

Transform from Engineer-to-Order to Configure-to-Order

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Abstract

This bachelor's thesis is done in co-operation with Wärtsilä Energy, development projects. The purpose of this thesis is to be able to give an analysis of which and what parts of their processes need to be improved to be able to have a workflow more focused around Configure-to-Order.

In the theory part of this thesis, the central definitions of different manufacturing processes like Configure-to-Order and Engineer-to-Order will be explained. There will also be an explanation of what a product configurator is and what benefits can come from utilizing them correctly.

The qualitative research method has been used in this thesis. Through interviews with experts and managers in the respective areas, to be able to get a deeper understanding of how they configure powerplants from sales lead to delivery today.

The results from this thesis are to be able to give an evaluation to Wärtsilä Energy about what and where to do improvements in their processes to be able to have a workflow more based around Configure-to-Order. Results also show a flowchart of the most used configurators that are being used to configure their projects.

Language: English

Key Words: Configure-to-Order, Engineer-to-Order, Product configuration, Product configurators

EXAMENSARBETE

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Abstrakt

Detta examensarbete gjordes i samarbete med Wärtsilä Energy, development projects. Syftet med arbetet var att kunna göra analys över vad och vilka delar av deras processer som kunde förbättras för att de skall kunna få ett arbetssätt mer fokuserat kring Configure-to-Order.

I teoridelen förklaras centrala begrepp för olika tillverkningsprocesser som Configure-to-Order och Engineer-to-Order. Det förklaras även vad produktkonfiguratorer är och vad de kan bidra till ett företag om använda på korrekt sätt.

En kvalitativ forskningsmetod har använts i detta arbete. För att få så bred uppfattning om hur de konfigurerar ett kraftverk från en potentiell kund tills leverans idag, har experter och ledare inom respektive område intervjuats.

Resultatet av arbetet är att ge en evaluering åt Wärtsilä Energy om var och vad som kan förbättras i deras processer för att kunna uppnå ett mer Configure-to-Order baserat arbetsflöde. I resultatet visas också ett flödesschema över de mest använda konfiguratorer som de använder sig av för att kunna konfigurera sina projekt.

Språk: engelska

Nyckelord: Configure-to-Order, Engineer-to-Order, produktkonfigurering, produktkonfiguratorer

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Tiivistelmä

Tämä opinnäytetyö on tehty yhteistyössä Wärtsilä Energy kehitysprojektien kanssa. Työn tarkoituksena oli antaa analyysi siitä, mitä osia voitaisiin parantaa, jotta ne voisivat työskennellä keskittyneemmin Configure-to-Orderin ympärillä.

Tämän opinnäytetyön teoriaosassa selitetään eri valmistusprosessien keskeiset määritelmät, kuten Configure-to-Order ja Engineer-to-Order. Lisäksi kerrotaan, mitä tuotekonfiguraattorit ovat ja mitä hyötyä niiden oikeasta käytöstä voi olla.

Tässä opinnäytetyössä on käytetty kvalitatiivista tutkimusmenetelmää. On haastateltu kunkin alueen asiantuntijoita ja johtajia, jotta saataisiin mahdollisimman kattava ymmärrys siitä, kuinka voimallaitokset konfiguroidaan myynnistä toimitukseen asti.

Tämän opinnäytetyön tuloksena on pystyvä antamaan arvio Wärtsilä Energylle siitä, mitä ja missä prosessissa pitäisi tehdä parannuksia, jotta työnkulku olisi enemmän Configure-to-Order pohjaista. Tulokset näyttävät myös vuokaavion heidän eniten käytetyistä konfiguraattoreistaan, joita käytetään projektien määrittämiseen nykyään.

Kieli: englanti

Avainsanat: Configure-to-Order, Engineer-to-Order, Tuotteen kokoonpano, Tuotteen konfiguraattorit

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1 Introduction

In this thesis, I'm going to examine what types of manufacturing processes or so-called business models there are. This thesis is also made for Wärtsilä Energy business and the manufacturing models are then researched to be able to give Wärtsilä an evaluation on how they can improve some parts of their operations to be more based around Configure-to-Order instead of Engineer-to-Order.

The theoretical framework of this thesis is based on five different manufacturing processes. Where the focus is on Engineer-to-Order and Configure-to-Order, what they are, how they are implemented, how to use them, what possible benefits can come from using those processes, and how they differ from one another.

There is also an examination of what market trends there are that are showing more companies in different industries are choosing to opt for a more Configure-to-Order based workflow. Lastly, there is also an analysis of what product configurators are, in what stages they are typically used, and what they can offer companies.

In the research part of this thesis, I will conduct interviews with experts of different product configurators and with team members from both the sales and delivery sides. To be able to do high-level mapping of the most used configurators that they use in a new powerplant project. I will also from these interviews be able to give an evaluation on how and where they might be able to integrate a more Configure-to-Order based workflow.

1.1 Background

This bachelor's thesis is made in cooperation with Technology & Product Management within the Wärtsilä Energy business. Where the largest growth segment for engine powerplants is in thermal balancing, typically taking place in developed countries or advanced energy markets that have extensive local requirements. A complex one-off engineering, procurement, and construction (EPC) power plant solution isn't a preferred option anymore. The offering is driven towards a leaner approach with increasingly more standardized equipment to lower the costs and reduce the project delivery risks and enhance competitiveness. With a workflow that is more based around Configure-to-Order,

the possibilities to offer a more standardized solution increase in comparison to a powerplant solution that is made from an Engineering-to-Order manufacturing process.

