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Internalizing externalities with internal carbon pricing

A case study on how to drive change and prepare for a low-carbon economy

Master's thesis in Supply Chain Management

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Abstract

To a larger extent than ever before are companies expected to take climate action and reduce their environmental footprint. Many actors within industry have long-term visions and strategies that include sustainability targets, but research has shown that companies are struggling to connect these long-term strategies to operational and tactical decision-making. One concept that potentially can bridge the gap between strategy and daily decision-making is internal carbon pricing, when CO_2e emissions are converted to a monetary value, the environmental impact is understandable and displayed in the common business language.

This study aims to assess how environmental sustainability can be integrated into decision-making through internal carbon pricing, which decisions should be affected as well as how the price level should be determined. The findings of this study suggest that internal carbon pricing can integrate environmental sustainability in decision-making in several different ways depending on how it is implemented. The best implementation strategy is contextual and depends on each company's situation and reasons for considering internal carbon pricing. In order to develop a suitable internal carbon pricing strategy, this report suggests following a constructed framework where firstly, the wanted position is determined. This guides what approach is suitable, which implementation options are possible, and lastly, how the price level should be determined and calculated.

The framework was developed in this Master's thesis and applied at the case company, Ericsson, where a strategy to internal carbon pricing was developed. This included identifying relevant implementation options for where to incorporate internal carbon pricing as well as calculating the recommended price level. Despite the great praise and traction that internal carbon pricing has received as a concept to mitigate climate change, very limited research on the topic exists. This thesis hopes to take the discussion around internal carbon pricing forward while more research is still needed.

Keywords: *Internal carbon pricing, environmental sustainability, organizational decision-making, strategy development, monetization*

Acknowledgments

This study is a result of a Master's thesis project conducted on behalf of Chalmers University of Technology and Ericsson during the spring of 2021. The thesis concludes the authors' five years of study to obtain a Master of Science degree in Industrial Engineering and Management with a specialization in Supply Chain Management at Chalmers University of Technology.

We are truly thankful for the opportunity to have conducted research on a very interesting, important, and promising topic, internal carbon pricing. It has been especially intriguing to study the topic at Ericsson, a company renowned for taking responsibility regarding sustainability and always being at the forefront of technological development. Specifically, we would like to extend our utmost gratitude to our supervisor at Ericsson, Thomas Essén who has helped us drawing attention to internal carbon pricing internally at Ericsson as well as providing support and access to all relevant stakeholders continuously during the study.

A special thanks go to our supervisor at Chalmers, Patricia van Loon, for the many meetings we have had. During these, valuable guidance, as well as constructive input, has helped us effectively conduct the Master's thesis. Additionally, we would like to thank our line manager at Ericsson, Anders Sjögren, for dynamic discussions and new perspectives on internal carbon pricing and how it can be integrated into current processes at Ericsson.

We would also like to thank the Supply Sustainability Program for their strong engagement and collaboration. Lastly, we appreciate everyone who has been involved in the Master's thesis, either as interviewees or by giving feedback and advice, it is clear that internal carbon pricing has received great attention recently at Ericsson and we have had many interesting discussions on the topic.

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1 Introduction

This chapter presents the importance of environmental sustainability, how this can be integrated into companies' decision-making, and how internal carbon pricing could facilitate the said integration. Subsequently, the problem under investigation is described along with the case study at Ericsson, and the aim of the study as well as the specific research questions. The delimitations of the study are also introduced, stating what has been excluded and why. Lastly, the disposition of the report is presented with a brief introduction to every chapter in this thesis report.

1.1 Background

Today, companies are demanded to take responsibility for the sustainable development of business activities (Thorlakson, Hainmueller, & Lambin, 2018). The World Commission on Environment and Development (1987) famously defined sustainable development as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*". The commission further established the definition of sustainability consisting of three main areas: economic, social, and environmental sustainability. A similar definition of sustainability was proposed by Crane and Matten (2007); "*the long-term maintenance of systems according to environmental, economic and social considerations*". Both definitions include environmental sustainability as a major factor for sustainability which Bonn and Fisher (2011) describe is related to the management of non-renewable and physical resources, effects on biodiversity, and pollution. To mitigate pollution and global warming, the Paris Agreement was introduced in 2015 and aims to limit global warming to a maximum of 2°C (United Nations Framework Convention on Climate Change, n.d.). An initiative in line with the said agreement is the European Union's aim to be climate neutral by 2050 through its "*2050 long-term strategy"* (European Comission, 2017). The greenhouse effect, caused by the emission of greenhouse gases (GHGs), is a significant contributor to global warming (Zillman & Sherwood, 2017), and the private sector is a big source of GHG emissions and can play a significant role in mitigating climate change (Krabbe et al., 2015). Therefore, companies need to act on climate change although many of them do not know how to integrate environmental sustainability into the organization despite understanding the importance and advantages (Bonn & Fisher, 2011).

One way to integrate environmental sustainability into an organization is via internal carbon pricing. With internal carbon pricing, the impact of GHG emissions is translated into monetary terms, thus making the environmental impact more understandable since the impact is presented in common business language (Aldy & Gianfrante, 2019). According to Ahluwalia (2017), this makes it easier to evaluate and consider environmental sustainability in decisions making since a monetary measure is being used. Internal carbon pricing can internalize the cost of GHG emissions from the business activities performed by the company, thereby incentivizing the company to lowering emissions (Ahluwalia, 2017). Despite the expected benefits, there is only limited knowledge on how companies can implement internal carbon pricing, hence more research is needed.

1.2 Problem description

Existing research on macro-carbon pricing, such as carbon taxation, is rather comprehensive. However, publications in scientific journals on internal carbon pricing, where the scope is limited to one company and its supply chain, are rather scarce and only a handful of papers exist on the topic (e.g., Bento & Gianfrante, 2020; Harpankar, 2019). These papers have discussed the potential, incentives, and challenges with internal carbon pricing, but no holistic framework or approach has been introduced for the successful development of an internal carbon pricing strategy. For a more detailed introduction to internal carbon pricing, industry reports are available from non-governmental organizations (NGOs). One such example that should be mentioned is CDP, a non-profit charity that publishes reports on the current status of internal carbon pricing adoption, and industry best practices (CDP, n.d.). Moreover, examples of companies that openly disclose and describe their work with internal carbon pricing are few. One example is Microsoft who implemented an internal carbon price back in 2012 and have published reports regarding their work on internal carbon pricing (DiCaprio, 2013). However, companies exist in different contexts which suggests that a uniform, homogenous approach to internal carbon pricing might not be suitable for all organizations. This implies the need for more research on the topic to help companies adopt an appropriate internal carbon pricing strategy developed to mitigate their GHG emissions.

1.2.1 Case study at Ericsson

As established, internal carbon pricing is a relatively new concept that has gained traction among NGOs working with sustainability but not yet in academia. Previous research (e.g. Rashid, Rashid, Warraich, Sabir, & Waseem, 2019; Sachdeva, 2008) has shown that in these situations, it is often beneficial to conduct case studies. Accordingly, a case study was conducted at Ericsson AB, hereinafter referred to as Ericsson. Ericsson was deemed a suitable case company for several reasons.

Firstly, the company operates in the information and communication technologies (ICT) industry, an industry which, according to Malmodin and Bergmark (2015) today does not account for a large share of the global GHG emissions. However, ICT companies can enable up to a 15% reduction of all global GHG emissions through their products in use according to research conducted by Ericsson (Malmodin & Bergmark, 2015). Thus, it should be of interest that ICT companies such as Ericsson have high ambitions and knowledge when it comes to environmental sustainability.

Secondly, the case company Ericsson have 100’000 employees and 227 BSEK in revenues (Ericsson, 2021a) and is a leading actor in both its industry and supply chain. It is of great importance to have a sustainability mindset in these leading companies, something that Thorlakson, de Zegher, and Lambin (2018) pointed out. They showed that leading companies with global supply chains have a tremendous possibility to affect their suppliers and sub-suppliers in terms of environmental and social issues. Ericsson’s supply chain consists of 20’000 suppliers (Global Supply Chain Sustainability Manager, personal communication, February 18, 2021) and the company certainly fits into that category of supply chain leaders.

Lastly, Ericsson is a company that recently has profiled itself as an actor that takes a greater responsibility when it comes to sustainability, this is shown both in their published material (Ericsson, 2021b) and through the data collection in this study. Additionally, most of the interview respondents in this study had heard of, and have a positive attitude towards, internal carbon pricing.

1.2.2 Sustainability at Ericsson

The case study was mainly conducted within the supply organization at Ericsson and the researchers worked in close cooperation with the Supply Sustainability Program. The program is part of a joint initiative between different departments at Ericsson and works cross-functionally to integrate sustainability into all business units at Ericsson. The Supply Sustainability Program and other sustainability programs are all connected to Group Function Sustainability which is the central department that set Ericsson's sustainability strategy and goals and works closely with the executive team. Thus, close cooperation with Group Function Sustainability has been integral to the case study. One of the goals set is that Ericsson will be carbon neutral from own operations by 2030, visualized in Figure 1.1. Own operations in this context include emissions from their own vehicles and facility energy usage for both offices and production sites, ref. Scope 1 and 2 emissions in Section 2.1.2.2. The short-term goal is that by the end of 2022, Ericsson will be a forerunner in providing low emission supply, and having reduced emissions from their own activities (i.e. own activities, outbound transport, and business travel) by 35% since the baseline year 2016 (Ericsson, 2021b).

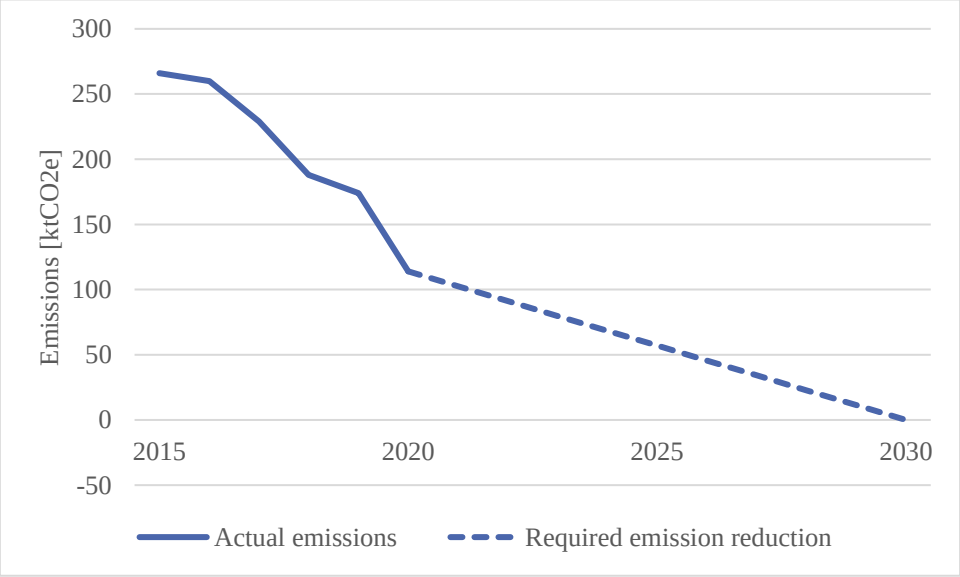

Figure 1.1. Ericsson's current emissions and required future emission reduction to meet the neutrality target

Ericsson have identified an action that can be taken to both reach their neutrality goal and to demonstrate sustainability leadership, this is to introduce internal carbon pricing. The idea was first developed during an innovation competition held at the company where one team proposed the introduction of internal carbon pricing, but before implementation, research on the topic must be conducted as internal carbon pricing is a relatively new area and the corporate maturity

on the topic is low. Thus, there is a need from both Ericsson and academia to research internal carbon pricing further.

1.2.3 Aim

The study aims to assess how environmental sustainability can be included in corporate decision-making with internal carbon pricing and how companies can formulate their internal carbon pricing strategy. This includes researching which processes should incorporate internal carbon pricing in decision-making as well as proposing a suitable calculation method, through which an internal carbon price can be calculated and applied in these processes. The price is expected to reflect the detrimental effect of a company's GHG emissions or should be based on and in line with internal climate neutrality targets.

1.2.4 Research questions

Based on the aim, two research questions have been phrased, further specifying what will be studied at Ericsson. The findings will then be generalized to fulfill the aim presented in the previous section. One important aspect is to understand in which decisions an internal carbon price should be introduced to drive the desired change necessary to reach the internal climate neutrality targets. It is also important to investigate which price should be used in these decisions to support the behavioral change. Accordingly, the following research questions have been formulated.

RQ 1 *What approach should Ericsson take to internal carbon pricing and in which decisions should it be part of the basis for decision-making?*

RQ 2 *What price (in \$/tCO_2e) should Ericsson use when implementing internal carbon pricing in order to effectively make environmental sustainability part of their decision-making?*

1.2.5 Delimitations

The case study on internal carbon pricing will be based on Ericsson. At Ericsson, the scope will be limited to the emissions reported in Ericsson (2021b), that is scope 1, 2, and selected scope 3 emissions. The scopes are defined according to the Greenhouse Gas Protocol (2004), see Figure 2.1 for a visualization of the emissions within each scope and a more detailed description. The remaining scope 3 emissions, i.e. those not reported by Ericsson on an annual basis will not be within the scope of this Master's thesis due to the lack of available data and limited relevance for the topic of internal carbon pricing. Furthermore, only GHG emissions will be studied in the form of CO_2 equivalents in order to address climate change through global warming, aligned with the Paris Agreement. Due to this, further regulations specifically on GHGs will likely be introduced to prepare for a low-carbon society. Therefore, emissions primarily contributing to other environmental issues than global warming will not be considered, for example, emissions related to acidification. A similar perspective is presented by Porter and Reinhardt (2007), the authors argue that climate change must become part of risk management and that GHG emissions will be increasingly scrutinized, regulated, and priced.

1.3 Thesis outline

Table 1.1 presents the disposition of the thesis, the chapters, and the content of each chapter to give an overview of the report.

Table 1.1. Chapters and chapter content in this report

Chapter	Chapter Content
1. Introduction	Gives the reader an understanding of the context of the thesis and introduces environmental challenges and how they affect organizations in general and the case company Ericsson in particular. Thereafter, the thesis aim, research questions, and delimitations are discussed.
2. Literature	Presents the findings of the literature study and introduces the reader to several areas that are important for the analysis and conclusion. The topics of sustainability and global warming, carbon offsetting, and internal carbon pricing are discussed in detail. Lastly, a theoretical framework is presented which combines findings presented earlier in the chapter and connects to the research questions.
3. Methodology	Describes the methodology and methods used in the project. An overview of the research design and research process is followed by a description of the methods used for data collection.
4. Empirical findings	Presents the relevant data collected from interviews, observations, and quantitative data from Ericsson as well as external interviews.
5. Analysis	Combines the collected data with findings in the literature chapter in order to answer the study's research questions and the price calculations are presented. The concept is illustrated and tested in a pilot case.
6. Discussion	Interprets the results of the study and discuss the managerial and academic implications of the results. Reflections regarding the chosen methodology and research process are raised to understand the validity and reliability of the outcome.
7. Conclusion	Concludes the report by answering the aim and research questions of the study and summarizes key findings.

2 Literature

The literature chapter presents theories, academic findings, and industry approaches to relevant topics and will be used as input in the analysis when answering the thesis research questions. Initially, global warming and corporate climate reporting standards are described, followed by a section outlining several approaches to carbon offsetting. Thereafter, a general introduction to how environmental sustainability can be incorporated in companies' strategy at different levels is given, followed by the concept of internal carbon pricing along with different methodologies on how to use internal carbon pricing as well as calculation methods. The literature findings related to internal carbon pricing are then summarized in a theoretical framework.

2.1 Environmental sustainability

As previously mentioned, the World Commission on Environment and Development (1987) established the definition of sustainability by including mainly three areas: economic, social, and environmental sustainability. Yohe et al. (2007) showed that nations' ability to achieve sustainable development in all three areas is not mainly dependent on how they can reduce vulnerability to natural disasters, but rather on how well the world can mitigate climate change and global warming.

2.1.1 Global warming

Global warming is defined as "*an increase in the earth's atmospheric and oceanic temperatures widely predicted to occur due to an increase in the greenhouse effect resulting especially from pollution*" (Merriam-Webster, n.d.). Zillman and Sherwood (2017) explain that when the sun emits shortwave radiation, it passes through the atmosphere, and most of it is absorbed by the surface of the earth. Part of the energy, however, is re-emitted as longwave radiation from the surface. Greenhouse gases prevent the longwave radiation from leaving the atmosphere and thus warms the entire planet and makes it habitable. With an increase of GHGs in the atmosphere, the greenhouse effect will be stronger and thus lead to global warming (Zillman & Sherwood, 2017). The magnitude of the effects of global warming heavily depends on how large the temperature rise is. Harris, Roach, and Codur (2017) have compiled different types of global warming impacts at five distinct levels of temperature rise (1°C to 5°C) compared to pre-industrial temperature. The effects are categorized in freshwater supplies, food and agriculture, human health, coastal areas, and ecosystems, and in the scenarios with larger temperature rises the impacts are almost dystopian. Serious droughts and large water supply reductions in Africa and the Mediterranean, increasing starvation as yields decline by a third in Africa, 300 million people suffering coastal flooding, and potentially half of the species face extinction are all expected effects of a 4°C temperature rise. To not reach the scenarios described above, the Paris agreement was signed in 2015 by almost all countries in the world and is a legally binding treaty aiming to limit global warming to a maximum of 2°C, preferably below 1.5°C (United Nations Framework Convention on Climate Change, n.d.). Additionally, according to the United Nations Framework Convention on Climate Change (n.d.), the member countries must be climate neutral by 2050 for this goal to become reality. Based on the Paris agreement, the European Union has undertaken a long-term strategy to meet the climate

neutrality goal (European Comission, 2017). The Commission explains that a societal change is needed to meet these targets and different actors and industries need to change to a varying extent depending on their current practices.

Mechanisms for reducing the carbon footprint by pricing carbon have been implemented on national, regional, and subnational levels. According to the World Bank (2020), in 2020, 45 nations were covered by either an emission trading system (ETS), a system where the right to emit a certain quantity of carbon is traded, or carbon taxes. This means that today 12% of global GHG emissions are covered by one of the two pricing schemes while another two nations, China, and Germany, have scheduled to implement ETSs in 2021, covering another 7.1% of global GHG emissions (World Bank, 2020). Furthermore, Ahmad and Hossain (2015) explain that also companies around the world are, to an increasing extent, disclosing their emissions and the activities they make to reduce them in order to satisfy media, political leaders, environmental activists, customers, and investors who consider the issue of global warming seriously. Coppola, Krick, and Blohmke (2019) surveyed more than 1’000 chief financial officers (CFOs) and the results support Ahmad and Hossain's (2015) proposition, companies are feeling the pressure to act on climate change. The pressure stems from a range of different stakeholders and the largest pressure comes from clients and customers who expect companies to understand their own carbon footprint and that they are actively trying to reduce it (Coppola, Krick, & Blohmke, 2019).

2.1.2 Corporate climate reporting

As of today, most companies are not forced to report their carbon footprint in the same way as they report financial statements (Aldy & Gianfrante, 2019). However, governmental actors, companies, and investors can choose to voluntarily report and disclose their environmental impact to NGOs. One such example is CDP which runs a global environmental disclosure system. Almost 10’000 companies report through CDP, and many large institutional investors are requesting companies to disclose through CDP regarding climate change, water security, and forests (CDP, n.d.).

In climate reporting, there is no industry standard that every company adheres to. However, Greenhouse Gas Protocol is an organization creating the most widely used reporting standards in industry. For example, 92% of the Fortune 500 companies which report emissions through CDP, are using the Greenhouse Gas Protocol Corporate Standard (Greenhouse Gas Protocol, n.d.). Green (2010) argues that the success of the Greenhouse Gas Protocol, which may seem unlikely as no power is delegated from nation-states, stems from three key benefits companies receive while using the standard reporting framework. Firstly, using the Greenhouse Gas Protocol reduces transaction costs for companies as they do not have to develop their own reporting structure, nor do they have to worry about switching reporting standard as the Greenhouse Gas Protocol is so widely adopted. Secondly, the first-mover advantage was important for the growth of the protocol. At the time of establishment, no other organization, private nor public, had the same competence as the Greenhouse Gas Protocol which meant that the few attempts that had been made to create a similar standard prior to the protocol were inferior and thus did not have the same reach. Lastly, Green (2010) informs that companies and organizations who reported according to the standard had the authority to publish their result,

thus, the protocol became a way for companies to brand themselves and burnish their reputation in relation to sustainability.

2.1.2.1 Greenhouse gas protocol: accounting principles

Similarly to the Generally Accepted Accounting Principles, or the International Financial Reporting Standards for financial accounting, the Greenhouse Gas Protocol Corporate Standard mandates that GHG accounting and reporting is based on several principles (Greenhouse Gas Protocol, 2004):

- *Relevance* is the first principle, aimed to ensure that reported GHG inventory, i.e. all emitted GHG during a time period, serves the decision-making needs for both actors within and outside the company.
- *Completeness* is the second principle and refers to that all emissions within the chosen scope (See Chapter 2.1.2.2 for information on scope) and any exclusion of emissions should be explained, disclosed, and justified.
- *Consistency* is the third GHG accounting and reporting principle and explains that methodologies, methods, calculations, data, and other factors should remain the same unless otherwise clearly documented and explained, ensuring comparability of reported values over time.
- *Transparence* is the fourth and penultimate principle dictating that assumptions, calculations, datasets, and other relevant factors are transparently disclosed and explained.
- *Accuracy* is the final principle which means that emissions should not systematically be over, nor under actual emissions and that companies aim to reduce uncertainties in data where they may exist.

2.1.2.2 Greenhouse gas protocol: scope

To manage GHG emissions effectively, understanding direct and indirect emissions is key since it will help a company understand the GHG risks and opportunities in its operations and value chain according to Aldy and Gianfrate (2019). In order to describe and distinguish between direct and indirect sources of emissions, the Greenhouse Gas Protocol (2004) have defined three different scopes of emissions, scope 1, scope 2, and scope 3 which are widely adopted in industry (visualized in Figure 2.1).

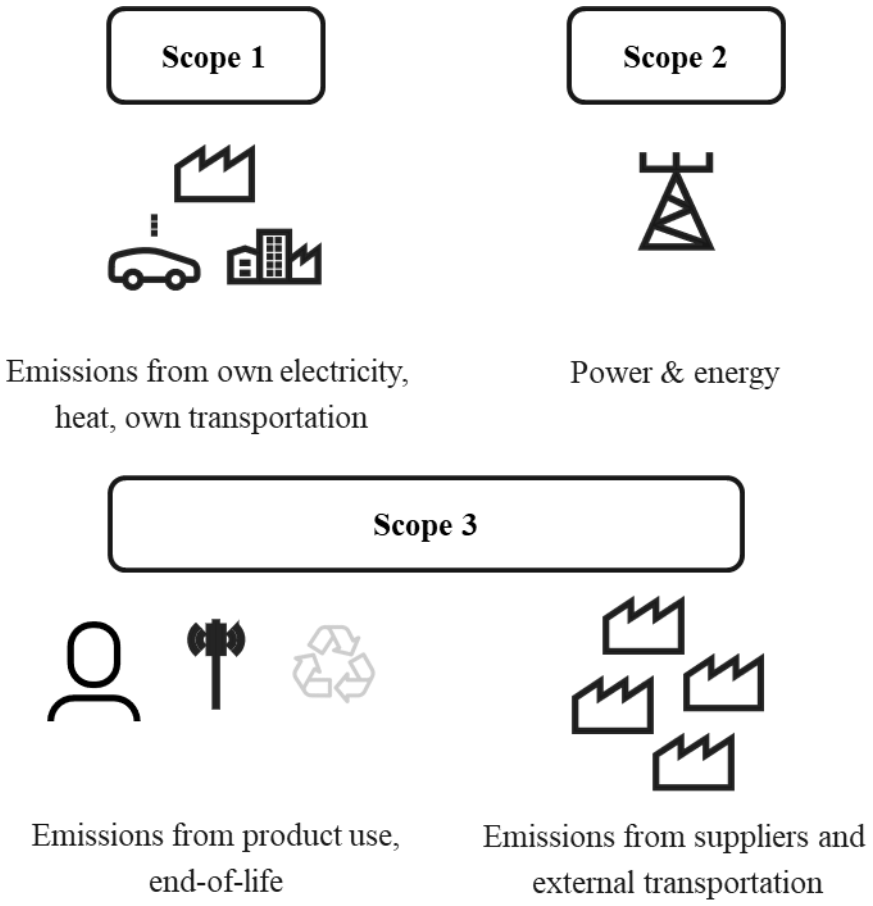

Figure 2.1. Emissions included in scope 1, 2, and 3 respectively

The three scopes used in the Green House Protocol (2004) are defined as follows. Scope 1 emissions are direct GHG emissions that are generated by resources owned or controlled by the company. These emissions are usually process emissions, emissions stemming from own heat or electricity production, and transportation emissions when performed with the company's owned vehicles. Scope 2 emissions include a limited part of the indirect GHG emissions, the emissions generated by purchased electricity, heat, cooling, and steam. In scope 3, all other indirect emissions, and emissions generated by resources not owned or controlled by the company, are included. Examples of Scope 3 emissions include, but are not limited to, emissions from the production of purchased materials, supplier energy usage, and product transportation from a third-party logistician.

