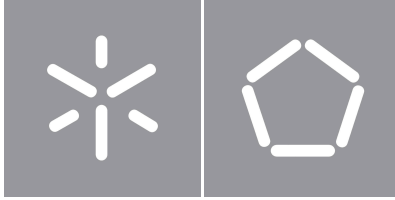


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Decarbonization in the Sports Industry: A Case Study of Energy Efficiency Initiatives



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Masters Dissertation
Master's in Industrial Engineering and Management

Dissertation supervised by
Professora Doutora Paula Fernanda Varandas Ferreira

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Acknowledgements

I would like to dedicate this work to my brother, who, wherever he's, I hope is proud of me...

First and foremost, I'd like to thank my family and friends for walking this five-year path with me, never letting me down, and teaching me to trust my work.

A special thank you to Decathlon Production Portugal for giving me the opportunity to participate in the internship, for letting me be part of such an important project, and for making me feel at home during the whole time. Thanks to Diogo, Rita and my supervisor Mafalda for all their support, help and teachings even when everything seemed impossible. Thanks to Maria and Luana, who embarked on the adventure of internship with me and became my friends during the trip.

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Statement of Integrity

I hereby declare having conducted this academic work with integrity.

I confirm that I have not used plagiarism or any form of undue use of information or falsification of results along the process leading to its elaboration.

I further declare that I have fully acknowledged the Code of Ethical Conduct of the University of Minho.

University of Minho, Braga, december 2023

Maria Margarida Pinto Coelho Silva Carneiro

Abstract

Decarbonization in the Sports Industry: A Case Study of Energy Efficiency Initiatives

This dissertation was developed as the final part of the Master's Degree in Industrial Engineering and Management at the University of Minho. This project is the result of a curricular internship at Decathlon, a multinational in the sports retail sector, which sells sporting goods from a wide range of sectors. The focus of this work was to encourage the decarbonization of production, taking into consideration the Science Based Targets initiative (SBTi) and improved energy efficiency, in the company's panel of suppliers. In recent years, concern about climate change has crossed all generations and sectors, given the urgency and severity of the issue. In particular, companies, as the main parties responsible for this issue, have come under increasing pressure to promote sustainable changes in order to avoid compromising the lives of future generations and to remain competitive in the market. In this way, reducing greenhouse gas emissions has to be one of the priorities for companies today.

To begin with, suppliers were audited on the CO₂ emission reduction actions they had committed to when signing the SBTs. Here it was possible to identify the percentages of actions that had already been completed, those that were in progress and those that had not yet been started. That said, the energy efficiency maturity level of Decathlon's supplier panel was ascertained through a survey. Analysis of the supplier panel surveys made it possible to determine the most common problems and, by studying and investigating this topic, to propose some practices that could improve the energy efficiency maturity of most of them.

Initially, actions were suggested for the entire supplier panel and, later, more specific actions according to the type of supplier process. It was also possible to carry out a more detailed analysis of Decathlon supplier B, which manufactures bicycles. Here too, the biggest problems were analyzed in detail and specific improvements were proposed.

Keywords Decarbonization of production, Energy Efficiency, Improvement Proposals, Science Based Targets initiative (SBTi)

Resumo

Descarbonização na Indústria do Desporto: Um Caso de Estudo de Iniciativas de Eficiência Energética

A presente dissertação foi desenvolvida como parte final do Mestrado em Engenharia e Gestão Industrial da Universidade do Minho. Este projeto é o resultado de um estágio curricular na Decathlon, uma multinacional do setor do retalho desportivo, que comercializa artigos de desporto de variados setores. O foco deste trabalho foi incentivar a descarbonização da produção, tendo em conta a Science Based Targets initiative (SBTi) e melhoria da eficiência energética, no painel de fornecedores da empresa. Nos últimos anos, a preocupação com as alterações climáticas tem sido transversal a todas gerações e setores dada a urgência e a severidade do tema. Em especial as empresas, como grandes responsáveis nesta temática, têm sido cada vez mais pressionadas a promover alterações sustentáveis de forma a evitar o comprometimento da vida das gerações futuras e a continuarem competitivas no mercado. Desta forma, ao dia de hoje, a redução das emissões de gases com efeito de estufa tem de ser uma das prioridades das empresas.

