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Power, Cooling and Ventilation as part of Network Construction

Sustainable Construction Process for Conditions in Network Facilities

Master's thesis

Management in Sustainable Business

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Management in Sustainable Business Abstract
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There is a major transformation going on in the information technology and telecommunication industry. Telecommunication in Europe and Finland is already highly regulated, and sustainability reporting will bring more regulative demands starting from the financial year 2024. New network generations are increasing the electricity usage in the equipment facilities which is causing higher room temperatures, and cooling devices are needed more often to keep the temperature levels feasible. Hence there is a need for more comprehensive facility room conditions contemplation that takes the overall conditions into account before telecom equipment will be implemented. The purpose of the thesis is to describe how to combine cooling and ventilation equipment construction into the same assignments with electricity and power backup devices implementation to improve sustainability in the process. The commissioning company of the thesis is Telia Finland Oyj, a part of Telia Company whose headquarters are located in Stockholm, Sweden.

The thesis uses qualitative and quantitative research to point out the process steps of the combined cooling and electricity systems, which can be made more sustainable. In the process, regulative trends concerning the industry are discussed, as those will also affect the sustainability of the networks. Additionally, to the technical process, the thesis studied how the process change was seen among the stakeholders, and through the interview questions untangled the further development paths for the process. The interviews connected to the study were conducted as a quantitative anonymous questionnaire among the closest process stakeholders.

The findings from the research performed highlight that in order for the commissioner to have a more sustainable process in the network, further development must be conducted. Having the process technically the same for electricity and cooling assignments is only one step towards a wider sustainability approach in construction. Lifecycle management plays a crucial role in sustainable construction of equipment and facilities. By improved communication with stakeholders and developing the instructions there are better possibilities to reach the sustainability targets set by the company, and reducing travelling during the delivery. By searching new innovations and promoting circular economy in the supply chain it is possible to further improve the environmental sustainability of the process.

Keywords Telecommunication, sustainability, HVAC, lifecycle management
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1 Introduction

1.1 Commissioning Company

Telia Finland Oyj is a part of Telia Company whose headquarters are located in Stockholm. The company has over 2,500 employees and almost 4.5 million subscription customers in Finland, including mobile, fixed telephony, broadband and TV subscriptions. (Telia Company, 2023a) The company is constantly investing in its networks to ensure the availability of secure and reliable connections. Operator business is much more than only traditional cable and mobile subscriptions. Today Telia Finland Oyj offers a wide range of services for its customers. In Telia's own words, the company is one of the largest TV companies in the Nordic countries and one of Finland's leading companies offering ICT services to companies. (Telia, 2023d) They are helping customers to keep up with the technological transformation towards the 4th industrial revolution for example with 5G and IoT. Telia also offers its customers top sports content e.g. Finnish Ice Hockey League, popular entertainment programs and up-to-date news. The company provides IT services for all sized businesses through Europe's most secure data centre in Helsinki. The services are carried out through several brands - Telia, MTV and Telia Cygate (Telia Company, 2023b). Telia Finland has come quite a journey from a state-owned department to a part of an international listed company. Hence, there have been many changes in the organization and operating models over the years (Turpeinen, 2011).

1.2 Background

There is a major transformation going on in information technology. While constructing the infrastructure behind telecommunication networks in this rapidly changing world many crucial aspects have to be considered. To build up a process that regards the cost-effectiveness and sustainable construction, the whole infrastructure in the equipment facilities has to be taken into consideration. To master the economic and environmental impact of the construction it is important to have a wider view of the processes around. When there is an obvious connection between different tasks, binding them together is expedient (Internal Communication, 2021).

The need for combining power and cooling construction emerged after the power constructing team started developing the construction process for installing power equipment

in 2020. First, the electricity was taken into more precise control. Higher demands, e.g. in documentation, raised more questions, and the need for more accurate view on cooling and ventilation should also be taken into consideration when constructing the site conditions. In this thesis, the author will concentrate on describing more combined process to construct telecom equipment rooms concerning power and cooling conditions. The aim is to describe a process that can be flexibly transformed to fit different types of work, e.g. preventive maintenance and co-location. Rapidly developing technologies in the field of communications have emerged the need for more thorough contemplation of the necessity for sufficient electricity and cooling when there still lies the earlier technology generations in the equipment facilities. It is natural to combine the power and cooling equipment into the same process since they are organically bound together. The cooling devices use the same power as telecom network equipment (Internal Communication, 2023). Since the cooling-related equipment has been implemented as part of maintenance processes the structured process has not existed before, so the cooling needs have not been taken into account in advance while constructing the facilities for telecommunication needs. To lighten the background, the thesis will also describe some factors about the development of the process before adding cooling and ventilation. Assessing the changes in the process is set to fit for the organization at the end of the year 2023 because of the ongoing transformation (Internal Communication, 2023).

1.3 Research Questions

This thesis' purpose is to represent the combined process for planning and implementation of power and cooling equipment in Telia Finland Oyj. The combined process will promote the company's environmental goals of circularity and zero emissions (Telia yrityksenä, 2023). The thesis will manifest the answers to the question: How should power and cooling equipment-related works be combined into one sustainable process? And, how the different process steps will benefit the sustainability of network infrastructure construction? The interviews connected to the study were conducted as a quantitative anonymous online questionnaire among the closest process stakeholders.

The change will be mostly practical for the company, but also the purpose of the research is to collect knowledge about how aware the people involved in the process are about sustainability. Hence, the activities towards a more sustainable process could also be recognized and conducted better when there will be understanding of the level to discuss at, and possibly how to improve awareness. Also finding the lacking activities during the change

process will be revealed, and the needed corrections for further development can be conducted. The electricity and cooling construction process needs to be fluently connected to Telia Finland Infra Strategy, and hence to Telia Company's strategy to build transparency through the company (Telia Company, 2023e).

2 The Telecom Industry Commonly Used Equipment and Affecting Regulations

This chapter will concentrate on the current state of the commonly used power and cooling systems in the telecom industry in Finland as well as the guidelines on how the equipment should be sized up. Power systems typically consist of a rectifier and batteries, but in some cases, if backup is not needed, the rectifier can be installed only to convert the power. There are regulations that set frames for backup times and sites' physical conditions. The main document to follow on building networks is the "Regulation on resilience of communications networks and services and of synchronisation of communications networks". The regulation gives guidelines to set the right priority rating for the installed network components at sites (Traficom, 2021).

2.1 Regulated Priority Ratings in Facilities' Resilience Consideration

Priority rating sets several demands for the networks' equipment facilities for resilience and security. "Regulation on resilience of communications networks and services and of synchronisation of communications networks" sets the priority rating based on the communications service type, the number of users and the geographic coverage (Figure 1). The priority rating for the facilities where the network components are located shall be classified by the highest priority communications network or service component placed in the facilities (Traficom, 2023, p. 3).

Figure 1 Priority rating (Traficom, 2021)

Priority rating	Communications network or service component
1	A component that affects communications services in an area of more than 60,000 km², or

	a component that affects • a public telephone service of ≥ 200,000 users, or • an SMS service of ≥ 200,000 users, or • an internet access service of ≥ 200,000 users, or • an email service of ≥ 500,000 users, or • a mass communications service of ≥ 300,000 users, or • other communications service of ≥ 600,000 users.
2	A component that affects communications services in an area of more than 20,000 km², or a component that affects • a public telephone service of ≥ 50,000 users, or • an SMS service of ≥ 50,000 users, or • an internet access service of ≥ 50,000 users, or • an email service of ≥ 200,000 users, or • a mass communications service of ≥ 100,000 users, or • other communications service of ≥ 300,000 users.
3	A component that affects • a public telephone service of ≥ 1,000 users, or • a public telephone service of ≥ 20,000 users, provided over an internet access service, or • an SMS service of ≥ 10,000 users, or • an internet access service of ≥ 1,200 users, or • an internet access service of ≥ 2,500 users, provided in a coaxial cable-based cable television network, or • an email service of ≥ 100,000 users, or • a mass communications service of ≥ 50,000 users, or • other communications service of ≥ 100,000 users.
4	A component that affects • a public telephone service of ≥ 250 users, or • a public telephone service of ≥ 10,000 users, provided over an internet access service, or • an internet access service of ≥ 250 users, or

	• an internet access service of ≥ 1,500 users, provided in a coaxial cable-based cable television network, or • an email service of ≥ 30,000 users, or • a mass communications service of ≥ 20,000 users, or • other communications service of ≥ 50,000 users.
5	• A fixed telephone network concentrator, or • an access network component of a fixed network internet access service, serving more than 100 users, or • a base station of a fixed wireless internet access service, or • a terrestrial mass communications network component, serving more than 50 households, or • an optical fibre-based cable television network component, serving more than 50 households, or • a coaxial cable-based cable television network component, serving more than 4,000 households, or • a component that affects an email service of more than 5,000 users.

When the priority rating is being set by the network components placed into the facilities, the securing power supply can be dimensioned by the regulated backup times shown in the Figure 2. To put the priority rating into a more understandable context, it can roughly be said that priority rating 5 represents a single mobile base station and priority rating 3 is set to base station controller (BSC) locations that serve several base stations. This study will concentrate on priorities 3 – 5.

Figure 2 Resilience requirements for the power supply (Traficom, 2021)

Priority rating	Backup time of emergency power supply	Emergency power station and the other requirements
1	≥ 3 hours	A stationary emergency power station secured by: • N+1 redundancy for the stationary emergency power station, or

		• -extending the backup time of the emergency power supply unit to at least 6 hours, or • an available mobile emergency power station with the necessary connections
2	≥ 6 hours	A stationary emergency power station, or an available mobile emergency power station with the necessary connections
3	≥ 12 hours	Possibility to connect a mobile emergency power station, if the use of an emergency power station is possible in the location
4	≥ 6 hours	Possibility to connect a mobile emergency power station, if the use of an emergency power station is possible in the location
5	≥ 3 hours	Possibility to connect a mobile emergency power station, if the use of an emergency power station is possible in the location

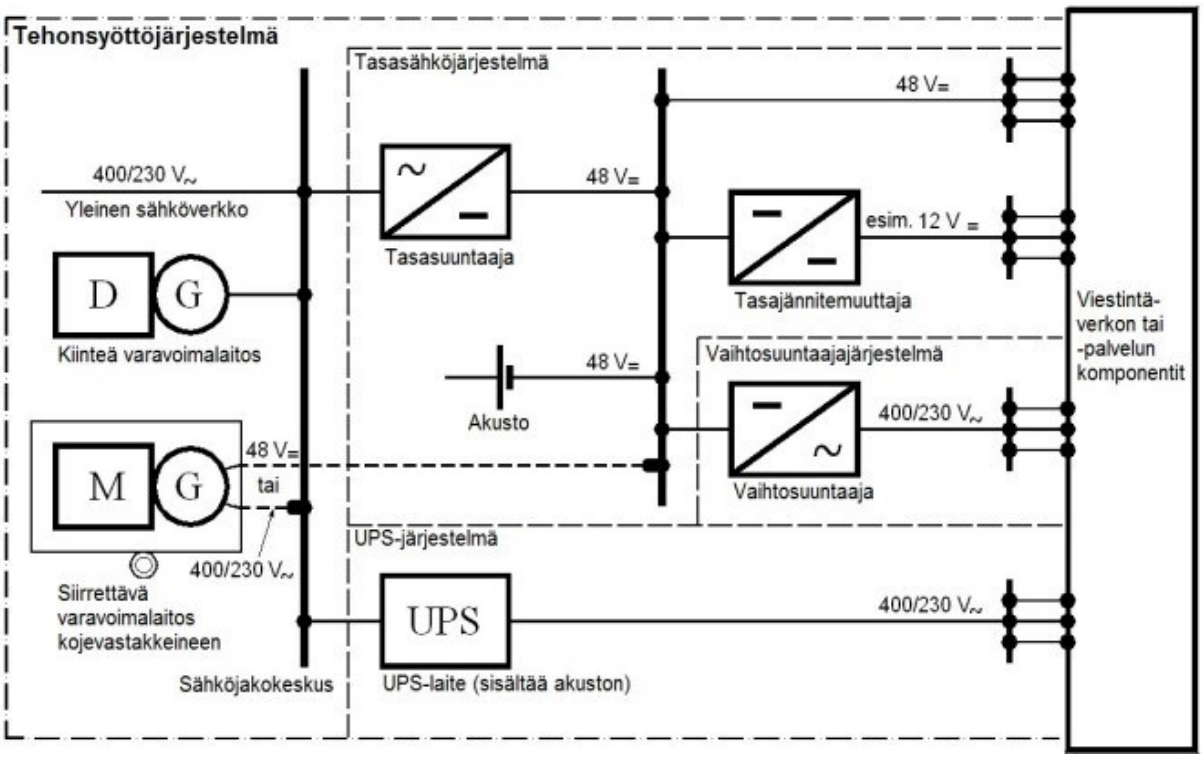
2.2 Securing the Power

There might occur faults in the power supply equipment and power cuts in the public electric network. Hence, the power supplies are required to be secured with emergency power supply units. Public communications networks or service components' power supplies consist of several components. The principle of the power supply system is shown in Figure 3 (Traficom, 2021, p. 6). The commonly used components are translated into English below:

- Yleinen sähköverkko - Electric power network
- Kiinteä varavoimalaitos – Stationary emergency power station
- Siirrettävä varavoimalaitos – Mobile emergency power station
- Sähköjakokeskus – Distribution board
- Tasasähköjärjestelmä – DC power system
- Tasasuuntaaja – Rectifier
- Akusto – Batteries
- Vaihtosuuntaaja - Inverter

- Viestintäverkon tai -palvelun komponentit – Telecommunications network services or components

Figure 3 Principle of power supply system with accumulators and a UPS (Traficom, 2021, p. 6)



2.2.1 Rectifiers

The rectifiers are used to convert 230 VAC power from electricity connection to telecom network devices commonly powering 48 VDC. The rectifier acts as a power supply for telecom devices and also maintains the backup battery charge. The dimensioning of the rectifier should be based on the total capacity need of the devices and it should be sufficient to load the batteries after a possible power cut. The rectifier must be able to recharge the batteries to 80 % of its nominal capacity within 48 hours, and at the same time feed the whole site's telecom load. The rectifier systems also enable different backup times for different loads based on the national regulations using load shedding. Rectifiers have a modular construction, and they shall be equipped with at least N+1 power modules redundancy. Except the rectifiers powering an access network component serving ≤ 30 subscriber connections when it is not required (Traficom, 2021, pp. 10–11). Rectifiers' energy efficiency have been improved during the last few years implementing higher energy efficiency capable power modules into rectifier systems (Delta Electronics, 2023). Thus, the

equipment utilized in construction are accompanying the corporate sustainability actions in energy efficiency.

2.2.2 Batteries

The batteries are the most common reserve power applications in telecom networks' backup systems. There are several types of batteries to provide the needed 48V current for the network devices, e.g. 2V and 12V cells. The cells are serially connected to provide a 48V system (Nyström, 2022, ss. 12–13). The amount and size of the rectifier's battery fuses, load sheddings, the average room temperature, and the distance between the batteries and the rectifier are the first factors to know defining the correct dimensioning for the batteries. It is also appropriate to find out the facility floor's carrying capacity, and if there is a separate room to place the batteries. The capacity for the battery backup system is defined through many other factors, and there is a significant battery selection tool to calculate the optimal battery setup, and to meet the standards (Pihlajasalo, 2020).

For the facilities where it is not possible to implement enough cooling, it is possible to utilize batteries that are more resilient for higher temperature conditions (Enersys, 2023). Also, lithium-ion batteries are becoming more common in telecommunication use. Lithium batteries are physically smaller for their higher energy density, so they can be installed in smaller rooms, and also they are lighter by physical weight. (Polarium, 2023) The lithium battery cells are typically made of two chemistry types Nickel Manganese Cobalt (NMC) or Lithium Iron Phosphate (LFP). NMC technology has a greater cycle life, a lower self-discharge rate and higher energy density. LFP cells have lower energy density and cycle life, but still, they have good performance in the correct conditions, and they are also less expensive than NMC cells. Also, NMC includes cobalt which is considered to have major sustainability risks in the supply chain, e.g. the political risks in the countries that have cobalt mines, and the use of child labour (Campbell, 2020). Lithium batteries can also be used in different energy storage models, and in some locations even replace diesel-powered emergency power stations (Internal Communication, 2023).

2.2.3 Emergency Power Stations

On higher prioritized sites, there is a need to use emergency power stations to ensure the resilience of the network components. Practically the power stations are diesel generators, and they can be stationarily installed which start automatically in case of a power cut, or the

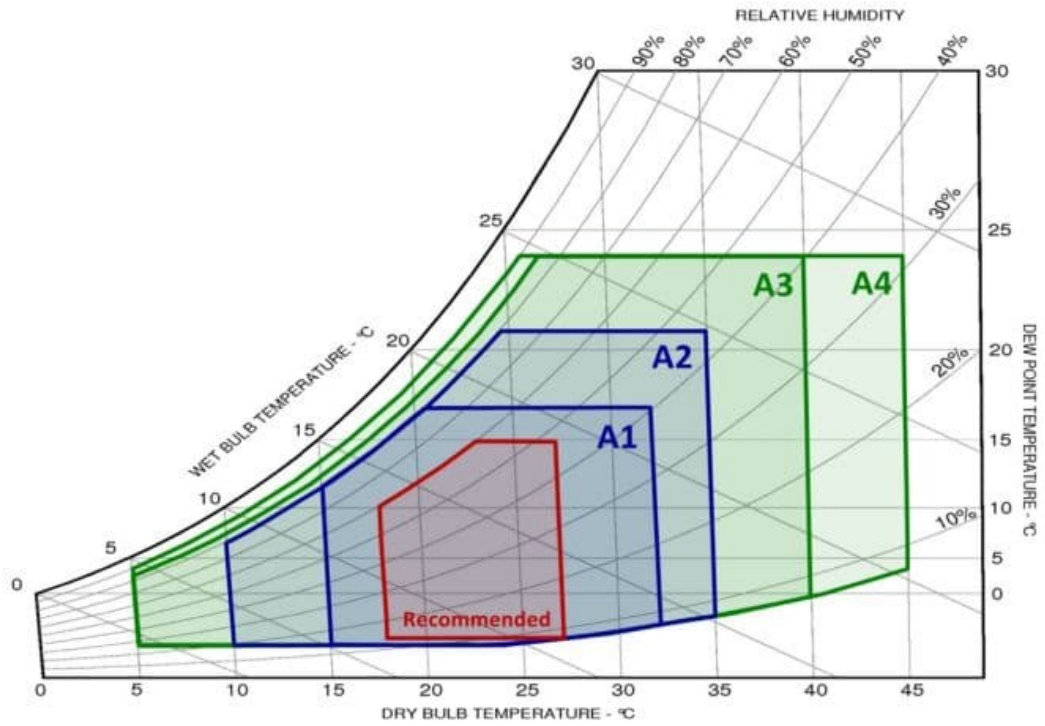
facilities might have a possibility to connect a mobile emergency station in case of a power cut that lasts longer than the batteries can provide the power. Using stationary power stations the battery backup capacity can be lower. For example, in the facilities at priority rating 3 with a stationary automatic emergency power station the minimum battery backup time is three hours. (Traficom, 2021, p. 9) Although stationary power stations can be a rapid help during power cuts, they still have remarkable disadvantages. A generator always needs to be located in a separate room, and even greener fuels are available nowadays, the amount of fuel should be enough for a week's use. This set challenges for fuel tanks' placement in the facilities.

2.3 Cooling and Ventilation Solutions

When planning the equipment facilities, the room size and overall heat causing power inside the room must be taken into account to define the possible need for active cooling. The telecom devices have their individual operating temperatures. The telecom devices can operate in significantly high temperatures, e.g. Cisco's equipment can run up to 82 °C before the CPU will be taken offline (Cisco Systems, 2023), but still the optimal temperature is between 10 and 35 °C. Thus, the temperature is a crucial factor in equipment's and facilities' lifecycle management. High temperatures can harm the backup systems even more than the telecom devices, e.g. right room temperature provides a longer battery lifecycle as the batteries' optimum operational temperature is usually near 20 °C and temperature increase decreases the battery life cycle. For example, Enersys PowerSafe V batteries' lifecycle decreases by approximately 50 % for 10 °C room temperature increase (Enersys, 2022). In Telia Finland's activities, the main reason for cooling the facilities is to optimize the battery lifecycle, whilst the sensible room temperature also reduces unwanted reclamations about noise or heat issues (Internal Communication, 2023).

According to the goals in Telia Company's sustainability programme (Telia Company, 2023a, pp. 73–126), the aim is to utilize ventilation as much as possible to keep the temperatures at the wanted level, and implement cost-efficient and energy-efficient cooling solutions (Nyström, 2022, p. 19). (Internal Communication, 2023) The recommended temperature ranges are set to Telia's instructions using the ASHRAE chart (Demetriou, 2019) (Figure 4).

Figure 4 ASHRAE Thermal Guidelines for Datacom Equipment



The facility's temperature variation can be out of the recommended range (Figure 4) not more than 11,5 % of the time, which means 1007,4 hours a year. The recommendation concerns all the facilities with lead-acid batteries. Figure 4 describes the temperature conditions for the equipment facilities. The facility that meets the described ranges shall be considered as "hot site", and actions to remove extra heat shall be started (Internal Communication, 2022; (Nyström, 2022, p. 19).

- Recommended temperature 18 – 27 °C
- Temperature may vary from recommended inside the range 15 – 32 °C max 10 % of the time, meaning 876 h a year (ASHRAE A1)
- Temperature may vary from recommended inside the range 10 – 35 °C max 1 % of the time, meaning 87,6 h a year (ASHRAE A2)
- Temperature may vary from recommended inside the range 5 – 40 °C max 0,5 % of the time, meaning 43,8 h a year (ASHRAE A3)

The set temperature levels can be reached by several different solutions. There are a few factors to take into account when planning the cooling solution. For example, the heat load can be so high that free cooling systems wouldn't give enough cooling capacity, then active cooling is the only solution. Also, some structural obstacles can make free cooling an

unfavourable solution. The lightest solution is that the air flows through the vents unfiltered and without fans, which is known as “No cooling” version in the company’s instructions. The temperature value settings for different cooling solutions are shown in Figure 5 (Internal Communication, 2023)

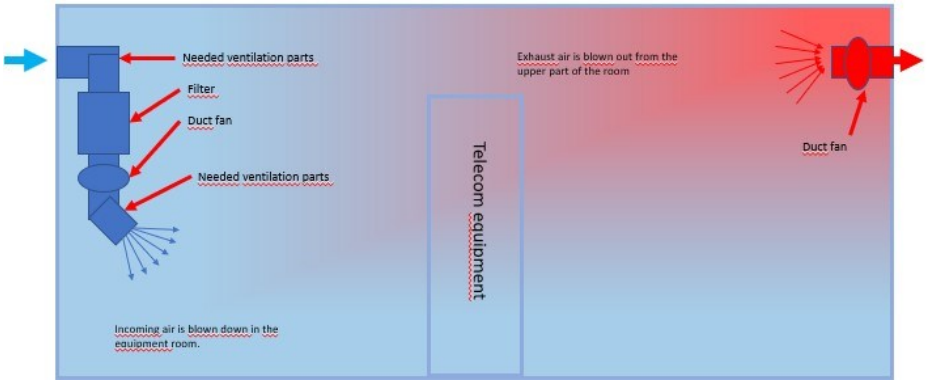
Figure 5 Temperature settings for cooling equipment

Cooling solution	Temperature setting for fan	Temperature setting for cooling device	Temperature setting for heating	High temperature alarm	Low temperature alarm
No cooling	-	-	+ 13 ºC	+ 35 ºC	+ 10 ºC
Free cooling (Fan)	+ 20 ºC	-	+ 13 ºC	+ 35 ºC	+ 10 ºC
Active cooling	-	+ 20 ºC	+ 13 ºC	+ 35 ºC	+ 10 ºC
Active cooling & Fan	+28-30°C (+4°C hysteresis in relation to the cooling machine.)	+24-26°C (-4°C hysteresis in relation to the fans.)	+ 13 ºC	+ 35 ºC	+ 10 ºC

2.3.1 Ventilation

Ventilation is considered as low-cost system while planning the facilities’ cooling systems. Typically the systems are implemented by installing duct fans to strengthen air flow in the facility, which is the most considerable solution in the company instructions. The fans can be used in inlets as well as in outlets of ventilation, when the inlet leads the fresh air through the filters to the equipment room, and the warm air is blown out through the outlets. Duct fans can be used in cases where the heat load is not very high. Also, the possible noise issues must be considered in planning. The spinning fans’ motors can cause resonance in building structures (Internal Communication, 2023). Using airflow to cool down the facilities is the solution to be considered first because of its low installation costs, but also lower costs in maintenance and power usage. (Systemair, 2023) There are typically two types of motors running duct fans used in installations, AC powered and DC powered EC (electronically commutated) motors. The commonly sized (315 mm radius or less) fan motors’ power usage is around 200 W at maximum. EC fans are typically used in emergency cooling (Internal Communication, 2023). As the solution does not need any refrigerants, and not necessarily use complex electronic circuits, they are burdening less nature by using less resources in manufacturing.

