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The Economic Impact of Greenhouse Gas Emissions on a Firm's Financial Performance: Using Anaplan as Primary Tool

TESI DI LAUREA MAGISTRALE IN MANAGEMENT ENGINEERING INGEGNERIA GESTIONALE

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Abstract

In a world where the imperative of reducing carbon emissions is prevailing and stringent global regulations tighten their grip, an undeniable reality surfaces—environmental responsibility carries tangible costs that extend beyond mere accounting; they demand proper internalization.

This thesis takes a transformative path, aiming to translate a company's greenhouse gas (GHG) emissions into tangible costs, uncovering the complex financial implications concealed behind corporate sustainability. Building upon the existing body of knowledge that investigates the link between corporate environmental performance (CEP) and corporate financial performance (CFP), this research explores how the costs stemming from carbon regulations impact key financial indicators such as Return on Assets (ROA), Return on Equity (ROE), Return on Sales (ROS), Earnings per Share, Net profit, Tobin's Q, credit risk, as well as overall firm credibility and reliability.

Motivated by the aspiration to contribute to climate change awareness, this research proposes a solution that not only unveils the complex relationship between greenhouse gas (GHG) emissions and financial health but also, and moreover, proposes an internalization of costs related to those emissions in the financial statements and financial results of firms. Leveraging Anaplan and enhancing an existing greenhouse gas (GHG) emissions accountability solution, this research pioneers a bridge between emissions and their economic aftermath. By incorporating greenhouse gas (GHG) emissions expenses into the financial framework of firms and, specifically, through the income statement, financial metrics are transformed to account for environmental consequences of firms' activities.

This thesis aims to offer an overview of the current regulatory landscape concerning emissions reduction as well as the existing research findings demonstrating the financial consequences of greenhouse gas (GHG) emissions. It proceeds to illustrate the creation and modeling of an Anaplan framework highlighting this relationship. The final model obtained presents companies with a stark choice: either curtail emissions or face an inevitable rise in costs.

Keywords: Economic Impact, Financial, GHG, Carbon Emissions, Anaplan

Abstract in Italiano

In un mondo in cui l'imperativo di ridurre le emissioni di gas a effetto serra (GHG) è diventato prevalente e le regolamentazioni mondiali al riguardo stringono la morsa, emerge innegabilmente una realtà: la responsabilità ambientale comporta costi tangibili che che richiedono un'adeguata internalizzazione da parte delle organizzazioni.

Questa tesi intraprende un nuovo approccio, con l'obiettivo di convertire le emissioni di gas a effetto serra (GHG) di ciascuna azienda in costi tangibili, scoprendo le complesse implicazioni finanziarie che si nascondono dietro la sostenibilità aziendale. Basandosi sul bagaglio di conoscenze esistenti che indagano il legame tra la performance ambientale aziendale e la performance finanziaria aziendale, questa ricerca esplora il modo in cui i costi derivanti dalle normative sulle emissioni di anidride carbonica hanno un impatto su indicatori finanziari chiave come il rendimento delle attività (ROA), il rendimento del capitale (ROE), il rendimento delle vendite (ROS), l'utile per azione, l'utile netto, il Tobin's Q, il rischio di credito, nonché la credibilità e l'affidabilità complessiva dell'azienda.

Motivata dall'aspirazione di contribuire alla tutela del cambiamento climatico, questa ricerca propone una soluzione che non solo svela la complessa relazione tra le emissioni di gas a effetto serra (GHG) e la salute finanziaria delle aziende, ma propone anche, e soprattutto, un'internalizzazione dei costi legati a tali emissioni nei bilanci e nei risultati finanziari di queste ultime. Sfruttando Anaplan e migliorando una soluzione esistente per la contabilizzazione delle emissioni di gas serra (GHG), questa ricerca è all'avanguardia nel creare un vero e proprio ponte tra le emissioni e le loro conseguenze economiche. Incorporando le spese per le emissioni di gas serra (GHG) nel quadro finanziario delle imprese, in particolare, attraverso il conto economico, le metriche finanziarie vengono trasformate per tenere conto delle conseguenze ambientali delle attività delle imprese.

Questa tesi intende proporre una panoramica dell'attuale scenario normativo in materia di riduzione delle emissioni nonché dei risultati delle ricerche esistenti che dimostrano le conseguenze finanziarie delle emissioni di gas a effetto serra (GHG). Successivamente, illustra la creazione e la modellazione di un framework Anaplan che evidenzia questa relazione. Il modello finale ottenuto pone le aziende di fronte a una scelta ardua: ridurre le emissioni o affrontare un inevitabile aumento dei costi.

Parole chiave: Impatto Economico, Finanziario, Gas Serra, Emissioni di Carbonio, Anaplan

Contents

Introduction

In recent years, there has been a notable shift in global priorities, with a growing emphasis on addressing climate change and its associated impacts. At the heart of this effort lies the imperative to reduce greenhouse gas (GHG) emissions, an essential action to prevent an imminent environmental crisis. Governments, businesses, and individuals worldwide are uniting to combat climate change, propelling the world toward a more sustainable future. This transformation has profound implications for businesses, necessitating a re-evaluation of their strategies, operations, and financial performance in relation to greenhouse gas (GHG) emissions.

The Current GHG Emission Context: A Shift Towards Green and Decarbonization

The scientific consensus is clear: human activities, notably the burning of fossil fuels, deforestation, and industrial processes, are driving the increase in greenhouse gas (GHG) concentrations in the Earth's atmosphere. This greenhouse effect results in rising temperatures, altered weather patterns, sea-level rise, and ecological disturbances.

In response to these concerns, a worldwide effort to promote sustainability and decarbonization measures was born. Policymakers worldwide started enacting ambitious climate policies, setting greenhouse gas (GHG) reduction targets, and promoting the transition to renewable energy sources and sustainable practices. This transition is not only an ethical obligation but also an economic imperative. Businesses across various sectors recognize that aligning with sustainability goals is vital for mitigating climate change and ensuring their long-term viability and competitiveness.

Introduction of Regulatory Frameworks for Emission Management: From Externalities to Tangible Costs

A key driver of change in this regard is the implementation of regulatory frameworks compelling companies to account for and mitigate their greenhouse gas (GHG) emissions. Governments are imposing carbon pricing mechanisms, setting emission reduction goals, and mandating reporting requirements for businesses. This regulatory landscape has transformed greenhouse gas (GHG) emissions from externalities into tangible costs that businesses must consider in their financial planning and risk assessments. Consequently, understanding the implications of greenhouse gas (GHG) emissions on financial performance has become an essential task for companies striving to adapt to this evolving landscape effectively.

It is in this changing environmental and regulatory backdrop that the motivation for this thesis emerges. The central argument posits that greenhouse gas (GHG) emissions can no longer be viewed in isolation from financial metrics; instead, the latter are intrinsic factors that influence a company's bottom line. Thus, it is critical to comprehend how carbon emissions impact various financial aspects, including cost structures, revenue streams, market competitiveness, and overall profitability. This understanding will not only assist companies in adapting to the evolving economic environment but also aid policymakers in crafting more effective regulations and incentives for sustainable practices.

The Necessity of Measuring GHG Emissions' Impact on Financial Performance: Utilizing Anaplan as a Tool

In addition to exploring the intricate relationship between greenhouse gas (GHG) emissions and financial performance, this thesis aims to bridge the gap between qualitative acknowledgment and quantitative precision. The primary objective is to create a model that quantifies the impact of CO_2 emissions on a company's financial performance in economic terms.

By recognizing the importance of expressing environmental issues in financial and economic terms, the research seeks to develop a methodological framework that moves beyond the existing acknowledgements concerning the correlation between emissions and financial outcomes. Instead, it endeavors to provide a structured approach for precisely calculating and expressing this impact in monetary units. This approach enhances the clarity and tangibility of environmental regulations and empowers decision-makers with actionable insights, both on the business and the regulatory sides.

Anaplan's Role in the Thesis

In the pursuit of this ambitious goal, Anaplan emerges as the central tool of choice. Leveraging Anaplan's versatile capabilities such as data integration, scenario planning, cost allocation, sensitivity analysis and robust reporting, an efficient model is developed. Anaplan's prowess in financial modelling and its adaptability to complex data sets make it an ideal partner in this project.

This model will enable a quantitative understanding of how greenhouse gas (GHG) emissions influence financial aspects such as costs, revenue streams, cash flows, profitability, financial risk, and overall economic health. It will provide the means to quantify the potential economic consequences of adopting emission reduction strategies or failing to meet regulatory requirements. In essence, Anaplan serves as the conduit through which environmental data and financial metrics converge, facilitating a deeper comprehension of the monetary ramifications of sustainability practices.

Personal Background and Motivations

In October 2022, in parallel to my master's studies at Politecnico di Milano, I had the opportunity to start working as Junior Consultant for Profit&, a financial consulting company implementing Anaplan solutions.

I spent the first few months completing the Anaplan training courses, which enabled me to start using the tool effectively and become a certified model builder. As I got to know my colleagues and the current projects and solutions offered by Profit&, my business tutor, pointed me in the direction of a sustainability and greenhouse gas (GHG) emissions application. More specifically, he told me that this application would enable any company deploying it to account for its CO2 emissions and I became increasingly involved with it. Several ideas were generated within the company about how to improve this accounting system for greenhouse gas (GHG) emissions, and the concept of measuring their economic impact was finally considered.

My keen personal interest in sustainability, in the reduction of CO2 emissions and in the Sustainable Development Goals (SDGs) prompted me to investigate the matter further. Starting with simple online research into the economic impact of CO2 emissions, I began by looking at existing studies and trying to understand whether this concept had already been explored. This then led me to look at all the international regulations and legislation that had been adopted on the costs and taxes associated with CO2 emissions.

This is how, in January 2023, a real research project began, going far beyond the conceptualization of a conventional model on Anaplan; instead, I started to rely on the connection between certain academic aspects concerning my research and my professional activity. More specifically, I aimed to combine the financial aspects covered by Professor D'Agostino in the first year of my master's degree with the development of this sustainability application measuring the economic impact of CO2 emissions.

After 10 months of work, in October 2023, most of the greenhouse gas (GHG) part of the model covering the economic impact of carbon emissions was finally completed. By then, there was only one thing left to do: complete my master's thesis, thus combining my academic knowledge, the start of my professional career and my ever-greater interest in sustainability. The structure of the thesis and the given detailed plan below retrace this academic, professional, and personal journey.

Thesis Plan

The thesis, titled ***'The Economic Impact of GHG Emissions on a Firm's Financial Performance: Using Anaplan as Primary Tool'*** is structured into several sections.

The first chapter delves into the complex global landscape of carbon reduction instruments, providing an overview of the regulatory context that shapes emissions policies worldwide. Additionally, a literature review is undertaken to discuss the existing body of knowledge on the relation between corporate environmental performance (CEP) and corporate financial performance (CFP).

The second chapter of the thesis represents the bridge between the theoretical concepts discussed in the first chapter and the objectives that will be reached; the chosen methodology, anchored in the utilization of Anaplan as the modeling platform, is presented.

The final chapter showcases the tangible results and deliverables generated by the model, including user interfaces and possible deployments. A transparent reflection on the model's capabilities and areas for potential improvements and limitations is discussed.

1 Regulatory Context and Literature Review

The first chapter of the thesis commences with an overview of the current global landscape concerning carbon emissions reduction, carbon pricing instruments, and the existing policies and regulations in place. Subsequently, a thorough literature review will provide the main foundations for this research, offering a consolidated view of the knowledge that has already been accumulated around greenhouse gas (GHG) emissions' economic impact on firms.

1.1. Regulatory Context

The growing urgence to confront the challenges of climate change has shifted mindset and priorities, well reflected in the increasingly stringent regulatory measures that have been put in place worldwide to address the mitigation of greenhouse gas (GHG) emissions.

This section of the thesis investigates this dynamic regulatory landscape, with a particular emphasis on the emerging trend of implementing taxes or prices on carbon dioxide (CO2) emissions. Its objective is to provide an extensive exploration of the mechanics of these regulations, shedding light on the evolving framework for greenhouse gas (GHG) emissions accountability mechanism. Furthermore, it elucidates the variations in regulatory approaches among different nations, dissects the intricacies information retrieval within this evolving context, and underscores the importance of recognizing these emissions taxes and prices as essential costs that businesses can no longer afford to overlook in their economic considerations.

International Story Leading to Regulatory Taxes on CO2 Emissions

The road to the establishment of regulatory taxes on CO2 emissions for firms has been paved by a collective global recognition of the pressing need to address climate change. This international story is rooted in decades of scientific research, observations, technological advances, and societal engagement. Several key developments have contributed to this awareness.

Early observations provided the initial foundation, with naturalists and scientists noting long-term climate variations and weather pattern changes, such as the Little Ice Age affecting Europe and other regions over centuries. In the 19th century, pioneers like John Tyndall and Svante Arrhenius started investigating the role of greenhouse gas (GHG) in Earth's temperature regulation. Arrhenius proposed that human-generated CO2 emissions from fossil fuel combustion could lead to global warming.

The mid-20th century saw advancements in climate science, including the development of computer models and improved access to climate data. These models indicated the possibility of global warming due to increasing greenhouse gas (GHG) concentrations. In parallel, Charles David Keeling initiated continuous measurements of atmospheric carbon dioxide (CO2) concentrations at Mauna Loa Observatory. His data showed a significant and continuous rise in CO2 levels, providing compelling evidence of increasing greenhouse gas concentrations in our atmosphere.

To provide a reliable, science-based foundation for understanding climate change, the Intergovernmental Panel on Climate Change (IPCC) was established by the United Nations in 1988. The IPCC's reports included an evaluation of the physical science of climate change, possible impacts on ecosystems and societies, as well as mitigation and adaptation strategies. It quickly became a guide for policymakers and governments around the world.

The Kyoto Protocol, established in 1997, was a pivotal milestone in global climate action. In fact, for the first time it introduced mandatory emission reduction targets for industrialized nations. Although the protocol did not directly impose taxes or prices on emissions, it played a significant role in elevating worldwide awareness and commitment to addressing the latter.

The 21^{st} century brought climate change to a wider audience, increasing awareness and global understanding of the issue. Media coverage and documentaries, advances in climate science, extreme weather events, Global Climate Summits, and youth-led movements, exemplified by Greta Thunberg's "Fridays for Future," resulted in concerns about carbon emissions and associated climate change moving from a scientific to a social concern.

In 2015, the Paris Agreement built upon the groundwork laid by the Kyoto Protocol, strengthening the international community's determination to combat climate change. This agreement encouraged countries to adopt a variety of policies, among them carbon pricing mechanisms like emissions taxes, to help them achieve their emissions reduction objectives.

Finland's groundbreaking move in 1990, when it implemented the world's first carbon tax policy, stands as a pivotal moment in the journey toward climate change awareness. Along with the previously mentioned milestones that collectively led to a heightened sense of urgency, Finland's forward-thinking initiative marked the beginning of a worldwide endeavor to combat climate change: diminish greenhouse gas emissions by levying prices on carbon dioxide emissions. Since then, a multitude of other countries and regions have followed suit by adopting carbon tax policies and comparable carbon pricing strategies to encourage emission reductions and foster the transition to cleaner and more sustainable energy sources.

Carbon Pricing Strategies: Two Distinct Mechanisms

Two distinct categories of regulations have arisen as fundamental instruments in addressing greenhouse gas emissions and climate change: carbon tax policies and Emissions Trading System (ETS) policies.

Carbon tax policies involve imposing a consistent charge on each unit of emitted carbon dioxide, introducing a stable yearly cost for emissions but without necessarily defining precise emission reduction objectives. On the contrary, Emissions Trading System (ETS) policies establish a maximum emissions limit, with emission allowances being allocated or auctioned to emitters. This permits emitters to trade these allowances in a market, ensuring a targeted emissions reduction level while introducing price flexibility based on market dynamics. More specifically, each Emissions Trading System (ETS) is designed to be implemented by a group of nations that choose to adopt it. For instance, 27 European nations plus Iceland, Liechtenstein and Norway have decided to participate in the EU Emissions Trading System, encompassing around 40 percent of the EU's total greenhouse gas (GHG) emissions (2021), as reported by Appunn and Wettengel (2023) for Clean Energy Wire.

Both these regulatory strategies share the goal of reducing greenhouse gas (GHG) emissions and have been implemented by various countries and regions worldwide, but they employ distinct methods to achieve this objective, as *per* their definition. Here are some of the primary differences between the two.

1. **Emissions Pricing Mechanism**

Carbon Tax: A carbon tax assigns a fixed yearly price to each unit of greenhouse gas (GHG) emissions. Emitters pay a consistent tax rate for each ton of emissions they produce, and this tax rate is determined by the government or by regulatory authorities.

Emissions Trading System (Cap-and-Trade): Often referred to as a cap-and-trade policy, an Emissions Trading System (ETS) establishes an overall emissions limit, the "cap", for a specific sector or region. Emitters are allocated or can purchase emission allowances, often called carbon credits, which can be traded in a regulated market. The market determines the prices of these allowances.

2. **Price Predictability or Emissions Quantity**

Carbon Tax: A carbon tax provides price predictability since the tax rate remains stable over a considered year. However, it does not guarantee a specific emissions reduction target.

Emissions Trading System (Cap-and-Trade): Emissions Trading Systems ensure that specifically set emissions reduction goals are met, as they enforce a set cap on emissions. Nevertheless, it introduces price variability because the cost of emission allowances depends on market dynamics and the latter have the tendency to fluctuate on a day-by-day basis.

3. Economic Efficiency

Carbon Tax: Carbon taxes offer price predictability, facilitating businesses' ability to anticipate and manage emissions costs.

Emissions Trading System (Cap-and-Trade): Cap-and-trade systems guarantee the achievement of a specific emissions target but introduce pricing fluctuations due to market supply and demand. Emissions are exchanged on a transactional basis through regulated markets.

4. Revenue Generation

Carbon Tax: Carbon taxes generate revenue for the government, which can be used for various purposes, such as supporting clean energy initiatives, subsidizing renewable technologies, or providing revenue returns to citizens through dividends or tax reductions.

Emissions Trading System (Cap-and-Trade): Emissions Trading Systems can create revenue for participating companies, by selling emission allowances, but may as well become a loss, when further allowances need to be bought at high prices. Still, their primary focus is on attaining emissions reductions, with revenue generation as a secondary outcome.

5. Administrative Complexity

Carbon Tax: Carbon taxes are relatively straightforward to implement and manage, employing a fixed tax rate that applies consistently over a year.

Emissions Trading System (Cap-and-Trade): Cap-and-trade systems offer emitters flexibility to find the most cost-effective methods of reducing emissions, as they can trade allowances. Nevertheless, they necessitate a more complex infrastructure for market oversight, administration, and regulation.

6. Emissions Categorization and Distinction

Carbon Tax: Generally, this type of regulation assigns a tax price to emissions which, in most cases, is applied across the board to all emissions, making no distinction or categorization. There are, however, some countries that have introduced different tax prices that increase or decrease according to the emissions in question. A practical example is Luxembourg, which in 2023 introduced a price of $32.63 for emissions from fossil fuels and a price of $48.11 for gasoline and liquid fuels. Meanwhile Denmark distinguishes between fossil fuels and f-gases with two separate prices, France and Switzerland prefer to maintain a general tax applicable to all types of CO2 emissions.

Emissions Trading System (Cap-and-Trade): Emissions Trading Systems introduce a more intricate and dynamic framework. In a cap-and-trade system, emissions are divided into allowances, each representing a specific quantity of GHG emissions. These allowances can be distributed in various ways, but one critical distinction arises in the allocation of free and auctioned allowances.

The concept of free allowances allows a certain percentage of emissions allowances to be allocated to emitters without cost. This allocation is often based on historical emissions or other predefined criteria. Emitters can use these allowances to cover their emissions without incurring a direct financial expense. This approach has the advantage of easing the transition to lower-carbon technologies for existing emitters, as they receive some allowances for free, reducing the immediate financial burden associated with emissions reduction.

In contrast, the auctioned allowances approach mandates that a percentage of allowances is sold through competitive bidding. Emitters must purchase these allowances in an open market, creating a direct financial cost for emitting GHGs. Auctioned allowances, therefore, introduce a stronger economic incentive for emitters to reduce their emissions. The competitive nature of the auction system encourages emitters to adopt cleaner technologies and practices in their quest to acquire allowances at the lowest cost possible. This arrangement incentivizes innovation and creates a market-based pressure for emissions reduction.

Balancing Carbon Pricing Instruments: Sector-Specific and General Approaches in Carbon Taxation and Emissions Trading Systems

Carbon taxation and Emissions Trading Systems (ETS) may represent distinct methods of tackling greenhouse gas (GHG) emissions, yet they share a common principle: the importance of sector-specific approaches. Amid these differences, both carbon pricing strategies emphasize the need to tailor emissions reduction efforts to specific sectors of the economy.

Carbon taxation, which involves levying taxes on carbon emissions, provides flexibility in implementation. Tax rates can be customized for various sectors, such as transportation, energy, industry, and agriculture, reflecting the carbon intensity of activities within each sector. This approach offers sector-specific incentives for emissions reduction while enabling governments to generate revenue for reinvestment in environmental programs. However, it's important to note that some countries opt for a more general carbon pricing tax, which does not differentiate across sectors, instead applying a uniform tax rate across the board.

Conversely, Emissions Trading Systems (ETS), or cap-and-trade, establishes emissions caps for specific sectors or industries. Within this framework, each sector has its emission allowances and an associated market for trading those allowances. Like carbon taxes, Emissions Trading Systems (ETS) recognizes that different sectors exhibit varying capacities for emissions reduction and sets sector-specific caps to guarantee targeted emissions reductions. Nonetheless, it's important to acknowledge that some regions might apply Emissions Trading Systems (ETS) in a more generalized manner, covering multiple sectors with a uniform approach.

Both sector-specific and general strategies underscore the inadequacy of a one-size-fits-all approach in confronting the intricate challenge of emissions reduction. They acknowledge the diverse nature of emissions sources in the economy and the need for customized or broader solutions, depending on the national context. Sector-specific approaches facilitate precise emissions reduction strategies within each sector, while more generalized approaches can offer administrative simplicity and uniformity. The choice between these strategies often depends on a country's unique circumstances and goals in addressing climate change.

Global Landscape: A Varied Journey Towards Sustainability

As mentioned previously, the journey began in 1990 when Finland pioneered the world's first carbon tax policy. The tax applied to fossil fuels, such as coal, oil, and natural gas, based on their carbon content. It provided a financial incentive for individuals and businesses to reduce their carbon emissions by either using cleaner energy sources or increasing energy efficiency. A year later, in 1991, Norway implemented a carbon tax on petroleum which specifically focused on emissions from offshore petroleum production. The tax incentivizes industry to reduce emissions by taxing each ton of $CO2$ emitted.

Since then, numerous other nations and regions have followed suit by adopting carbon tax policies and comparable carbon pricing strategies to encourage emission reductions and promote the shift towards cleaner and more sustainable energy sources. Those instruments have evolved over time and continue to be sculpted to better suit every country or region’s needs.

Notably, the European Union (EU) launched the European Union Emissions Trading System (EU ETS) in 2005, which has grown to become the world's largest Emission Trading System, encompassing multiple European countries and a wide range of sectors, including energy, industry, and aviation. This cap-and-trade system introduced a groundbreaking approach, where companies buy and sell emissions allowances to meet their targets within a regulated market.

A few years later, in 2008, Switzerland implemented a carbon tax as part of its strategy to reduce greenhouse gas emissions. In 2010, Ireland introduced a carbon tax on fossil fuels, including coal, peat, and oil. Both taxes, still in use today, cover fossil fuels and are levied on the carbon content of the latter.

Subsequently to its departure from EU, in 2021, the United Kingdom introduced the UK Emissions Trading System (UK ETS), underscoring its commitment to carbon pricing policies independently.

The United States introduced its own innovative instruments, beginning with the Acid Rain Program in 1995. Although it targeted sulfur dioxide emissions, it marked the U.S.'s foray into market-based mechanisms to reduce harmful emissions. In 2008, the Regional Greenhouse Gas Initiative (RGGI) emerged, covering several Northeastern states, and primarily focusing on reducing carbon dioxide emissions from power plants. Simultaneously, the Western Climate Initiative (WCI) brought together a coalition of U.S. states, Canadian provinces, and Mexican states, demonstrating the power of regional cooperation in the pursuit of emissions reductions.

In 2013, at the forefront of climate action, California launched its cap-and-trade program, covering various sectors as part of a broader effort to combat climate change. While Quebec initiated a cap-and-trade program in the same year, establishing a linked carbon market with California, British Columbia introduced a carbon tax in 2008, covering the combustion of fossil fuels. The tax applied to gasoline, diesel, natural gas, and heating fuel. The revenue generated from the tax, still in use today, offsets other taxes, making it a revenue-neutral approach that encourages energy conservation.

Australia implemented the Australian Carbon Pricing Mechanism in 2012, featuring a carbon tax and designed to curtail emissions from major emitters. New Zealand, on the other hand, established its comprehensive Emissions Trading Scheme (NZ ETS) in 2008, covering a spectrum of sectors, including forestry, energy, industry, and agriculture.

China, as the world's largest emitter of greenhouse gases, embarked on the development of pilot Emissions Trading Systems (ETS) programs in different regions from 2013 to 2017, ultimately leading to plans for a national ETS. South Korea joined the ranks in 2015 with the Korean Emissions Trading System (KETS), designed to regulate emissions from major sectors, including power generation and industry.

All those examples mentioned above are not an exhaustive list – on the contrary; Chile, South Africa, and many others could be mentioned – but are intended to highlight the diversity of current situations around the world and the fragmented framework they constitute.

In fact, each of these carbon pricing policies and Emissions Trading Systems (ETS) implementations is tailored to the specific needs and circumstances of the countries and regions that adopt them. While they share the common objective of reducing greenhouse gas (GHG) emissions, they exhibit variations in design, coverage, and stringency. These differences reflect the unique economic structures, industrial profiles, and environmental priorities of each jurisdiction. The resulting 73 carbon pricing initiatives spread across the 35 national jurisdictions and 33 sub-national jurisdictions illustrates the flexibility, adaptability but also the complexity of carbon pricing mechanisms in addressing the challenge of climate change on a global scale.

These policies, both in their differences and common goals, underscore the significance of international cooperation and innovation in the quest for a sustainable and low-carbon future. As the world continues to grapple with the imperatives of climate change, the evolution of carbon pricing and emissions trading systems represents a dynamic response to one of the most pressing global challenges of our time. Consequently, carbon taxing policies as well as Emissions Trading Systems (ETS) should never be perceived during this thesis as a static situation but rather as a constantly evolving framework within the different regions of the world, but also at national as well as sub-national levels.

Greenhouse Gas Emissions Accountability

The world's complex and fragmented landscape of carbon pricing regulations, characterized by a multitude of diverse approaches implemented at national and regional levels, has necessitated the development of a standardized framework for ensuring transparency and accountability in the measurement and reporting of greenhouse gas (GHG) emissions. In response to this need, the Global Greenhouse Gas Protocol, often referred to as the GHG Protocol, has emerged as a critical solution. Developed collaboratively by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD), the GHG Protocol stands as a globally recognized standard for quantifying and reporting GHG emissions.

It offers a systematic and consistent methodology that allows organizations, governments, and industries to calculate and disclose their emissions data, facilitating comparisons, benchmarking, and the establishment of meaningful reduction targets. By providing a comprehensive and unified approach to emissions accounting, the GHG Protocol plays a crucial role in harmonizing the diverse global carbon pricing initiatives, enabling a more coordinated and transparent global response to the challenge of carbon emissions reduction without duplicating existing efforts or creating inconsistencies in reporting practices. This framework helps bridge the gaps between different carbon pricing regulations, fostering a clearer understanding of the global carbon landscape, and facilitating a more effective response to the urgent challenge of climate change mitigation.

Introduced in 2001, the GHG Protocol introduced the concept of categorizing emissions into three scopes, streamlining the process of comprehensive carbon footprint assessment.

Each of those scopes as well as their mutual interactions play a crucial role in capturing the comprehensive emissions profile of organizations, reshaping how emissions are assessed and managed.

Scope 1 Emissions encompass direct emissions from sources owned or controlled by a company. This includes emissions from the combustion of fossil fuels during industrial processes and within a company's facilities. It also incorporates emissions from company-owned vehicles and equipment. The primary categories within Scope 1 emissions are:

- ***Stationary Combustion Emissions***: Resulting from the utilization of fuel sources, such as oil and gas, within structures or machinery owned or utilized by your organization. This encompasses equipment such as industrial machinery powered by fuel for various industrial processes.
- ***Mobile Combustion Emissions:*** Generated by company-owned vehicles, such as cars and trucks.
- ***Fugitive Emissions:*** Released from the use of chemicals supporting air conditioning, refrigerators or fire suppression systems and equipment.

Scope 2 Emissions focus on indirect emissions stemming from the generation of purchased energy. These emissions arise from the production of electricity, heat, or steam that a company procures and consumes. Measuring Scope 2 emissions is typically more straightforward than the other Scopes, thanks to the information available on the energy consumption through, for example, electricity or heating bills.

Scope 3 Emissions encompass a wide range of indirect emissions associated with a company's value chain. These emissions result from sources that are neither owned nor controlled by the organization but are related to its activities. Scope 3 emissions are notably comprehensive and include numerous categories:

- ***Purchased Goods and Services Emissions***: Resulting from the cradle-to-gate processes and steps such as raw materials extraction, goods production, and transportation.
- ***Capital Goods Emissions***: Once again resulting from the production of capital goods purchased or acquired.
- ***Fuels and Energy Related Activities Emissions***: Covering emissions generated by fuels or energy-related activities such as fuel combustion or energy generation that aren't, however, accounted for in the other Scopes.
- ***Upstream and Downstream Transportation and Distribution Emissions***
- ***Wastes Generated in Operations Emissions***: Associated with the disposal and treatment of products sold by the reporting company at the end of their life.