Inicialmente os fornecedores foram auditados quanto às ações de redução de emissões de CO₂ que se haviam comprometido a cumprir aquando da assinatura dos SBTs. E aqui foi possível identificar as percentagens de ações já concluídas, as que estavam em andamento e as que ainda não tinham sido iniciadas. Posto isso, foi apurado o nível de maturidade em eficiência energética do painel de fornecedores da Decathlon através de um inquérito. A análise dos inquéritos do painel de fornecedores permitiu apurar quais as problemáticas mais comuns e, através do estudo e investigação deste tópico, propor algumas práticas que poderiam melhorar a maturidade em eficiência energética na maioria deles. Numa primeira abordagem foram sugeridas ações para todo o painel de fornecedores e, mais tarde, ações mais específicas de acordo com o tipo de processo do fornecedor. Para além disso, foi possível elaborar uma análise mais detalha no fornecedor B da Decathlon, responsável pelo fabrico de bicicletas. Também neste fornecedor foram analisadas, em detalhe, as maiores problemáticas e propostas melhorias específicas para este caso.

Palavras-chave Descarbonização da produção, Eficiência Energética, Propostas de Melhoria, Science-Based Targets initiative (SBTi)

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Acronyms

ACA Absolute Contraction Approach.

BECCS Bioenergy Carbon Capture and Storage.

CCUS Carbon Capture Utilisation and Storage.

CDP Carbon Disclosure Project.

COP Coefficient of Performance.

DERs Distributed Energy Resources.

DPP Decathlon Production Portugal.

EIIs Energy-Intensive Industries.

EPIs Energy-Intensive Manufacturing Industries.

GCV Gross Calorific Value.

GDP Gross Domestic Product.

GHG Greenhouse Gas.

HVAC Heating, Ventilation and Air Conditioning.

IEA International Energy Agency.

IEC International Electrotechnical Commission.

IPCC Intergovernmental Panel on Climate Change.

KPIs Key Performance Indicators.

PICA Physical Intensity Convergence Approach.

R&D Research and Development.

SBTi Science Based Targets initiative.

SBTs Science-based targets.

SDA Sectoral Decarbonization Approach.

SEUs Significant Energy Users.

SOP Standard Operating Procedure.

TDS Total Dissolved Solids.

U.S. United States.

VCF Volume Correction Factor.

VFD Variable Frequency Drives.

WMO World Meteorological Organization.

WRI World Resources Institute.

WWF World Wide Fund for Nature.

Part I

Introductory material

Chapter 1

Introduction

The present dissertation entitled “Decarbonization in the Sports Industry: A Case Study of Energy Efficiency Initiatives” was developed under the scope of the Master’s in Industrial Engineering and Management at University of Minho. The development of this work was only possible thanks to the six-month internship at Decathlon Production Portugal located in Maia, Portugal.

This chapter aims to explain the context and motivation of this project, its objectives, the research methodology used and the structure of the dissertation.

1.1 Context and Motivation

In recent years, climate change has been a topic of constant discussion and concern. Indeed, the Earth’s climate has changed several times throughout its history, going through ice ages and warm periods. The problem is that these climate changes occurred very slowly and naturally, which is no longer the case today. Scientists cannot explain the amount of warming in such a short time with natural causes, so humans are responsible for this event. The worst part is that most living things cannot adapt to these radical changes and are, therefore, endangered (National Geographic Society, 2022).