1.2 Aims of the study

The main focus of this thesis is to perform a theoretical study of what business models mean in practice and mainly how Engineer-to-Order (ETO) and Configure-to-Order (CTO) differ from each other in the current literature.

The second aim is to evaluate based on how Wärtsilä Energy configures a power plant from sales lead to delivery today, what Wärtsilä Energy could do to have a workflow that is more based around Configure-to-Order (CTO).

1.2.1 Structure

In this thesis, there are going to be 8 main chapters, with subchapters going more into detail. The main chapters are the as following:

1. Introduction
2. Theoretical Framework
3. Research Methods
4. Results
5. Discussion
6. Conclusion
7. References
8. Appendix

1.3 Limitations of the study

Due to this study's nature, the collected data studied will be confidential. This version contains everything but the results and the conclusion which will be held due to confidentiality.

2 Theoretical Framework

This chapter is a review of the current literature regarding manufacturing processes and how Engineer-to-Order (ETO) differs from Configure-to-Order (CTO). What market trends are leading the way for a more Configure-to-Order based workflow? There will also be a review of product configurators and product configuring.

2.1 Manufacturing processes

There are many different manufacturing processes, in this thesis, the focus is on Engineer-to-Order (ETO), Configure-to-Order (CTO), Assemble-to-Order (ATO), Make-to-Order (MTO) and Make-to-Stock (MTS). Each of these has its strengths and weakness deepening on how they are used and in what industries. Which process that is used by a company is based on factors like market targets and business goals. There is also the possibility to use a combination of these processes depending on what the specific needs are from the customer and what products companies offer.

2.1.1 Engineer-to-Order

Engineer-to-Order (ETO) is a complex and challenging manufacturing process. It requires a customer order for the manufacturing of the product to start. This process is mostly used in companies where the customer has very specific needs for their product. An example of this is where the customer has a few measurements that are dependent on the location or a product with a set of new functionalities that are needed but don't exist yet. Out of the five manufacturing processes, Engineer-to-Order has the longest lead time for the customer since everything must be engineered from scratch and a lot of feedback loops with the customer are needed to produce the product. Even though it has the longest lead time, once the product is made and delivered, the customer gets exactly what they ordered. With this manufacturing process, the possibilities in variations are in theory endless. (Logistiikan Maailma, 2023)

2.1.2 Configure-to-Order

According to (Siemens, 2022) Configure-to-Order (CTO) is a manufacturing process that is based on design selection from pre-defined options or variations at the time when the

customer makes their order. Companies have a set of products that they have already engineered, defined, and validated different variations of the product with all different parts and specifications that the customer can choose from when making the order. It's then for the company to order the needed parts and materials to manufacture and assemble the product.

2.1.3 Assemble-to-Order

Assemble-to-Order (ATO) is quite alike Configure-to-Order in that sense it is a manufacturing process where the customer chooses the desired parts for the product from a set product line that has a few predefined variations and options to choose from. The process for assemble-to-order starts with the manufacturer stocking up on subassembly parts based on their historical data and an overall judgment of the current market. Once the customers have made their orders and chosen from the different variations of the product with the different parts, the manufacturer can then assemble the parts into the final product the customer ordered and ship it. (CFI Team, 2023)

What differentiates ATO from CTO is that the company stocks up on the subassembly parts and other inventories to then be able to quickly assemble and deliver the products once the customer places an order. The Assemble-to-Order process can be seen as a variation of both make-to-order and make-to-stock-manufacturing processes. (CFI Team, 2023)

2.1.4 Make-to-Order

Make-to-order or (MTO) is a pull-type manufacturing process that begins once the customer has made their order. (Hayes, 2020) describes Make-to-Order as a process where customers can purchase customized products according to their specifications. Then the manufacturing of the product can only start once there is a confirmed order. Make-to-Order is also known as mass customizing. Since the manufacturing of the product can't begin until the customer order is received, it creates extra lead time for when the customer gets the ordered product. However, it allows the company to offer more customization for the customer rather than the customer going to a retailer.

The Make-to-Order process is a pull-type operation meaning that companies will only start to make products when they know there is a stable demand. It is typically used in industries

where the product that needs to be produced per specification are only a few. This type of process is mostly used in more specialized industries like aircraft or bridges. (Hayes, 2020)

2.1.5 Make-to-Stock

Make-to-Stock (MTS) is the manufacturing process that is based on a forecast. In this process, the most vital tools are production planning and production scheduling. All products are made in one period and the next period is used to fulfill customer orders. In today's world companies would like to avoid having a big inventory of already built and finished products since they are a big cost to have. However, a smaller inventory isn't optimal either because of extra costs that come from missed delivery times and overtime. The Make-to-Order process would ideally match the forecasted finished goods the company would need to make to match the demand in the following period. (Simens, 2022)

(Segal, 2022) describes Make-to-Stock as a manufacturing process that estimates how many products they could make, and manufacture enough so their inventory match the forecasted customer demand. (Segal, 2022) also says that theoretically, this process is a way to prepare for fluctuations in demand if done correctly. If not, the company may get too much inventory which in turn leads to extra costs in inventory, but it's also possible that they have not met the demand and missed out on revenue due to unavailable inventory. The forecast is then vital in this process to make correct and is also its biggest disadvantage if not correctly forecasted.

