbines to power generators that provide electricity, but internal combustion engines also play a significant role in providing alternative means of power.

According to Accelleron (2023), applications of internal combustion engines in power plants included:

Backup Power: Internal combustion engines are often used in power plants as backup power sources during grid outages or emergencies. Diesel engines are ideal for this role due to their cost-effectiveness, compactness, simplicity, and reliability. They can quickly respond to power needs, making them perfect for critical systems like hospitals and data centers. Diesel engines are also economical for short-term high-power needs, such as during blackouts.

Peaking Power: Internal combustion engines provide extra power during high demand periods in power stations. These engines are used only when needed, usually for a few hours. Diesel engines are ideal because they can provide power almost instantly. Engines for peaking power are typically larger than those for backup power and can be grouped together to provide more power. They can be installed in stationary power plants or as part of a distributed generation network, consisting of smaller power generation systems located close to where the power is used.

Distributed Generation: Internal combustion engines are increasingly used for distributed generation, improving grid efficiency and reducing transmission losses. These engines range from small units to large power plants, depending on community needs. They support renewable energy by providing power when wind or solar is unavailable. Using biogas, they offer a sustainable option. Combined Heat and Power (CHP) plants can include these engines to generate power and recover heat, making them suitable for locations close to demand areas.

2.6 Engine Disassembly and Reassembly Overview

Engine disassembly is the process of taking an engine apart to inspect, repair, replace its components or in this case for the ease of transportation (Studocu, n.d.). When an engine needs to be transported to a main site for repair or reassembly, disassembly becomes a crucial step. Here's why:

- **Reducing Size and Weight**: Disassembling the engine reduces its size and weight, making it easier and safer to transport. This is especially important for large engines used in heavy machinery or industrial applications.
- **Preventing Damage**: By disassembling the engine, individual components can be securely packed and protected, reducing the risk of damage during transit.
- **Ease of Handling**: Smaller, disassembled parts are easier to handle and move, especially when using cranes, forklifts, or other lifting equipment.

Engine reassembling involves putting all the components back together in the reverse order of disassembly. It's crucial to follow the instructions in the service manual carefully to ensure the engine is properly reassembled and functions correctly when put back into service.

According to Studocu (n.d.), both processes involve the use of special services tools in each phase and transportation. These tools are designed to handle specific tasks that standard tools cannot, ensuring the job is done efficiently and safely. Examples include

- **Engine Hoists and Stands**: Used to lift and support the engine during disassembly and reassembly.
- **Torque Wrenches**: Ensure bolts are tightened to the manufacturer's specifications.
- **Valve Spring Compressors**: Used to remove and install valve springs without damaging them

3 Research Methodology

The research methodology section outlines the methods and procedures used to conduct the study. This section is crucial as it provides transparency and allows others to replicate the study if needed. The methodology details research, data collection methods, data analysis techniques, and ethical considerations. By clearly describing the methodology, the study's validity and reliability are enhanced.

3.1 Research Approach and Data Collecting Methods

The research approach for this study is qualitative. This qualitative study explores the engine disassembly and reassembly process through stakeholders' perspectives, focusing on deep insights into complex phenomena. The process is divided into three phases—sale, disassembly, and reassembly—for clarity and manageability. Stakeholders provided input on process developments and requirements. Interviews were conducted via Microsoft Teams, with sample invites and interview questions detailed in Appendices 1 and 2 respectively.

3.2 Data Analysis Methods and Techniques

This thesis employs a qualitative approach to data collection and analysis. The data collection methods were meetings, emails, chats, review of existing company documents, 24 interviews, and participation in a project engine disassembly phase. These methods are used to gather comprehensive insights from various stakeholders over the key stages of sale, disassembly and reassembly as defined by the company.

