YRKESHÖGSKOLAN NOVIA

# Evaluation of Guaranteed Asset Performance Agreements

Case: Wärtsilä Lifecycle Agreements & Agreement Proposal Management

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**DEGREE THESIS**


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**Abstract**

This thesis has been made for Wärtsilä Energy Business, Agreements Lifecycle & Agreements Proposal Management. The purpose of the thesis is to investigate how well Wärtsilä performs on guaranteed key performance indicators and what differences and challenges there are in the investigated Guaranteed Asset Performance Agreements compared to the concept.

The theory covers general information about long-term service contracts and important factors that are valuable for equipment owners as well as information about the Guaranteed Asset Performance Agreement, key performance indicators, sales procedure, and Agreement delivery.

A so-called mixed-method approach was used to collect both quantitative and qualitative data. Through interviews, discussions, and data gathering through forms with internal stakeholders could qualitative and quantitative data be gathered and stored through notes, recordings, and Excel files. Other relevant quantitative data could be collected through the company's internal databases. The process of structuring and analyzing the collected data are presented through text and figures.

The result of the thesis consists of individual result for each agreement investigated where challenges and actual performance data is presented and discussed. Further, a final conclusion for the evaluated Guaranteed Asset Performance agreements is presented by discussing similarities and findings from the collected information.



Language: English
Key Words: Service agreements, guarantees, performance

**EXAMENSARBETE**


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**Abstrakt**

Det här examensarbetet har gjorts åt Wärtsilä Energy Business, Agreements Lifecycle & Agreements Proposal Management. Syftet med examensarbetet är att undersöka hur Wärtsilä har presterat på garanterade nyckeltal samt vilka skillnader och utmaningar det finns i deras Guaranteed Asset Performance avtal i verkligheten med jämförelse till konceptet.

Teoring täcker allmän information om långtids service avtal och viktiga faktorer som produkters ägare värdesätter. Dessutom presenteras information om Guaranteed Asset Performance avtalet, nyckeltalen, försäljnings proceduren och service avtals leverering.

Ett så kallat mixed tillvägagångssätt användes för data insamling av så väl kvantitativ och kvalitativ data. Genom intervjuer, diskussioner och data insamling med hjälp av formulär från interna intressenter kunde kvalitativ och kvantitativ data samlas in och förvaras genom anteckningar, inspelningar och Excel filer. Annan relevant kvantitativ data samlades in från företagets databaser. Processen av att strukturera och analysera den insamlade datan presenteras genom text och diagram.

Examensarbetets resultat består av individuella resultat för varje undersökt avtal, där utmaningar och faktiska prestandan presenteras och diskuteras. Till slut presenteras en slutsats för de utvärderade Guaranteed Asset Performance avtalen där likheter och fynd från den insamlade datan diskuteras.



Språk: Engelska
Nyckelord: Service avtal, garantier, prestation

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## List of Abbreviations

GAP = Guaranteed asset performance

O&M = Operation and maintenance

LDs = Liquidated damages

AA = Annual availability

PA = Power availability

CRM = Customer relationship management

OEM = Original equipment manufacturer

LCOE = Levelized cost of energy

KPI = Key Performance Indicator

# 1 Introduction

This chapter will present this thesis background which will be followed by the problem definition and purpose of the study. After that, the delimitations and confidentiality of the paper are discussed. Finally, the disposition is presented to give the reader a better understanding of the composition of this paper.

## 1.1 Background

Today the Energy market is going through a major change where the power generation with fossil fuels such as coal, diesel, and heavy fuel oil is being phased out by renewable solutions such as wind turbines and solar panels because of the declining cost and environmental benefit for the climate. This earlier method of producing electricity by fossil fuels has been a very stable way to produce electricity. The source of power is bunkered at the power generation site and the generating sets have been running continuously on the same load, this means that the electricity grid has also been very stable.

Renewable solutions cannot give the same stability because operators cannot affect them in the same way as machines that can be turned on and off whenever they want. Wind turbines will not generate any electricity on the days when there are no wind and solar panels will not generate any on nights and cloudy days. This creates a risk on the grid that there can be days when the electricity demand is much higher than the supply. The solutions are then to either have some energy storage system, for example, pumped water or batteries. Another alternative would be to have gas engine balancing power plants that can quickly start-up and provide stability to the grid.

The advantage of a gas engine balancing power plant is that it can start and stop very quickly, it can run for shorter periods to stabilize the grid compared to gas turbines which take much longer to start and stop. The climate has now proven to be more inconsistent. People are in more need of electricity to heat their homes and it would be a disaster to not have available and reliable backup power generation systems. Wärtsilä gas reciprocating engines have a proven track record of high reliability and availability that can help to supply electricity to the grid when the renewables are not enough.

## 1.2 Problem Area

A Guaranteed asset performance agreement is a rather recent form of service agreement that was introduced a couple of years ago. With this agreement, Wärtsilä guarantees the availability and reliability of the power plant by taking on the maintenance while the customer takes care of the operation. In this agreement, it requires to have a site advisor from Wärtsilä who gives advisory service and follows up and reports the availability, reliability as well as other contractual guarantees. This is a new concept and only a couple of agreements have been sold, there can be risks that could not be foreseen in the concept and sales stage which is showing now.

Wärtsilä has previously given availability and reliability guarantees in their O&M agreements, which is an agreement where they take care of both the operation and maintenance. These are of course easy for Wärtsilä to follow up and evaluate as it is the operator of the plant. For GAP agreements there has not been any study on how well Wärtsilä performs on these guarantees when it is not the operator and only gives advisory service instead of actual operation. The performance of this new agreement type has until now generated limited or no studies and follow-up data for the management to evaluate. Thus, there is a clear need for this research.

## 1.3 Purpose

The purpose of this thesis is to investigate how well Wärtsilä performs on the guarantees in a GAP agreement and what kind of challenges are faced and to find out what differences there are between the concept, contract, and actual delivery of the agreement. If the actual agreement deviates from the contract and concept, it will be investigated as to why that is the case and if there are similarities on deviations on multiple installations. Based on that, recommendations will be made and informed to the stakeholders.

## 1.4 Delimitation

Wärtsilä Energy Business lifecycle agreements & agreement proposal management ordered this thesis to get a better understanding of how well the availability and reliability guarantees are performed compared to what has been estimated during the sales stage. Therefore, a complete financial evaluation of GAP agreements will not be made, only how the guaranteed availability and reliability affect the agreement between the customer and Wärtsilä.

## 1.5 Confidentiality

This thesis will include confidential information that cannot be shared outside of Wärtsilä. No real names will be shown, and all enclosures will be classified and not included in the official version.

## 1.6 Disposition

The first chapter has introduced the background, problem area, and purpose of the thesis. Furthermore, confidentiality and delimitations were also briefly discussed. After that, there will be information about Wärtsilä in brief, general information about the company, and a little bit on Energy Services and service agreements. In the third chapter, the theoretical framework for the thesis is presented. Information about the GAP agreement and the guarantees such as availability and reliability will be discussed. Basic information about Wärtsiläs sales procedure and contract policy are brought up and general information about service contracts. The following chapter will present the thesis method, research, and solution approach which was used to get the result. The fifth chapter will present the final result. The main findings from the evaluation will be analyzed and discussed. In the final chapter, the thesis theory, methods and results will be critically discussed and overviewed. Proposals will be presented for further research and a final conclusion will be made.

# 2 Wärtsilä in Brief

Wärtsilä was founded in 1834 in Tohmajärvi Finland when the governor of Karelia approved the construction of a sawmill. Since that the company has changed market many times, from sawmill to shipyard and paper machine manufacturer to name a few. Today Wärtsilä is a global leader in the Marine and Energy market where they are providing a broad range of products and services. It is 4 stroke multifuel reciprocating engines are leading the change to the usage of renewable fuels such as hydrogen and ammonia to reduce carbon dioxide emissions for both the marine and energy market. This together with a large global service network helps Wärtsilä to become their customers' most valuable partner when tackling the world's problems, we are facing right now. (Wärtsilä, 2021a)

## 2.1 Company in General

The company has four different segments, Marine Power, Marine Systems, Voyage, and Energy. Marine Power offers engines, propulsion systems, hybrid technology, and integrated powertrain systems to customers together with performance-based agreements and lifecycle solutions. Marine Systems consists of Electrical Systems, Exhaust Treatment, Gas Solutions, and Shaft Line Solutions with full lifecycle ownership. Voyage is on a mission to create a smart digital infrastructure for ships that will optimize the energy usage for the vessel by using complex algorithms, software, and data. Wärtsilä Energy helps customers in the transition to a 100% renewable energy future with their highly efficient gas engines, which can run on a hydrogen blend together with energy storage systems and optimization technology. By looking at net sales from January to September 2021, Marine Power holds the biggest portion, which is 40 %, and Energy is a close second with 37 %. Of the total net sales, overall business areas services stand for 55 %. (Wärtsilä, 2021b) (Wärtsilä, 2021c)

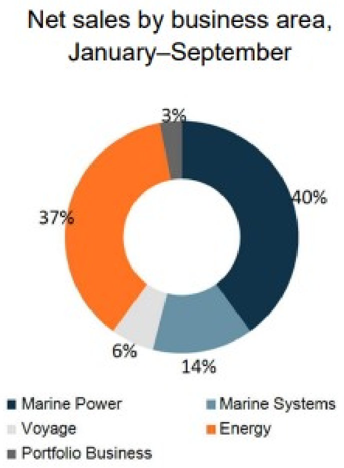


Figure 1. Wärtsilä net sales by business area.

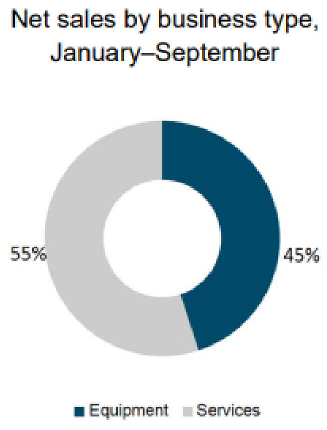


Figure 2. Wärtsilä net sales by business type.

## 2.2 Energy Services

Wärtsilä Energy Services offers many different lifecycle solutions to their customers. For example, full-service agreements with spare parts and labor included maintaining the power plant, and conversion of existing diesel engines to gas operating engines. Wärtsilä also offers power plants electrical & automation system upgrades when their current E&A system becomes obsolete. On top of that, the customers can also choose to have service from the expertise centers together with a service agreement that monitors their power plant and give expert insight, guidance, and support for the operation and maintenance.

## 2.3 Energy Agreements

Energy agreement is a lifecycle solution within Energy Services that helps the customer with the maintenance and operation of the power plant. Depending on what type of agreement the customer wants there are a couple of different solutions. For example, there are Optimized Maintenance agreements where Wärtsilä supplies spare parts and regular maintenance of the power plant and optionally the customer can also choose to have the expertise center services included. Then there are more complex agreements such as an O&M agreement where Wärtsilä handles all the maintenance and operation of the power plant or GAP agreement where Wärtsilä ensures the reliability, performance, and availability of the power plant. For customers, it is in most cases very important to have high availability and reliability of the power plant to get the required output whenever they need it, as it can be crucial to their operation or business. For example, customers who operate a balancing power plant to ensure the balance between electricity production and consumption need to have high reliability and availability of their power plant to always be able to supply electricity when needed.