2.2 Process of Engineer-to-Order

To get an understanding and definition of what Engineer-to-Order is and what the process looks like. Firstly, we must look into the concept of customer order decoupling point (CODP) see Figure 1. The CODP is used to describe what manufacturing process we are working with according to where the information regarding material and information flow that the product is based on. If it is based on customer orders or forecasts of customer demand. Figure 1 shows the position of CODP in this case four manufacturing processes. If a company is wanting to lower its lead times, they want to have an MTO, or ATO manufacturing process since it is more work done before the customer order is confirmed and will move the company closer to the customer. If a company wants to offer more

customizable products and do more engineering and have more interactions with the customers and don't have to rely on the forecast as much, they need to opt for an ETO or MTO process where the COPD moves to the left side and then the lead times will become longer. (Powell, Strandhagen, Tommelein, Ballard, & Rossi, 2014)

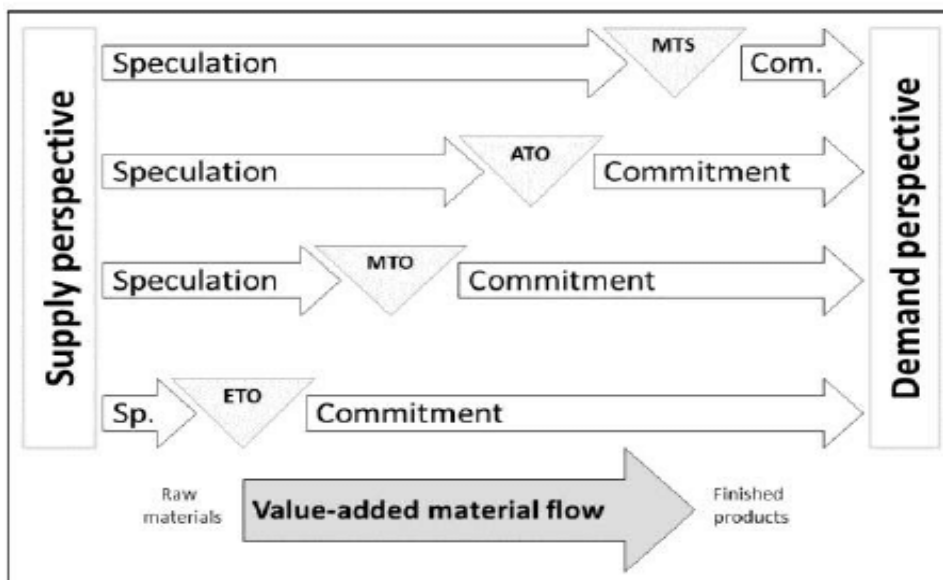


Figure 1 Customer order decoupling point in different manufacturing processes (Powell, Strandhagen, Tommelein, Ballard, & Rossi, 2014)

The process of an Engineer-to-Order manufacturing process may vary depending on the customer-specific product and the industry in which the company operates. However, the following are six steps or subassemblies that have been taken forward by (Little et al., 2000).

The first step is to configure the product and agree on specifications with the customer to minimize any errors or misunderstandings. The product configuration is the central step as it defines the product's parts. Any misunderstandings between the customer and manufacturer in this stage will lead to rework in the upcoming steps like designing and manufacturing the product. From the product configuration, the company wants to understand the functionality, performance, and starting point of the design from the customer. (Little et al., 2000).

When the customers' needs for the product are understood and agreed upon the next step is to make a judgment about the work that needs to be done to make sure it is possible to deliver the product to customers on time. This is done by a master production system.

The third steps are the design step. Where the team can start to develop a conceptual design for the product. Depending on the product the design stage can be more time-consuming than the manufacturing of the product. The design stage must be controlled since it is no easy step in the process and depending on the product it may need to be split up into different categories like mechanical-, electrical, and civil design. To not always have to design from scratch the product and all its necessary parts it is possible to take from previous models or products that have similar features and, in that way, also get down the hours spent on design. (Little et al., 2000) (erp-information, 2023).

The fourth step in an Engineer-to-Order process is project requirement planning. When there are only a limited number of recourses like there are in an ETO manufacturing process there is a need for a set deadline for every customer order. Every order a company accepts must take in mind the required workload and the forecasted need of all teams and steps for the entire process. There is a big chance the project will become late, or teams need to work extra time to get it across the finish line.

After project requirements planning is done, the company must develop the necessary manufacturing and supply chain processes that are needed to produce the product. There is going to be a need to source the material, components, and special equipment needed to produce it, as well as a schedule for manufacturing of parts and the final assembly is needed to the manufacturing floor. This schedule is needed to make sure there won't occur any delays because they are hard in this process to recover from.