Many other categories part of Scope 3 could be mentioned such as Business Travel Emissions, Employee Commuting Emissions, Upstream and Downstream Leased Assets Emissions, Processing and Use of Sold Products Emissions, etc. With a total of 15 precise categories, accounting for Scope 3 emissions can become complex due to the wide range of activities and emissions sources involved.

Shifting Paradigms: Carbon Pricing Strategies and the Internalization of GHG Emissions Costs

In the context of the numerous climate mitigation measures discussed previously, including carbon taxing regulations, Emissions Trading Systems, and the adoption of standardized accounting practices introduced by the GHG Protocol, it becomes increasingly evident that firms must embrace a fundamental shift in their operational and financial approach. These multifaceted regulatory frameworks aim to internalize the external costs associated with greenhouse gas (GHG) emissions. By assigning a price to carbon emissions, they force companies to recognize and account for the environmental impact of their activities, reflecting the real environmental costs incurred by society.

Consequently, firms are now compelled to internalize carbon emissions related expenses as intrinsic operational costs. Instead of treating environmental considerations as externalities, businesses must integrate the costs of emissions into their financial strategies, decision-making processes, and long-term planning. This internalization of greenhouse gas (GHG) expenses represents a paradigm shift in corporate accountability, sustainability, and risk management, as it compels organizations to consider the true environmental costs of their activities while striving for reduced emissions and more sustainable practices.

With carbon taxation, firms directly face levies on emissions, making it clear that these emissions come with a price tag. Emissions Trading Systems (ETS), by setting sector-specific or region-specific emissions caps, compels companies to account for their emissions within allocated limits, potentially leading to costly emissions allowance purchases if limits are exceeded. This evolving perspective underscores the imperative for businesses to integrate carbon emissions into their financial considerations, as these emissions now carry tangible economic consequences. As carbon pricing strategies continue to gain prominence, firms must adapt by not only reducing emissions but also by recognizing and mitigating the financial risks associated with their carbon footprint, a crucial step in the pursuit of sustainability and long-term viability.

1.2. Literature Review

It is worth noting that the relationship between financial performance and greenhouse gas (GHG) emissions has already been a subject of investigation in numerous research studies and within broader literature. Understanding and accounting for the emerging costs associated with greenhouse gas (GHG) emissions are critical aspects of addressing the environmental challenges we face today. Indeed, existing research has provided robust evidence of emissions' impact on financial indicators, including Return on Assets (ROA), Return on Equity (ROE), Earning Before Interests and Taxes (EBIT), credit and systematic risks, among others.

Foreword

It is crucial to acknowledge that the available content in the field of financial performance and its relationship with greenhouse gas (GHG) emissions is relatively recent and has seen significant development over the last decade. The subject discussed is in constant evolution, with ongoing research and analysis continuously deepening our understanding of the intricate connection analyzed. As global awareness of climate change and its economic ramifications has grown, scholars and researchers have been increasingly focusing on this dynamic intersection. The research carried out in this thesis is therefore geared toward an area that continues to expand and refine, which is, so to speak, in its very beginning stages.

This literature review highlights the wealth of existing knowledge and findings that underscore the significance of emissions in the financial landscape. These insights serve as a solid foundation for future discussions on measuring the economic impact of greenhouse gas (GHG) emissions. To shape and build an effective framework aiming to measure the economic impact of greenhouse gas (GHG) emissions, it is in fact essential to draw from these emerging ideas and points from the literature.

The structure of the review follows a logical progression, starting with broader research that investigates the relationship between corporate environmental performance (CEP) and corporate financial performance (CFP) as foundational pillars. It then delves into more specific research that considers financial indicators and measures in greater detail. This structured approach allows for a comprehensive understanding of the topic.

Literature Review: A Broader Approach

Indeed, within the realm of corporate sustainability, there's been a growing interest in understanding how carbon dioxide (CO_2) emissions relate to a company's financial performance. Researchers have been particularly keen on exploring whether there's a negative link between a company's environmental efforts and its financial success. This idea primarily revolves around the interplay between corporate environmental performance (CEP) and corporate financial performance (CFP). By corporate environmental performance (CEP), it is intended to a company's ability to effectively manage and mitigate its environmental impact. This encompasses the company's approach in addressing the environmental consequences of its activities and its efforts to reduce waste and emissions (Dragomir, 2018).

Several research papers investigate and test the existence of a possible positive relationship between corporate environmental performance (CEP) and corporate financial performance (CFP), providing valuable insights into the complex dynamics that can influence a company's financial health and, perhaps crucially, becoming the starting point for this thesis.

Busch and Lewandowski (2017) conducted a meta-analysis in their paper "Corporate Carbon and Financial Performance." Their main research goal was to investigate the relationship between corporate carbon performance and financial performance, addressing the question of "*When does it pay to be green?*". They employed meta-analytical techniques, synthesizing data from 32 empirical studies, encompassing 68 estimations and 101 775 observations. Effect sizes were measured using Pearson correlations or, in cases where those were not available, estimates were derived from T-statistics, standard errors or p-values.

Their findings revealed that "*carbon emissions vary inversely with financial performance, indicating that good carbon performance is generally positively related to superior financial performance*". Their outcomes confirmed the existing positive relationship between corporate environmental performance (CEP) and corporate financial performance (CFP).

Trumpp and Guenther (2017) also sought to explore the dynamics between corporate environmental performance (CEP) and corporate financial performance (CFP) with a focus on shaping the latter relation. Their paper, titled "Too Little or too much? Exploring U-shaped Relationships between Corporate Environmental Performance and Corporate Financial Performance" analyzed an international sample of 2361 firms, from 2008 to 2012.

Their findings revealed empirical evidence of a U-shaped relationship between carbon performance and profitability, and this pattern also extended to the relationship between carbon performance and stock market performance, but the latter was primarily observed in manufacturing industries.

Their results supported the notion of a 'too-little-of-a-good-thing' effect, where the nature of the relationship (positive or negative) depended on the level of corporate environmental performance (CEP). This finding suggests that the relationship is not strictly negative but rather non-linear, but once again confirms the existence of a nexus.

Du and Li (2018) conducted a study titled "Research on the Correlation Between Carbon Performance and Enterprise Performance" to investigate the relationship between carbon performance and corporate performance.

They utilized the Ordinary Least Squares (OLS) method to analyze the relationship and selected cross-sectional data of carbon emissions from the world's top 500 enterprises in the 2011-2013 Carbon Disclosure Project (CDP), a reputable and comprehensive source of carbon emissions information, ensuring the consistency and comparability of the data used in the analysis.

Their research, processed using STATA11, revealed a positive correlation between carbon performance and corporate value. Since carbon performance specifically refers to the ability of companies in managing and reducing their carbon emissions, the presented results sustain once again the positive dynamics between corporate environmental performance (CEP) and corporate financial performance (CFP).

Lee, Min, and Yook (2015) analyzed the impact of environmental research and development (R&D) investment on the relationship between corporate environmental performance (CEP) and corporate financial performance (CFP). In other terms, the authors focused on how carbon emissions and investments in environmental research and development (R&D) affected the financial performance of firms.

They utilized a fixed-effect model for estimation and analyzed data from a panel dataset of 362 Japanese firms spanning from 2003 to 2010. Their research uncovered a consistent decrease in firm value due to carbon emissions, indicating that the market penalizes firms more consistently for negative environmental performance. Conversely, companies that make credible commitments to environmental responsibility, as evidenced by their investments in environmental technology, receive a positive reception from the market. This outcome suggests a positive relationship between corporate environmental performance (CEP) and corporate financial performance (CFP), reinforcing the importance of considering environmental responsibility for financial performance.

Literature Review: Specific Financial Measures and Metrics

Through the analysis of the positive relation between corporate environmental performance (CEP) and corporate financial performance (CFP), we started with a general understanding that being environmentally responsible is good for business. It is now necessary to delve deeper into those complex connections by investigating detailed financial measures. These measures not only provide concrete quantification but also grant us unique insights into how precisely a company's greenhouse gas (GHG) emissions affect its financial performance. The following literature takes a close, methodical, and meticulous look at how environmental factors impact a range of specific financial indicators.

The paper "An Efficiency Perspective on Carbon Emissions and Financial Performance" by Trinks, Mulder, and Scholtens (2020) sheds light on the impact of carbon efficiency on firms' financial outcomes through quantifiable financial measures. In fact, the 4 central hypothesis under examination posits that:

- Carbon efficiency positively correlates with financial performance, specifically Return on Assets (ROA).
- Carbon efficiency positively correlates with firms' valuation, measured through Tobin's Q.
- Carbon efficiency negatively correlates with financial risk, precisely systematic risk.
- Carbon efficiency negatively correlates with financial risk, precisely total risk.

The methodology employed in this research entailed a meticulous process of data collection, the utilization of the directional distance function (DDF) model for measuring carbon efficiency, rigorous regression analysis to uncover the intricate interplay between carbon efficiency and financial performance, and a comprehensive set of robustness checks to fortify the integrity of the results.

More precisely, the data collection spanned a total of 9 years, from 2009 to 2017, and encompassed a robust dataset comprising 1572 firms from across 47 different countries. With the dataset firmly in hand, the authors turned their attention to the crucial task of quantifying carbon efficiency, an instrument which captures the extent to which firms minimize carbon emissions in their production processes. To achieve this, they harnessed the capabilities of a directional distance function (DDF) model. This model, with its capacity to make comparisons between a firm's carbon emissions and those of best-practice peers, served as the linchpin in assessing the extent to which carbon emissions could be minimized within a given input-output structure.

Trinks, Mulder, and Scholtens then shifted their focus to examine different aspects of a company's financial performance. They looked at how well companies were doing in the short term, measured by Return on Assets (ROA), and how they were valued in the long term, which was assessed using Tobin's Q. Additionally, the study delved into the complexity of financial risks, both systematic and total. Finally, the four-hypothesis set initially were tested through a regression analysis.

It is important to note the methodological rigor applied in this research. The use of fixed effects estimators, robustness analyses, control factors, as well as the carefulness to diligently tackle potential selection bias within the used samples, all ensures the results reliability.

The study's findings reveal that carbon-efficient companies tend to outperform their less carbon-efficient counterparts in terms of financial performance. Specifically, the research indicates that carbon-efficient firms exhibit greater profitability, higher overall firm value and reduced financial risk. A 0.1 higher carbon efficiency is associated with a 1% higher profitability and 0.6% lower systematic risk.

Concerning profitability, carbon-efficient companies demonstrated a higher return on assets (ROA), intended as their ability to generate more profits relative to their total assets. This observation suggests that the reduction of carbon emissions within operating or production processes positively impacts a company's financial performance.

Moreover, the results unveiled a positive correlation between carbon efficiency and firm value, as measured by Tobin's Q. This implies that companies with higher carbon efficiency levels tend to possess greater long-term value, reflecting investors' perception of their increased worth and sustainability.

Carbon-efficient firms were also associated with lower financial risk; specifically, the systematic risk which represents the risk that cannot be diversified away through portfolio diversification is positively related to carbon emissions. This implies that companies more adept at managing and mitigating environmental risks associated with lower carbon emissions have a more stable financial performance.

In conclusion, these findings underscore the advantages of carbon-efficient production from both operational and risk management perspectives. Companies prioritizing the reduction of carbon emissions in their production processes can achieve enhanced financial performance, encompassing heightened profitability, reduced risk, and increased overall firm value.

In their article "The Effect of Carbon Emission Disclosure on the Financial Performance", Marietza and Hatta (2021) examine the impact of carbon emissions disclosure on financial performance in companies of various sectors such as agriculture, mining, manufacturing, infrastructure, utilities, and transportation, listed on the Indonesia Stock Exchange.

The study, spanning from 2016 to 2018, employs panel data regression analysis as its analytical approach. Marietza and Hatta set carbon emissions disclosure as the independent variable, while the dependent variables encompass financial performance indicators and, specifically, the Return on Assets (ROA), Return on Equity (ROE), and Return on Sales (ROS). Control variables, including growth, size, leverage, and capital intensity, are also considered. Carbon emissions disclosure is measured using an index developed by Choi et al. (2013) based on data extracted from annual and sustainability reports of the sample companies.

By valuating the significance of each regression coefficient of the independent variable, carbon emissions disclosure, on the dependent variables, Return on Assets (ROA), Return on Equity (ROE), and Return on Sales (ROS), the study indicates that carbon emissions disclosure has a significant positive effect on financial performance. The results of the regression analysis consistently indicate a positive and statistically significant relationship between carbon emissions disclosure and financial performance indicators.

These findings lend empirical support to the hypothesis that disclosing carbon emissions can lead to improved financial performance. The study also suggests that such disclosure enhances a company's credibility, attracts investors, and demonstrates a commitment to environmental responsibility, all of which can contribute to better financial outcomes. This analysis aligns with the principles of stakeholder theory, providing insight into the motivations behind carbon emissions disclosure and its impact on financial performance in Indonesian companies.

Van Emous, Krušinskas, and Westerman (2021), in their article "Carbon Emissions Reduction and Corporate Financial Performance: The Influence of Country-Level Characteristics", investigate the relationship between carbon emissions reduction and corporate financial performance (CFP). Particularly, they focus on Return on Assets (ROA), Return on Equity (ROE), Return on Sales (ROS), Tobin's Q and the Current Ratio. The relationship between carbon emissions reduction and corporate financial performance (CFP) is examined through regression models with those financial indicators as dependent variables.

A notable enhancement compared to other research lies in the extended recent sample period, spanning from 2000 to 2020, and a more substantial sample size, amounting to 9265 observations on 1785 firms representing 53 countries. Additionally, the study incorporates moderating variables, encompassing the overall carbon emissions of a country, the presence of carbon emissions legislation, and the firm's responsibility level, gauged through its ESG (Environmental, Social, and Governance) score. Also, to tackle the challenge of endogeneity, the study incorporates lagged dependent variables, country-specific characteristics, and various control variables; those include size and leverage at firm-level, overall carbon emissions, GDP growth and carbon emissions-related legislations at country-level.

For Return on Assets (ROA), the results highlight a strong significant relationship with carbon emissions reduction; firms that reduce their emissions tend to have a higher Return on Assets (ROA. The magnitude of the obtained coefficient suggests that a 100% reduction in greenhouse gas (GHG) emissions leads to a 31.76% increase in ROA.

The same results are obtained for Return on Equity (ROE), meaning that firms that reduce their emissions tend to improve their Return on Equity (ROE). The coefficient for this relationship, however, is lower in significance compared to the one with Return on Assets (ROA).

On the other hand, regarding Return on Sales (ROS), the findings indicate an even more pronounced impact of carbon emissions reduction in comparison to its effects on Return on Assets (ROA) and Return on Equity (ROE). This implies that the reduction of carbon emissions exerts a more substantial influence on the Return on Sales (ROS).

The study's examination of Tobin's Q, which serves as an indicator of stock market performance, does not yield a significant correlation with carbon emissions reduction. This implies that reducing carbon emissions does not appreciably impact a company's stock market performance.

Moreover, with regards to the Current Ratio, a metric assessing a firm's ability to meet short-term financial obligations, the investigation does not reveal any substantial connection with carbon emissions reduction. Essentially, this points to the conclusion that carbon emissions reduction has minimal influence on a firm's liquidity.

In summary, Van Emous, Krušinskas, and Westerman's research highlights that carbon emissions reduction exerts a favorable influence on profitability indicators, encompassing Return on Assets (ROA), Return on Equity (ROE), and Return on Sales (ROS). However, this positive effect does not translate into substantial alterations in stock market performance, measured through Tobin's Q, or liquidity, proxied by the Current Ration.

Miah, Hasan, and Usman (2021) delve into the repercussions of carbon emissions on both financial and non-financial firms operating in emerging economies. Their research, titled "Carbon Emissions and Firm Performance: Evidence from Financial and Non-Financial Firms from Selected Emerging Economies", investigates the potential impact of carbon emissions on various performance metrics, including Return on Assets (ROA), Tobin's Q, Z-score, and credit ratings. Additionally, it scrutinizes whether these impacts differ between financial and non-financial firms.

The methodology employed in this research entails the collection of data from a substantial sample, comprising 104 financial firms and 328 non-financial firms, spanning 22 emerging economies during the period of 2011-2020. Data was meticulously procured from reliable sources such as the World Bank databases. The analytical approach hinges on regression techniques, specifically Ordinary Least Squares (OLS) and Two-Stage Least Squares (2SLS) regression, including in-depth control variables, both at the firm and country levels.

The study consistently reveals a negative correlation between carbon emissions and Return on Assets (ROA), Earnings per Share, Tobin's Q, and credit scores. This indicates that higher carbon emissions are associated with both decreased profitability and reduced earnings per share, reflecting an overall diminished profitability on a per-share basis. Moreover, higher carbon emissions are likely to decrease market value and credit ratings, resulting in less financial stability. In must be noted that these findings remain consistent for both financial and non-financial firms, highlighting their broad applicability.

In summary, the research illustrates the adverse repercussions of carbon emissions on the selected performance indicators for both financial and non-financial firms operating in emerging economies. These outcomes underscore the urgent need to address carbon emissions and implement sustainable practices to foster improvements in financial and market-based performance.

The "Analysis on the Relationship between Carbon Emission Reduction and Company Market Value using Resource-Based Theory" by Xu, Zhang, Bai and Cao (2020) investigates the connection between carbon emissions' reduction and the resulting market value of companies. In fact, the authors posit that actively reducing carbon emissions can pave the way for improved economic performance and endow companies with a competitive advantage. The research is grounded in resource-based theory, suggesting that a firm's competitive advantage and performance are highly dependent on its unique resources and capabilities, and the way it leverages the latter.

The research methodology is based on panel data, primarily featuring Fortune Global 500 companies and data collected between 2009 and 2014. Carbon emissions data is sourced from the carbon disclosure report in London (UK) while financial data is obtained from the Financial Times, also published in London (UK). The analytical approach relies on regression analysis and control variables such as operating capacity, profitability, development capabilities, and company size are considered. With those statistical instruments in hands, the authors offer clear evidence of the significant positive relationship existing between carbon emission reduction and a company's market value, supporting their initial hypothesis.

Safiullah, Kabir, and Miah (2021) investigate the impact of firm-level carbon emissions on credit ratings. More specifically, the authors investigate whether carbon emissions are perceived as a higher risk of default by credit rating agencies.

The study's regression analysis stands on a large dataset of US firms from 2004 to 2018, and strongly relies on the use of instrumental variables (IV). This key tool is used to tackle possible issues related to endogeneity when examining how firm-level carbon emissions are connected to credit ratings. The authors define geographic location as their main instrumental variable, specifically relying on the average carbon emissions score of neighboring firms within the same three-digit zip code in the US. By following this approach, a causal link between carbon emissions and credit ratings can be established while minimizing potential distortions and variables that could impact the results of the estimation.

The authors also rely on reverse causality by considering past emissions to approximate future credit ratings. In fact, by using lagged values of the carbon emissions variables in their analysis, they can mitigate the concern that credit ratings may influence current carbon emissions. Moreover, a "difference-in-differences" analysis is performed to take advantage of a major environmental disaster resulting from the explosion and sinking of the Deepwater Horizon oil rig in the Gulf of Mexico, leading to a massive release of oil into the surrounding waters. This oil spill event, which occurred in 2010, serves as an exogenous shock that affected certain firms' carbon emissions. By comparing the changes in credit ratings of firms before and after the disaster, the researchers have been able to assess whether carbon emissions effectively caused changes in credit ratings, which represents an important result for their investigation.

Finally, Safiullah, Kabir, and Miah uncover a substantial and consistent negative relationship between a firm's carbon emissions and its credit ratings. In essence, their findings suggest that higher carbon emissions are associated with lower credit ratings across various aspects of emissions. This adverse influence is mediated by increased cash flow uncertainty in firms with elevated carbon emissions.

Particular attention must be paid to these results; higher cash-flow uncertainty is justified by the authors by mentioning the combination of regulatory compliance costs, environmental risks, and potential financial constraints related to carbon emissions. The specific mention of the Regional Greenhouse Gas Initiative (RGGI) and the Paris Climate Agreement can be found on page 2 of the article. This same page states that the Regional Greenhouse Gas Initiative (RGGI) establishes a mandatory market-based program among several states in the United States to reduce greenhouse gas emissions. It also mentions that 195 nations signed and adopted the Paris Climate Agreement in December 2015 to limit the global temperature increase.

The article explains that carbon-intensive firms are subject to increased regulatory scrutiny and face stringent rules and regulations related to carbon emissions. This leads to higher compliance costs, which can erode profitability and future stable and predictable cash flows. Moreover, carbon-intensive firms are more likely to face environmental issues such as compliance and litigation costs, research and development costs, clean-up costs, carbon-related management costs, and reputational damage costs. These additional costs and risks associated with carbon emissions can further contribute to cash flow uncertainty. Finally, carbon-intensive firms may be required to pay a high price for their carbon emissions under carbon trading mechanisms. This can constrain the economic resources available to service their debt, leading to increased uncertainty in cash flows. The arguments put forward by the authors in support of the consistency of their statistical results only serve to reinforce the conclusion that carbon emissions indeed have a negative impact on credit ratings.

Conclusion

Numerous research studies have explored the relationship between corporate environmental performance (CEP) and corporate financial performance (CFP), with the aim of uncovering whether there is or not a significant connection between a company's environmental efforts and its financial success. The authors have employed divers methodologies, preferred different tools and instruments, and considered a range of financial measures, including Return on Assets (ROA), Return on Equity (ROE), Return on Sales (ROS), financial risks and more. While they may differ in their approaches, their collective findings emphasize the relevance of considering environmental responsibility when evaluating financial performance. More precisely, they call for a nuanced exploration of how a company's greenhouse gas (GHG) emissions directly affect its own financial standing.

Table 1: Literature Review Summary

Title	*Authors*	*Contributions*
Corporate Carbon and Financial Performance	Busch and Lewandowski (2017)	Carbon performance is positively related to financial performance.
Too Little or too much? Exploring U-shaped Relationships between Corporate Environmental Performance and Corporate Financial Performance	Trumpp and Guenther (2017)	Evidence of a U-shaped relationship between carbon performance and profitability.
Research on the Correlation Between Carbon Performance and Enterprise Performance	Du and Li (2018)	Positive correlation between carbon performance, intended as the ability of companies in managing and reducing their carbon emissions, and corporate value.
The impacts of carbon (CO2) emissions and environmental research and development (R&D) investment on firm performance	Lee, Min, and Yook (2015)	Consistent decrease in firm value due to carbon emissions and, conversely, consistent increase in firm value for companies committing to environmental responsibility.
An Efficiency Perspective on Carbon Emissions and Financial Performance	Trinks, Mulder, and Scholtens (2020)	Carbon-efficient firms exhibit greater profitability proxied by Return on Assets (ROA), higher overall firm value measured through Tobin's Q, and reduced financial risk.
The Effect of Carbon Emission Disclosure on the Financial Performance	Marietza and Hatta (2021)	Disclosing carbon emissions can lead to improved financial performance through higher credibility and investors' attraction.
Carbon Emissions Reduction and Corporate Financial Performance: The Influence of Country-Level Characteristics	Van Emous, Krušinskas, and Westerman (2021)	Carbon emissions reduction exerts a favorable influence on profitability indicators, encompassing Return on Assets (ROA), Return on Equity (ROE), and Return on Sales (ROS).

Carbon Emissions and Firm Performance: Evidence from Financial and Non-Financial Firms from Selected Emerging Economies	Miah, Hasan, and Usman (2021)	Reveals a negative correlation between carbon emissions and Return on Assets (ROA), Earnings per Share, Tobin's Q, and credit scores.
Analysis on the Relationship between Carbon Emission Reduction and Company Market Value using Resource-Based Theory	Xu, Zhang, Bai and Cao (2020)	Clear evidence of the significant positive relationship existing between carbon emission reduction and a company's market value.
Carbon Emissions and Credit Ratings	Safiullah, Kabir, and Miah (2021)	Substantial and consistent negative relationship between a firm's carbon emissions and its credit ratings. Carbon-intensive firms are subject to increased regulatory scrutiny and face stringent rules and regulations related to carbon emissions. This leads to higher compliance costs, which can erode profitability and future stable and predictable cash flows.

2 Methodology

2.1. Presentation of Anaplan

What is Anaplan?

Anaplan is a leading provider of cloud-based business planning, forecasting, and performance management software. Anaplan firmly stands that, nowadays, companies must make informed decisions quickly enough to answer shifts in the market while navigating the unknown and preparing for what's next; as mentioned on their website, "Traditional planning isn't enough".

Anaplan is in fact designed to replace traditional, spreadsheet-based planning and analysis with a more agile, centralized, and collaborative approach. It provides a range of solutions across different business areas, making it a versatile tool suitable for a diversified range of industries and organizations.

What is it used for?

Anaplan's key advantage lies in its versatility, making it well-suited for a diverse array of planning, analytical, and modeling purposes across various sectors and industries. Its main solutions support the following functions:

- ***Finance***: Anaplan supports budgeting, forecasting, and financial modeling, allowing them to make data-driven decisions and track financial performance effectively.
- ***Sales and Marketing***: Anaplan enables organizations to align their sales, marketing, and operational plans to optimize inventory, demand, and supply chain management. It assists sales teams in setting targets, incentive compensation planning, and sales performance analysis and supports marketing teams in planning campaigns, allocating budgets, and measuring the effectiveness of marketing initiatives.
- ***HR and Workforce***: It supports HR departments in areas like headcount planning, compensation planning, and workforce modeling.
- ***Supply Chain***: Anaplan helps organizations plan and optimize their supply chain, manage inventory, and improve logistics operations.

These four primary functions exhibit cross-functional applicability across a wide array of industries, and are therefore proposed to serve clients specialized in the following sectors:

- ***Consumer Goods***: Anaplan assists consumer goods companies in areas such as demand planning, supply chain optimization, sales and marketing and performance management.
- ***Financial & Business Services***: Anaplan provides financial institutions and business services companies with solutions for financial planning, risk management, and performance analytics.
- ***Manufacturing***: Anaplan helps manufacturing industries with production planning, inventory management, and supply chain optimization to streamline operations and reduce costs.
- ***Retail***: Anaplan offers retail businesses tools for merchandise planning, demand forecasting, and inventory management to improve sales and profitability.
- ***Technology, Media & Telecommunications***: Anaplan supports technology, media, and telecommunications companies in various aspects, including sales performance management, revenue planning, and financial consolidation, enabling them to adapt to the ever-evolving landscape of their industries.

What are the results of Anaplan implementation?

Anaplan's ability to streamline and automate various planning, budgeting, and forecasting processes is a key factor in improving efficiency. It eliminates manual data entry, therefore reducing errors and saving time for more strategic activities.

Moreover, Anaplan's advanced data modeling and analytics features ensure data accuracy, resulting in more informed decision-making. By providing real-time insights and fostering collaboration among different departments, Anaplan empowers organizations to make well-informed decisions based on the latest information available.

The platform also enables scenario planning, which supports businesses in understanding the potential impact of different strategies, as well as the consideration of best- and worst-case scenarios.

Additionally, Anaplan simplifies financial consolidation, helps in achieving cost reductions, and enhances customer satisfaction by ensuring timely deliveries. Anaplan can also assist businesses in complying with regulatory requirements and making more sustainable decisions by providing insights into the environmental impact of various strategies. All these advantages contribute to Anaplan's position as a leading planning and performance management solution.

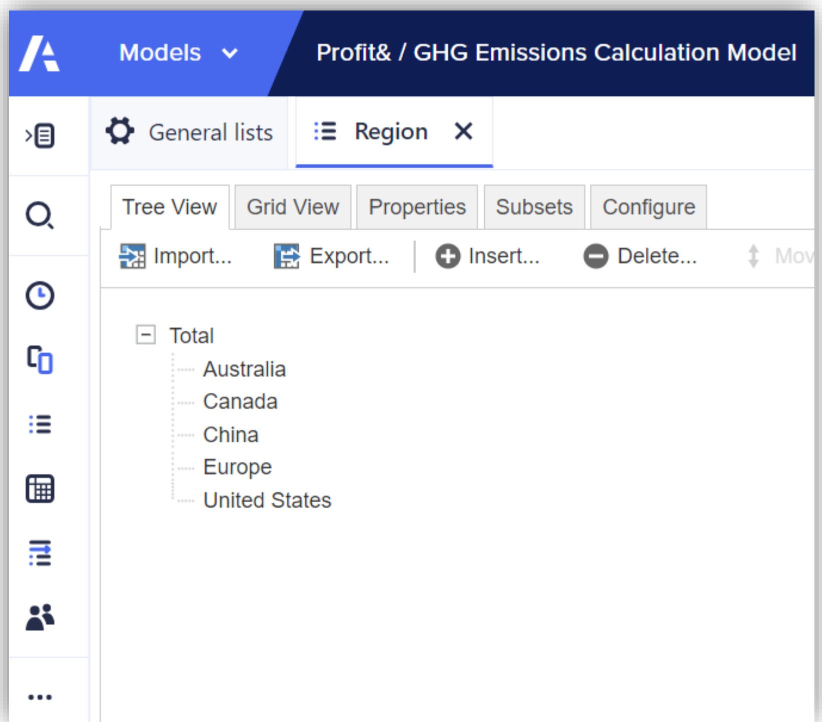
How does it work: Back End Part

Behind the scenes, everything starts from Anaplan's official training and certification programs with the aim of equipping future model builders and users with the knowledge and skills to make the most of the platform. The training programs spans a wide range of courses suitable for all proficiency levels, from beginners with Levels 1 and 2, to intermediates, reaching Level 3, to advanced, finally becoming Anaplan Architects.