# 3 Theory

This chapter will build the theoretical framework of the thesis where there will be deeper information about industrial service agreements between original equipment manufacturers and operators of the equipment. A guaranteed asset performance agreement and its main guarantees, availability, and reliability of a power plant. Also, Agreement delivery will be discussed.

## 3.1 Service contracts in general

In the Industrial market, there has previously been that a customer buys machinery and takes responsibility for its complete lifecycle, only buying spare parts from the manufacturer or spare part supplier and performing the maintenance by themselves. Today it is more common that a customer is buying the machinery from a manufacturer but also the service of the equipment from the manufacturer or from a third party. This has to do with the ever-increasing complexity of machinery both on the mechanical side and on the automation side and that it is usually more cost-effective to outsource the maintenance than to train own personnel and buy expensive special tools that are needed to perform some maintenance procedures. Because of this, it is very important that equipment manufacturers can give a structured lifecycle solution that suits the customer's needs. According to (Van Horenbeek, Van Ostaeyen, & Pintelon, 2012) both service providers and buyers would like to have more transparency in the service agreements so that they are based on well-grounded data and decisions.

In the article Maintenance Service Contracts and Business Models: A Review the advantages for the service buyer can be described as following: (Van Horenbeek, Van Ostaeyen, & Pintelon, 2012)

- The organization does not require to only use its own personnel and resources for maintenance. Some skills can be difficult to develop and training for these skills may also be very expensive and are therefore instead hired via maintenance providers.

- Service suppliers have more technical expertise and experience related to both planned and unplanned maintenance.
- The service suppliers are usually up to date with the latest upgrades and maintenance technology which can make maintenance go smoother and drive down costs.
- Service suppliers have more flexibility to implement new technologies compared to buyers of the machinery.
- Service buyer does not have to buy expensive maintenance tools and training, therefore saving on investment costs.

The advantages for the OEM as a service supplier or other third-party service supplier are for example following: (Van Horenbeek, Van Ostaeyen, & Pintelon, 2012)

- Large continuous income when there is a long-term service agreement in place.
- It is harder to copy quality service compared to products and can therefore be a major factor for the customer when deciding on which company to go for.
- Easier to keep customers satisfied when the OEM can support with problems.

Other than that, it reduces the risk of breakdown and unplanned service when outsourcing to those with more experience and up-to-date knowledge about the latest technology. (Van Horenbeek, Van Ostaeyen, & Pintelon, 2012)

### 3.1.1 Traditional important factors in service agreements

Everything starts with understanding the customer’s requirement, for being able to communicate and coordinate everything that is necessary for a possible contract between both parties. This includes for example how the product characteristics can provide extra value to the end customer, how the operational requirements and environment will be where the customer plans to operate the equipment, what the customer’s capabilities and resources are to operate and maintain the equipment, infrastructure and where the plant is located. Pricing and scope between customer and service provider and cultural aspects are also to be carefully considered. (Kumar, Markeset, & Kumar, 2004)

For companies that use industrial products in their business, such as in manufacturing, mining, heavy logistics, or electricity and heat generation the product's availability, high efficiency, and supportability are key factors when choosing the equipment provider. (Kumar, Markeset, & Kumar, 2004)

How the customer plans to operate the equipment with load and running profile and the environment it is going to operate in are crucial factors for the OEM to know about when selling service agreements and the product as it impacts on the product's technical characteristics, such as output and maintenance intervals. Other than that, the location where the equipment is has an impact on the service the OEM can provide. If the equipment is located in a very remote area far away from the service provider, it will cost more to provide the same quality service compared to if the equipment would be close to a workshop from the service provider. Other constraints that will influence on a service agreement related to the location and environment are local legislations, regulations, political issues, and other aspects that must be discussed between both parties.

Many customers who buy equipment for their business have their own people that they could use in the operation but in some countries with not many resources available within the specific field for maintenance and operation of the equipment, it can be a challenge to not have a service agreement with a service provider. To train the personnel for more complex overhauls that may not occur very often can result in more expenses and time due to ineffective work compared to outsourcing the maintenance too, for example, the OEM. It is therefore necessary that the customer explains how they expect to have service provided to the OEM or other service provider when defining the scope of the agreement. (Kumar, Markeset, & Kumar, 2004)

When deciding on the price it is a benefit for the service provider to have an insight into the customer's budget as it helps to make the pricing and invoice model so that it suits both parties. Some fees can be fixed and include a couple of different services in the same package, for example, remote support from the OEM or equipment monitoring with condition reports. There can also be variable fees that vary depending on the operating profile of the equipment, this can be maintenance and service which is related to how much the equipment will be operated. Pricing methods that are usually used are regarded as mark-up prices and target prices. They are both cost-based. The service provider calculates cost and adds a margin on that cost to get the price to the customer. Prices can be used for an organization's marketing strategy, it can show potential customers and investors the added value of services a company can offer at a certain price. (Kumar, Markeset, & Kumar, 2004)

Another crucial factor that may influence a contract between two companies or organizations is the cultural aspect. Because of this, both sides can look at an issue in completely different ways and not have an understanding of each other. When delivering service, it is up to the service provider to improve its knowledge of the customer's culture and devote time and effort to the delivery process. For an organization to succeed internationally, it is required that they develop and practice negotiation and delivery skills across many cultures so that they do not lose deals related to the cultural ignorance and differences between the parties. (Gulbro & Herbig, 1999)

To have a smooth and effective delivery process of the service agreement it is very important to define and analyze in detail what is in the service supplier scope and what is in the customer scope. This is necessary for the OEM or other service providers, so they have a clear definition of what to be included in the services package. (Kumar, Markeset, & Kumar, 2004)

When negotiating and defining the scope of a service agreement it is mostly referring to the product and planned services. It is also important to have an agreement between each other on how it works with unplanned maintenance and who's to cover for those kinds of events. When there's still a warranty on the products it is clear who will cover for new parts but when the warranty is over there needs to be clear who will fix the unplanned maintenance. (Kumar, Markeset, & Kumar, 2004)

Then on to what is unplanned service. Product failures or breakdowns which are unpredictable and could not be foreseen. Unplanned maintenance can be minimized by monitoring the product parameters and when any of them are beginning to be out of their tolerance, it should be fixed as soon as possible to avoid any bigger problems. This leads to less downtime for the product which means it is reliability and availability are also better. For the service provider and service buyer, it is important to have a plan on how to take care of any unplanned failures or breakdowns. This will help to ensure that no conflicts occur related to unplanned maintenance, and it helps to create a long and healthy relationship between both parties. (Kumar, Markeset, & Kumar, 2004)

Planned service on the other hand is all procedures and maintenance that lead to performance improvements for the product and contributes to avoiding unplanned events. Other than that, it can also include product upgrades and modifications because of technology improvements. Usually planned maintenance is following the original equipment manufacturer’s service manual with intervals for when certain services must be performed. Other than that predictive maintenance based on monitoring of the equipment or product is also considered planned maintenance as it is not unpredictable. When the planned maintenance is as effective and smooth as possible it affects the availability positively, as it reduces the time the equipment is down, and the owner can operate its product more. (Kumar, Markeset, & Kumar, 2004)

### 3.1.2 Important factors in energy service agreements

Having efficient products that can extract as much energy as possible from the fuel has always been a very important factor for customers. Today it is even more important than ever before because people need reliable electricity and heat. At the same time emissions needs to decrease to stop global warming and get rid of particles and NOX emissions that are harmful to humans and other living species.

For many customers and financers, it is very important to have the OEM as the service provider because they are of course the ones that have the most knowledge about the product but also the ones that can support the customer with new inventions that can be implemented and create additional value. With performance guaranties from the OEM, lenders also feel extra security to lend out money to the customer because they know that the financial predictability is very accurate, and it is easier for them to evaluate and calculate the return on their investment. In some cultures, it is almost a requirement to have the OEM as the service provider because they are the most trustworthy and the ones who can give the most guarantees on the performance of the power plant and agreement.

To outsource the maintenance and sometimes also the operation to another company with more expertise within the field can be an important factor for some customers as they might want to focus mainly on their core business. For example, gold mining companies which often have their own power plants to power their operation often like to outsource both the maintenance and operation of the power plant so they can focus on their core business and not have to worry about training personnel to maintain and operate the power plant. Another factor is also that when they outsource the operation and maintenance to a service provider with a lot of knowledge the availability and reliability of the power plant are also usually higher. This can be crucial to their business because the mining may stop if the power plant cannot deliver power and the customer can lose a lot of revenue and margin if that happens. To customers who need a high availability and reliability of the power plant, it is also an important service factor to have the service provider workshop and field service engineers close by so they can help as soon as possible when there’s a requirement.

Regarding not having the expertise and knowledge required it is important for some customers to have the opportunity that the OEM starts the agreement with operation and maintenance in their scope and gradually train the customer’s personnel so that they eventually can take over the operation and minor maintenances from the OEM. This is very important as it means they can use local labor which gets the education by the OEM and the OEM are at last left with supplying spare parts, major overhauls, advisor services, and remote support.

### 3.1.3 Value for customer in Thermal Power Plants

In a thermal power plant, it is the fuel and lube oil that is the biggest operational cost to the customer. Fuel costs can be up to 80% of the operating cost and in the world today, the prices for oil and gas can jump up very quickly. It is, therefore, necessary to improve fuel efficiency to reduce operating costs and at the same time reduce the emissions per produced kilowatt.

There are many different ways to do this. It can be everything from changing one single component because of wear, or some new innovation that helps bring the efficiency, reliability, and availability up for the power plant. It can also be modernization of the operation and maintenance of the power plant like gathering data and optimizing the operation of the equipment. By performing major overhauls of the equipment, it usually increases the efficiency as old worn components are changed for new ones.

When looking at saving money for the equipment is necessary to look at the whole lifecycle and analyze it over its lifetime. Quick savings can lead to extra costs in the future so it is usually better to go for the option provided by the OEM or service provider even though it is usually a bit more expensive than what the customer would like. When it comes to operation and maintenance it reduces the chance of unplanned events and increases the reliability compared to an inexperienced operator who plans to perform everything by themselves.

By outsourcing the maintenance to a service provider or the OEM the Levelized cost of energy can be reduced which results in a better margin for the customer. At the same time, the customer does not have to worry about all the maintenance planning, training of personnel, tools, safety, etc because the service provider will take care of that. Another benefit of outsourcing the maintenance is that the service provider will give the customer a price on the services and that will help the customer to plan his budget.

## 3.2 GAP agreement

A guaranteed asset performance agreement is a service solution from Wärtsilä where the availability and reliability of customers' power plants are guaranteed based on site conditions, engine type, running hours per year, and how much the engine has previously been run. The customer manages the operation of the power plant while Wärtsilä takes care of the maintenance and its management. Meaning all the necessary spare parts for both engine and the auxiliaries which are to be maintained by Wärtsilä are provided by the service agreement as well as field service to perform the major overhauls. Unplanned maintenance is also covered up to a certain cap by the agreement. In case of larger breakdowns, only a recovery guarantee can cover. A recovery guarantee is like an insurance that is invoiced separately, and the price is based on the mechanical output of the engine and its cylinder bore.