The final step is the assembly or production. The schedule for the final assembly stage is important to have since the assembly in the Engineer-to-Order process is most vulnerable to any delays. And delays in this stage of the process often lead to a missed deadline which in turn means extra costs for the company. Reasons, why delays may occur in this stage, are due to missing parts or the production of a few needed sub-assemblies isn't ready for a week. However, if everything is in place then the product can be produced according to the schedules and delivered on time. (Little et al., 2000).

2.3 Process of Configure-to-Order

As with the manufacturing process for Engineer-to-Order the Configure-to-Order manufacturing process may vary depending on the product that is being configured and in which industry the company operates.

Oracle has taken forward a generic approach for how a supply chain of a Configure-to-Order company completes customer orders. Oracle has split the process into six levels, order management, order promising, supply orchestration, product information management, supply planning, and inventory management.

The process starts with order management where the sales team gets a lead on a possible customer. The sales team tries to sell the solutions/ products the company makes by giving the customer access to their configuration model. Then it jumps to the third level, where the customer chooses or builds the product from the configuration model see Figure 2. The model is where the company's solutions or product lines are, from here the customer chooses the product. When the customer chooses the product variations there are a few main components that are required for the product to work that is standard and will always be included in the product. There is also the option to choose a few more variants or extra components to the product that it doesn't require to run but could give extra performance. All these options have already been engineered and defined to work with the product. If there are other components that the customer would like to have, that have not yet been configured we move into the fourth stage which is product information management where a new product can be designed and created (Casey, 2011).

When the product is configured and agreed upon by both customer and manufacturer, we go back to the first step to agree on the order. Then moving into the second step which is schedule. In which the time frame to produce the product is defined, and a schedule is made to make sure that the product moves forward according to plan. When the time frame for the product is set. The supply request is made for the materials and custom components that are needed. Simultaneously as the supply request is made in the fifth step, they make the work order for the product that is then handed over to the factory which produces the product when the supply request is confirmed. Once the supply order has been confirmed and the supply's been delivered to the factory, we move onto the last

step which is inventory management which is where the product is manufactured and assembled to be ready to be shipped to the customer. (Casey, 2011)

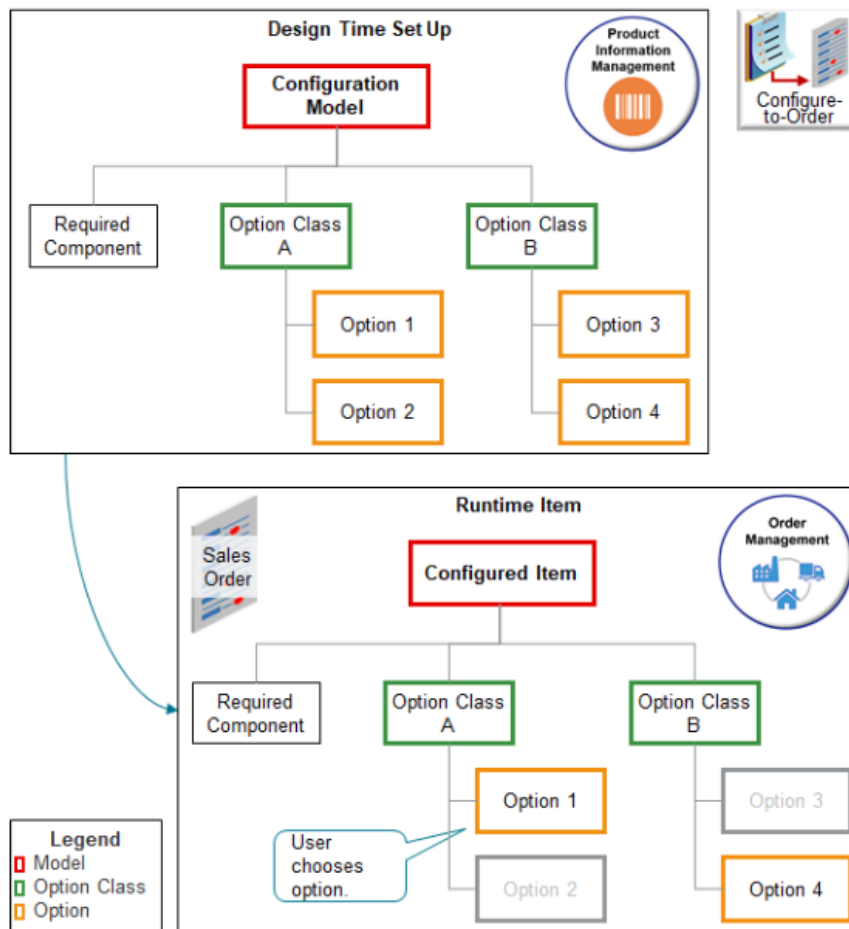


Figure 2 Configuration model from (Casey, 2011)

2.3.1 What differentiates ETO from CTO?

Configure-to-Order and Engineer-to-Order are both manufacturing processes in which there is a degree of customization of products, but between the two manufacturing processes, there are a few distinct differences in this subchapter the main difference from the current literature is taken forward.