Once certified, users can start designing customizable models to reflect an organization's data, structure, and business processes, by using a set of fundamental elements:

- ***Lists***: Lists serve as the bedrock for organizing and categorizing data by various attributes, such as products, customers, geographic regions, or any other pertinent dimensions. Lists offer a structured way to manage and access data efficiently (Fig. 1.1).

Figure 1.1: Example of List in Anaplan



- ***Versions and Time***: Anaplan's versioning capability allows users to craft, manage, and assess multiple iterations of plans or scenarios by considering the time dimension. Versions can be structured around distinct timeframes, such as actuals, budget, and forecasts, various planning scenarios, or any specific variations essential to informed decision-making (Fig. 1.2).
- ***Modules***: At the core of Anaplan's functionality are modules, serving as the central hubs where data storage, calculations and formulas are orchestrated. For example, data modules can be used to store data pulled from different sources, including enterprise resource planning (ERP) systems, customer relationship management (CRM) software, and spreadsheets. Data modules can combine, organize, or aggregate this data for analysis within the platform. On the other hand, calculation modules enable users to perform complex calculations and apply business logic to their models. Calculation modules can handle large-scale, multidimensional calculations quickly and accurately. Modules, in general, can be considered as the spreadsheets and databases of Anaplan, providing the workspace for creating, analyzing, and manipulating business models (Fig. 1.3 & 1.4).

All these components work collaboratively to facilitate dynamic and adaptive business planning and analysis. Lists supply the essential context, modules serve as dynamic repositories for data and calculations, while versions and time empower organizations to explore diverse planning scenarios and conduct historical comparisons.

Model builders are encouraged to follow a structured approach or sequence of steps called with the acronym DISCO, standing for Data, Input, System, Calculation and Output. DISCO outlines the key stages of working with data within the platform, starting from data input, going through processing, defining calculations, and ending with the desired output or results. This acronym helps users understand the fundamental flow of operations when utilizing Anaplan for planning, analysis, and reporting purposes.

Figure 1.2: Time Settings in Anaplan

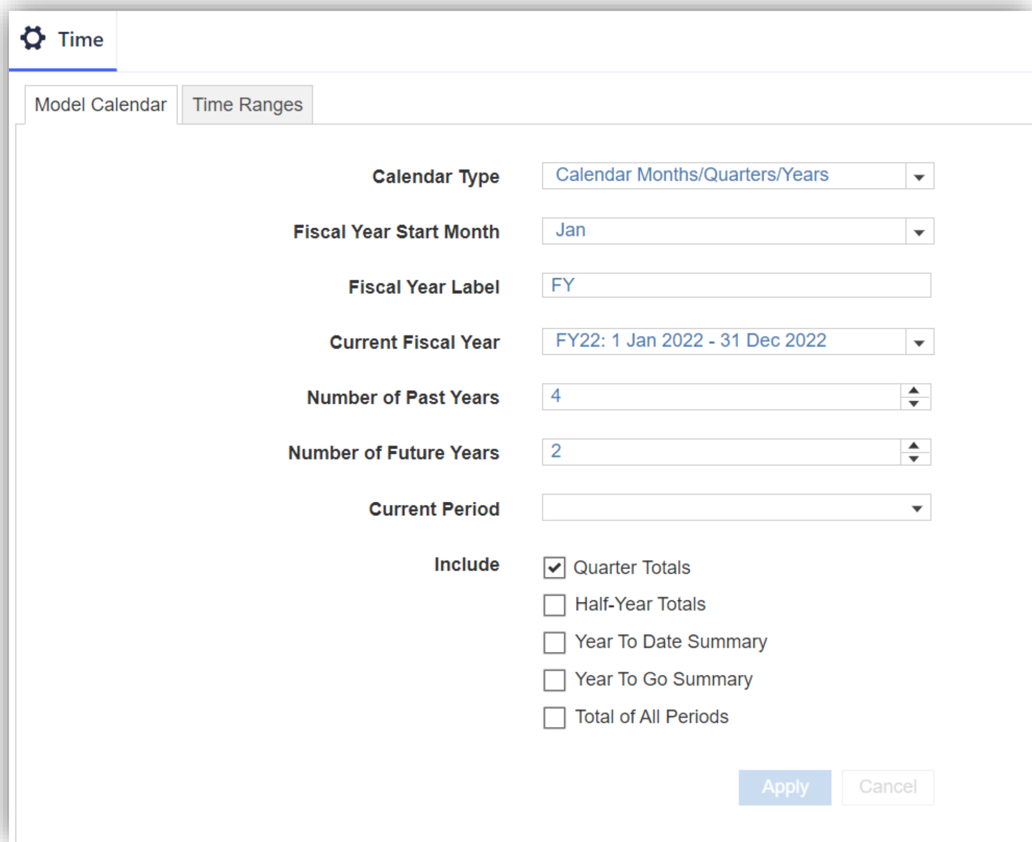
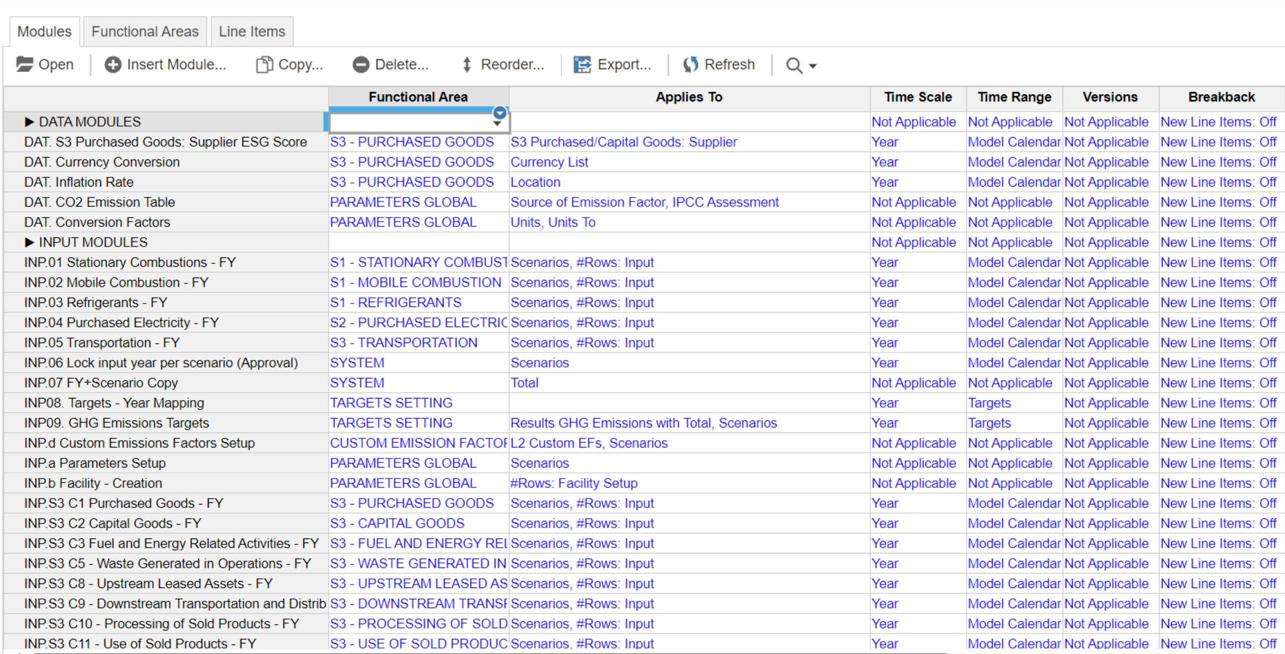
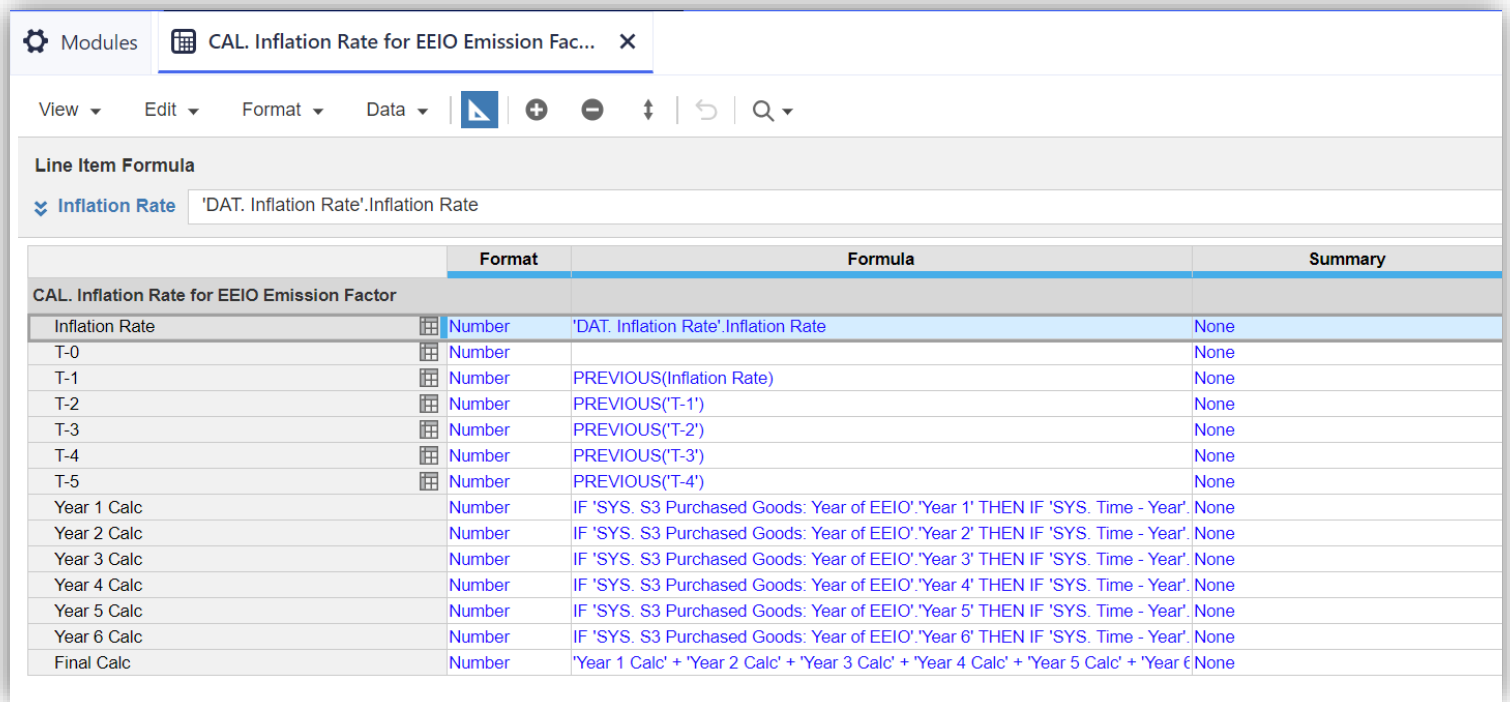


Figure 1.3: Modules Overview in Anaplan



	Functional Area	Applies To	Time Scale	Time Range	Versions	Breakback
▶ DATA MODULES			Not Applicable	Not Applicable	Not Applicable	New Line Items: Off
DAT. S3 Purchased Goods: Supplier ESG Score	S3 - PURCHASED GOODS	S3 Purchased/Capital Goods: Supplier	Year	Model Calendar	Not Applicable	New Line Items: Off
DAT. Currency Conversion	S3 - PURCHASED GOODS	Currency List	Year	Model Calendar	Not Applicable	New Line Items: Off
DAT. Inflation Rate	S3 - PURCHASED GOODS	Location	Year	Model Calendar	Not Applicable	New Line Items: Off
DAT. CO2 Emission Table	PARAMETERS GLOBAL	Source of Emission Factor, IPCC Assessment	Not Applicable	Not Applicable	Not Applicable	New Line Items: Off
DAT. Conversion Factors	PARAMETERS GLOBAL	Units, Units To	Not Applicable	Not Applicable	Not Applicable	New Line Items: Off
▶ INPUT MODULES			Not Applicable	Not Applicable	Not Applicable	New Line Items: Off
INP.01 Stationary Combustions - FY	S1 - STATIONARY COMBUST	Scenarios, #Rows: Input	Year	Model Calendar	Not Applicable	New Line Items: Off
INP.02 Mobile Combustion - FY	S1 - MOBILE COMBUSTION	Scenarios, #Rows: Input	Year	Model Calendar	Not Applicable	New Line Items: Off
INP.03 Refrigerants - FY	S1 - REFRIGERANTS	Scenarios, #Rows: Input	Year	Model Calendar	Not Applicable	New Line Items: Off
INP.04 Purchased Electricity - FY	S2 - PURCHASED ELECTRIC	Scenarios, #Rows: Input	Year	Model Calendar	Not Applicable	New Line Items: Off
INP.05 Transportation - FY	S3 - TRANSPORTATION	Scenarios, #Rows: Input	Year	Model Calendar	Not Applicable	New Line Items: Off
INP.06 Lock input year per scenario (Approval)	SYSTEM	Scenarios	Year	Model Calendar	Not Applicable	New Line Items: Off
INP.07 FY+Scenario Copy	SYSTEM	Total	Not Applicable	Not Applicable	Not Applicable	New Line Items: Off
INP08. Targets - Year Mapping	TARGETS SETTING		Year	Targets	Not Applicable	New Line Items: Off
INP09. GHG Emissions Targets	TARGETS SETTING	Results GHG Emissions with Total, Scenarios	Year	Targets	Not Applicable	New Line Items: Off
INP.d Custom Emissions Factors Setup	CUSTOM EMISSION FACTOI	L2 Custom EFs, Scenarios	Not Applicable	Not Applicable	Not Applicable	New Line Items: Off
INP.a Parameters Setup	PARAMETERS GLOBAL	Scenarios	Not Applicable	Not Applicable	Not Applicable	New Line Items: Off
INP.b Facility - Creation	PARAMETERS GLOBAL	#Rows: Facility Setup	Not Applicable	Not Applicable	Not Applicable	New Line Items: Off
INP.S3 C1 Purchased Goods - FY	S3 - PURCHASED GOODS	Scenarios, #Rows: Input	Year	Model Calendar	Not Applicable	New Line Items: Off
INP.S3 C2 Capital Goods - FY	S3 - CAPITAL GOODS	Scenarios, #Rows: Input	Year	Model Calendar	Not Applicable	New Line Items: Off
INP.S3 C3 Fuel and Energy Related Activities - FY	S3 - FUEL AND ENERGY REI	Scenarios, #Rows: Input	Year	Model Calendar	Not Applicable	New Line Items: Off
INP.S3 C5 - Waste Generated in Operations - FY	S3 - WASTE GENERATED IN	Scenarios, #Rows: Input	Year	Model Calendar	Not Applicable	New Line Items: Off
INP.S3 C8 - Upstream Leased Assets - FY	S3 - UPSTREAM LEASED AS	Scenarios, #Rows: Input	Year	Model Calendar	Not Applicable	New Line Items: Off
INP.S3 C9 - Downstream Transportation and Distrib	S3 - DOWNSTREAM TRANSI	Scenarios, #Rows: Input	Year	Model Calendar	Not Applicable	New Line Items: Off
INP.S3 C10 - Processing of Sold Products - FY	S3 - PROCESSING OF SOLD	Scenarios, #Rows: Input	Year	Model Calendar	Not Applicable	New Line Items: Off
INP.S3 C11 - Use of Sold Products - FY	S3 - USE OF SOLD PRODUC	Scenarios, #Rows: Input	Year	Model Calendar	Not Applicable	New Line Items: Off

Figure 1.4: Example of a Calculation Module in Anaplan



How does it work: Front End Part

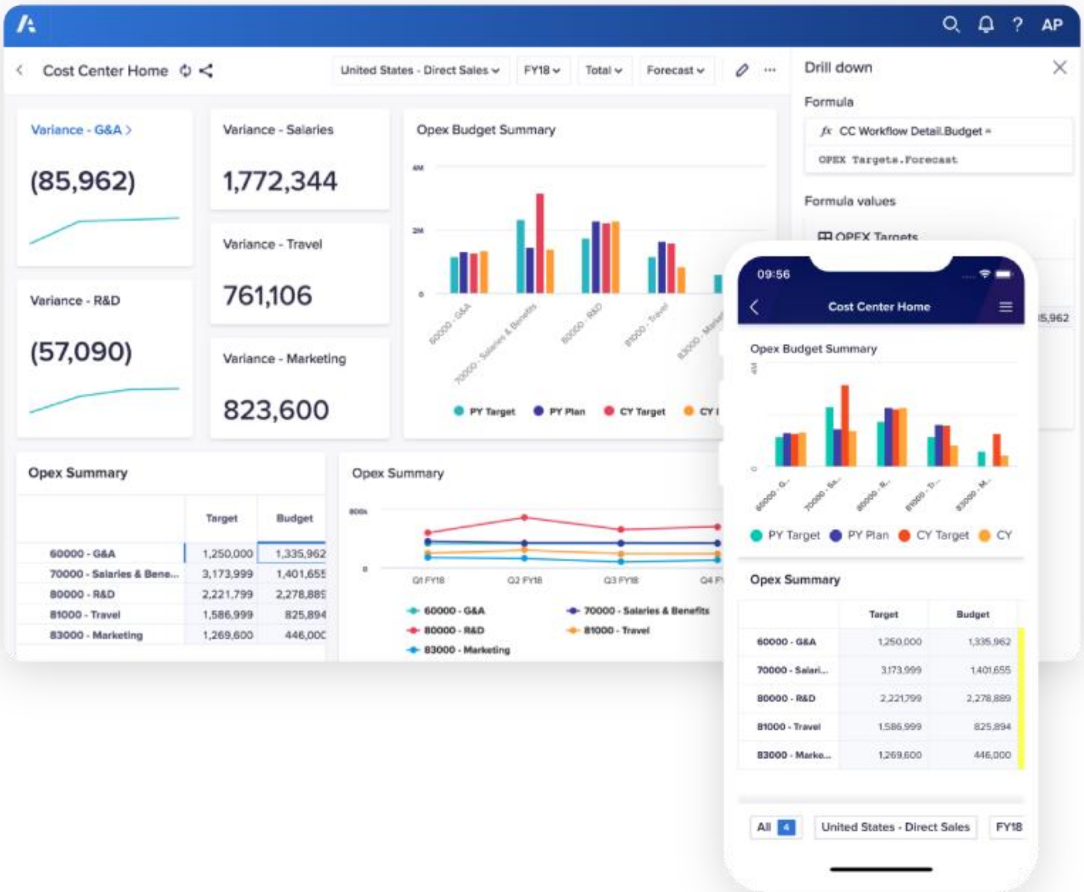
Once all the previous back-end elements have been built and interconnected according to the specific logic of each organization, the results displayed in spreadsheet form and hardly usable can be completely transformed into a front-end section, completely transforming the outputs into something much more user-friendly and interactive.

Anaplan's dashboard and reporting capabilities empower users to provide visual representation of data with grids, graphs, map charts and key performance indicators (KPIs). These visual insights support the analysis of an organization's current performance and facilitate ongoing progress monitoring (Fig. 1.5). Moreover, real-time updates with Anaplan front-end are a notable attribute; any changes made by one user are instantly reflected to all the others, creating a dynamic and real-time planning and analysis environment. All users are always working with up-to-date information, fostering accuracy in decision making processes. Collaboration is promoted, enabling multiple users to engage in planning discussion, propose changes and provide valuable insights. This collaborative environment encourages transparency and alignment within the organization, ensuring that everyone is on the same page.

Of course, Anaplan supports user access management on a role-based basis, ensuring that each front-end user interacts with the data and features relevant to their specific responsibilities. This tailored access not only bolsters security but also streamlines user efficiency, as individuals can focus on their pertinent tasks.

Figure 1.5: Example of Anaplan's Interactive Interface

Source: https://www.anaplan.com/platform/user-experience/



Key Features

In summary, Anaplan is a versatile cloud-based platform that transforms business planning and performance management. It combines robust back-end data processing and modeling with an intuitive front-end interface, facilitating data-drive decision-making and collaboration. Its extensive client base across different industries witnesses its effectiveness in streamlining planning processes and improving overall business performance.

Cloud-Based Platform: Anaplan is hosted in the cloud, enabling users to access it from anywhere with an internet connection. This cloud-based nature ensures quick and real-time data updates.

Modelling & Planning: Anaplan is centered around data modeling and planning capabilities. It allows users to create custom data models tailored to their specific business needs, structure, and processes.

Scalability: Anaplan is highly scalable and adaptable, allowing organizations to manage their planning and performance management needs regardless of their size or complexity.

Collaboration: The platform promotes collaboration among teams and departments. Multiple users can simultaneously access and work on plans, providing real-time insights and feedback.

Data Integration: Anaplan integrates with various data sources, allowing users to consolidate data from across the entire organization.

Version Control: Users can create, compare, and manage different versions of plans and scenarios, facilitating "what-if" analysis and decision-making.

User-Friendly Interface: Anaplan offers an intuitive user interface, making it accessible to a wide range of users, from financial analysts to HR managers.

2.2. Objectives

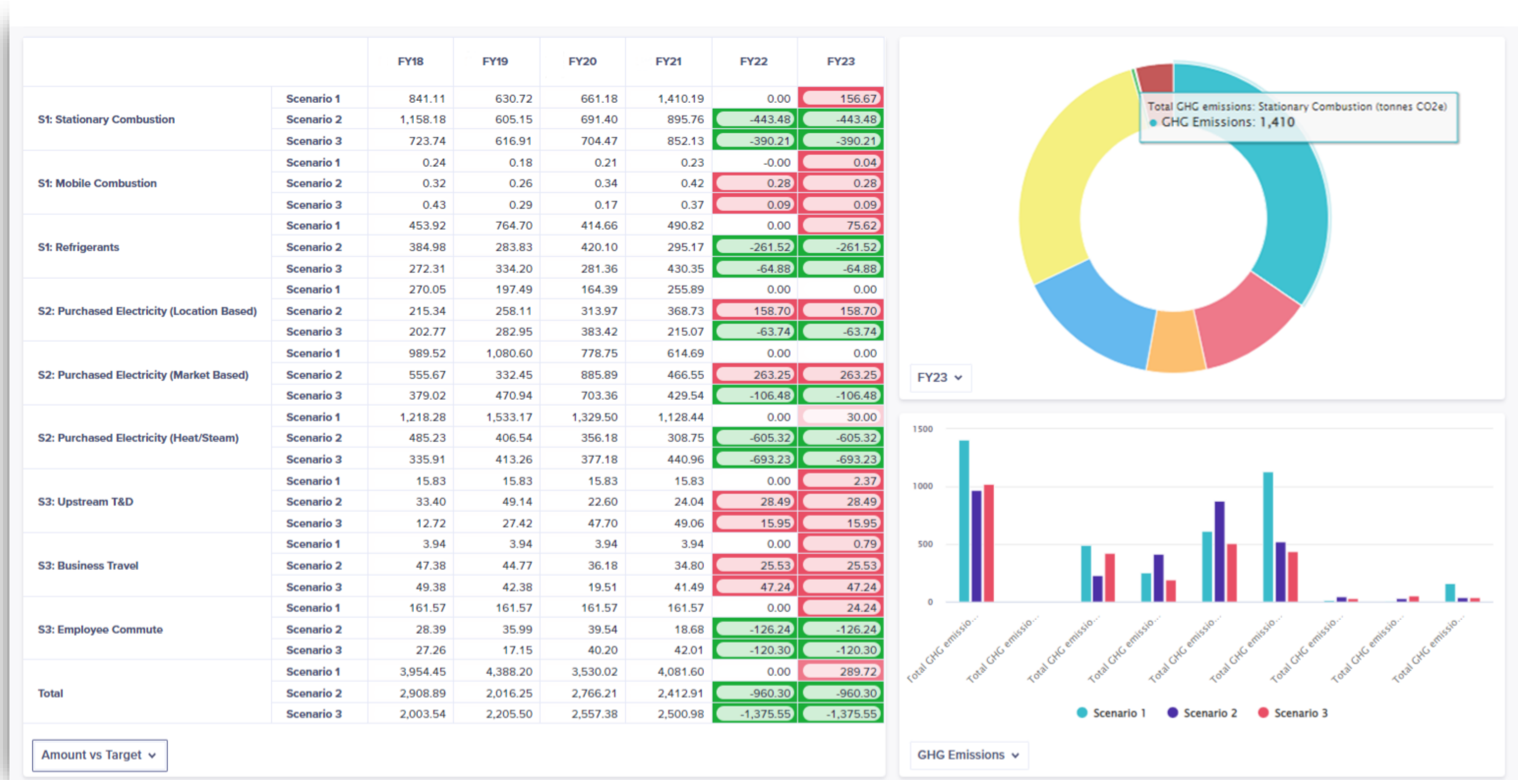
The Starting Point

The starting point of the thesis involved the utilization of a greenhouse gas (GHG) emissions application developed by Profit& to facilitate the monitoring and accountability of carbon emissions in accordance with internationally defined protocols. This application specifically addresses emissions tracking and categorization based on the three defined scopes by Greenhouse Gas Protocols: Scope 1, Scope 2, and Scope 3, as elaborated in the initial chapter of the thesis. The model's granularity extends to encompass the subcategories under each scope, ensuring a comprehensive approach to emissions management. This level of detail contributes to the completeness of the model, allowing for a thorough and nuanced assessment of greenhouse gas (GHG) emissions across the various activities of a company (Fig 2.1 & 2.2). The main features of the solution are:

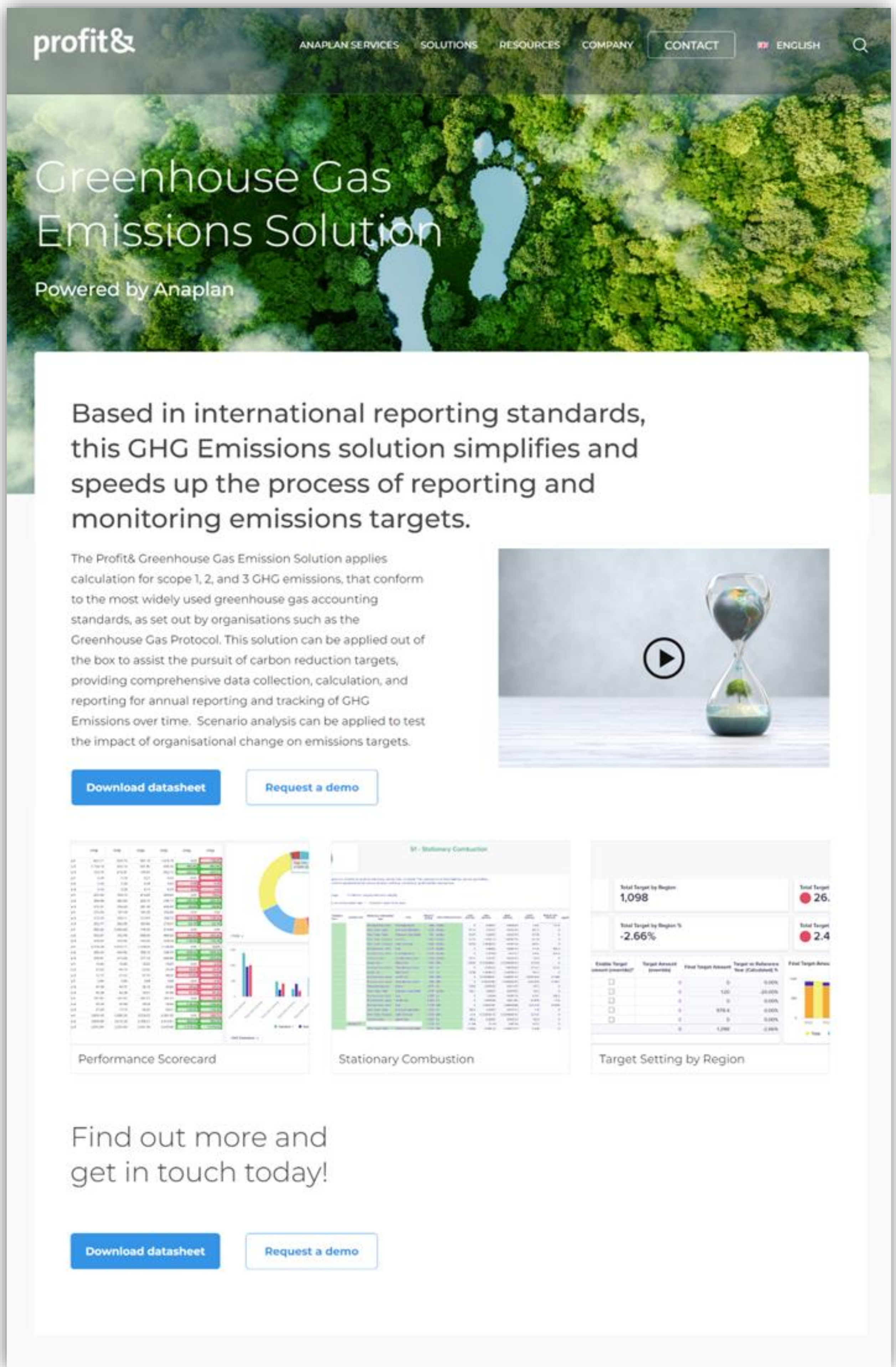
- ***Centralized Database***: The model features a central database equipped with core dimensions and entities essential for storing data related to carbon emissions calculations. Users can also create custom entities, like emissions factors and facilities, tailoring the database to specific organizational needs.
- ***Calculation Engine***: The robust calculation engine computes carbon emissions for Scope 1, Scope 2, and Scope 3, aligning with The Greenhouse Gas Protocol.