2.2 Carbon offsets

Investments in carbon offsetting are essential for any company or individual who wants to achieve carbon neutrality according to The Economist (2020). Lovell and Liverman (2010) explain that the carbon offset market is complex and complicated and has been characterized by a polarized debate in both media and academia. In essence, there are two separate offset markets, one voluntary market and one regulated compliance market (2011). The compliance market is mainly for countries and a few companies that are bounded by caps on how much they can emit. One way to increase the allowed quantity of emissions is via carbon offsetting where the actor purchases carbon credits and the money is spent following strict standards on

emission reduction projects or GHG removal (Kollmuss, Zink, & Polycarp, 2008). The voluntary market on the other hand is not as structured due to the lack of a clear market standard for how offsetting should be performed and measured (Lovell & Liverman, 2010). Dhanda and Hartman (2011) conducted a review of the voluntary carbon offset market and identified that 117 different actors were calculating and offsetting carbon emissions for companies and individuals.

Dhanda and Hartman (2011), explain the corporate voluntary market: A company emitting carbon that wants to offset parts of, or all, their emissions pay money to an offset provider. The offset provider then sponsors or engage in projects that reduce emissions of some sort, or that remove GHG from the atmosphere. The offset providers often follow one, or multiple, offset standards which ensure that companies can report the investments as "negative" emissions in their climate report (Dhanda & Hartman, 2011), this process is illustrated in Figure 2.2. Multiple competing standards regarding what counts as a legit carbon offset project exist but according to Kim and Pierce (2018) there are four common traits among the standards: additionality, permeance, absence of leakage, and verification. Additionality means that the emission reduction project would not have happened if it were not funded by the offset provider (Kollmuss et al., 2008). Permeance means that the project continues for its expected lifetime and thus contributes to emission reductions for the entire time, Kim and Pierce (2018) exemplify with a tree-planting project. If the trees are cut down, the project cannot be considered permeant since there will be no CO_2 reductions without the trees (Kim & Pierce, 2018). According to Kollmuss et al. (2008), leakage in this context refers to potential increases of emissions outside of the scope of the project. Kim and Pierce (2018) exemplify a project that prevents a particular forest to be cut down if the loggers travel to the next forest and cut that down, the net reduction due to the project is zero. Lastly, a project is verifiable if the other three criteria are documented and established by a third-party authority (Kollmuss et al., 2008; Kim and Pierce, 2018).

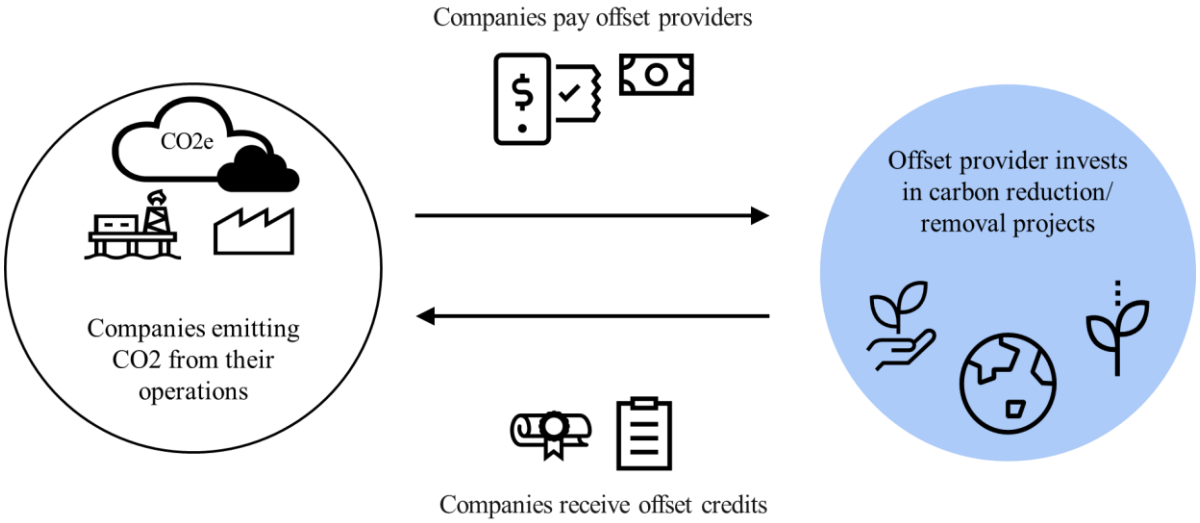

Figure 2.2. Carbon offset logic

2.2.1 Critique and difficulties

Dhanda and Hartman (2011) have pointed out some critiques and weaknesses associated with the carbon offsetting system. Firstly, no certification standard is in place in the voluntary market, creating the possibility that some offset credits traded may be worthless. Nevertheless, two plausible solutions to this problem could be to either educate buyers to make informed decisions or implement a certified third-party validator that ensures the quality of the traded offsets. Secondly, reaching carbon neutrality and net-zero emissions is not done only by offsetting all scope 1, 2, and 3 emissions. Instead, the ideal path to net-zero emissions would be to determine the company's carbon footprint through calculations and analysis, reduce these emissions as much as possible through different actions, and then offset the remaining emissions that cannot be reduced. Kollmus et al. (2008) propose two different concepts that are cumbersome to avoid when it comes to carbon offsetting: additionality and leakage. Additionality creates some difficulties since the reduction in emissions from an offset project needs to be calculated from a non-existing reality where the project has not been implemented, and where the emissions, in theory, would have been emitted. This non-existing reality will always be subjective and cannot be verified in any way. In essence, if the project would have happened without the funding from the offset purchase, the project is non-additional and thus should not be valid carbon offsetting. Leakage can also be problematic for carbon offsets. In some cases, it can be impossible to examine a carbon offset project's effect on GHG emissions outside of its boundaries. Because of this, some standards exclude specific sources of leakages that are hard to estimate.

2.2.2 Greenhouse gas removal techniques

Several different methods and types of projects are valid for carbon credits on both offset markets. On the compliance market, there are roughly 200 types of projects according to UNEP DTU (2021) and the four main project types are renewable energy, methane capture, energy efficiency, and fuel switch. All projects have in common that they either remove GHGs from the atmosphere or reduce current emissions in some way (Selin, 2011).

To reach net-zero GHG emissions and thus complying with the EU long-term strategy of being climate neutral in 2050, it is not enough to only avoid and reduce emissions, but the offsets projects need to remove carbon from the atmosphere (The Economist, 2020). According to the European Academies Science Advisory Council (2018), one way to remove GHGs is by using negative emission technologies, also referred to as GHG removal (GGR) methods. Table 2.1 below presents GGR methods, based on the Royal Society and Royal Academy of Engineering (2018).

Table 2.1. GGR methods, definition, technology readiness level, and cost per tCO_2 removed, based on the Royal Society and Royal Academy of Engineering (2018)

GGR method	**Short definition**	**Technology readiness level (1-9)**	**Cost [$/$tCO_2$]**
Afforestation and reforestation	Carbon reduction from the atmosphere by establishing or re-establishing forests	8-9	3-30
Wetland, peatland, and costal habitat restoration	By rewetting high-carbon-density coastal ecosystems, these absorb CO_2 from the atmosphere	5-6	10-100
Soil carbon sequestration	CO_2 is absorbed into the soil as a result of improved and changed land management	8-9	3
Biochar	Carbon is stored in the soil via pyrolysis, i.e. thermally decomposing biomass into a stable form such as charcoal	3-6	0-200
Bioenergy with carbon capture and storage	Atmospheric CO_2 is absorbed and locked in temporary plants until it is permanently stored underground in geological formations, the biomass is used to generate electricity	4-9	100-300
Ocean fertilization	By increasing the oceanic photosynthesis with additional nutrients dropped in the ocean, more CO_2 is absorbed from the atmosphere to the ocean	1-5	10-500
Building with biomass	By utilizing materials such as timber in construction, harvesting can be done continuously in the forests and ensure continuous absorption of CO_2 emissions and storage in buildings	8-9	0

Enhanced terrestrial weathering	Silicate rocks are broken (weathered) to increase the reactive surface area and thus accelerate chemical reaction that binds CO_2 from the atmosphere	1-5	50-500
Mineral carbonation	The above-mentioned silicate rocks are instead converted to carbonates by injecting CO_2 into the rocks. This creates a stable mineral that stores the carbon and can later be sold for commercial purposes	3-8	50-300
Ocean alkalinity	The alkalinity is increased in the ocean by adding ions and molecules to dissolve high quantities of CO_2 to its ionic form	2-4	70-200
Direct air capture	CO_2 is captured from the air in a separating agent and stored geologically, mineralized, or used in other ways	4-7	200-600 (short term) 100 (long term)
Low-carbon concrete	5% of the CO_2 emissions stem from cement and concrete production, Low-carbon concrete is a collection of technologies that can decrease emissions and store CO_2 in the material itself	6-7	50-300

2.3 Environmental sustainability in organizational decision-making

Several different approaches towards how sustainability can be more included in organizational decision-making exist. Most publishers seem to agree that sustainability is most effectively integrated into decision-making using a top-down approach (e.g. Borland, Lindgreen, Amvrosini, & Vanhamme, 2018; Bonn & Fisher, 2011), thus recommending that companies start by including sustainability in their vision and corporate strategy and then ensure that the organization supports the long-term vision and strategy. Borland et al. (2018) explain that companies can fundamentally choose one of three types of business strategies and their relation to sustainability. Firstly, companies can develop a traditional strategy based on theories such as Porter's five forces (Porter, 1998) or the value chain model (Porter, 1985). Teece (2007) argues that constructing a corporate strategy based on these models will facilitate a linear business model and a static company. Borland et al. (2018) believe that these linear and static

traits of companies with traditional strategies stem from the fact that sustainability is not dealt with in the frameworks for developing strategies, and that they presume that ecological and social sustainability is not affected by businesses.

Secondly, the concept of transitional strategies is explained by Borland et al. (2018) as strategies that resemble traditional linear business strategies but with a larger focus on minimizing the purchases of precious or environmentally detrimental materials, thus increasing circularity a little bit while not completely changing the business model. Companies developing transitional strategies essentially want to reduce their impact on the environment rather than eliminating the impact through a completely new mindset and business models. Five cornerstones in transitional business strategy that is coupled with a linear business model are the *transitional 5 R's*: *Reduce, Reuse, Repair, Recycle,* and *Regulate*. These cornerstones aim to reduce unnecessary waste, reuse as much material as possible, avoid landfills of scrapped products, and be prepared for stricter regulations that likely will see the light of day in this area.

Lastly, transformative business strategies are radically different from traditional and transitional strategies. Transformative strategies do not take an anthropocentric approach, but rather an ecocentric approach. Borland et al. (2018) explain that these companies do not aim to reduce emissions, but instead eliminate them altogether. Moreover, these companies tend to be circular and operate in a closed-loop cycle. Executives following this strategy have a long-term mindset and view social sustainability as part of the larger well-being and balance of the planet's ecosystem. Borland et al. (2018) explain that companies aiming for this fully circular ecocentric strategy should follow five transformational R's: *Rethinking* the business model; *Reinventing* products, processes, and technologies; *Redesigning* products and processes in line with ecological requirements; *Redirect* products after end-of-life to the producing company; *Recover* all products after end-of-life from customers.

All three examples of strategies mentioned above, traditional, transitional, and transformative, are examples of what Bonn and Fisher (2011) label corporate strategies. The authors argue that these corporate strategies must be translated into business unit level strategies and functional unit level strategies in order to be effective. The business-level strategy may include directives related to how the individual business units contribute to the corporate strategy, for example how the unit can become more energy-efficient, how the production/supply unit can invest in more sustainable production technologies and raw material from suppliers. The functional strategy is specific for each function and describes how the function will work to support the business unit and the corporate strategy. For HR this can for instance be to favor recruitment candidates with a passion for sustainability (Bonn & Fisher, 2011).

Bonn and Fisher (2011) also explain that if a company wants to include environmental sustainability into the decision-making process, it is of utmost importance to create a work culture where employees are passionate about environmental sustainability, and where the sustainable business practice is rewarded within the firm. One way to create such a culture is to perform environmental initiatives within and outside of the firm, such as investing in research and development (R&D) to create more efficient products, CSR, and invest in green energy.

2.4 Internal carbon pricing

According to Aldy and Gianfrate (2019), the fundamental principle behind internal carbon pricing is to assign a monetary value to a company's own GHG emissions. The internal carbon price will also build on the business language within the company through its monetary value, making the cost and impact of GHG emissions more understandable (Ahluwalia, 2017). The aim is to internalize the cost of CO_2 equivalents emitted from business activities performed by the company and to make the company financially incentivized to reduce carbon emissions (Ahluwalia, 2017). Implementing an internal carbon pricing scheme at a company can be rather complex, but it does demonstrate climate awareness to its external stakeholders (Ahluwalia, 2017; Harpankar, 2019). Ecofys, The Generation Foundation, and CDP (2017) also point out if other tools are already in place to meet carbon targets, internal carbon pricing may not be needed to reach the specific target.

2.4.1 Four approaches

An internal carbon price could be applied in different ways. These ways can be generalized into three main approaches: carbon fee, shadow pricing, and implicit carbon pricing (Harpankar, 2019). Also, according to Ahluwalia (2017), a fourth approach can be established, a hybrid pricing approach, most commonly the use of a carbon fee and shadow price in parallel. Furthermore, which approach to use is dependent on what the company wants to achieve. If the main goal is to investigate the implications of further regulations on carbon, a shadow price is suitable (Harpankar, 2019). On the other hand, if the aim is to do more and reduce the company's GHG emissions, a carbon fee can be added to drive investments and change behaviors. The approach will also determine the degree of influence on the company's decision-making. According to CDP (2021a), a collected fee will have the strongest influence and impact, while the application as a financial indicator, like a shadow price, will have a medium impact and only tracking the internal carbon price, without applying it to decisions, like an implicit price, will have the weakest impact.

2.4.1.1 Carbon fee

With the carbon fee approach, a monetary value is assigned to one ton of GHG emissions. Then, when the company's business activities emit GHGs, the fee is charged by the company itself, and transferred into a carbon fee fund, to internalize the cost of GHG emissions. The carbon fee fund can be used in different ways but usually to subsidize investments that support the further reduction of GHG emissions (Ahluwalia, 2017). For example, investments can be related to carbon capture, renewable energy, carbon offsets, or energy efficiency projects. The fee creates incentives to reduce GHG emissions and transition to low-carbon activities, and eventually support innovation, since the company will try to minimize the cost related to the GHG emissions, increasing competitiveness over time (Harpankar, 2019; Topping, 2019). Moreover, the carbon fee is generally applied to scope 1 and scope 2 emissions while scope 3 emissions are often excluded since these are difficult to accurately measure. However, one exception is business travel which easily can be calculated based on distance traveled and sometimes be subject to the carbon fee as well (Ahluwalia, 2017).

Since the carbon fee can affect the bottom line, the aim is to incentivize behavioral and cultural change to prepare for a low-carbon economy (Ahluwalia, 2017). However, a carbon fee can be challenging to implement. The company needs to have the right knowledge and resources to develop, implement and administrate the carbon fee program. For example, the carbon fee fund needs to collect the fee in some way, then evaluate potential investments and allocate funds to the selected projects. Also, because it is an actual monetary fee charged, stakeholder buy-in can be the greatest challenge (Ahluwalia, 2017). The carbon fee concept has already been adopted by multiple forerunners in environmental sustainability, for example, Microsoft target negative carbon emissions in scope 1, 2, and 3 by 2030, which will be achieved via an internal carbon fee (DiCaprio, 2013).

2.4.1.2 Shadow pricing

Through shadow pricing, a theoretical price is assigned to GHG emissions, an actual fee is not charged. The shadow price is a tool to assess risks (Bento & Gianfrate, 2020; Topping, 2019), and evaluate investments or strategy (Ahluwalia, 2017; Aldy & Gianfrate, 2019). A shadow price on carbon emission can be used to determine the impact GHG emissions will have on the return of different investments. It can also be used to model the potential impact of different regulatory prices on carbon imposed by governments in the future (Harpankar, 2019), through carbon taxes or ETSs (Aldy & Gianfrate, 2019; Bento & Gianfrate, 2020; Harpankar, 2019). Because of this, shadow pricing can help build the business case for low-carbon investments and R&D (Ahluwalia, 2017). The price itself is most often based on external resources (Ahluwalia, 2017; Harpankar, 2019), see Section 2.4.3.1 for more information on this pricing method. Also, the shadow prices used by companies are generally higher than the carbon fees, since the shadow price is no actual fee, but an assessment tool (Harpankar, 2019).

Ahluwalia (2017) raises a few concerns related to shadow pricing. To begin with, the fact that a shadow price is a theoretical price is limiting. For example, applying a shadow price may not be enough to drive investments towards low-carbon options, since these decisions are influenced by other market factors in the short run. Also, the lack of long-term consistency in climate strategy among governments creates a problem for firms to set their shadow price because it drastically can change in a short period of time.

2.4.1.3 Implicit carbon pricing

Unlike the previously described approaches, implicit carbon pricing sets the price on GHG emissions retroactively (Harpankar, 2019) and works more as a key performance indicator (KPI) rather than a tool to drive change. The price is based on the cost of previously implemented projects aimed to reduce GHG emissions and fulfill regulations (Ahluwalia, 2017). Because of this, the implicit carbon price for a ton of GHGs that has been reduced is equal to the cost of reducing those GHG emissions (Harpankar, 2019). Moreover, implicit carbon pricing is primarily used in an early stage of internal carbon pricing by companies who need to get a better understanding of their carbon footprint, improve internal communication, and realize the cost of regulatory compliance (Ahluwalia, 2017). Also, implicit carbon pricing can be used to benchmark internal carbon prices, before introducing a carbon fee or a shadow price.

2.4.1.4 Hybrid carbon pricing

Hybrid carbon pricing can take multiple forms but is essentially a combination of the previously described carbon pricing approaches. These combinations can form unique carbon pricing approaches to better suit a specific company's needs and strategy to reach its environmental sustainability targets. According to Ahluwalia (2017), the most combination of a carbon fee to reduce GHG emissions, and a shadow price to evaluate investments, e.g., Disney is using this hybrid approach.

2.4.2 Implementation options

In addition to choosing an approach to internal carbon pricing, a company must understand in which processes, or in which departments that the internal carbon price should affect decision-making. Ecofys et al. (2017) present eight such decisions/approaches to where and how internal carbon pricing can be implemented in a company. These are explained and summarized in Table 2.2. It is important to note that a company can use one, or several of the applications listed in Table 2.2. The column Possible approaches refer to which of the two main approaches (shadow price or carbon fee) that can be used in the specific type of application. When a type of application only is considered to work with a carbon fee it is because it requires a financial flow of money, something that is not possible with a shadow price.

Table 2.2. Eight different applications of internal carbon pricing (abbr. ICP), definition, most common approach, and the Greenhouse Gas Protocol scope they impact. Based on Ecofys et al. (2017) and Greenhouse Gas Protocol (2004)

Type of ICP application	Description	Possible approaches	Scope
Capital expenditure (CapEx) decisions	Changes in carbon emissions due to the investment are multiplied with ICP, this "cost" or "revenue" is used in the return on investment calculation, thus, strengthening business cases for sustainable investments. The carbon price could be paid to an internal fund or be used for theoretical analysis.	Shadow price Carbon fee	1,2,3
Procurement	Applying a carbon price based on the carbon footprint of the purchased goods or services. If this carbon price is considered, the business case is strengthened for low-carbon products and services. The carbon price could be paid to an internal fund, a supplier fund, or be used for theoretical analysis.	Shadow price Carbon fee	2,3

Supplier fund	A supplier fund can be established, aimed to financially support emission reduction projects in the supply chain. The fund can be filled with ICP revenues from for example applying a carbon fee on purchased goods and services.	Carbon fee	3
R&D	In a similar way to capital expenditure decisions, ICP can be used to analyze the environmental impact of R&D proposals. The carbon price for the proposal could be paid to an internal fund or be used for theoretical analysis.	Shadow price Carbon fee	1, 2,3
Operational decisions	ICP can be used to reveal hidden climate costs and opportunities if used to visualize the carbon footprint of a company's assets used in operations or the supply chain. This can strengthen the business case for more energy-efficient assets or optimized logistics activities. The carbon price could be paid to an internal fund or be used for theoretical analysis.	Shadow price Carbon fee	1,2,3
Carbon fee on business units	Departments are charged based on their contribution to the company's emissions within the selected scope. This approach internalizes the environmental costs and the ICP revenue can be used to invest in emission reduction projects in the firm/supply chain, offsetting, or as a bonus to employees.	Carbon fee	1,2,3

Bonuses	Revenues gained from a carbon fee are used to pay individual employees remuneration based on how much they have contributed to lower the emissions. Depending on how it is applied, this could incentivize business travelers to travel by train. Alternatively, the ICP can link managers' bonuses to the energy efficiency of their business units.	Carbon fee	1,2,3
Carbon offset purchases	Revenues gained from a carbon fee can be reserved for purchasing carbon credits (See Chapter 2.2). The offset purchases can either be made from the overall company or individual business units and thus fully integrate climate impact in decision-making.	Carbon fee	1,2,3

In addition to the application approaches in Table 2.2 explained by Ecofys et al. (2017), Ahluwalia (2017) suggests that a carbon fee can be applied depending on the activities performed, if the company want to reduce air travel, having a high, targeted carbon price on business travel may be effective. Harpankar (2019) adds that the internal carbon price can be varied between business units instead of being applied uniformly to all business units, this may cause complexity, however.

2.4.3 Calculation methods

According to Chang (2017), the internal carbon price is commonly measured and defined in dollars per metric ton carbon dioxide equivalent emitted, $/t$CO_2$e. There is no single method for calculating the internal carbon price suitable for a specific organization. The right method depends on the firm's objectives, expected results from implementing internal carbon pricing, and how progressive they are in their sustainability ambitions. The different pricing calculations can be categorized into four main methods, these are presented below.

2.4.3.1 External resource

The first and simplest method is to base the price on external price-setting mechanisms (Ecofys et al., 2017). I4CE and EPE (2016) explain that the price can be set to the current EU ETS price of carbon or setting the price equal to the current carbon tax level that the company is required to pay. This method would mean that the internal carbon price reflects the actual cost for the company of emitting one unit of CO_2e. For the company to be more proactive in its carbon pricing strategy, Ecofys et al. (2017) suggest that the price can for example be based on expected future carbon tax levels or the expected future EU ETS price for carbon dioxide emissions. Other externally derived prices can for example be the environmental damage of

emitting one unit of GHG for society (e.g. De Bruyn et al., 2018). Regardless of which externally derived price is used, this method is suitable for companies that do not have large resources to spend on internal carbon pricing but still want to ensure that they are prepared for the low carbon market by being compliant with potential future regulation and future-proofing their investments and assets (Ecofys et al., 2017). The drawbacks with using an externally calculated price are that, since it does not consider the specific company or its climate-related goals, it does not guarantee that climate neutrality goals are met, and it is difficult to say whether the company will be able to thrive in a low carbon market (Ecofys et al., 2017).

Should this method be applied with De Bruyn et al.'s (2018) list of environmental prices, the internal carbon price would be somewhere in the range of 21.8 $/tCO$_2$e and 94.4 $/tCO$_2$e. De Bruyn et al. (2018) recommend corporations to use their central value: 56.6 $/tCO$_2$e. Should the price be chosen based on the EU ETS price, it would be 44.33 $/tCO$_2$e as of April 16th, 2021 (Ember, 2021).

2.4.3.2 Benchmarking

The second method is to benchmark industry peers and determine an internal carbon price based on how you want to position yourself in relation to the competitors (Ecofys et al., 2017; I4CE & EPE, 2016). Benchmarking internal carbon pricing can for example be done with CDP's reports (CDP, 2015; CDP, 2017; CDP, 2021b) and datasets that disclose companies internal carbon prices as well as group them together by sector and geographical area, thus making the benchmarking rather convenient (I4CE & EPE, 2016). The benchmarking method is beneficial when customers value sustainability from their suppliers highly, thus providing the company a competitive edge (Ecofys et al., 2017). Additionally, applying this method provides them with larger incentives to develop sustainable products and services compared to their competitors. Benchmarking is similar to the externally calculated price method in that the resources required are relatively small and the method is commonly deployed by companies who want to prepare for and thrive in a low-carbon market rather than taking a climate leadership role. Additionally, due to the lack of considerations for the internal situation at the specific company, it cannot be ensured that climate neutrality goals will be met (Ecofys et al., 2017).

According to a report from CDP (2021b), the average carbon fee price level used by companies who apply their carbon fee on scope 1 and scope 2 emissions is 22 $/tCO$_2$e. Companies who instead apply a shadow price on only scope 3 emissions use an average price level of 49 $/tCO$_2$e. When further analyzing the data in CDP (2021b) it is revealed that the highest reported price levels are 532 $/tCO$_2$e and 459 $/tCO$_2$e for using a carbon fee and shadow price respectively. It is important to note that these prices are averages across all regions and all industries. Further, two other examples that can be noted are Microsoft and Ben & Jerry's, two advocates for internal carbon pricing. Both companies use a carbon fee system covering scope 1, 2, and selected scope 3 emissions. Microsoft's price is 15 $/CO$_2$e (Smith, 2020), and Ben & Jerry's use a price of 10 $/tCO$_2$e (Gold Standard, n.d.).