Complexity and product design are the first differences between the processes that are found. Products made from the Engineer-to-Order process is more complex and require a higher level of customization since they mostly are made from scratch to meet the exact specification that the customer gives. Products made from CTO processes however are built from standardized pre-engineered and pre-defined components and variations like size,

colour, and special materials. Where no extra engineering needs to be done to get the product manufactured and delivered. (Deskera Content Team, u.d.) (EASA, 2021)

Costs are the next difference between the two models since the ETO process is more complex and needs a higher level of customization and sometimes specialized manufacturing processes tend to be more expensive than the CTO process. Product made from the CTO process tends to be cheaper since there is less work due to the standardized premade product lines and variations. In the ETO process, there is more design work that is needed, where a lot of time is spent which in turn leads to the next difference which is lead time. Due to more engineering, scheduling, and ordering of components and material in Engineer-to-Order that drags out the time frame for the product and makes the products made from ETO have a longer lead time. (GREALOU, 2021) (Deskera Content Team, u.d.)

2.4 Market trends leading toward CTO

(Seiler, Greve, & Krause, 2019) said that with more companies using a modular product architecture the use of an Engineer-to-Order based manufacturing process don't meet all customer demands as efficiently and effectively as possible. This could better be done by combining the use of Configure-to-Order with modular product manufacturing. This chapter will take forward four trends that show that the market wants products and solution that is made from modular product architecture and Configure-to-Order based manufacturing process.

2.4.1 Industry 4.0

Industry 4.0 isn't a new and upcoming trend more as it is a current trend that companies work with a lot with trying to integrate into their manufacturing process. In ways like integrating more advanced manufacturing processes, like automation using artificial intelligence and industrial Internet of things (IIOT) with Industry 4.0 companies could take a set of measurements in the manufacturing phase, from different production lines. By doing so, if needed they can adjust the product line in real time. And change settings if needed before the product line is completed, every part has defects that could have been changed sooner if the information were given. By integrating artificial intelligence into the product line there are fewer aspects left to chance. (Brighton Science, 2021) (Essentra Components, 2023)

2.4.2 Customer experience

SuperOffice conducted a survey where they asked almost 2000 business professionals from different markets to share their targets for the upcoming 5 years. Customer experience was at 45.9% and beat both products at 33.5% and pricing at 20.5%. In the survey they found out that having a good customer experience tends to have the customer spending more money and they might come back, they also found that customers in today's market may spend more and pay a premium for a product if they have been well met and have easy to use interfaces for them to choose parts and build products with their own chosen parts. (Stattin, 2023)

To develop a good customer experience there needs to be a lot of time and money invested to do so, as a company they invest to have a long-standing relationship with the customer and want to give them a personalized experience. To create the best customer experience a company might invest in omnichannel's which are channels the company has to communicate with customers and since some customers might be more engaging than others it is important to keep the communication between all channels like live chat or forms from the webpage or social media. Another great way to give the best customer experience is to respond fast if questions or errors appear. If customers have purchased a product and it malfunctioned the only thing, they care about is for the manufacturer to help them fix the product so it's back to working as intended. (Stattin, 2023)

2.4.3 Sustainability

A more talked about trend that gained a lot of traction the recent years is sustainability. Companies strive to make more sustainable products that have been produced by sustainable materials. There has been a big change in the market where customers rather pay a premium for products that are and have been produced with sustainable materials.

For the production process to become more sustainable, companies will have to gather data to better streamline manufacturing processes. To get towards a more sustainable workflow in their factories more unarmful materials are going to need to be used, and there is going to be a change to do more with less waste and recycle the waste into other processes for other products or parts where possible. (Brighton Science, 2021)

2.4.4 Mass customization

Mass customization in today's market is all about delivering personalized products to the customer. It can be done two different ways either by making each product specific to the customer or for the customer to configure their product from the company's predefined modules and variations. Mass customization in companies can increase cash flow, and give a competitive advantage compared to competitors. (Gandhi, Magar, & Roberts, 2013)

According to KPMG there will become a change in what products companies are delivering instead of how they are delivering them, KPMG says that instead of upgrading and making more power or storage to a product more options or variants of said product will be developed instead. There will be a change towards creating more customer-centred products that prepare help customers to meet the need of tomorrow. (KPMG, 2023)

2.5 Modularization

Modularization and Configure-to-Order have similar features, companies can integrate modularization when wanting to split a product into a set of modules that they offer. When integrating modularization to a company the goal is to be able to have a solution for a customer that can be built together using modules that the customer can configure from their need. A benefit for companies that are using this approach in their way of working is that it lowers the time spent in design phases since all new ideas and modules are developed to fit within the product line that already exists, there is no need to develop a whole new product.

To better get an understanding of modularization and integrated modular systems there are a few terms that the team at modular management has put in a list and described, the most important will be explained below. (Martin, All you need to know about modularization, 2021)

- Module, module interface, and modular system
- Modular product architecture
- Configuration
- Product configurator

- Cost of Complex

A module is a part of a modular system, in a module there are specific and defined interfaces for what can be done, and each module is supported by the company's strategies. Each module also has a module interface, the interface's job is to interact or connect with its surroundings. A module interface can have two different main functions, either to connect with other modules and share information from one module to another or to be more scientific and show the placement of a missing or upcoming module. The modular system is then built up of multiple modules that can be configured according to the customer's needs. The systems can be ordered or ranked and shared since the sub-modules can be accessed by multiple modular product architectures. (Martin, All you need to know about modularization, 2021)