As part of the GAP agreement, there will be an onsite support engineer or advisor from Wärtsilä who together with online expert insight services from the expertise center can ensure the safe operation of the power plant. An onsite engineer's most important tasks are the following: (Wärtsilä, 2018)

- Strive to give uninterrupted operations of the power plant.

- Support in unplanned maintenance and emergency repairs.
- Perform and help in minor scheduled maintenance activities such as spark plug replacement and filter replacements.
- Be part of daily checks and look after the plant so it is kept in good condition.
- Train the customer personnel in O&M of the power plant.
- Assist customers with keeping the power plant safe and that the health and safety qualifications are fulfilled.
- Be the main contact person between the power plant and Wärtsilä's technical expertise when troubleshooting unplanned maintenance.
- Make sure that the logbook is kept up to date with all daily checks, emergency activities, and repairs
- Establish so that the power plant reaches the guaranteed availability and reliability.
- Make certain that all the safety parts and exchange parts are at hand in the power plant.
- Assist in resolving warranty claims between customer and Wärtsilä.

For a customer to have a GAP agreement it requires that Wärtsilä has field service and workshops in the country to make sure that the performance guarantees are reached. In case there is no field service presence in the country, Wärtsilä will need to have mechanics and electricians at site. The power plant also needs to be connected to the expertise center to enable condition monitoring and remote operational support and guidance. (Wärtsilä, 2021d)

### 3.2.1 Guarantees fundamental

Other than investment cost of an engine power plant, the fuel and running costs are crucial factors when determining how well the power plant's economic success is. Therefore, availability is very important as it tells how much the operator can run the plant and from there, make revenue estimates. Reliability on the other hand, shows how well developed the product is and it is also very important when a power plant is needed to balance the grid. (Bredthauer, et al., 2008)

### 3.2.2 Annual availability

Annual availability is a measure of time that the engine or power plant is capable of running over an annual period due to planned and unplanned maintenance (see equation 1). If an engine has an average availability of 93% and a power plant contains 10 same engines with the same running profile, then the annual plant availability is also 93%. Therefore, it is independent of the required power capacity the power plant needs to produce and only dependent on the time. (Bredthauer, et al., 2008)

$$AA = \frac{period\ hours - unavailable\ hours}{period\ hours} \quad (1)$$

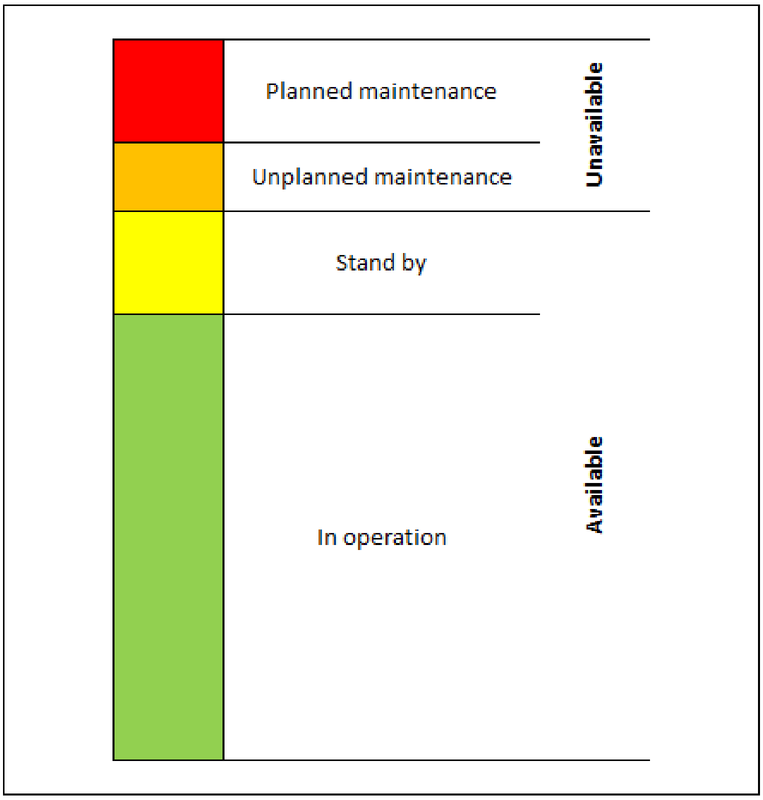


**Figure 3. Visualization of annual availability (Own figure)**

In reference to equation 1 and figure 3. The annual availability would be the period hours minus the planned and unplanned maintenance, divided by the annual period hours. When operating with standby engines and calculating the annual availability, it may occur times when many engines are down at the same time even though the plant has standby engines. For example, see figure 4. In this case, the plant consists of eight 10 MW engines running and two standby 10 MW engines. It happens that 10 times this year 8 engines will not be available to produce power but there are enough dark green areas (standby hours) to cover up for that, so the annual availability will still be over 100%.

### 3.2.3 Power availability

Power availability is typically used for calculating how many standby engines there is needed to cover a certain power output of a plant. If a power plant requires to always have an output of 80 MW and the plant consists of eight 10 MW engines it will not always be able to give an output of 80 MW as engines will be forced to shut down for maintenance. When a major overhaul is due to be performed it will have a big impact on the power availability as one engine is down and the plant cannot deliver the required output, on top of that they will most likely start overhauling the next one right away when the first one is done. Standby engines can therefore be started to cover up so the plant can deliver it is promised power output. (Wärtsilä, 2021e)

By again looking at figure 4 and thinking about how power availability is defined (equation 2). Each time the power plant cannot deliver it is requested output of 80 MW it decreases the power availability as the standby hours cannot cover up for that. If there would be no outages below the 80 MW line the power availability would be 100 %. (Wärtsilä, 2021e)

$$PA = 100\% - \frac{Loss\ of\ requested\ energy\ (MWh)}{Net\ Max\ Power\ after\ derating\ (MW) \cdot PH} \quad (2)$$

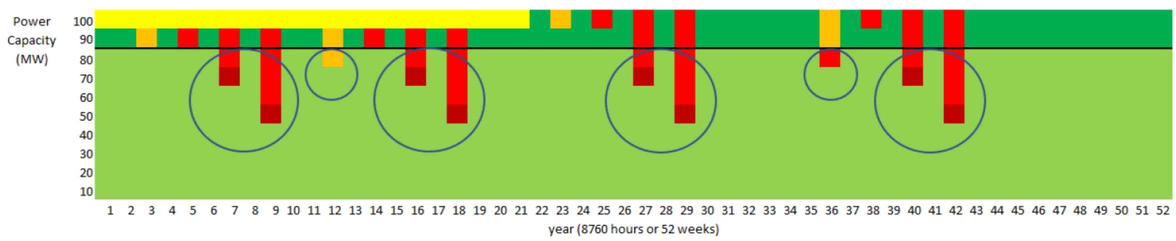


**Figure 4. Visualized 100 MW Power plant downtime over a year (Wärtsilä, 2021e)**

### 3.2.4 Reliability

What is reliability? In the article *Improving the foundation and practice of reliability engineering* Terje Aven describes it as:

> *Formally defining system reliability is the ability of the system to perform its intended function.* (Aven, 2017)

In Oxford's learner's dictionary reliability is described in a way that it is the same, as the lifecycle quality of a product or system.

> *The quality of being able to work or operate for long periods without breaking down or needing attention.* (Oxfords learner's dictionary)

There are many ways to measure the reliability of a system because they can all be so different. A traditional way has been to estimate the probability of a system failure over a specified period, how many times the system will fail, and the expected time to failure. In Wärtsilä the time of which the system is down over an annual period is also an important reliability measure as it affects both annual and power availability.

Reliability is something that can be difficult to measure as there are so many factors in a system that affects its reliability. It can be factors that relate to the actual system, for example, mechanical defects in a component, or it can be outside factors that affect the reliability, such as bad fuel quality. Then there are also human errors that may affect the reliability of a system. It can for example be, that an overhaul has not been performed correctly and may cause some damage to the system. Within reliability engineering, this is something that engineers always try to investigate and find ways to improve processes and factors that can improve reliability. (Aven, 2017)

One good example of how to have more reliable engines in a power plant is to do preventive maintenance based on data from sensors and analysis of the lubricating oil. These can be small unplanned maintenances but if they are overlooked, they may cause bigger problems, and then the unplanned maintenance would be much more expensive.

### 3.2.5 Other guarantees

Other than availability and reliability guarantee to ensure that the customer has the needed capacity there is also an option to have starting reliability to ensure that the engines do not have many failed starts as they can be needed to ramp up quickly to support the grid.

Another optional service that can be offered is Energy efficiency management which is basically heat rate monitoring with recommendations on how to maintain the optimal efficiency of the engines. In other words, it is a guarantee of the efficiency of the genset as heat rate is defined as following. (Wärtsilä, 2021e)

$$Heat\ rate = \frac{Thermal\ Energy\ In}{Electrical\ Energy\ out} \tag{3}$$

## 3.3 Energy agreement business sales procedures

Selling an agreement starts with new agreement opportunities that are identified by sales and registered in the customer relationship management system by an opportunity owner. An opportunity leader is appointed, who's not necessarily the same as the opportunity owner, but they can be the same person. The opportunity leader is appointed based on the classification of the opportunity which has three different classes. A, B, and C classes. A class agreements are the most complex ones, such as GAP and O&M agreements because of the higher risk they naturally have. B class agreements are for example regular Optimised Maintenance agreements and C class is Parts Predict Agreements where there are small risks. (Wärtsilä, 2020)

All service agreements are sold in a team selling environment, it is not done by just one person and is not possible because of sales processes that need to be followed. Opportunities for a service agreement are led by an opportunity team leader which also adds all the necessary people to be part of the opportunity team. The opportunity leader must inform each team member of what's required from them and how they are part of the opportunity's success. The team is as large or small as it is required to successfully close the opportunity. Typically, the teams consist of sales support people from the Agreement Proposal Management team, local agreement sales representatives, who are often from the closest office to where the opportunity is and, the legal, and business controller can be included when necessary. (Wärtsilä, 2020)

The opportunity leader should always try to develop the opportunity forward and get it closed. It is, therefore, necessary that the opportunity leader has the skills and experience to handle the opportunity, especially A class agreement that requires a lot of experience, sales skills, and leadership skills because there it is harder to identify and clarify the requirements from the customer and technical aspects. It is the responsibility of the opportunity leader to constantly review the risk and reward for the opportunity and to report the progress within the team. Cost calculations, responsibilities, and delivery terms are to be verified that they can be met together with Agreement management. The opportunity team leader functions as a coordinator for the whole sales process of the agreement but also as a representative contact person to the customer and negotiator of the agreement. (Wärtsilä, 2020)

### 3.3.1 Sales process

All sales within Service Agreements should follow the EB Sales Contract Policy and follow the set-out procedures from the EB Agreements Sales Procedures document which is discussed in the above chapter. When the opportunity leader wants a cost calculation, he shall make a service offer request to the area responsible Support & Development Manager in CRM who will prepare an offer together with insight from relevant area business support people and in case the agreement is a part of a newbuild project, of course also with proposal engineers, managers and Business Development Managers from newbuild. (Wärtsilä, 2020)