Figure 6 The principle of cooling installations in Telia Finland's facilities (Internal Communication, 2023)



2.3.2 Active Cooling

In situations where ventilated air flow is not giving the needed cooling capacity or installing the ventilation is not feasible due to the location's specific features, active cooling shall be implemented. People might know active cooling devices better as air source heat pumps, that consist of indoor and outdoor units. When heat pumps are used to support telecom facilities conditions, the device shall be set on cooling mode, and the temperature shall be set by the values shown in Figure 5. Air source heat pumps (ASHP) can provide cooling power almost three times compared to the input power used (Panasonic, 2023). Hence, as advantages of ASHPs can be mentioned low primary energy consumption, and they also have low costs in installation and maintenance. The coefficient of Performance (COP), which is used to present the efficiency of systems, is on a good level compared to the costs in investment and maintenance, although the COP varies with ambient temperature. ASHPs pollution causing concerns are notably low unless there will not be any refrigerant leakage (Gaur et al., 2021).

2.3.3 Emergency Cooling

As the regulations' explanatory memorandum points (Traficom, 2020, p. 36), if the facility must be secured to be resilient for longer than three hours power cuts, the securing power systems shall be sized so that all the systems that secure communication services will work the needed time. This means that e.g. electronic locks, fire and burglar alarms must keep working the needed resilience time, as well as the cooling. In these situations, DC powered fans are used. The fans use the facility's battery backup and their power is controlled with an

external DC controller or they can be controlled by the facility monitoring system in locations with priority rating 3 or higher (Internal Communication, 2023).

Figure 7 DC fans installed as an emergency cooling device

By the regulations, it is not mandatory to install backup systems for active air conditioning devices, but in some locations, it can be reasonable to install the equipment to backup system with an external inverter to get 230 VAC out of 48 VDC batteries. The solution can be considered in the facilities where the piping for fans would be too complicated to implement, and sufficient battery capacity is available. (Internal Communication, 2023) For emergency cooling purposes used EC fans have the same sustainability impacts as mentioned in 2.3.1, but they are typically using the facility's battery backup, so they can partly make the networks more resilient.

2.4 Sustainability Related Societal Trends and Regulative Guidelines in the Industry

Now that the world seems to step from crisis to crisis, many think tanks have made their own studies about the societal future directions. The COVID-19 pandemic changed the world very quickly, especially the working life when employees in many industries started working remotely instead of commuting to the office. As the pandemic developed the working conditions and speeded up the digitalisation at several levels, the ongoing war in Ukraine has had a huge impact on the ways people see the future. (Dufva & Rekola, 2023) The Finnish Innovation Fund Sitra has published the Megatrends 2023 report, which sets some framework to help people and businesses by giving new angles for thinking and to find

innovations. It is important to find solutions that can help the world in the future, though there are factors like war shaking world politics, economics and environmental views as well. The megatrend publication by Sitra gives some views about the five themes: nature, people, power, technology and economics (Dufva & Rekola, 2023). These are commonly recognized trends, and the trends the company mentions in its 2022 annual and sustainability report, mainly conform to them (Telia Company, 2023a, p. 76).

As the telecom industry is very highly regulated in many ways, the power backup and many other aspects must be secured by international and local laws and regulations, e.g. physical security in certain priority rated sites (Traficom, 2021, p. 12). The companies can answer to several societal questions by fulfilling the regulated demands, as well as with the sustainability actions that can promote that the construction meets the regulations.

The United Nations' Sustainable Development Goals (SDGs) that Telia Company has included in their strategy connects it to the sustainability targets. (Telia Company, 2023a, pp. 73–126) The power and cooling process has straight connections to several SDGs in the company's strategy. With SDG 9 the process can make an impact towards new technologies that could help with less consumption and combined innovations, e.g. with other property users or landlords. This will lead to more sustainable cities and communities (SDG 11) and cleaner energy usage (SDG 7). By optimizing the equipment to be used to fit better for the specific locations and with better instructions policy is possible to reach responsible production (SDG 12). All actions to be taken improve this kind of process and will relate it to climate actions (SDG 13). By ensuring strong partnerships (SDG 17) it is possible to make decent work and economic growth (SDG 8) for the whole supply chain.

Figure 8 SDGs in Telia Company's strategy (Telia Company, 2023a; UN, 2023)

As an international company, Telia has to follow local laws and regulations as well as the international guidelines. European Union sets the regulative guidelines and laws for acting in Europe. In 2018 European Parliament established the European Electronic Communications Code (European Electronic Communications Code, 2018), which sets up the framework for the communication networks industry in the EU region and the corresponding local laws. The laws are refined by regulations, that Finnish Transport and Communications Agency prescribes and controls (Traficom, 2021). The regulations play a significant role in evaluating the cooling and power backup systems' capacity by setting the specific hourly backup times and demands for physical security.

The electricity installations and equipment must follow the Electrical Safety Act 1135/2016 (Electrical Safety Act/1135/2016). The law specifies the personnel to perform the installations and how the installations shall be done. Land Use and Building Act (Laki Sähköisen Viestinnän Palveluista 917/7.11.2014/2015) have to be followed when doing other installations and constructing new sites. The Land Use and Building Act will be reformed in 2025 when the new law comes to force promoting digitalization and demanding the decrease of emissions (Ministry of the Environment, 2023).

3 Purpose and Objectives of Development Work

After many changes in the organization and processes electricity construction was recognized to be a pivotal set of different actions to be taken into account in network construction. In late 2019 the Infra Networks Unit decided to establish a separate Power team whose responsibility was to support mobile networks construction, and maintenance-based investments. The team started in January 2020. In the second half of 2021 also fixed networks' facility changes and fixed access networks were included as a part of the team's responsibilities. Transport network equipment modernization started new discussions about the factors affected by the equipment combination at facilities, so the need for more profound conditions contemplation emerged, and cooling constructing was decided to be included as a part of power construction. In 2022 Power team started to practice the cooling construction supported by the air conditioning and ventilation experts. The cooling is now part of the team's responsibilities from the beginning of 2023 (Internal Communication, 2023).

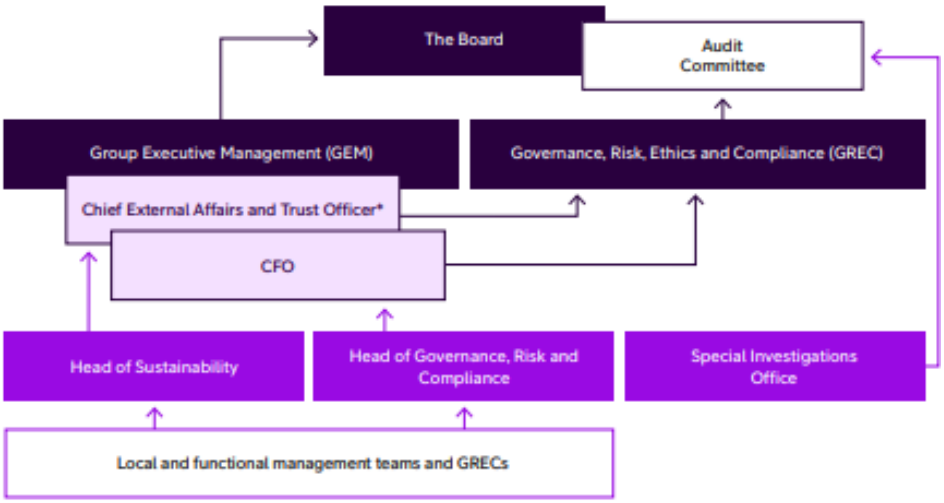
3.1 The Company's Sustainability Programme as a Part of the Process

The importance of sustainability has been recognized in Telia Company many years ago. Sustainability is led by the corporate sustainability unit, and there are also appointed sustainability representatives in local country organisations. Sustainability is recognized as a pivotal part of the purpose of the company, 'Reinvent better connected living' includes four strategic ingredients that aim to improve people's digital connectivity, promote inclusion and diversity, and deliver sustainably (Telia Company, 2023d). Telia is also committed to promote diversity in its activities, equal and inclusive working culture, and ensuring the health and safety of the employees and people working for the company processes.

Telia has a remarkable role promoting sustainability in many ways. The company has set the goal by 2030 to be zero waste using circular economy and zero emission company over the whole value chain. The science-based targets for 2025 are a 50% decrease in the company's own emissions, a 29% decrease in emissions caused by customers using the products and services, the suppliers representing 72% of the supply chain's emissions have set SBTs, and 84% of waste materials will be reused or recycled (Telia, 2023e). The sustainability organization is continuously improving the sustainability-related terms in Telia Company, and for example, it was announced in September 2023 that the company's targets for net-zero greenhouse gas emissions across its value chain by 2040 have been approved by the Science Based Targets initiative (SBTi) (Telia Company, 2023f).

The company's management system is built on one common strategy, targets, purpose and values (Telia Company, 2023b), and it is ensuring the alignment of country level focus areas and goals with the common strategy. The Board is overseeing the sustainability in the whole company, and it receives sustainability performance reports at least twice a year.

Figure 9 Telia Company sustainability governance (Telia Company, 2023, p. 78)



The management system (Telia Company, 2023c) includes several certifications that are performed by an independent accredited third party. Telia Finland brands have the following ISO certifications:

- ISO 9001 Quality
- ISO 14001 Environment
- ISO 45001 Occupational health & safety
- ISO 27001 Information security
- ISO 20000-1 Service
- ISO 22301 Business continuity
- ISO 50001 Energy efficiency

Quality and environment certifications have a direct connection to construction processes. It is important to follow that all activities in the process are being run in a correct manner to deliver with high quality, so the facility conditions construction is bound to ISO 9001 by following the described process and regulations related to the process activities. Environmental factors must be considered at every step in the process, but mostly these questions emerge in logistics and managing the materials. In construction material logistics and warehousing must be arranged with high accuracy and security, and materials removed from the network must be processed correctly by ISO 14001 terms. Reusable equipment shall be sent to the recycling warehouse, so applicable devices could be addressed to a new location, and end-of-life or defective equipment shall be sent to a recycling partner for proper processing. (Internal Communication, 2023) ISO 45001 is taken into account when Telia's internal employees or subcontractors are doing activities in Telia's processes. All the

activities must be performed safely, and the equipment facilities shall be planned and implemented so that the risks to people and the environment will be minimized. The author sees that other certifications are concerning the conditions construction process more indirectly. The process can be seen to support the other parts of the company to manage the other certifications, e.g. energy efficiency must always be considered for the whole facility when planning a single equipment installation, and correctly sized backup installed with high quality affects business continuity.

3.2 Work Types

At Telia Finland, the power equipment construction team is located in the Infra unit's Transport business line. The unit is responsible for arranging the possibilities for telecommunication network equipment to be deployed to the sites as well as to manage the premises and infrastructure maintenance. The power team's responsibility is to support other constructing departments in the Infra matrix with their daily actions by ensuring conditions at equipment premises. Hence, there are several types of assignments that the Power team is handling by ensuring the facility conditions for new equipment installations. The team manages the installations that generate investment costs in several subprocesses where the physical installations are being done by partnering subcontractors, Thus, subcontractors are the most important stakeholders for the process deliveries, and material suppliers also play an essential role in the supply chain (Internal Communication, 2021).