For building products within a modular system there must exist a structure or process for how the products will be manufactured this is done from a modular product architecture. An example that was given from the literature was the use of phones and computers, both can be made by one company, but they have different ways of being manufactured therefore they have different modular product architectures. (Martin, All you need to know about modularization, 2021)

Configuration within modularization is combining modules from a series of configuration rules that are set within the modular product architecture. Configuration rules are a set of rules that decides what modules can be combined with what is within a modular product architecture. It gives the manufacturers or companies a solution to build from the specific needs the customer asked for. (Martin, All you need to know about modularization, 2021)

A product configurator is a software tool that gives the configuration rules. A product configurator can be made for the customers in the form of a sales configurator but is also used internally within the company for several different uses. Examples of uses are to calculate (BOMs) bills of materials that are needed to produce the product it can be used in engineering or to compile and generate drawings for new customer-configured products.

Cost of complexity is the process used to describe expenses companies get from releasing new products or new variants of a product to the market while simultaneously keeping track of all the different products that are being produced. If a company has a lot of

products and product variations that cause a higher cost of complexity where business with fewer products and more product variants that are similar to one another would have a lower cost of complexity. It's a way for companies to get a view of their economy of scale, scale however, in modularization it's on the module level instead of per product. (Martin, All you need to know about modularization, 2021)

2.6 Product configurator

The definition of a product configurator is, Gartner has defined as software whose main task is to support the product development task like pricing, modelling products, or testing. It is usually made from a few components an engine that does the calculations and a user interface. (Gartner, u.d.)

(Haug, Hvam, & Mortenses, 2012) defined a product configurator as a type of expert software-based system, with a focus on creating specifications for products. They said that product configurators have helped companies reduce lead times and resulted in fewer errors and shortened new employees' learning curve.

2.6.1 Benefits of implementing product configurators

Autodesk has made up a list of benefits gained from implementing product configurators to business-to-business relationships. A few of the listed benefits are, reduced lead times, increased efficiency, elimination of rework, and an increase in market shares. (Autodesk, 2017)

To be able to get reduced lead times by using configurators the companies need to implement them so they can help by automation the quote-to-product process, which means sales and customer service can focus on other assignments and help customers in more needing matters. When all information for how to produce a quote is gained upfront, there is no need for anyone to track down missing information from sales that was missing from the order, the configurator can automate all from sales and production drawings, make (BOMs), and scheduling so the product order faster gets to manufacturing which in turn reduces lead time. (Autodesk, 2017)

Same for increased efficiency the configurators can automate the quote to production which in turn enables engineers and sales to focus on designing and developing new

products and sales can spend more time on the customer and give them a good customer experience instead of making paperwork. The customer service teams may focus on more, hard-solved problems when they occur, and the configurators can make accurate quotations that in turn leads to fewer queries from customer. (Autodesk, 2017)

With complex products, there's a need for more complex configurators which in turn makes more complex pricing. This process is made simpler with configurators that have pre-defined rules on how to move forward and can from there create precise pricing, and the chance of human errors is therefore greatly decreased. With this, there can be made a lot of cost saving, as most error's often gets discovered too late, usually when the products reach manufacturing and the rework required to fix the errors are usually expensive. (Autodesk, 2017)

Lastly, the biggest listed benefit of using product configurators is the revenue increase. Since the configurator can give more throughput without any extra personnel and also help get more business and market share, this is done by making it easier for the sales teams to do business with original equipment manufacturers(OEMs) which tends to increase the market share. (Autodesk, 2017)

Autodesk found from their study that the use and implementations of one or more product configurators decrease lead time by 40-80% (Autodesk, 2017)

2.7 Product Configuration

Pulkinen found out in his study that configuring products today is a way to define a product that is made for the assemble-to-order manufacturing process, which could also be done for Configure-to-Order since the difference between the two processes are that Configure-to-Order doesn't have any inventory ready for manufacturing. Pulkinen later mentions that today configuring also is known in the industry as providing customers with different variations or options for their products. That configuration is a way of mass customization, where the customer could choose from their specific need what they want. (Pulkinen, Product Configuration in Projecting Company: The Meeting of Configurable Product Families and Sales-Delivery Process, 2007)

According to Martin from Modular Management product configuration is the process of selecting parts for a product in a defined way, so the product may be manufactured and delivered according to the specific customer order. A product configuration may either be done by a software solution or by a member of a sales team that does the configuration manually in the software. Depending on the industry product configuration may look different, some might only use product configuration internally to create bills of materials (BOMs) or others might use it in sales to support the sales teams. (Martin, Modular Management, 2021)

2.7.1 Sales configurator

According to Sääksävuori and Immonen, the word configurator can have different meanings depending on whom might be speaking. Software suppliers and its consultant can have different meanings of the word to those in operation and have big differences and are not alike. Different meanings usually are sales configuration and product structure configurator. (Sääksvuori & Immonen, 2002)

A sales configurator manages the properties of a product that affects its sales and the rules regarding said properties. Those rules then define what combination of sales properties are allowed and forbid the rest of the combinations, and the configurator automatically prevents the use of them. (Sääksvuori & Immonen, 2002) says that sales configurators can also deal with other types of information needed in sales, it can provide information like possible market areas or generate specific price lists for customers depending on its properties. (Sääksvuori & Immonen, 2002)