2.4.3.3 Internal consultation

A third method to setting the price for internal carbon pricing mentioned by Ecofys et al. (2017) is by consulting internally at the company to determine a price level that is high enough to influence the behavior of employees. This method is best used when a substantial change in behavior or culture is intended or when the internal carbon price is expected to influence and increase investments in carbon reduction projects (Ecofys et al., 2017). Although the introduction of this internal carbon price would with high certainty affect the business decision to be more environmentally sustainable, it is difficult for companies to estimate and forecast how large this effect will be since the price is not connected to any tangible goal. Thus, the internal consultation method is beneficial for companies that do not have tangible environmental sustainability goals, but still want to be a driver of climate change mitigation. Lastly, internal consultation requires rather large resources both during the consultation phase where concerned managers are to discuss price levels, and when trying to analyze the impact of different prices (Ecofys et al., 2017).

2.4.3.4 Technical analysis

The fourth and final method presented by Ecofys et al. (2017) for calculating an internal carbon price includes performing a technical analysis, factoring in the internal goals and conditions at the company, and based on that, calculating an optimal internal carbon price. Calculating the internal carbon price in this way requires large resources for the detailed analysis and complete data over their carbon footprint as well as the costs associated with reducing and offsetting GHG emissions internally and externally (Ecofys et al., 2017). The upside to this method, however, is that the price can be set to ensure that environmental targets are met on time Ecofys et al. (2017). Moreover, investments in GHG reduction initiatives are accelerated and the emissions which are not cost-efficient to reduce can be offset accordingly (see Chapter 2.2 for a detailed description of carbon offset). The price can be calculated in slightly different ways based on the scope of the internal carbon price and the goals of implementing it, generally, the price is set to ensure that a certain environmentally sustainability target is met by dividing the cost of reducing or offsetting emissions with all total emissions. This calculation method is thus mainly used by companies who aim to take a leading role in mitigating climate change, one such company is Microsoft (DiCaprio, 2013). Microsoft is a forerunner in internal carbon pricing practice and, according to DiCaprio (2013), calculate their carbon price by first summing the costs related to project and initiatives that reduce their carbon footprint and then dividing that with their total emissions:

$$Internal\ carbon\ price\ = \frac{Total\ cost\ of\ environmental\ initiatives\ portfolio\ [\$]}{Total\ GHG\ emissions\ [tCO_2e]}$$

$$= \frac{Cisp\ +\ Cgpp +\ Cco}{Total\ GHG\ emissions}$$

Where Cisp is defined as the cost of internal sustainability projects, Cgpp the cost of green power purchases, Cco the cost of carbon offsets respectively.

Another perspective to the technical analysis is presented by Mikolajczyk, Liese, Brüning, Bartlett, and Kaya (2017) is to first calculate the marginal abatement cost curve (MACC) for

the corporation (i.e. the cost for reducing one extra tCO_2e). This MACC presents possible ways to reduce the environmental impact for the company, how much they would cost in $\$/tCO_2e$, and the total CO_2e-reduction potential. Following the calculation of the MACC, the company can set the carbon price at a level where it ensures that a particular environmental target is met (Mikolajczyk et al., 2017). This method also provides a reasonable input for the investment strategy, as the costs and benefits of the different projects are presented.

If applying the latter method, the calculation of one's abatement cost is naturally vital for the accuracy of how well the targets can be met (Mikolajczyk et al., 2017). WALGA (2014) has produced a detailed report on how to calculate a company's, or a country's, MACC. For each project that can reduce emissions the marginal abatement cost (MAC) is calculated as:

$$MAC = \frac{NPV\ of\ the\ project\ [\$]}{Total\ GHG\ emissions\ abated\ due\ to\ the\ project\ [tCO_2e]}$$

Where the NPV, net present value, is calculated as:

$$NPV = Discounted\ revenues\ [\$] - Discounted\ losses [\$]$$

Where the discounted revenues are the total incremental revenues and savings that occur due to the project and discounted losses are the total incremental costs and expenditures that occur due to the project.

The abated GHG emissions are calculated by summarizing the incremental emission reductions and discount to present value. The MAC calculation is done for all potential projects that can van reduce the carbon footprint of the company. The full marginal abatement cost curve can then be constructed by visualizing all projects' marginal abatement cost on the y-axis, and the total emission reduction potential for each project is visualized by how wide the bar is (Mikolajczyk et al., 2017). Mikolajczyk et al. (2017) conclude by saying that the internal carbon price can be set at a price level where all projects with a lower MAC than the internal carbon price can be funded by the carbon fee revenues.

2.4.3.5 Price considerations

Independent of the approach and calculation method, the internal carbon price application can vary within a company. It is important to decide whether the internal carbon price should be uniform or differentiated within the company (Ahluwalia, 2017; Ecofys et al., 2017; Harpankar, 2017). I4CE and EPE (2016) exemplify; the price can vary depending on the region in order to follow legislative requirements or the internal carbon price can vary depending on the type of project for which it is used. A second crucial decision related to the internal carbon price is whether it is static or evolutionary over time (Ahluwalia, 2017; Ecofys et al., 2017). If an evolutionary pricing strategy is chosen, the price will generally increase over time (Aldy & Gianfrate, 2019; Ecofys et al., 2017).

Regardless of which price calculation method is used, the price should be validated and fully understood by whoever performs the calculation (CDP & the We Mean Business Coalition, 2015). If the price is set too high it can be detrimental to the financial well-being of the company, if it is set too low, however, the introduction of internal carbon pricing will not have the expected effect on decision-making. CDP and the We Mean Business Coalition (2015) have

identified an internal carbon price band displaying a successful trajectory of how to reach a price level at which internal carbon pricing has transformational effects. *Targeted* (higher than 80 $/tCO$_2$e) price levels can be imposed from a central authority in the company and is used in certain areas, for example, to switch a particular fuel to another. With a price level classified as either *Operational* (20-50 $/tCO$_2$e) or *Transformational* (50-80 $/tCO$_2$e), a carbon fee would generate substantial revenues which can be used to reduce own emissions or offsetting. The *Introductory* (0-20 $/tCO$_2$e) price band is important as it can be used at the beginning of a company's internal carbon pricing journey.

Given that a company uses an evolutionary pricing approach, the price will gradually increase until it has reached the *Transformational* price band. If this journey is combined with carbon offsets, the company can plan when to reach carbon neutrality (CDP & the We Mean Business Coalition, 2015).

2.5 Theoretical framework

Based on the theory presented in Section 2.4, a theoretical framework for internal carbon pricing can be constructed, shown in Figure 2.3. The framework aims to connect the most relevant topics within the literature on internal carbon pricing and simplifies for companies aiming to create a holistic strategy for their internal carbon pricing implementation. The point of departure in the framework is the desired purpose with the environmental sustainability work of a company and which position it wants to take. On the one hand, a leading role through the *Climate leader* path is available where environmental sustainability goals are prioritized and set more ambitious, for example, compared to the Paris Agreement, and where the internal carbon price has financial impact and implications. On the other hand, if a company wants to do less, just prepare for and follow regulations, the *Climate preparer* path is well suitable. However, it is important to keep in mind that the *Climate leader* path still includes preparing and following regulations as well. From the desired position, the next step is to select an internal carbon pricing approach based on the previous choice. The *Climate leader* path leads to two options, either a carbon fee or a hybrid approach, while the *Climate preparer* path can choose a shadow price or an implicit carbon price. The hybrid carbon pricing approach in this context consists of a combination of a carbon fee and a shadow price, thus also creating financial flows and implications. The main reason for the separate approaches for the two paths is that companies with a carbon fee and/or hybrid approach collect revenue and invest the money in emission reduction and/or emission offsets, thus being more progressive. Moving on to the relation between chosen internal carbon pricing approach and the decisions in which to implement the internal carbon price, several options are only possible when having a monetary flow related to the carbon price. These are the options that only companies on the leading path can take, whereas the other four options are possible with any approach. Lastly, the method for determining the price is dependent on the point of departure. Leading companies will often aim for a specific target and seek behavioral change within the company. The technical analysis is highly suitable for companies with specific targets, whereas the internal consultation is optimal for companies that want to ensure a behavioral change. These two calculation options are also the most labor and resource-intensive. On the contrary, companies who aim to prepare for the

low-carbon market are well-off with a less complicated method such as the external price or benchmarking.

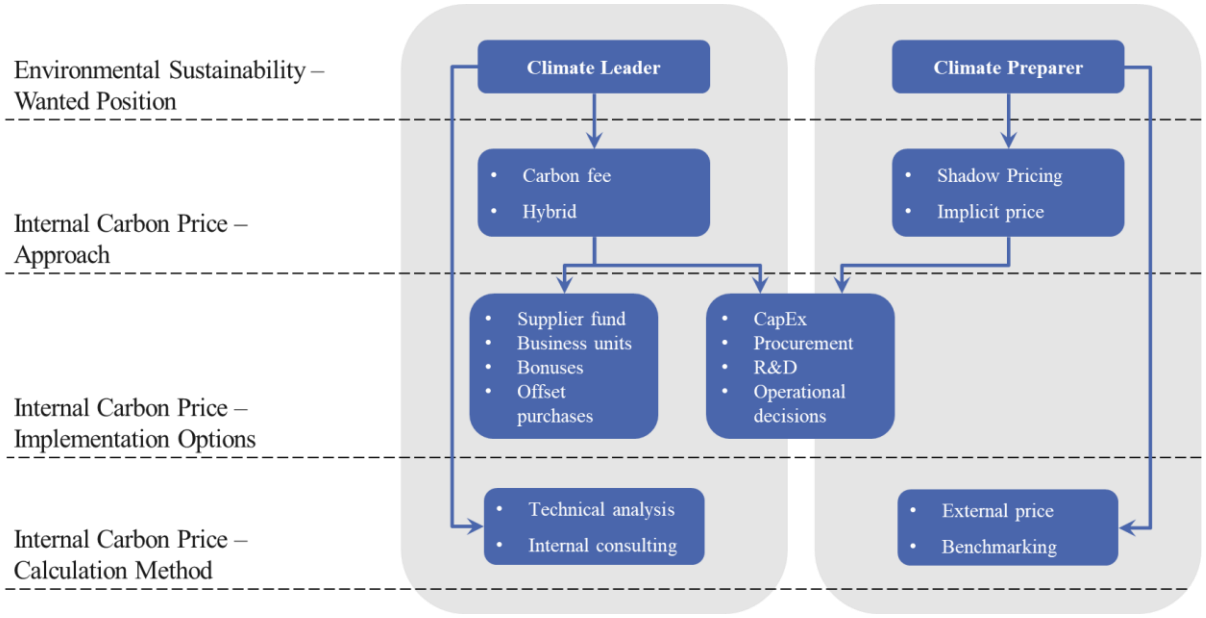

Figure 2.3. Theoretical framework for creating a holistic strategy for internal carbon pricing implementation

3 Methodology

In this chapter, the methodology behind the study is introduced. First, the research process and design are presented followed by the different methods used for data collection, i.e., literature review, interviews, observations, and quantitative data collection. Further, both the qualitative and quantitative analyses performed are described. Lastly, the research quality and ethics are discussed.

3.1 Research process and design

To answer the research questions, an abductive reasoning approach was applied throughout the study, a popular method in business research (Bryman & Bell, 2015). This enabled to switch focus between the concepts presented through the literature review, and the empirical data collected through the interviews, observations, and quantitative data collection (Blomkvist & Hallin, 2015). The abductive approach is suitable to apply when clarification needs to be introduced regarding a specific problem, and the abductive approach seeks to explain the problem in the most natural and manageable way possible (Bryman & Bell, 2015). Furthermore, both qualitative and quantitative data were collected for the study. Qualitative data originated from the interviews, observations, and the literature review, while the quantitative data were collected through internal databases at the case company. Also, primary and secondary data were used for the study which can act as a complement to each other.

The research process is illustrated in Figure 3.1. The thesis was initiated with a pre-study on the topic of internal carbon pricing, research methodology, and the case company Ericsson. This familiarized the researchers with the context, previous research, and the process of qualitative research while also serving as a basis for the literature review that was performed thereafter, presented in Chapter 2. In parallel, introductory meetings were held with sustainability representatives, supervisors, and managers at Ericsson in order to introduce the case company and receive a network of contacts which were utilized when sampling the first interview respondents. Subsequently, a period of data collection occurred where interviews were held, observations of different kinds took place, and quantitative data was collected through the internal databases at Ericsson. The data gathered was later analyzed and the findings from the analysis were then tested on a decision at Ericsson to see if the result would have any impact and to illustrate the practical usage of the concept. The tested and validated findings were then used to draw conclusions and answer the research questions.

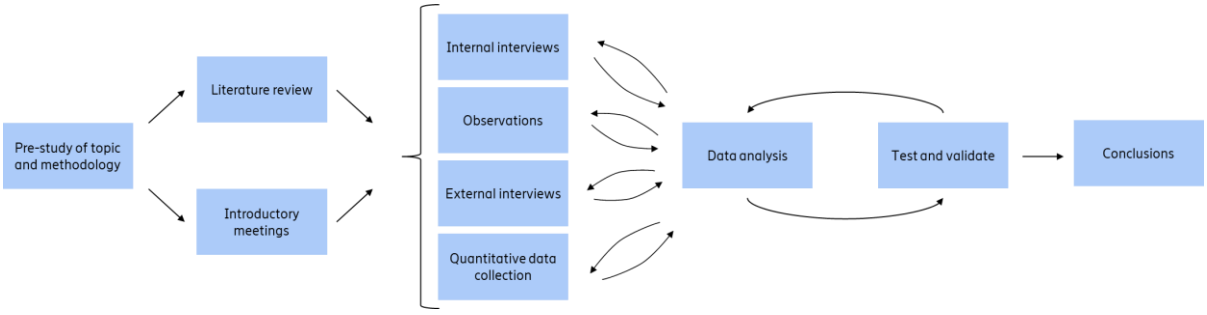

Figure 3.1. The research process used during the study

3.2 Data collection

The topic of this thesis project, internal carbon pricing, is as stated a relatively new and academically unexplored topic. In these cases, Rashid et al. (2019) propose conducting a case study as it provides the researchers with another source of data in addition to the scarce existing literature. Sachdeva (2008) adds that case studies are beneficial tools for increasing the generalizability of the findings. Because of these reasons, a case study was conducted at Ericsson where a large part of the data used in this report was gathered.

Four main types of data collection methods were applied during the study when collecting different types of data. During interviews and observations, primary data was collected. The interviews were held with professionals at Ericsson with specific knowledge of sustainability, finance, and process architectures, and the observations took place when the researchers attended internal management meetings relevant to the study. Secondary data was collected through a literature study and by retrieving quantitative data from the case study company's internal databases. This usage of different types of data increases the validity of the study (Yauch & Steudel, 2003).

3.2.1 Literature review

The literature review was performed mainly through the Chalmers Library database, but also open databases like Google Scholar were used, see Table 3.1 for a summary of the databases and the number of hits for some keywords. In specific cases, encyclopedias like Merriam-Webster and Britannica were used to define common concepts. Also, publicly available reports like annual reports from Ericsson were searched to gain data in a preliminary stage of the study to improve the understanding of the case company and its context. Some keywords that were defined and used in the literature search are presented in Table 3.1 below, together with the number of hits in each database.

Table 3.1. Examples of keywords and databases used during the literature review

Keyword	**Google Scholar** Articles, books, scholarly literature, conference papers, dissertations, etc.	**Scopus** Peer-reviewed articles only	**ScienceDirect** Books and articles published by the publisher Elsevier	**Chalmers Library Database** Filtered for peer-reviewed articles in academic journals only
"Internal Carbon Pricing"	274	23	40	64
"Greenhouse gas protocol"	7 440	1 363	381	1 328
"Environmental sustainability" + "Organizational decision-making"	1 230	83	113	440

After screening literature available on internal carbon pricing, it was concluded that the published material was not sufficient to support this thesis and the creation of the theoretical framework. Thus, literature was searched for on Google and through the resource library provided by the Carbon Pricing Leadership Coalition. One organization that has published extensive material regarding internal carbon pricing is CDP and has been used frequently through this report. CDP reports have been found both via Google and when cited in articles published in journals.

3.2.2 Interviews

During the study, three rounds of interviews were conducted. In the following sections, the interview techniques used are described, followed by a more detailed description of each interview round. The internal interviews were designed to provide knowledge about Ericsson's situation and how internal carbon pricing can be applied and contextualized to meet their needs, in line with the theoretical framework presented in Section 2.5. The purpose of the external interviews was to understand and learn from companies that already had implemented internal carbon pricing.

3.2.2.1 Techniques

According to Yin (1994), interviews are an important source of information in case studies. All the interviews in this study were semi-structured, which implies that a predefined framework of questions was used for the interviews and several of these were open-ended and lead to discussion and follow-up questions. Semi-structured interviews are often better compared to structured interviews since interviews must be somewhat flexible in order to be successful (Wallén, 1996). However, interviews can be subject to challenges, like bias or poor recall from the respondents (Yin, 1994). Semi-structured interviews are generally between thirty and sixty minutes long according to DiCicco-Bloom and Crabtree (2006). Thus, the interviews were scheduled to last within this timeframe.

Adams (2015) mentions that when performing semi-structured interviews, one must ensure adequate time for both preparations, iteration of structure, interviews, and analysis. When preparing the interview guide, it is highly beneficial to first rank questions according to how essential they are to receive an answer to. This ensures that, during the interview, it is easier to prioritize between different questions, should there be a lack of time. Adams (2015) also describe a beneficial structure for the interview guide where the interviewer starts with simple and easy questions to start off at a good note, followed by non-sensitive but relevant and prioritized questions. Questions that may be political or awkward should be left until the latter part of the interview, and if the interviewer asks for criticism of a particular topic, it is beneficial to first ask for positive aspects of the same topic to avoid hostility (Adams, 2015). This interview technique was used when asking some of the questions during this study.

The interviews were conducted by two interviewers at a time, one lead the interview, and the other acted as a support, took notes, and assisted when needed. This approach is in line with Adams (2015) and Trost (2010) who suggest dividing responsibilities and conducting the interviews by two interviewers. Furthermore, the internal interviews were recorded to secure that no data was lost and to afterward be able to go back and listen to what was said. Also,

recording is more suitable when the topic is less sensitive (Adams, 2015), which was the case for these interviews. However, recording interviews can bring some drawbacks. The interviewee may not speak freely and accordingly withhold certain information (Al-Yateem, 2012), and the transcription of the interviews will also take time (Trost, 2010). To secure that the respondents did not withhold information, the respondents were informed that they would be anonymized, and their responses were kept confidential.

The interview guide used in the first and second interview rounds as well as the external interviews can be found in Appendix I and were constructed per Adams (2015) strategies previously mentioned. A good strategy for creating semi-structured interviews that were mentioned by Adams (2015) and applied in the interview rounds was to first ask a closed-ended question on a topic and then follow up with an open-ended question to increase the nuance to the answer. This strategy is beneficial as it opens the possibility to use the answers to the closed-ended question and say for example "*9 out of 10 respondents say yes to X*" while it also allows the respondents to elaborate in the answer to the follow-up question (Adams, 2015). Furthermore, during the progress of the data collection, some minor changes, and improvements were done to the interview guide. It is common to iteratively improve the interview guide after the first few interviews (Adams, 2015; Bauer & Gaskell, 2000). Iterations and improvements of this sort were done to the interview guide for used in the first-round interviews and are displayed in Appendix II.

3.2.2.2 Internal first-round interviews

As mentioned, the first interview round focused on understanding Ericsson's sustainability activities today and their long-term environmental strategy. Thus, it was deemed suitable that individuals with knowledge and a profession in environmental sustainability were part of the target population as well as senior managers that devise the long-term strategy at Ericsson. Exponential non-discriminative snowball sampling was used to identify specific individuals to interview in the first round. The method is designed so the respondents nominate new individuals to participate in the next interview (Etikan, Alkassim, & Abubakar, 2016; Sachdeva, 2008). According to Etikan et al. (2016), this method is beneficial because hidden populations can be discovered and interviewed, and the interviewer is not limited to his or her knowledge about the population. On the other hand, a particular circle in the sample could become overrepresented due to the subjective nomination of candidates (Etikan et al., 2016) and some interviewees might not be able to nominate new candidates. This was deemed a suitable method for this study as the initial interview candidate had a professional network that included many individuals in the target population.

The interview guide used during the interviews can be found in Appendix I, in line with Adams (2015) suggestion, that the interview guide can be iterated to improve the quality of the interviews described in the previous Section, 3.2.2.1, the interview guide was updated for clarification purposes and can be found in Appendix II. All interviewees agreed to conduct the interviews while being recorded which allowed for more accurate transcriptions. The number of interviews performed had not been defined beforehand. New interviews were scheduled until clear patterns in the answers could be defined and no new insights could be generated from having more interviews, i.e., a saturation approach was used to decide the sample size.

According to Guest, Bunce, and Johnson (2006), saturation generally occurs after around twelve interviews if the respondents are homogenous. As visualized in Table 3.2, nine interviews were held in the first round which was deemed sufficient to see clear patterns and common perspectives. In total, 235 minutes (3 hours and 55 minutes) of interviews were conducted, with an average duration of 25 minutes over the nine interviews.

Table 3.2. First round interviews presenting participants, date, duration, and role

Participant	Date	Duration	Role
Respondent 1	2021-02-18	30 min	Internal Project Manager within Strategy
Respondent 2	2021-02-22	20 min	Manager and Environmental Specialist
Respondent 3	2021-02-23	25 min	Global Supply Chain Manager
Respondent 4	2021-02-24	20 min	Global Supply Chain Sustainability Manager
Respondent 5	2021-02-24	30 min	Supply Chain Design Manager
Respondent 6	2021-02-24	25 min	Head of Supply Planning
Respondent 7	2021-03-01	30 min	Senior Supply Chain Manager
Respondent 8	2021-03-02	30 min	Sustainability Director
Respondent 9	2021-03-03	25 min	Head of Global Supply Chain Management

3.2.2.3 Internal second-round interviews

For the second round of internal interviews, the target population was different although some respondents partook in both rounds, see Table 3.3. For the second round, the ideal respondents would not only have a good understanding of sustainability but also work within an area that would be affected by one or more of the implementation options, described in Section 2.4.2. Due to the diverse respondent pool and the limited time of the research project, the saturation approach used for the first round of interviews could not be applied to achieve saturation in all areas. Instead, nine interviews were conducted, and the data gained was deemed sufficient as a ground for analysis. A similar snowball sampling method was used when selecting respondents for the second interview round as well.

The interview guide used for the interviews can be found in Appendix I, no iterations were made to the guide as the quality of the answers was deemed good from the first interviews. All respondents agreed to record the interviews. In total, 360 minutes (6 hours) of interviews were conducted with an average duration of 40 minutes.

Table 3.3. Second round interviews, participants, role and responsibility, length, date, topic

Participant	Date	Duration	Role
Respondent 1	2021-03-15	50 min	Supply Chain Design Manager
Respondent 2	2021-03-15	40 min	Global Supply Chain Sustainability Manager
Respondent 3	2021-03-15	45 min	Supply Chain Designer and Environmental Program Manager
Respondent 4	2021-03-23	35 min	Internal Project Manager within Strategy
Respondent 5	2021-03-26	35 min	Environmental Product Manager
Respondent 6	2021-03-26	40 min	Internal Project Manager within Strategy
Respondent 7	2021-03-30	25 min	Strategic Environmental Analyst
Respondent 8	2021-03-30	50 min	Global Supply Chain Manager
Respondent 9	2021-03-31	40 min	Senior Environmental Specialist

3.2.2.4 External interviews

In addition to the internal interviews at Ericsson, several interviews with external participants were conducted. Due to the novelty of internal carbon pricing and the scarce literature available on the topic, the interviews served as valuable information sources as well as interesting discussion partners on topics related to success factors and challenges during implementation, calculation methods, application areas, the approach used, etc. For these interviews, convenience sampling was used, a sampling method where researchers select respondents that are readily available for participation according to Sachdeva (2008). Respondents were primarily identified via LinkedIn where employees stating that they work, or have worked, with internal carbon pricing projects were approached and asked to participate. The interviews were also semi-structured although slightly less structured than the internal interviews to allow for a good discussion. Instead of having pre-written questions, the researchers constructed a guide with a few key topics to be discussed. This interview guide can be found in Appendix I. The interviews were not recorded, the reasons for this were that both the financials and environmental information can be sensitive for the companies to share. However, the interviewees did accept to participate in the thesis as anonymous respondents and during the interviews, notes were taken. About ten individuals and companies were approached to participate, however, three interviews were conducted due to a lack of responses. In total, 165 minutes (2 hours and 45 minutes) of interviews were conducted with an average duration of 55 minutes over the interviews. In Table 3.4 below, the external interviews are visualized.

Table 3.4. External interviews, participant, date, and duration

Participant	Date	Duration
Company X	2021-03-15	45 min
Company Y	2021-03-17	30 min
Company Z	2021-03-18	90 min

3.2.3 Observations

Throughout the study, several observations were performed at Ericsson, presented in Table 3.5. According to Yin (1994), observations can be divided into two types, direct (passive) observations and participant (active) observations. All the observations presented in Table 3.5 were participant observations, where an active role was taken through questions and discussions. Observations are beneficial since events and context can be studied in real-time, but it is also challenging because it is time-consuming and since the event is observed, it may proceed differently (Yin, 1994). The observations validated other primary data collected, and new knowledge was acquired, in line with Wallén (1996) and Yin (1994). Also, the observations can bridge the potential gap between what is being said during the interviews and the reality (Mays & Pope, 1995). In most cases, two observers participated in the observations, which increases the reliability of the observational evidence according to Yin (1994). In total, the researchers performed 875 minutes (14 hours and 35 minutes) worth of observations, with an average duration of about 55 minutes per observation.