3.2.1 Fixed Networks

The fixed networks could be better understood as cable networks that nowadays consist of fibre cables and the related devices as the old copper lines have been widely dismantled (Telia, 2023b). The fibre network devices need comparatively much power to work at site locations as they can handle big amounts of networking capacity, and the power caused heat stays in the transmitting facility since the signal is converted from electrical power to light's wavelengths that are transferring data through fibre cables (Paussu, 2022, pp. 18–19). Fixed telecommunication networks consist of three domains. Core networks are used to provide nationwide and global connections for long distances. Aggregation networks are used to build connections to metropolitan areas, and they usually consist of in ring topology connected metro switches. Access networks are yet more local to connect the users to the network through the connection by the service provider (Savi et al., 2015). Mobile base stations' transmission connections are also provided through fibre networks. This study is

concerning with conditions' process support mostly aggregation and access networks' construction, so the fixed network construction is conducted in facilities at priority ratings 3 and 4.

As fibre networks can provide high speed and networking capacity their energy efficiency is good compared to megabytes, but still increasing data speeds cause growth in the overall power usage. Assessing the overall sustainability of fixed networks' operating energy is only a drop in the ocean. Cables are usually located underground, so they are excavated into the soil, so construction work would be more crucial in contemplating the sustainability of fixed networks. Fixed network construction generates amounts of waste, and construction waste amounts are reported in Annual and sustainability report (Telia Company, 2023a, p. 109). The table below shows the amounts of different types of waste in the whole company reported for the years 2021 and 2022.

Figure 9 Construction waste in 2021 and 2022 (Telia Company, 2023a, p. 109)

Waste (kilotons)	2022	2021
Construction waste	66	81
Stone, gravel, asphalt	38	55
Impregnated wooden poles	21	20
Metals	3	3
Cables	3	2
Wooden material from construction	1	<1
Electronic waste	2	1
Batteries	1	1
Office waste	2	2
Total	71	85

3.2.2 Mobile Networks

During the last decade, there has been a rapidly developing trend in mobile networks construction demands. After 2010 there was the first competition of 4G business and very quickly the technology developed and the industry turned to 5G networks in Finland. Although having the hottest 5G competition, there still are two older mobile generations in use which are causing load to the backing infra. The more equipment there is at the site, the more there is need for power, and higher power usage causes more heat. All three commercial operators in Finland have announced that they will shut down 3G services during 2023 - 2024 (DNA Oyj, 2021; Elisa Oyj, 2023; Telia, 2023a). In Telia Finland's process, the site facilities conditions are being checked before the actual mobile base station installations for the significant availability of electricity, and after the change, also the correct room

temperature. The electricity and physical conditions are considered as important as the transmission lines for the mobile base stations (Internal Communication, 2023).

Mobile networks have developed rapidly during the last ten years and the last couple of years the operators have been competing for 5G customers. Implementing new technologies alongside the earlier network generations increases energy. New technologies can have better features compared to the earlier generations, and e.g. 5G network has been noticed to be much more energy efficient than 4G. (Lahti, 2023) Except 5G has better energy efficiency than the earlier generations it also enables modern use in industrial environments, e.g. remote machinery control and automated quality control for its low latency and network slicing feature. Network slicing can be a feasible solution for smaller industrial applications to create virtualized networks utilizing the existing 5G networks while minimizing the costs, both capital expenditure CAPEX and operational expenditure OPEX. 5G could also enable a sustainable ICT environment for IoT solutions in Smart city applications and hence promote economic growth and digitalization while more people are moving to urban environments (Rao & Prasad, 2018).

3.2.3 Co-location

In Finland, the law requires operators to enable other companies to place their equipment into the facilities the competitive company is mastering. Co-locating several operators' equipment into the same rooms, it has to be ensured that there is enough room and electric capacity, and that all the equipment room conditions fulfill the regulations. By the law for electronic communication's services paragraph 53, availability to implement the competitor's equipment must be granted if it is not causing excessive hindrance for the facility holder (Laki Sähköisen Viestinnän Palveluista 917/7.11.2014/2015). The co-location conditions process is a part of the sales process in the operator business, which is supported by the electric constructions team to ensure the technical readiness in the facility for external operator's installations. The co-location process starts by availability inquiry by another operator to locate their equipment in the facility holder's room. Most usually the inquiries are being made for constructing mobile coverage, but they might concern fixed connections as well. The earlier mentioned 3G shut down by all the Finnish customer connections offering operators can be seen in the availability inquiry numbers (Internal Communication, 2023). From sustainability point of view, co-locating is reasonable in an economic way when every operator will not build separate infrastructure in the same buildings, although it is not always possible to avoid different network construction needs. Also, there is a societal angle when

real estate owners, building societies and landlords don’t have several operators to communicate with.

3.2.4 Faults and Modernization

Modernizing the equipment is a part of lifecycle management. The modernization is a process where the end-of-life equipment renewal is typically implemented proactively following yearly programmes. The modernization programme is based on equipment lifecycle information, as well as on other risks in the facilities, e.g. hot site. (Internal Communicaton, 2023) A remarkable amount of rectifiers and batteries are being modernized within network construction processes when new mobile base stations or core network devices need more electric capacity. The facilities where end-of-life equipment are located and the locations are not included in the other network construction programmes shall be considered to be emerged on the modernization list. Modernization can be conducted by expedient optimization of equipment lifecycles. During the last five years amounts of new devices have been installed and their lifecycle is coming to an end soon, so a proper lifecycle management process must be implemented to respond to the coming years’ needs.

The need for modernizing the devices might also emerge in case of malfunction. This kind of reactive assignements are divided into two priority levels to recognize critical (Prio1) and non-critical (Prio2) SiteFault assignments. The failures that jeopardize telecommunications, or might cause danger for people or for other property near the facility, need instant attention and must be promptly repaired. The incidents that need this kind of instant reacting should be set on the highest priority. The critical incident can be e.g.:

- Severe bulging of a battery
- Crack in a battery cell case
- Battery voltage collapse (interruption) or strong heating of the battery cell
- Failure in the rectifier system so that it is unable to supply the tele-load and charge the battery within 48 hours
- Risk of fire
- Risk of personal injury for anyone

If there are more than two battery strings installed to the backup system, a single string failure is not considered as critical failure (Internal Communication, 2018). The failures might emerge e.g. when some equipment sends alarm information about malfunction, e.g. battery test could fail and the batteries are noticed to be corrupted. In such cases, if warranty period

is expired, there is a need to invest to new battery equipment. Modernizing the rectifiers is not as critically dependent on the warranty period because of their modular construction, and components can be changed. Nonetheless rectifiers may have other critical issues that need instant reactions. For example, the issues in rectifiers can cause a risk of fire, and the equipment should be replaced immediately. (Internal Communication, 2023) The modernized rectifier must meet the capacity requirement in the facility.

3.3 Planning and Documentation of the Works

3.3.1 Planning

All the assignments start with onsite planning visit. Its purpose is to collect necessary information about the facilities' current conditions. According to the collected data the coming installations can be planned comprehensively enough to fulfill also possible future installations. The installation planning document shall include general pictures of the facility, pictures and statement of the current equipment. Also calculations and statement of needed installations shall be presented (Nyström, 2022, pp. 23–24). The current planning instructions set demands to contemplate the facility with wider view than only the current assignment, so the planning process has already been created considering sustainability questions. Although the stakeholders must be reminded about the process from time to time.

3.3.2 Documentation

Subcontractors must produce several documents that express the conditions after installations. The documents must accurately match the executed installations, so they can better serve the future installations as well. Telia Finland require the following documentary to accept the delivery:

- DC system diagram
- Electrical distribution circuit diagram
- Grounding diagram
- Switchboard diagrams
- Rectifier main diagrams
- Electricity as built layout of the site drawing
- Commissioning inspection report
- Quality Report

- Report of verification inspection
- Final delivery document

Commissioning inspection must be carried out before the electrical installations are taken into use and the report of the inspection must be handed to the customer. The commissioning inspection report must be performed by a professional electrician (Tukes, 2023a). By comprehensive documentation the coming assignments' planning can be made lighter in the future, and in the best situation the planning could be conducted on the desk without separate visit to the location.

3.4 The Challenges in the Process

As it is well known, the development process usually starts with identification of the challenges in the current ways of working. Very often the needed changes are being run maybe too staight forward without further contemplation of the effects caused by the change. (Baloh et al., 2018) The change process should always follow the certain steps to succeed. Power construction process has changed many times during the years, but there has been lack of prior clarifications, which direction the process should be developed. The same happened with the start of current power constructions team in the beginning of 2020, but this time the concerned team was involved in the change process (Internal Communication, 2020). The developing team found out that the process instructions were not up to date. Going through and possibly updating the existing instructions, and creating new ones was a major task to be carried out. Also documentation of facilities and works were not found comprehensive enough. The team wanted to build a documentation process that would also help future installations, and possibly decrease the need for onsite planning in coming assignments. The planning and documentation have been recognized as time consuming entities inside the assignments, so it was agreed that paying extra attention to get feasible documentation from the facilities during a couple of years would be needed to get big amount of documentation updated (Internal Communication, 2020).

One major challenge in infra construction is the number or locations. Telia Finland is maintaining about 5,000 facilities from single base station locations to bigger data centres. Also different sub-processes and other operators' needs via the co-location process cause sometimes difficulties aligning the needed operations into the same assignment when all the needs from outside of the company could not be anticipated (Internal Communication, 2023).

3.5 The Questionnaire Results

As the process development is already underway, it was necessary to find out if there are some factors that might have been unseen. It was considered to be important to hear the thoughts about the change from closely involved stakeholders to see if the development is going to the right direction. The research was conducted as a qualitative questionnaire during the summer of 2023. Altogether the invitation to the questionnaire was sent to ten people involved in the process in Telia and subcontractors' organizations, and six answers were received. The interviewees answered anonymously. The questionnaire is also a part of communication with the stakeholders, and communication is recognized to be a major element in the change project's success (Hornstein, 2015). By the interview questions, the author was striving to figure out the interviewees' personal thinking, as well as the overall conception of the change inside the organizations. The qualitatively structured open questions questionnaire as a research method is justified to find out possible biases towards the change, and give interviewees a possibility to express their own thoughts openly (Appendix 2). The three first questions were targeted to more concrete factors in the process, and the other three concentrated more on organizational and personal aspects.

The first question was: How do you see the process where electricity and cooling works are on the same assignment is affecting the productivity? The answers point out that setting the assignments to a wider scope has a positive effect on productivity. The interviewees tell on general level that wider assignment helps to see the whole facility's conditions as a whole, and savings can be reached in planning, resourcing as well as in travelling. It is valuable to plan sufficient electricity and backup systems, but also the correct temperature conditions have positive effect on equipment lifecycle. The second question's purpose was to deepen the answers to the first one, and it asked if there have been changes in concrete parts of the process. The instructions in the process were seen clearly improved. Material use has become easier after clarifying the catalogues with the equipment suppliers. It was still mentioned that challenges in availability of some materials still existed. The timing of the assignments was told to be easier and clearer when electricity and cooling works can be communicated with the same purchaser, albeit some interviewees told that material availability can hamper the time setting. The communication between the stakeholders is now better after improving the meeting practises in the process. There were also comments that communication is at the same level as earlier, and the change wasn't very visible, and this kind of answers can be possible if the interviewees haven't been part of the process very long. It was also mentioned that by getting the assignments earlier to the subcontractors, anticipation of the works has improved.

The questions 4 – 6 concentrated more on the interviewees' personal opinions, and on the feedback in their organizations. The answer to the fourth question showed that overall the people involved in the process have received the change positively, even in the beginning there has been versatile feedback. Some feedback told that it has been good to get acquainted with cooling equipment, and considering cooling as part of the plans was mentioned to drive the execution of assignments to more reasonable direction. Some answers mentioned the personal development needs when new technologies must be understood which was seen as a positive professional development. The fifth question was about connections between the process and the interviewees' companies. Some of the answers stated that the straight connection could be difficult to see, but this kind of comments might also reveal the need to improve the sustainability awareness in the organizations. Mostly the connection was seen to improve the equipment lifecycle. The answers to the sixth interview question showed that the organizations in the process chain have recognized some improvement needs in their own organizations, but the bigger changes have not been executed. It can be found in the answers that in the most of organizations in the chain the small improvements are being executed continuously to become more sustainable.