According to Yaashikaa, Senthil Kumar, Saravanan, Karishma, and Rangasamy (2023) it was the combination of factors: rapid industrialization and increasing world population that led to an increase in greenhouse gases. In fact, the concentration of CO₂, a greenhouse gas that occurs naturally in the atmosphere and plays a critical role in the Earth’s temperature, has risen to unprecedented levels and is projected to continue to rise (Tran, Nguyen, Ly, Joo, and Vasseghian, 2023). Carbon dioxide belongs to a group of gases that are capable of producing the so-called greenhouse effect, i.e. they have the ability to absorb infrared radiation, shop heat and influence temperature (Scheiner, 2023). Against the current background, decarbonization seems to be the only way for humanity to counteract the rise in temperature on Earth and avoid a catastrophic scenario. Decarbonization is the gradual reduction of greenhouse gases in the atmosphere, taking into account the main economic and environmental factors. Thus, the ultimate goal of decarbonization is to reduce CO₂ emissions (Fan et al., 2021; Law, Foscoli, Mastorakos, and Evans, 2021).

Reducing carbon emissions as a systemic and social problem requires the collective commitment of all

sectors of society, rather than relying solely on the actions of a single industry or sector (J. Yang et al., 2020; Xu, He, and Long, 2014).

For this reason, governments have been trying to curb global warming in the past years. One of the most recent event where several countries came together to talk about this problem was the Paris Agreement in 2015, which set long-term goals, such as efforts to significantly reduce global greenhouse gas emissions to limit global temperature increases to 2 degrees Celsius this century and 1.5 degrees in the future. It also calls for reviewing countries' commitments every five years and providing funding to developing countries for climate change mitigation, resilience building and adaptation (European Parliament, 2018).

According to Nurdawati and Urban (2022), there are several approaches to decarbonize the industry: consumption measures such as design and reuse, improving energy efficiency, replacing fossil fuels with low-carbon sources (e.g., biomass and reusable hydrogen), electrification of processes supported by low-carbon energy sources, Carbon Capture Utilisation and Storage (CCUS), and negative emission technologies such as Bioenergy Carbon Capture and Storage (BECCS).

Decathlon indirectly contributes to environmental impact because behind its products lies the need for raw material extraction and conversion into components, releasing greenhouse gases in the process. For this reason, Decathlon has given clear priority to this issue and has launched a project, in 2020, called "Decarbonize the Production" to reduce greenhouse gas emissions and join the SBTi. This work was developed to integrate the third step of this project, named reduction, particularly in energy efficiency programs.

1.2 Objectives

The main objective of this work is to promote the decarbonization of production by improving energy efficiency in the different production areas covered by Decathlon, attempting to answer the following research question: "What are the best tactics to promote decarbonization by improving energy efficiency in the supplier panel of a company in the sports retail sector?" Considering that to promote the decarbonization of production it is necessary to know the reality of each production sector and the behaviours of the different factories, the objectives of this project are the following:

- To verify if the actions that suppliers had undertaken to carry out when signing the SBTi are being complied with;
- To visit all the suppliers included in the Decathlon list and to survey the maturity of energy efficiency (achieve a 100% rate of surveys deployed);

- To propose an action plan to improve energy efficiency in the group of suppliers studied;
- To prioritise the most critical suppliers and to elaborate a more detailed analysis and action plan for them.

1.3 Research Methodology

In order to answer the research question identified it was necessary to think about the necessary data and the techniques to collect them. The "research onion" (Figure 1), created by Saunders et al. (2009), can help to understand the stages that should be passed in the development of research.