Before an offer can be committed to the customer there needs to be an offer review of the proposal where the necessary experts should be involved. Firm offers have an exact scope, location, and detailed information from the customer on what’s required. Price indications on the other hand can be sent to a customer for feasibility studies and are therefore not a binding offer. They should mainly be used for internal modeling of the financials and help to make scope decisions etc. (Wärtsilä, 2020)

After negotiations and acceptance of the proposal from both the customer and company, there will be the preparation of the contract together with legal counsel where the risks and benefits are considered as a whole and where the opportunity owner and leader are responsible for reviewing the contract and its content together with opportunity team members. Primarily a Wärtsilä service agreement template shall be used but it is also possible to use customers' templates if they insist, as long as they fulfill all the requirements from Wärtsilä. (Wärtsilä, 2020)

When preparations of the contract are done and the opportunity leader is confident that everything is fine, such as fees, scope, responsibilities, guarantees, and other commercial and legal details are agreed the opportunity leader shall call to a contract review where they will ensure that the contract follows all Wärtsiläs policies and if there are any deviations that they have been approved. It is mandatory to have a contract review before signing it with the customer. For A-class agreements and agreements where it occurs deviations compared to the standard scope it also needs to be a meeting to discuss the contract review. For agreements that have deviations, it is the opportunity owner's responsibility to seek approvals for those deviations. (Wärtsilä, 2020)

When the contract is signed, marked close, and won in CRM and all the approvals and reviews are approved as they must be, the opportunity owner must organize a meeting with agreement management for hand over. It is up to the opportunity leader to inform agreement management of all the necessary detail and information such as technical, operational, and commercial procedures. (Wärtsilä, 2020)

## 3.4 Agreement management

Agreement management manages long-term service agreements by supporting the customers with high-quality lifecycle management and operational services.

The Agreement Manager is responsible for the agreement between the customer and Wärtsilä. The main responsibilities of the Agreement Manager are to keep track of the lifetime action plan and performance according to the scope of supply in the agreement, customer relationship and satisfaction, account planning, renewals, agreement specific environmental health and safety plans and issues, insurance management, reporting for both externals and internal stakeholders and other actions stated in the agreement.

There are many different support functions within the company that supports the agreement delivery success. For example, the expertise center supports the agreement by providing maintenance planning and operational management services such as expert insight reports and remote operational support. Business control supports by providing insight into the profitability and development targets, risk management, financial planning, forecasting, and reporting.

# 4 Methodology

This chapter will present the methods used in this thesis. First, we will go through the research approach, and the quantitative and qualitative methods and after that, we will go through more in detail about the thesis solution approach and its methods.

## 4.1 Research approach

The research approach is mainly abductive, which means that the research process started with unexcepted facts, and the process is therefore devoted to its explanation. One weakness here can be that the easiest explanation is often used and therefore the answer to the problem may not be deep enough to get the full information required to make the best decision for the solution. As the purpose of this thesis was to investigate how well the company has performed on the guarantees in the GAP agreements there will be many different explanations for what has gone good and bad. There may also be the same explanations and patterns from multiple power plants and therefore the research approach may also be considered inductive. Inductive research is when a pattern is made from observations which then creates a theory from the pattern. (Bell, Bryman, & Harley, 2015)

By looking at the data collected from this thesis it can be concluded that it is both qualitative and quantitative, it is therefore a so-called mixed-method approach which is something that emerged in the mid to late 1900s. Johnson and Onwuegbuzie hoped that the mixed methods approach to research provided researchers with an alternative to believing that the quantitative and qualitative research approaches are incompatible and, in turn, their associated methods “cannot and should not be mixed”. (William, 2007)

In the first part where the data collected from the contracts are quantitative, the same with the data collected from the Agreement Managers who report the guarantees to the customer is also quantitative. The interviewing part of the Agreement Managers, On-site Engineers, and Maintenance Planners on things that have gone well, challenges, and suggestions on improvements are qualitative.

## 4.2 Solution approach

In this chapter, all the methods used in this thesis work will be gone through and explained. The reason for using this solution approach was that it would be very useful for personal development and something of high value for the involved stakeholders. It was also the most natural solution approach to use as there were not any existing structured data available in any database.

### 4.2.1 Information and data gathering

The first data I received was in November, a list of installations where Wärtsilä has GAP agreements. The list also included Energy Storage Solutions from Wärtsilä. This needed to be filtered out as the work for this thesis did not include any research for these kinds of installations. Afterward, I had discussions with two supervisors from the Performance team within the department. In these discussions, we filtered down the list to six contracts that would be worthy of investigating. This was mainly due to the fact that many had not enough running hours so the information and data from these contracts would be very limited. And that we needed to get at least one contract from each area.

| Responsit | Responsit | Country | Contract Name | Column2 | Contract Type | Equipment |
|---|---|---|---|---|---|---|
| EUAF | Europe | United Kingdom | [redacted] | ES&O | Guaranteed Asset Performance | [redacted] |
| EUAF | Europe | United Kingdom | [redacted] | ES&O | Guaranteed Asset Performance | [redacted] |
| AMER | North Americ | Puerto Rico | [redacted] | | Guaranteed Asset Performance | [redacted] |
| EUAF | Europe | United Kingdom | [redacted] | | Guaranteed Asset Performance | [redacted] |
| EUAF | Africa West | Mali | [redacted] | ES&O | Guaranteed Asset Performance | [redacted] |
| AMER | North Americ | Bahamas | [redacted] | | Guaranteed Asset Performance | [redacted] |
| AMER | North Americ | USA | [redacted] | ES&O | Guaranteed Asset Performance | [redacted] |
| AMER | North Americ | USA | [redacted] | ES&O | Guaranteed Asset Performance | [redacted] |
| EUAF | Europe | Germany | [redacted] | | Guaranteed Asset Performance | [redacted] |
| EUAF | Europe | Germany | [redacted] | | Guaranteed Asset Performance | [redacted] |
| AMER | Central Amer | Mexico | [redacted] | | Guaranteed Asset Performance | [redacted] |
| MEA | Australasia | Australia | [redacted] | | Guaranteed Asset Performance | [redacted] |
| AMER | South Americ | Brasil | [redacted] | | Guaranteed Asset Performance | [redacted] |
| EUAF | Europe | Germany | [redacted] | | Guaranteed Asset Performance | [redacted] |
| AMER | North Americ | USA | [redacted] | ES&O | Guaranteed Asset Performance | [redacted] |
| AMER | Central Amer | Peru | [redacted] | | Guaranteed Asset Performance | [redacted] |
| EUAF | Europe | Italy | [redacted] | | Guaranteed Asset Performance | [redacted] |
| AMER | North Americ | USA | [redacted] | ES&O | Guaranteed Asset Performance | [redacted] |
| AMER | North Americ | USA | [redacted] | ES&O | Guaranteed Asset Performance | [redacted] |
| EUAF | Europe | Hungary | [redacted] | ES&O | Guaranteed Asset Performance | [redacted] |
| EUAF | Europe | Finland | [redacted] | ES&O | Service+ GAP | [redacted] |
| AMER | North Americ | USA | [redacted] | ES&O | Service+ GAP | [redacted] |
| MEA | South Asia | India | [redacted] | | Guaranteed Asset Performance | [redacted] |
| AMER | North Americ | Mexico | [redacted] | ES&O | Guaranteed Asset Performance | [redacted] |
| EUAF | Europe | Spain | [redacted] | | Guaranteed Asset Performance | [redacted] |
| AMER | North Americ | USA | [redacted] | ES&O | Service+ GAP | [redacted] |
| AMER | North Americ | USA | [redacted] | ES&O | Guaranteed Asset Performance | [redacted] |
| AMER | North Americ | USA | [redacted] | ES&O | Guaranteed Asset Performance | [redacted] |

**Figure 5. GAP agreement contract list**

In the list above we only see the name on the contract, location, and equipment. For the purpose of the agreement which was to investigate the guaranteed KPIs, it is needed to get information on what kind of guarantees each contract has. The Lifecycle Performance team has documented all contracts in which Wärtsilä has a guaranteed KPI and its value in an online Excel file. To double-check and better understand the guaranteed KPI the contracts were also downloaded from M-files. The contracts were also needed for understanding why some installations may have performance issues related to the contract while some may not.

Going further we decided that it would be best to start off by making a Microsoft Forms that could be sent out to the Agreement Manager, On-site engineer, and Maintenance planner. This would help me in gathering data for the same questions from different sites and it also helps to have some insight into the agreement before a full interview. I prepared the questions and went through them with multiple Business Development Managers, Lifecycle Performance Managers, and my supervisor to make sure that I have the most important covered. The forms were sent out via email one by one to the people I wanted to interview together with an invitation to a Teams meeting so that they would get some pressure to answer the forms before the meeting. Questions of the Microsoft Forms were the following:

1. Name of Installation
2. Please enter your name
3. How does the plant operate?
    a. Baseload (>5000 running hours)
    b. Intermediate load (2000-5000 running hours)
    c. Balancing (<2000 running hours)
4. Please specify more specifically how the plant operates, and seasonal variations?
5. Please choose your job
    a. Agreement Manager
    b. On-site engineer
    c. Maintenance planner
6. What has been the challenge for the maintenance planner for the GAP agreement compared to an O&M agreement where we have people at the site? Is there something that can be improved?
7. What have been the challenges for the On-site engineer/advisor? Please explain and give suggestions if there is something that can be improved.
8. What has been the challenge for the Agreement Manager for the GAP agreement compared to for example O&M agreements?
9. How are the guaranteed KPIs: s monitored?
10. Is the site engineer involved in planned overhauls?

11. If the site engineer is not involved in the planned overhauls, please specify why? And if the advisor is involved please explain how.
12. Is the site engineer involved in unplanned overhauls?
13. Please specify how the site engineer has been involved in the unplanned overhauls and if the site engineer has not been involved explain why?
14. Is the site engineer involved in operations?
    a. Yes
    b. No
    c. No site advisor in this agreement
15. If the site engineer is involved in the operations, please specify how? If not involved explain why.
16. Are safety spare parts available at the site?
    a. Yes
    b. No
17. Are exchange spare parts available at the site?
    a. Yes
    b. No
18. Is there a fully equipped workshop at the site?
    a. Yes
    b. No
19. Who overhauls the exchange spare parts?
    a. Wärtsilä
    b. Customer
20. If there are no exchange or safety spare parts available at the site, how has this impacted the downtime and guarantees in the agreement?
21. Have there been any planned maintenance performed by Wärtsilä under this agreement?
    a. Yes
    b. No
22. If there has been planned maintenance under this agreement performed by Wärtsilä, please explain which overhaul and how it went? Where there any challenges?
23. Have there been any major unplanned maintenance in this agreement?

a. Yes
b. No

24. If there has been major unplanned maintenance in this agreement, please specify what happened?
25. Have there been any minor unplanned maintenance that affected the guarantees in this agreement?
    a. Yes
    b. No
26. If there has been minor unplanned maintenance in this agreement that has affected the guarantees, please specify what happened?
27. How has the auxiliary equipment affected the guarantees? More unplanned downtime?
28. Have field services been involved in the unplanned services and were they easily accessed when needed?
29. What's the response time from field service?
30. How does the field service work when they perform an overhaul? 24/7 in shifts or 8 hours per day for example?
31. Spare parts ordered for overhauls, are they ordered just in time? has there been missing spare parts for an overhaul that have impacted the downtime?
32. How has the expertise center supported the agreement to better achieve the guarantees? For example expert insight reporting, maintenance planning, and remote support? Has there been any predictive maintenance performed based on expertise center services?
33. Who performs the fluid analysis?
    a. Wärtsilä
    b. Customer
34. Have there been any predictive maintenance done based on the fluid analysis results?
35. Have the customer followed Wärtsilä's recommendations when it comes to predictive maintenance based on analysis and expertise center suggestions?