Here is how they fit into data analysis methods:

Table 1. Data Collection / Analysis Methods (Author)

Data Collection Method	**Data Analysis Method**
Meetings, Emails, Chats	Content Analysis, Thematic Analysis
Review of Company Documents	Document Analysis
Interviews	Narrative Analysis, Thematic Analysis
Participation in Project Engine Disassembly Phase	Ethnographic Analysis, Case Study Analysis

3.2.1 Data Analysis Techniques

Triangulation in qualitative research uses multiple methods or data sources to develop a comprehensive understanding of phenomena, enhancing credibility and validity. In this thesis, triangulation was achieved through:

- **Multiple Data Sources**: Meetings, emails, chats, company documents, interviews, and participation provided a well-rounded perspective on engine disassembly and reassembly.
- **Cross-Verification**: Data from different sources were cross-verified for consistency and reliability.

- **Diverse Perspectives**: Including internal and external stakeholders assured diverse perspectives.
- **Contextual Analysis**: Observations and participation provided contextual insights.
- **Software Tool**: BPMS software was used to create graphical process maps for each phase.

3.2.2 Ethical Considerations

Informed Consent: All participants provided informed consent prior to the commencement of data collection.

Confidentiality: The confidentiality of data from the thesis was ensured by redating some of the results of the thesis. The company for which this thesis is conducted specializes in delivering large industrial plants that demand extensive project management. Despite facing tough competition, they successfully execute project deliveries worldwide. Background material will be provided for content that will not be publicly available.

Data Security: Data collected during the research was securely stored and only accessible to authorized personnel.

4 Results

4.1.1 Overview of Data Collection and Analysis

The process involves several sub-processes, some occurring simultaneously to save time. Table.1 outlines methods ensuring cross-verification and reliable findings. The findings are divided into three phases:

Sale Phase: Secures the project by documenting customer requirements, road survey, and finalizing the sale, setting clear objectives for subsequent phases.

Disassembly Phase: Includes engine production, dismantling, and transportation, requiring careful planning to handle parts safely.

Reassembly Phase: Focuses on reassembling equipment on-site, ensuring functionality through collaboration with stakeholders.

Triangulating data sources provides a clear understanding of process flow, challenges, and stakeholder roles.

4.1.2 Process Map Development and Flow Identification

After the thesis was assigned, a kick-off meeting was conducted with the company supervisor to establish objectives and expectations. This was followed by 24 in-depth, semi-structured interviews conducted over a six-month period, engaging stakeholders from diverse roles including project mechanical engineering, operations, technical sales support, logistics, and engineering (see appendix 3.) for project schedule and participants. Each interview lasted 25–30 minutes and provided critical insights into the end-to-end processes. The email invite sent, and interview questions are seen in appendix 1 and 2 respectively. Six representative transcripts are included in the appendices 4-9 to ensure readability and focus. These were selected to reflect core findings and perspectives from each phase. Full anonymized transcripts are available upon request, adhering to confidentiality agreements.

The interviews were supplemented by two progress discussion meetings and a site visit to the 46TS engine disassembly ground, ensuring a holistic understanding of operational workflows. Stakeholder expertise spanned the three mapped phases:

Sales Phase (customer tender to contract signing): Informed by technical sales support managers, product planning Engineers, and transport managers roles.

Disassembly Phase (contract signing to shipping): Insights from project managers, specification management, design teams and logistics coordinators, and disassembly company.

Reassembly Phase (shipment arrival to engine reassembly): Contributions from field service coordinators, field service team and commissioning management team.

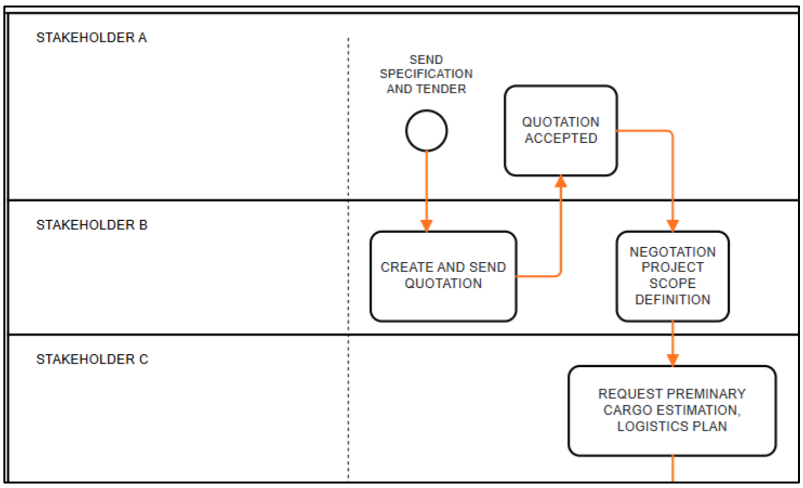

Figure 8. Sale Phase. Full Process Flow can be Found in Appendix 10. (Author)