Sales configurators are usually integrated with product-lifecycle management (PLM) software, however not all PLM systems support the use of configuring the product structure. If it does, configurators can use sales items that are managed in PLM to create a product structure in PLM with the sales items and the chosen variations that were selected and defined in the sales configuration. (Sääksvuori & Immonen, 2002)

2.7.2 Product structure configurator

A product structure configurator or a technical configurator may be a part of a PLM system or be its own software that is connected to the PLM system but not built into it. For a

product structure configurator to run, it is dependent on the output from the sales configuration as input to be able to function and to the configuration. It then builds up a product structure that matches the sales configuration and gives it as the output. The issues with product structure configurations are that it's very easy to quickly get thousands of different variations of the wanted product. (Sääksvuori & Immonen, 2002)

2.7.3 Configuration rules

Definition for the rules of the configurator differ from the origin of the configurator but the rules are typically either sequential, relational, or constraint-based configurators. Sequential configurators are among the most used ones and work by asking questions in a predetermined way. A sequential configurator is built up by it-then questions which leads to a combination that has been predefined. A sequential configurator however often builds upon one question and splits that way, an example that Martin from modular management used was if you want to order a new car and perhaps a sportscar, and the first question in the sequence where about trunk size which depending on the answer could lead towards a branch where there are no sportscars. To find a sportscar there is now a need to reset the configurator and start over with another answer. This configuration is not fit for more complex products and is hard to maintain. (Martin, Modular Management, 2021).

A relational configurator on the other hand is based on charts that show what connects with what. It's created by building multiple charts with compatible and incompatible variations of the product. It works by choosing one component on the x-axis and one on the y-axis and in the intersection between, information regarding the component's compatibility is shown. For every new component that gets added to the chart it gets harder to maintain and harder to use the more components get added. And if two components' compatibility changes that lead to a whole redo of the chart and every component since you can't change them once they have been integrated, and the information if the components are compatible or not doesn't give any more value to the operator to why, so each relational configurator gives information if it's technical compatibility between the components, that means they fit technically, or if they are application compatible meaning they fit for application or in use cases. And lastly, they are commercially compatible meaning they restrict the compatibility based on commercial reasons and it could be a danger to others. (Martin, Modular Management, 2021).

The last rule is constraint-based product configurator. It's the most complex and hard to use and understand but if used for a longer period multiple benefits can be gained from it. It is the absolute most powerful and cost-effective for more complex products and multiple variations. With a constraint-type product configurator, the user needs to select the needed attributes of either a real or digital component, it then secures the data and that the selected components are consistent throughout the whole product. This type of configurator doesn't only establish if components are compatible or not it also gives an evaluation as to why they are compatible or not. (Martin, Modular Management, 2021).

3 Research methods

In this chapter of the thesis, the practical part of how it's been made will be explained. The methods used to achieve the results will be presented as to why the choice to do so is according to a qualitative method.

For the interviews, the questions were made to branch into different sides of the organization and weren't that specific but a bit broader, to get an understanding of how they viewed the different questions and what their standpoint on them was. This also gave an overview of their information flow and understanding of these topics between different teams. The list of persons that were called for interviews, was made with the help of my supervisor. The interviews were held via Microsoft Teams and took approximately 30 minutes. There were 10 interviews where 9 of them showed up, which resulted in a participation rate of 90%.

3.1 Quantitative vs qualitative methods

Every research problem can be viewed from two different views either from a quantitative or a qualitative standpoint. How these methods then are used is depending on the researcher and what he wishes to get out of the research. Both methods will shortly be explained below. (Olsson & Sörensen, 2011).

Quantitative research is when the researcher is objective towards to subject and has a more outside standpoint, the quantitative method can often be seen as short and doesn't involve any direct communication between the researcher the interview staff, or the subjects. The research questions have been structured and formulated well in advance and the whole research is then built upon these problems. The research relation between theory and research itself is built upon testing of hypothesis so you want to achieve a conformation on the hypothesis, which can be done once the data is gathered from the subjects. The results gained from research that has used a quantitative method are based on a quite large amount of interview staff or subjects, and the gained data then also has a limited number of variables on how this data can be used to confirm the hypotheses that were made earlier. (Olsson & Sörensen, 2011).

Research made from a qualitative method can then be seen as the opposite of research made using a quantitative method. In a qualitative the researcher is then more subjective towards the topic and has a standpoint where he can be seen from inside. Which in turn means he or she that does the research interact with the interview staff and usually holds the interviews themselves. In this kind of method, there is a big importance that the interviewer then can take the information gained from said interviews and interpret and describe it correctly. If the quantitative method could be seen as short this method is usually then longer and more complex and builds upon a long-lasting contact between the interview staff. This method of researching is more flexible and the problems, depending on the topic and timeframe can gradually become deeper and deeper since new information can occur at a later stage in the research which in turn leads to the researcher going back and perhaps taking a deeper look into that side as well since it could affect the results otherwise in a later stage. The results in this type of research often build upon a smaller amount of interview staff than those are used in quantitative methods, but there are a larger number of ifs and variables in this type of research since the data collected needs to be interpreted correctly by the interviewer for the results to be correct. There is also big importance on the questions asked, so the interview staff understands the questions and can answer correctly. The results gained from using a qualitative method are more specific and describe the state of the subject more than measuring it which it does with a quantitative method. (Olsson & Sörensen, 2011).