After that, the interviewing started with all of the Agreement Managers for each contract which in total was five, three On-site engineers were available, and only one maintenance planner as that was enough. All the interviews were recorded, and they were asked about challenges they are facing in the contract and what suggestions they have for future GAP agreements as well as what has been good, etc. This was very valuable information to try and analyze further. Both the Agreement Managers and the On-site engineers have the data on the KPIs which they sent to me after the meetings. The data received was in many different structures. Most of the followed-up data I got was the monthly reports which are usually only provided to the customer. As all the monthly reports were different it took a while to get a complete understanding of all of the information that they contained. Some followed-up data was also received in Excel spreadsheet format and from Qlik Sense Hub where the performance data for O&M agreements are uploaded and only for some GAP agreements.

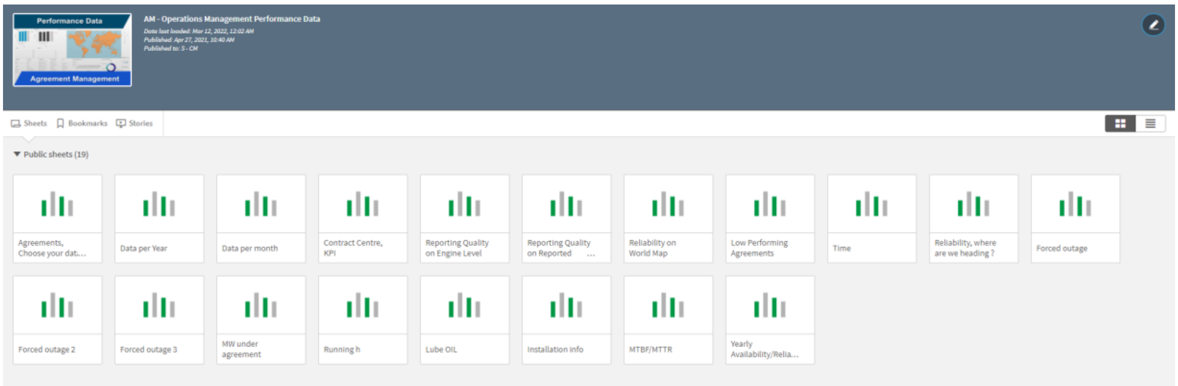


**Figure 6. Qlik Sense Hub O&M Performance data dashboard**

### 4.2.2 Information and data processing

The platform that was selected for processing the data and information was Microsoft Excel as it is perfect for calculating, plotting, and analyzing the quantitative data from the following up KPIs. It is also a good tool to use for making comparison tables when analyzing the qualitative information received from the interviews and Microsoft Forms. As it is an Office 365 application it will also be easy to transfer everything to Microsoft Word and PowerPoint.

As the data received is in many different structures, it is important to get it structured in the same way for every single GAP agreement. At first, the data will be gathered and structured separately for every agreement as they are all different in the way of guaranteed KPI, operating hours, equipment, size, and so on. The working file will have a separate Excel sheet for every agreement where it will be looking as in figure 7. Depending on the received data the followed-up KPI will either be for every month or year. What may also differ is that for some agreements the guarantee is reliability instead of availability as in figure 7. An installation cannot have both reliability and availability guaranteed so both will not be considered at the same time for the same agreement. The guaranteed KPI is given every year and therefore it is necessary to get the average of the 12 months to see if it is above or below the target. Some months will probably have much lower availability or reliability due to planned or unplanned overhauls and other months will have much higher and therefore it is a must to get the average of the whole year.

| | | | |
|---|---|---|---|
| **Installation:** | Example | **Agreement Code:** | xx |
| **Contract name:** | xxx | **Contract number:** | xx |
| **Contract starte date:** | 1.1.2022 | **Equipment:** | 5 x W20V34SG |
| **Contract end date:** | 24.12.2022 | **Availability Guarantee** | 95% |

| | **2021** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Janurary | February | March | April | May | June | July | August | September | Oktober | November | December |
| **Actual Availability** | 92,00% | 95,00% | 94,00% | 97,00% | 95,00% | 99,00% | 98,00% | 92,00% | 97,00% | 96,00% | 99,00% | 98,00% |
| **Average Availability** | 96,00% | | | | | | | | | | | |

**Figure 7. Template for organizing quantitative data**

When the data is structured as in figure 7 the process of plotting the data in charts begins. It's decided that a column chart is the best because it shows every month or year value separately and target lines can be added to show where the guaranteed value is and where the actual value is month by month or year by year and on average for the whole period with a separate line.

In figure 8 we see an example of how the chart for every agreement will be made. Here columns represent the actual availability for each month. The red line is the guaranteed availability, and we can see January, March, and August are very much below the target. In this example that is okay because if the green line which is the average availability is higher than the red line it is kept above the guaranteed number.

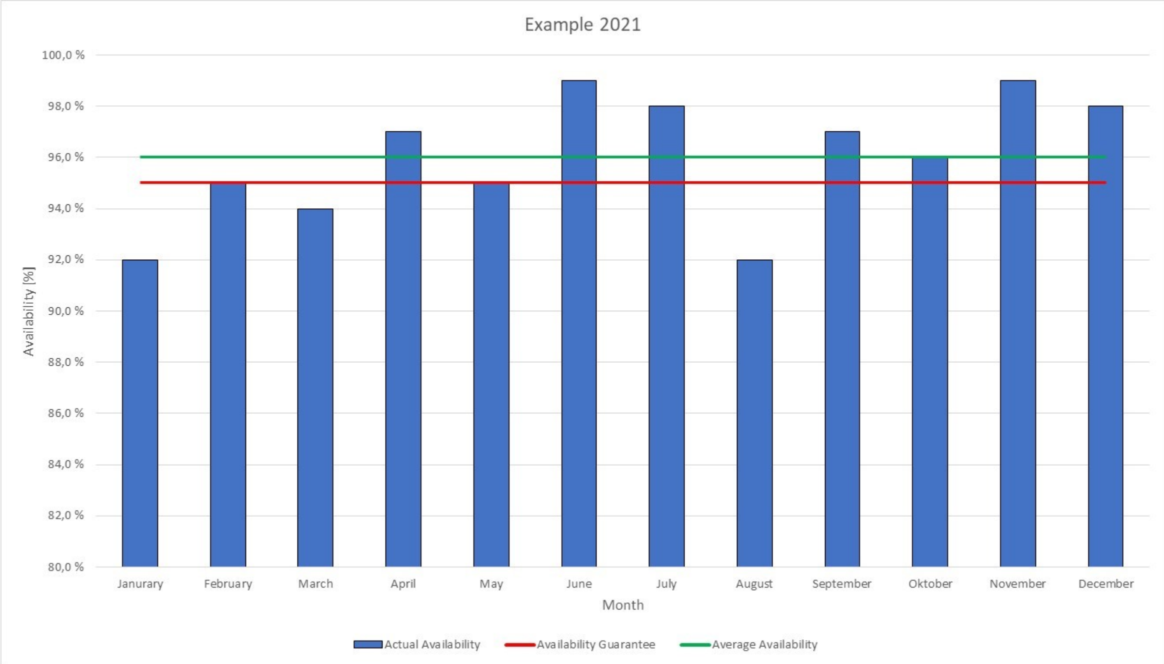


**Figure 8. Example chart**

After that, we needed to get the structure on how to set up the qualitative data from all of the interviews. The best solution that we came up with was to make a table in excel where the challenges and technical issues faced in the agreement were listed in one column. In the second column the source of the challenge or problem would be identified from the contract, explanation from the interview with the Agreement Manager or the Microsoft Forms they answered. In the third column, a suggestion on how this challenge or problem could be avoided would be listed down.

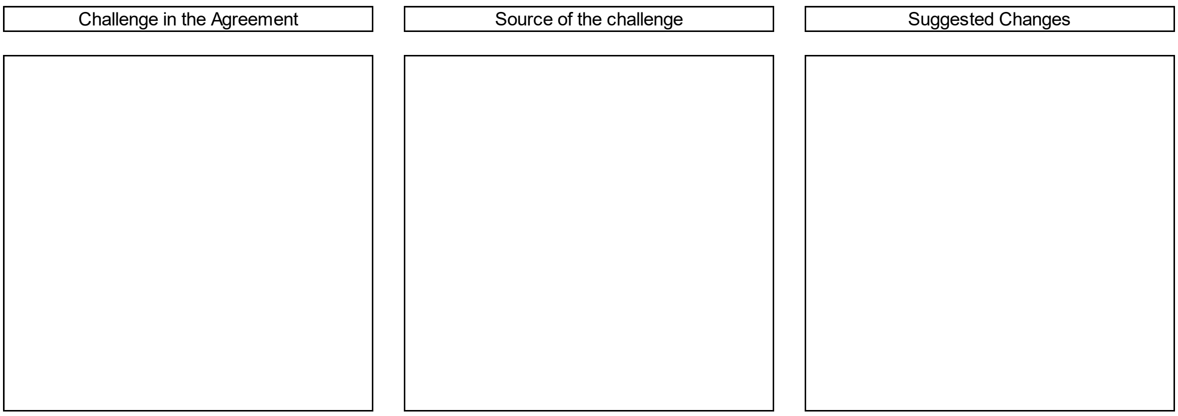


**Figure 9. Template for organizing qualitative data**

There is a huge amount of qualitative and quantitative data available for being able to identify the challenges and issues faced by each agreement. Everything could not be listed down and only the most important information could be taken into consideration.

When everything was done for all the agreements it was time to start and look for correlations between all of them, what kind of similar issues could be identified and what kind of similar positive things do they have in common that contribute to the success of the agreement. The easiest similarities could be seen from the responses in the Forms in the shape of pie charts. The similarities and success factors, as well as issues, were all listed down to get a full picture of what's been good and what's been less good.

# 5 Results

This chapter will present the result of the thesis. First, the result for each agreement will be presented. Afterward, a conclusion for all the investigated agreements will be gone through.

## 5.1 Individual agreement result

This section will present the result for each single GAP agreement investigated in this thesis work. The presented outcome will be gone through and discussed.