4 Project Planning and Execution

The process of site conditions has encountered a massive change during the last three years. The current power construction team was established in January 2020 to be responsible for mobile sites' electric connections' installations, and on the way the scope was expanded to include all electricity in the equipment facilities. In 2022 the fixed network sites were added to the process, which made the 2023 added cooling works a natural part of the process too. The instructions have been quite fragmented by location and form because of the earlier organization structures, and many changes in organization. In 2022 was found very good collaboration between the right teams to develop the processes, and the collaboration has become even closer after organization changes in Telia Finland Infra in the spring of 2023. The collaborative groups are located in the same production line Telia Finland Infra Transport. The site managing orgazation is responsible for managing all Telia Finland's equipment facilities and has experts for electricity and cooling, as well as for real estate management, and the Power team is part of the construction management organization purchasing the subcontracting and materials (Internal Communication, 2023).

4.1 Change of Electricity Installations Process

Before the current team started in 2020 there was more fragmented process for managing the power equipment and battery installation assignments. There were separate playbooks only for the maintenance work types faults and modernization to describe how the particular assignment should have been managed. The playbooks were actually quite well compiled, but they were working best in separate assignment environments where different construction process needs were not so well taken into consideration. Also, power equipment installations for telecommunications networks needs were constructed as part of mobile networks construction process. There was an expertise gap in power related construction while the process was concentrating on mobile networks' improvement. The organization started activities for closing the expertise gap by introducing new construction model, where electricity related installations were separated from the telecom construction process and power equipment should be installed before mobile installations. In January 2020 a new team started with dedicated resources, including team lead and project managers. Also, required stakeholder meeting practises were started for communicating the new process (Internal Communication, 2020).

The new team started to build a new process by gathering up the earlier power related instructions to find out if they were up to date, or if something was missing. It found out that some of the activities had become practices without any concrete instructive material available. During 2020 power equipment construction was still executed by the existing playbooks, but as Power Team was established to develop processes, new approach for the subcontractor assignments was started. Then was the first time to combine different assignments together, e.g. lifecycle-based modernizations were conducted within fault repairing assignments, and modernization list was crosschecked with roll out locations in the roll out process to avoid unnecessary multiple assignments for the same facility location. Also need for some service product changes were recognized to remove overlapping invoicing and clarify the product catalogue. One remarkable part was renewing planning and documentation products, and separating them from installing products (Internal Communication, 2020). The new products were evaluated within an RFQ process for subcontracting contracts and implemented utilizing the change of agreement period. At the same time, more detailed documentation requirements were implemented to make an inventory of equipment facilities and update the documentation. To invest in better documentation was seen as an investment for the future when more comprehensive information about the facilities could lighten forthcoming assignments' planning (Internal Communication, 2020).

In the spring of 2020 the established team started to take responsibility of supporting telecommunications networks deployment by agreed power assignment categories. There were four power related categories in the beginning to delimit to address the assignments to the correct process:

A. No changes
B. Small – purchase within telecom assignment
    - Battery expansion (≤ 200 Ah)
    - Rectifier module expansion
    - Rectifier distribution breaker change
C. Medium – purchase by Power Team (inside the equipment room)
    - Battery change
    - Battery expansion (> 200 Ah)
    - Rectifier system installation
    - Rectifier system change
    - Outdoor rectifier system
    - New location
D. Large - purchase by Power Team (outside the equipment room)
    - Riser expansion
    - Main switchboard breaker expansion
    - Electric connection expansion

The category setting turned out to be confusing for the process, so it needed some clarification. During the second half of 2020 new responsibility definitions were made to transfer more electricity concerning activities on Power team's responsibility. 5G rollout programme was about to be so large in 2021 that mobile network equipment implementation process needed to be faster, and the mobile construction process needed all its resources and expertise to concentrate on mobile networks concerning activities. At this point also in the beginning of year 2020 defined power equipment installation catogories were called off, and all electric installations, except changing single rectifiers' distribution breakers, were started to address to Power Team in the late 2020. (Internal Communication, 2020) After removing the confusing categories it was easier to keep up with the wanted documentation demands when there were less project managers to review the documents. After the change there are only two indications for the need of power related assignments to communicate whether Power team's actions are needed or not: 'No Power tasks' to indicate that there is no larger electricity activities than distrubution breaker adding or change needed on the

rectifier, and Power team Rollout to indicate that electricity on the site location needs further contemplation.

When the definitions and delimitations in the process were clarified, it was easier to concentrate on the nuances in service products in the winter 2021. Higher demands for the documentation was released in new service agreements when the service products were shaped to better support wider documentation. During 2021 electricity construction process started to function in a way that the primary target was. There was a desire that electricity would be implemented about a yearly quarter before mobile installations, so the telecom equipment implementation would be fluent. (Internal Communication, 2021) At the same time in 2021 fixed network modernization process needed help with ensurin the site conditions, and the decision to turn also fixed networks concerning electricity assignments to Power Team was made. Thus, facilities with priority ratings 3 and 4 (Figure 1) were pointed to be in Power Team's responsibility in telecom network changes.

In 2022 the process had been made up and running (Internal Communication, 2021), and there were more possibilities to further develop the tools and instructions which should be continuously developed to meet the process needs. To discuss about sustainability in the process, the author finds several elements in the process to be developed in the future. Optimizing the batteries and rectifiers to be used in installations would help with material forecasting and possibly could lead to more cost-efficient purcasing of the equipment. It can still be challenging to define the number of equipment types, so the spare part logistics process and warehouses could be feasible. The list of reusable materials must be developed to help subcontractors to return the usable equipment to be reused in new locations. It was recognized that managing the whole equipment facility's electricity the possible cooling needs must be taken into consideration while sizing the electric connections, and the number of such cases seemd to increase (Internal Communication, 2021), so the separately constructed cooling was found as a bottleneck in base station installations. That is why the overall conditions in the equipment rooms must be contemplated in a bigger scope.

4.2 Adding the Cooling Installations to the Process

Cooling equipment installations have been constructed as totally unattached assignments until 2022. Needs for cooling in the facilities have earlier been emerging mostly reactively, after receiving high temperature alarms via monitoring systems, and without particular process. If the facility's temperature has risen high enough, it might already have harmed batteries before the cooling equipment implementation. To get cooling related activities

managed effectively there must be a structured process that promotes structured construction timeline, and fosters timely purchasing. Discussions and preparations for managing cooling construction as part of electricity assignments started in the autumn 2021. First the cooling works were supposed to be added to the power process during 2022, but it was postponed due to changes in the organization. Still the first cooling devices were constructed by Power Team in 2022 as part of cluster construction model in mobile network construction and in fixed network modernization process. It was practicable since the cluster model makes several facility locations a project to improve mobile networks coverage and capacity inside a defined geographical area or municipality, and there is a designated project organization for every cluster which includes experts for all needed equipment. Fixed aggregation networks' improvements require activities in facilities with higher priority rating that might have much equipment inside, and hence the overall conditions check is more critical in such locations to ensure resilience after the implementation of new equipment (Internal Communication, 2022).

The benefits of contemplating the temperature levels and need for cooling at the facilities are natural to be carried out at the same time with electricity and power equipment planning. Hence, the power equipment can be sized correctly and the electric connection capacity can be ensured to be high enough to serve all the needed devices. Operating in very versatile locations installing cooling devices can point out to be impossible, and then heat load must be tried to move outside of the room, and possibly batteries must be selected from types that tolerate higher operating temperatures. Also, the loads for each phase on the whole facility's electric connection will be checked. E.g., if the main fuses are 3x25 A, every 25 A phase's load should fit into the maximum amperes, and possibly the phases should have exactly as possible the same load (Internal Communication, 2021).

Planning the cooling and ventilation as part of the whole facility's conditions, it is possible to decrease the need for travelling to the location many times before the installations. But as Telia's subcontractors have expertise in electric and telecom installations, especially the active cooling solutions are made by third party companies, the cooling installation still means an extra visit to the location. Only qualified personnel can conduct installations for refrigerant containing devices (Tukes, 2023b).

4.3 Travelling During the Delivery

First, travelling was increasing because of excluding the power equipment process from the telecom process and conducting separate planning visits to site locations. It was still seen as

a reasonable change to get more expertise in electricity planning and implementation and to have all regulations taken properly into consideration in conditions' planning. (Internal Communication, 2020) To decrease visiting times at the same location in one assignment the instructions have been developed and subcontractors must have the correct competence to deliver the assignments. The process has been communicated so that every assignment shouldn't include more travelling than necessary. The basic assignment that concerns power equipment shouldn't need more than two site visits, one for planning and the other for installation. Most of documentation is based on the information gathered during the planning visit and at the site located documentation shall be the sketch corrected at the location after installations, so the final documents shall be delivered in an electronic format to the specific location. Thus, documentation doesn't cause additional travelling (Internal Communication, 2021).

The basic assignments are predictable about travelling, but there still are several exceptions that might cause more travelling. Typically active cooling devices, and emergency power station maintenance or installations are performed by external third parties. There are also some regulative reasons when extra travelling is acceptable, e.g.:

- power cut notifications in apartment houses
- on-site training (e.g. factories, building sites, power plants)
- verification check (implementing electric connection >3x35 A)
- large site with amounts of cabling or other activities

There is a certain policy for the changes conducted in fixed network locations which also can cause several visits. The change management process operates requests for changes in the network that require switching off the power in the facility or might cause a risk for network connections, and grants permits for actions. In some cases, the permit for change is granted only for night hours, e.g. due to customer connections, which can cause extra travelling as well (Internal Communication, 2023).

4.4 The Process Steps After the Change

The author has justified the change inside the organization so that after including the cooling and ventilation contemplation in the electricity assignments there will be a structured site conditions process for the whole infrastructure inside the facilities. Earlier, the Power Team was purchasing 'Power equipment' assignments from subcontractors, but in the combined

process there will be ‘Electricity and cooling’ assignments to clarify the process scope for the stakeholders. Having cooling needs included in the same assignment with all other infra, the needed electricity capacity will be automatically ensured at the same time, and unexpected additional costs will not so easily emerge. Having all needed plans presented together at the same time for the room lessor the process promotes a more professional image of the company (Internal Communication, 2023).

4.4.1 Assignment and Planning

Even though the assignments have mainly the same steps there are still several ways how the subcontractors are receiving them, and how they will be generated into the work control system. As the subcontractor agreements are more like partnerships in spirit, in some work types the subcontractor is the best to indicate whether there will be electricity or cooling constructive needs in the facility or not. There are work types in the conditions process where subcontractors are allowed to proceed with further planning activities. One is Site Faults that are emerging through the maintenance process, and the subcontractor will get alerted of equipment malfunction. In Site Fault situations the regional maintenance partner will check out the location and indicate the needed activities in the work control system, and create a purchase proposal for services and materials. The other work type where subcontractors indicate the need for changes in infra conditions is Mobile rollout programme related construction. Mobile rollout is a turnkey process where the same subcontractor performs the overall delivery from planning and necessary permissions to implementation of mobile network devices. In the mobile roll out process subcontractors must contemplate the whole facility’s conditions so that they meet the requirements in regulations and instructions after implementing the mobile equipment. The implementation of mobile network devices will change the electricity, battery and cooling capacity needs, and subcontractors must indicate if infra conditions need changes. If changes are needed the subcontractor must tell the needed activities in the work control system, and create a purcahse proposal for services and materials (Internal Communication, 2023).

In Site Modernization and Fixed networks’ work types’ processes, Telia is always the instance to give input for the locations in the work control system. Both processes are based on yearly programmes, which are gathered from Telia’s internal information. Fixed network locations will emerge from Telia’s network planning organization, and the Modernization programme will be generated from lifecycle information. The modernization programme is gathered by crosschecking lifecycle information with current mobile and fixed network programmes to avoid overlapping assignments to the same facility locations. In the

modernization process subcontractors are allowed to proceed straight with the purchase proposal, but since the fixed network locations are typically rated with higher priority and the change costs in the assignments are higher the plans must always be presented to Telia's experts to ensure the technical feasibility of activities and possible future capacity needs for networks' construction. The planning also includes providing information for the final documents that will be needed and corrected in the final documentation of the assignment. Now that cooling and ventilation equipment installations are being planned at the same time with the electrical equipment installations, cooling plans shall be included in the same technical implementation plan by Telia Finland's cooling works instructions (Internal Communication, 2023).