Table 3.5. Observation, date, duration, topic, and participants

Observation	Date	Duration	Topic	Participants
Meeting 1	2021-02-15	120 min	Strategy execution	• Internal steering group on strategy execution within networks supply
Meeting 2	2021-02-15	50 min	Greenhouse gas reporting	• Internal Project Manager within Strategy and Sustainability • Strategy Manager • Other thesis students
Meeting 3	2021-02-16	60 min	Inventory management and governance	• Head of Outbound Logistics • Head of operations • Internal Project Manager within Strategy and Sustainability • Other thesis students
Meeting 4	2021-02-17	45 min	Climate action for sourcing	• Global Supply Chain Sustainability Manager • All of Ericsson Supply Organization

Meeting 5	2021-02-18	90 min	Sustainability/ profitability trade-off	• Internal Project Manager within Strategy and Innovation • Other thesis students
Meeting 6	2021-02-18	60 min	Climate action for sourcing	• Global Supply Chain Sustainability Manager • Other thesis students
Meeting 7	2021-02-19	60 min	Supply climate action	• Internal Project Manager within Strategy and Sustainability • Strategy Manager • Other thesis students
Meeting 8	2021-02-22	45 min	Circular business at supply	• Global Supply Chain Manager • Internal project leader within collaboration and communication • Other thesis students
Meeting 9	2021-02-22	30 min	Ericsson production and operations	• Operations Manager • Other thesis students
Meeting 10	2021-02-25	45 min	GHG reporting and calculation	• Senior Environmental Specialist • Internal Project Manager within Strategy and Sustainability • Strategy Manager • Other thesis students
Meeting 11	2021-02-25	45 min	Introduction to the executive sustainability team	• Executive Climate Action Manager • Senior Environmental Expert • Other thesis students

Meeting 12	2021-02-25	30 min	Tactical planning supply sustainability	• Global Supply Chain Manager • Internal project leader within collaboration and communication • Other thesis students
Meeting 13	2021-02-26	30 min	Supply chain design	• Senior Supply Chain Manager • Other thesis students
Meeting 14	2021-03-04	30 min	Climate action measurement at Ericsson Supply	• Senior Supply Chain Manager • Other thesis students
Meeting 15	2021-03-10	45 min	Scope 1 and 2 emissions	• Senior Environmental Specialist • Internal Project Manager within Strategy and Sustainability
Meeting 16	2021-04-08	90 min	Actions to meet climate neutrality	• Internal Project Manager within Strategy and Sustainability

3.2.4 Quantitative data

To calculate the internal carbon price to be recommended according to the logic described in Section 2.4.3.4, suitable and reliable data had to be collected. Certain data used is publicly available through Ericsson's annual sustainability report (Ericsson, 2021b) whereas other datasets were confidential and retrieved via senior environmental professionals at Ericsson. The majority of the data used were in Excel format and used by the environmental professionals to calculate and analyze Ericsson's internal and external emissions. When using secondary data, the concern of reduced validity and reliability can occur, however, this was deemed to be of minimal relevance in the study as the data is scrutinized by Ericsson's employees as well as external auditors prior to publication of the annual sustainability report (Executive Climate Action Manager, personal communication, February 25, 2021). These datasets were used to understand Ericsson's facility and fleet emissions, energy and certificate purchases, and internal cost of reducing emissions, and they are presented in Section 4.3.

3.3 Data analysis

In the following section, a high-level description of how the qualitative and quantitative data analysis was performed is given. The results of these analyses can be found in Chapter 5.

3.3.1 Qualitative data analysis

Since both qualitative and quantitative data were collected in the project, several analysis methods had to be applied in order to extract information and knowledge from the data. For the primary information collected through interviews, a thematic content analysis was performed. The recordings were transcribed and saved shortly after the interview was conducted. Once all interviews in the first interview round were completed, conclusions were drawn with qualitative content analysis. The analysis followed the six stages of the thematic analysis presented by Braun and Clarke (2006) in table 3.6 below.

Table 3.6. Six stages of thematic analysis during the thesis. Structure based on Braun and Clarke (2006)

Stage	Process description
Familiarization	Transcribing interviews, reading qualitative data, and noting ideas for codes and themes
Code generation	Coding relevant features in a systematic way across all transcribed interviews
Theme search	Comparing codes and the data behind them and build potential themes of similar codes
Review of themes	Understand whether or not themes work and make sense in relation to the coded data and the entire data set (all interviews)
Definition and naming themes	Continue refining specifics of each theme and the entire analysis, develop clear names for each theme and describe them in an understandable way
Report production	Select relevant examples from the data and relate the content analysis to the research questions, literature, and the aim of the thesis.

3.3.2 Quantitative data analysis

The secondary quantitative data, i.e., the datasets covering emissions, were analyzed in Excel where the internal carbon price was calculated. The results were then benchmarked against industry peers and external price-setting tables. In addition, the calculations were done with the aid of estimated emission reductions in an analysis where the price and emissions were recalculated on a per annum basis to visualize how climate neutrality in 2030 can be achieved with internal carbon pricing.

3.4 Research quality

In the following sections, the concepts of research validity and reliability are introduced, followed by a display of how the measures taken in this thesis study in order to achieve high validity and reliability. Subsequently, a more general discussion about the chosen method and limitations is presented.

3.4.1 Research validity and reliability

According to Yin (1994) and Gibbert, Ruigrok, and Wicki (2008), there are four common evaluation criteria when evaluating the quality of a case study: *internal validity*, *construct validity*, *external validity*, and *reliability*. *Internal validity* is associated with the analysis phase of the study and is considered high if the reasoning presented is logical and the causal argument is plausible enough to defend the research conclusion (Gibbert et al., 2008). Three measures taken to achieve higher research validity include (1) formulating a research framework and demonstrating causal relationships, (2) pattern matching, i.e. comparing predicted or previously observed patterns with the patterns identified in the case study, and (3) theory triangulation, where researchers can apply multiple perspectives in order to verify their findings (Gibbert et al., 2008). *Construct validity* on the other hand refers to how well the study is conceptualized, thus answers whether the study investigates what it claims to investigate (Gibbert et al., 2008). This is of great importance when collecting data for the study and can be addressed by minimizing the researchers' bias through triangulating data and using data from different sources when analyzing a problem (Yin, 1994). A second measure that can be taken to increase the *construct validity* is to establish a logical chain of evidence, ensuring that there is a clear path from the project's aim and research question to the conclusion (Gibbert et al., 2008). *External validity* covers the extent to which the findings of a study can be inferred to a greater population, alternatively; how generalizable the findings are (Gibbert et al., 2008). Case studies are commonly criticized for lacking in terms of external validity, but Yin (1994) argues that analytical conclusions often are generalizable from case studies, whereas statistical conclusions seldom are. Two tactics that can be taken to increase the external validity to use theory and compare the case study findings, and to replicate findings in multiple case studies, thus increasing the validation (Yin, 1994; Gibbert et al., 2008). Lastly, *reliability* means that independent research teams conducting the same study would arrive at the same conclusions which, according to Gibbert et al. (2008), is reached by being transparent and ensuring replicability. Yin (1994) describes that transparency can be reached by constructing a case study protocol, a detailed description of how the case study was conducted. Moreover, Yin (1994) also suggests that replicability can be addressed by constructing a case study database with all documentation and notes needed to understand how the case study was conducted.

In Table 3.7, a record is given of which of the above-mentioned actions have been taken in this Master's thesis study and in which section of the report it is reflected. However, certain actions have not been taken for different reasons. For example, both Yin (1994) and Gibbert et al. (2008) explained that external validity can be achieved through doing multiple case studies. The researchers of this thesis study opted for another action to increase the external validity, by comparing the findings of one case study with findings in literature in the interest of time and available resources.

Table 3.7. Four evaluation criteria and where they are reflected in the report. Based on Yin (1994)

Case study evaluation criteria	Measure taken to increase the quality	Reflected in this report	Description
Internal validity	Formulating a framework and causal relationships	Section 2.5	Causal relationships explained and framework presented
	Matching of patterns found in empirical data and theory	Section 5.1-5.4	Literature findings compared with external interviews, internal interviews, and price calculations
Construct validity	Use data from multiple sources	Chapter 1, 2, 3, 4, 5, and 6	Multiple sources used; the full list of sources presented in the bibliography
	Establish a clear linkage between aim and research questions to conclusion	Chapter 6	Research questions answered as well as reflection on the fulfillment of the aim
External validity	Compare theory and case study findings	Chapter 5, 6	Literature findings and the internal situation at Ericsson is compared
Reliability	Maintain an internal case study database with documentation	Performed, not reflected in the report itself	Microsoft Teams database for the study was maintained, not reflected in the report

3.4.2 Limitations and reflections

An abductive approach has been applied throughout the study. However, it would have been possible to use other approaches and still get similar empirical findings. A more deductive approach would have been possible instead of formulating the research questions as described in Section 1.2.3, hypotheses could have been phrased and thereafter tested if true or not. One such area where this could have been applied is the theoretical framework. Hypotheses could have been formulated in order to test and validate the framework, nonetheless, today the theoretical framework is built on logical casual relations described in Section 2.5. Also, it could be determined that no satisfying number of published articles were available to support the literature chapter, especially on the topic of internal carbon pricing. Because of this, other

sources of information had to be used to expand and substantiate the literature chapter in this report. One such source is CDP, a non-profit charity that publishes extensive reports regarding internal carbon pricing and best practices. This source of information was deemed credible since they are found as references in the published articles and quoted in other trustworthy publications, even if CDP is a charity with its own interest and could be biased.

Regarding the 18 internal interviews, an increase in the number of interviews was deemed not to have provided any additional empirical findings and the responses from the interviews provided a stable basis for analysis. However, the ambition was to conduct more than the three external interviews. But due to the poor response rate and the limited population, it was only possible to conduct the three interviews. Since these interviews provided information from companies who already had, or soon would, implement an internal carbon price, the information has been very helpful in providing a lot of insights, therefore it would have been desirable to perform more of this type of interviews. Nonetheless, the applied methods for data collection in this study were deemed suitable due to the qualitative nature. It might have been possible to conduct a survey to gain more data from external parties and thereby possibly solve the problem that occurred with the low response rate in the external interviews. However, a survey is not a guarantee for more data, and in this case, it is important to understand what the companies who have implemented an internal carbon price have done and understand their way of thinking. Therefore, a survey was deemed not suitable, instead, interviews were a better option.

The observations have been an important complement to the interviews in order to bridge the potential gap between what was being said during the interviews and the reality, in line with Mays and Pope (1995). Through the observations, it has been possible to establish that the responses from the interviews did not contradict what could be observed in the everyday life of the organization. The observations were not always related to meetings regarding environmental sustainability, but even these meetings validated what was being said during the interviews in many aspects.

3.5 Research ethics

According to the Swedish Research Council (2017), the researchers are responsible for the participants and the impact of the research. Because of this, the research has been conducted in line with good research practice which principles are based on integrity according to All European Academies (2017). The principles in good research practice are *reliability*, *honesty*, *respect*, and *accountability*. *Reliability* is related to the quality of the research and is affected by the design of the study and the methodology used (All European Academies, 2017). The design of the study and the choice of methodology in terms of quality were presented in the previous Section 3.4. *Honesty* relates to researching in a transparent and unbiased way and communicate the full result (All European Academies, 2017). In the study, the full result has been presented in Chapter 4, and how the research has been conducted is in detail described in Chapter 3, nothing has been left out on purpose. Furthermore, *respect* for participants and others involved has been a priority throughout the study. Sensitive information, like the names of participants, was anonymized, and their responses were kept confidential. Lastly, the researchers are *accountable* for the research in this study.

Furthermore, it is important to inform participants that they are subject of research and receive their consent to participate (Swedish Research Council, 2017). The authors of this study informed participants of interviews beforehand, that it would be subject to research and the participants had to give their consent. The recording of the internal interviews was also preceded by information about the research, that it was voluntary, and possible to end at any time, in line with the Swedish Research Council's (2017) good research practice. Also, during the interviews, the participants had the opportunity to end the interview at any time if they felt the need to.

4 Empirical findings

In this chapter, the empirical findings from the interviews, observations, and quantitative data are introduced. First, the information gathered from the interviews held at Ericsson and with external companies is presented, followed by some key observations made during the spring at internal meetings related to the thesis. Lastly, the quantitative data needed for the internal carbon price calculation is presented. See Chapter 3 for an in-depth description of how the information was gathered.

4.1 Interviews

In the following sections, the interview findings are presented and illustrated to provide a comprehensive understating of the as-is situation related to sustainability at Ericsson, the path to reaching carbon neutrality in 2030 as well as more focused interviews on the topic of internal carbon pricing. Lastly, learnings from companies with a higher maturity regarding internal carbon pricing are presented based on the interviews held with representatives of these companies.

4.1.1 First round

During the first round, managers and sustainability specialists answered several questions. The following sections describe the content in a detailed manner based on transcriptions and the thematic content analysis, Section 3.3. Some questions were easily quantifiable and the answers to yes or no-questions are presented in Figure 4.1, and the responses to whether Ericsson mainly is a *Climate leader* or a *Climate preparer* are shown in Figure 4.2.

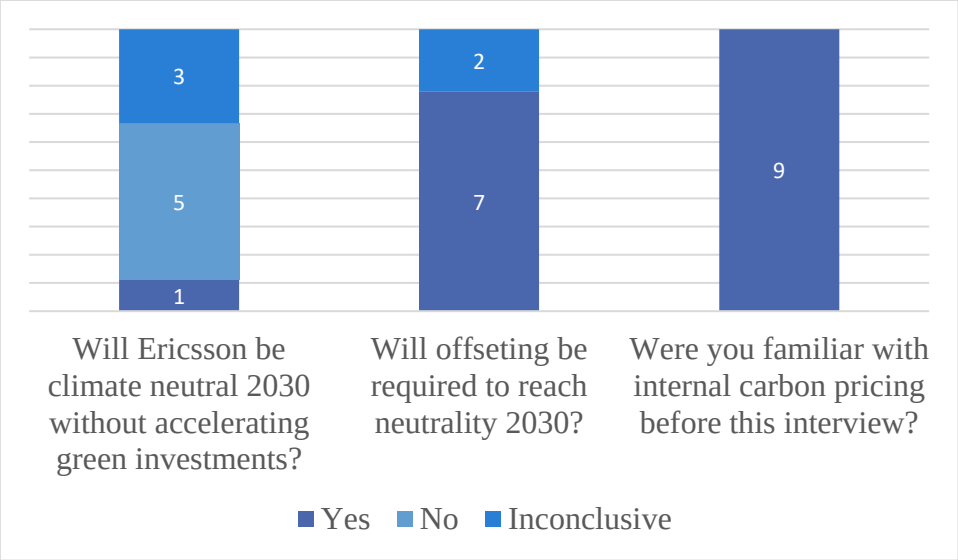

Figure 4.1. Answers to quantifiable questions

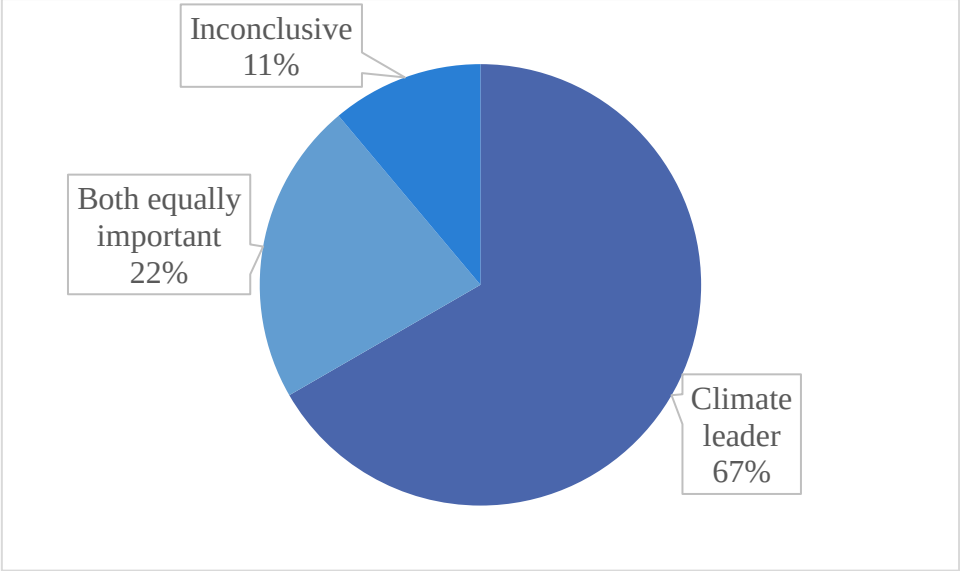

Figure 4.2. Response to Ericsson being a climate leader or preparer

4.1.1.1 Ericsson's current focus areas

The initial topic of discussion during most interviews was related to what Ericsson are doing well in terms of sustainability today. The two major areas mentioned are Ericsson's thorough emission reporting and communication as well as the fact that sustainability and sustainable business opportunities are part of Ericsson's mission and corporate strategy. For reporting and communications, the interviewees referred to the annual sustainability report which presents emission data as well as Ericsson's performance in other sustainability areas. For example, Respondent 2 mentioned, "*I really like that we give out this sustainability and CSR report and that we communicate this throughout the whole company* ". The communications aspect focused on both the internal communication regarding the high ambition from Ericsson's executive management as well as the communication to external stakeholders, "*sustainability is a large part of our brand and something we see as a competitive edge*" which Respondent 6 said. The second major category where interviewees believed Ericsson performed well is, as mentioned, related to the integration of sustainability in the corporate strategy, Respondent 5 explained that "*sustainability has a strategic importance for the executive management team*", and another respondent added that the CEO and CFO often are responsible for communicating sustainability initiatives both internally and externally. Additionally, Respondent 9 is largely responsible for devising the supply strategy for Ericsson, and he/she explained that one of the focus areas in the current strategy is sustainable supply chains and to be a forerunner in providing a low-carbon supply of 5G radios.

Several respondents also explained that multiple initiatives are ongoing within the company and especially the supply organization. To exemplify, Respondent 5 explained how his/her organization was part of implementing a more circular material flow, "i*n my organization, I have several people working with retrieving excess material […] so circular economy is another focus area within sustainability for us*". One key strategic decision that Ericsson took a few years back has also been pointed out as a beneficial project from an emission reduction perspective, this is the regionalization of production and warehouses which was well-explained

by Respondent 1, "*historically we purchased and produced all our products in China and then shipped the products globally. A couple of years ago, however, we decided that Ericsson needs a global presence on all continents*". The respondent later explained that the regionalization decision was taken mainly based on cost and revenue aspects but had very positive effects on emission reductions.

A visual representation of Ericsson's current focus areas within sustainability according to the respondents is presented in Figure 4.3 below.

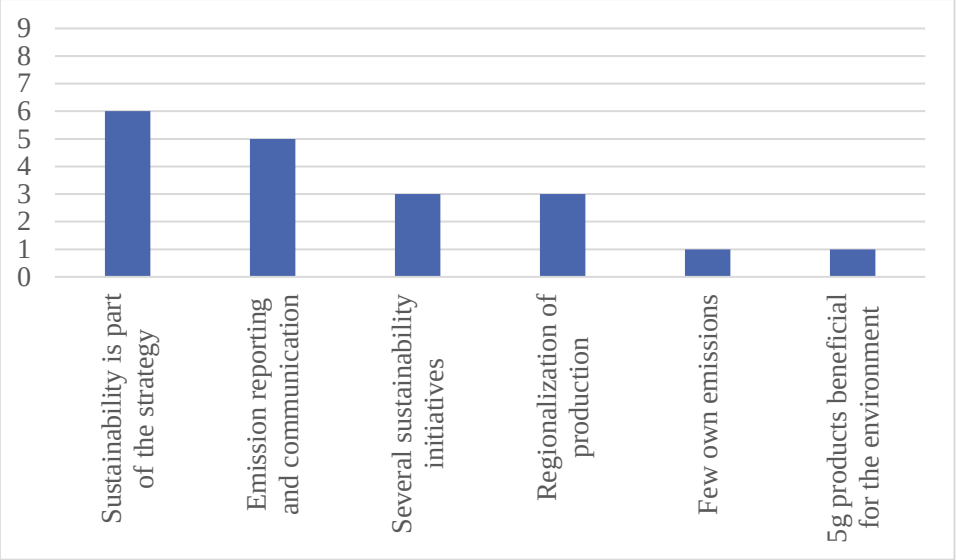

Figure 4.3. Ericsson's current focus areas within sustainability

4.1.1.2 Areas for Improvement

As mentioned above, the regionalization project has reduced Ericsson's transportation emissions immensely, a majority of the respondents now want to continue this initiative and regionalize the inbound flow as well, i.e. having suppliers in the same continents as the production. Respondent 7 explained that "*large CO2-potentials can be found on the inbound side of our supply chain. We still have a long distance between component manufacturer and our production sites which often leads to air freight of components*". Respondent 2, who works at one of the production sites in Europe said in a similar fashion "*to our production in [European city], everything is basically from China*".

An area that is linked to inbound regionalization, and which was mentioned in almost all interviews, is related to internal and external transportation. Internal transportation relates to vehicles owned and operated by Ericsson. Both Respondent 1 and 8 agreed that Ericsson must switch their vehicles to establish a fossil-free fleet. When it comes to external, transportation several mentioned this as the most difficult task to manage although they had some ideas on how emissions from transports can be reduced. For example, Respondent 7 has led the implementation of train transportations between China and Germany, and he/she argues that this method of transportation can be used to a larger extent in order to substitute air freight. Respondent 6 believes that more can be done from a planning perspective to reduce transportation, but it is also a matter of transportation mode selection from the operational staff.

Respondent 9 agrees and explain that air freight and transportation, in general, can be reduced with better planning, "*Ericsson have a large potential emission reduction in better cooperation and planning between our different organizations […] an easy win is to merge our current parallel product flows and return flows […] it reduces the need for transportation and buffers while also reducing costs*". Lastly on the topic of transport, Respondent 3 provided a nuanced answer on the difficulties of reducing emissions from transportation, "*there are so many factors that play into how we can optimize transportation at Ericsson in the best possible way, one large part is further regionalization to ensure that we source, produce and distribute goods within a limited geographical area. Another factor is that we need to dimension the buffers large enough to avoid express air shipments, in order to do that we need a very good demand plan that shows the true demand [...] we need to balance having a good forecast accuracy and plan according to it, weighing how much capital we can tie in our buffers, for which products it is worth having a higher service level, very much linked to the segmentation project, which customers it is worth sending last-minute air freight to and so on. As you can see, there are a lot of factors that must be considered*".

Six out of nine respondents argued that, despite sustainability being part of the corporate strategy, more can be done to ensure that this becomes reality in the whole organization. To do this, more collaboration was named the most important enabler. Respondent 6 explain the situation a couple of years ago, just before he/she joined as a manager in the supply chain organization "*We [Ericsson] have a department working full-time with this [sustainability strategy], but I see a disconnect. We [Ericsson] have these corporate sustainability targets and a strategy, but it is not anchored in the department that actually can reduce these emissions [Supply]. We [in the supply organization] had no initiatives, programs, KPIs, projects – nothing was being done in order to achieve the corporate goals*". However, in the last year sustainability has been brought up on the agenda due to the new strategy development by Respondent 6 and 9. Another respondent believed that still, more can be done in terms of cooperation and collaboration to ensure that all departments are onboard with the sustainability work performed at the corporate level.

Several respondents explained that there is a large potential to reduce emissions that occur in the supply chain, but not in the direct control of Ericsson. These could for example be reducing the emissions from "*products in use*" and to force suppliers to lower their emissions. "*We should of course start reducing emissions in the supply chain where we have the most emissions, and this is products in operation at customer-site*" as mentioned by respondent 4. Respondent 2 adds that "*we cannot force our customers to only use our products with 100% green electricity*". Another respondent adds that the R&D function is currently very focused on making new products more energy efficient. Another action that Ericsson can take to make their supply chain emissions lower is to demand better sustainability performance from their suppliers which was mentioned by four out of nine respondents. Respondent 8 said, "*a large part of our emissions is from suppliers that emit carbon emissions, and we have this responsible source program that is trying to address the emissions from there*". Respondent 4 is managing the mentioned program and explains that "*suppliers with metal processing, aluminum parts, or die casting have large emissions*".

A different aspect of energy efficiency that four different respondents brought up during the interview is related to the energy usage at Ericsson's facilities, i.e. production units and offices. Respondent 1 says "*I want us to utilize our own products to use IoT and smart factories for example. Then we could manage our energy usage more effectively and have support tools that ensure that our purchased energy is utilized in the best possible way with minimal waste*". Respondent 9 adds that "*We [Supply] have taken lead in reducing* CO_2 *emissions from transportation under 2021 and the next step is to reduce energy usage in our facilities*".

Data management and measurement is another area where several respondents believe more can be done, for example, Respondent 4 believes that Ericsson can be more transparent with sourcing sustainability data as it could facilitate cooperation with other companies focused on sustainable supply chains. Respondent 2 adds that *"we still have some areas [emissions in the supply chain] that we have not even mapped*".