The first installation that was investigated is in Europe and will be referred to as installation A. The installations consist of Wärtsilä 16V50DF operating flexible baseload. It is an industrial plant which is producing heat and power for its own processes. The guarantee is 98% reliability and there is no On-site engineer in this agreement, therefore it is the customer who reports the unplanned downtime to Wärtsilä. As there is no On-site engineer in the agreement the Agreement Manager also gets less insight and may not be able to give the same kind of support as in agreements where we have an On-site engineer. This could possibly be avoided with an engineer that visits the plant twice per week and is such not a full-time On-site engineer but with similar tasks and responsibilities. Then the unplanned downtime could also be better followed up as the engineer would have a closer working relationship when visiting the customer a couple of times per week. Another challenge in the agreement is that the customer is not always able to solve unplanned maintenance by themselves, which they are responsible for according to the contract. Therefore, they need to call for help from the Agreement Manager who organizes support from field service. This takes time and affects the unplanned downtime for the engine.

Following reliability that has been reported since 2017 can be seen in a chart in figure 10, where only in the year 2021 the reliability reached over 98%, and as such, it was the first year that LDs were not paid. Otherwise, the reliability has been under 98% for previous years and the average for all 5 years is at 95,77%.

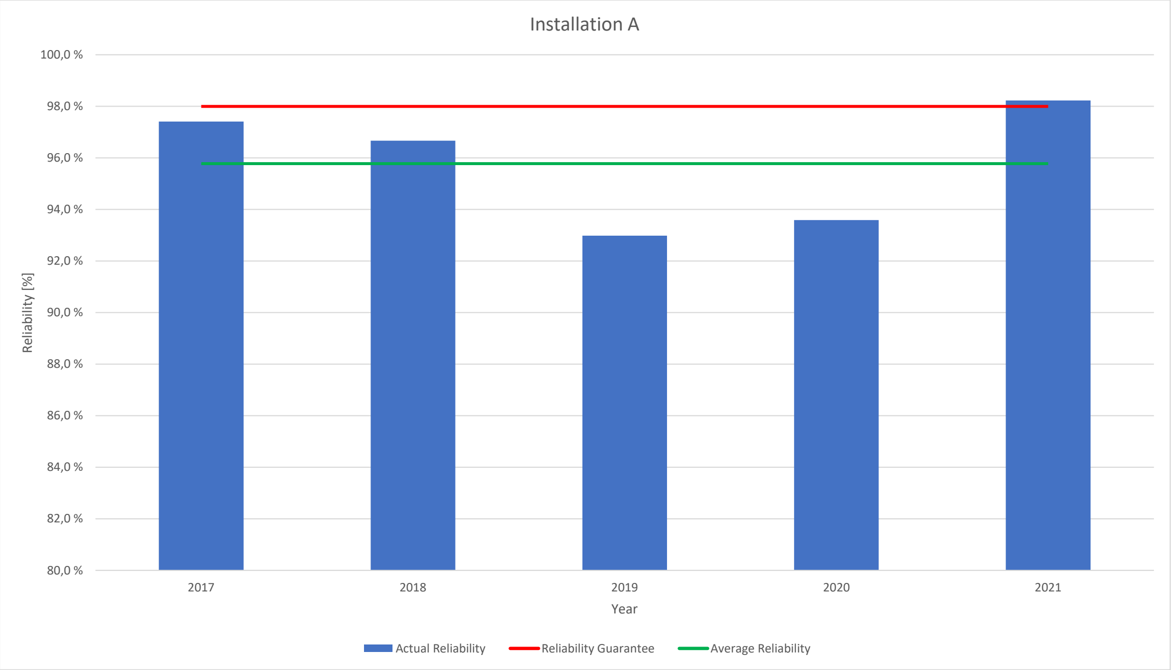


**Figure 10. Reliability chart for installation A**

The second installation investigated is also located in Europe and will be referred to as installation B. This power plant consists of Wärtsilä 20V34SG engines which are operating intermediate load. It is a Combined Heat and Power plant and as such, it runs more during colder periods when heating is required. The guarantee investigated is reliability which is 95% for the first 3 years and after that, it will be 97%. As part of the agreement, there is an On-site engineer available at the site who monitors and reports the unplanned downtime to the Agreement Manager. Because the power plant is still under warranty there is also a person at site handling this, otherwise, it would be too much for the On-site engineer to also support warranty-related issues.

Challenges faced in the agreement are that overhauls and work are specified from 1000 hours intervals and not minor work such as 50,100- and 500-hours intervals. This creates a problem to who is responsible to perform this work. There have been some compromises but Wärtsilä still needs to perform also minor work which was not intended. This can be avoided in the future by better defining that the customer is responsible to perform the minor works and daily tasks required up to a certain overhaul interval which Wärtsilä will perform.

Another challenge is that Wärtsilä needs to perform all unplanned maintenance, as there can be very small things happening that the customer could easily do, Wärtsilä still needs to perform this as it is how it is stated in the contract. This of course affects the unplanned downtime when there is a lead time to get a field service engineer to the site and perform the unplanned maintenance. The solution to this problem can be quite complex. If the unplanned maintenance is related to a larger overhaul interval Wärtsilä should come and do the unplanned maintenance, but then it can be hard to sometimes quickly locate why the unplanned downtime has happened and who would be the responsible part to solving it.

As mentioned, it can be hard to justify the source of the unplanned maintenance and as well it is hard to justify for both the On-site engineer and customer to when Wärtsilä is responsible for unplanned downtime as it is not clearly stated in the contract. An example of a problem is that there is something wrong with the auxiliaries or engine, but it is not a big issue, and the engines can still run. What if the customer wants to fix the issue and claim unplanned downtime, but the engines could still operate so are they allowed then to claim unplanned downtime? This is something that in the future needs to be better clarified in the contracts.

The reported reliability since the start in January 2021 can be seen in figure 11. After commissioning, commonly, the plant faces some reliability issues, and the reliability is therefore lower the first months. This was also the case for this installation as they had some issues with oil leakage and generator braker failures the first months. Otherwise, as they got these issues fixed the rest of the year was very good and the average reliability was about 96% which is above the guaranteed 95% for the first 3 years.

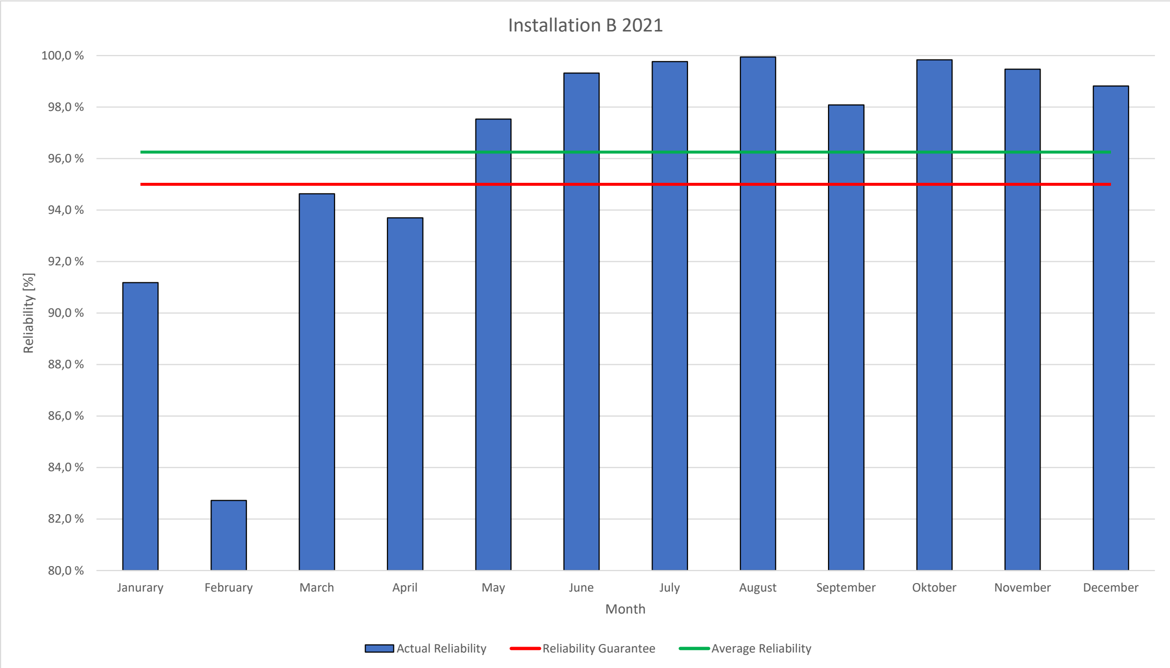


**Figure 11. Reliability chart for installation B**

The third installations investigated is in North America and will be referred to as installation C. This power plant consists of Wärtsilä 12V34LPG engines running on liquified petroleum gas and it is operating as flexible baseload. The guarantee investigated is availability and the guarantee is at 94%. The power plant started operating in June 2021 and it was expected to run continuously but in November due to high cost of LPG the power plant began running less and has therefore been underutilized.

As part of the agreement there are 1 On-site engineer from Wärtsilä together with 1 E&A engineer, 1 Senior Mechanical engineer and 4 shift supervisors for the first 6 months to get the customers personnel trained and up to speed with the operation and maintenance of the power plant. From January there are left only the On-site Engineer and Senior Mechanical engineer.

There have been very few challenges in this agreement for the Agreement Manager and On-site engineer to handle, it is highlighted by the On-site engineer that it is common with some small reliability issues after commissioning of a new power plant, that is also why there are extra people from Wärtsilä for the first 6 months to train customers personnel and take care of issues when they occur. The success of this can be traced back to the fact that already in the beginning of the negotiation, the sales responsible from Wärtsilä included the Agreement Manager in the discussion which helped to get a good understanding of the agreement, as well as a good relationship from the beginning with the customer and the Agreement Manager could quickly get up to speed with preparation work for the agreement. Also, the On-site engineer have very good control of the reporting, advising etc. The only challenge the On-site engineer currently have faced is the training of the personnel which can be demanding until they are up to speed.

From figure 12. We can see that the availability has been very high for this installation. The installation has not had any bigger issues that have affected the unplanned downtime a lot. Only month where the availability is a bit lower is in November where they performed a 4000-hour overhaul for all of the 4 engines. The average availability between June 2021 and February 2022 is about 99% which is extremely good and a lot above the guaranteed availability at 94%. This has of course to do with the fact that they have not yet performed any major overhauls and that they have very little unplanned maintenance.