Planning all the needed changes at the same time will benefit the whole construction chain ensuring that the electric connections and backup systems will meet the needs of the load after implementing the telecommucation equipment. The overall costs for the infrastructure installations will be defined and the accuracy of the costs will improve. Presenting all the changes in the same plans to the lessor the permissions can be caught more easily, and the landlords will not be surprised with extra needs during or after the other installations. So, by planning the changes visiting the location once the process will decrease travelling, and promotes responsibility towards the community. Conducting the planning activities in a larger scope was seen as a viable change in the study.

4.4.2 Ordering and Delivery

The purchase orders will be executed in an ordering system based on the proposals made by subcontractors. Telia's project managers check that the proposals meet the planning documents, insert the necessary accounting information and check the important dates for the delivery timeline, and approve the proposal to generate purchase orders. The system will generate the material and service purchase orders and transfer them to suppliers and the subcontractors through electronic interfaces (Internal Communication, 2023).

Material suppliers confirm the delivery dates after receiving the orders which can be followed in the material and logistics system. Typically materials are requested to be delivered to subcontractors' location, but it is also possible to request the delivery to the site location as well. When the materials are sent the transportation information can be followed in the logistics system, and after receiving the delivery the subcontractor shall check the correspondence of delivery and the documents. The subcontractor shall either confirm the correct delivery or submit a reclamation if there is an imperfection in the delivery. At latest at

this point, the subcontractor shall inform the estimated implementation date in the work control system and submit possible change requests to Telia. The implementation should be set as soon as possible after receiving the material since the material warranty usually starts from the moment when the goods receipt is recorded (Internal Communication, 2023).

Subcontractors deliver the material to the site location and make the planned installations and equipment implementation following the instructions. The implementation includes all necessary measurements that shall be reported in the final documentation. The documentation has been mainly provided in the planning phase of the assignment, so the site located documentation should be deliverable at this point with hand written values, and additional visits for documentation deliveries to site locations should not be needed. There can be different timing for electric connection, rectifier and batteries, and cooling installations, so there are separate information fields for each system in the work control system. The assignment's ticket in the work control system shall not be closed until the last one of the systems included in the assignment is implemented (Internal Communication, 2023).

For the commissioning customer company delivering the implementations is the most difficult to manage, and subcontractors play a much bigger role in this phase. Minimizing the visits to the location during the assignment depends on the subcontractor's ability to manage its resources. Of course, there can be third parties to affect the timing, e.g. the electric companies have their own schedules delivering the installations for electric connections which was also mentioned in the interview answers.

4.4.3 Documentation and Invoicing

Subcontrator's warranty period for installations starts from the implementation date. After implementation, subcontractors must update and transcribe the final documentation based on the values gathered during the implementation, and upload the documentation into Telia's document inventories. Power equipment inventory where information of electric connections, batteries, rectifiers, cooling devices, and possible emergency power stations are located, must also be updated as part of the documentation. The assignment can be handed over to the purchaser when all documentation is being uploaded and the necessary systems have been updated. When the subcontractor hands over the assignment also invoice proposal is sent to the purchaser via the electronic ordering system. The purchaser checks the documentation and the proposal for the invoice. The purchaser approves the invoice terms in the ordering system for an acceptable delivery. Purchaser can also request corrections if

needed before approving the delivery. At last, the purchaser updates the final approval date in the work control system to close the assignment (Internal Communication, 2023).

Producing documents comprehensive enough it will be possible to conduct even more sustainable implementations in the future when, in the best scenario, the planning can be conducted without visiting the location at all.

4.5 Supported Changes for the Network Infrastructure Construction

The change in the process will not only have an effect on Telia Finland, but the whole supply chain. More comprehensive instructions for the activities and different equipment installations will make the production more structured, and help subcontractors concentrate on their essential targets in the assignments. Also, Telia's purchasing project managers will benefit from the decent instructions, and new employees will be easier to orientate to the process. Of course, the instructions should be well communicated with all the stakeholders, to strengthen the patrnerships. (UN, 2023) The SDG 17 related partnerships creation can make a strong foundation for the development, and help the supply chain work for the other SDGs mentioned to be directly connected to the process in the chapter 2.4. Also making the process more structured and transparent in actions by better communication with people, and with sensible competence targeting can lead to better employee satisfaction through the whole supply chain and so the impact can be connected to SDG 8, decent work and economic growth. When there will be possibilities for every link in the production chain to develop their own internal ways of working each stakeholder can find the process that is the most suitable for their purposes, and to hit the common targets. Motivated people having the right and meaningful positions increases well-being in organizations, and encourages people to watch that the material resources use will be more sustainable. Contemplating the processes with a wider scope, performance economy could be a viable business model to execute in this kind of process. Using science-based drivers choosing the materials and using a responsible supply chain to implement the equipment, and optimizing them to fit better for the specific locations are crucial calls for the future (Stahel, 2010), and tools to build more responsible consumption and production that is meant around SDG 12. Cleaner energy use (SDG 7) is possible by optimizing the energy usage in the equipment facilities, and the best scenario would be to get rid of the diesel generators which can still be difficult for current resiliency regulations, especially in higher priority ratings' facilities (Traficom, 2021, pp. 3 & 8).

5 Recommendations and Future Insights

As one can see by the prevailing megatrends (Dufva & Rekola, 2023), the world is changing quickly and not the least by digitalized services and products. Telecom networks are a pivotal part of digitalization, so the industry must keep developing itself. New technologies are emerging all the time and people find new possibilities to use them. The regulations must keep up to date as well which will force experts and legislators to make new guidelines to answer the demands of the new technologies.

The energy crisis and the lessons learned from the COVID-19 pandemic have been speeding the development of the green transition and can emerge new innovations to support environmental sustainability. In many situations thinking green can also make economic savings and help businesses simplify the processes. By challenging the ways of working people more straightforward approach to many tasks can be found and that will lead to less load for the environment. For example, in the author's study case, combining the processes that earlier have been run separately, it is possible to decrease the waste of time from travelling when several actions will be done during the same visit to the site facility. The author anticipates that the new technologies will emerge to help the telecom business to find solutions for more sustainable performance in the future. Also, there might be some new businesses around the developing technology solutions. For example, there could be businesses offering power storage solutions and combining self-produced energy to support power storages. Also, different heat recovery systems might emerge to support smaller site locations as they already do in large data centres (Telia, 2023c).

All in all, there were found several side processes to be considered at the same time, so the main process and necessary instructions must be updated first. That is not a one team show, but the development must be carried out on a larger scale in the company.

5.1 New Technologies and Methods to Improve Sustainability

In this chapter will be pointed some of the initiatives that could increase sustainability, and which are being discussed in the company as potential targets to invest in. Of course, the company’s sustainability programme must be kept in mind when assessing the new initiatives, so the responsible sourcing methods will be described as well. Today sustainability is one of the major topics in the world when different risks cause uncertainties

for geopolitic and economic stability. There are also new sustainability reporting regulations affecting businesses.

5.1.1 Lithium-Ion Batteries and Virtual Power Plants

As it was told in chapter 2.2.2, lithium-ion batteries are an emerging technology in backup solutions. With lithium-ion batteries the facilities' resiliency could be improved, and in some situations, diesel-powered emergency power stations would not be needed for higher battery backup capacity to fit into a smaller package. For the physically smaller size, and especially for higher energy density lithium batteries could also be used in different energy storage systems, which could make the telecommunication network's facilities the electrical network serving power plants. These kinds of solutions are called virtual power plants (VPP), which make the facilities' backup battery system a small power plant to serve commercial electric networks and their customers. For example, Elisa has installed the systems in early 2023 (Lassila, 2023), and Telia has its own development project on VPPs as well. With VPPs telecom operators could adjust their facilities' electric power according to the telecom networks' needs, and through reserve markets offer the backup systems' capacity to be used to power the electrical power networks. (Fingrid, 2017) With reserves, the grid company can also balance the deviations in the electrical power networks. Assessing this kind of concept the author can see versatile possibilities in the business field. Nevertheless, to invent working concepts, initiatives like this will take some time to develop a desirable solution since there are several stakeholders, internal and external, to participate the development process, which affects the process timeline. This kind of innovations could emerge new business models for the energy storage management, and hence bring new service operators to the telecom industry field, and hence even provoke a new kind of industry. For further development it might be reasonable to include solar panels to the locations where the VPPs are installed to improve the facilities' redundancy during power cuts, and decrease the need for purchased energy to load the batteries. Solar panels are already used at several locations, but the real benefits demonstration still needs more measurements. (Internal Communication, 2023) There are also new solutions in the lithium-ion batteries field that might affect the construction of mobile base stations, especially in remote radio systems while implementing indoor coverage, and offering customers better dedicated resilience. The network equipment manufacturers are also developing the devices to be more energy efficient (Nokia, 2023a).

5.1.2 Digitalization to Improve the Processes

Digitalization would help to optimize activities by offering more sustainable ways to monitor the site conditions. So, the facilities' remote connections should be improved to give more accurate information about the equipment. It would help the company offer faster reaction times in fault situations, and it also could reduce unnecessary site visits by subcontractors when the type of fault or malfunction could be verified before starting the car, or possibly some of the alarm types could be fixed remotely. Verifying the type of faults remotely would also make it possible that the right spare parts could be collected without a separate checkout at the facility. Battery conditions and tests could better be monitored and the data could be used to improve lifecycle management. Remote connections could also support roll-out construction-related assignments when the real-time data about the site connections would be better available. First, it would enable planning to be conducted remotely when the current equipment configuration could be checked online and a physical visit to the site wouldn't be needed. Feasible connections would make new equipment to show up in the inventories right after implementation, so control centres could see the new configuration minutes after the implementation. If the equipment could be documented automatically, the documentation would become lighter and the possibility of human error would be decreased (Internal Communication, 2023).

From the author's research results can be highlighted that further development of the planning of equipment installations systems could be integrated into the same systems, so the coming installations could be seen in advance as planned changes to better avoid overlapping assignments for the same site location. The implementation process could be more flexible and different stakeholders could be served better when the assignments' progressive information would be available in real-time. Having comprehensive documentation of the facilities could make this kind of development possible, and less emitting due to minimized travelling needs to the locations.

5.1.3 Circular Economy and Lifecycle Management

Also, the circular economy which is mentioned in the company's strategy (Telia, 2023c), will carry on in the process structure. If the removed equipment can not be reused, it will be recycled (EPEA, 2023). The process is already reusing the usable equipment, but the recycling process needs more attention during the next couple of years when large amounts of equipment will be modernized. To support the recycling process, and reusing equipment, the lifecycle management of site conditions related equipment must be renewed. It is

important to use only safe and working equipment so old warehouses need to be contemplated, and possibly cleaned up of equipment that is not valid for future implementation. By more efficient lifecycle management the reusable equipment could be separated from the recyclable material. By updating the reusable item list the whole supply chain could be updated for the latest changes, and unnecessary requests about the single material items managing after decommissioning could be minimized (Internal Communication, 2023). Knowing the correct ways to manage the decommissioned and dismantled equipment would minimize dispensable transportation as well, and hence help the process to avoid generating unnecessary emissions. The author suggests that managing the material returning within the equipment decommissioning assignments more regular auditions for stakeholders' warehouses managing Telia's material should be developed. The audits are already conducted as part of the certification audits, but more regular follow-up in partners' locations might even make the third-party audits lighter.

In the author's opinion lifecycle management turns out as the most important factor to make the facility conditions processes more sustainable. Having accurate information about the facility conditions and equipment installed inside the facilities there could be more effective ways to manage the overall lifecycle of the facilities. The process performance and the site conditions should be measured to generate feasible data to better forecast needed activities concerning the facility maintenance. A better view of the lifecycle would also help to forecast the needed yearly costs to effectively maintain the infrastructure supporting the telecommunications networks. Managing the overall lifecycle of facilities it would be possible to better target correct activities to the correct locations, and hence for example unnecessary or uneconomic investments for the end-of-life facilities could be omitted.