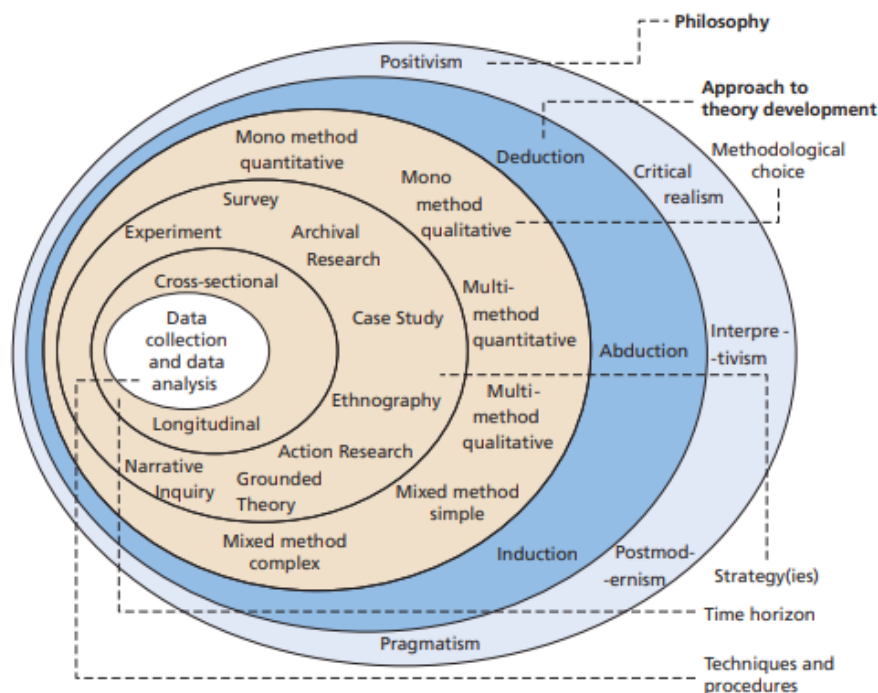


Figure 1: The "research onion". Retrieved from (Saunders et al., 2009)

To reach the center of the "onion," i.e., the choice of data collection techniques and analysis procedures, a number of layers must be passed through: Philosophy, Approach to Theory Development, Methodological Choice, Strategy, and Time Horizon.

1.3.1 Research Philosophy

According to Saunders, Lewis, and Thornhill (2019), the research philosophy encompasses a set of beliefs and assumptions about how knowledge is created.

This thesis was developed with the research philosophy of pragmatism in mind, where research begins with the identification of a real-world problem and seeks to identify tangible solutions that can guide future

action. Indeed, pragmatists are more interested in practical outcomes than abstract distinctions, which fits with the way data was collected (surveys), the visits to companies, and the development of concrete action plans that are present in this project (Saunders et al., 2019).

1.3.2 Approach to theory development

In planning the research project's design, it's important to define whether the research is more focused on testing existing theories (theory testing) or on developing new theories (theory building).

In the case of this project, it can be said that the inductive approach was taken, as the research started with the collection of data to explore the topic of energy efficiency and then the theory was developed (Saunders et al., 2019).

1.3.3 Methodological choice

Based on the activities carried out in this project, a research approach was used that included both quantitative and qualitative data collection techniques. Visiting suppliers or identifying key issues are examples of qualitative approaches while the surveys provided quantitative analysis.

Johnson, Onwuegbuzie, and Turner (2007, p.123) said: "Mixed methods research is the type of research in which a researcher or team of researchers combine elements of qualitative and quantitative research approaches (e.g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purposes of breadth and depth of understanding and corroboration.", so, it can be concluded that, in this project, it was used a mixed method.

1.3.4 Research Strategy

The research strategy that best fits this work is the case study since it's an "empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (Yin, 2003, p.13). In fact, this project was dedicated to investigating the phenomenon of climate change, namely ways of reducing its consequences in the current context of companies.

1.3.5 Time horizon

This project collected data from several suppliers in the current year, suggesting a cross-sectional approach, but at the same time followed up on measures implemented in previous years, also suggesting a

longitudinal analysis.

1.4 Dissertation Structure

This dissertation is divided into six distinct chapters to provide a coherent framework for the presentation of the research results and findings.

In the first chapter, the project is introduced, and the reasons for its existence are explained, along with the contributions it aims to make. This chapter also outlines the project's goals and provides an explanation of the research methodology used.

The second chapter is dedicated to the literature review that supports this project on decarbonization, SBTi, and energy efficiency. This chapter serves as the intellectual foundation upon which subsequent chapters build.