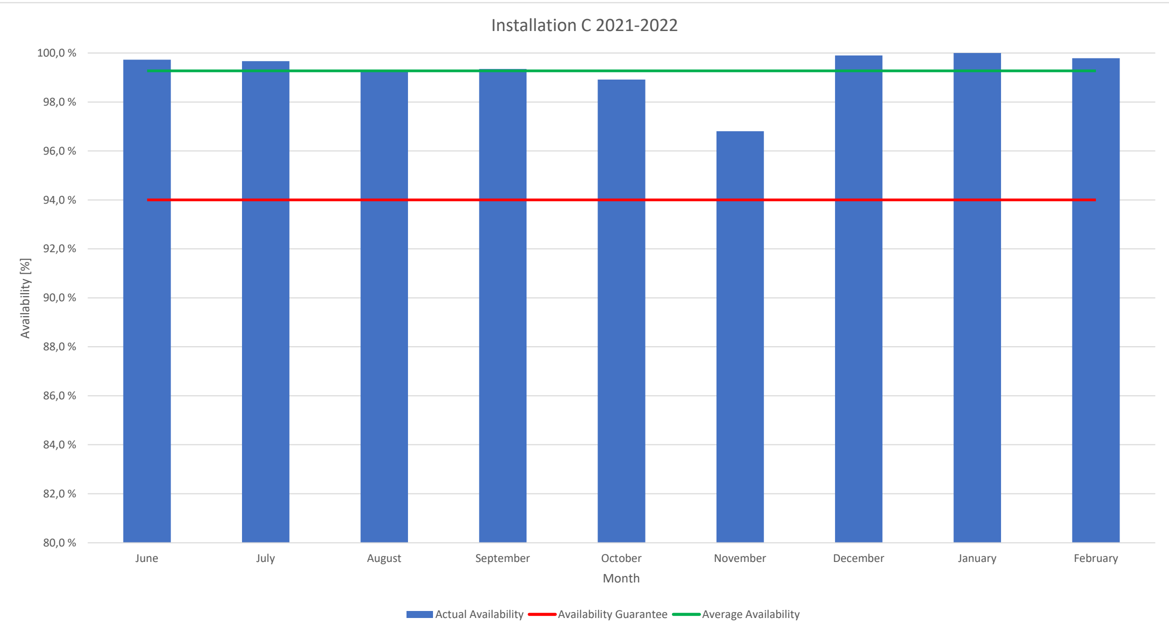


**Figure 12. Availability chart for installation C**

The fourth installation investigated is in South America and will be referred to as Installation D. It consists of Wärtsilä 20V34SG engines operating as transitional baseload. The investigated guarantee for this installation is availability at 96% and there is an On-site engineer from Wärtsilä to support the customer and report the downtimes. According to the Agreement Manager there was a challenge in the beginning of the agreement to find a suitable On-site engineer as there were not many with the required knowledge in that region for the position. There were also other smaller challenges related to the preparation work for the agreement that needed to be taken care of by the Agreement Manager that was not really accounted for in the sales stage.

Another issue is that the intention has been to change spark plugs every 2000 hours but in practice the spark plugs are changed earlier which result in increased costs compared to planned cost. When spark plugs need to change earlier than 2000 hours it also has a negative impact on the availability. It is also highlighted that there are other tasks and jobs from the Service Configurator that are not as in reality. There are also reliability issues such as water leakage in a cylinder head which caused two days extra downtime for one engine. This resulted with usage of exchange parts that they intended to use for the planned maintenance.

Here it is also highlighted by the Agreement Manager that the first months should not be taken into consideration for the guaranteed availability as it is common with reliability issues and way of working is not fully up to speed when everything is new. It can be seen in figure 13 that the average availability is still above the guaranteed availability at 96%. It is important to keep in mind that there have not been any bigger overhauls performed yet which can have a big effect on the availability. Still if the reliability issues with unplanned maintenance are delt with, there is a good chance to be above the guaranteed 96% in the future also.

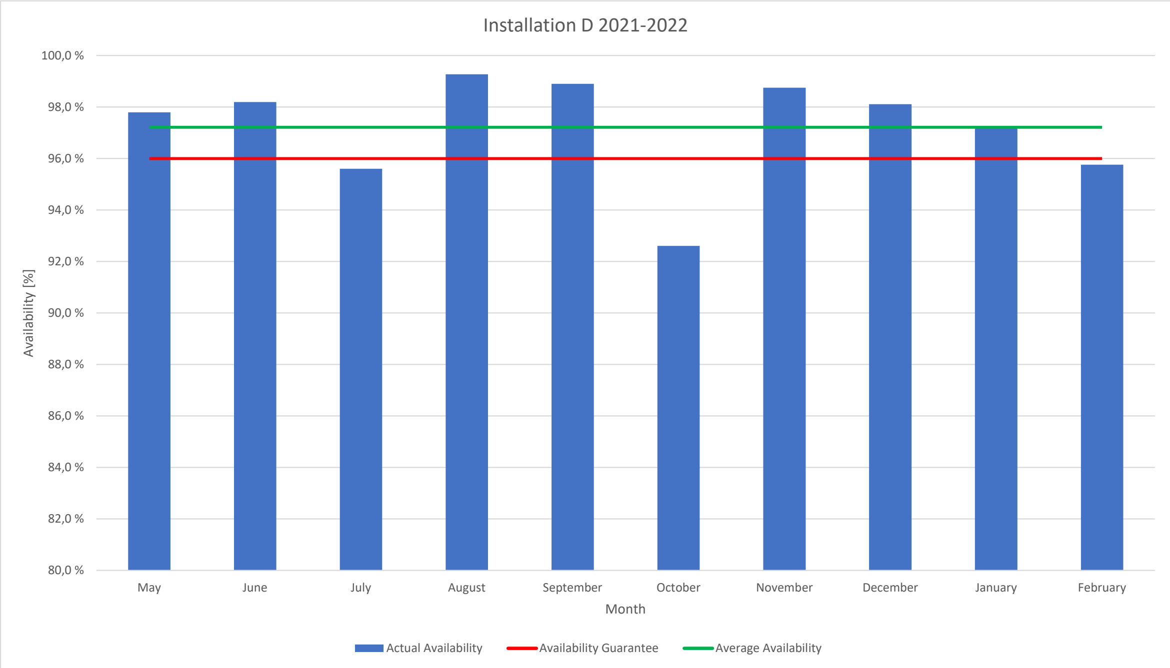


**Figure 13. Availability chart for installation D**

The fifth installation investigated is in Asia and will be referred to as installation E. It consists of Wärtsilä 20V34SG engines operating on continuous basis except during maintenance periods. The power plant had an O&M agreement will full crew from November 2016 before the current GAP agreement became effective from July 2021. The followed-up guarantee in this agreement is availability at 92%.

As the installations was not new when the GAP agreement started the reliability issues which are usually faced after commissioning were of course avoided. Even though the operating hours are quite high, and one could assume that there would be an increase in unplanned maintenance the availability is very high for all months, except August and January-February where major planned maintenance was performed.

Challenges faced in the agreement is that the customer tends to rely a lot on the On-site engineer for operational deviations and expect everything to be guided by that person, this creates a big workload and can be stressful for the person holding the On-site engineer position. A solution would be to have at least two On-site engineers from Wärtsilä to support the customer with both electrical and mechanical questions and issues.

In figure 14 the average availability since the start of the GAP agreement is about 95,7% which is above its guaranteed number of 92%. As mentioned, the power plant has performed major overhauls that effects the availability and from reading the monthly reports for the GAP agreement it can be concluded that the installation has had very little reliability issues.

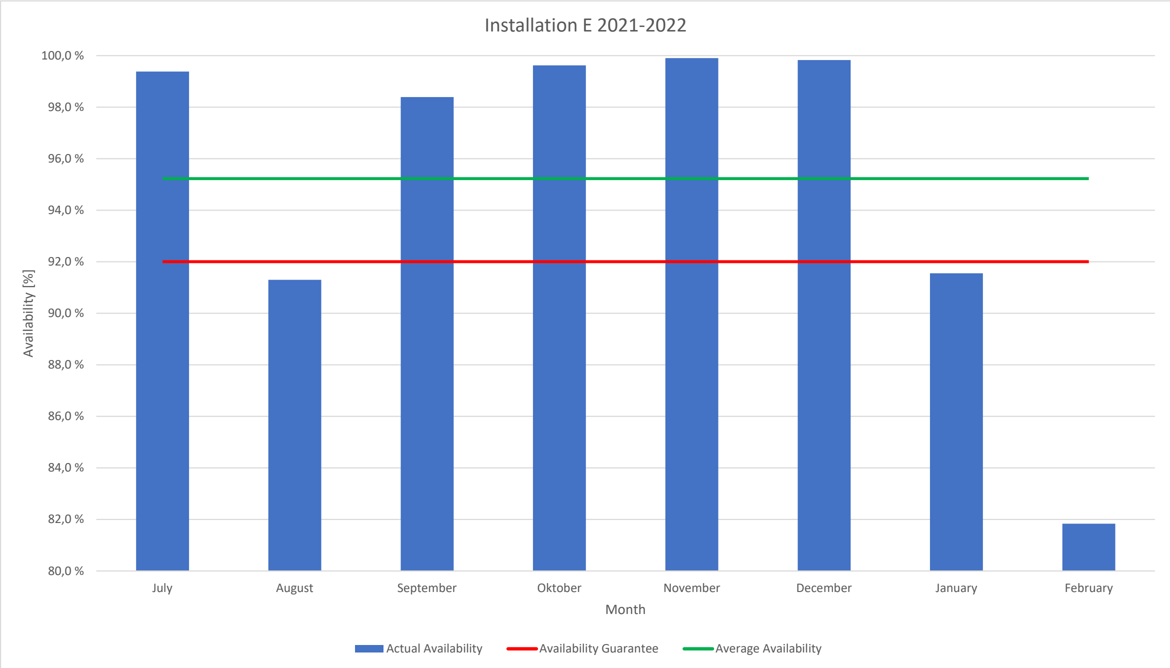


**Figure 14. Availability chart for installation E**

The sixth and final installation investigated is in South America and will be referred to as Installation F. It is consisting of Wärtsilä 18V50SG engines which has been converted from 18V46. The guarantee investigated is power availability and that is why the plant has one standby engine to start when another needs to be stopped for planned or unplanned maintenance.

The challenges faced in the agreement is related to the maintenances which Wärtsilä is not responsible to perform. Here the Agreement Manager see a risk when there is another part performing an overhaul which can have an affect on the performance guarantees and therefore would like to have a supervisor from Wärtsilä to also be part of the smaller overhauls.

As there is no function to report the power availability in Qlik Sense hub it is only the availability which has been reported. This is of course also good data, but it makes it hard for central organisation to see how the guaranteed KPI has performed, which in this case is power availability and not availability. It was explained by the Agreement Manager that the power availability has in fact always been kept at 100% which means that there have always been enough engines running thanks to the extra standby engine. The data available can be seen in figure 15 where availability is about 96,8 % for the period and the power availability is at 100%.