- ***User-Friendly Data Input*:** Intuitive data input screens guide users through populating the carbon emissions model, ensuring a seamless and user-friendly experience.
- ***Import Routines*:** Easy-to-use import routines facilitate the smooth transfer of business data. Once the model is populated for the initial year, initializing new scenarios or versions becomes a swift process using existing data.
- ***Automatic Data Transfer*:** The application supports automatic data transfer routines from source systems, reducing manual intervention and ensuring a streamlined flow of information.
- ***Executive Dashboard*:** Interactive dashboards offer a visual representation of results, providing a holistic view aiding in decision-making processes.
- ***Multiple Time Periods*:** The application supports multiple time periods, enabling the tracking of carbon emissions targets over several years. This feature is essential for organizations engaged in long-range sustainability planning.
- ***Multiple Scenarios*:** Users benefit from the ability to create and analyze multiple scenarios, making it convenient to test the impact of different strategies. Through scenario analysis, emissions targets can be set, and variance analysis performed.

Figure 2.1: Performance Scorecard by Emissions Scope



		FY18	FY19	FY20	FY21	FY22	FY23
S1: Stationary Combustion	Scenario 1	841.11	630.72	661.18	1,410.19	0.00	156.67
	Scenario 2	1,158.18	605.15	691.40	895.76	-443.48	-443.48
	Scenario 3	723.74	616.91	704.47	852.13	-390.21	-390.21
S1: Mobile Combustion	Scenario 1	0.24	0.18	0.21	0.23	-0.00	0.04
	Scenario 2	0.32	0.26	0.34	0.42	0.28	0.28
	Scenario 3	0.43	0.29	0.17	0.37	0.09	0.09
S1: Refrigerants	Scenario 1	453.92	764.70	414.66	490.82	0.00	75.62
	Scenario 2	384.98	283.83	420.10	295.17	-261.52	-261.52
	Scenario 3	272.31	334.20	281.36	430.35	-64.88	-64.88
S2: Purchased Electricity (Location Based)	Scenario 1	270.05	197.49	164.39	255.89	0.00	0.00
	Scenario 2	215.34	258.11	313.97	368.73	158.70	158.70
	Scenario 3	202.77	282.95	383.42	215.07	-63.74	-63.74
S2: Purchased Electricity (Market Based)	Scenario 1	989.52	1,080.60	778.75	614.69	0.00	0.00
	Scenario 2	555.67	332.45	885.89	466.55	263.25	263.25
	Scenario 3	379.02	470.94	703.36	429.54	-106.48	-106.48
S2: Purchased Electricity (Heat/Steam)	Scenario 1	1,218.28	1,533.17	1,329.50	1,128.44	0.00	30.00
	Scenario 2	485.23	406.54	356.18	308.75	-605.32	-605.32
	Scenario 3	335.91	413.26	377.18	440.96	-693.23	-693.23
S3: Upstream T&D	Scenario 1	15.83	15.83	15.83	15.83	0.00	2.37
	Scenario 2	33.40	49.14	22.60	24.04	28.49	28.49
	Scenario 3	12.72	27.42	47.70	49.06	15.95	15.95
S3: Business Travel	Scenario 1	3.94	3.94	3.94	3.94	0.00	0.79
	Scenario 2	47.38	44.77	36.18	34.80	25.53	25.53
	Scenario 3	49.38	42.38	19.51	41.49	47.24	47.24
S3: Employee Commute	Scenario 1	161.57	161.57	161.57	161.57	0.00	24.24
	Scenario 2	28.39	35.99	39.54	18.68	-126.24	-126.24
	Scenario 3	27.26	17.15	40.20	42.01	-120.30	-120.30
Total	Scenario 1	3,954.45	4,388.20	3,530.02	4,081.60	0.00	289.72
	Scenario 2	2,908.89	2,016.25	2,766.21	2,412.91	-960.30	-960.30
	Scenario 3	2,003.54	2,205.50	2,557.38	2,500.98	-1,375.55	-1,375.55


profit&
ANAPLAN SERVICES
SOLUTIONS
RESOURCES
COMPANY
CONTACT
ENGLISH
Greenhouse Gas Emissions Solution
Powered by Anaplan
Based in international reporting standards, this GHG Emissions solution simplifies and speeds up the process of reporting and monitoring emissions targets.
The Profit& Greenhouse Gas Emission Solution applies calculation for scope 1, 2, and 3 GHG emissions, that conform to the most widely used greenhouse gas accounting standards, as set out by organisations such as the Greenhouse Gas Protocol. This solution can be applied out of the box to assist the pursuit of carbon reduction targets, providing comprehensive data collection, calculation, and reporting for annual reporting and tracking of GHG Emissions over time. Scenario analysis can be applied to test the impact of organisational change on emissions targets.
Download datasheet
Request a demo
Performance Scorecard
Stationary Combustion
Target Setting by Region
Find out more and get in touch today!
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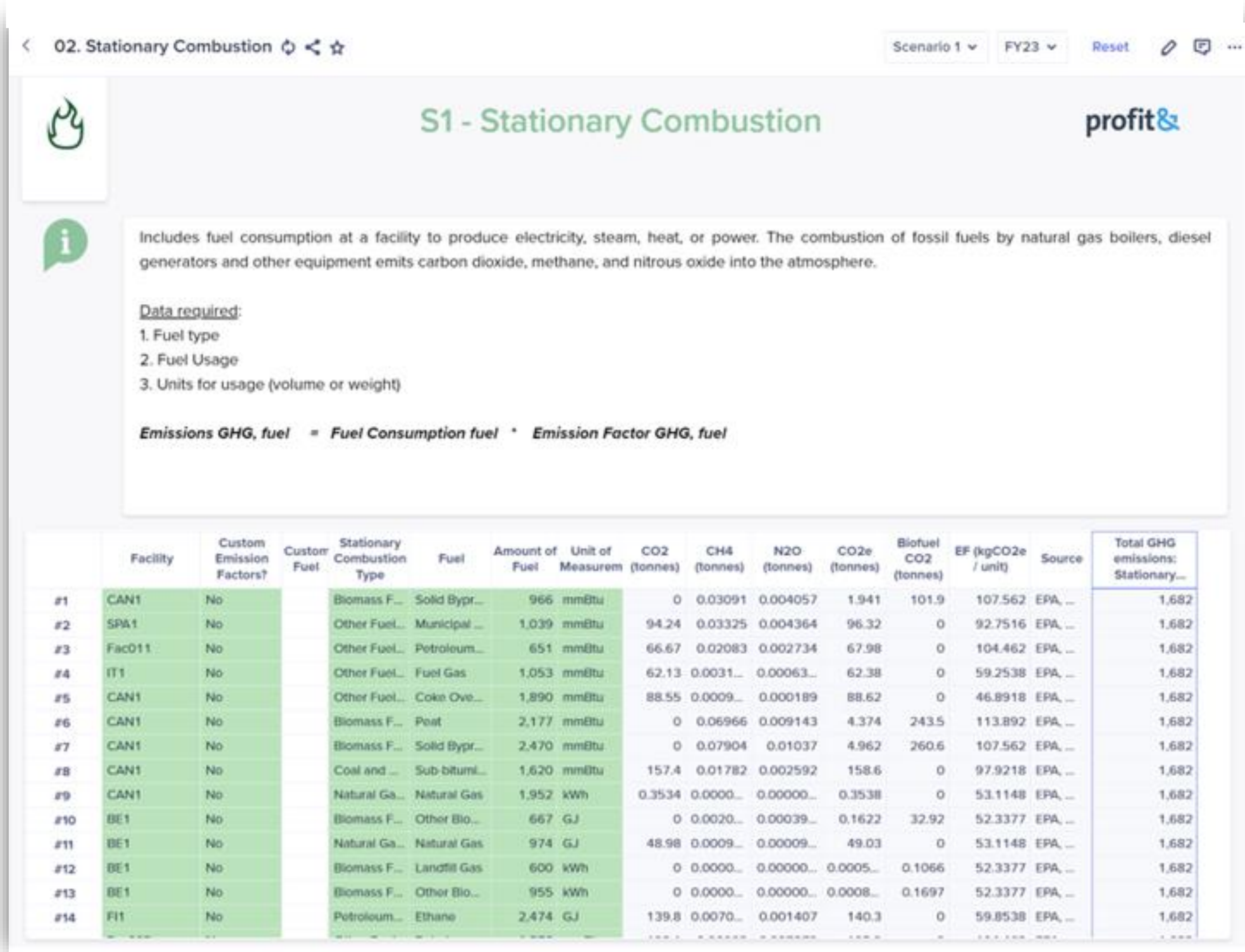
Request a demo

Figure 2.2: Interface for Scope 1 Emissions Calculation



Further Developments & Objectives

The Greenhouse Gas Emissions App, while comprehensive in its approach to emissions accountability, serves as a foundational basis for the thesis's overarching objective—**to transform emissions accountability into something quantifiable in economic terms**. The primary objective is in fact to establish connections between the existing solution on one side, the existing stringent regulatory landscape on the other side, and, finally, the evidence presented in the literature review, affirming that carbon emissions significantly influence firms' financial performance.

From a regulatory perspective, the thesis seeks to incorporate a model segment providing a comprehensive overview of international regulations. Specific datasets will capture information on carbon pricing policies, including the location, carbon taxation prices applied, emissions threshold allowances (both free and auctioned), and emissions trading prices. Emphasis is placed on creating a dynamic component for managing emissions allocation, particularly within Emission Trading Systems (ETS). Anaplan's capabilities will be harnessed to support the management of both freely allocated allowances and activities in the Emissions Trading Systems' markets—extending even to a facility level. The objective is to calculate the costs associated with emissions under both carbon taxation mechanisms and Emissions Trading Systems.

Simultaneously, drawing insights from the literature review, the thesis aims to conceptualize the proven financial impact of carbon emissions. Financial indicators gleaned from relevant papers, such as Return on Assets (ROA), Return on Equity ROE), Return on Sales (ROS), and others, will be employed to measure the influence of the previously calculated costs on the firm's financial performance. The goal is to quantify the economic repercussions of greenhouse gas (GHG) emissions on a company's financial viability.

This dual-pronged approach combines regulatory compliance and financial impact assessment to provide a complete understanding of the multifaceted relationship between emissions, regulations, and financial performance.

The objective of the thesis, in simpler terms, is to quantify greenhouse gas (GHG) emissions in economic terms, and to measure their impact on the financial health of a company. The final outcomes will be to obtain an additional part of the existing model that measures the economic impact of CO2 emissions in terms of costs, as well as a financial analysis that establishes a link between corporate environmental performance (CEP) and corporate financial performance (CFP).

The next parts will discuss precisely these two areas. Firstly, the conceptualization of the regulatory context and how it can be used to calculate the costs associated with CO2 emissions under different regulations and legislations. Secondly, the modelling of the financial impact discussed in the literature review using financial indicators.

2.3. Data Collection & Model Construction: The Regulatory Context

To achieve the stated objectives, the initial step involves leveraging the existing part of the model supporting the greenhouse gas (GHG) emissions accountability to calculate the corresponding costs under the various international regulations.

As discussed in Chapter 1, under the Regulatory Context section, each country employs a different carbon pricing instrument, which can take the form of either carbon taxation through a yearly fixed price, or Emissions Trading Systems (ETS), under which allowances are either freely allocated or auctioned. In both cases, carbon pricing instruments are set differently in each country to suit its specific needs. Given the fragmented international situation, to streamline the process of data collection and model construction, it was essential to divide the search into two distinct processes based on the two carbon pricing instruments in place. Firstly, data pertaining to carbon taxation was gathered and logic deriving from it was built. Secondly, data related to Emissions Trading Systems (ETS) was compiled and modelized.

Data Collection & Model Construction: Carbon Taxation Policies

As highlighted when comparing the carbon taxation policies to the Emissions Trading Systems (ETS) (refer to Chapter 1, section 1.1, *Carbon Pricing Strategies: Two Distinct Mechanisms)*, carbon taxation resulted in being a more straightforward approach to pricing emissions. This simplicity is due to the predictability of pricing, as carbon taxes are typically set on an annual basis.

The main challenge lies in the way the carbon taxation price is applied, as certain countries employ multiple prices to accommodate variations in taxed activities. While many nations choose a general carbon price for all greenhouse gas (GHG) emissions, the differences peculiar to every country should be taken in high consideration when defining the logic applied for calculating expenses linked to carbon emissions resulting from the latter.

A meticulous exploration of available data on carbon taxation rates implemented in each country has been necessary to carefully select relevant data sources while discarding less reliable ones. The process proved to be quite time-consuming due to the frequent challenges of outdated or incomplete information. Ultimately, in May 2023, Statista released an exhaustive report encompassing updated carbon taxation rates until March 2023. This publication served as a valuable source of reliable and comprehensive data, enabling the construction of a data module on Anaplan covering all taxation prices applied worldwide. The following image (Fig 3.1) provides an overview of this data module, dimensioned by scenarios and years. Also, the collected data can be found in Appendix 1.

Figure 3.1: Data Module of Carbon Taxation Prices by Country ($/tCO2e)

DAT. Carbon Taxes Pricing | Scenario 1 | FY23

	General Carbon	Transports	Fossil-fuels	F-gases	Gasoline and Liq	LGP and Natural	Upper	Lower	Heating Fuels
Switzerland	130.8								
Denmark			26.53	21.9					
Spain	16.31								
Estonia	2.175								
Finland		83.74	57.64						
France	48.5								
United Kingdom	22.28								
Ireland			44.59		52.74				
Iceland							38.53	3.219	
Liechtenstein	130.8								
Luxembourg			32.63		48.11				
Latvia	16.31								
Netherlands	55.59								
Norway	90.86					7.349			
Poland			0.07919	14.44					
Portugal	26.01								
Slovenia									
Sweden	125.6								
Ukraine	0.8204								

With the established carbon emissions taxation prices for each country in hand and, on the other hand, our starting point being the calculated emissions for each Scope following GHG Protocols, a systematic approach is needed. The aim is to either apply the general CO2 taxation price applied in a country or, in instances of multiple rates, select and apply the appropriate one. A meticulous effort was required to define the correct logic to apply through formulas for each Scope and its respective subcategories, while considering the various international taxation schemes. This was necessary to enable the model to autonomously apply these taxation prices accurately.

To illustrate the systematic approach that has been put in place and is now followed by the model through the calculation formulas, the specific example of Scope 1: Stationary Combustion is illustrated here. As elucidated earlier, the previously established model enabled the determination of total carbon emissions by meticulously accounting for each Scope. In this instance, our attention is directed towards emissions originating directly from sources under the ownership or control of the company. Specifically, we delve into emissions resulting from stationary combustion, a consequence of fuel source utilization (refer to Chapter 1, section 1.1, *Greenhouse Gas Emissions Accountability*). We will focus on a hypothetical facility based in Finland, emitting greenhouse gas (GHG) emissions resulting from fossil fuels, for the year 2020. The following steps illustrate what the user goes through to account for those emissions in the application, and the incremental steps added to build the bridge from simple emissions to tangible cost.

1. In the first step, the user starts by choosing the corresponding facility which, in this case, is FI1 (Fig. 3.2).

2. In the second step, the user selects the stationary combustion type coming from a pre-defined dropdown list (Fig. 3.3).

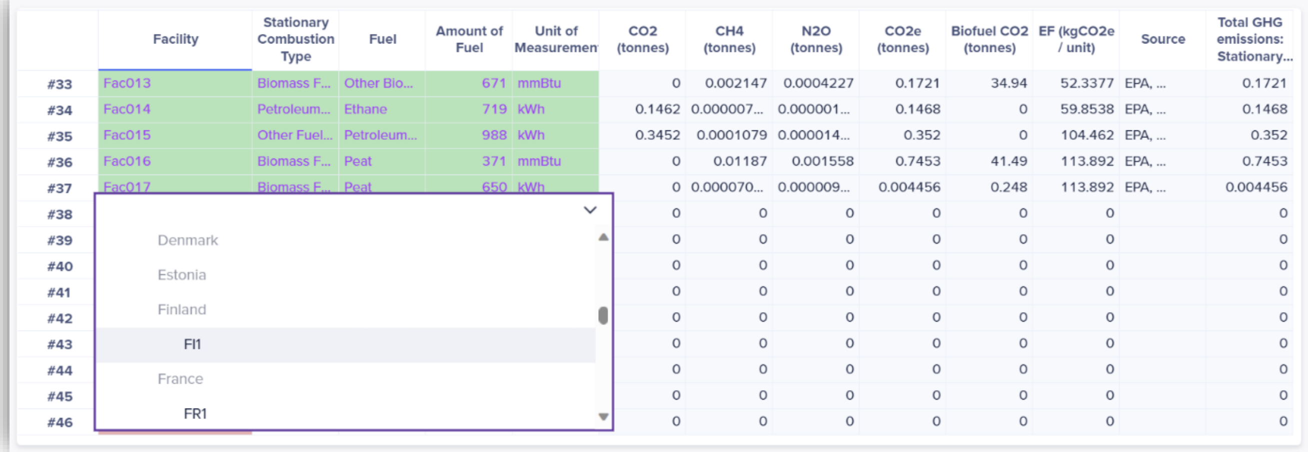
3. In the third step, the user selects the fuel used in the stationary combustion process he is accounting for. For every stationary combustion type, some specific fuels are available and can be chosen (Fig. 3.4).

4. In the fourth step, the user adds the amount of fuel used (Fig. 3.5).

5. In the fifth step, the user adds the unit of measurement (Fig. 3.6).

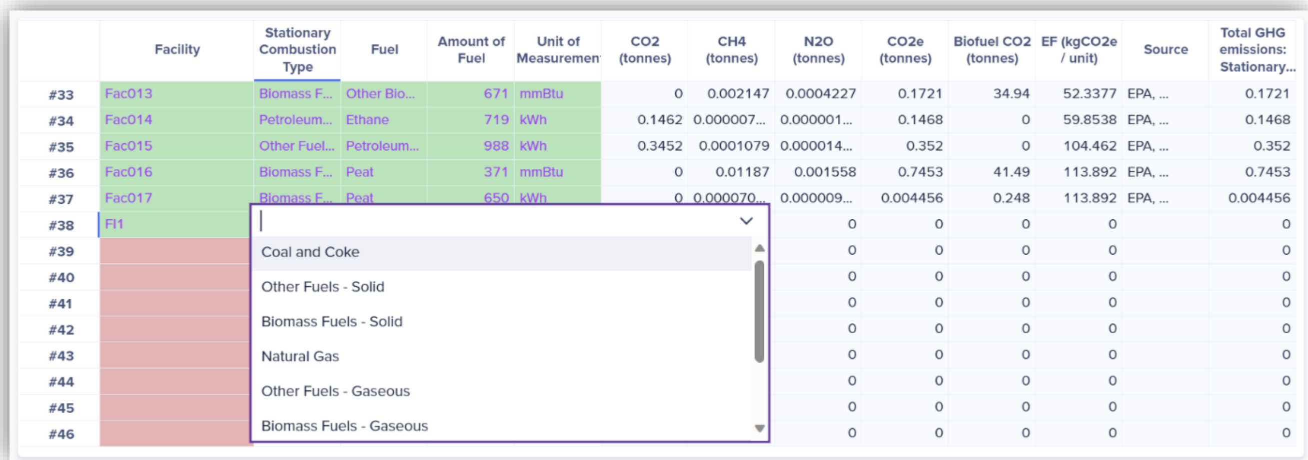
6. In the sixth step, the corresponding total greenhouse gas (GHG) emissions are calculated (Fig. 3.7).

Figure 3.2: Step 1 - Facility Selection



	Facility	Stationary Combustion Type	Fuel	Amount of Fuel	Unit of Measuremen	CO2 (tonnes)	CH4 (tonnes)	N2O (tonnes)	CO2e (tonnes)	Biofuel CO2 (tonnes)	EF (kgCO2e / unit)	Source	Total GHG emissions: Stationary...
#33	Fac013	Biomass F...	Other Bio...	671	mmBtu	0	0.002147	0.0004227	0.1721	34.94	52.3377	EPA, ...	0.1721
#34	Fac014	Petroleum...	Ethane	719	kWh	0.1462	0.000007...	0.000001...	0.1468	0	59.8538	EPA, ...	0.1468
#35	Fac015	Other Fuel...	Petroleum...	988	kWh	0.3452	0.0001079	0.000014...	0.352	0	104.462	EPA, ...	0.352
#36	Fac016	Biomass F...	Peat	371	mmBtu	0	0.01187	0.001558	0.7453	41.49	113.892	EPA, ...	0.7453
#37	Fac017	Biomass F...	Peat	650	kWh	0	0.000070...	0.000009...	0.004456	0.248	113.892	EPA, ...	0.004456
#38						0	0	0	0	0	0		0
#39						0	0	0	0	0	0		0
#40						0	0	0	0	0	0		0
#41						0	0	0	0	0	0		0
#42						0	0	0	0	0	0		0
#43						0	0	0	0	0	0		0
#44						0	0	0	0	0	0		0
#45						0	0	0	0	0	0		0
#46						0	0	0	0	0	0		0

Figure 3.3: Step 2 - Stationary Combustion Type Selection

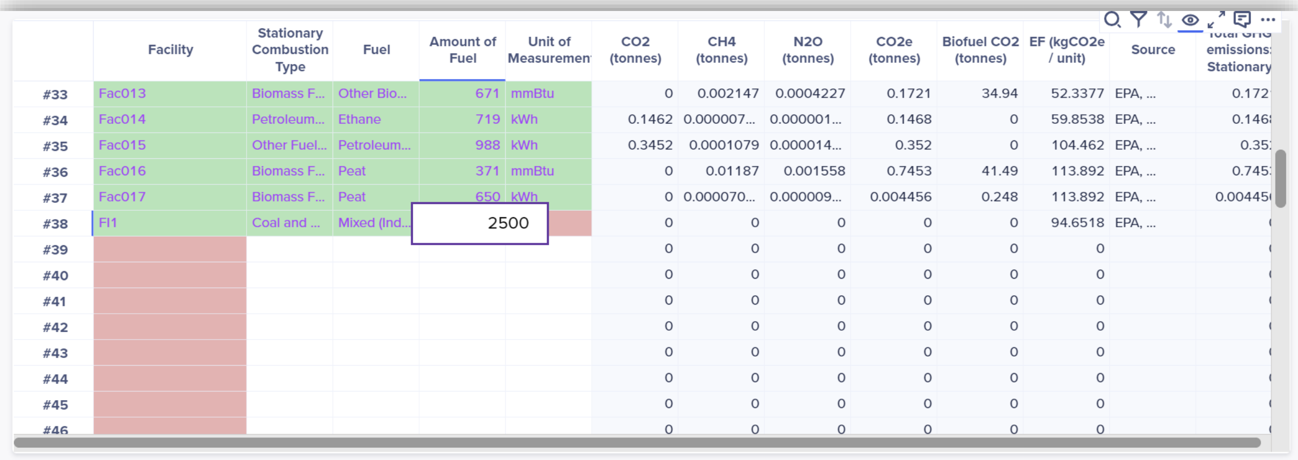


	Facility	Stationary Combustion Type	Fuel	Amount of Fuel	Unit of Measuremen	CO2 (tonnes)	CH4 (tonnes)	N2O (tonnes)	CO2e (tonnes)	Biofuel CO2 (tonnes)	EF (kgCO2e / unit)	Source	Total GHG emissions: Stationary...
#33	Fac013	Biomass F...	Other Bio...	671	mmBtu	0	0.002147	0.0004227	0.1721	34.94	52.3377	EPA, ...	0.1721
#34	Fac014	Petroleum...	Ethane	719	kWh	0.1462	0.000007...	0.000001...	0.1468	0	59.8538	EPA, ...	0.1468
#35	Fac015	Other Fuel...	Petroleum...	988	kWh	0.3452	0.0001079	0.000014...	0.352	0	104.462	EPA, ...	0.352
#36	Fac016	Biomass F...	Peat	371	mmBtu	0	0.01187	0.001558	0.7453	41.49	113.892	EPA, ...	0.7453
#37	Fac017	Biomass F...	Peat	650	kWh	0	0.000070...	0.000009...	0.004456	0.248	113.892	EPA, ...	0.004456
#38	FI1							0	0	0	0		0
#39								0	0	0	0		0
#40								0	0	0	0		0
#41								0	0	0	0		0
#42								0	0	0	0		0
#43								0	0	0	0		0
#44								0	0	0	0		0
#45								0	0	0	0		0
#46								0	0	0	0		0

Figure 3.4: Step 3 - Fuel Selection

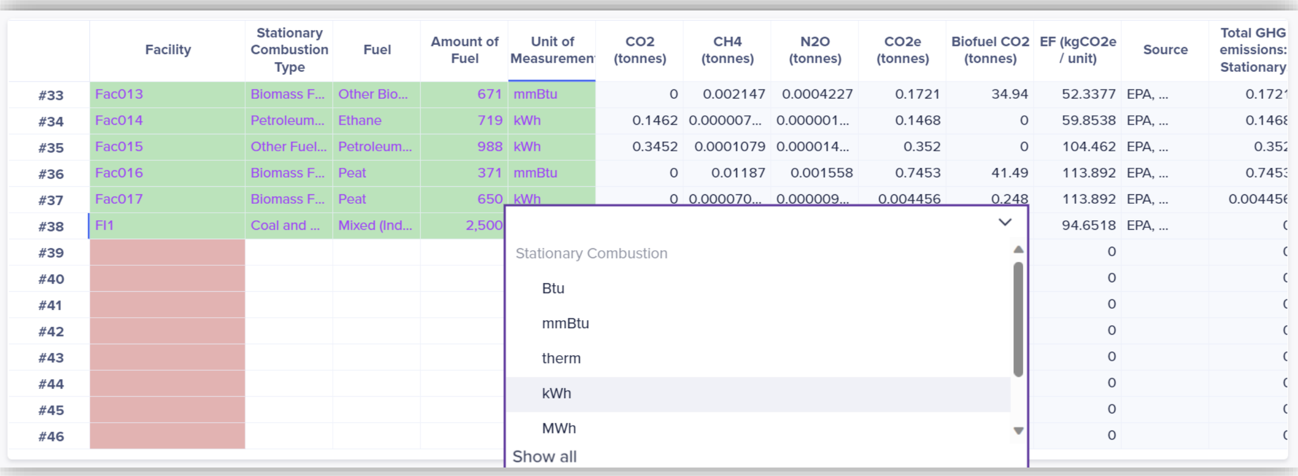
	Facility	Stationary Combustion Type	Fuel	Amount of Fuel	Unit of Measuremen	CO2 (tonnes)	CH4 (tonnes)	N2O (tonnes)	CO2e (tonnes)	Biofuel CO2 (tonnes)	EF (kgCO2e / unit)	Source	Total GHG emissions: Stationary
#33	Fac013	Biomass F...	Other Bio...	671	mmBtu	0	0.002147	0.0004227	0.1721	34.94	52.3377	EPA, ...	0.172
#34	Fac014	Petroleum...	Ethane	719	kWh	0.1462	0.000007...	0.000001...	0.1468	0	59.8538	EPA, ...	0.146
#35	Fac015	Other Fuel...	Petroleum...	988	kWh	0.3452	0.0001079	0.000014...	0.352	0	104.462	EPA, ...	0.35
#36	Fac016	Biomass F...	Peat	371	mmBtu	0	0.01187	0.001558	0.7453	41.49	113.892	EPA, ...	0.745
#37	Fac017	Biomass F...	Peat	650	kWh	0	0.000070...	0.000009...	0.004456	0.248	113.892	EPA, ...	0.00445
#38	FI1	Coal and ...							0	0	0		
#39									0	0	0		
#40									0	0	0		
#41									0	0	0		
#42									0	0	0		
#43									0	0	0		
#44									0	0	0		
#45									0	0	0		
#46									0	0	0		

Figure 3.5: Step 4 - Insert the Amount of Fuel



	Facility	Stationary Combustion Type	Fuel	Amount of Fuel	Unit of Measuremen	CO2 (tonnes)	CH4 (tonnes)	N2O (tonnes)	CO2e (tonnes)	Biofuel CO2 (tonnes)	EF (kgCO2e / unit)	Source	Total GHG emissions: Stationary
#33	Fac013	Biomass F...	Other Bio...	671	mmBtu	0	0.002147	0.0004227	0.1721	34.94	52.3377	EPA, ...	0.172
#34	Fac014	Petroleum...	Ethane	719	kWh	0.1462	0.000007...	0.000001...	0.1468	0	59.8538	EPA, ...	0.146
#35	Fac015	Other Fuel...	Petroleum...	988	kWh	0.3452	0.0001079	0.000014...	0.352	0	104.462	EPA, ...	0.35
#36	Fac016	Biomass F...	Peat	371	mmBtu	0	0.01187	0.001558	0.7453	41.49	113.892	EPA, ...	0.745
#37	Fac017	Biomass F...	Peat	650	kWh	0	0.000070...	0.000009...	0.004456	0.248	113.892	EPA, ...	0.00445
#38	FI1	Coal and ...	Mixed (Ind...	2500		0	0	0	0	0	94.6518	EPA, ...	
#39						0	0	0	0	0	0		
#40						0	0	0	0	0	0		
#41						0	0	0	0	0	0		
#42						0	0	0	0	0	0		
#43						0	0	0	0	0	0		
#44						0	0	0	0	0	0		
#45						0	0	0	0	0	0		
#46						0	0	0	0	0	0		

Figure 3.6: Step 5 - Select the Unit of Measurement



	Facility	Stationary Combustion Type	Fuel	Amount of Fuel	Unit of Measuremen	CO2 (tonnes)	CH4 (tonnes)	N2O (tonnes)	CO2e (tonnes)	Biofuel CO2 (tonnes)	EF (kgCO2e / unit)	Source	Total GHG emissions: Stationary
#33	Fac013	Biomass F...	Other Bio...	671	mmBtu	0	0.002147	0.0004227	0.1721	34.94	52.3377	EPA, ...	0.172
#34	Fac014	Petroleum...	Ethane	719	kWh	0.1462	0.000007...	0.000001...	0.1468	0	59.8538	EPA, ...	0.1468
#35	Fac015	Other Fuel...	Petroleum...	988	kWh	0.3452	0.0001079	0.000014...	0.352	0	104.462	EPA, ...	0.352
#36	Fac016	Biomass F...	Peat	371	mmBtu	0	0.01187	0.001558	0.7453	41.49	113.892	EPA, ...	0.7453
#37	Fac017	Biomass F...	Peat	650	kWh	0	0.000070...	0.000009...	0.004456	0.248	113.892	EPA, ...	0.00445
#38	FI1	Coal and ...	Mixed (Ind...	2,500							94.6518	EPA, ...	
#39											0		
#40											0		
#41											0		
#42											0		
#43											0		
#44											0		
#45											0		
#46											0		

Figure 3.7: Step 6 - Total GHG Emissions Calculation

	Facility	Stationary Combustion Type	Fuel	Amount of Fuel	Unit of Measuremen	CO2 (tonnes)	CH4 (tonnes)	N2O (tonnes)	CO2e (tonnes)	Biofuel CO2 (tonnes)	EF (kgCO2e / unit)	Source	Total GHG emissions: Stationary...
#33	ac013	Biomass F...	Other Bio...	671	mmBtu	0	0.002147	0.0004227	0.1721	34.94	52.3377	EPA, ...	0.1721
#34	ac014	Petroleum...	Ethane	719	kWh	0.1462	0.000007...	0.000001...	0.1468	0	59.8538	EPA, ...	0.1468
#35	ac015	Other Fuel...	Petroleum...	988	kWh	0.3452	0.0001079	0.000014...	0.352	0	104.462	EPA, ...	0.352
#36	ac016	Biomass F...	Peat	371	mmBtu	0	0.01187	0.001558	0.7453	41.49	113.892	EPA, ...	0.7453
#37	ac017	Biomass F...	Peat	650	kWh	0	0.000070...	0.000009...	0.004456	0.248	113.892	EPA, ...	0.004456
#38	I1	Coal and ...	Mixed (Ind...	2,500	kWh	0.801	0.000093...	0.000013...	0.8072	0	94.6518	EPA, ...	0.8072
#39						0	0	0	0	0	0		0
#40						0	0	0	0	0	0		0
#41						0	0	0	0	0	0		0
#42						0	0	0	0	0	0		0
#43						0	0	0	0	0	0		0
#44						0	0	0	0	0	0		0
#45						0	0	0	0	0	0		0

The process related to the accountability of greenhouse gas (GHG) emissions stops here; from now on, to calculate the costs deriving from these registered emissions, the correct taxation price must be applied. The following steps therefore necessitate some further developments and building in the model. By referring to the data collected previously, made available in the Appendix 1 and accessible in one of the data modules in Anaplan, four different carbon taxation prices applicable to Stationary Combustion emissions can be identified: the ***General Carbon*** taxation price, the ***Fossil Fuels*** taxation price, the ***LGP and Natural Gas*** taxation price and the ***Gasoline and Liquid Fuels*** taxation price. More specifically, since we are considering Finland in 2020, two different taxation prices may be applied to stationary combustion emissions, as reported in the following picture.