However, when performing research today, a method of combing both quantitative and qualitative methods is more used. But whatever way is used or if it's a combination of methods the researcher has used to conclude, the goal of the research is to find the relation between the theory and reality and be able to put it forward. (Olsson & Sörensen, 2011).

3.2 Qualitative Method

In this chapter, I will present why I chose to do this thesis according to a qualitative method, my framing of questioning, and my prior knowledge and understanding of the topic. I will also give an insight into how the interview questions were structured.

This research is done with a qualitative method, to be able to understand the big picture. By understanding their standpoint on the topic and getting an idea of they view these

issues. Since I don't have much experience or prior knowledge regarding this topic, apart from knowing the different manufacturing processes existed and roughly what they were I first made a deep dive to understand the differences between Engineer-to-Order and Configure-to-Order. Because I did this, it was easier for me to understand the interviewee's understanding of my questions.

The nature of this research problem was quite broad, so for my framing of questioning, I therefore, tried to formulate it in a broader way to get as much information out of the interviewees, which might lead to the questions being more difficult to answer. The questions were structured to have three main topics, those were manufacturing process/business models, product configurations, and information flow between phases.

The focus of these questions was to gather information regarding the configurators Wärtsilä Energy uses to configure solutions from the early sales phase to the delivery phase. How they use them, in what stages of a new sales lead, and once they have the customer how they configure a product from there and onwards to the delivery phase, and what configurators they use along the way.

4 Results

In this chapter, the results gained from the interviews are presented. First providing some background on why the question was asked and then a summary of the answers from the interview is presented below the question.

4.1.1 Questions regarding Manufacturing process / Business model

[Classified]

4.1.2 Product Configurators

[Classified]

4.1.3 Information flow between phases

[Classified]

4.2 Flowchart of configurators used from sales phase to delivery phase

[Classified]

5 Discussion

From these results gained from the interviews, it's possible to get an overview of how they configure a powerplant in sales and delivery today. Based on the theoretical analysis and the results, in the upcoming sub-chapters, I will discuss possible challenges and opportunities Wärtsilä Energy might meet when trying to implement a workflow that is more based around Configure-to-Order.

5.1.1 Challenges

[Classified]

5.1.2 Opportunities

[Classified]

6 Conclusion

The work for this thesis has now come to an end, I will look back and reflect a bit on the work that has been made for this thesis if the results matched the wanted results that were set at the start of this thesis. The wanted results set at the start of the work was to perform a theoretical study on business models with a focus on what differentiates Engineer-to-Order from Configure-to-Order. The other wanted result was to see how Wärtsilä Energy configures powerplant solutions today and be able to evaluate how they can adapt and integrate a workflow that is more based around Configure-to-Order.

6.1 Method

The method I chose for the research was qualitative because I wanted to talk with the interviewees to understand and get as much information as possible, I thought it would be more helpful to talk with interviewees to better understand how everything works together. In hindsight, I think it also would have been possible to conduct this research with a quantitative method and make a survey with similar questions that I would have sent out to a lot more persons than I have now interviewed. I could then also perhaps have gathered a list of the main configurators they use in each phase and made a matrix where they easily could have selected which configurators are dependent on which and for them to formulate freely and write answers to the other questions. I now performed my interviews over Microsoft Teams which gave me the advantage to record the meeting so I could go back and listen to what exactly was discussed. But I also think I would have been able to get a better understanding if I would have conducted the interviews face to face and perhaps had them show me how the configurators work and explain how the whole supply chain works. Looking back, however, I am pleased with my choice of method and the interviews I think I was able to get a picture of how they work today and that I was able to identify a few challenges and opportunities for them.

6.2 Results

[Classified]

6.3 Own Reflections

[Classified]

6.4 Continued Research

There are possibilities for continued research on this topic since the results for this thesis was more suggestion and evaluation of what challenges and opportunities the company might meet when trying to implement a more Configure-to-Order based workflow. Continued research there could be assessed on how to build up the modules and where these modules are needed to be able to standardize the processes and products to be able to transform a company from an Engineer-to-Order manufacturing process to Configure-to-Order one.

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8 Appendix

Interview Questions

Manufacturing process/ Business models

- 1) In your opinion how big percentage of a project would you consider is configure-to-order (from the last four projects)?

Product configurators

- 2) What is your understanding of a product configurator?
- 3) How big percentage of your product portfolio has configurable elements?
 - a. Do these configurable elements have configuration rules?
 - b. Where can you find documented configuration rules for the products?
- 4) In sales/ delivery phase how many configurators do you use? (What are they)
 - a. Purpose of the configurator?
 - b. Are there configurators that are dependent on another configurator?
 - c. If yes, what are the dependencies to be able to run a configurator?
- 5) According to these configurators you mentioned, rank them from most important to least important.
- 6) In what order are the configurators usually run for powerplant project?

Information Flow between phases

- 1) How much of the information gathered in the sales phase is still valid once the solution is in delivery phase?
 - a) Is the rest of the information then missing or incorrect, what is that because of?