Key activities within these processes included defining the project scope, agreeing on INCO terms, and conducting road surveys to address transportation challenges. Flowcharts created using BPMS tool were instrumental in visualizing the process flows and timelines, allowing for the identification of inefficiencies. Drafts of the process maps were carefully reviewed and refined based on stakeholder feedback before being finalized. Appendix 2 provides the interview frameworks and appendix 10,11 and 12 shows finalized process maps for each phase respectively.

4.1.3 Stakeholder Identification

Stakeholders are defined as individuals or groups who have a vested interest in a company or project (Barney, 2023), and their influence can extend both upstream and downstream. For this study, internal and external stakeholders were identified through a combination of semi-structured interviews, targeted questions such as “What are your sources of information and final outputs, and who are the other stakeholders you collaborate with?” (see appendix 2), as well as email correspondence, meetings, group discussions, and observations from an engine disassembly exercise. These efforts provided a comprehensive view of the stakeholder landscape, which is presented in the table below

Table 2. Stakeholder Identification Table (Author)

STAKEHOLDERS	ROLE

4.1.4 Challenges and Pain Points

The engine disassembly and reassembly process are fraught with operational, logistical, and communication challenges across its lifecycle. From contractual ambiguities during the sale phase to documentation gaps in reassembly, inefficiencies arise due to misaligned stakeholder roles, resource constraints, and fragmented workflows. This section highlights these pain points, categorizing them by phase to pinpoint critical bottlenecks and their impacts. Challenges are presented on the table below

Table 3. Challenges and Impacts (Author)

PHASE	CHALLENGES	IMPACT

5 Discussion

This section is an inside look and evaluation of the thesis' results presented concerning the initial aims and objectives in Section 5.1, the limitations of the work in Section 5.2, the consistencies and inconsistencies in Section 5.3, and suggestions for project improvements in Section 5.4.

5.1 Initial aims and objectives

To meet the aim of the project four objectives were established. The first objective was to develop a process map of all essential activities from the sale phase to the reassembly phase for engine dismantling and site re assembly. This was successfully accomplished by developing three distinct process maps seen in appendix 10,11 and 12, one for each phase. The insights gained from this initial work laid a solid foundation for addressing subsequent objectives with greater confidence.

The second objective was to identify process flow and the key stakeholders in the process. Through interviews, stakeholders provided detailed descriptions of the process flows from their perspectives, identified other collaborators, and reviewed the draft process maps to ensure accuracy and make necessary corrections.

The third objective of the project was to determine challenges and pain points encountered and propose solutions. Table 2 highlights 33 challenges identified in all process phases. Proposed solutions for these challenges are discussed in detail later in Section 5.4.

The last objective was to create supporting documentation, which was successfully achieved through the completion of this thesis.

5.2 Limitations

Several limitations were encountered during the development of this thesis. One significant constraint was the restricted access to certain tools utilized by stakeholders, such as

Salesforce software. This limitation impeded a comprehensive understanding of the challenges related to tool integration with reassembly planning.

Another major limitation was the time and location of the stakeholders, who were dispersed across different parts of the world. The varying time zones posed challenges in scheduling and conducting interviews. Additionally, some stakeholders did not respond to interview invitations, further complicating the data-gathering process.

5.3 Consistencies and inconsistencies

Throughout the development of the thesis, and after adopting an objective and comprehensive perspective, several consistencies were identified. A key determinant for deciding on engine disassembly was clearly outlined, namely location constraints, as well as height and weight requirements—factors well understood by most stakeholders.