Figure 3.8: Carbon Taxation Prices by Country

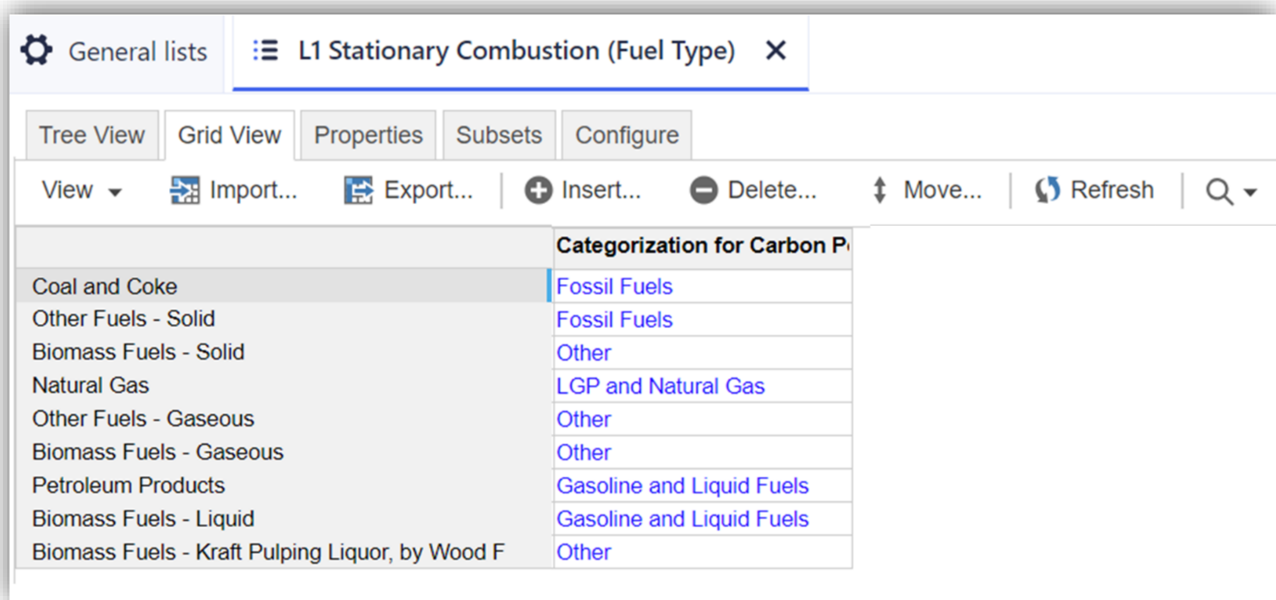
DAT. Carbon Taxes Pricing | Scenario 1 ▾ | FY20 ▾

	Carbon Ta:	General Carbo	Transports	Fossil-fuels	F-gases	Gasoline and L	LGP and Natur	Upper	Lower	Heating Fuels
Taiwan, China	☐									
Vietnam	☐									
Vanuatu	☐									
Samoa	☐									
East Asia & Pacific		6.197								
Switzerland	☑	99.44								
Denmark	☑			25.93	21.98					
Spain	☑	16.4								
Estonia	☑	2.187								
Finland	☑		67.8	57.96						
France	☑	48.77								
United Kingdom	☑	22.28								
Ireland	☑		28.43	21.87						
Iceland	☑	31.34								
Liechtenstein	☑	99.44								
Latvia	☑	9.842								
Norway	☑							52.89	3.009	
Poland	☑	0.07194								
Portugal	☑	25.83								
Slovenia	☑	18.92								
Sweden	☑	119.4								
Ukraine	☑	0.3846								
Albania	☐									

In cases such as Switzerland, Spain, and France, where a single general taxation price is imposed, the process is simplified; it remains sufficient to multiply the total greenhouse gas (GHG) emissions by the latter to obtain the resulting costs. However, for countries like Finland and Ireland having more than a single taxation price in place, the process requires a structured logic behind it. Since the choice of taxation price depends on the stationary combustion type and on the fuel selected during steps 3 and 4, a mapping between the fuels and the carbon taxation policies must be created. In other words, for every fuel selected during emissions accountability, the model should be able to retrieve the correct taxation price (Fig. 3.9).

Thanks to this mapping and a set of *IF* functions (conditional), once the user has selected a stationary combustion type and a fuel, the model is able to retrieve the correct taxation price to apply. More specifically, the model follows three possible paths:

Figure 3.9: Stationary Combustion Fuels Mapping to Taxation Prices



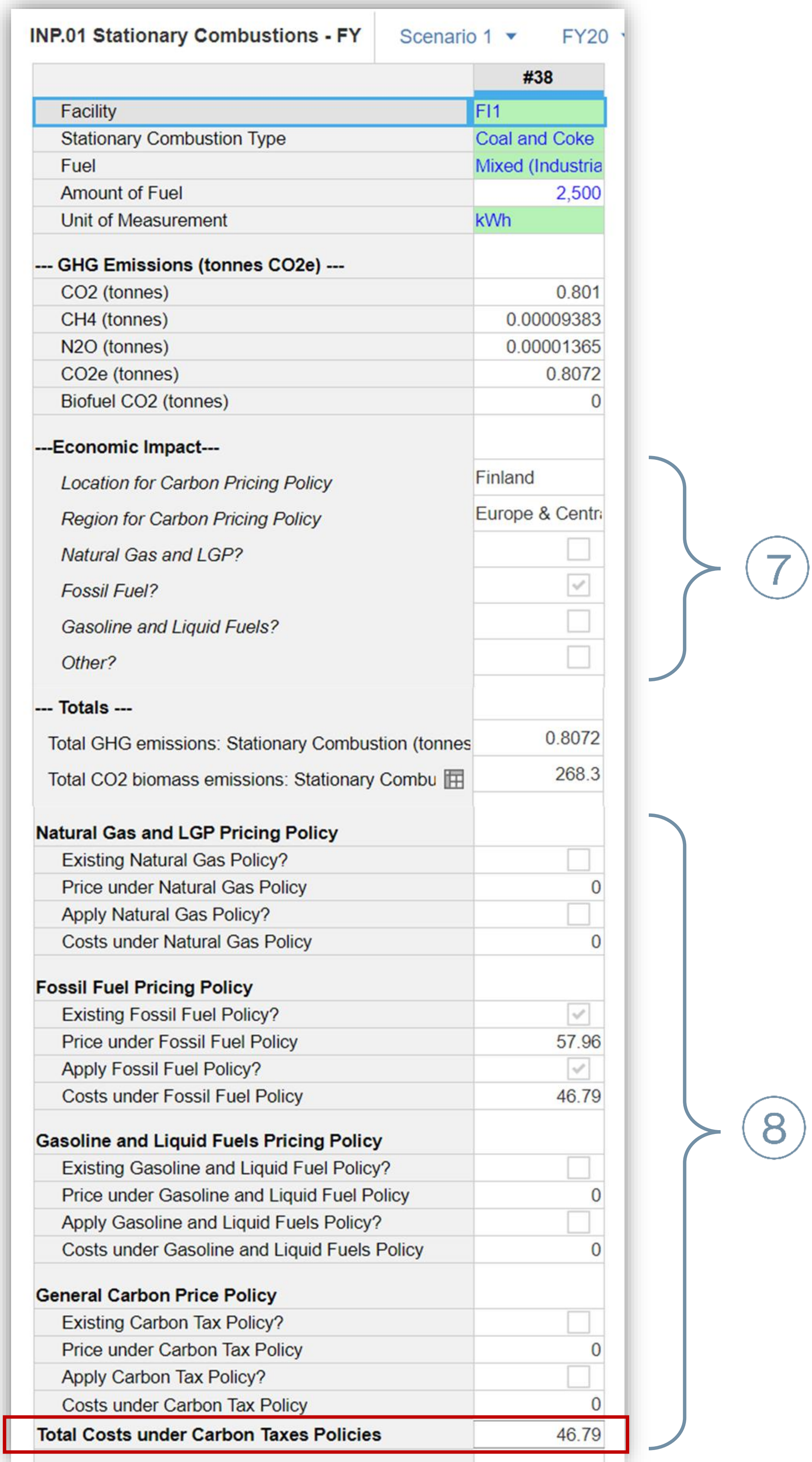
	Categorization for Carbon P
Coal and Coke	Fossil Fuels
Other Fuels - Solid	Fossil Fuels
Biomass Fuels - Solid	Other
Natural Gas	LGP and Natural Gas
Other Fuels - Gaseous	Other
Biomass Fuels - Gaseous	Other
Petroleum Products	Gasoline and Liquid Fuels
Biomass Fuels - Liquid	Gasoline and Liquid Fuels
Biomass Fuels - Kraft Pulping Liquor, by Wood F	Other

- If emissions are accounted for with a facility operating in a country not applying any carbon taxation policy, no taxation price is applied, and carbon taxation costs are null.
- If emissions are accounted for with a facility operating in a country applying a general carbon taxation price, this price is retrieved, and carbon taxation costs are calculated based on the latter.
- If emissions are accounted for with a facility operating in a country applying more than a single carbon taxation price, the activity type and the fuel serve as basis for the model to retrieve the correct taxation price to apply. Emissions costs deriving from it are calculated.

7 In the seventh step, since the user selected *Coal and Coke* as stationary combustion type and *Coal Coke* as fuel, the model maps the emissions as Fossil Fuels emissions through a ticked box (Fig. 3.10).

8 In the last step, the model follows the built logic to check if Finland applies any carbon taxation price; it retrieves the price applied to emissions resulting from fossil fuels and the resulting costs are calculated (Fig 3.10).

Figure 3.10: Calculation Overview from Step 1 to Step 7



	#38
Facility	FI1
Stationary Combustion Type	Coal and Coke
Fuel	Mixed (Industria
Amount of Fuel	2,500
Unit of Measurement	kWh
--- GHG Emissions (tonnes CO2e) ---	
CO2 (tonnes)	0.801
CH4 (tonnes)	0.00009383
N2O (tonnes)	0.00001365
CO2e (tonnes)	0.8072
Biofuel CO2 (tonnes)	0
---Economic Impact---	
Location for Carbon Pricing Policy	Finland
Region for Carbon Pricing Policy	Europe & Centr
Natural Gas and LGP?	☐
Fossil Fuel?	☑
Gasoline and Liquid Fuels?	☐
Other?	☐
--- Totals ---	
Total GHG emissions: Stationary Combustion (tonnes	0.8072
Total CO2 biomass emissions: Stationary Combu	268.3
Natural Gas and LGP Pricing Policy	
Existing Natural Gas Policy?	☐
Price under Natural Gas Policy	0
Apply Natural Gas Policy?	☐
Costs under Natural Gas Policy	0
Fossil Fuel Pricing Policy	
Existing Fossil Fuel Policy?	☑
Price under Fossil Fuel Policy	57.96
Apply Fossil Fuel Policy?	☑
Costs under Fossil Fuel Policy	46.79
Gasoline and Liquid Fuels Pricing Policy	
Existing Gasoline and Liquid Fuel Policy?	☐
Price under Gasoline and Liquid Fuel Policy	0
Apply Gasoline and Liquid Fuels Policy?	☐
Costs under Gasoline and Liquid Fuels Policy	0
General Carbon Price Policy	
Existing Carbon Tax Policy?	☐
Price under Carbon Tax Policy	0
Apply Carbon Tax Policy?	☐
Costs under Carbon Tax Policy	0
Total Costs under Carbon Taxes Policies	46.79

Starting from the accounting of emissions, the model can categorize them to apply the most appropriate taxation price and subsequently calculates the costs that result from these emissions.

Data Collection & Model Construction: Emissions Trading Systems (ETS)

It is now necessary to delve into the intricacies of the second instrument of carbon pricing, namely Emissions Trading Systems (ETS). Emissions Trading Systems (ETS) are implemented at national level, setting an annual limit on emissions allowances within a given country. As explained in Chapter 1, these allowances are categorized into two types: those granted without cost, called free allowances, and those available for purchase or sales on a regulated market, called auctioned allowances. To incorporate these aspects into the existing model, a prerequisite comprises data research to obtain a comprehensive overview of countries implementing limits on greenhouse gas (GHG) emissions through Emissions Trading Systems (ETS). This includes gathering information on the yearly allowances set at country level and the prices established in the corresponding trading market.

For multinational corporations operating across diverse countries, the acquisition and management of emissions allowances has become a critical aspect of compliance. The company is assigned a predetermined number of free allowances in each country, and if these prove insufficient to cover annual emissions, the entity is compelled to participate in the allowances market to procure the necessary additional allowances, incurring financial costs. The effective management of these allowances is therefore a key point that necessitates further enhancements in the existing model.

To facilitate the explanation of the methodology employed, the process will be detailed step by step from a user point of view, incorporating the steps 1 to 6 illustrated previously. Moreover, the specific example of a user managing the case of France for the year 2023 will be examined. We therefore consider that the user has accounted for the emissions resulting from the facilities operating in France through steps 1 to 5, and that the total greenhouse gas (GHG) emissions have been calculated in accordance with step 6.

As prerequisite, data on countries applying Emissions Trading Systems (ETS) is searched and allowances data is collected. The same challenges of carbon taxation policies data research are encountered but reliable information is finally found through a Statista dataset. A data module is built on Anaplan, containing the yearly emissions allowances set by country over time (Fig. 4.1), reported in Appendix 2. For France, the considered example here, the allowances have been highlighted. Compared to 2018, the number of allowances has decreased, well reflecting the sustainability objectives of the country with a reduction of emitted greenhouse gas (GHG) emissions over time.

Figure 4.1: Data Module of ETS Allowances by Country

DAT. ETS Policies by Country — Scenario 1

		FY18	FY19	FY20	FY21	FY22	FY23	FY24
Denmark	Free Allowances	7,726,416	7,141,898	6,449,596	4,866,070	4,909,216	4,837,763	4,837,763
	Auctioned Allowances	12,136,000	6,614,000	6,719,500	5,476,500	4,460,500	4,460,500	4,460,500
	Total Allowances	19,862,416	13,755,898	13,169,096	10,342,570	9,369,716	9,298,263	9,298,263
Spain	Free Allowances	57,263,358	57,857,775	57,170,397	45,997,414	45,868,235	45,489,360	45,489,360
	Auctioned Allowances	83,684,500	49,781,000	50,285,000	46,471,000	39,980,500	39,980,500	39,980,500
	Total Allowances	140,947,858	107,638,775	107,455,397	92,468,414	85,848,735	85,469,860	85,469,860
Estonia	Free Allowances	3,283,874	3,151,643	2,982,844	2,550,892	2,500,571	2,460,348	2,460,348
	Auctioned Allowances	9,082,500	5,796,000	5,864,000	4,684,000	4,180,500	4,180,500	4,180,500
	Total Allowances	12,366,374	8,947,643	8,846,844	7,234,892	6,681,071	6,640,848	6,640,848
Finland	Free Allowances	16,966,971	16,093,422	15,306,036	12,771,537	13,020,574	12,978,782	12,978,782
	Auctioned Allowances	16,201,000	8,830,500	8,970,500	7,700,000	6,344,500	6,344,500	6,344,500
	Total Allowances	33,167,971	24,923,922	24,276,536	20,471,537	19,365,074	19,323,282	19,323,282
France	Free Allowances	67,485,756	66,231,987	64,238,057	55,693,980	52,863,009	52,783,792	52,783,792
	Auctioned Allowances	53,050,000	28,914,500	29,374,000	27,468,000	23,029,500	23,029,500	23,029,500
	Total Allowances	120,535,756	95,146,487	93,612,057	83,161,980	75,892,509	75,813,292	75,813,292
Faroe Islands	Free Allowances	0	0	0	0	0	0	0
	Auctioned Allowances	0	0	0	0	0	0	0
	Total Allowances	0	0	0	0	0	0	0
United Kingdom	Free Allowances	51,357,132	49,622,985	48,058,253	0	0	0	0
	Auctioned Allowances	101,053,000	0	111,025,500	0	0	0	0
	Total Allowances	152,410,132	49,622,985	159,083,753	0	0	0	0
Georgia	Free Allowances	0	0	0	0	0	0	0
	Auctioned Allowances	0	0	0	0	0	0	0

Since every country applying an Emissions Trading System (ETS) has a regulated market for auctioned allowances, prices are dynamic and are set because of offer and demand mechanisms. Since those prices change on a day-to-day basis, average yearly prices by country are collected and uploaded into a second data module (Fig 4.2). The information collected through The World Bank is reported in Appendix 3. For France, the yearly allowances trading price has more than tripled compared to 2018, once again reflecting the stringent regulations and the aim of reducing emissions through leveraging on higher emissions costs.

Figure 4.2: Data Module of ETS Prices by Country

DAT. ETS Pricing — Scenario 1 — ETS Price

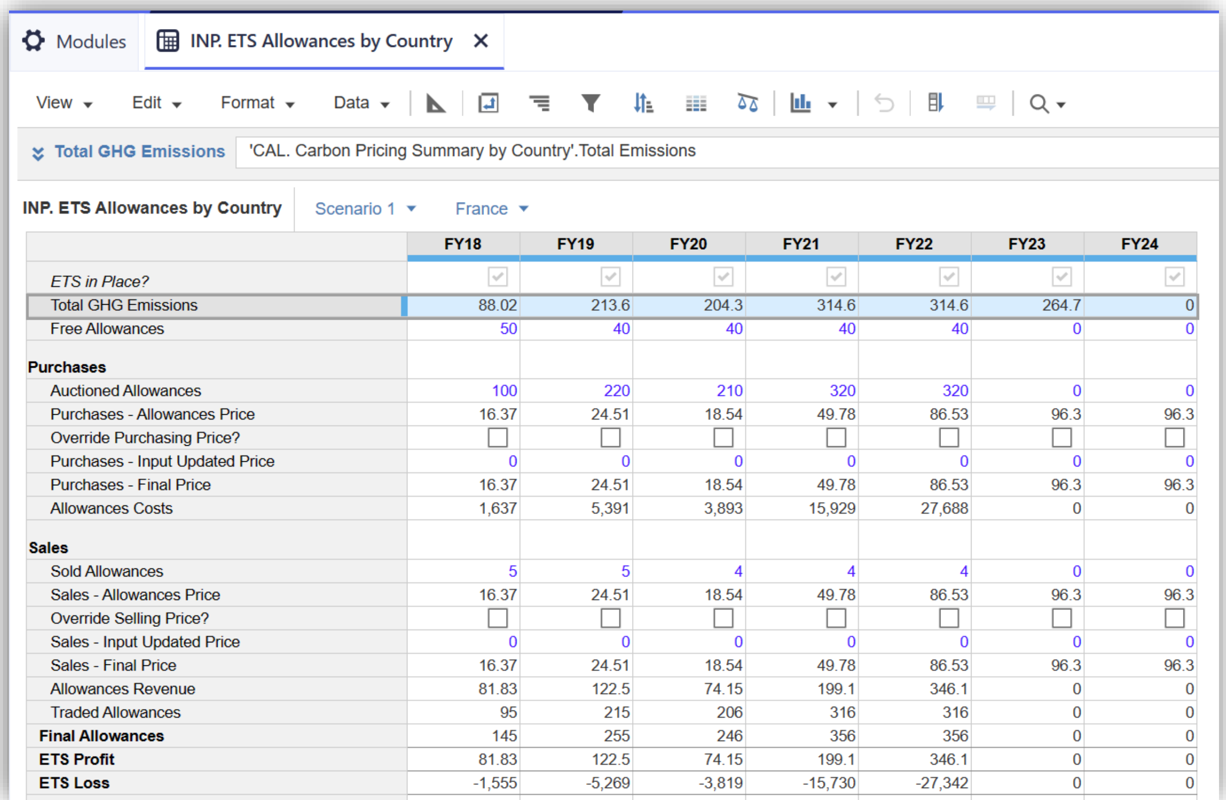
	FY18	FY19	FY20	FY21	FY22	FY23	FY24
Denmark	16.37	24.51	18.54	49.78	86.53	96.3	96.3
Spain	16.37	24.51	18.54	49.78	86.53	96.3	96.3
Estonia	16.37	24.51	18.54	49.78	86.53	96.3	96.3
Finland	16.37	24.51	18.54	49.78	86.53	96.3	96.3
France	16.37	24.51	18.54	49.78	86.53	96.3	96.3
Faroe Islands							
United Kingdom	16.37	24.51	18.54	49.78	98.99	88.13	88.13
Georgia							
Gibraltar							
Greece	16.37	24.51	18.54	49.78	86.53	96.3	96.3
Greenland							
Croatia							
Hungary	16.37	24.51	18.54	49.78	86.53	96.3	96.3
Isle of Man							
Ireland	16.37	24.51	18.54	49.78	86.53	96.3	96.3
Iceland	16.37	24.51	18.54	49.78	86.53	96.3	96.3
Italy	16.37	24.51	18.54	49.78	86.53	96.3	96.3
Kazakhstan			1.112	1.177	1.081	1.125	1.125

The bridge between these data and the previously existing features of emissions accountability is built through calculation modules; the latter are necessary to enable and support allowances management and transform greenhouse gas (GHG) emissions allowances into tangible costs.

A first module has been developed to support allowances management at country level; in this instance, its logic is illustrated with France.

7 As a continuity of step 6, in the seventh step the module retrieves the total greenhouse gas (GHG) emissions accounted for facilities operating in France. The user immediately has an overview of the total carbon emissions for a specific year (Fig. 4.3).

Figure 4.3: Step 7 - Total GHG Emissions by Country



	FY18	FY19	FY20	FY21	FY22	FY23	FY24
ETS in Place?	☑	☑	☑	☑	☑	☑	☑
Total GHG Emissions	88.02	213.6	204.3	314.6	314.6	264.7	0
Free Allowances	50	40	40	40	40	0	0
Purchases							
Auctioned Allowances	100	220	210	320	320	0	0
Purchases - Allowances Price	16.37	24.51	18.54	49.78	86.53	96.3	96.3
Override Purchasing Price?	☐	☐	☐	☐	☐	☐	☐
Purchases - Input Updated Price	0	0	0	0	0	0	0
Purchases - Final Price	16.37	24.51	18.54	49.78	86.53	96.3	96.3
Allowances Costs	1,637	5,391	3,893	15,929	27,688	0	0
Sales							
Sold Allowances	5	5	4	4	4	0	0
Sales - Allowances Price	16.37	24.51	18.54	49.78	86.53	96.3	96.3
Override Selling Price?	☐	☐	☐	☐	☐	☐	☐
Sales - Input Updated Price	0	0	0	0	0	0	0
Sales - Final Price	16.37	24.51	18.54	49.78	86.53	96.3	96.3
Allowances Revenue	81.83	122.5	74.15	199.1	346.1	0	0
Traded Allowances	95	215	206	316	316	0	0
Final Allowances	145	255	246	356	356	0	0
ETS Profit	81.83	122.5	74.15	199.1	346.1	0	0
ETS Loss	-1,555	-5,269	-3,819	-15,730	-27,342	0	0

8 As step eight, the user can input the freely granted allowances allocated to the French subsidiary. In this case, France is allocated 50 metric tons of CO_2e (Fig. 4.4).

9 As step nine the user can manage, through the module, the purchasing and selling dynamics of allowances. In other words, if the France subsidiary fails to comply to freely allocated allowances, additional allowances must be bought directly from the trading market. On the contrary, if too many allowances are available, the user can sell the latter. Calculations are made

using the yearly annual price but the ability to override this price with updated data is available. In this specific case the user purchases 220 metric tons of CO_2e using the annual yearly price (Fig. 4.5) and sells 5 metric tons of CO_2e using a higher price of $98 per metric ton of CO_2e (Fig. 4.6). The module finally calculates the total loss or profit resulting from those dynamics.