Chapter three introduces the company where the internship was completed, which is integral to this project. More information is provided about Decathlon's history, values, and operational activities.

In the fourth chapter, the core of the thesis begins with the framework of the decarbonization project and the presentation of the suppliers selected for the project. This chapter follows up on the SBTs actions and identifies the main issues related to energy efficiency in the supplier panel. In addition, this chapter identifies the most critical supplier that was further analysed in terms of energy efficiency.

The fifth chapter provides suggestions for improving energy efficiency among suppliers and presents more specific suggestions for the most critical supplier.

The last chapter, the sixth, concludes the project by summarising the project, explaining the difficulties and limitations of the project, and making some suggestions for future work in this area.

Chapter 2

Literature Review

The purpose of this chapter is to provide a literature review on the topic of sustainability, specifically decarbonization of production. First, the concept of decarbonization is introduced, a context of carbon emissions is given, different options for decarbonize the production are presented and the barriers and challenges of this topic are discussed. Then, the pathway of decarbonization energy efficiency, is described, and finally, the Science-Base Target Initiative is examined.

2.1 Decarbonize the production: a definition

Decarbonization has been studied for some years now. In the first definitions of decarbonization, for example according to Kanoh (1992), it refers to the gradual reduction in the typical carbon dioxide content per unit of primary energy over time. However, a few years later, according to Sun (2005) the definition of decarbonization had to take into account the social and economic aspects.

Contemporary interpretations of decarbonization, for example the one from the Intergovernmental Panel on Climate Change (IPCC) defines decarbonization as " The process by which countries or other entities aim to achieve a low-carbon economy, or by which individuals aim to reduce their carbon consumption." (Edenhofer, 2015, p. 120).

These definitions show that decarbonization has multiple functions like reducing carbon intensity, reshaping energy systems, and reliance on low-carbon or carbon-free energy sources. The overarching objective of decarbonization is frequently centered on mitigating climate change's impacts by curbing greenhouse gases (GHG) emissions, which are instrumental in driving global temperature increases. For instance, Rissman et al. (2020) shows the imperative of achieving net-zero GHG emissions by 2050–2070 to constrain global warming to a 2°C rise, underscoring that decarbonization is a crucial component of climate change mitigation efforts due to its potential to slash GHG emissions and moderate global warming.

Yet, the advantages of decarbonization aren't confined solely to climate considerations. It also yields other advantageous outcomes for both the environment and the economy. These encompass enhanced air quality, reduced reliance on fossil fuels, and economic opportunities linked to the adoption of low-carbon technologies. Sofia, Gioiella, Lotrecchiano, and Giuliano (2020), for instance, delve into these aspects within the context of an Italian cost-benefit analysis supporting a decarbonization scenario for 2030. Their

findings reveal a gamut of positive benefits stemming from diverse mitigation strategies across all sectors, notably including reductions in air pollution emissions, thus translating into tangible improvements in human health.

2.2 Global Context of Carbon Emissions

In fact, the increase of greenhouse gases in the atmosphere has eminent consequences for human health and may even threaten our existence, (Chen, Xu, Yao, and Ding, 2023). The graph from Figure 2 shows that the global atmospheric concentration of carbon dioxide (CO_2), one of the most important greenhouse gases, has been increasing.