However, certain inconsistencies also emerged during the project. One notable issue was the varying frequency with which third parties were engaged for the actual reassembly process. Additionally, upstream stakeholders had minimal or no awareness of the extent to which third parties were involved in performing reassembly tasks.

5.4 Suggestions for process improvements

The process can be considered a vital part of achieving the company's high-quality, reliable solutions in terms of engine delivery. The challenges outlined in table 3 span multiple phases of the process lifecycle, from sales to disassembly and reassembly. To better prioritize the challenges, it was evaluated across three key dimensions on a scale 1 -5 Likert scales (not just recurrence and importance). Frequency × Severity × Solvability matrix (F x S x S) is a tri-dimensional prioritization framework combining frequency, severity, and solvability, derived from risk management (FMEA), cost- benefit analysis, and Agile/Lean practices, like bug-triaging methodology in software engineering done by Kaner et al. (n.d.).

- Frequency – How often the issue occurs (recurrence).
- Severity– The magnitude of its impact (cost, time, safety, reputation).

- Solvability – How feasible it is to mitigate or resolve the issue (feasibility of mitigation).

Table 4. F x S x S Matrix Framework (Author's own)

This approach ensures focus not just on the "biggest" problems, but also on those where solutions can be realistically implemented for maximum ROI.

6 Conclusion

Process mapping plays a great role in process improvement. It is essential to map out the process of engine disassembly and reassembly at site. The process is a crucial part of the delivery project to ensure customer success. In summary, this thesis has helped visualize Company X's process of disassembling and reassembling large-scale 4-stroke engines through in-depth research, engine disassembly exercise and 24 stakeholder interviews, addressing critical transportation constraints for engines used in power plant projects.

The findings of the thesis are:

- Comprehensive process maps covering 3 key phases: sales, disassembly, and reassembly.
- Process flow was clearly established.
- 33 challenges identified across the three phases.

- Recommended solutions using F x S x S matrix framework, prioritizing issues on a range of levels 1 to 5, ensuring that the most critical problems are addressed first and with the most effective solutions.

Future work (improvements) are as follows:

-
-
-
-

By identifying these pain points and providing actionable insights, this thesis supports Company X in achieving its goals of performance excellence and continuous improvement. Ultimately, the findings pave the way for more efficient and effective project delivery, enabling the company to sustain its leadership position in the energy market.

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Appendix

Appendix 1. Email Invite for Interview

Good day,

My name is ******, am part of the EEQ Projects Team in Vaasa and I am currently Working on a thesis project focused on mapping the engine dismantling and re assembling process, with the goal of developing a process map. Your expertise and insights would be incredibly valuable to this research, especially on the **** section.

I would like to request a brief interview with you to discuss your experiences and perspectives on this topic. The interview will take approximately 25 mins and can be scheduled at your convenience.

Please let me know your availability, and I will do my best to accommodate your schedule. Your participation would contribute to the success of this project.

Thank you for considering this request. I look forward to your positive response.

Appendix 2. Interview Questions

- What is your role?
- What's the role of the team for the engine's disassembly or reassembly process?
- What are sources of information/chain of command?
- What are the other stakeholders you work with during the process?
- What are the key steps involved?
- What's the final output, document wise?
- Are KPIs (key performance indicators) measured or tracked?
- What are the challenges during this process

Appendix 3. Project schedule for stakeholder engagement

Note: Zoom to 220% for clear details.

Project Schedule

Appendix 4. Abridged interview transcript I

Position: Senior Chief Project Engineer (Mechanical)

Appendix 5. Abridged interview transcript II

Position: General Manager

Appendix 6. Abridged interview transcript III

Position: Product Planning Engineer

Appendix 7. Abridged interview transcript IV

Position: Team Coordinator

Appendix 8. Abridged interview transcript V

Position: General Manager,

Appendix 9. Abridged interview transcript VI

Position: General Manager,

Appendix 10. Sale Phase

Note: Zoom to 220% for clear details.

Appendix 11. Disassembly Phase

Note: Zoom to 220% for clear details.

Appendix 12. Reassembly Phase

Note: Zoom to 220% for clear details.