Figure 4.4: Step 8 - Input of Free Allowances

INP. ETS Allowances by Country Scenario 1 ▾ France ▾

	FY18	FY19	FY20	FY21	FY22	FY23	FY24
ETS in Place?	☑	☑	☑	☑	☑	☑	☑
Total GHG Emissions	88.02	213.6	204.3	314.6	314.6	264.7	0
Free Allowances	50	40	40	40	40	50	0
Purchases							
Auctioned Allowances	100	220	210	320	320	0	0
Purchases - Allowances Price	16.37	24.51	18.54	49.78	86.53	96.3	96.3
Override Purchasing Price?	☐	☐	☐	☐	☐	☐	☐
Purchases - Input Updated Price	0	0	0	0	0	0	0
Purchases - Final Price	16.37	24.51	18.54	49.78	86.53	96.3	96.3
Allowances Costs	1,637	5,391	3,893	15,929	27,688	0	0
Sales							
Sold Allowances	5	5	4	4	4	0	0
Sales - Allowances Price	16.37	24.51	18.54	49.78	86.53	96.3	96.3
Override Selling Price?	☐	☐	☐	☐	☐	☐	☐
Sales - Input Updated Price	0	0	0	0	0	0	0
Sales - Final Price	16.37	24.51	18.54	49.78	86.53	96.3	96.3
Allowances Revenue	81.83	122.5	74.15	199.1	346.1	0	0
Traded Allowances	95	215	206	316	316	0	0
Final Allowances	145	255	246	356	356	0	0
ETS Profit	81.83	122.5	74.15	199.1	346.1	0	0
ETS Loss	-1,555	-5,269	-3,819	-15,730	-27,342	0	0

Figure 4.5: Step 9 – Input of Purchased Allowances

INP. ETS Allowances by Country Scenario 1 ▾ France ▾

	FY18	FY19	FY20	FY21	FY22	FY23	FY24
ETS in Place?	☑	☑	☑	☑	☑	☑	☑
Total GHG Emissions	88.02	213.6	204.3	314.6	314.6	264.7	0
Free Allowances	50	40	40	40	40	50	0
Purchases							
Auctioned Allowances	100	220	210	320	320	220	0
Purchases - Allowances Price	16.37	24.51	18.54	49.78	86.53	96.3	96.3
Override Purchasing Price?	☐	☐	☐	☐	☐	☐	☐
Purchases - Input Updated Price	0	0	0	0	0	0	0
Purchases - Final Price	16.37	24.51	18.54	49.78	86.53	96.3	96.3
Allowances Costs	1,637	5,391	3,893	15,929	27,688	0	0
Sales							
Sold Allowances	5	5	4	4	4	0	0
Sales - Allowances Price	16.37	24.51	18.54	49.78	86.53	96.3	96.3
Override Selling Price?	☐	☐	☐	☐	☐	☐	☐
Sales - Input Updated Price	0	0	0	0	0	0	0
Sales - Final Price	16.37	24.51	18.54	49.78	86.53	96.3	96.3
Allowances Revenue	81.83	122.5	74.15	199.1	346.1	0	0
Traded Allowances	95	215	206	316	316	0	0
Final Allowances	145	255	246	356	356	50	0
ETS Profit	81.83	122.5	74.15	199.1	346.1	0	0
ETS Loss	-1,555	-5,269	-3,819	-15,730	-27,342	0	0

Figure 4.6: Step 9 – Input of Sold Allowances and Trading Price

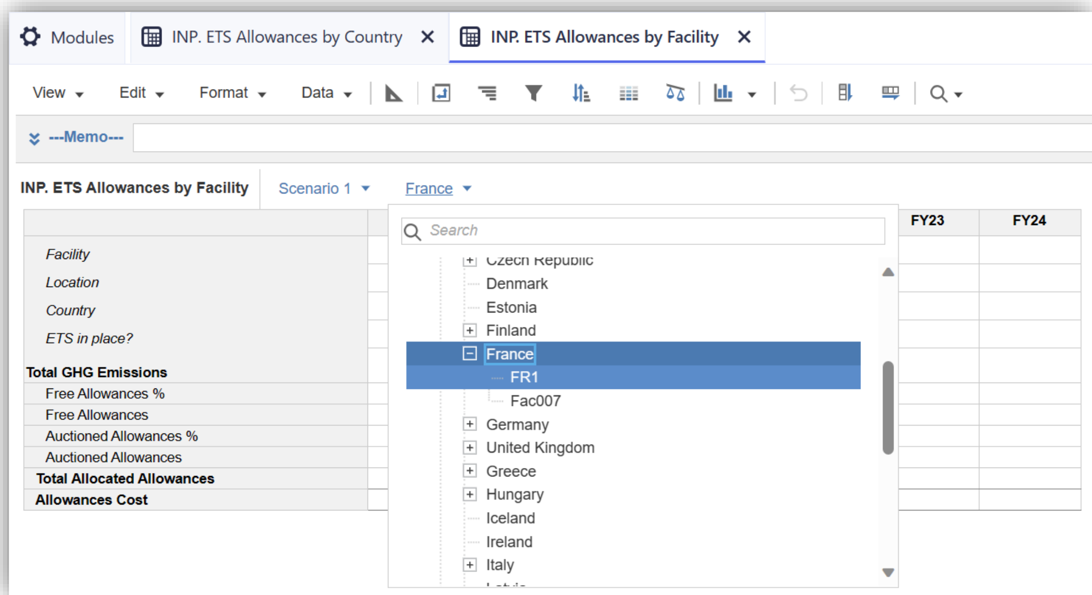
INP. ETS Allowances by Country — Scenario 1 — France

	FY18	FY19	FY20	FY21	FY22	FY23	FY24
ETS in Place?	☑	☑	☑	☑	☑	☑	☑
Total GHG Emissions	88.02	213.6	204.3	314.6	314.6	264.7	0
Free Allowances	50	40	40	40	40	50	0
Purchases							
Auctioned Allowances	100	220	210	320	320	220	0
Purchases - Allowances Price	16.37	24.51	18.54	49.78	86.53	96.3	96.3
Override Purchasing Price?	☐	☐	☐	☐	☐	☐	☐
Purchases - Input Updated Price	0	0	0	0	0	0	0
Purchases - Final Price	16.37	24.51	18.54	49.78	86.53	96.3	96.3
Allowances Costs	1,637	5,391	3,893	15,929	27,688	21,186	0
Sales							
Sold Allowances	5	5	4	4	4	5	0
Sales - Allowances Price	16.37	24.51	18.54	49.78	86.53	96.3	96.3
Override Selling Price?	☐	☐	☐	☐	☐	☑	☐
Sales - Input Updated Price	0	0	0	0	0	98	0
Sales - Final Price	16.37	24.51	18.54	49.78	86.53	98	96.3
Allowances Revenue	81.83	122.5	74.15	199.1	346.1	481.5	0
Traded Allowances	95	215	206	316	316	215	0
Final Allowances	145	255	246	356	356	265	0
ETS Profit	81.83	122.5	74.15	199.1	346.1	481.5	0
ETS Loss	-1,555	-5,269	-3,819	-15,730	-27,342	-20,704	0

Once emissions allowances are managed at national level, and France subsidiary is compliant with regulations in the sense that free and auctioned allowances cover its effective emissions, allowances can also be allocated at facility level. A second module is therefore developed supporting allowances management at facility level.

10 As the next step, the user selects the facility of choice. In this case, facility FR1 that operates in France (Fig. 4.7).

Figure 4.7: Step 10 - Facility Selection



11 As step eleventh, the module retrieves the corresponding amount of greenhouse gas (GHG) emissions for FR1 based on emissions accountability steps that have already been completed (Fig. 4.8).

12 Now, the user allocates a percentage of free available allowances and auctioned allowances managed at country level, to this specific facility. In this case, the user allocated 10% of free allowances to FR1, as well as 45% of auctioned allowances; a total of 101.8 metric tons of CO2 are allocated to the facility. Given the cost of auctioned allowances traded at national level, the costs corresponding to the latter are also calculated for this specific facility (Fig. 4.8).

Figure 4.8: Step 11 & 12 - Allowances Allocation by Facility based on Total GHG Emissions

INP. ETS Allowances by Facility · Scenario 1 · FR1

	FY18	FY19	FY20	FY21	FY22	FY23	FY24
Facility	FR1	FR1	FR1	FR1	FR1	FR1	FR1
Location	France	France	France	France	France	France	France
Country	France	France	France	France	France	France	France
ETS in place?	☑	☑	☑	☑	☑	☑	☑
Total GHG Emissions	71.16	184.7	176.6	294.1	294.1	98.22	0
Free Allowances %	0%	0%	0%	0%	10%	10%	0%
Free Allowances	0	0	0	0	4	5	0
Auctioned Allowances %	0%	0%	0%	0%	93%	45%	0%
Auctioned Allowances	0	0	0	0	293.9	96.75	0
Total Allocated Allowances	0	0	0	0	297.9	101.8	0
Allowances Cost	0	0	0	0	25,750	9,534	0

Results Summary: Greenhouse Gas (GHG) Emissions & Incurred Costs

By utilizing the constructed modules, the model is now capable of effectively implementing carbon reduction policies. This process begins with the accountability of emissions, allowing the model to accurately categorize them by Scope and type, and assign the appropriate taxation rates. Furthermore, the model facilitates the management of emissions allowances under Emissions Trading Systems (ETS) regulations. In both scenarios, the model supports the calculation of costs deriving from greenhouse gas (GHG) emissions regulations, providing a broad understanding of the financial implications stemming from these policies.

Two additional modules have been built to provide a result summary. The first one operates at the national level for each country, while the second one operates at the level of production points, for each facility. Let's once again consider the example of France and of the facility FR1 and break down step by step how these modules work.

Firstly, these two modules check whether the country under consideration or the facility's country under consideration implements an emissions taxation policy and/or an Emissions Trading System (ETS). Taking the case of France as an example, we observe that this country implements both instruments, which is effectively in line with the data collected previously and reported in Appendixes 1 and 2.

Next, the module retrieves the total emissions for each accounted Scope and, by applying the correct taxation price in case of any, calculates the total costs resulting from the latter. Subsequently, based on the total emitted emissions, the model gathers the allowances that have been allocated for free to the country under consideration or the production point under consideration, as well as the allowances that have been purchased, along with the costs associated with it.

The modules consequently display the total costs resulting from emissions taxation policies and from Emissions Trading Systems (ETS). Finally, they calculate the overall costs associated with emissions, or in other words, the total expenses that a company bears because of its pollution.

Figure 4.9: Results Summary by Country

CAL. Carbon Pricing Summary by Country — Scenario 1 ▾ — France ▾

	FY18	FY19	FY20	FY21	FY22	FY23	FY24
Country for Carbon Pricing Policies	France	France	France	France	France	France	France
Region for Carbon Pricing Policy	Europe & Centr	Europe & Centr	Europe & Centr	Europe & Centr	Europe & Centr	Europe & Centr	Europe & Centr
ETS in place?	☑	☑	☑	☑	☑	☑	☑
Carbon Taxing Policy in place?	☑	☑	☑	☑	☑	☑	☑
Carbon Taxes Policies Approach							
Scope 1: Mobile Combustion							
Mobile Combustion Total GHG Emissions	0.003972	0.006687	0.005081	0.002958	0.002958	0.002958	0
Mobile Combustion Total Costs	13.49	9.144	10.41	12.11	11.39	11.21	0
Scope 1: Stationary Combustion							
Stationary Combustion Total GHG Emissions	1.145	11.29	77.22	198.3	198.3	148.4	0
Stationary Combustion Total Costs	92,561	63,214	64,593	147,752	139,022	326,241	0
Scope 1: Refrigerants							
Refrigerants Total GHG Emissions	72.79	174.5	102.7	102.7	102.7	102.7	0
Refrigerants Total Costs	100,397	153,285	80,900	102,851	96,774	95,224	0
Scope 1: Refrigerants, Mobile & Stationary Combu							
Scope 1 Total GHG Emissions	73.94	185.8	179.9	301	301	251.1	0
Scope 1 Total Costs	192,972	216,509	145,503	250,615	235,808	421,476	0
Scope 2: Purchased Electricity							
Scope 2 Total GHG Emissions	13.68	16.62	13.11	2.395	2.395	2.395	0
Scope 2 Total Costs	18,765	0	0	0	0	0	0
Scope 3: Transports							
Scope 3 Total GHG Emissions	0.4048	11.2	11.2	11.2	11.2	11.2	0
Scope 3 Total Costs	20,054	9,087	8,845	9,500	8,938	8,797	0
Total Incurred Costs under Carbon Taxes Policie	231,865	225,781	154,527	260,416	245,047	430,525	0
Emissions Trading Systems Approach							
Total Emissions	88.02	213.6	204.3	314.6	314.6	264.7	0
Free Allowances for GHG Emissions	50	40	40	40	40	50	0
Auctioned Allowances for GHG Emissions	145	255	246	356	356	265	0
Total Incurred Costs under ETS	1,555	5,269	3,819	15,730	27,342	20,704	0
Total Costs for GHG Emissions	233,420	231,050	158,346	276,146	272,389	451,229	0

Figure 4.10: Results Summary by Facility

CAL. Carbon Pricing Summary by Facility — Scenario 1 ▾ — FR1 ▾

	FY18	FY19	FY20	FY21	FY22	FY23	FY24
Facility	FR1	FR1	FR1	FR1	FR1	FR1	FR1
Location	France	France	France	France	France	France	France
Country for Carbon Pricing Policies	France	France	France	France	France	France	France
Subject to ETS?	✓	✓	✓	✓	✓	✓	✓
Subject to Carbon Taxes Policy?	✓	✓	✓	✓	✓	✓	✓
Carbon Taxes Policies Approach							
Scope 1: Mobile Combustion							
Mobile Combustion Total GHG Emissions	0	0	0	0	0	0	0
Mobile Combustion Total Costs	0	0	0	0	0	0	0
Scope 1: Stationary Combustion							
Stationary Combustion Total GHG Emissions	0.2334	11.29	76.12	195.9	195.9	0	0
Stationary Combustion Total Costs	46,281	31,607	32,296	73,876	69,511	0	0
Scope 1: Refrigerants							
Refrigerants Total GHG Emissions	70.93	173.4	100.5	98.22	98.22	98.22	0
Refrigerants Total Costs	75,298	114,964	60,675	77,138	72,581	71,418	0
Scope 2: Purchased Electricity							
Purchased Electricity Total GHG Emissions	0	0	0	0	0	0	0
Purchased Electricity Total Costs	0	0	0	0	0	0	0
Total Incurred Costs under Carbon Taxes Policie	121,579	146,571	92,971	151,014	142,092	71,418	0
Emissions Trading Systems Approach							
Total GHG Emissions	71.16	184.7	176.6	294.1	294.1	98.22	0
Free Allowances for GHG Emissions	0	0	0	0	4	5	0
Purchased Allowances for GHG Emissions	0	0	0	0	293.9	96.75	0
Total Incurred Costs under ETS	0	0	0	0	25,750	9,534	0
Total Costs for GHG Emissions	121,579	146,571	92,971	151,014	167,842	80,952	0

2.4. Economic Impact & Model Construction: The Literature Review

The results obtained with these Anaplan modules support the idea that greenhouse gas emissions indeed constitute a tangible and inherent cost for a company. Their impact cannot be ignored; rather, it should be internalized.

In line with existing literature, particularly highlighted by Safiullah, Kabir, and Miah (2021), the results emphasize that companies with high carbon emissions face increased regulatory scrutiny, leading to stringent rules and compliance obligations related to carbon emissions. In the context of emissions taxation policies, as the pricing for emissions increases, the costs incurred by companies will also escalate if emission reduction measures are not implemented. Moreover, within Emissions Trading Systems (ETS), countries steadily reduce the allowances to align with sustainability targets, causing prices in emissions markets to rise progressively. It is crucial for companies to adapt their emissions in accordance with allocated allowances; otherwise, the necessity for additional, expensive allowances becomes inevitable. This results in additional expenses such as compliance costs, carbon management expenses, and costs associated with reputational damages. These supplementary costs contribute to heightened uncertainty in cash flows, potentially impacting the financial stability and profitability of carbon-intensive firms.

In finer detail, the actual costs linked to greenhouse gas (GHG) emissions have been integrated into the income statement, acknowledging them as authentic and inherent expenses within the financial reporting. To enhance transparency and visibility, a dedicated module has been developed. This module serves the purpose of visualizing the income statement, specifically showcasing, and detailing the costs associated with carbon emissions under each country's regulation. This ensures a complete representation of the financial impact of emissions on the overall financial performance of the company (Fig. 5.1).

Figure 5.1: Income Statement by Function

OUT. Income Statement by Function by Country Scenario 1 ▾ France ▾

	FY18	FY19	FY20	FY21	FY22	FY23	FY24
Country for Carbon Pricing	France	France	France	France	France	France	France
Region for Carbon Pricing	Europe & Centr	Europe & Centr	Europe & Centr	Europe & Centr	Europe & Centr	Europe & Centr	Europe & Centr
Total GHG Emissions	88.02	213.6	204.3	314.6	314.6	264.7	0
Revenues	350,000	356,789	368,475	400,123	450,982	681,732	0
Cost of Goods Sold	-20,000	-26,371	-30,287	-50,938	-51,425	-60,394	0
Gross Profit	330,000	330,418	338,188	349,185	399,557	621,338	0
Other Operating Profit	40,000	43,526	45,768	50,928	51,637	50,987	0
Other Operating Expenses	-20,000	-24,365	-23,647	-27,564	-30,758	-34,523	0
Administrative Expenses	-15,000	-16,724	-17,485	-18,354	-18,987	-20,465	0
Marketing Expenses	-11,784	-11,789	-13,425	-13,987	-15,648	-20,847	0
Distribution Expenses	-7,254	-8,234	-8,987	-10,324	-9,876	-11,425	0
General Expenses	-12,546	-13,987	-15,625	-14,536	-15,678	-16,749	0
GHG Emissions Expenses	230,310	220,513	150,709	244,685	217,705	409,821	0
ETS Allowances Cost	1,637	5,391	3,893	15,929	27,688	21,186	0
ETS Allowances Revenues	81.83	122.5	74.15	199.1	346.1	481.5	0
ETS Allowances Profit / Loss	-1,555	-5,269	-3,819	-15,730	-27,342	-20,704	0
S1: Pricing for Stationary Combustion	92,561	63,214	64,593	147,752	139,022	326,241	0
S1: Pricing for Mobile Combustion	13.49	9.144	10.41	12.11	11.39	11.21	0
S1: Pricing for Refrigerants	100,397	153,285	80,900	102,851	96,774	95,224	0
S2: Pricing for Purchased Electricity	18,765	0	0	0	0	0	0
S3: Pricing for Transports	20,054	9,087	8,845	9,500	8,938	8,797	0
Carbon Taxes Regulations	231,865	225,781	154,527	260,416	245,047	430,525	0
Credit Risk Price	0	0	0	0	0	0	0
Other GHG Emissions Expenses	0	0	0	0	0	0	0
EBIT	73,106	78,332	154,078	70,663	142,542	158,495	0

With a higher granularity, this module establishes a direct nexus between data pertaining to the accountability of greenhouse gas (GHG) emissions and its consequential costs on the one hand, and, on the other hand, the financial data of the company. Its aim is therefore to integrate the latter thereby recreating annual results within the model, adding a new entry to the income statement: the total expenses resulting from greenhouse gas (GHG) emissions. Currently reliant on manual data input, the envisioned path consists of the integration of the current model features into the financial management framework. This approach not only enhances transparency but also provides a concrete view of all the expenses borne by the company using it, including those associated with greenhouse gas (GHG) emissions, supporting a holistic financial management strategy.

With the establishment of the income statement and the incorporation of financial data, the focus now shifts concretely towards financial indicators. These model's enhancements integrate the research insights provided particularly by Trinks, Mulder, and Scholtens (2020), Van Emous, Krušinskas, and Westerman (2021), and Miah, Hasan, and Usman (2021), and comprises:

- ***Return on Assets (ROA)***: Calculated by dividing the company's Net Profit by its Total Assets, the Return on Assets (ROA) is a profitability ratio that measures a company's efficiency in generating profits from its assets. While a rising Return on Assets (ROA) often indicates improved operational efficiency and profitability, a lower value may suggest inefficiency in asset utilization or declining profitability. Given the scale of the costs associated with greenhouse gas (GHG) emissions and their increasing trend over time, such costs could undermine profitability through a reduction in Net Profit.
- ***Return on Equity (ROE)***: Return on Equity (ROE) is a financial metric that measures the profitability of a company in relation to its shareholders' equity; it indicates how efficiently a company utilizes its equity to generate profits, a measure often used by investors. Calculated by dividing the Net Profit of the company by its Shareholders' Equity over a specific period, this indicator could be impacted by rising greenhouse gas (GHG) emissions expenses through a decrease in Net Profit.
- ***Return on Sales (ROS)***: Also known as profit margin, Return on Sales (ROS) is a financial metric that measures the profitability of a company in relation to its Revenue. It represents the portion of Revenue that translates into Operating Profit after deducting operating expenses, in this case embedding costs resulting from greenhouse gas (GHG)emissions. Once again, a rise in those costs due to more stringent regulations over time may have a negative impact on this indicator. A lower value would suggest that a bigger portion of revenue is consumed by operating expenses, potentially impacting the overall profitability.
- ***Net Profit Margin***: This indicator assesses a company's profitability by measuring the percentage of Net Profit generated from its total Revenue. It measures how efficiently a company converts its sales into profits after considering all expenses, including operating costs, interests, taxes and, in our

model, expenses resulting from greenhouse gas (GHG) emissions. As those expenses increase over time, a bigger portion of revenue is consumed, not translating into Net Profit anymore, causing this indicator to fall.

- ***Earnings per Share***: Widely used by investors, Earnings per Share represents the portion of a company's profit allocated to each outstanding share. In other words, it provides insight into how much profit a company is generating on a per-share basis. Calculated by dividing the Net Profit by the number of shares during a specific fiscal year, this indicator can, in turn, be impacted by a rising emissions' cost through Net Profit.

Thus, another module is built in the model to calculate each of these indicators based on the financial data sourced from the income statement (Fig. 5.2).

Figure 5.2: Financial Indicators

CAL. Financial Indicators - Copy | Scenario 1 | France

	FY18	FY19	FY20	FY21	FY22	FY23	FY24
Total GHG Emissions Costs	230,310	220,513	150,709	244,685	217,705	409,821	0
Total GHG Emissions	88.02	213.6	204.3	314.6	314.6	264.7	0
Net Profit	47,519	50,916	100,151	45,931	92,652	103,022	0
Shareholders' Equity	400,000	452,756	420,987	509,384	514,362	565,427	0
Revenues	350,000	356,789	368,475	400,123	450,982	681,732	0
EBIT	73,106	78,332	154,078	70,663	142,542	158,495	0
Total Assets	1,000,000	1,657,382	2,095,820	2,456,345	2,564,536	2,874,637	0
Shares and Convertible Options	459,147	576,920	591,081	622,635	627,732	668,619	0
ROE	11.9%	11.2%	23.8%	9.02%	18%	18.2%	0%
ROA	7.31%	4.73%	7.35%	2.88%	5.56%	5.51%	0%
ROS	15.2%	17.1%	37.6%	17.7%	31.6%	24.6%	0%
Net Profit Margin	13.6%	14.3%	27.2%	11.5%	20.5%	15.1%	0%
Earnings Per Share	10.3%	8.83%	16.9%	7.38%	14.8%	15.4%	0%

To summarize, significant improvements have been incorporated into the initial version of the model supporting emissions accountability. Firstly, the model has been updated to encompass data modules that hold information concerning carbon reduction instruments implemented worldwide. Specifically, for carbon taxation policies, the model adeptly categorizes emissions and applies the appropriate taxation prices. On the other hand, in the case of Emissions Trading Systems (ETS), the model seamlessly manages all aspects related to allowances, including their administration both at national and at facilities levels.

In both scenarios, the model calculates the resultant costs arising from greenhouse gas (GHG) emissions. Following this calculation, a financial dimension is introduced through an inclusive income statement, which incorporates the previously computed costs. These financial outcomes are subsequently leveraged to derive financial indicators, providing a representation of the overall financial health of the company. This multifaceted approach ensures a complete and integrated framework for evaluating the economic impact of greenhouse gas emissions on the company's financial performance.

3 Greenhouse Gas Emissions: An Anaplan App

The last chapter of this thesis presents the obtained results, effectively showcasing the economic impact of greenhouse gas (GHG) emissions through the utilized tool. This section particularly highlights the interfaces now integrated into the application offered by Profit&, encompassing the greenhouse gas (GHG) emissions economic impact and the financial analysis resulting from it. Subsequently, a potential deployment of the solution is discussed to provide a concrete explanation of how this tool could be commercialized and what would be its added value. Lastly, the limitations of the current model are emphasized, elucidating the current challenges, and outlining the forthcoming improvements.

3.1. Results & Deliverables

In the previous methodology section, the focus was primarily on the back-end development. The current section shifts to the front-end, showcasing the results through graphical and interactive interfaces supported by the software. This part effectively introduces the product itself — what is presented to the client and what would be used, in practice.

It is worth highlighting that, in the context of this thesis, only the outcomes derived from the development concerning the economic impact aspect are showcased. For a prospective client expressing interest, the complete model is made available, encompassing the intricate emissions accounting component, which stands as a substantial portion of the overall product.

The interfaces showcased below adhere to the logical navigation sequence designed for a potential user. To start, the user lands on a homepage supporting the navigation between the several pages of the model (Fig. 6.1).

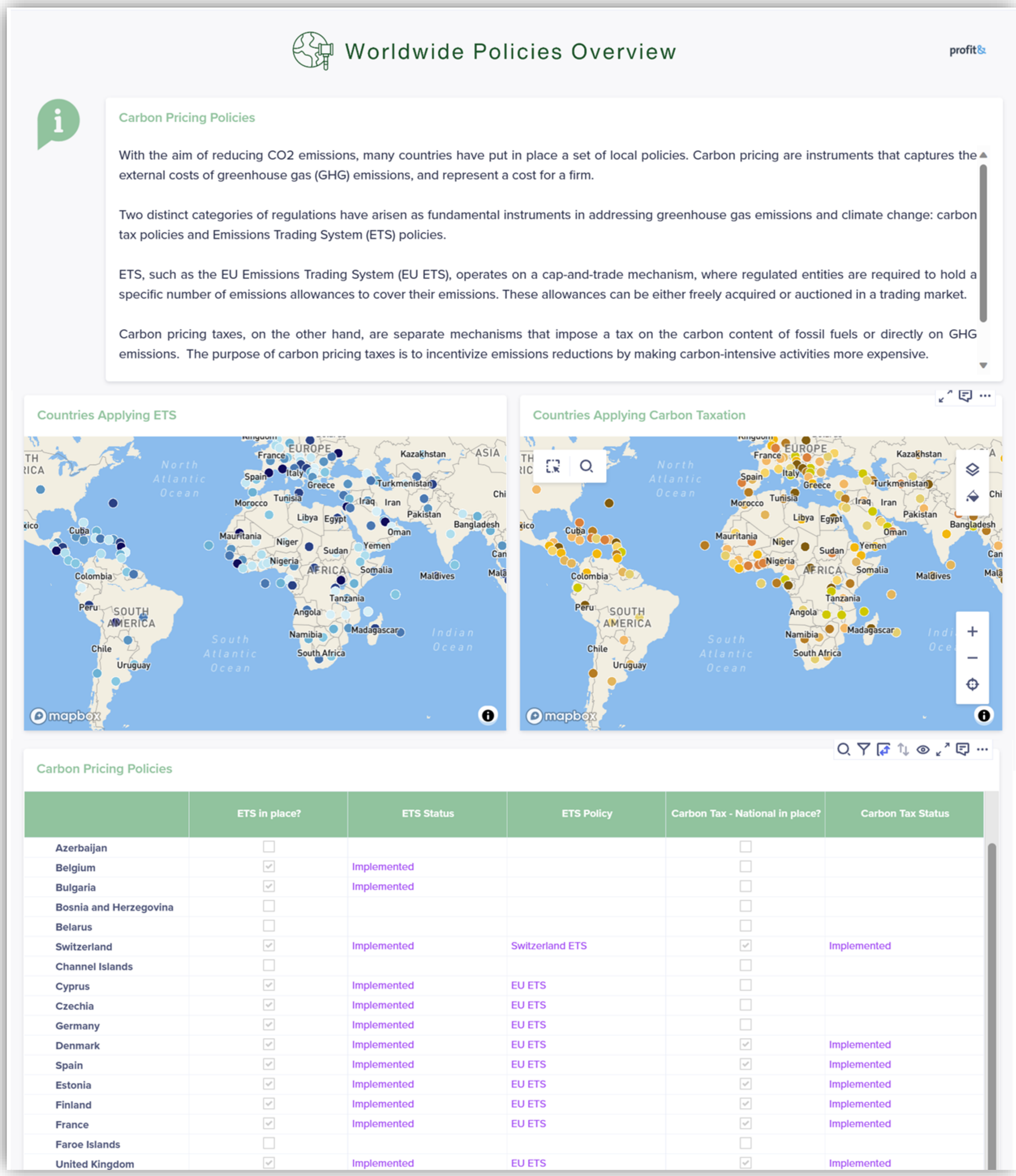
Figure 6.1: Home Page

The page titled ***Worlwide Policies Overview*** (Fig. 6.2) provides the user with a global outline of the policies implemented for carbon emissions reduction. Two map charts evidence the countries' differences in regulations; on the left, countries applying carbon taxation policies are highlighted wile, on the right, countries having implemented an Emissions Trading System (ETS) are displayed. Then, a grid provides a country-by-country insights with the implementation year of each policy, as well as the status of the latter that ranges from "In Consideration", to "Scheduled", to "Implemented".

For a higher granularity, the two following pages titled ***Carbon Taxing Policy*** (Fig. 6.3) and ***Emissions Trading System*** (Fig. 6.4) allow the user to go into more details about each regulation.

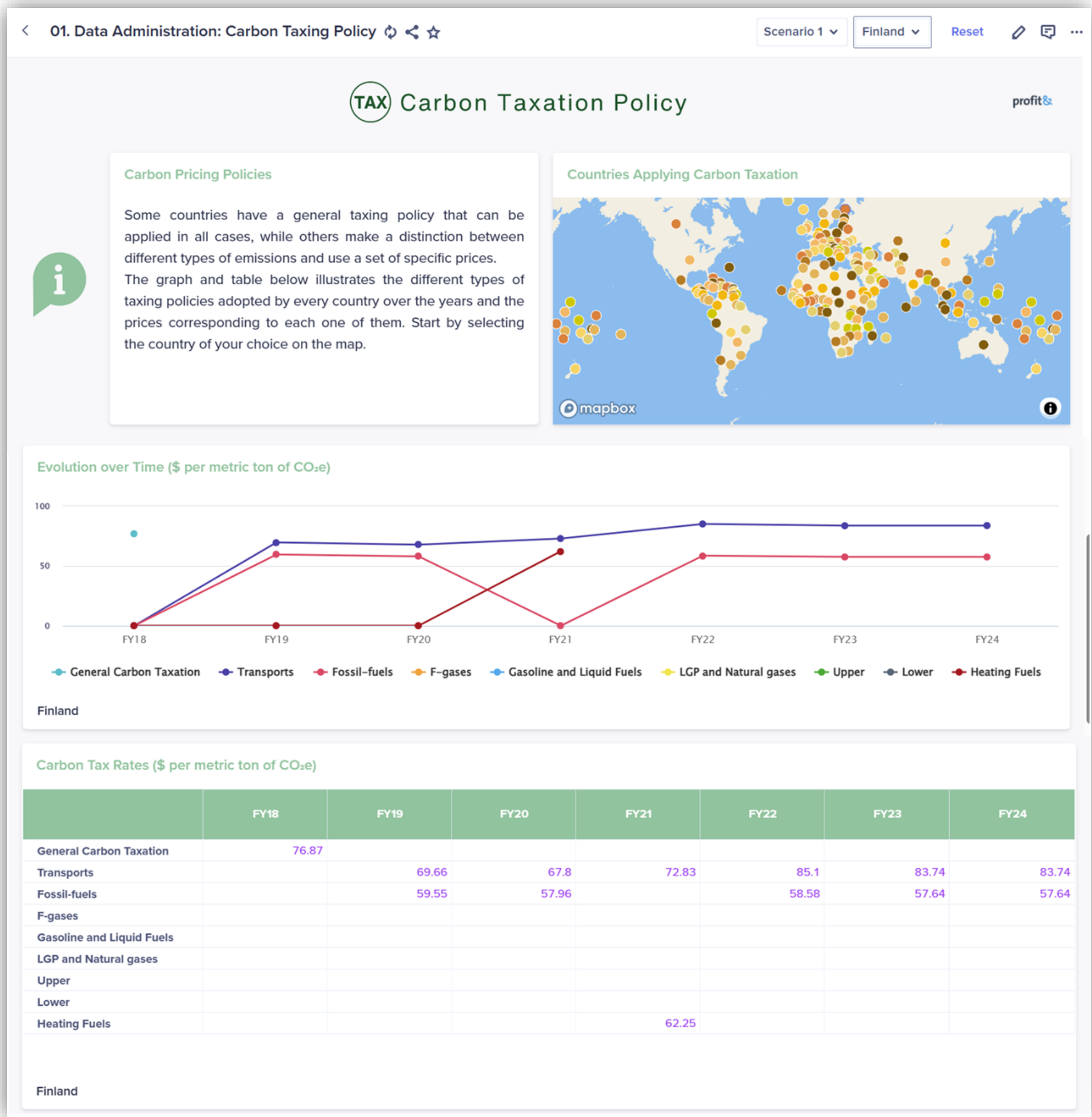
As for the ***Carbon Taxation Policy*** page, data on the different taxation prices in place is presented, as well as a graph showing how these prices have been evolving over time. Also, the page focusing on the ***Emissions Trading Systems***, provides both tabular and graphical views of the allowances allocated to each country as well as the allowances trading price over time.