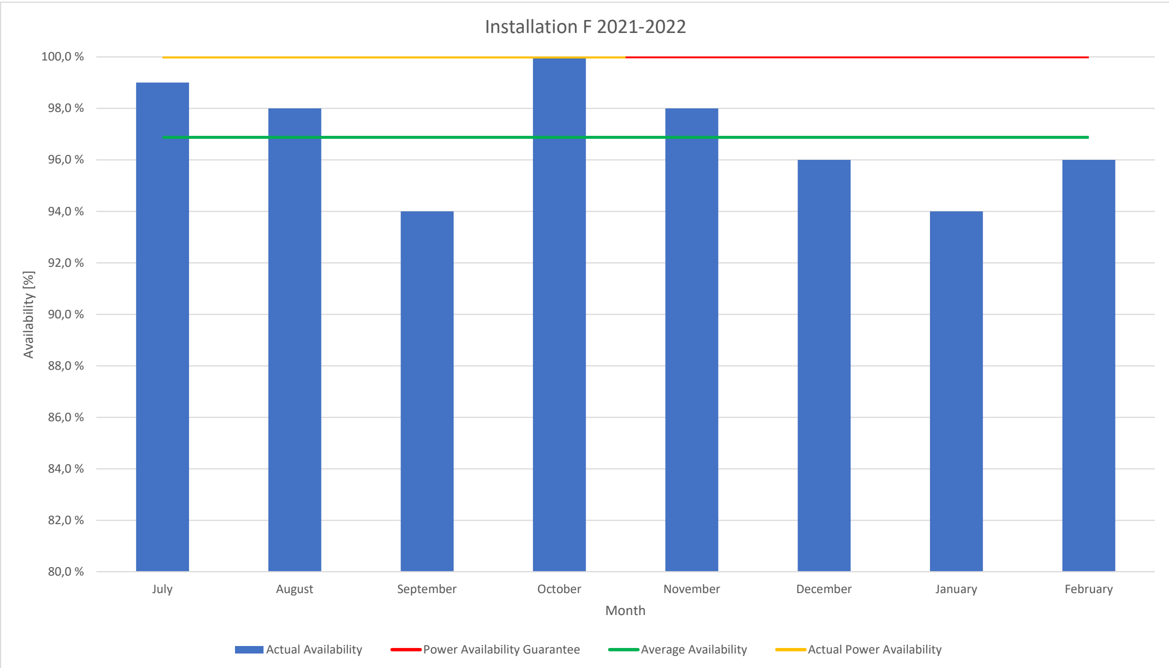


**Figure 15. Availability chart for installation F**

## 5.2 Conclusion

Similarities and findings from the individual agreement result, Microsoft Forms and interviewing data collections can be seen in appendix 1 and are following.

The On-site engineer has a very important role for this agreement concept to work. It is of course an already known reality, but it is also strengthened by the fact that the only investigated agreement in this thesis that did not have an On-site engineer is also the one where the guaranteed KPI has not been reached 4 out of 5 years and were LDs have been paid. The job for the On-site engineer is according to the description in theory chapter 3.2. A little bit different depending on the scope of the agreement and power plant. In some agreements the job is more towards training and advising the customers personnel on operations and maintenance together with the reporting and organizing of planned and unplanned maintenance. In other agreements it is more towards the responsibility to ensure that the power plant keeps its guaranteed KPIs and follows the contract by organizing planned, unplanned maintenance and other necessary tasks that are required. As such it is less involvement in the advising and training to the customer how to operate the power plant. From the data collection it can be concluded that the On-site engineers do have a big workload on their shoulders because they are the customers go to person when something is wrong, or they need help with something. Therefore, depending on the scope of the agreement with what kind of guarantees and what Wärtsilä is responsible for it should be considered if one person can handle everything or if it needs to be two or three On-site engineers to support the customer with achieving everything in the proposed agreement. If it is a must to only have one On-site engineer in the agreement it should be considered what responsibility that On-site engineer must have. The most important tasks the On-site engineer needs to do for the agreement to work is:

- Make sure that the logbook is kept up to date with all daily checks, emergency activities and repairs.
- Support in unplanned maintenance and emergency repairs.
- Assist customer with keeping the power plant safe and that the health and safety qualifications are fulfilled.
- Be main contact person between the power plant and Wärtsilä’s technical expertise when troubleshooting unplanned maintenance.
- Establish so that the power plant reaches the guaranteed availability and reliability.
- Make certain that all the safety parts and exchange parts are at hand in the power plant.
- Assist in resolving warranty claims between customer and Wärtsilä.

The cooperation between Agreement Manager, On-site engineer and the Maintenance planner from the expertise center seems to be very good. The Maintenance planners gets a lot of insight from the On-site engineer which helps when preparing and planning maintenance. The Agreement Manager and On-site engineer gets support from the Maintenance planner and expertise center when they require so. With input from expertise center predictive maintenance have been performed and the owners usually follow the recommendations.

In figure 16 we see a comparison between the investigated agreements on the most important factors. Five out of six have achieved their guaranteed KPI so far. The only installation which has not is also the only one where there is no On-site engineer included in the agreement. All installations are connected to the expertise center and have expert insight, only installation B did not have it for the first year of operation. Only for two installations Wärtsilä is responsible for the unplanned maintenance while every installation has safety spare parts available at site to use for unplanned events. For the installations that did not have an O&M agreement before the current GAP agreement field service is used from 2000- or 4000-hours overhaul, while for the two installations that had a O&M agreement before field service is used from 8000- and 12 000-hours overhaul which can be a risk when it is not Wärtsilä who is in control of the smaller overhauls. For three installations the performance data is also available in Qlik Sense.

| | Installation A | Installation B | Installation C | Installation D | Installation E | Installation F |
|---|---|---|---|---|---|---|
| Availability | | | 99,27% | 97,22% | 95,23% | 96,88% |
| Power Availability | | | | | | 100,00% |
| Reliability | 95,77% | 96,25% | | | | |
| Type of operation | Baseload | Intermediate load | Baseload | Baseload | Baseload | Baseload |
| Number of On-site engineers | 0 | 1 | First 6 months 7 persons. After 2 left. | 1 | 1 | 1 |
| Expert Insight | Yes | From year 2 | Yes | Yes | Yes | Yes |
| FS overhaul starting from | 4000 | 2000 | 4000 | 2000 | 12000 | 8000 |
| Safety spare parts | Yes | Yes | Yes | Yes | Yes | Yes |
| Guarantee reporting in WiseLT | No | No | Yes | No | Yes | Yes |
| Unplanned maintenance | Excluded | Included | Included | Excluded | Customer buys spare parts sep. | Excluded |

| |
|---|
| Green = Good |
| Red = Concern |
| Yellow = Neutral |

Figure 16. Comparison matrix

As mentioned in the result for the individual agreements must tasks and works be better defined. For example, the customer is responsible to perform all the smaller jobs up to a certain overhaul interval were Wärtsilä instead would be responsible to perform the works or defining the tasks by splitting them into separate categories and stating who is responsible for what. This should then also be applicable for the unplanned maintenance works so that Wärtsilä would not be responsible to perform the minor unplanned maintenances as it takes time to get field service coordinated and to site, which affects both reliability and availability guarantees.

During the data collection it was noticed that every single Agreement Manager have their own monthly report that they go through and send to the customer. This is something that could be developed so that there is a template that can be used as base and modified to suit the agreement and the customer. By uploading the reported data to Qlik Sense, the monthly reports could utilize Qlik Sense functions and graphs to show the guaranteed KPIs. It would be easily accessed by others who work with performance or sales support etc. It would ensure that every customer would get similar service around the world.

At last, the common challenges and issues after commissioning and starting of the new agreement is something that was highlighted by multiple people in this thesis methodology part. A proposal would of course be that the guaranteed KPIs are not considered for the first months after commissioning and start of the agreement. It is something that seems fair because when something is new, no one is fully up to speed with how everything will be working, and new relationships are being established.

# 6 Discussion

The purpose of this thesis was to investigate how well Wärtsilä has performed on the guarantees and what kind of challenges are faced in the GAP agreements. As there have not been made a study on this before, there was a clear need for someone to do an investigation and report the available data and findings to the department.

By looking at the result, this thesis has presented the available data for the investigated GAP agreements and highlighted challenges and issues as well as reported things that have gone well. This can be to great help for the department when further developing the GAP agreement concept and contract. It can therefore be concluded that it has fulfilled its purpose.

To do an investigation of multiple agreements is very extensive and the scope could have been much bigger with further investigation on more guarantees, issues, costing, financials etc. Therefore, it was decided from the beginning that the scope of the thesis should be limited to the availability and reliability guarantees, and the challenges faced by the Agreement Managers and On-site engineers. For the future there's a big opportunity to do further research on the guarantees when there are more GAP agreements available to analyze, the current GAP agreements have more years of operational data, and hopefully data on the guarantees are more easily accessible. When it comes to further research on challenges and things that can be improved in GAP agreements it should be limited to a maximum of three agreements as there can be huge number of factors that impact on issues. That would mean a lot of data collection and mapping to get a full understanding of the whole project.

The challenges faced in this thesis was data collection on the guarantees. As previously mentioned, they are for most of the agreements not uploaded to Qlik Sense and therefore needs to be collected from the monthly reports and structured manually. Another challenge was to find suitable time for the interviews because of the big time zone differences.

The reliability of the thesis is strong because the data on the guarantees were collected from the Agreement Managers and On-site engineers monthly reports. They were happy to explain how they collected the data to calculate the guarantees and why some months the availability or reliability were lower. All the people interviewed were also very open to what kind of challenges and issues they are facing. That led to very good discussions on what kind of suggestion could be used to avoid such a problem in the future.

Finally, during the writing of this thesis I have been working as a Support & Development Manager at the Agreements Proposal Management team with supporting Business Development Managers and Capture Team Leaders for service agreement opportunities. This thesis work has developed my own understanding of GAP agreements which helps me in my daily work to give even better support in future GAP agreement opportunities. I have received a huge amount of support from my colleagues as they've seen the importance of this thesis. Therefore, I would like to thank everyone involved that have supported me with this work. First my supervisor from Wärtsilä, Pasi Hautakoski who has taken time with me each week to discuss the progress of the thesis and given me motivation to keep going and doing the best I can. I would also like to thank Hanna Strandberg and Sofia Nystén who have acted as mentors and guided me through the work and all the Business Development

Managers, Agreement Managers, On-site engineers, and maintenance planners for the good support in the interviews. Last but not least, I would like to thank my supervisor from Novia University of Applied Sciences, Roger Nylund who has guided, supported and always been available for a discussion when needed. The meaningful feedback has been of great value to be truly satisfied with this thesis.

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# Appendices

## Appendix 1.

| | Installation A | Installation B | Installation C | Installation D | Installation E | Installation F |
|---|---|---|---|---|---|---|
| Challenges | Less insight to the installation for the Agreement Manager when there is no On-site engineer in the agreement. | Definitions in the contract for minor tasks are not clearly defined to who is responsible for them. Big workload for the On-site engineer. | No major challenges, only thing pointed out is the smaller problems faced after commissioning | Challenge to find suitable On-site engineer and other preparations. Also spark plug changes and other reliability issues. | Customer depend a lot on the On-site engineer and tend to push more responsibility towards him and Wärtsilä | Agreement Manager points out risk when Wärtsilä is not the one who performs also smaller overhauls. |
| Success factor | Customer is now starting to handle more smaller reliability issues on their own. | Good cooperation between the Agreement Manager, On-site engineer and Maintenance Planner. | Agreement Manager already involved in the sales stage. Got good understanding and enough time for preparation. | After getting up to speed with the way of working and handling reliability issues the data has looked well. | Had O&M agreement before the current GAP agreement. Follows Wärtsiläs recommendations. | Had O&M agreement before the current GAP agreement. Have N+1 to achieve power availability guarantee. |
| My own reflections | Would be good to have at least part time Engineer visiting the installation and supporting in the agreement. | Similar installaitons could need two On-site engineers in the future. | Good that there were multiple people from Wärtsilä at the site for the first 6 months to get up to speed. | Here we see the importance of having enough time for preparations for a new installation and agreement. | Good that the customer follows Wärtiläs recommendations even though the On-site engineer gets a lot of responsibility. Would be good to have two On-site engineers instead of one. | Here we see that it is easier to go from O&M to GAP than starting a new GAP agreement. |