Lastly, there has been a cost-focus in decision-making at Ericsson and decisions have solely been taken based on monetary grounds, this was mentioned by three of the interviewees. Respondent 1 says that "*five years ago, Ericsson's approach to a decision was to identify the applicable legal framework and then find the cheapest solution, but now sustainability has an increased strategic importance*". Respondent 8 agrees and states that in the current year of 2021 "*there should be no contradiction between making good business and also do it in a sustainable way*".

A visual representation of Ericsson's areas of improvement within sustainability according to the respondents is presented in Figure 4.4 below.

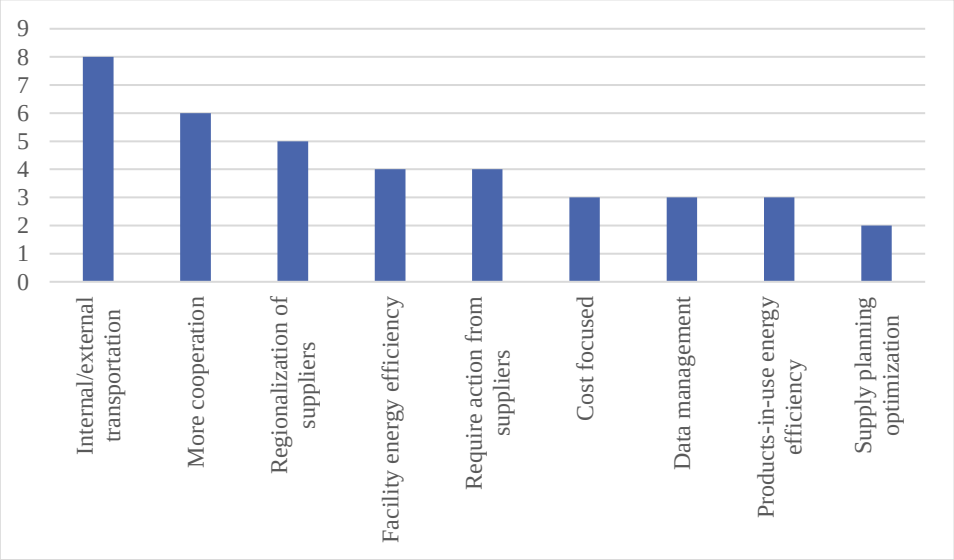

Figure 4.4. Ericsson's areas for improvement according to respondents

4.1.1.3 Internal Carbon Pricing

Eight out of the nine respondents indicated during the interviews that the internal carbon pricing approach needs to include real money, thus charging an actual carbon fee, to drive the desired behavioral change and reduce emissions. Respondent 9 said, "*actually putting a price on carbon, only then it will have a big impact on how we work and think*" and "*fake prices will*

have no impact". In line with this, Respondent 5 argued that an actual fee is needed because "*money talks*" and Respondent 6 said, "*It [a shadow price] is only internal money that in the end does not matter at all*". Furthermore, Respondent 2 stated that an internal carbon price would create leverage when arguing for greener investments. Respondent 6 stated, "*we need to connect it [internal carbon pricing] to real money*", making it very clear that the interviewee wanted to see an actual fee and not a shadow price or implicit price. Also, another respondent argued that the extra cost to become climate neutral must come from some budget, and that budget could well be from a carbon fee fund.

Furthermore, most of the respondents believed that an internal carbon price would create a better understanding among employees about the impacts of GHG emissions since the impact is translated into monetary terms and making it more visible across the organization. For example, Respondent 2 stated, "*If we just calculate that these [emissions] are so much, then for some people this does not say anything basically. So, if we put the money there, the value there, then this would give leverage. Especially for people who are not too familiar with CO_2 emissions and their environmental impact*". Respondent 6 also said, "*It [internal carbon pricing] makes it visible, you get it [the cost of emissions] on paper and can use it in decision-making. So, I believe in it [internal carbon pricing]*". Using only one parameter for decisions would also ease decision-making, suggested by another respondent who also believes an internal carbon price could help employees understand the relationship between emissions and costs, today it is hard for a lot of people to grasp the consequences of emitting X tons of CO_2 compared to Y tons.

Some respondents also pointed out that an internal carbon pricing program needs to be simple and easy to administrate, the benefits need to outweigh the administrative burden. Respondent 4 stated, "w*hen you are working with sustainability, the administrative parts have to be super easy. So, it [using an internal carbon price or not] depends on if you can make it very simple because otherwise, you must allocate more time to administration than to the actual sustainability work. Adding more time and more resources than reducing the emissions*". Furthermore, Respondent 8 argued that implementing an internal carbon price only in internal operations would be beneficial in an early stage.

A visual representation of Ericsson's ideas about internal carbon pricing according to the respondents is presented in Figure 4.5.

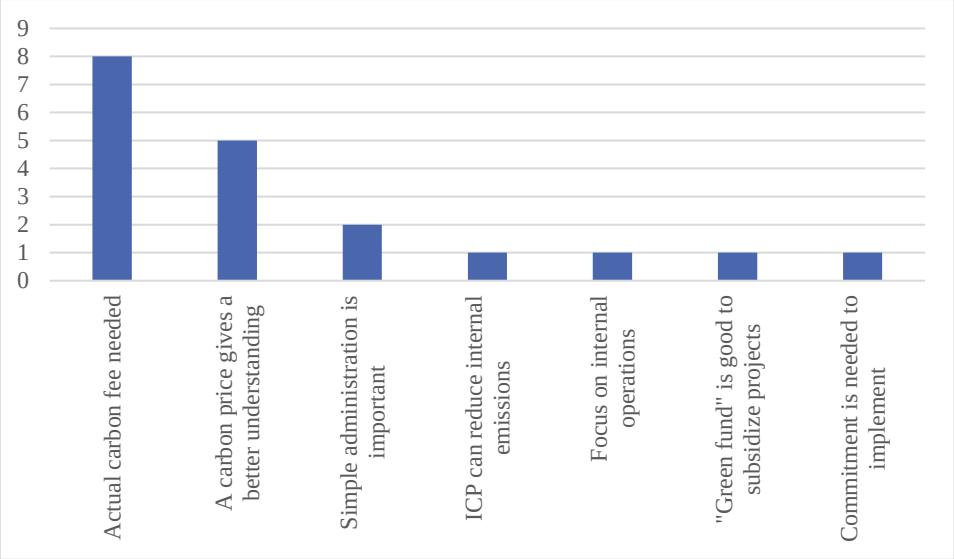

Figure 4.5. Initial thoughts and reflections regarding internal carbon pricing

4.1.1.4 Carbon Offsets

Carbon offsets were discussed in the interviews and seven out of nine respondents stated that carbon offsetting is required in some form to reach the net-zero emission target. The last two respondents were not able to answer the question due to limited knowledge about the area. However, all the seven respondents who believed carbon offsets are necessary to reach net-zero emissions mentioned that it is impossible to reduce the actual emissions to zero. Respondent 1 stated, "e*ven if you do everything you can, there will still be some emissions left and then you need some sort of negative emissions to compensate*". Also, Respondent 2 said, "*we cannot make our products not consume electricity and cannot make transportation like zero emissions, this is where we do not have the technology today*". Furthermore, several respondents mentioned that offsets are not the main solution to become climate neutral but instead just a small part to compensate for the last remaining emissions. For example, Respondent 8 said, "*in some cases, we might buy carbon offsets, but the main goal is to make the real transformation happen*". Also, combining carbon offsets with internal carbon pricing was mentioned during the interviews. Another respondent stated that carbon offsets in combination with an internal carbon price could be a good combination to cut emissions and reach net-zero. Lastly, one respondent suggested that it would be preferable to achieve the negative emissions internally by using their own carbon-capturing technology and avoid buying offsets. For example, installing their own solar cells at the facilities and sell the excess power produced back to the market.

4.1.2 Second round

During the second-round interviews, managers and environmental specialists answered questions related to the preferred approach, where to implement an internal carbon price, the overall attitude towards internal carbon pricing, key enablers, and key challenges. This section describes the content in a detailed manner based on transcriptions and the thematic content analysis, Section 3.3.

4.1.2.1 Preferred approach

Figure 4.6 presents the results related to which approach is preferred by the interviewees, and which they believe best suits Ericsson. Two out of nine believe the carbon fee is the most suitable approach Ericsson should use. This is strongly related to the incentives created by the fee and message associated with an actual fee. Respondent 7 said, "*a carbon fee is a very powerful measure and sends a strong signal to act on reducing emissions".* Another respondent pointed out the benefits with the fund which the carbon fee creates, "*it is especially good to earmark money for green investments and sustainability"*. However, respondent 8 mentioned some drawbacks with the carbon fee, primarily that it most likely will have to be applied company-wide, otherwise, it can be perceived as unfair and strange.

Furthermore, three out of nine respondents prefer to start with a shadow price, and then transition to a carbon fee when the knowledge and routines are widespread in the organization. The three interviewees that prefer this approach stated that Ericsson should start on a small scale with the shadow price to gain understanding and spread awareness, then transition to a carbon fee. Respondent 4 stated, "*a shadow price will take us far in the beginning […] but when we gain interest and the knowledge increases, then you can start working with that [a carbon fee]"*. Another respondent said, "*it is easier to start on a small scale with a shadow price and then successively make the transition [towards a carbon fee]"*. Also, another two respondents believe a hybrid approach is the most suitable approach to use at Ericsson since this would provide the benefits from both the carbon fee but also the shadow price. For example, Respondent 8 said, "*there is this hybrid approach, like a combination between shadow pricing and a carbon fee, this is probably what we [Ericsson] should use because then we can apply the different tools in different situations"*.

However, two of the nine respondents believe that it does not matter which approach Ericsson uses if it is implemented in the right way and drives change in behavior. Both were positive to internal carbon pricing as a concept at Ericsson, but whether to use a shadow price or a carbon fee is not the most significant aspect. Respondent 2 stated, "*it [to use a shadow price or carbon fee] is heavily related to the implementation and how it is handled, so it does not play a significant role, only it is communicated in a good way. If it is communicated in a good way, both can turn out awesome"*. According to respondent 3, the main purpose of potentially implementing internal carbon pricing at Ericsson would be to increase awareness and provide the opportunity to make conscious decisions, related to environmental sustainability.

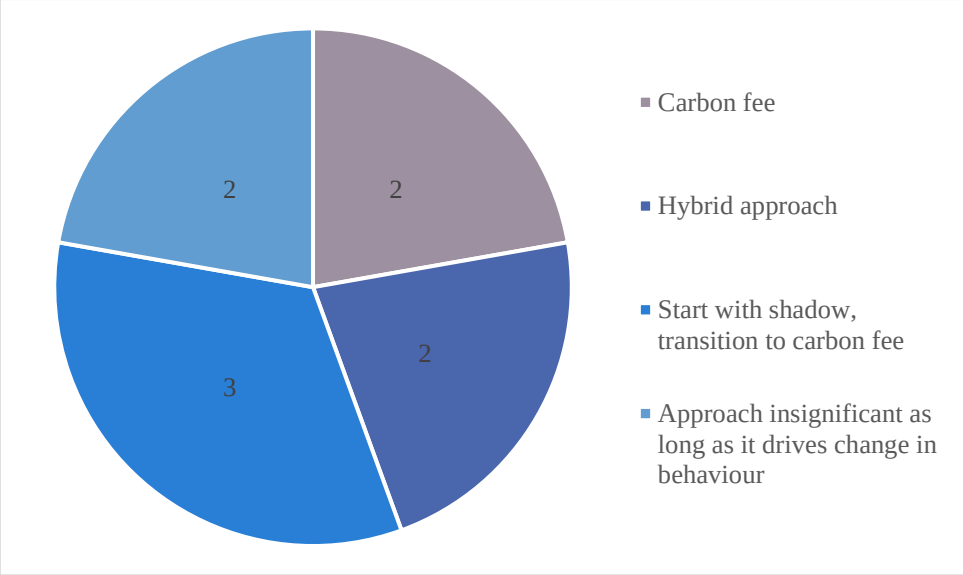

Figure 4.6. Preferred internal carbon pricing approach among respondents

4.1.2.2 Where to implement internal carbon pricing

The main area of discussion during the second-round interviews was where to implement an internal carbon price at Ericsson. Figure 4.7 summarizes the answers according to the categories presented in the theoretical framework, Section 2.5. *Inconclusive* in this context implies it was not possible to tell whether the interviewee was either *positive* or *negative* toward the implementation in the specific category.

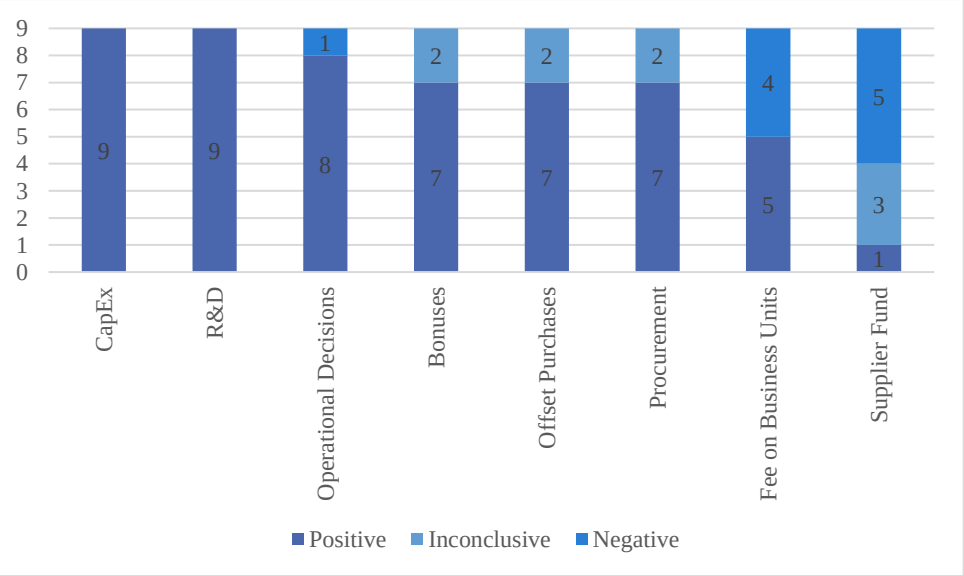

Figure 4.7. Respondents attitudes to different implementation options

When asked about CapEx, all interviewees were positive about implementing an internal carbon price in this area. For example, Respondent 9 replied, "*Yes absolutely, it is crucial to use in these decisions. For years we have tried to point out the importance of environmental sustainability in this kind of decisions"*, really emphasizing the importance of integrating environmental sustainability into decision-making. Related to CapEx, mergers and acquisitions

(M&A) were mentioned by one of the other interviewees as a potential area of application. The respondent said that it would be good to be able to investigate the carbon-related risk of a potential M&A and highlight this parameter, something Respondent 6 agreed on. Also, for R&D, all interviewees were positive about the implementation of an internal carbon price. Respondent 7 said, "*I think it is essential to include in R&D, I mean R&D is early in the product lifecycle, so this affects and facilitates a lot for the rest of us"*. However, some concerns were raised regarding the data needed to compare products in an early stage. One respondent said, "*we have to have comparable data in order to be able to fairly assess the products".*

Furthermore, eight out of nine respondents were positive towards an implementation in operational decisions. Respondent 8 stated, "*I believe internal carbon pricing is super good to include in operational decisions. To estimate the cost of greenhouse gas emissions and display all costs in the same format to compare the options X, Y, and Z".* Also, Respondent 1 pointed out the potential to use internal carbon pricing to connect long-term and short-term strategies, "*I think so [that operational decision-making can make use of internal carbon pricing]. We are working internally with this where we try to connect the long-term supply strategy with our more operational and tactical strategies and decisions*". However, the respondent who was negative towards an implementation in operational decisions raised concerns regarding the potential extra time need to handle the internal carbon price, the respondent said, "*in these decisions, time is a more important factor".*

Moreover, seven of the respondents were positive towards using parts of the fund collected from a potential carbon fee to bonuses, two answers were inconclusive. One respondent mentioned, "*a bonus system would both increase the motivation, increase awareness, and have other positive effects".* However, the form of the bonus system was heavily discussed, several interviewees pointed out that an individual employee bonus would require too much administration to be feasible to implement. Also, questions regarding incentives were raised. Respondent 8 said, "*the position we want to strive for, is to be good at sustainability because we want to, because there are positive effects related to the environment, our climate, and global warming, not because of money and bonuses. This implies that if we introduce bonuses in order to use money as an incentive, do we remove the bonuses then when we reach the point where we have achieved our climate work? And what signals do we send when we use money as a policy instrument to increase motivation? Are we doing it the right way then?".*

Regarding offset purchases, seven respondents were positive towards using the fund to purchase offsets or in some way remove carbon from the atmosphere, while two respondents provided inconclusive answers. Several respondents argued that it will be impossible to lower Ericsson's actual emissions to zero, without offsetting or in some other form remove carbon from the atmosphere. For example, Respondent 1 said, "*we can lower our emissions, but we will still emit greenhouse gases even in the future. Because of this, we need to be able to handle these emissions, and I believe offsetting is the right tool to use"*.

Furthermore, in procurement, seven respondents were positive to implement an internal carbon price, while two respondents provided inconclusive answers. However, several respondents raised concerns regarding the data required to compare suppliers. Respondent 9 said, "*for some purchases, we have very precise data regarding emissions, but there are still some differences*

between the same type of for example transports, different trucks can be used and so on. And for materials and components it becomes even more complicated [to get comparable data]". But several respondents suggested putting pressure on the suppliers and their work on sustainability. One respondent mentioned, "*we have to make demands. More and more people are talking about sustainability and then we must demand this from our suppliers as well. We should only work with suppliers who can prove that they are working with sustainability"*. Also, Respondent 6 stated, "*Using it in procurement is aligned with a more long-term ambition, but it might not be the first area of implementation"*.

Regarding the fee on business units, five respondents provided positive answers, while four respondents believe this would not be suitable for Ericsson to use. Many of the respondents who provided positive answers pointed out the reduced administration as an advantage. Respondent 2 said, "*This [fee on business units] feels a lot more controlled and easier to administrate and run".* However, the same respondent also raised concerns about business units only increasing their budgets to cope with the new costs associated with the emissions, and then the effect would be zero. Also, another respondent believed that this would not be a proactive system and mentioned that "*you pay for sins you have already committed and maybe you learn from that, depending on how big the bill is. But I do not know how much impact it would have. We want to increase awareness and be proactive, making the right decision from the beginning"*. The respondents who argued against a carbon fee on business units mainly believed that it was not enough to only ask on a business unit level for change but instead wanted effect in each decision that was taken.

Lastly, one respondent was positive towards introducing a supplier fund, while three provided inconclusive answers and five were negative. The respondent who provided a positive answer said, "*maybe this is not something we should implement everywhere, but only with the suppliers where it makes the most sense"*. However, respondent 6 mentioned, "*primarily this fund [collected from a carbon fee] should be used internally. So primarily scope 1 and scope 2 emissions, our factories, our fleet vehicles, and maybe business travel. But primarily scope 1 and scope 2"*.

4.1.2.3 Attitudes towards internal carbon pricing

When asked about their attitudes toward internal carbon pricing, the interviewees' responses were in general very positive, as shown in Figure 4.8. All respondents agreed that it is feasible to implement internal carbon pricing at Ericsson provided it is done correctly. For example, Respondent 9 said that "*I definitely think that it is feasible as long as we do not intend to set an unreasonably high price and move around huge sums of money to our fund"*. The respondents were also very positive about implementing carbon pricing at Ericsson, for example, Respondent 7 said "*to be honest I cannot see why anyone would be against this [internal carbon pricing] because it is only positive for us. It is of course positive from a sustainability perspective and it also secures Ericsson's business in the long run*". Another respondent explained "*prior to this meeting [the interview], I was very skeptical and unsure about how and why we would need to price carbon. But if we want to raise awareness and really take action in the different departments, this is a very good approach*". The respondent marked inconclusive to internal carbon pricing at Ericsson said more information on the topic

was needed for him/her to make an informed decision. He/she emphasized that the value of using internal carbon pricing must exceed the indirect costs related to administrating it.

Lastly, during discussions regarding whether to have one single price or multiple prices for different emissions, the answers were slightly more evenly distributed. Respondent 1 for example were negative because of the unreliable data for some emissions and that "*it would only create more confusion*". For the two labeled as inconclusive, they believed that it is good to start with one price for simplicity purposes and then use different prices once the maturity in the organization is high enough. Those who were positive about using different price levels believed that it is a good way for the company to emphasize where to prioritize emission reductions. For example, Respondent 6 said, "*if we have different carbon fees, we can steer decisions in the right areas where we need to reduce emissions*", however, he/she did mention that if a shadow price is used instead of a fee, using multiple shadow prices might complicate things and lead to a lack in trust in the prices. Another respondent argued that since Ericsson have different levels of control over different emissions, it is reasonable to have a higher carbon fee for those emissions that Ericsson have the power to reduce and "*I do see a problem in setting an equal carbon fee for Scope 3 if we want to include them in the pricing scope. This is because Ericsson cannot control these to a 100% so it would definitively feel strange"*. The respondent also said that if there is also a shadow price, it would not be of equal importance whether they are the same or not.

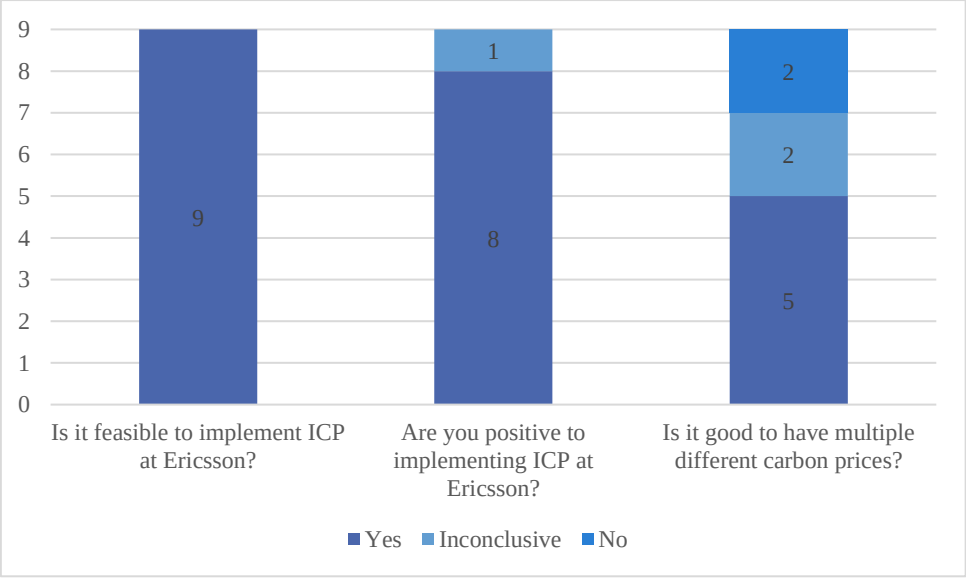

Figure 4.8. Quantifiable response to the feasibility of internal carbon pricing (abbr. ICP) at Ericsson

4.1.2.4 Key enablers and challenges

The interviewees were asked what they view as key enablers to implement internal carbon pricing at Ericsson, the results are visualized in Figure 4.9. Simplicity and top-down communication were mentioned by a majority (five) of the respondents. Respondent 8 explained simplicity as an important enabler, "*it is very important that the method is easy to apply, especially in a transitional phase when this is implemented. Otherwise, it might just be another large chunk of work that we have to spend time on and analyze […] this should not be*

something that takes a lot of time and is overly complicated although it is vital that we include carbon pricing in our decision-making". Another respondent agrees and adds that carbon pricing must be "*easy to understand for the employees*".

Top-down communication and CXO commitment go somewhat hand in hand, Respondent 5 said that "*this must be anchored at the executive level so that when it is time for implementation, we can explain that this has been decided by top-management*". Respondent 4 also said that "*From my extensive experience at Ericsson, these things must be top-down […] Börje [Börje Ekholm, Ericsson's CEO] must help drive this implementation, then it is really possible. We are herd animals after all*". Four respondents mentioned that when carbon pricing is integrated into the decision-making processes, it must also be integrated and supported by the IT systems used at the company. For example, Respondent 1 mentioned that to avoid too much manual work, internal carbon pricing should be "*included in the digitalization and automation initiatives*" at Ericsson today and another respondent added that "*although I mentioned before that we need a behavioral change, this is impossible without system support as well*". Lastly, a couple of respondents believed that a reasonable price level is key to gain support for the implementation. One respondent emphasized that if the price is too low, it can be counter-productive because people might think that since they can afford to pay a higher fee, it is okay to choose the alternative with higher emissions. Respondent 9 also discussed the price but from a slightly different perspective "*the cost to emit must be in relation to our quite aggressive sustainability targets, otherwise, it might send strange signals in the organization*".