Figure 6.2: Worldwide Policies Overview Interface



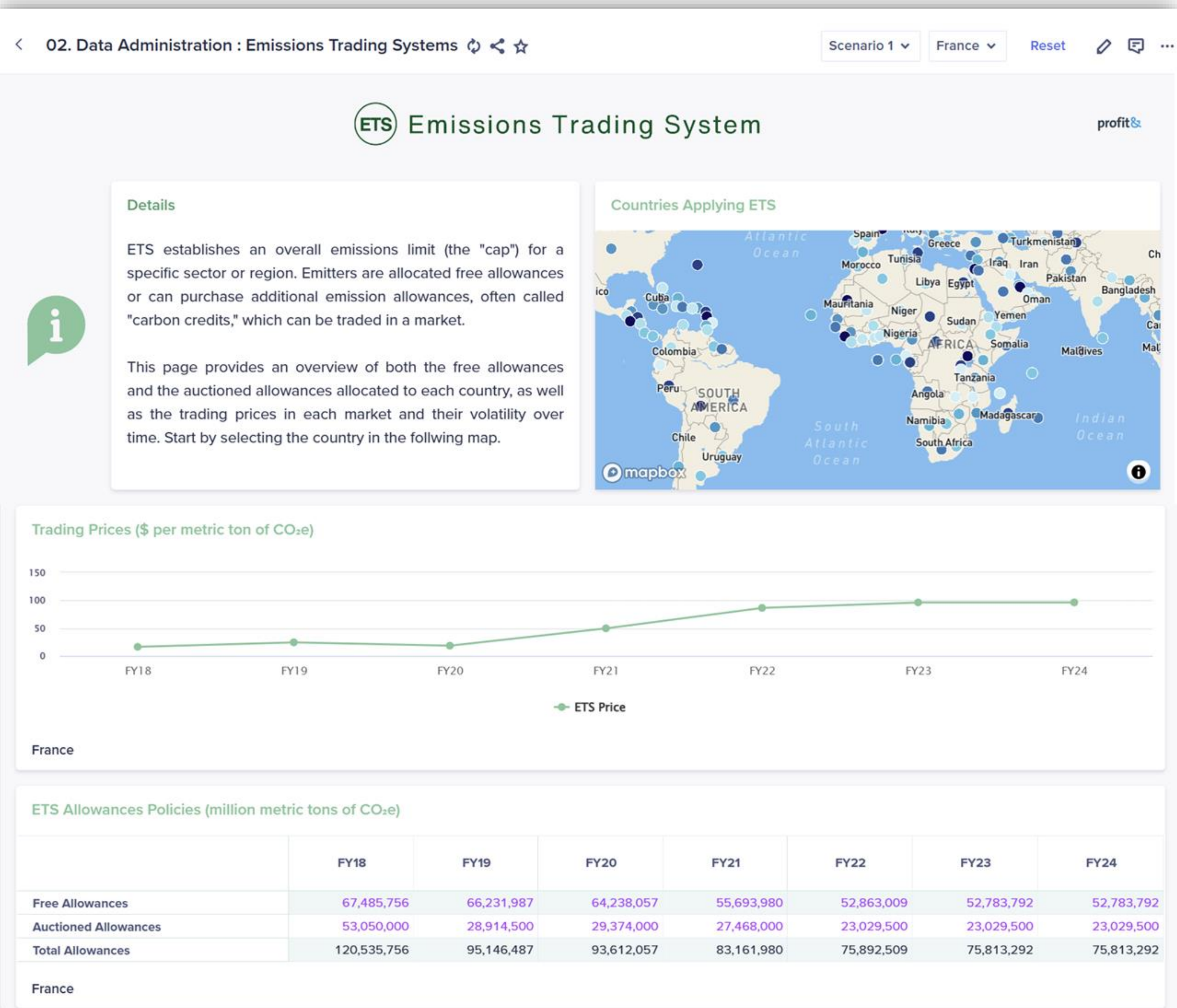
	ETS in place?	ETS Status	ETS Policy	Carbon Tax - National in place?	Carbon Tax Status
Azerbaijan	☐			☐	
Belgium	☑	Implemented		☐	
Bulgaria	☑	Implemented		☐	
Bosnia and Herzegovina	☐			☐	
Belarus	☐			☐	
Switzerland	☑	Implemented	Switzerland ETS	☑	Implemented
Channel Islands	☐			☐	
Cyprus	☑	Implemented	EU ETS	☐	
Czechia	☑	Implemented	EU ETS	☐	
Germany	☑	Implemented	EU ETS	☐	
Denmark	☑	Implemented	EU ETS	☑	Implemented
Spain	☑	Implemented	EU ETS	☑	Implemented
Estonia	☑	Implemented	EU ETS	☑	Implemented
Finland	☑	Implemented	EU ETS	☑	Implemented
France	☑	Implemented	EU ETS	☑	Implemented
Faroe Islands	☐			☐	
United Kingdom	☑	Implemented	EU ETS	☑	Implemented

Figure 6.3: Carbon Taxation Policy Interface



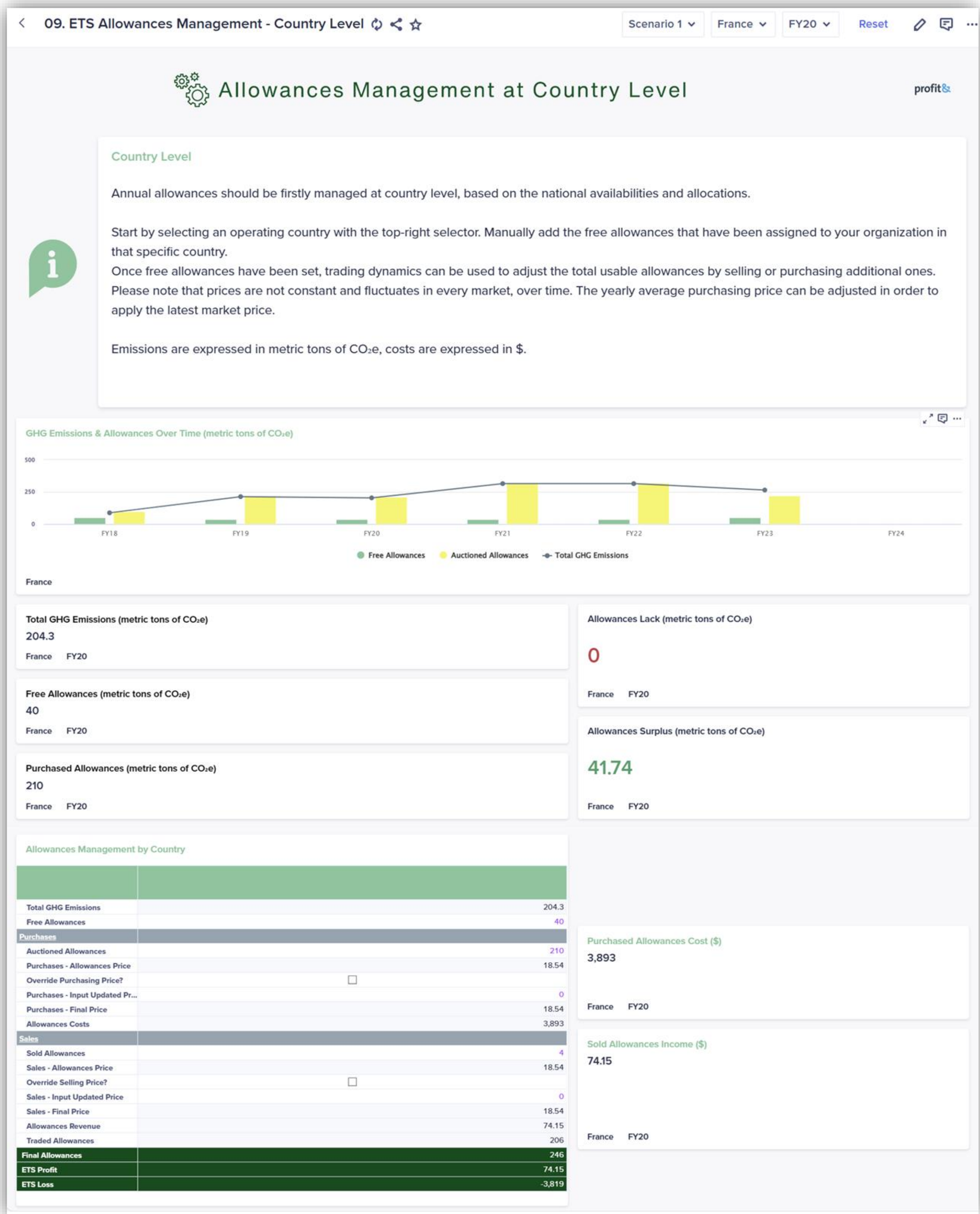
	FY18	FY19	FY20	FY21	FY22	FY23	FY24
General Carbon Taxation	76.87						
Transports		69.66	67.8	72.83	85.1	83.74	83.74
Fossil-fuels		59.55	57.96		58.58	57.64	57.64
F-gases							
Gasoline and Liquid Fuels							
LGP and Natural gases							
Upper							
Lower							
Heating Fuels				62.25			

Figure 6.4: Emissions Trading System Interface



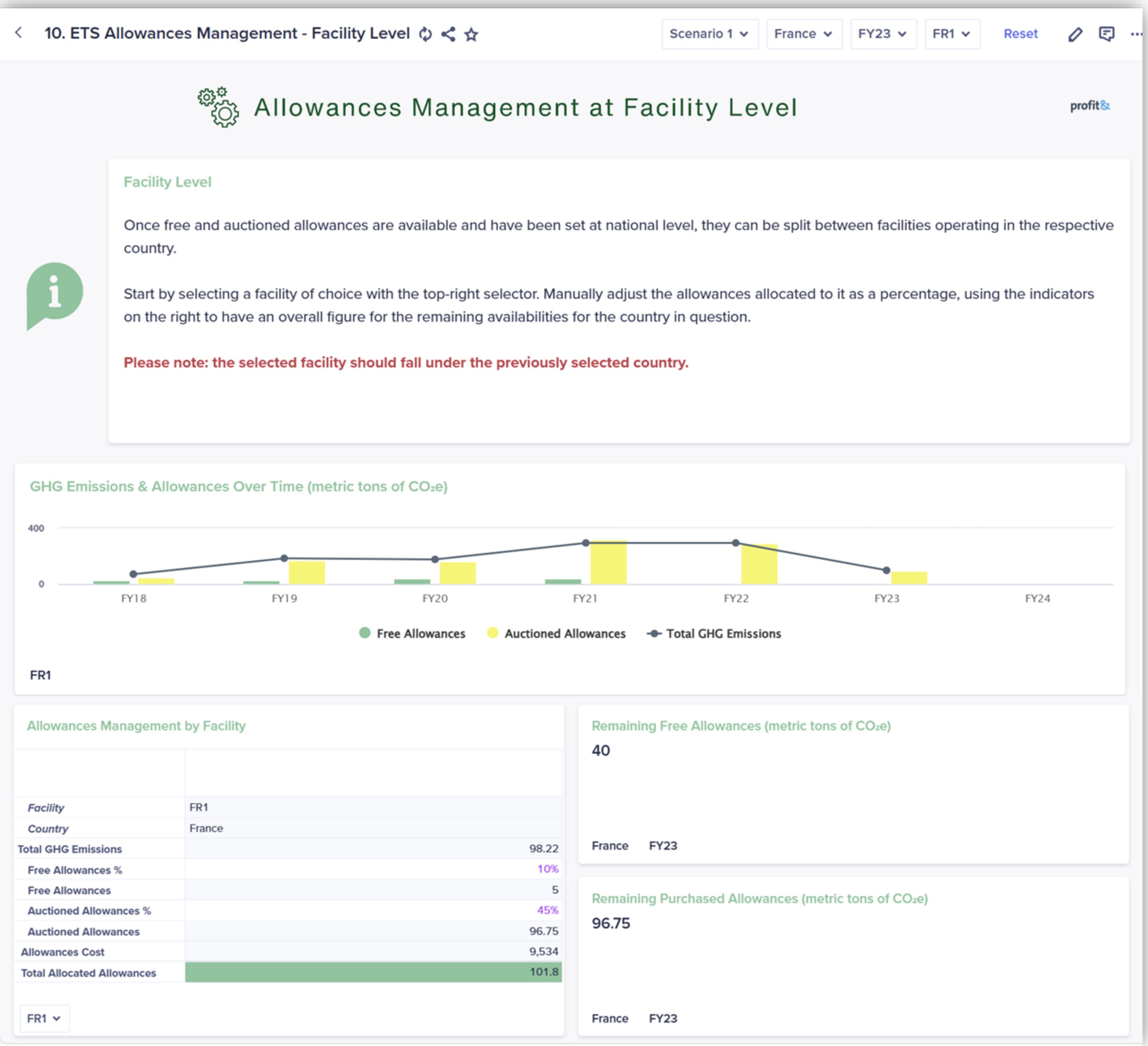
The next two pages are used to manage allowances under Emissions Trading Systems (ETS) as explained in the methodology, this time more interactively and with simpler interfaces. The page titled ***Allowances Management at Country Level*** (Fig. 6.5) enables user to efficiently oversee their allowances through an intuitive interface. Several key performance indicators (KPIs) display important data such as the total emissions for the chosen country, selectable with the top-right selector. Two additional indicators present the available allowances, distinguishing between those obtained freely and those auctioned. The use of color in two other KPIs serves to highlight any surplus or deficit of allowances, capturing the user's attention.

Figure 6.5: Allowances Management at Country Level Interface



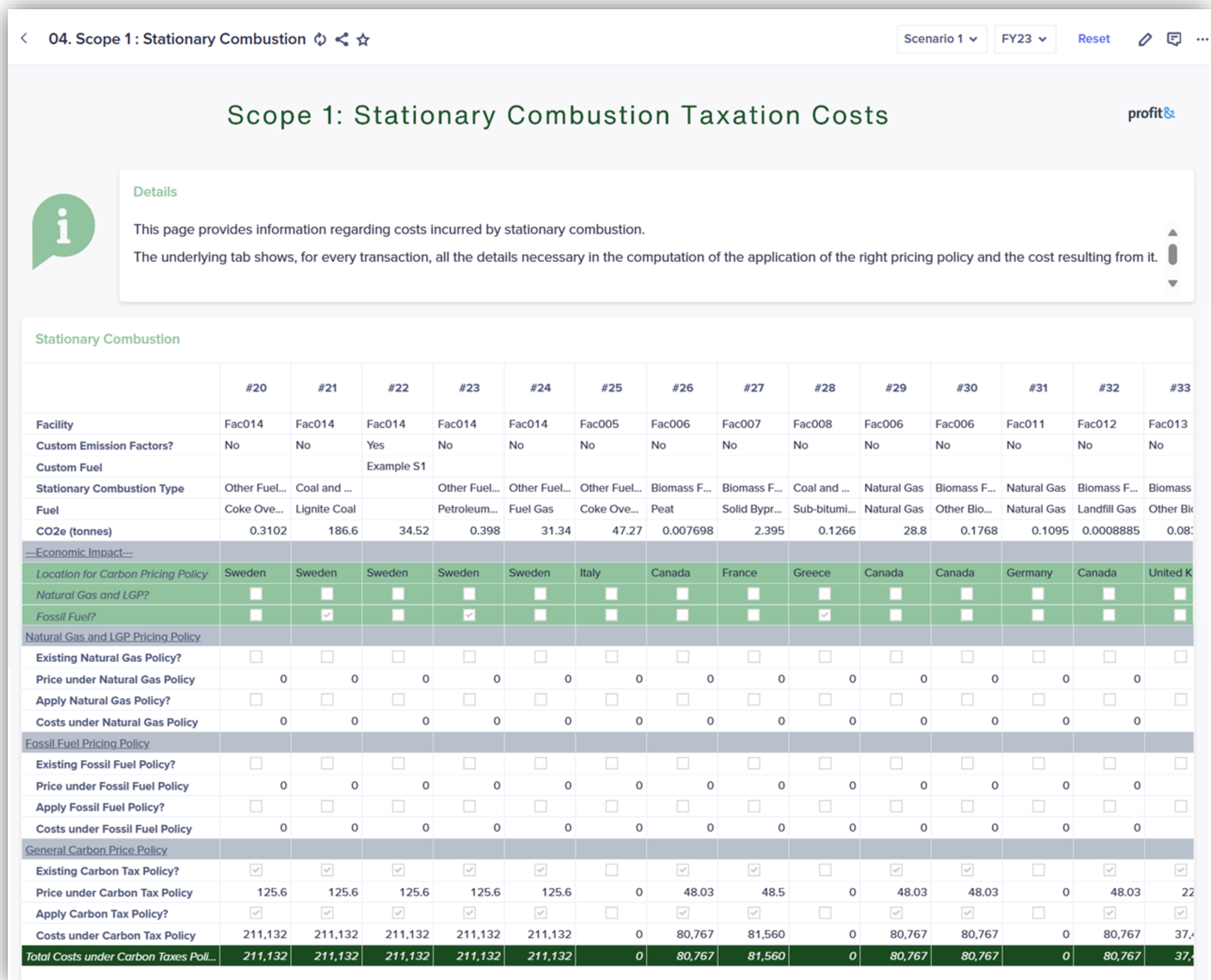
The subsequent page, ***Allowances Management at Facility Level*** (Fig. 6.6), is intricately linked to the prior one. This interface facilitates allowances management at the facility level. Here, users can allocate a percentage of both free and auctioned allowances, originally available at the country level, to a specific facility through an interactive grid. A graphical representation illustrates how emissions are covered by allowances over time. Additionally, two key performance indicators (KPIs) streamline the allocation process by providing a clear display of the remaining allowances available for distribution.

Figure 6.6: Allowances Management at Facility Level Interface



If the user is overseeing a country with an established carbon taxation policy, the subsequent page, titled ***Scope 1: Stationary Combustion Taxation Costs*** (Fig. 6.7), offers an overview of how the model employs these carbon taxation policies to correctly apply them to accounted emissions. While pages supporting emission accountability are accessible to the user, they are not displayed here as they fall outside the current thesis scope. Following the completion of this accountability process, the model, through the subsequent page, computes the corresponding costs by applying the correct carbon taxation price. The displayed page pertains specifically to stationary combustion emissions, but analogous pages are available to the user for each scope category.

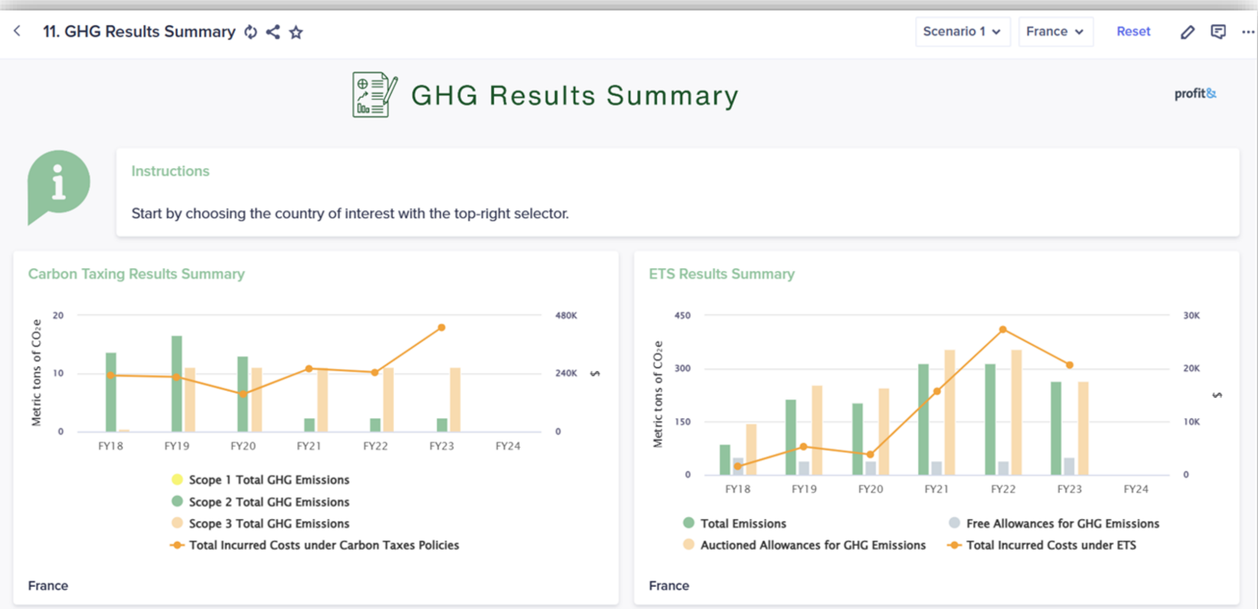
Figure 6.7: Scope 1 - Stationary Combustion Taxation Costs



	#20	#21	#22	#23	#24	#25	#26	#27	#28	#29	#30	#31	#32	#33
Facility	Fac014	Fac014	Fac014	Fac014	Fac014	Fac005	Fac006	Fac007	Fac008	Fac006	Fac006	Fac011	Fac012	Fac013
Custom Emission Factors?	No	No	Yes	No	No	No	No	No	No	No	No	No	No	No
Custom Fuel			Example S1											
Stationary Combustion Type	Other Fuel...	Coal and ...		Other Fuel...	Other Fuel...	Other Fuel...	Biomass F...	Biomass F...	Coal and ...	Natural Gas	Biomass F...	Natural Gas	Biomass F...	Biomass
Fuel	Coke Ove...	Lignite Coal		Petroleum...	Fuel Gas	Coke Ove...	Peat	Solid Bypr...	Sub-bitumi...	Natural Gas	Other Bio...	Natural Gas	Landfill Gas	Other Bi
CO2e (tonnes)	0.3102	186.6	34.52	0.398	31.34	47.27	0.007698	2.395	0.1266	28.8	0.1768	0.1095	0.0008885	0.08
---Economic Impact---														
Location for Carbon Pricing Policy	Sweden	Sweden	Sweden	Sweden	Sweden	Italy	Canada	France	Greece	Canada	Canada	Germany	Canada	United K
Natural Gas and LGP?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Fossil Fuel?	☐	☑	☐	☑	☐	☐	☐	☐	☑	☐	☐	☐	☐	☐
Natural Gas and LGP Pricing Policy														
Existing Natural Gas Policy?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Price under Natural Gas Policy	0	0	0	0	0	0	0	0	0	0	0	0	0	
Apply Natural Gas Policy?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Costs under Natural Gas Policy	0	0	0	0	0	0	0	0	0	0	0	0	0	
Fossil Fuel Pricing Policy														
Existing Fossil Fuel Policy?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Price under Fossil Fuel Policy	0	0	0	0	0	0	0	0	0	0	0	0	0	
Apply Fossil Fuel Policy?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Costs under Fossil Fuel Policy	0	0	0	0	0	0	0	0	0	0	0	0	0	
General Carbon Price Policy														
Existing Carbon Tax Policy?	☑	☑	☑	☑	☑	☐	☑	☑	☐	☑	☑	☐	☑	☑
Price under Carbon Tax Policy	125.6	125.6	125.6	125.6	125.6	0	48.03	48.5	0	48.03	48.03	0	48.03	22
Apply Carbon Tax Policy?	☑	☑	☑	☑	☑	☐	☑	☑	☐	☑	☑	☐	☑	☑
Costs under Carbon Tax Policy	211,132	211,132	211,132	211,132	211,132	0	80,767	81,560	0	80,767	80,767	0	80,767	37,
Total Costs under Carbon Taxes Poli...	*211,132*	*211,132*	*211,132*	*211,132*	*211,132*	*0*	*80,767*	*81,560*	*0*	*80,767*	*80,767*	*0*	*80,767*	*37,*

Having applied the emissions price associated with taxation policies and ensuring proper management of allowance trades under Emissions Trading Systems (ETS), the model now calculates and presents the total costs related to greenhouse gas emissions through the page titled ***GHG Results Summary*** (Fig. 6.8). For the selected country, users gain an overview of accounted emissions along with costs arising from both emissions' reduction instruments. The left graph displays carbon taxation costs by scope over time, while the right graph illustrates costs related to Emissions Trading Systems (ETS). A grid provides detailed results, showcasing the total costs under carbon taxation policy, the total costs under Emissions Trading Systems (ETS), and ultimately, the overall expenses stemming from greenhouse gas (GHG) emissions.

Figure 6.8: GHG Results Summary Overview



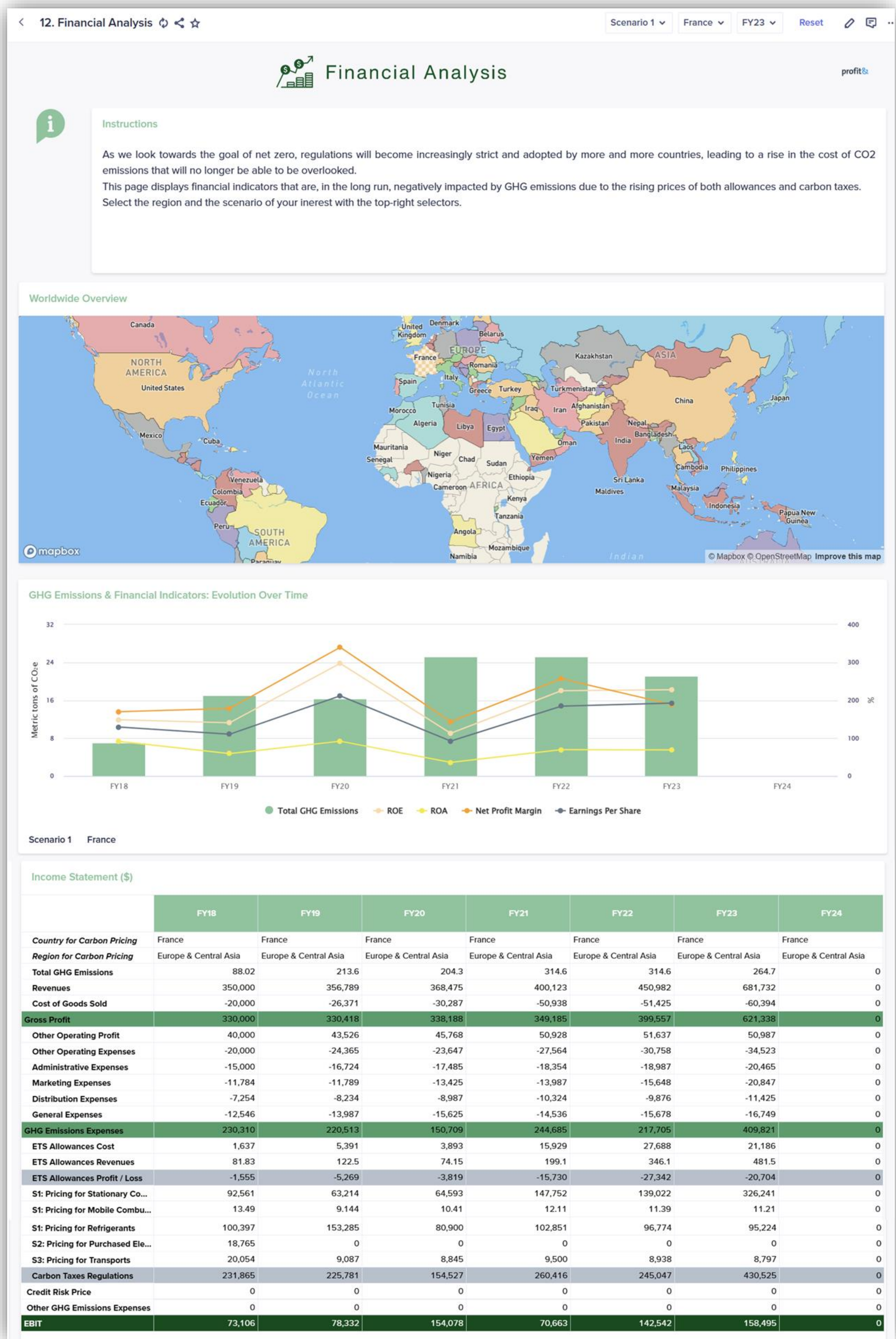
Emissions (metric tons of CO_2e) & Costs ($) Summary

	FY18	FY19	FY20	FY21	FY22	FY23	FY24
Carbon Taxes Policies Approach							
Scope 1: Mobile Combustion							
Mobile Combustion Total GH...	0.003972	0.006687	0.005081	0.002958	0.002958	0.002958	0
Mobile Combustion Total Costs	13.49	9.144	10.41	12.11	11.39	11.21	0
Scope 1: Stationary Combustion							
Stationary Combustion Total ...	1.145	11.29	77.22	198.3	198.3	148.4	0
Stationary Combustion Total ...	92,561	63,214	64,593	147,752	139,022	326,241	0
Scope 1: Refrigerants							
Refrigerants Total GHG Emiss...	72.79	174.5	102.7	102.7	102.7	102.7	0
Refrigerants Total Costs	100,397	153,285	80,900	102,851	96,774	95,224	0
Scope 1: Refrigerants, Mobile ...							
Scope 1 Total GHG Emissions	73.94	185.8	179.9	301	301	251.1	0
Scope 1 Total Costs	192,972	216,509	145,503	250,615	235,808	421,476	0
Scope 2: Purchased Electricity							
Scope 2 Total GHG Emissions	13.68	16.62	13.11	2.395	2.395	2.395	0
Scope 2 Total Costs	18,765	0	0	0	0	0	0
Scope 3: Transports							
Scope 3 Total GHG Emissions	0.4048	11.2	11.2	11.2	11.2	11.2	0
Scope 3 Total Costs	20,054	9,087	8,845	9,500	8,938	8,797	0
Total Incurred Costs under Car...	231,865	225,781	154,527	260,416	245,047	430,525	0
Emissions Trading Systems Ap...							
Total Emissions	88.02	213.6	204.3	314.6	314.6	264.7	0
Free Allowances for GHG Em...	50	40	40	40	40	50	0
Auctioned Allowances for GH...	145	255	246	356	356	265	0
Total Incurred Costs under ETS	1,555	5,269	3,819	15,730	27,342	20,704	0

France

Finally, the concluding interface titled ***Financial Analysis*** (Fig. 6.9) offers a revision of the income statement by incorporating expenses resulting from greenhouse gas (GHG) emissions. This page presents a detailed income statement outlining the financial results of the company, accounting for its environmental consequences in terms of tangible costs. Financial metrics are transformed to account for those consequences and, using a graph, greenhouse gas (GHG) emissions' evolution over time is compared to Return on Assets (ROA), Return on Sales (ROS), Return on Equity (ROE), Earnings per Share and Net Profit. In the long term and following the findings presented in the literature, it can be expected that an increase in greenhouse gas (GHG) emissions will be repercussed to those financial metrics, provoking a decrease conveyed through the costs accounted for in the revised income statement.