The lifecycle for the building structures is not very unambiguously mentioned in the regulations, neither in the current laws (Land Use and Building Act 132/5.2.1999/2000) nor in the law coming into force in 2025 (Building Act 751/2023/2025), although there are still some guidelines for different building parts' lifecycle in the building industry (Nordström, 2021, pp. 17–18), but e.g. for batteries the technical lifecycle is told in suppliers' technical documentation (Enersys, 2022). So, it would be expedient to manage the lifecycle in two categories: Real estate, e.g. for the building structures, and Technical equipment, e.g. batteries and rectifiers. The model would help to set the same lifecycle management process for different types of site locations. The facility's overall lifecycle would be defined by the longest lifecycle expectation which presumably is the building structure's expected lifecycle, so for totally new equipment shelters lifecycle starts to count from the building's implementation day. There are still many facility locations e.g. in apartment buildings that

must be considered differently when the whole building's lifecycle is not in the operator's hands. This kind of locations would get different, more technical equipment-based lifecycle expectations.

5.1.4 Liquid Cooling and Waste Heat Management

Increasing energy prices and desire to build more sustainable solutions have emerged new innovations around the networks' heat management. One of these initiatives is liquid cooling which is claimed to be even 50 – 90% more energy efficient than conventional cooling systems (Nokia, 2023b; nVent, 2023). With the solutions the waste heat could also be used to warm up other parts of the facilities which makes the systems even more sustainable. Still, many current solutions would better fit to centralized facilities and data centres. Waste heat can turn out an issue, especially when mobile networks' equipment rooms are located in bigger buildings (Internal Communication, 2023). The waste heat in equipment facilities should be caught to benefit the whole surrounding facility better. The solution could be technology to exchange the waste heat to be used e.g. in buildings' radiator circuits, and there could be the possibility for new business concepts as well.

5.2 Sustainable Investments for Network Development

Telia Company is already promoting sustainable principles in investment protocol, and the company is relying on a global supply chain. The company's suppliers must comply with the Supplier Code of Conduct, and they must comply with the security and privacy requirements while handling personal and sensitive data throughout their whole supply chain. Responsible sourcing also includes a due diligence process to ensure the company's suppliers align with Telia standards. The due diligence process has a risk-based approach to identify possible risks, and consists of three steps:

1) An up-front risk assessment to identify high-risk triggers
2) An in-depth due diligence assessment if high risks are identified in the up-front risk assessment
3) High-risk suppliers identified during the in-depth due diligence assessment will be reported to the Group sourcing management team for selection or monitoring decisions

Due diligence assessment results are graded as high, medium and low, and potential high-risks could lead to disqualification of the supplier, or trigger a supplier audit. Due diligence assessment covers several factors to be considered (Telia Company, 2023a):

- Anti-bribery and corruption
- Conflict minerals
- Environment
- Human rights
- Labor rights
- Management and ownership structure
- Occupational health and safety
- Privacy
- Security
- Trade sanctions

These corporate requirements might affect the process, especially while searching for new power and cooling equipment suppliers. Also assessing the existing supplier's price cannot be the only criteria assessing the equipment to be implemented. There must be a broader understanding of the company’s sustainability programme, and assessing the used equipment their lifecycle and recycling possibilities must be taken into account as well.

In Western countries the decisions to utilize non-Chinese suppliers’ products has become a more common trend in the late 2010s, and the situation has made more geopolitical and political tendencies. Chinese technology products have been claimed to be cyber security risk-causing elements, and hence unwanted in many companies' networks, and e.g. black listed in the United States. The European Union has set the General Data Protection Regulation (GDPR) to answer the questions about how data shall be used in the EU area. (Morris, 2021). Making sustainable strategic investments with carefully chosen suppliers’ products also in the infrastructure construction, not only in mobile networks (Telia, 2022), would be possible to make more societal impact bringing new features into use and possibly help new innovations emerge. These kinds of decisions can be seen as ethical investments in the long term to promote commonly accepted social values, but also as impact investments by making a responsible impression of the company’s activities. Such investments can lead to a development that is connected to SDG 9 concerning industry, innovation and infrastructure (UN, 2023) by challenging the conventional ways to contemplate the business.

Being located in the European Union it is possible for businesses to call for funding from EU agencies for society-developing solutions. Telia received a €15.535 million grant to develop the 5G Northern European Transport Corridor (HaDEA, 2023). The funding is addressed to improve cross-border continuity in the network services by Telia Sweden, Telia Finland and LMT in Latvia (Telia Company, 2022). The grant was a part of the first share of the total amount of €2 billion funding euros during 2021-2027. In December 2022 European Commission granted the first share of nearly €150 million in financial support via the European Health and Digital Executive Agency (HaDEA) for 38 different projects to develop high-performance 5G and digital backbone infrastructure under CEF Digital (Connecting Europe Facility). The second call for proposals closed on 21 March 2023, its budget is € 240 million, and the selected projects were not published yet in October 2023 (date taken as limitation for the present study).

5.3 Risks to be Managed in the Future

There are several risks that can affect the telecommunications industry. As it has been pointed out in this thesis and some megatrends (Dufva & Rekola, 2023), a massive transformation is ongoing in the industry. The changes can emerge from new technologies or regulative guidelines. Digitalization is spreading more to different areas of life, and it affects the investments inside the industry.

5.3.1 New Technologies Affecting the Regulations

There is a possibility that backup times for 5G will be prolonged as it was earlier with LTE networks. 5G networks should now have 15 minutes backup, which lets operators manage the sites' backup with smaller battery capacity. (Traficom, 2020, p. 36) The emergency power supply units might also be serving cooling devices that are now left out of the scope, but ventilation must already be backed up by the sites' priority rating. Backing up the cooling as well might be under discussion in the near future, especially when contemplating the higher priority ratings. Also, 6G technology will have its own effect on the industry, and regulative terms. 6G is claimed to bring AI-supported connections in use to make real-time end-to-end connections between the users and IoT services. In some preferences, 6G is anticipated that 2030 would be the decade of 6G, and The International Telecommunication Union (ITU) has established a group to explore new technologies for time after 2030. Finland has also announced the 6Genesis flagship program for the 6G ecosystem's development already in 2018, so it can be expected that Telia Finland could be involved in the first development

steps deploying 6G networks. 6G is expected to operate in terahertz frequencies instead of the gigahertz frequencies in 5G. 6G enabling a huge connection of smart devices and high data rate demands have naturally increased energy consumption estimates, which will affect the requirements for network facilities infrastructure (Dogra et al., 2021).

5.3.2 New Building Act in 2025

The Land Use and Building Act will be reformed in 2025 when the new Building Act comes to force promoting digitalisation and demanding the decrease of emissions for the whole lifecycle of buildings (Ministry of the Environment, 2023). The act will guide to carbon reduction in construction taking the negative and positive climate impacts into account for the building's lifecycle, which will be the biggest change compared to the current Land Use and Building Act. (Finnish Government, 2023b; Land Use and Building Act 132/5.2.1999/2000,) The act will also foster circular economy, and by essential technical requirements buildings must be designed to be adaptable and they should be usable for a long time. Buildings must basically be planned and built as low-carbon buildings and the buildings' climate statement must be included in the building permit application. In the author's opinion this could be a risk especially when the operator wants to build a separate building for telecom equipment locating purposes since the cities could read the new act differently as they have done interpreting the current act as well. For the same reason, there lies a risk in lightened permission demands as well, even though the new act's purpose is to make the permission process smoother. Another risk might be the legislator's ability to adopt clarifying decrees on the climate declaration, declaration of building products and limit values for the carbon footprint under the National Building Code of Finland. The new building act might also make the demolition of end-of-life locations easier, and the operator could decrease its OPEX costs by selling unnecessary estates (Finnish Government, 2023b).

5.3.3 Sustainability Reporting Regulations

The ability to meet new expectations and regulations was mentioned as a risk in the corporate sustainability report for the financial year 2022 (Telia Company, 2023a, p. 116), e.g. impact on revenue, legal compliance and the company's reputation was recognized. The Corporate Sustainability Reporting Directive (CSRD) (European Commission, 2023) will be a significant risk. The CSRD dictates that over 500 people employing, and listed companies, except listed micro-enterprises, must report their sustainability performance. The first time to publish the report according to the new directive shall be in 2025 for the 2024 financial year.

By meeting the new rules companies will help their stakeholders to access the sustainability information to assess the ESG-related impact of the company. The new directive will generate work for the company's sustainability organization to assess the impact measurement tools and the reporting process to ensure that the reported contents will meet the needed standards. Telia Company's sustainability reports for the prior years (Telia Company, 2023a, pp. 73–127) are quite comprehensive and their contents already have good correspondence to the new regulations, although sustainability is a matter that needs due diligence in developing the processes. CSRD itself is more a corporate level risk, and it has a less straight impact on single construction processes, but still, there are factors that are linked to the reporting, e.g. the number of yearly dismantled batteries. The awareness of sustainability pillars among the company's personnel should be improved to build broader understanding that it is much more than thinking green, even the company already have internal training about sustainability, but the online courses are not necessarily giving everyone an understanding of what is it all about. Understanding would help the sustainability organization with gathering the information from productive company parts when people would see the reason why they are asked such information.

5.3.4 Geopolitical Situation

As it was already pointed out in Chapter 5.2 the geopolitical and political tendencies have increased around the globe, and different offensive actions are being conducted in Europe as well. In February 2022 started the war in Ukraine, which has already had versatile impacts on European supply chains and overall economics worldwide. For supplies, the crisis has caused side effects in supply chains which have emerged for different reasons, e.g. technology bans and disruptions in the supply chains, as well as higher energy prices. (Liadze et al., 2023) On the demand side, there have been trade restrictions, and financial risk. Public and defence expenditures have increased, so countries and businesses have been forced to tighten their monetary policies. Also, trade restrictions are causing many difficulties doing international business in both directions, import and export. In the telecommunication business, and especially in telecom infrastructure construction the war in Ukraine has affected the material prices, and also the installing costs including transportation. (Internal Communication, 2023) Promoting circular economy and aiming to the company's targets it is also crucial to have a transparent supply chain when the dismantled materials are being sold to be reused somewhere else. It is important to ensure that the materials will not be delivered against the trade restriction policies.

5.3.5 Competence and Labour Availability

There are many claims that the labour availability would be deteriorating in Finland, and also the government programme commits itself to the lack of competent labour in the Finnish labour market. The government promises to answer to the shortage of expertise by making it easier to recruit people from outside of Finland, and hence also improve possibilities for economic growth (Finnish Government, 2023a). In 2022 Ministry of Social Affairs and Health also published the Social Security Committee's report about the labour market and working life transformation (Alasoini et al., 2022). In January 2023 Ministry of Economic Affairs and Employment released a report on the shortage and matcing of labour sums (Ministry of Economic Affairs and Employment, 2023) which showed that the ICT sector is one of the fields that have a remarkable shortage on possible employees. The power team in Telia Finland have been privileged to find good young talents to develop to the business and bring their own personalities and expertise parts of an efficient process developing team. The author has also noticed that women are still not seen very often in meetings with the installing personnel. Also many times one can meet the same people in different company's outfits, which can tell that the industry is run by quite a small amount of people. The industry should be made more tempting for new coming people. It would also be reasonable to have more academic cooperation to develop the education structures to better correspond to the telecom demands.

5.3.6 Asset Arrangements and New Operators

During the last couple of years, there has been a trend to make arrangements for ownerships among the telecommunications operators. In 2019 started a new 100% Telia-owned company to be responsible for the mast business. In 2021 Telia Company sold 49% of Telia Towers' Finnish and Norwegian businesses to Brookfield & Alecta, and in 2022 49% of Swedish Telia Towers was sold to the same stakeholder (Telia Towers, 2023). The change decreased the number of facilities to maintain and removed masts and poles from the asset portfolio in Telia Finland. The same kind of arrangements have been made by Telia's competitor Telenor as well. In Finland DNA Tower is part of the mast business under Telenor Infra (Telenor, 2023).