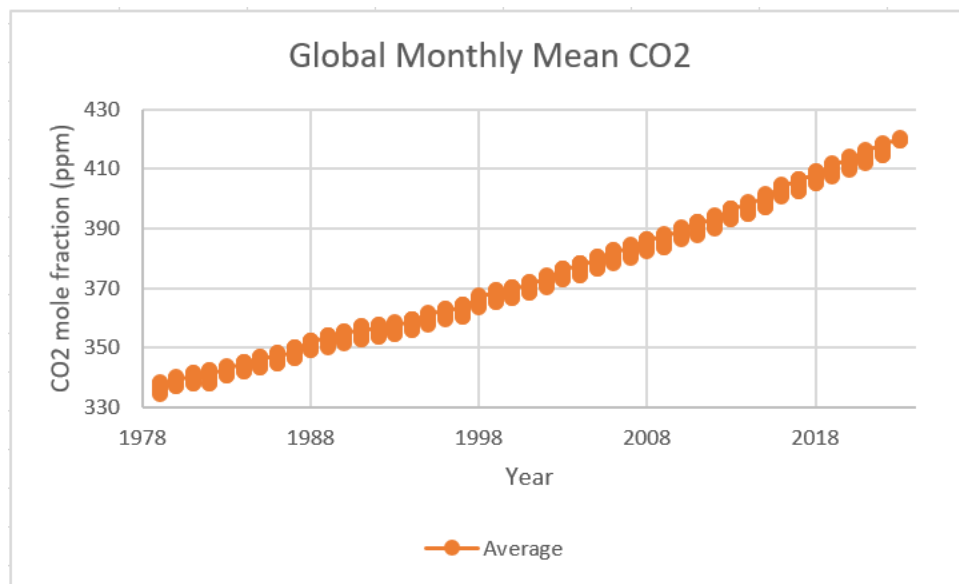


Figure 2: Global atmospheric CO_2 concentration. Retrieved from (Lan et al., 2023)

According to a 2021 press release from the World Meteorological Organization (WMO), the impacts of climate change are becoming more apparent. Some of the consequences mentioned in the press release include warming and acidification of the oceans, melting of glaciers, and an increase in extreme weather events (Bhatia, Ranganathan, and World Resources Institute, 2004). For this reason, there has been global pressure to reduce these gases, particularly CO_2 , as, according to Olivier, Schure, and Peters (2017) and Ritchie et al. (2020), this gas contributes about 73% of total GHG emissions (excluding land). There are several gases with the capacity to create the greenhouse effect such as the well-known CO_2 , methane (CH_4), nitrous oxide (N_2O) and even less significant hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF_6). It is possible to identify the contribution of these gases to global greenhouse gas emissions by converting them to CO_2 equivalent (multiplying each gas by its one hundred global warming potential value). In this

way, Figure 3 shows the breakdown for each gas of the amount of warming that one tonne of the respective gas would create relative to one tonne of CO₂, on a one hundred-year time scale. Carbon dioxide was the largest contributor to emissions, accounting for around three quarters (74.4%) of total emissions. Methane contributed 17.3%; nitrous oxide 6.2%; and other emissions (HFCs, CFCs, SF₆) 2.1%.