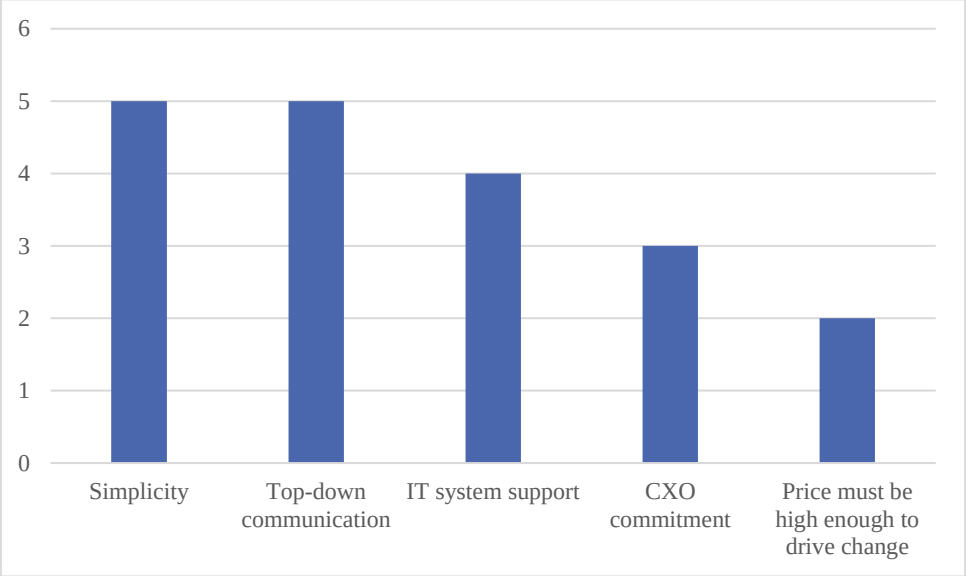

Figure 4.9. Key enablers for implementing internal carbon pricing

When it comes to challenges regarding implementation, the number of answers was fewer as shown in Figure 4.10. The main difficulty, according to respondents, is related to attaining correct and comparable data in all decisions. Respondent 5 said, in relation to using the carbon price in procurement, "*we must make sure that the data from different suppliers is comparable and have the same scope […] it is unfortunate that there is no clear international standard*". Another respondent working in the supply organization mentioned that it is difficult to get correct (if any) data regarding emissions that occur in their upstream supply chain. The other

mentioned challenges are related to avoiding too much manual work and administration, and how to coordinate and raise awareness in a large organization such as Ericsson. Respondent 2 said, "*the value of using carbon pricing must exceed the costs associated with it, such as administration. Otherwise, it is better to just earmark money for sustainability*". And another respondent added that "*we must avoid a situation where we just do a lot of manual calculations*". Regarding coordination and awareness, Respondent 8 said, "*when it comes to sustainability at such an extremely large company […] the first thing is to raise awareness and get the entire organization to understand why we do this*". Respondent 3 adds that "*we must explain to everyone that is impacted by this at Ericsson why and how we want to implement carbon pricing*".

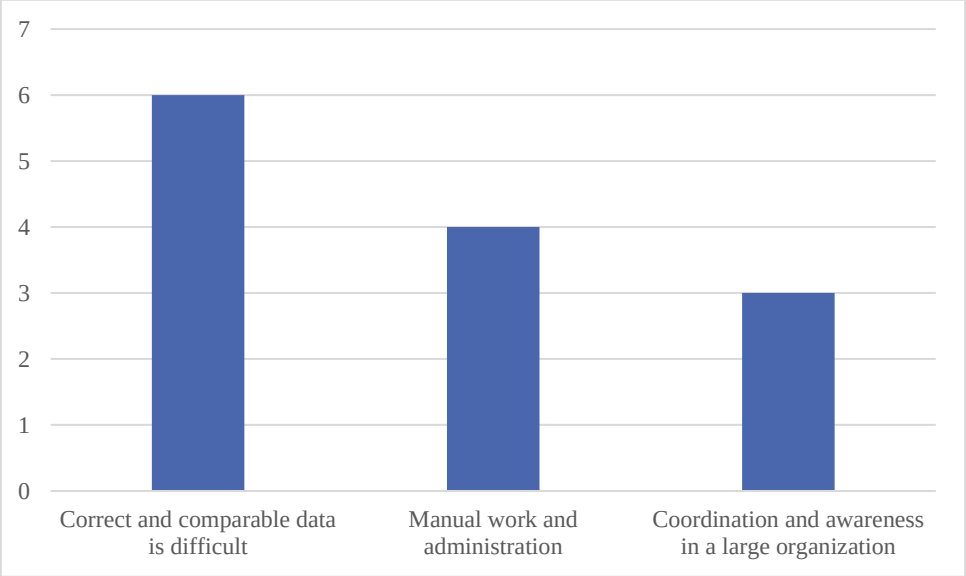

Figure 4.10. Key challenges for implementing internal carbon pricing

4.1.3 External interviews

For the external interviews, the anonymized companies X, Y, and Z were interviewed. Company X implemented an internal carbon price back in 2018 and is using a shadow price, mainly focused on procurement. In procurement, the shadow price is applied for purchases of products that emit more than 350 tCO_2/year. Throughout the company, one uniform internal carbon price is applied, corresponding to about 60 €/tCO_2e and the finance department is responsible for the price itself as well as the administration. Initially, the price level was based on external resources, more precisely the EU ETS price, but now a technical analysis is applied where cost-benefit analysis is used to determine the price level needed to reach the company's 2030 neutrality target. According to company X, the internal carbon price has increased the awareness about GHG emissions at the company and helped lower the company's carbon footprint. Also, the company have faced challenges with their internal carbon price since they did not know how to use and implement it in the beginning, but they decided to go for it and are learning as they go. Company X also points out CXO commitment (i.e. commitment from the executive management), communication, reliable data, and to start small with a low and uniform price as key enablers to their successful implementation and use of an internal carbon price.

Company Y have not yet launched their internal carbon price but have come a long way in their preparations. The internal carbon price will be used in different applications, for example, CapEx-decisions. The price level is confidential and was not disclosed during the interview but there will be one central team who assists the business units with how the internal carbon price should be applied. The company expects the internal carbon price to have a positive effect on behavior among employees, helping them make more conscious decisions with regards to environmental sustainability and when implemented, the internal carbon price is likely to be the most impactful project related to the company's work with environmental sustainability. Furthermore, to start using an internal carbon price, company Y emphasizes the need for CXO commitment, communication, and to start with a low price to get going. Company Y suggests starting with applying the internal carbon price where you already know your data about your carbon footprint since reliable data is a key to a successful implementation. Furthermore, the company stated that there are two main paths for using an internal carbon price. The first path is primarily for risk management and then a shadow price is suitable. The second path is to transition to a low carbon economy and then a carbon fee is the most suitable approach. Also, according to the company, implicit pricing is not something companies use.

Company Z is active in a non-energy intensive industry and initially used a shadow price but did not see the desirable effects they wanted from an internal carbon price. Because of this, the company transitioned to a hybrid approach where a carbon fee is applied to business units and their scope 1 and scope 2 emissions. According to the company, companies operating in non-energy intensive industries have to in some way include a carbon fee since a shadow price will not be effective on its own. The fee is allocated to an internal fund that is administrated centrally and used to purchase clean technology, e.g. solar panels. The fee the business units have to pay to the fund is removed from each individual business unit's CapEx budget for next year to minimize administration but also to attract attention since the heads of the business units lose parts of their budget. At the same time, a shadow price is used in other areas like for example CapEx-decisions over 1 million Euros. The price level is set to 40 €/tCO_2e and was based on benchmarking. Company Z have identified educating and training employees on the subject, explain the concept of internal carbon pricing, how company Z is using it and why, as their biggest challenge with internal carbon pricing. Beyond training and education, the company identified CXO commitment, more specifically CEO and CFO commitment, and the availability of reliable data as key enablers to the implementation of the internal carbon price. Also, through this implementation, the company have experienced several benefits with internal carbon pricing. To begin with, with internal carbon pricing, emissions have become more visible and meaningful to decision-makers now when it is included as a cost. Also, this helps the company future-proof decisions against future carbon taxes, and it holds decision-makers accountable for the sustainability outcome. Lastly, company Z have through their work with internal carbon pricing reduced their GHG emissions and are on the right path to achieving their sustainability targets.

4.2 Observations

The observations shown in Table 3.5 in Section 3.2.3 generated several insights. These are presented in the following sections in the form of takeaways from the meetings or specific quotes.

4.2.1 Ericsson's sustainability strategy

During several meetings, the topic of Ericsson's sustainability work was discussed. During Meeting 1, Ericsson's Global Head of Supply Chain Management said, "*we should be proud of being a leader and forerunner when it comes to sustainability and climate action*". During Meeting 5 and 6, the importance of sustainability to Ericsson was elaborated upon. In Meeting 6 one participant said that Ericsson work with sustainability both internally, anchored with executive management, and externally with other companies, "*we require our suppliers to create a strategy to reach emission reduction targets, it is no longer enough to just measure emissions*". In Meeting 5, a strategy and innovation project manager emphasized that Ericsson is taking a larger responsibility today than it has historically but also noted that sustainability cannot take the overhand of profitability, "*The companies who are profitable are also those that can change the course of the future*". During Meeting 2, it was explained that Ericsson reports climate emissions in line with the Greenhouse Gas Protocol standards. They report Scope 1, 2, and what they deem possible to influence of Scope 3 emissions.

4.2.2 Ericsson's climate action in the supply chain

The topic of sustainability in the supply chain was discussed in multiple meetings. In Meeting 4, it was mentioned that Ericsson requires strategic suppliers to align with the Paris agreement target of halfling emissions every decade. During an interesting conversation in Meeting 16, one employee partially credited former U.S. President Donald J. Trump for accelerating Ericsson's emission reductions. The tariffs imposed on European and Asian products sped up the regionalized production and supply strategy which has proved to not only reduce supply chain costs but also reduce emissions from transportation greatly. In Meeting 7 and 8, high ambitions for Ericsson's supply chain were shared. For example, in Meeting 7 it was said that "*our established target is to be a forerunner in providing low carbon supply by 2022*". In Meeting 12, one participant said, "*We want to promote a best-in-industry low-carbon emission supply chain*" and in Meeting 14 this was supported, and it was emphasized that this covers the end-to-end supply chain from raw materials to end-user.

4.2.3 Actions required to meet neutrality targets

The meetings were not only focused on the targets and ambitions, during several meetings the actions required to achieve neutrality and a low-carbon supply chain were on the agenda. In Meeting 11, a sustainability manager on the executive level explained that offsetting will be required to reach full neutrality and added that "*we must use nature-based sources to capture CO_2e emissions from the atmosphere*". This was heard in Meeting 6 as well, "*we should offset in the most effective way the remaining emissions that cannot be reduced or eliminated*". In Meeting 15, some concerns arose regarding offsets where a senior environmental specialist shared that offsetting is difficult because it usually is hard to show a causal relationship between offset investments and the lasting CO_2 reduction in the world. In Meeting 16, one participant

said that there must be a long-term focus when it comes to offset purchases and since Ericsson cannot risk that their offset investments are made without purpose, for example, if a tree were to be burnt down in a forest fire. In Meeting 15, green energy was also discussed as a part of reaching neutrality. Ideally, Ericsson want to have energy production at all facilities, e.g. solar panels, because green certificate purchases can be problematic in some countries. Another option is to have contracts with the energy supplier that secures the production of green energy. In three meetings, the topic of internal carbon pricing arose as well. In Meeting 16, there were discussions regarding how much it will cost to make energy efficiency projects that reduce the need for scope 1 and 2 energy emissions. It was concluded that an estimate of $500'000 annually would go a long way and could be a budget used when calculating the internal carbon price. Additionally, the respondent expects a linear decrease of scope 1 facility emissions until 2030 where they are 90% less than today. The car fleet was said to be carbon neutral in 2030 (linear reduction) and scope 2 energy consumption is expected to increase linearly by 20% until 2030. In Meeting 13 with a manager working with supply chain design explained the need for integrating environmental and financial costs "*how can we compare and balance environmental impact in relation to cost? Right now, we are quite far away from having directives on this matter*". And in Meeting 7 one participant said, "*When choosing transport solutions, it would be helpful to have a price of the carbon impact and not only the weight of the emissions as today*".

4.3 Quantitative data

The quantitative data used to answer the research questions include the company's emissions, current and historic green power purchases, costs for green projects and the abated emissions due to them, and offset purchases.

4.3.1 Current emissions

Ericsson's current emissions in scope 1 and 2, and selected emissions in scope 3 are shown in Table 4.1 below. These are used for calculating the internal carbon price in Section 5.4.

Table 4.1. Ericsson's scope 1, 2, and selected scope 3 emissions [ktCO$_2$e]

Emission Type	**2020**	**2019**	**2018**	**2017**	**2016**
Facilities' Energy use (S1)	7	11	11	14	14
Fleet Vehicles	33	38	43	59	61
Facilities' Energy Use (S2)	74	124	134	156	185
Total scope 1 and 2 emissions	**114**	**173**	**188**	**229**	**260**
Business Travel	17	114	110	123	154
Product Transport	112	139	215	129	146
Employee Commuting	30	60	61	69	73
Use of Sold Products	34'000	33'000	32'000	34'000	34'000
Total scope 1, 2 and partial 3 emission	**34'273**	**33'486**	**32'574**	**34'550**	**34'633**

4.3.2 Energy certificate costs

In Table 4.2, the cost, in €/MWh, for green certificates in December 2020 is presented, this data is used for calculating the cost of green power purchases in Section 5.4. During Meeting 15, the following was mentioned about the different types of certificates:

- *Guarantees of Origin* (GoO) is a certificate that can be purchased by individual actors that guarantee that one MWh of electricity from a specific renewable energy source is produced. GoOs are used by countries in Europe.
- *International Renewable Energy Certificates* (I-RECs) work in a similar fashion to GoOs but are used in Asia, Africa, South America, and Australia, and follow the global international-REC standard.
- *Renewable Energy Certificates* (RECs) follow the same standard as I-RECs but are only purchased and sold in North America.

It should be noted that I-RECs prices often are referred to as I-RECs including or excluding Australia at Ericsson due to the high price for energy certificates in Australia. The Average shown in the right column of Table 4.2 is the average cost of purchasing one-third of each specific type of certificate in that region.

Table 4.2. Ericsson's average costs [€/MWh] for purchasing green energy certificates based on region and energy source in December 2020

Type	Solar	Wind	Hydro	Average
GoO	0,33	0,28	0,23	0,28
I-REC	4,03	3,52	2,94	3,50
I-REC excl. Australia	0,95	0,77	0,54	0,75
REC	1,37	1,22	0,45	1,01

4.3.3 Carbon offset costs

The costs for offsetting carbon emissions used when calculating Ericsson's internal carbon price is shown in Table 4.3 below. The costs used were from Section 2.2.2 where GHG removal methods were discussed in detail.

Table 4.3. Costs related to different GHG removal technologies

GHG removal method	Cost [$/tCO$_2$]
Afforestation and reforestation	20
Bioenergy with carbon capture and storage	200
Direct air capture	400

4.3.4 Estimated green energy purchases

In 2030, Ericsson expect to source energy from green power purchase agreements and on site renewable energy production. However, these two types of sources might not fulfill the total required energy consumption at Ericsson, the remaining non-green energy purchases will be compensated with energy certificates. Thus, the total scope 2 emisions will be zero. The expected share of energy from each source is visualized in Figure 4.11 below.

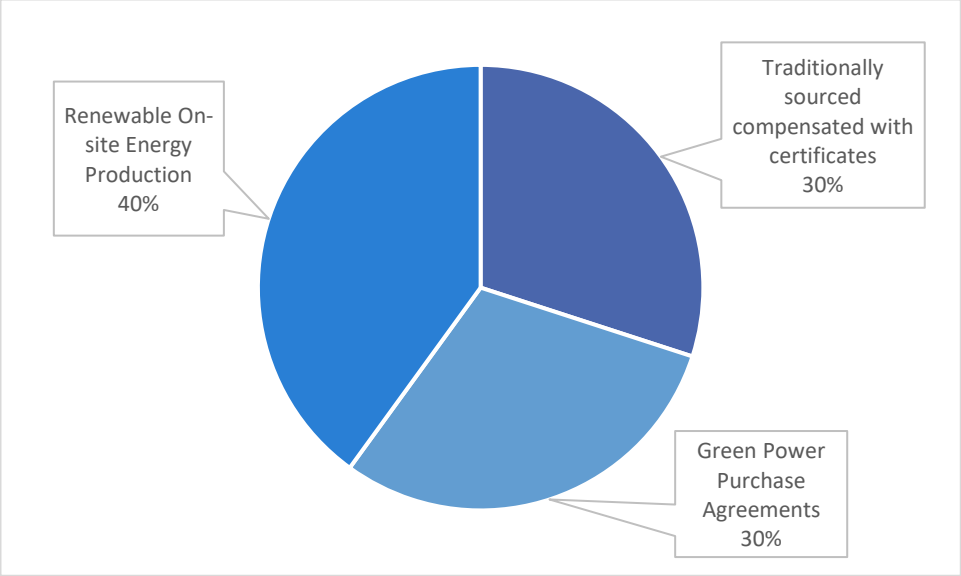

Figure 4.11. Estimated share of sources to Ericsson's energy consumption in 2030

The costs associated with purchasing energy certificates are shown in Section 4.3.2, Table 4.2. The costs related to green power purchase agreements and CapEx required to fund on-site energy production vary across the world depending on several factors. The estimates provided to the researchers are displayed in Table 4.4 below and reflect the long-term marginal additional cost per MWh compared to purchasing non-green energy.

Table 4.4. Estimated marginal average additional cost of energy sources compared to energy from fossil sources

Energy Source	**Marginal average additional cost [$/MWh]**
Power Purchase Agreement	3,2
Onsite Renewable Energy	5,7

4.3.5 Estimated offset quantities

In Table 4.5, the estimated share of emissions that Ericsson will offset is presented. This data was estimated by Ericsson sustainability personnel based on the logic that they should aim to reduce emissions as much as possible until the few years prior to 2030 where they should become climate neutral, and thus, offsetting all outstanding emissions.

Table 4.5. Ericsson's estimated offsets as a percentage of total emissions annually until 2030

Year	Share of emissions to offset
2021	0%
2022	0%
2023	0%
2024	0%
2025	0%
2026	0%
2027	20%
2028	50%
2029	75%
2030	100%

4.3.6 Confidential data

Data related to the current energy consumption at Ericsson, divided into geographical areas and production/office sites were retrieved from Ericsson. This data, however, is confidential and thus not published in this report. The use of this data is explained in Section 5.4 where the calculation logic is described.

4.3.7 Pilot case data

In order to test and illustrate the concept of internal carbon pricing, a supply chain design decision will be introduced in Section 5.6. All data used in the case is presented in Table 4.6 below, except the emission data for the different options which is confidential. The shipments are all of a specific product that Ericsson want to consolidate at one production site, in Brazil or Mexico. All the demand is coming from North America, so producing in Mexico would result in lower emissions. In Section 5.6, the case is described in further detail and the internal carbon price will be integrated into the total landed cost calculations for the specific product.

Table 4.6. Data for pilot case

Shipments	Distance [km]	Transportation Mode	Weight [kg/unit]	Quantity
Netherlands - Brazil	10 000	Air	8	4 000
Netherlands - Mexico	9 700	Air	8	4 000
Brazil - Mexico	8 000	Air	8	4 000

5 Analysis

In this chapter, the literature and empirical findings are linked together to form a basis for analysis. The chapter follows the outline from the theoretical framework presented in Section 2.5 so initially, Ericsson's wanted position is established, and based on that, which approach to use is discussed, followed by a section describing and discussing where the price should be used. Subsequently, a section presenting calculations and assumptions needed to determine the price level. Lastly, Section 5.5 discusses key enablers and challenges to implanting an internal carbon price at Ericsson.

5.1 Wanted position

When working with internal carbon pricing, the first step is to determine the company's wanted position, as shown in the theoretical framework in Section 2.5. According to the framework, there are two different positions, with corresponding paths. The *Climate leader* path is most suitable when the company prioritizes their environmental sustainability work, e.g. by allocating financial resources to it, by striving for more ambitious goals than for example the Paris Agreement, and/or aiming to transition to a low carbon economy. The second path is the *Climate preparer* path which is suitable when a company wants to work with risk management and only prepare for new potential regulations related to GHG emissions. Furthermore, the theoretical framework is based on the literature chapter and during the external interviews, the professionals working with internal carbon pricing had a similar perspective as to what is reflected in the framework. For example, company Y stated that there are two paths a company can use for internal carbon pricing, either to use it for risk management or to transition to a low carbon economy.

During the first-round interviews, eight out of the nine respondents stated that Ericsson is a climate leader, or both a climate leader and preparer, and therefore should use the *Climate leader* path in the framework. For example, Respondent 6 said, "*sustainability is a big part of our brand and something seen as a competitive edge"*. However, some interviewees pointed out that Ericsson still have to manage risk, which is the focus of the other path, but this is not a problem since a shadow price still can be used during the *Climate leader* path through the hybrid approach. Also, during the same interview round, most interviewees stated that Ericsson still have to accelerate green investments to reach the 2030 neutrality target, something indicating that environmental sustainability will require even more attention in the future at Ericsson. Also, the 2030 neutrality target is an indication in itself that Ericsson is a leader when it comes to environmental sustainability since this is a more ambitious target than for example the European Union's target to be climate neutral by 2050, in line with the Paris Agreement. Based on this, it can be concluded that Ericsson should use the *Climate leader* path, highlighted in Figure 5.1. This is also supported and confirmed by several of the observations made at Ericsson. For example, during Meeting 1 it was mentioned that Ericsson and its employees "*should be proud of being a leader and forerunner when it comes to sustainability and climate action"*.

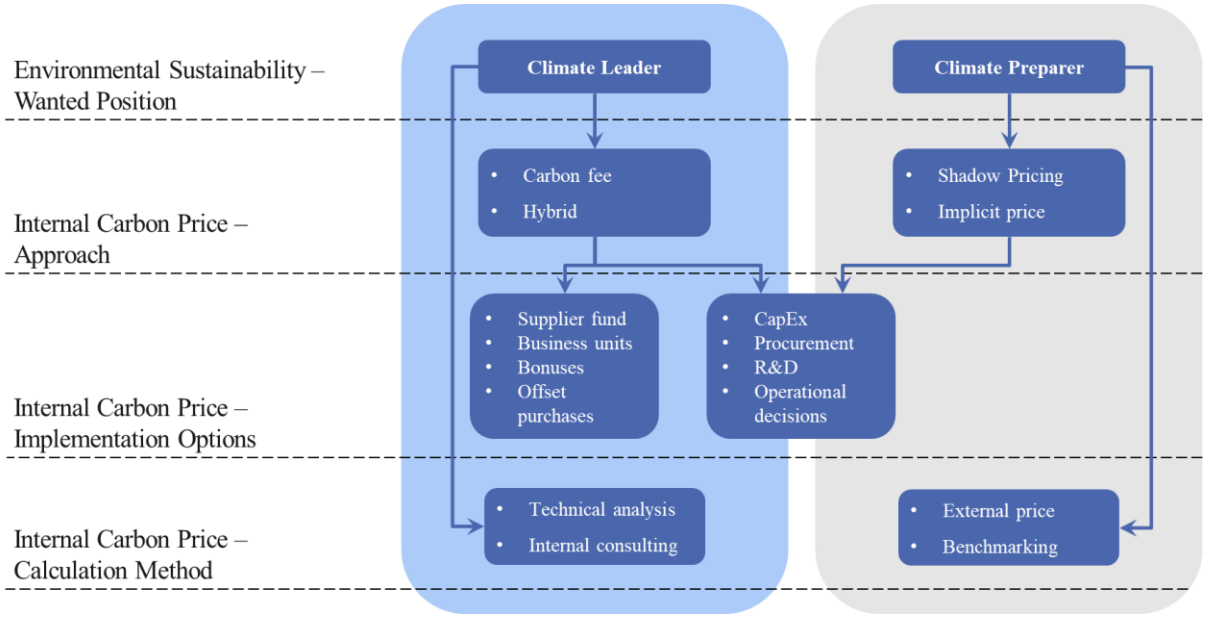

Figure 5.1. Theoretical framework with the climate leader path highlighted

Furthermore, committing to the *Climate leader* path implies that a carbon fee or hybrid approach is suitable to use. This makes it possible to apply the internal carbon price in any of the processes presented in the theoretical framework. Also, through the *Climate leader* path, a technical analysis or internal consultation are applicable calculation methods since these are based on internal parameters and can therefore be related to the company's own environmental sustainability targets. However, the use of an implicit pricing approach and to determine the price level through only external resources or benchmarking is not suitable.

5.2 Approach

As described by Harpankar (2019) and Ahluwalia (2017) in Section 2.4.1, there are four different approaches to internal carbon pricing and which one to use can be hard to determine. According to Ahluwalia (2017), a carbon fee can be used to earmark money for green investment and create incentives for the company to reduce GHG emissions, drive behavioral and cultural change, and help transition to a low carbon economy, something Company Y and Z also pointed out during the external interviews. Also, during the first-round interviews, eight out of nine respondents indicated that the internal carbon pricing approach at Ericsson need to include real money, in other words, a carbon fee. One respondent made this very clear and stated, "*we need to connect it [internal carbon pricing] to real money*". This approach, however, leads to one main challenge, described by Ahluwalia (2017) as stakeholder buy-in. At Ericsson, this appears to be a minor challenge as both more and less senior executives have expressed during the interviews the need for an actual fee.