Making some arrangements in the mast business is not only changing the model in the telecom industry. Telia started the Open Fiber concept in 2016, and in 2020 a new company was established to manage the fiber network construction. Valokuitunen is owned by a Finnish investment company CapMan's Infra fund that's stakeholders are e.g. Finnish

pension company Ilmarinen, City of Espoo and Church pension fund (60%), and Telia (40%) (Valokuitunen, 2023). In the fibre business there have also started new operators to build fibre networks. There are as well bigger international investment companies (GlobalConnect, 2023; Valoo, 2023) as smaller locally operating cooperatives.

6 Conclusions and Reflections

To clarify the understanding about the state of the process the study was revealing and showed that the change has been desired also among the subcontractors, and not only from Telia's point of view, even though it might have been questioned in the beginning. In the interview answers some of the issues were repeated by different interviewees which gives a reliable scope for the development targets. As conclusions, the author points out the parts of the process that need the most development according to the people interviewed, but also to the research done.

6.1 Construction Process Development Steps

As it has been described in the thesis the combined process is already up and running in the technical sense of implementing the equipment. It is justified that for the organization the method has been the right one to make a structured process for continuously increasing needs for constructing cooling and ventilation to serve the telecommunications networks. By organizing the equipment and installations' purchase process the facility management can better concentrate on their expertise, and develop the facility management which will be supported by the purchase process. Also cooling and ventilation devices are already documented in the same equipment inventory, so the subcontractors can conduct the updates in the inventory on the same sign-in.

To look back on when the process development started, the gaze must be turned to the year 2019, even though it was not known then that the process would be responsible for a wider scale of assignments. Mobile rollout view was turning more and more on 5G network implementation, and the assignment volumes were anticipated to increase. Organizational changes affected the employment in power equipment purchasing and facility management, so there was a need for process development. The team to purchase power equipment and the installations started in January 2020 with high expectations of more efficient rollout processes and more expedient modernization of rectifiers and batteries. In the very beginning, there were demands to report the conducted actions and achieved milestones, so

the team had comprehensive memos about the progress. Very soon was noticed that sustainability as a topic was linked to the throughput of the process, and the sustainability office was contacting the team with reporting questions concerning the equipment usage and recycling. So, the process was started to consider as a sustainability improving factor in network construction and facility maintenance, and all electricity installations were included. The process has been developed by new documentation requirements and planning instructions, and also found more energy efficient technology, e.g. the rectifiers power modules to decrease energy usage in Telia's networks. The overall assessment of the needed electricity installations in the company's network facilities works as a solid base for including cooling and ventilation in the same process.

Implementing cooling and ventilation as part of the existing power equipment process started during the year 2022 when the Power Team started constructing the cooling devices within the cluster-based mobile rollout and aggregation network assignments, but a small timeout in the second half of 2022 seemed to be reasonable before the final launch. As the technical process steps were described in the chapter 4.4, the organization should continue conducting the up and running process. It is a good start for transforming the process towards more sustainable future, and that could also be seen in the research questionnaire answers where the interviewees told that combining the assignments is taking the process in the right direction. Learning new and getting more responsibilities were also told to be motivating.

For developing the process further, the instructions of all process parts must be assessed critically, and the instructions that are not valid any more must be updated. It is also important to identify unnecessary instructions and remove them from the process. It is much easier to produce new instructions from the scratch than read through the existing ones and conduct necessary updates. There are actions for instruction updates on wider scale, but the teams connected to the facility conditions must take the bigger role to improve the instructions. When instructions are in feasible shape they will help in coming subcontracting negotiations and generate less questions about the single service products. The service products are also one of the most important elements to be developed which was pointed out in the interview questions. The products must be easy to understand, and same kind of activities concerning products must have the same structure.

6.2 Lifecycle Management

The list of the material Telia wants to be returned was mentioned several times in the interview answers. The same issue is recognized on Telia's side as well (Internal Communication, 2023), and updating the list is the first activity in a bigger entity of material management. Managing the material is in the crucial role while executing circular economy activities. By the instructions the company tells its stakeholders which of the materials are still valid to be reused in the company's network, or should they be handed to the recycling process. Of course, the answers are about the issues that are the most visible to the stakeholders, but the material handling is still just a small part of lifecycle management. For more sustainable construction Telia needs to improve the facilities' lifecycle management in terms of circular economy.

The lifecycle management process needs to be developed to concern the whole facilities in the same process. Hence the process will be able to consider all assets in the same process, not only separate equipment or building structures. When all assets will be in the same process the overall repair debt will be easier to manage so that the maintenance backlog will be as small as possible. Measuring the lifecycle management process can be done by the number of locations modernized per year and by the invested euros. Managing the depreciation of the assets is also part of lifecycle management. The devices must have expedient depreciations set to suit the defined lifecycles, and the depreciation for different types of equipment should be taken into consideration while modernizing the devices. The applicable lifecycle management with sustainable investing makes it is possible to keep up with the developing technology which could help meeting the future demands better. Correctly structured and conducted lifecycle management will make the infrastructure behind the telecommunications networks more resilient and secure. To build secure networks and investing responsibly the process can promote the company's slogan 'Reinventing better connected living'.

6.3 Communication

Several interviewees mentioned communication deficiency during the change process as a challenge, even though the change has been communicated in bi-weekly held follow-up meetings with the subcontractors. Communication turns out to be the most important tool while making changes in the organizations as it is pointed out in the literature as well (Hornstein, 2015). The author can identify with the situation where one can feel there is not

enough information. These situations might connect with the cases where someone to communicate makes assumptions that the receiver knows enough about the subject, and does not ensure the message is understood. These observations show that communications need to be improved.

The meeting practices must be newly considered to ensure the right attendees, and the calendars will not fill up with unnecessary meetings. The important stakeholder groups to meet regularly to ensure expedient communication inside the process are:

- Mobile network construction process
- Fixed network construction process
- Site Management
- Company logistics
- Subcontractors
- Material suppliers

Of course, some other functions inside the company are important e.g. to draw the financial guidelines and ensure the investments. The sustainability organization might be more regularly contacting the departments managing the facilities, especially according to batteries, for the yearly sustainability reporting. The regular meetings shall be used to communicate about the performance of deliveries, and they have a formal schedule.

The subjects like new instructions or tools shall be communicated separately from the regular meetings. For example, new instructions must be communicated in the educative sessions before they will be taken into force. Thus the stakeholders can discuss the instruction and ask clarifying questions. The changes in the process or tools can be communicated with the stakeholders involved, so e.g. subcontractors are given a possibility to affect the decision, and the change will not complicate their work in vain.

6.4 Evaluating the Thesis Process

The thesis process has been very educative for the author, especially regarding to the regulative material. In the beginning of the process there already was an understanding that the telecommunications industry is highly regulated, but during the thesis process the author needed to dig deeper into the European regulations that make the base for the national regulations and laws in Finland. The thesis topic and its connection to sustainability have

been clear from the very beginning of the studies, although the scope of the topic was way smaller back then because of the author's smaller understanding about sustainability. During the journey sustainability has been a part of discussions, and the commissioning organization has been given some tips of assessing sustainability. As an educational process, the whole studies have supported the thesis process by giving tools and methods e.g. for strategy and change management, which are clearly connected to the thesis topic. Overall all the studies have effectively supported the thesis.

A big help for the thesis writing process has been the possibility to use working hours, even it has been difficult to find free time slots from the work calendar time to time. Also, internal information and the organization has supported the author with the thesis. Finding connections to sustainability has been easy, and the company's sustainability communication and reporting have given concrete interfaces between the process and the company's sustainability targets. The thesis itself answers well to the research questions defined in the beginning. On the question how power and cooling equipment related works should be combined into one sustainable process is described in a technical sense in the chapter 4.4 where the additional research question 'How the different process steps will benefit the sustainability of network construction?' is answered as well. All process steps have their crucial connection to the sustainable construction. Overall combining the equipment that serve the same telecommunication networks is viable to ensure that all factors affecting the site conditions will be checked, and the conditions in the facilities meet the requirements. To attach the combined process with the SDGs one can say that the process is promoting SDG17 by building strong collaboration with stakeholders towards the common goals, climate action SDG13 by reducing unnecessary travelling during the deliveries and conducting circular economy in material logistics. The process is aiming to be more responsible in consumption, and ESG terms are being considered more making when decisions in material use which is connected to SDG 12, responsible consumption and production. By constructing more secure and resilient facilities to serve telecommunications networks the process is fostering SDG9 for better infrastructure, and hence promotes the coming innovations connected to the industry. SDG3, good health and well-being are also carefully considered in the process, and all the decisions are being made with the guiding principle 'Health and Safety first'. Now that the technical definitions of the process has been set the concrete sustainability development recommendations in the chapters 5 and 6 should be promoted to make the process meet the company's sustainability targets better.

6.5 Reflection

The idea of the thesis about combining different construction activies regarding telecommunication network facilities' infrastructure was clear already while the author was applying for studies in Management in Sustainable Business Master programme, and when it was proposed for the commissioning company for the first time. The connection to sustainability was very obvious knowing the commissioning company's sustainability targets. The thesis process has progressed expeditiously as it was also mentioned in the feedback from the commissioning company. They were gratified that the author could schedule the thesis process well with the daily responsibilities towards the company. Overall the most important for the commissioner was that the combined process was brought into action during 2023, and the technical purchasing process was implemented. Of course, the process still needs further development, which the thesis is pointing out.

Looking back the thesis writing process the author must thank Telia Finland as the commissioning company for the opportunity to combine studying and working. Most of the courses during the master's programme could have been connected to the thesis, and to several occasions inside the organization during the studies. The study process has given the author a broader understanding about sustainability and to its connection to business management. Understanding the three pillars of sustainability, and how they are connected will help the author to better support his employer taking ESG factors into account while making future decisions. In the author's opinion the thesis is answering well for the research questions and the goal of the study was reached offering concrete proposals for further development of power and cooling construction process, and why not for other construction processes as well. Improving the facilities infrastructure equipment's lifecycle management the process can support the commissioning company's sustainability targets. To make the whole supply chain meet the Telia Company's 2040 targets will be made possible by improved communication, and increased awareness about the sustainability impact of every link in the supply chain.

On personal level the whole learning process has been fruitful giving the author amounts of information about sustainable business management, but most importantly, capabilities to find and recognize the future trends and insight around sustainability. The author sees that sustainability starts with people, so making people aware of their impact, and getting them involved will make societies act better for the environment, and hence the economies can develop to a more sustainable direction.

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Appendix 1. Thesis Data Management Plan_Karhunen

Management and Storage of Research Data

Research data includes survey, observation and internal information of the commissioning company. The survey is conducted via Webropol portal offered by HAMK, and the data is collected anonymously. The data collected during the survey and observations is saved on the author's personal hard drives in two different locations, and the access to the files need identification. The data from the commissioning company is confidential, and any sensitive information shall be handled as classified, as it was agreed in the thesis agreement.

Processing of Personal Data and Sensitive Data

No personal or sensitive data is collected or published in the thesis. The data from the commissioning company is confidential, and any sensitive information shall be handled as classified, as it was agreed in the thesis agreement.

Ownership of Thesis Data

The reseach data is owned by the author of the thesis and is only used for research purposes, and to be analysed in the thesis. All the commissisioning company's data is owned by the company. Any inventions may be made within the scope of the author's duties associated with the employment relationship between the author and the commissioning company shall pass directly to the employer under the Act. (section 4 of the Act on the Right in Employee Inventions (656/1967)).

Further Use of Thesis Data After the Work Is Completed

The research data will not be used further. The author of the thesis stores the data in a secure manner for a period of one year from the date of approval of the thesis, so that the results of the thesis can be verified and deleted in a secure manner, if necessary.

Appendix 2. Interview Questions

Experiences About the Change of Electrical and Cooling Installations Process

1. How do you see the process where electricity and cooling works are on the same assignment is affecting the productivity?
2. Mention your own observations. Are some of the following factors got better/worse? It can also be mentioned if you don't see any change. (Is there improvements from your organization's point of view?)
    a) Instructions
    b) Use of materials
    c) Scheduling
    d) Communication
    e) Something else to notice
3. How are combined assignments affecting the time used for travelling to hte site? Is there difference between the assignment phases (e.g., planning/installation)?
4. How have the people involved in the electricity and cooling process experienced the change?
5. Does the process have a clear connection to your company's sustainability program?
6. Are there any improvements you have done in your organization or noticed something to be changed to get more sustainable?