Figure 6.9: Financial Analysis Interface



	FY18	FY19	FY20	FY21	FY22	FY23	FY24
Country for Carbon Pricing	France	France	France	France	France	France	France
Region for Carbon Pricing	Europe & Central Asia	Europe & Central Asia	Europe & Central Asia	Europe & Central Asia	Europe & Central Asia	Europe & Central Asia	Europe & Central Asia
Total GHG Emissions	88.02	213.6	204.3	314.6	314.6	264.7	0
Revenues	350,000	356,789	368,475	400,123	450,982	681,732	0
Cost of Goods Sold	-20,000	-26,371	-30,287	-50,938	-51,425	-60,394	0
Gross Profit	330,000	330,418	338,188	349,185	399,557	621,338	0
Other Operating Profit	40,000	43,526	45,768	50,928	51,637	50,987	0
Other Operating Expenses	-20,000	-24,365	-23,647	-27,564	-30,758	-34,523	0
Administrative Expenses	-15,000	-16,724	-17,485	-18,354	-18,987	-20,465	0
Marketing Expenses	-11,784	-11,789	-13,425	-13,987	-15,648	-20,847	0
Distribution Expenses	-7,254	-8,234	-8,987	-10,324	-9,876	-11,425	0
General Expenses	-12,546	-13,987	-15,625	-14,536	-15,678	-16,749	0
GHG Emissions Expenses	230,310	220,513	150,709	244,685	217,705	409,821	0
ETS Allowances Cost	1,637	5,391	3,893	15,929	27,688	21,186	0
ETS Allowances Revenues	81.83	122.5	74.15	199.1	346.1	481.5	0
ETS Allowances Profit / Loss	-1,555	-5,269	-3,819	-15,730	-27,342	-20,704	0
S1: Pricing for Stationary Co...	92,561	63,214	64,593	147,752	139,022	326,241	0
S1: Pricing for Mobile Combu...	13.49	9.144	10.41	12.11	11.39	11.21	0
S1: Pricing for Refrigerants	100,397	153,285	80,900	102,851	96,774	95,224	0
S2: Pricing for Purchased Ele...	18,765	0	0	0	0	0	0
S3: Pricing for Transports	20,054	9,087	8,845	9,500	8,938	8,797	0
Carbon Taxes Regulations	231,865	225,781	154,527	260,416	245,047	430,525	0
Credit Risk Price	0	0	0	0	0	0	0
Other GHG Emissions Expenses	0	0	0	0	0	0	0
EBIT	73,106	78,332	154,078	70,663	142,542	158,495	0

3.2. Solution's Deployment

The application, already available on the Profit& website, is currently being offered to one of the global leaders in the oil & gas sector. The concept is to market the model to interested clients as a service rather than a product. Profit& would render assistance in terms of configuration and installation, with occasional updates also being ensured.

It is important to note that everything that has been built, both in the back end and front end, can be customized according to the client's needs. Primarily, this customization is based on five elements. Based on the current features within the model, these five elements have varying degrees of customization as a function of what has already been set, as visible on the following graphs.

Data Inbound: Involves integrating the client's data based on the sources they currently possess and utilize.

Calculation Engine: Encompasses customizing the accounting of emissions and the economic and financial impact calculations according to the client's specific requirements.

Workflow: Addresses the customization of processes currently employed by the client.

Reporting: Involves creating functional interfaces tailored to the client's needs and requirements, including the selection of data types, charts, colors, and cosmetic aspects.

Data Outbound: Focuses on integrating and utilizing data generated by the model within the tools used by the client.

Given the diverse levels of customization possible for the model, the tariffs will be established by considering these specific needs and the corresponding labor days required from the Profit& team. These tarriffs will also fluctuate based on the type of prodile required to perform some changes, distinguishing between roles such as Anaplan Model Builder and Anaplan Architect, for instance. However, for the time being, given the preliminary state of the product, the specific prices and deployment modes are still to be defined.

3.3. Conclusion & Limitations

In conclusion, considering the increasingly stringent global regulations implemented to reduce greenhouse gas (GHG) emissions, the imperative to develop a model that internalizes costs associated with the latter has arisen. The examination of existing literature, although relatively nascent in this field, revealed a discernible correlation between corporate environmental performance CEP) and corporate financial performance (CFP). Incentivized by both professional and academic backgrounds, the construction of such a model with the use of Anaplan commenced nine months ago.

The evolution from an existing model focused on greenhouse gas (GHG) emissions accountability witnessed several enhancements. These refinements aimed to assimilate the regulatory landscape encompassing emissions on a global scale into the model, with the objective to apply it to the accounted emissions, finally extrapolating the economic impact of these emissions. The resultant model segment effectively translates greenhouse gas (GHG) emissions into tangible costs, influencing a firm's financial performance. In essence, this initiative serves as a proactive response to evolving environmental regulations, providing organizations with a practical tool to assess and internalize the economic and financial consequences of their greenhouse gas (GHG) emissions.

However, while the economic impact segment represents a noteworthy enhancement to the initial application built to support greenhouse gas (GHG) emissions accountability, it is crucial to acknowledge inherent limitations.

A first limitation arises from the paper titled "Interactions between Emission Trading Systems and Other Overlapping Policy Instruments" published by OECD (20122). This paper explores the dynamics emerging when an Emission Trading System (ETS) is combined with overlapping policy instruments, such as carbon taxes, targeting emissions from the same sources. The complexity of such interactions necessitates a country-by-country analysis to understand properly how policies are applied on an individual basis and how they should be collectively enacted. In the enhancements made to the model, these complex interactions were not explicitly considered. Instead, a simplified approach was taken, assuming that when a country employs several carbon reduction instruments, they are applied independently. The total costs derived from greenhouse gas (GHG) emissions were considered as the sum of the costs associated with each individual application. This simplification was adopted acknowledging that a more accurate representation of reality would require a thorough analysis of each specific case.

A second challenge would involve delving deeper into the specifics of each policy within the model. For instance, the model applies carbon taxation policies omitting certain pricing systems, like the one utilized by a small minority of countries such as Mexico, due to its significant deviation from the more prevalent approaches adopted by the majority of countries. The limited time in recent months has constrained a thorough exploration of each country's unique characteristics, leading to the incorporation of only the most common taxation policies into the model.

Similar considerations apply to Emissions Trading Systems (ETS) and the associated allowances market. In the case of the European Union, the European Energy Exchange (EEX) AG serves as the primary market for trading dynamics, with exchanges officially occurring four days a week. The embedding of such systems into the model is conceivable in the near future.

It is crucial to note that these initial challenges have been consciously accepted by Profit&. The rationale behind this acceptance is the recognition that constructing an overly strict model lacking space for customization would be less advantageous than the current model. Despite its incompleteness in certain aspects, the existing model offers greater flexibility and adaptability to potential customers' needs.

A third challenge involves revisiting the literature analysis and conducting a more thorough exploration of additional financial indicators that have been discussed but not yet incorporated into the model. Notably, indicators such as Tobin's Q and credit risk have not been modeled due to time constraints. In particular, addressing the case of credit risk necessitates extensive research as it involves constructing a credit evaluation system based on a firm's greenhouse gas (GHG) emissions and corporate environmental performance CEP). The objective for the future is to persist in this direction to integrate these indicators into the model as well.

Lastly, a potential future enhancement in the model is explored in the work of Brouwers, Schoubben, and Van Hulle (2018) titled "The influence of carbon cost pass through on the link between carbon emission and corporate financial performance in the context of the European Union Emission Trading Scheme." The findings indicate that positive carbon emission performance doesn't always translate into improved financial performance. Lower carbon emissions are only advantageous if companies cannot pass on carbon costs to consumers. Essentially, the study suggests that firms capable of transferring these costs to end users or customers experience a mitigated negative impact of emissions related costs on their financial performance.

However, it is imperative to note here that the primary objective of incurring costs associated with emissions was to reduce the latter. Introducing a mechanism for passing on these costs to end customers, while potentially minimizing their impact on the firm's overall financial performance, could inadvertently undermine the primary objective of emission reduction. This aspect opens up a potential path for extension and deeper exploration within the context of the thesis.

A Appendix A

A.1. Carbon Taxation Prices Applied in 2018

$ per tCO2e	General Carbon Taxation	Fossil-fuels	F-gases	Upper	Lower
Japan	2.74				
Switzerland	100.9				
Denmark		28.82	24.96		
Spain	24.8				
Estonia	2.48				
Finland	76.87				
France	55.3				
United Kingdom	25.46				
Ireland	24.8				
Iceland					
Liechtenstein	100.9				
Latvia	5.579				
Norway				64.29	3.729
Poland	0.0854				
Portugal	8.493				
Slovenia	21.45				
Sweden	139.1				
Ukraine	0.01544				
Argentina					
Chile	5				
Colombia	5.67				
Mexico				3.007	0.3726

A.2. Carbon Taxation Prices Applied in 2019

$ per tCO2e	General Carbon Taxation	Transports	Fossil-fuels	F-gases	LGP and Natural gases	Upper	Lower
Japan	2.602						
Singapore	3.694						
Switzerland	96.46						
Denmark			26.39	22.58			
Spain	16.85						
Estonia	2.247						
Finland		69.66	59.55				
France	50.11						
United Kingdom	23.59						
Ireland	22.47						
Iceland	35.71						
Liechtenstein	96.46						
Latvia	5.056						
Norway						59.22	3.381
Poland	0.0784						
Portugal	14.31						
Slovenia	19.44						
Sweden	126.8						
Ukraine	0.3684						
Argentina			1		6.24		
Chile	5						
Colombia	5.173						
Mexico						2.994	0.371
Canada	15.						
South Africa							

A.3. Carbon Taxation Prices Applied in 2020

$ per tCO2e	General Carbon Taxation	Transports	Fossil-fuels	F-gases	LGP and Natural gases	Upper	Lower
Japan	2.686						
Singapore	3.51						
Switzerland	99.44						
Denmark			25.93	21.98			
Spain	16.4						
Estonia	2.187						
Finland		67.8	57.96				
France	48.77						
United Kingdom	22.28						
Ireland		28.43	21.87				
Iceland	31.34						
Liechtenstein	99.44						
Latvia	9.842						
Norway						52.89	3.009
Poland	0.07194						
Portugal	25.83						
Slovenia	18.92						
Sweden	119.4						
Ukraine	0.3846						
Argentina			1.189		5.944		
Chile	5						
Colombia	4.245						
Mexico						2.417	0.2987
Canada	21.1						
South Africa	7.06						

A.4. Carbon Taxation Prices Applied in 2021

$ per tCO2e	General Carbon Taxation	Transports	Fossil-fuels	F-gases	Gasoline and Liquid Fuels	LGP and Natural gases	Upper	Lower	Heating Fuels
Japan	2.609								
Singapore	3.714								
Switzerland	101.5								
Denmark			28.14	23.65					
Spain	17.62								
Estonia	2.349								
Finland		72.83							62.25
France	52.39								
United Kingdom	24.8								
Ireland		39.35	23.49						
Iceland			29.88	8.819					
Liechtenstein	101.5								
Luxembourg			23.49		40.12				
Latvia	14.1								
Netherlands	35.24								
Norway							69.33	3.871	
Poland	0.07862								
Portugal	28.19								
Slovenia	20.32								
Sweden	137.2								
Ukraine	0.3594								
Argentina			0.01217			5.543			
Chile	5								
Colombia	5								
Mexico							3.18	0.365	
Canada	31.83								
South Africa	9.151								

A.5. Carbon Taxation Prices Applied in 2022

$ per tCO2e	General Carbon Taxation	Trans ports	Fossil-fuels	F-gases	Gasoline and Liquid Fuels	LGP and Natural gases	Upper	Lower
Japan	2.365							
Singapore	3.686							
Switzerland	129.9							
Denmark			26.62	22.29				
Spain	16.58							
Estonia	2.21							
Finland		85.1	58.58					
France	49.29							
United Kingdom	23.65							
Ireland		45.31	37.02					
Iceland			34.83	19.79				
Liechtenstein	129.9							
Luxembourg			27.63		43.35			
Latvia	16.58							
Netherlands	46.14							
Norway	87.61					8.807		
Poland	0.07623							
Portugal	26.44							
Slovenia	19.12							
Sweden	129.9							
Ukraine	1.025							
Argentina			0.0027			4.994		
Chile	5							
Colombia	5.013							
Mexico							3.722	0.4173
Uruguay	137.3							
Canada	39.96							
South Africa	9.835							

A.6. Carbon Taxation Prices Applied in 2023

$ per tCO2e	General Carbon Taxation	Transports	Fossil-fuels	F-gases	Gasoline and Liquid Fuels	LGP and Natural gases	Upper	Lower
Japan	2.365							
Singapore	3.768							
Switzerland	130.8							
Denmark			26.53	21.9				
Spain	16.31							
Estonia	2.175							
Finland		83.74	57.64					
France	48.5							
United Kingdom	22.28							
Ireland			44.59		52.74			
Iceland							38.53	3.219
Liechtenstein	130.8							
Luxembourg			32.63		48.11			
Latvia	16.31							
Netherlands	55.59							
Norway	90.86					7.349		
Poland			0.07919	14.44				
Portugal	26.01							
Slovenia								
Sweden	125.6							
Ukraine	0.8204							
Argentina			3.269			3.339		
Chile	5							
Colombia	5.056							
Mexico			0.4124		4.071			
Uruguay	155.9							
Canada	48.03							
South Africa	8.926							

B Appendix B

B.1. Emissions Trading Systems Allowances by Country

		FY18	FY19	FY20	FY21	FY22	FY23
Austria	Free Allowances	19,364,427	18,776,348	18,185,631	18,449,400	18,813,216	18,791,700
	Auctioned Allowances	13,487,500	7,351,500	7,468,000	5,843,500	4,715,500	4,715,500
	Total Allowances	32,851,927	26,127,848	25,653,631	24,292,900	23,528,716	23,507,200
Belgium	Free Allowances	32,243,823	32,056,996	31,199,064	28,978,872	29,146,255	29,074,636
	Auctioned Allowances	24,573,000	14,361,000	14,521,500	10,042,500	8,171,000	8,171,000
	Total Allowances	56,816,823	46,417,996	45,720,564	39,021,372	37,317,255	37,245,636
Bulgaria	Free Allowances	11,770,073	10,143,838	8,015,996	6,822,918	6,638,436	6,624,627
	Auctioned Allowances	23,824,500	17,845,000	18,431,500	15,675,000	13,680,500	13,680,500
	Total Allowances	35,594,573	27,988,838	26,447,496	22,497,918	20,318,936	20,305,127
Cyprus	Free Allowances	2,192,980	1,883,331	1,285,776	1,199,414	1,196,665	1,196,665
	Auctioned Allowances	1,600,500	990,000	1,577,500	1,451,500	1,263,500	1,263,500
	Total Allowances	3,793,480	2,873,331	2,863,276	2,650,914	2,460,165	2,460,165
Czechia	Free Allowances	27,487,273	22,730,763	17,993,206	14,973,888	15,553,035	15,637,842
	Auctioned Allowances	37,802,500	25,553,500	29,569,500	11,535,000	8,430,000	8,430,000
	Total Allowances	65,289,773	48,284,263	47,562,706	26,508,888	23,983,035	24,067,842
Germany	Free Allowances	146,144,475	141,225,319	136,588,643	124,789,192	126,075,972	125,807,380
	Auctioned Allowances	172,220,000	127,561,500	107,433,000	100,462,500	84,230,000	84,230,000
	Total Allowances	318,364,475	268,786,819	244,021,643	225,251,692	210,305,972	210,037,380
Denmark	Free Allowances	7,726,416	7,141,898	6,449,596	4,866,070	4,909,216	4,837,763
	Auctioned Allowances	12,136,000	6,614,000	6,719,500	5,476,500	4,460,500	4,460,500

	Total Allowances	19,862,416	13,755,898	13,169,096	10,342,570	9,369,716	9,298,263
Spain	Free Allowances	57,263,358	57,857,775	57,170,397	45,997,414	45,868,235	45,489,360
	Auctioned Allowances	83,684,500	49,781,000	50,285,000	46,471,000	39,980,500	39,980,500
	Total Allowances	140,947,858	107,638,775	107,455,397	92,468,414	85,848,735	85,469,860
Estonia	Free Allowances	3,283,874	3,151,643	2,982,844	2,550,892	2,500,571	2,460,348
	Auctioned Allowances	9,082,500	5,796,000	5,864,000	4,684,000	4,180,500	4,180,500
	Total Allowances	12,366,374	8,947,643	8,846,844	7,234,892	6,681,071	6,640,848
Finland	Free Allowances	16,966,971	16,093,422	15,306,036	12,771,537	13,020,574	12,978,782
	Auctioned Allowances	16,201,000	8,830,500	8,970,500	7,700,000	6,344,500	6,344,500
	Total Allowances	33,167,971	24,923,922	24,276,536	20,471,537	19,365,074	19,323,282
France	Free Allowances	67,485,756	66,231,987	64,238,057	55,693,980	52,863,009	52,783,792
	Auctioned Allowances	53,050,000	28,914,500	29,374,000	27,468,000	23,029,500	23,029,500
	Total Allowances	120,535,756	95,146,487	93,612,057	83,161,980	75,892,509	75,813,292
United Kingdom	Free Allowances	51,357,132	49,622,985	48,058,253	0	0	0
	Auctioned Allowances	101,053,000	0	111,025,500	0	0	0
	Total Allowances	152,410,132	49,622,985	159,083,753	0	0	0
Greece	Free Allowances	13,957,456	13,726,877	13,389,027	10,898,451	10,789,479	10,701,388
	Auctioned Allowances	33,636,500	20,452,000	20,628,000	19,010,000	16,485,500	16,485,500
	Total Allowances	47,593,956	34,178,877	34,017,027	29,908,451	27,274,979	27,186,888
Croatia	Free Allowances	4,434,782	4,348,866	4,265,324	3,572,572	3,437,729	3,028,483
	Auctioned Allowances	4,607,000	2,924,000	2,941,000	2,097,500	1,769,000	1,769,000
	Total Allowances	9,041,782	7,272,866	7,206,324	5,670,072	5,206,729	4,797,483
Hungary	Free Allowances	9,852,632	9,548,458	9,241,670	8,482,677	8,467,974	8,276,561
	Auctioned Allowances	14,546,000	9,214,500	9,270,000	5,905,500	5,860,500	5,860,500
	Total Allowances	24,398,632	18,762,958	18,511,670	14,388,177	14,328,474	14,137,061
Ireland	Free Allowances	4,986,109	4,855,184	4,729,305	3,908,475	3,963,309	3,944,893
	Auctioned Allowances	9,069,500	4,943,000	5,022,000	2,788,500	2,029,500	2,029,500
	Total Allowances	14,055,609	9,798,184	9,751,305	6,696,975	5,992,809	5,974,393

Iceland	Free Allowances	1,399,965	1,482,546	1,405,547	1,723,669	1,723,704	1,738,817
	Auctioned Allowances	0	930,000	1,490,500	71,500	40,000	40,000
	Total Allowances	1,399,965	2,412,546	2,896,047	1,795,169	1,763,704	1,778,817
Italy	Free Allowances	67,168,037	64,364,719	62,749,035	45,781,421	44,778,393	44,597,251
	Auctioned Allowances	93,357,500	51,656,500	52,404,000	47,420,000	39,738,500	39,738,500
	Total Allowances	160,525,537	116,021,219	115,153,035	93,201,421	84,516,893	84,335,751
Liechtenstein	Free Allowances	1,048	861	681	0	0	0
	Auctioned Allowances	0	20,500	33,500	4,500	3,500	0
	Total Allowances	1,048	21,361	34,181	4,500	3,500	0
Lithuania	Free Allowances	5,494,201	4,947,666	4,600,903	4,552,212	4,617,686	4,552,585
	Auctioned Allowances	5,183,000	3,399,000	3,553,000	1,612,500	1,284,500	1,284,500
	Total Allowances	10,677,201	8,346,666	8,153,903	6,164,712	5,902,186	5,837,085
Luxembourg	Free Allowances	1,215,724	1,177,800	1,146,470	1,152,105	1,180,449	1,179,982
	Auctioned Allowances	1,166,500	681,500	689,500	145,000	56,500	56,500
	Total Allowances	2,382,224	1,859,300	1,835,970	1,297,105	1,236,949	1,236,482
Latvia	Free Allowances	1,599,997	1,476,875	1,302,456	1,124,599	1,116,085	1,100,894
	Auctioned Allowances	2,607,500	1,703,000	1,710,500	1,146,500	1,034,500	1,034,500
	Total Allowances	4,207,497	3,179,875	3,012,956	2,271,099	2,150,585	2,135,394
Netherlands	Free Allowances	43,732,156	42,903,266	41,779,765	39,189,897	38,358,966	37,944,636
	Auctioned Allowances	32,473,500	17,700,000	17,980,500	16,814,000	14,097,500	14,097,500
	Total Allowances	76,205,656	60,603,266	59,760,265	56,003,897	52,456,466	52,042,136
Norway	Free Allowances	16,176,633	16,097,040	15,833,479	12,170,771	11,888,324	11,888,300
	Auctioned Allowances	0	18,525,000	29,682,000	3,321,500	2,691,000	2,691,000
	Total Allowances	16,176,633	34,622,040	45,515,479	15,492,271	14,579,324	14,579,300
Poland	Free Allowances	66,440,719	61,740,129	43,313,153	43,250,729	42,472,586	42,390,359
	Auctioned Allowances	78,030,000	103,861,000	130,104,000	105,184,500	62,916,000	62,916,000
	Total Allowances	144,470,719	165,601,129	173,417,153	148,435,229	105,388,586	105,306,359
Portugal	Free Allowances	10,741,032	10,788,491	10,496,403	8,542,207	8,118,796	8,125,768

	Auctioned Allowances	17,035,500	10,303,500	10,396,000	9,587,000	8,300,500	8,300,500
	Total Allowances	27,776,532	21,091,991	20,892,403	18,129,207	16,419,296	16,426,268
Romania	Free Allowances	21,024,344	20,989,087	18,687,128	14,342,626	14,038,692	13,035,648
	Auctioned Allowances	46,511,000	30,386,500	33,008,500	9,335,500	6,069,000	6,069,000
	Total Allowances	67,535,344	51,375,587	51,695,628	23,678,126	20,107,692	19,104,648
Slovak Republic	Free Allowances	13,746,320	13,414,163	13,048,220	11,597,175	13,036,470	12,722,979
	Auctioned Allowances	14,906,500	9,932,500	9,963,500	5,240,000	4,296,500	4,296,500
	Total Allowances	28,652,820	23,346,663	23,011,720	16,837,175	17,332,970	17,019,479
Slovenia	Free Allowances	1,737,666	1,677,584	1,611,625	1,453,913	1,417,993	1,415,668
	Auctioned Allowances	4,289,500	2,648,000	2,668,000	2,454,500	2,137,500	1,415,668
	Total Allowances	6,027,166	4,325,584	4,279,625	3,908,413	3,555,493	2,831,336
Sweden	Free Allowances	21,783,685	20,711,593	19,189,269	16,857,452	16,821,740	16,765,500
	Auctioned Allowances	8,627,000	5,042,000	5,098,000	4,075,500	3,416,500	3,416,500
	Total Allowances	30,410,685	25,753,593	24,287,269	20,932,952	20,238,240	20,182,000
Malta	Auctioned Allowances	988,500	619,000	623,000	551,500	480,000	480,000
	Total Allowances	988,500	619,000	623,000	551,500	480,000	480,000

C Appendix C

C.1. Allowances Trading Prices by Country

$ per Allowance	FY18	FY19	FY20	FY21	FY22	FY23
Australia			10.2	11.96	11.85	10.64
China					9.2	8.153
Korea, Rep.	20.52	23.46	32.79	15.89	18.75	11.24
New Zealand	15.22	17.53	14.3	25.76	52.62	34.2
Austria	16.37	24.51	18.54	49.78	86.53	35.34
Belgium	16.37	24.51	18.54	49.78	86.53	96.3
Bulgaria	16.37	24.51	18.54	49.78	86.53	96.3
Switzerland	7.883	7.184	18.8	41.49	64.22	93.81
Cyprus	16.37	24.51	18.54	49.78	86.53	96.3
Czechia	16.37	24.51	18.54	49.78	86.53	96.3
Germany	16.37	24.51	18.54	49.78	86.53	96.3
Denmark	16.37	24.51	18.54	49.78	86.53	96.3
Spain	16.37	24.51	18.54	49.78	86.53	96.3
Estonia	16.37	24.51	18.54	49.78	86.53	96.3
Finland	16.37	24.51	18.54	49.78	86.53	96.3
France	16.37	24.51	18.54	49.78	86.53	96.3
United Kingdom	16.37	24.51	18.54	49.78	98.99	88.13
Greece	16.37	24.51	18.54	49.78	86.53	96.3
Hungary	16.37	24.51	18.54	49.78	86.53	96.3
Ireland	16.37	24.51	18.54	49.78	86.53	96.3
Iceland	16.37	24.51	18.54	49.78	86.53	96.3
Italy	16.37	24.51	18.54	49.78	86.53	96.3
Kazakhstan			1.112	1.177	1.081	1.125
Liechtenstein	16.37	24.51	18.54	49.78	86.53	96.3
Lithuania	16.37	24.51	18.54	49.78	86.53	96.3
Luxembourg	16.37	24.51	18.54	49.78	86.53	96.3
Latvia	16.37	24.51	18.54	49.78	86.53	96.3
Netherlands	16.37	24.51	18.54	49.78	86.53	96.3
Norway	16.37	24.51	18.54	49.78	86.53	96.3
Poland	16.37	24.51	18.54	49.78	86.53	96.3
Portugal	16.37	24.51	18.54	49.78	86.53	96.3
Romania	16.37	24.51	18.54	49.78	86.53	96.3
San Marino	16.37	24.51	18.54	49.78	86.53	96.3
Slovak Republic	16.37	24.51	18.54	49.78	86.53	96.3
Slovenia	16.37	24.51	18.54	49.78	86.53	96.3

Sweden	16.37	24.51	18.54	49.78	86.53	96.3
Canada				31.83	39.96	48.03

Acknowledgments

By reflecting on the completion of this thesis, two crucial points demand acknowledgments.

Firstly, attempting to articulate the complex workings of Anaplan and its varied applicability within the confines of a written document has proven to be quite a challenge. Coding complexities were often simplified, and the entirety of the back-end work hasn't been fully presented. Furthermore, conveying the dynamic and interactive nature of interfaces through screenshots falls short of capturing the full user experience.

Secondly, the work performed delves into the highly complex subject matter of international regulations. Navigating through various laws and jurisdictions, both at regional, national, and sub-national levels, required careful consideration and efforts. Still, given my academic and professional background, my comprehension of those arguments remains limited. I humbly recognize that the work and the modelling performed on Anaplan could contain errors due to information overflight, and that the whole could be improved with the guidance of someone specialized in the field.

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List of Figures

List of Tables