Shadow pricing is a tool to assess risks (Bento & Gianfrate, 2020; Topping, 2019), and evaluate investments (Ahluwalia, 2017; Aldy & Gianfrate, 2019), something company Y also pointed out during the external interviews. Also, according to Ahluwalia (2017), shadow pricing can help build the business case for low carbon investments and products. This was mentioned during the second-round interviews by all respondents as two feasible areas for implementation at Ericsson. In the same interview round, several interviewees mentioned that a shadow price

could be a point of departure for implementing an internal carbon price at Ericsson and then transition to also including a carbon fee. One respondent mentioned, "*a shadow price will take us far in the beginning […] but when we gain interest and the knowledge increases, then you can start working with that [carbon fee]"*. However, according to Ahluwalia (2017), a shadow price if implemented on its own can be challenging since it is only a theoretical price and therefore might not drive the desired change. This is also the experience of Company Z who implemented a shadow price but did not see the desired effects. Also, during the first-round interviews, almost all respondents wanted to see an actual price and one stated that "*fake prices will have no impact*".

During the second-round interviews, when asked about which approach would be best suitable for Ericsson, the respondents could not provide a coherent answer. Two respondents believed in only using a carbon fee, three interviewees wanted to start with a shadow price and then transition to including a carbon fee, another two respondents suggested using the hybrid approach, and the last two interviewees stated the approach was not that important, as long as it drives the desired change in behavior. Although the different responses, there is common ground among the wanted approaches mentioned during the interviews. For example, they all belong to the *Climate leader* path, since a transition from shadow to also including a carbon fee can be categorized as a hybrid approach, and because a carbon fee is the best way to drive behavioral change according to both company Z and Ahluwalia (2017). Company Z operates, similarly to Ericsson, in a non-energy intensive industry and argue that in these contexts a carbon fee is needed to change the mindset of employees. Thus, the answers from the second-round interviews, are in line with the literature, the theoretical framework, and the path established in Section 5.1.

Based on the previous paragraphs, it can be established that Ericsson need to implement a carbon fee in order to drive the behavioral and cultural change needed to be able to make the transition to a low carbon economy and create an incentive structure. However, a shadow price is also needed to incorporate the environmental cost in decisions where a carbon fee may not be suitable, for example in CapEx and R&D. This implies that a hybrid approach is the most suitable option for Ericsson to implement as their internal carbon pricing approach since this will provide the company with the benefits from both a carbon fee but also a shadow price. Respondent 8 mentioned during the second-round interviews that, "*there is this hybrid approach, like a combination between shadow pricing and a carbon fee, this is probably what we [Ericsson] should use because then we can apply the different tools in different situations",* which highlights the flexibility of using the hybrid approach. Also, company Z is using a hybrid approach after realizing that a shadow price on its own was not enough for a company operating in a non-energy intensive industry, just like Ericsson.

5.3 Implementation options

It was established in Section 5.1 that, since Ericsson are on the *Climate leader* path, all eight implementation options are viable. These implementation options are described in Section 2.4.2 and are split into two categories in the theoretical framework based on the requirement of a carbon fee for four of the options.

5.3.1 Implementation options requiring a carbon fee

Supplier fund is one potential way to use the revenues from the internal carbon price according to Ecofys et al. (2017) where the fund aims at reducing emissions in the supply chain. In the second round of interviews, it became evident that reducing supplier emissions is not the main aim of using an internal carbon price. For example, Respondent 6 said, "*primarily this fund [collected from a carbon fee] should be used internally. So primarily scope 1 and scope 2 emissions, our factories, our fleet vehicles, and maybe business travel"*. This reasoning is also consistent with the previously mentioned goal to be carbon neutral by 2030 within scope 1 and 2 emissions.

When applying a carbon fee on business units, departments are charged based on their contribution to the company's overall emissions within the selected scope (Ecofys et al., 2017). Company Z in the external interviews, Section 4.1.3 is a champion of this approach, they charge each department 40 €/tCO_2e they emit to reduce emissions and invest in renewable energy production. The response to this idea was somewhat split at Ericsson. The majority of respondents were positive about the idea because of the simpler administration and implementation compared to having a carbon fee paid in every operational decision. Those who opposed the idea argued that, if this approach is the only application area of the carbon price it might not lead to any change since departments can just adjust their budget, pay the fee and not change the behavior of their employees. These concerns could potentially be mitigated if applying the same strategy as Company Z, that charges departments a fee but also include shadow pricing in other decisions.

The topic of using carbon fee revenues for bonuses was heavily discussed during interviews. Ecofys et al. (2017) explain that these bonuses can be used to incentivize employees who contribute to lower the company's emissions. Those respondents who praised the use of funds for bonus payments believed that it would increase motivation and increase awareness. Those who were more skeptical discussed if bonuses are a reasonable incentive structure and raised questions regarding what happens with bonus payments when the sustainability targets are met.

Several technologies and methods for reducing the overall carbon dioxide levels in the atmosphere were presented in Table 2.1 based on research by the Royal Society and Royal Academy of Engineering (2018) as well as a potential way to spend the carbon price revenues in Table 2.2. In addition to the technologies, the ethics, and difficulties of using carbon offsetting were presented in Section 2.2.1. One of two main challenges that are difficult to avoid is related to how the gain is calculated. Kollmuss et al. (2008) explain that the calculation is based on a non-existing reality that is subjective and difficult to measure. The second challenged mentioned by Kollmuss et al. (2008) is connected to leakage. During the first interview round, several insights regarding the employees' attitude towards offsetting could be drawn. As mentioned in Section 4.1.1.4, seven out of nine respondents believe that offsetting will be required in order to reach the neutrality target, and the other two declined to answer. The reasoning behind most answers was similar to the one provided by Respondent 1, "*even if you do everything you can, there will still be some emissions left and then you need some sort of negative emissions to compensate*". However, some concerns were raised, Respondent 8 said "*in some cases we might buy carbon offsets, but the main goal is to make the real*

transformation happen". In Meeting 15, the issue of calculation was also raised. The general view among managers and sustainability personnel at Ericsson seems to be that offsetting should be done during the last years prior to 2030 to become carbon neutral. There are also questions to be answered regarding which technologies are used for offsetting the final emissions. An executive sustainability manager mentioned that "*we must use nature-based sources to capture CO_2e emissions from the atmosphere*". And in Meeting 16 a representative said that the longevity must be secured when it comes to offsetting and that planting trees is not good enough due to the large risk of leakage. Thus, it appears that the opinions at Ericsson are in line with the findings in the literature, there are difficulties with offsetting, but it will be required to compensate for the last emissions that cannot be reduced.

5.3.2 Implementation options regardless of chosen approach

Using the internal carbon price in CapEx decisions is also mentioned in Table 2.2 as one potential implementation option. In this case, the expected emissions are converted to financial terms and included in the return on investment calculations. This is a common application for the methodology and in the external interviews Section 4.1.3, it was understood that Company Y plan to use their carbon price in these types of decisions and Company Z already does with good results. All respondents at Ericsson were positive about using the carbon price for these types of decisions, and a senior environmental specialist said, "*Yes absolutely, it is crucial to use in these decisions. For years we have tried to point out the importance of environmental sustainability in this kind of decisions"*.

In procurement, the internal carbon price can be applied to include the environmental effect of purchased goods and services from suppliers (Ecofys et al., 2017). A majority of the respondents during internal interviews were positive towards including the internal carbon price in procurement decision-making under certain important conditions: the environmental footprint data must be reliable and comparable between different suppliers. Respondent 6 provided an answer that is well-aligned with the scope of the 2030-neutrality target, "*Using it in procurement is aligned with a more long-term ambition, but it might not be the first area of implementation"*. Company X has a relatively high maturity in using internal carbon pricing in procurement and expressed that suppliers generally have good and available data if asked for.

One application area that all respondents in the interviews were positive towards, including those respondents working with both supply and R&D, was to include the carbon price when evaluating R&D proposals. According to Ecofys et al. (2017), the expected environmental impact of a product is taken into account and converted to monetary terms and thus strengthen the business case for more sustainable products. Respondent 7 said that "*I think it is essential to include in R&D, I mean R&D is early in the product lifecycle, so this affects and facilitates a lot for the rest of us"*. However, concerns were raised when it comes to the reliability and comparability of data.

Lastly, in operational decision-making, companies can integrate CO_2e emissions in decision-making processes. According to Ecofys et al. (2017), this could for example strengthen the case for better usage of assets and optimized logistics activities. The response during interviews was in general very positive to this idea, for example, Respondent 8 said "*I believe internal carbon*

pricing is super good to include in operational decisions. To estimate the cost of greenhouse gas emissions and display all costs in the same format to compare the options X, Y, and Z". The only respondent who was negative to using internal carbon pricing in operational decisions believed that, in his/her decisions, time is more crucial than cost or sustainability.

5.3.3 Concluding remarks

As shown above, several factors must be considered when determining how and where to apply the internal carbon price. During the interviews it has become apparent that one key objective is to drive a behavioral change within the company and to do this, employees and decision-makers should see the carbon cost when they take the actual decision. The purpose of this is to improve the understanding of decisions taken and help employees make informed decisions. However, information may not be enough to drive change, as shown in the interview answers in Section 4.1.1.3 for example. Comments such as "*fake prices will have no impact"*, "*it [a shadow price] is only internal money that in the end does not matter at all"* and "*money talks"* highly suggests that information, as well as financial incentives, is needed. This goes in line with the analysis in Section 5.2 which concluded that a hybrid approach is suitable, and is important to remember when deciding which decisions that the internal carbon price should be used in. Lastly, the main key enabler mentioned in Section 4.1.2.4 is simplicity in order to not create too cumbersome tasks for employees and to have a simpler administration. With all this in mind, using a carbon fee on business units in combination with shadow pricing in CapEx decisions, procurement decisions, R&D decisions, and operational decisions appears to be a highly suitable approach for Ericsson. This design would combine the financial incentives for every department to reduce their emissions while also providing employees with carbon information in monetary terms for their decisions and avoid too complex financial administration.

The carbon fee on business units should cover departments' scope 1 and 2 emissions in line with the 2030 carbon neutrality target whereas the shadow prices can include emissions in all scopes to provide more information. However, it should be noted that successful application will require reliable and comparable data, as mentioned in several interviews. For the fee on business units, this is not an issue, as Ericsson already have a reporting structure for emissions and energy consumptions in scope 1 and 2. When it comes to shadow prices in operational, purchasing, R&D, and CapEx decisions, however, this may be an issue. But a suitable start would be to apply the shadow price to decision processes where the CO_2e impact is already known, such as when purchasing logistics services and business travel.

As established, when it comes to spending the funds collected through internal carbon pricing there are different possibilities. Bonuses and offset purchases are two of them and were discussed during interviews, the general attitude to both options is positive among the respondents in the interviews. Bonus payments should be made if they are done in a way that motivates employees to continue reducing emissions. Discussions around offset purchases have occurred during interviews and observation and the conclusion is that the focus should be on reducing emissions as much as possible and then offset the outstanding emissions to reach carbon neutrality.

5.4 Price calculations

To calculate the internal carbon price, the calculation approach must be determined. Based on the selected approach, the price for today will be calculated as well as the prices for the coming years until 2030. In the following sections, this is described and shown in detail.

5.4.1 Selection of price calculation approach

As shown in Section 2.4.3, the calculation of a company's internal carbon price can be done in different ways. Basing the price on external resources, e.g. equal to the EU ETS price as proposed by I4CE and EPE (2016), or determining the price via benchmarking against industry peers are two methods that require little resources but does not consider the internal situation at the company and does not signal *Climate leadership* which, as established, Ericsson is highly interested in. For these reasons, these two calculation methods will not be applied in this chapter although they will be discussed in Section 6.1. The two more cumbersome methods described in Section 2.4.3, basing the price on internal consultation or technical analysis are both suitable for companies aspiring to be *Climate leaders*. Internal consultation is good for driving behavioral change within the company. As explained in Ecofys et al. (2017), discussions take place with affected stakeholders to identify a price level that would have a significant impact on the decisions taken. Impact in decision-making has been mentioned in the interviews as one key gain from using internal carbon pricing, for example, one respondent said "*It [internal carbon pricing] makes it visible, you get it [the cost of emissions] on paper and can use it in decision-making. So, I believe in it [internal carbon pricing]*". The drawback with using an internal consultation method for calculating the price, however, is that it is difficult to understand the effect that carbon pricing will have on the overall emissions of the company since the price is not anchored in a specific sustainability target, as mentioned by Ecofys et al. (2017). Calculating the internal carbon price with a technical analysis on the other hand allows companies to set prices that ensure that emission reduction targets are met, as explained in Section 2.4.3.4 and said by company X in the external interview. This was deemed a suitable approach due to Ericsson's communicated target to be carbon neutral in 2030 from all scope 1 and 2 emissions (Ericsson, 2021b).

5.4.2 Price calculation

Two technical calculation methods were explained in Section 2.4.3.4. One is to calculate the abatement cost curve according to the logic of Mikolajczyk et al. (2017) where the cost of different potential initiatives to reach the sustainability target is listed and the price is set to ensure sufficient monetary resources to proceed with the initiatives. This method requires comprehensive knowledge about the planned and potential sustainability projects at the company and a detailed understanding or assumptions of the costs and abatement potential of the different initiatives. This was not possible to do in this Master's thesis and thus, the Microsoft approach (DiCaprio, 2013), explained in Section 2.4.3.4 and the formula presented, was applied.

$$Internal\ carbon\ price\ = \frac{Total\ cost\ of\ environmental\ initiatives\ portfolio\ [\$]}{Total\ GHG\ emissions\ [tCO_2e]}$$

$$= \frac{Cisp\ +\ Cgpp +\ Cco}{Total\ GHG\ emissions}$$

Where Cisp is defined as the cost of internal sustainability projects, Cgpp the cost of green power purchases, Cco the cost of carbon offsets respectively.

The cost of internal sustainability projects is related to investments to make operations and facilities more energy-efficient and reduce emissions within scope 1 and 2. After Meeting 16 with sustainability personnel at Ericsson, it was determined that $500'000 per year until 2030 is a reasonable project budget for internal carbon pricing calculations.

When calculating the annual cost of green power purchases, the researchers' starting point was the confidential energy consumption data from Ericsson's sites and the costs for purchasing green energy certificates. However, as displayed in Section 4.3.4, green energy can be purchased in different ways such as certificates which is the norm at Ericsson today, green power purchase agreements with the energy supplier, or having on-site renewable energy production. Also, in Table 4.4, it is displayed that the costs vary depending on which option is chosen, the total cost of ownership for on-site renewable energy production can be lower than the other two, but it does come with a CapEx. When calculating the costs for each alternative, the share of energy to come from each source is based on the assumption in Figure 4.11 from Ericsson sustainability personnel. This assumption covers Ericsson's global energy consumption although it will likely change from region to region. For simplification purposes, the overall global assumption was deemed suitable for the calculations.

The total cost for purchasing certificates was calculated according to the formula below:

$$Total\ cost\ of\ certificate\ purchases\ =$$

$$\%\ of\ energy\ usage\ to\ be\ covered\ with\ certificates$$
$$* \sum_i (Average\ cost\ for\ certificates_i\ [\$/MWh] * Energy\ usage_i\ [MWh])$$

Where i represent different geographical areas. Thus, the cost for certificates in the said area (equal parts wind, solar, and hydropower) is multiplied with Ericsson's energy usage in that area.

The total cost of transitioning to green power purchase agreements and on-site renewable energy production is calculated similarly.

$$Total\ cost\ of\ green\ power\ purchase\ agreements\ =$$

$$\%of\ energy\ usage\ to\ be\ sourced\ with\ agreements * Total\ energy\ usage\ [MWh]$$
$$* Average\ additional\ cost\ for\ using\ green\ power\ purchase\ agreement\ [\$/MWh]$$

$$Total\ cost\ of\ onsite\ renewable\ energy\ production\ =$$

$$\%\ of\ energy\ consumption\ from\ onsite\ energy\ sources * Total\ energy\ usage\ [MWh] * Average\ additional\ cost\ of\ producing\ onsite\ renewable\ energy\ [\$/MWh]$$

Due to the reasoning in Section 5.3.1, bioenergy with carbon capture and storage is a likely technology candidate for Ericsson to use for offsetting emissions. Additionally, the technology already has a rather high "readiness level" compared to other options. The price used for calculating the internal carbon price is the 200 \$/tCO_2e captured. However, in the near term, this factor will be zero in the price calculations as Ericsson will not start to offset their emissions until a few years in the future.

To calculate an internal carbon price that could be used today we need to enter the above values, the project budget, the cost for purchasing green energy (as it is today, with today's share of green energy purchases and today's split among the different ways of sourcing green energy, which is confidential from Ericsson), and the offset budget (which today is zero). This gives the following equation and price:

$$Internal\ carbon\ price\ = \frac{Total\ cost\ of\ environmental\ initiatives\ portfolio\ [\$]}{Total\ GHG\ emissions\ [tCO_2e]}$$

$$= \frac{Cisp\ +\ Cgpp +\ Cco}{Total\ GHG\ emissions} = 11\ [\$/tCO_2e]$$

Where Cisp is defined as the cost of internal sustainability projects, Cgpp the cost of green power purchases, Cco the cost of carbon offsets respectively.

The price of 11 \$/tCO_2e is in line with Ben & Jerry's (10 \$/tCO_2e), Microsoft's (15 \$/tCO_2e) who both are using a carbon fee approach. The CDP (2021b) benchmarking price for scope 1 and 2 emissions covered by a carbon fee (22 \$/tCO_2e) is slightly higher than the price calculated and the calculated price is significantly lower than Company X that uses a shadow price of about 60 €/tCO_2e. In the following section, the expected price changes over time will be analyzed.

5.4.3 Future prices and impact analysis

When analyzing this over time, it becomes more interesting but in order to do this, some assumptions have to be made about how the emissions will change over time. These estimations were given to the researchers by sustainability personnel at Ericsson. As displayed in Section 4.2.3, scope 1 emissions from facility energy use are expected to decrease linearly by 90% until 2030 compared to the baseline in 2020. Scope 1 emissions from the vehicle fleet are expected to decrease linearly to 0 in 2030 and Scope 2 energy usage is expected to increase by 20% by 2030 due to less outsourcing, more sales, and digitalized and connected production. However, the emissions from scope 2 energy usage will be zero due to energy certificate purchases, green power purchase agreements, and on-site renewable energy production. With these linear assumptions, a \$500'000 annual project budget for internal initiatives, and an offset increase according to Table 4.5 the internal carbon price can be calculated for each year until 2030 when Ericsson should be climate neutral. One additional assumption is that the carbon price cannot be set to be higher than the cost to offset one ton of CO_2e since then, it would make more

economical sense to offset the remaining emissions. The different prices are presented in Table 5.1 and the total emissions, offset quantities, and net emissions are displayed in Figure 5.2.

Table 5.1. Calculated internal carbon price levels for Ericsson until 2030

Year	Internal Carbon Price ($/tCO2e)
2021	11
2022	15
2023	19
2024	25
2025	34
2026	46
2027	107
2028	200
2029	200
2030	200

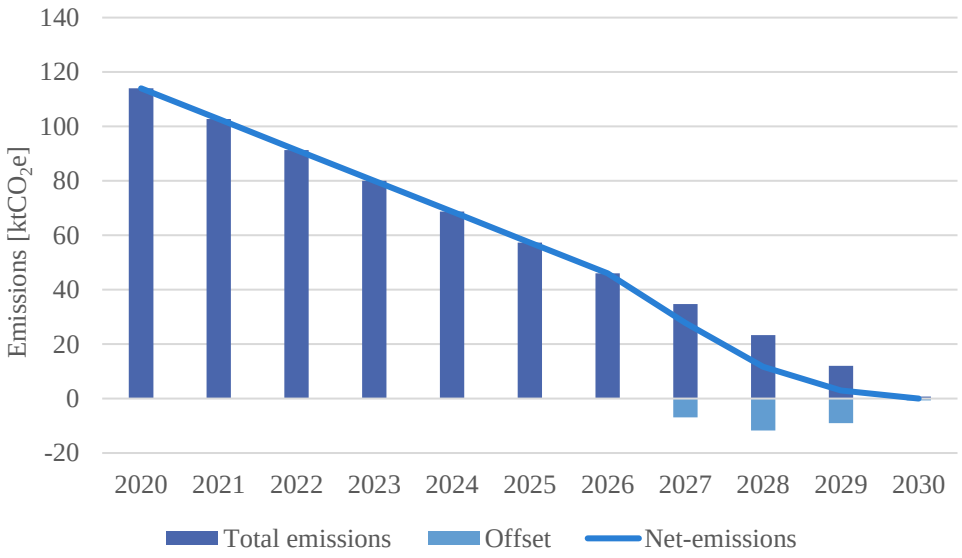

Figure 5.2. Projected emission reduction [ktCO2e] and offset quantities [tCO2e] until 2030

The vast increase in the internal carbon price in 2027, lasting until the final year of 2030 might seem alarming. However, this is due to the reduced emissions which are driving the price higher as well as the introduction of the offset budget according to the logic described earlier. Figure 5.3 illustrates the evolvement of the internal carbon price and the total budget (including offset purchases, green energy, and internal project budget).

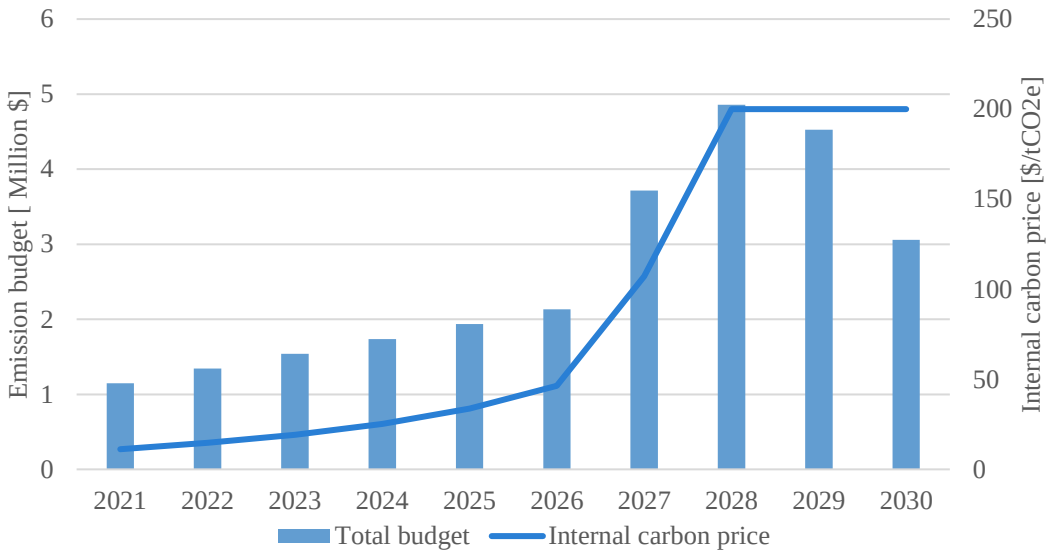

Figure 5.3. Expected total budget and internal carbon price until 2030

As shown, for 2022, the price is set to 15 $/tCO$_2$e but will increase in line with Table 5.1. However, since simplicity is a key enabler, increasing the price every year might not be the best option because this could lead to more administration and require more education. Instead, one solution can be to increase the price every second or third year and then determine the price simply by calculating the average price for those years. If the price is planned to increase every third year, the price for 2022-2024 would be equal to 20 $/tCO$_2$e, during the period 2025-2027 the price is equal to about 60 $/tCO$_2$e, and during 2028-2030 the price is equal to 200 $/tCO$_2$e. Based on the need for simplicity and simple communication, this is the recommended approach to Ericsson.

5.5 Implementation

Through the external interviews, it became clear that CXO commitment and communication are keys to the implementation. During all three external interviews, the companies pointed out the need for CXO commitment and support, more specifically CEO and CFO support, without which they would not have succeeded with their internal carbon pricing implementations. Also, this was discussed during the second-round interviews where three interviewees pointed out CXO commitment and five respondents mention top-down communication as important aspects in an implementation. One respondent said, "*from my extensive experience at Ericsson, these things must be top-down […] Börje [Börje Ekholm, Ericsson's CEO] must help drive this implementation, then it is really possible*", highlighting the request of top-down communication and CXO support within Ericsson.

Another important area mentioned during the second-round interviews and external interviews was reliable and comparable data. To be able to apply the internal carbon price, you must have the emissions data, e.g., if the internal carbon price should be applied in CapEx-decisions or R&D, you must estimate the total emissions from the investment or R&D proposal during its lifetime to provide a correct cost through the internal carbon price. Similarly, if the internal carbon price is applied within procurement, you must have comparable data from your

suppliers regarding the emissions from the goods purchased. If the emission data cannot be compared, the internal carbon price becomes more or less useless in this aspect since then internal carbon price can do more harm than good.

Also, during the second-round interviews, it became clear that the internal carbon price must be simple to use. Manual work and administration need to be minimized, otherwise, it may not become useful for Ericsson. Because of this, system support through digital and automated solutions was pointed out as another key to implementation, more manual work cannot be added to the workload. Furthermore, company Z stated that educating employees regarding internal carbon pricing was the biggest challenge they faced, something that also was discussed during the second-round interviews, that coordinating and increasing awareness in a large organization like Ericsson can be a challenge. This is related to the top-down communication previously discussed and needs to be handled at the highest level. It is important to consider how to educate employees on this topic and spark an interest in the concept.

To get going with an internal carbon price, the external interviews indicated to start on a small scale with a gradual approach and a low, uniform price. Company Y specifically pointed out to start where you have the data needed to get going, and from there collect more data in other areas and then expand the usage of the internal carbon price. At the same time, concerns regarding too low prices were raised during the second-round interviews. If the price is too low, this might not drive the desired change since employees will not consider the extra cost when it is insignificant. This leads to another consideration that must be made, whether the carbon fee and shadow price should be equal or not. During the interviews, a majority of respondents were positive about the idea of having different price levels. Also, as argued by Ahluwalia (2017), using a too low shadow price might not impact the decision at all. So, to keep simplicity in mind a suggestion is to use the price levels in Table 5.2. Then, the shadow price is expected to impact decisions more and it is in line with other shadow price levels used in industry, for example, Company X (60 €/tCO_2e). and the CDP average (49 \$/tCO_2e). This recommendation is also in line with Harpankar's (2019) findings that say that shadow prices generally are higher than carbon fee price levels.

Table 5.2. Recommended carbon fee and shadow price levels for Ericsson until 2030

Year	**Carbon fee [\$/tCO_2e]**	**Shadow Price [\$/tCO_2e]**
2021	11	60
2022	20	60
2023	20	60
2024	20	60
2025	60	200
2026	60	200
2027	60	200
2028	200	200
2029	200	200
2030	200	200

5.6 Pilot case

To test and illustrate the concept of internal carbon pricing in practice, some of the findings presented earlier in this chapter will be applied in a real decision at Ericsson. To introduce the case, one of Ericsson's older products is about to be replaced but there is still some demand (4'000 per year) for the product, only in North America. Today the production of this product is split between Mexico and Brazil, but the aim is to consolidate the production to one of these two sites. In this decision, a total landed cost analysis is performed where all costs considered, such as production cost, transportation cost, cost of capital, etc., are grouped for the two options. In this pilot case, the shadow price was multiplied with the total emissions for the respective options and integrated into the total landed cost. The impact of the carbon cost, its share in relation to the total landed cost, is illustrated in Figure 5.4 and Figure 5.5. 100% represents the cost if all production was done in Mexico. Thus, producing in Brazil is more expensive already without the shadow price included in the calculations.

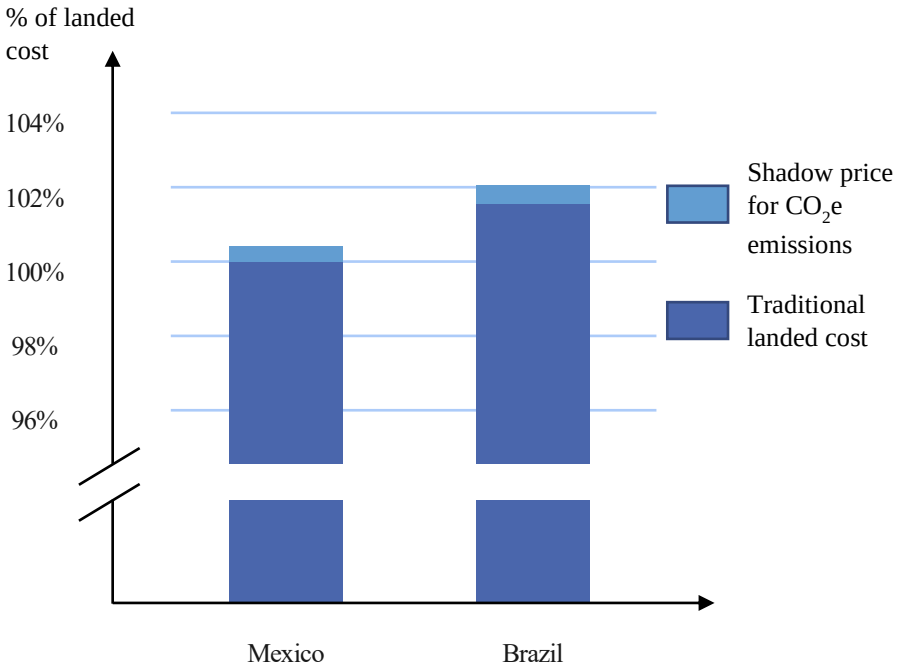

Figure 5.4. Total landed cost and impact of shadow price (60 $/t$CO_2e$)

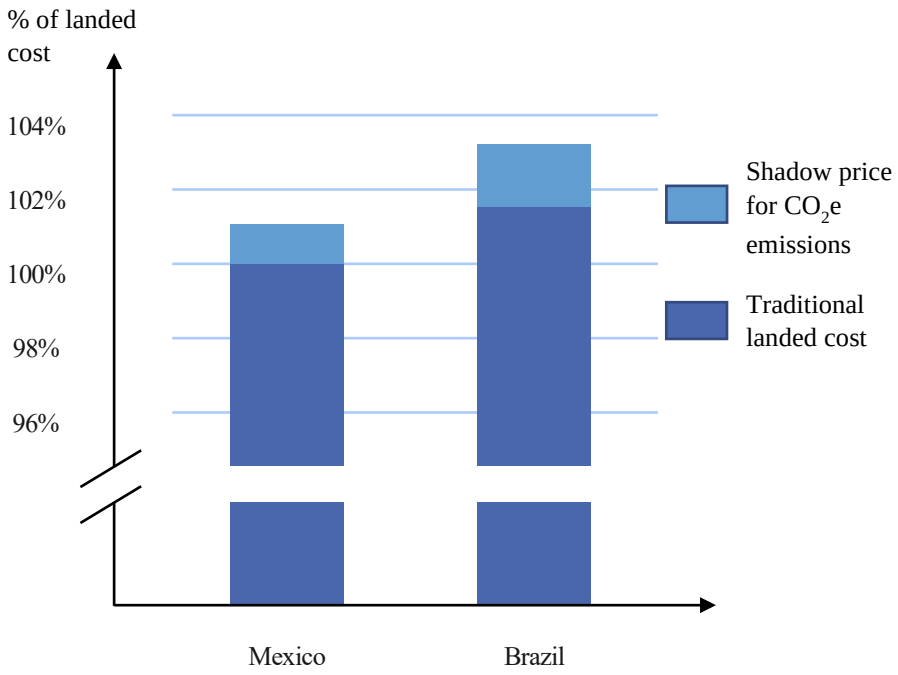

Figure 5.5. Total landed cost and impact of shadow price (200 $/tCO₂e)

Based on this pilot case, it can be concluded that the introduction of a shadow price in the current supply chain design decisions and calculations would not have a drastic or disruptive effect on the decision-making. However, the use of internal carbon pricing does indeed strengthen the business case for the low-carbon option, Mexico. These two findings are in line with the literature findings presented in Chapter 2 (e.g. Ahluwalia, 2017; Ecofys et al., 2017). The magnitude of the impact can be measured by how large the cost difference is between the two options with, and without, the shadow price added. In the base case, with no consideration for the carbon cost, the total cost difference between the two options is 1.49%. If a shadow price of 60 $/tCO₂e is applied, the difference between the two options is 1.73 percentage points, which is an increase of 15.6% of the cost difference, illustrated in Figure 5.4. If a shadow price of 200 $/tCO₂e is applied, the total cost difference between the two options is 2.27 percentage points, which constitutes an increase of 52.1% cost difference compared to the base case.

6 Discussion

In the first section of the following chapter, the authors discuss the results of the study and how the findings help answer the research questions formulated in the introductory chapter to the report. Following the discussion of the results, the methodology and methods used to attain the said result are reviewed and discussed. Subsequently, the authors give their perspective on the academic and managerial implications of these findings as well as provide suggestions for further research.

6.1 Results

The first research question formulated in Section 1.2.3 is the following:

What approach should Ericsson take to internal carbon pricing and in which decisions should it be part of the basis for decision-making?

In this thesis report, a theoretical framework was constructed, and several interviews were conducted to answer the first research question. The early findings showed that Ericsson would best fit in the *Climate leader* category in the framework and thus should mainly review the options and approaches on the left path in the framework, as discussed in Section 5.1. This also meant that all potential implementation options, or decision processes, were on the table to review. The final suggestion, that Ericsson should use a carbon fee on business units, and shadow pricing in CapEx, procurement, R&D, and operational decisions were taken on the basis discussed in Section 5.3. One key reason for the final suggestion stems from the otherwise difficult task of combining simplicity of the monetary flow and administration, with a positive effect and improved understanding for the individual decision-maker. By keeping the monetary flow simple with a carbon fee on business unit level, and shadow price to provide information to the individual decision-maker with information of the environmental economic impact of the decision taken, both criteria can be fulfilled.

When deciding on the areas to implement internal carbon pricing, it is vital to understand what kind of emission data is available and what additional data needs to be collected. If using a gradual approach to implementing internal carbon pricing as discussed in Section 5.5, it is reasonable to start were reliable and comparable data already exists and then expand. The same approach can be taken to which emissions that business units are charged for, starting with scope 1 and 2 which then can increase to selected scope 3 emissions at a later stage.

A topic that was not part of the initial scope of the report but at the later stages has become increasingly important is how the revenues collected from a carbon fee are used. There are many options when it comes to green investments within and outside the firm, these should be described clearly and transparently. If the money is well-managed, it could increase motivation for sustainability projects as found during the interviews.

The second research question formulated in Section 1.2.3 is the following:

What price (in $/tCO₂e) should Ericsson use when implementing internal carbon pricing in order to effectively make environmental sustainability part of their decision basis?

As mentioned in Section 5.4.3 and 5.5, the recommended price levels for Ericsson to start using next year are a carbon fee of 20 $/tCO₂e and a shadow price of 60 $/tCO₂e. The different price levels that have been presented in this report are shown below in Table 6.1 as well as the approach each company/organization use when applying its price. The EU ETS price and the value from De Bruyn et al. (2018) are not constructed for the purpose of internal carbon pricing but can be applied when using a shadow approach. It can be concluded that both recommended prices for Ericsson are in line with the comparable companies and organizations. Moreover, in Section 2.4.3.5, a price band was introduced and described. The recommended carbon fee price levels for Ericsson are, in the coming three years, just between the introductory (0-20 $/tCO₂e) and operational (20-50 $/tCO₂e) carbon price levels suggested by CDP and the We Mean Business Coalition (2015). The recommended carbon fee between 2025 and 2027 are on the lower end of the spectrum for transformational price levels (50-80 $/tCO₂e). Lastly, in the final years prior to 2030, when carbon neutrality should be achieved, the recommended price level is in the targeted (> 80 $/tCO₂e) price span. In Table 6.1, the recommended price levels are compared to other companies and organizations, S1, S2, and S3 refer to scope 1, scope 2, and scope 3 emissions covered by the internal carbon price respectively.

Table 6.1. Overview of prices presented in the report and suggested price levels for Ericsson

Company /Organization	**Approach**	**Price ($/tCO₂e)**
Ben & Jerry's	Carbon Fee	10
Microsoft	Carbon Fee	15
CDP Average (S1 & S2)	Carbon Fee	22
CDP Maximum	Carbon Fee	532
Company Z	Carbon Fee Shadow Price	40 (€/tCO₂e)
Company X	Shadow Price	60 (€/tCO₂e)
CDP Average (S3)	Shadow Price	49
CDP Maximum	Shadow Price	459
EU ETS	N/A	44.3 (€/tCO₂e)
De Bruyn et al. (2018)	N/A	56.6
Recommended for Ericsson	**Carbon Fee**	**20**
Recommended for Ericsson	**Shadow Price**	**60**

Moreover, in Section 5.5 it was suggested to start with a lower price in the beginning and then increase the price from that level. The recommendation of following a gradual price increase is in line with this approach. Accordingly, the price is set to 200 $/tCO₂e at the end of the period until 2030 which is higher than most prices displayed in Table 6.1. The price of 200 $/tCO₂e

stems from the fact that the offset cost is set to 200 $/tCO$_2$e, however, this does not constitute a significant increase in the total revenues from the carbon fee system because of the expected reduction in emissions, as shown in Figure 5.3. This is deemed a reasonable approach since the emissions should have been minimized as much as possible by that point and the only option to become carbon neutral is to offset the remaining emissions. Additionally, the price level of 200 $/tCO$_2$e for the carbon fee is still significantly lower than the highest carbon fee price level reported to CDP (2021b). When trying to analyze the future, it is important to keep in mind that some assumptions and today's truths are uncertain. Thus, it is beneficial to be flexible, re-evaluate and follow up the internal carbon price and its strategy over the coming years. For example, should another carbon offset method be used, or if the cost of offsetting changes, this would lead to a different internal carbon price in the final years. The long-term price level of direct air capture is expected to be 100 $/tCO2e (The Royal Society & Royal Academy of Engineering, 2018) which would half both the internal carbon price and the carbon fee revenues in the final years of the analyzed scenario.

6.2 Academic implications and further research

This thesis has collected knowledge and information published in both scientific and non-scientific journals and reviewed industry practice to come to the conclusions which can, as described in the previous section, be of value for industry professionals as well as to researchers aiming to study internal carbon pricing. Moreover, the theoretical and industrial knowledge has been concluded in a theoretical framework that can serve as guidance to internal carbon pricing strategy development. By applying the said framework in a detailed case study, this thesis has provided insights to academia regarding how internal carbon pricing can be introduced in large organizations and help reduce emissions. Lastly, this thesis has proposed a methodology for closing the gap between corporate strategies and functional unit level strategies and decision-making regarding environmental sustainability.

More research is still needed on the topic and several different perspectives would be of interest to investigate. For example, further research could build on the findings in this report and help companies selecting a suitable internal carbon pricing strategy, another perspective would be to research the effect, on CO_2 emissions or employee behavioral change, after a company has implemented internal carbon pricing in their practices. Both Company X and Z that have implemented internal carbon pricing states that the effects have been very positive, thus, it would be interesting with a study on the topic. Research regarding companies that in this report have been labeled *Climate preparer* would also be interesting to see, as this thesis has mainly been focused on the context of the case company, Ericsson, categorized as a *Climate leader*.

In addition to the previously mentioned topics, it could also be beneficial to further test and validate the framework presented in Section 2.5 which builds on both scientific and non-scientific articles and reports. A couple of areas where the authors of this thesis report would have benefited from having more research is related to the different implementation options and how the carbon price can be integrated into both the daily operations and in IT systems in the best possible ways. Lastly, a topic that arose both during the literature review as well as in multiple interviews, is the lack of international standards when it comes to sustainability. It would be of interest and importance to further research the topic on what is needed to create

long-lasting and widespread standards in terms of climate reporting, product carbon footprint, internal carbon pricing, and other similar topics.

6.3 Managerial implications

In Section 2.3, literature findings related to how environmental sustainability can be incorporated in organizational decision-making are presented. Borland et al. (2018) present three main types of business strategies that can be used by companies and they vary in how ambitious/transformative they are regarding incorporating environmental sustainability in the strategy. Regardless of the choice, it must be connected to the business unit level and functional unit level strategies to be effective, according to Bonn and Fisher (2011). The findings of this reports appear to suggest that internal carbon price can be an effective tool for connecting a corporate sustainability strategy to operational decision-making, thus closing the gap between the business strategy and the functional unit level strategy in terms of environmental sustainability. When reviewing the initial choice of wanted position in the framework it, to a certain extent, resembles the choice of business strategy which guides the following decisions that affect the business unit level and functional level strategies to a larger extent. However, internal carbon pricing does not only have the possibility to affect the strategy but by including the carbon price in for example operational decisions, the strategy is connected to the day-to-day work at the company.

Moreover, internal carbon pricing is a tool that companies can implement to ensure that they reach climate neutrality targets, by determining a price level high enough and the right scope of emissions included in order to take the actions and/or offset what is needed to reach neutrality, and prepares them for a low-carbon economy. This Master's thesis can guide managers in the multiple decisions that have to be taken before implementing internal carbon pricing which then has to be contextualized in their specific organization to meet their aims. When it comes to actual implementation, some of the key challenges, and several key enablers, are presented and discussed in this report (for example in Section 5.5).

Other findings in this report that can be of interest to general managers are related to the different ways of achieving climate neutrality. Arguably, the quickest and easiest way is to purchase energy certificates which are quite cheap, and offset the remaining emissions through a low-cost carbon offset scheme such as forestation, despite the large potential for leakage. These two actions would, on paper, make the company climate neutral. However, to convince internal and external stakeholders, such as customers, that the company is actually contributing to the transition towards a low-carbon economy, they may have to be more proactive. In relation to energy and electricity purchases, this could entail aiming to source a larger share of their total energy consumption from on-site renewable energy production or directly from the energy supplier with a green power purchase agreement. Regarding offsets, this would entail to, similarly to the case company Ericsson, view offsets as a last resort and purchase them only to compensate for the outstanding emissions that cannot be reduced. Furthermore, the choice of offset technology is of importance. The selection should ideally be a technology that has a low risk of leakage and where the quantity GHGs removed are easily measured and calculated.

7 Conclusion

This Master's thesis aimed to assess how environmental sustainability can be included in corporate decision-making with internal carbon pricing and how companies can formulate their internal carbon pricing strategy. This included identifying which decisions should be affected and what a reasonable price level is. Additionally, the price should reflect the detrimental effect GHG emissions have on a company or be anchored to their climate neutrality targets. In short, the findings in this report suggests that companies who aim to incorporate environmental sustainability in their decision-making with internal carbon pricing should first understand why they want to use internal carbon pricing to meet their needs, and what their needs are. This decision would guide them to the following decisions that have to be taken regarding what approach is suitable, which implementation options are possible, and lastly what price calculation method should be applied, all in line with the framework presented in Section 2.5.

In this thesis, this was done for a case company, Ericsson, where the conclusion, based on literature, quantitative data, and qualitative data, is that Ericsson should charge a carbon fee on business units and implement shadow pricing in CapEx decisions, procurement decisions, R&D proposals evaluations, and operational decisions.

If implemented next year, the optimal carbon fee price according to the technical analysis conducted in this report would be 20 $/tCO$_2$e, and the shadow price would be 60 $/tCO$_2$e, both of which will gradually increase to a level where the internal carbon price is equal to the cost of offsetting emissions with a sustainable GHG removal technology.

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Appendix I Interview guides

The questions presented in this Appendix were asked to Ericsson employees or external subject matter experts. The interview guide used in the first-round interview was later revised and the final version can be found in Appendix II.

First-round interview guide

1. Would you like to introduce what you work with? The role, responsibility, etc.
2. What do you think Ericsson is doing well in terms of environmental sustainability today?
    a. Do you see any potential areas for improvement for Ericsson to take even greater responsibility regarding environmental sustainability?
3. What do you think is most important for Ericsson regarding environmental sustainability going forward, being, and demonstrating climate leadership, (to strengthen brand value, gain a competitive edge, reach climate targets) or to prepare for stricter regulation and a low-carbon economy (be ahead of legislation, risk management)?
    a. Why do you think that?
4. According to Ericsson's sustainability policy, the aim is to be carbon-neutral by 2030. Do you think that Ericsson will reach the target at the current pace?
    a. Why/why not?
    b. If yes, do you believe there is still room for improvement?
    c. If no, what more do you think is needed?
5. Are you familiar with the concept of internal carbon pricing?
    a. If no: An internal carbon price places a monetary value on each unit of greenhouse gas that is emitted within the company. This fee is used in the decision-making and thus, factoring in environmental sustainability in investment- and operational decisions.
6. How do you feel about implementing internal carbon pricing at Ericsson?
7. Do you think carbon offsetting (i.e. investing in CO2 removal or reduction outside of Ericsson) will be part of the solution, while simultaneously reducing current emissions, to reaching the 2030 target?
    a. Why do you think that?

Second-round interview guide

1. Do you think it is possible to achieve a behavioral change, to a situation where employees are making greener decisions, without financial incentives to choose the environmentally kind options?
    a. How? / why not?
2. Shadow price, **a theoretical price that is assigned to GHG emissions where no actual fee is charged, and it is commonly used to assess risk and evaluate investments** – would this change the decisions?

3. Carbon fee, **an actual price is assigned to GHG emissions and the company charges itself for the emissions and transfers the money into an internal fund that subsidizes green investments** – would this change the decisions?
4. What do you think is the best approach of a carbon fee or a shadow price for Ericsson?
5. Is it feasible to implement a carbon fee system at Ericsson and govern the emissions and investments from collected fees?
    a. Why? / Why not?
6. Do you think it is feasible to have different carbon prices in different processes depending on which emissions are most important to focus on reducing, or do you think it should be the same price in all affected processes?
    a. Why?
7. In which decisions/processes do you think that an internal carbon price could beneficially be used at Ericsson?
    a. Why?
8. We have identified 8 areas/decisions where internal carbon pricing has been implemented beneficially at other companies and would like to have your opinion on these within Ericsson. Firstly, CapEx, *investments in fixed assets. The potential emissions from the investment are translated into monetary terms to assess the environmental effects, thus strengthening the business case for more environmentally friendly investments* – Are you positive about implementing this at Ericsson?
    a. Why / why not?
9. R&D, *similarly to CapEx, when evaluating the R&D proposal, the environmental impact from developing the product is also considered. This can strengthen the business case for low-emission, energy-efficient products* – Are you positive about implementing this at Ericsson?
    a. Why / why not?
10. Operational decisions, *ICP can be used in operational decisions, for example when deciding which shipping route to use, or which machines to use in production. An internal carbon price can then strengthen the business case for more sustainable options* – Are you positive about implementing this at Ericsson?
    a. Why / why not?
11. Procurement, *ICP can be implemented in procurement. The operational purchaser would then see both the purchase price and the carbon price of the component and then make a decision based on all information. This could be a theoretical price or a fee paid to a fund* – Are you positive about implementing this at Ericsson?
    a. Why / why not?
12. Business units, *departments can be charged based on their contribution to the company's emissions. Regularly, the whole company's emissions are calculated and the unit causing them are assigned to pay* – Are you positive about implementing this at Ericsson?
    a. Why / why not?

13. Bonuses, *the revenues gained from the ICP can be the basis for individual employees' bonuses, thus moving from business unit focus to individual. This could for example be applied to give larger bonuses to business travelers who travel by train compared to those traveling by air* – Are you positive about implementing this at Ericsson?
    a. Why / why not?
    b. Do you think this would be reasonable to implement for all employees, selected employees, managers?
14. Supplier fund, *if procurement pays an internal carbon fee on all purchased items, the money can be routed to a supplier fund for CO2 emissions. The money from the fund can be used to finance CO2 emission reduction products in the supply chain* – Are you positive about implementing this at Ericsson?
    a. Why / why not?
    b. Do you know if there are any ongoing projects where Ericsson and the suppliers are working together to reduce emissions?
15. Offset purchases, *the revenues gained from the internal carbon price are reserved for purchasing carbon offset credits. This money goes toward CO2 reduction or removal projects. This could for example be investing in tree planting or carbon capture* – Are you positive about implementing this at Ericsson?
    a. Why / why not?
16. Now that we have discussed these, do you see any other, perhaps specific, process where carbon pricing could be applied?
17. Are you positive or negative towards implementing internal carbon pricing at Ericsson?
18. What are the key enablers to make this reality at Ericsson?
19. What are the major difficulties?

External interview guide

1. What are your thoughts and experiences regarding internal carbon pricing?
2. Why are you using/planning to use an internal carbon price?
    a. How long have you used internal carbon pricing?
3. What approach are you using for internal carbon pricing (carbon fee, shadow price, implicit pricing, hybrid approach)?
    a. Does the shadow price have any actual effect on decisions?
    b. Will it turn into a fee?
    c. How is administration dealt with?
4. How was it implemented?
5. What were the major hindering and success factors?
6. Which decisions and processes are the internal carbon price applied in?
    a. Why these decisions specifically?
    b. Did you introduce the internal carbon price in all decisions at once, or gradually?
7. What is your current price?

    a. How was it determined?
    b. How often is it reviewed?
8. In hindsight, has the implementation of ICP been successful?
    a. What are some key learnings?
    b. Key benefits?
9. Do you see any change in the behavior of decision-makers due to the introduction of an internal carbon price?
    a. Have the emissions reduced since the introduction?

Appendix II Interview guide iterations

The final version of the first-round interview guide is presented in this Appendix.

Final version of the first-round interview guide

1. Would you like to introduce what you work with? The role, responsibility, etc.
2. What do you think Ericsson is doing well in terms of environmental sustainability today?
3. Do you see any potential areas for improvement for Ericsson to take even greater responsibility regarding environmental sustainability?
4. Which category of Ericsson's emissions do you think are the most important to reduce during the coming years?
    a. Why do you think that?
5. In our literature case studies, we have identified two main types of companies, these are companies that have the main goal of preparing for stricter regulation and a low carbon economy, the other type is companies who both want to be prepared but also to demonstrate climate leadership to internal and external stakeholders. Which one do you think Ericsson resembles most?
    a. Why do you think that?
6. According to Ericsson's sustainability policy, the aim is to be carbon-neutral by 2030. Do you think that Ericsson will reach the target at the current pace or will investments in green projects need to be accelerated?
    a. Why do you think that?
    b. If acceleration is needed, what more do you think has to be done?
7. Are you familiar with the concept of internal carbon pricing?
    a. If no: *An internal carbon price places a monetary value on each unit of greenhouse gas that is emitted within the company. This internal carbon price is used in the decision-making and thus, factoring in environmental sustainability in investment- and operational decisions.*
    b. How do you feel about implementing internal carbon pricing at Ericsson?
8. Do you think carbon offsetting (i.e. investing in CO2 removal or reduction projects) will be part of the solution, while simultaneously reducing current emissions, to reaching the 2030 target?
    a. Why do you think that?

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