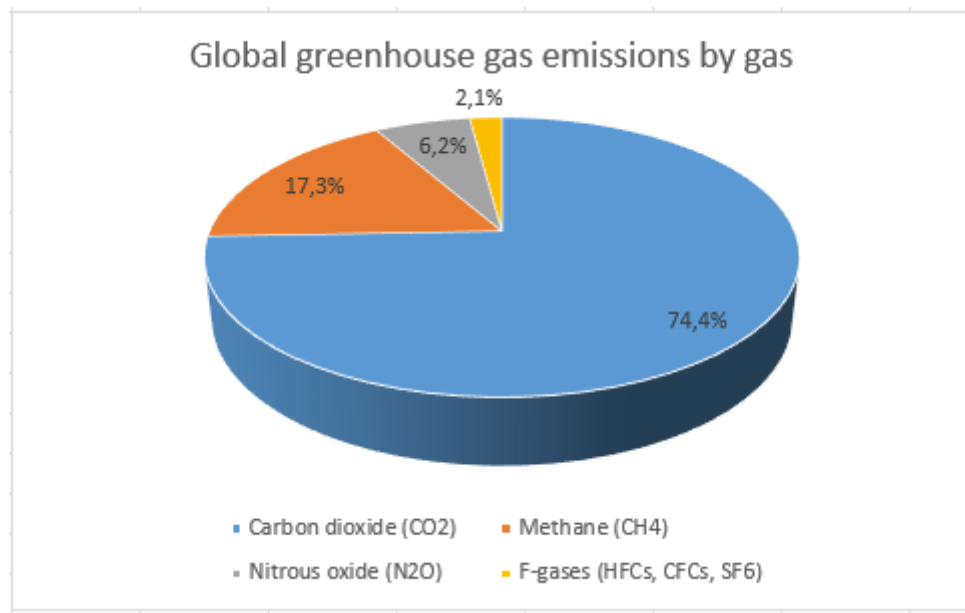


Figure 3: Global greenhouse gas emissions by gas. Retrieved from (Ritchie et al., 2020).

Besides that, according to Bataille et al. (2018), the production of commodities that use intensive energy is responsible for 1/3 of annual global greenhouse gas emissions.

The industrial sector plays a significant role in contributing to global greenhouse gas emissions, accounting for roughly 30% of the total emissions. Using United States (U.S.) as an example, it becomes clear that in 2021, the main sources of greenhouse gas emissions were the agriculture, transportation, industry and commercial and residential sectors (Figure 4).

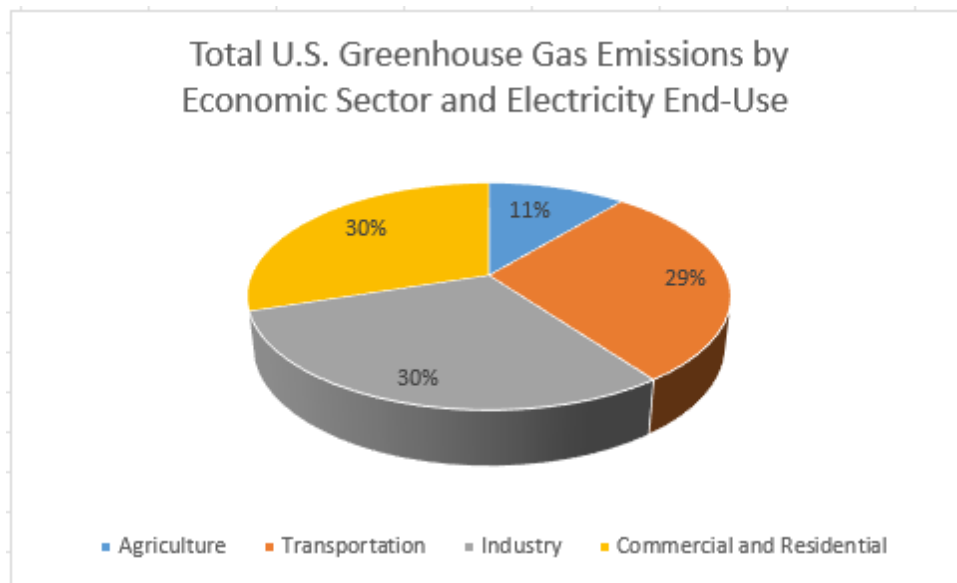


Figure 4: Total U.S. Greenhouse Gas Emissions by Economic Sector and Electricity End-Use in 2021. Retrieved from (U.S. Environmental Protection Agency, 2021).

Most of these emissions come from energy-intensive manufacturing industries (EPIs), which transform raw materials like iron, steel, aluminum, chemicals, cement, glass, and paper into essential products. These manufacturing processes are highly energy-intensive, demanding substantial amounts of energy inputs (Wesseling et al., 2017; International Energy Agency, 2020).

2.3 The Paris Agreement

In order to try to solve this problem, in 2015, one of the most important events in the field of sustainability took place and was called Paris Agreement (Salman, Long, Wang, and Zha, 2022). In this event, representatives of 196 countries signed the Agreement committing to reduce their greenhouses gases emissions in order to keep global warming well below 2°C and pursue efforts towards 1.5 °C compared to pre-industrial levels (Daniel Scott and Gössling, 2016). Four years later, a report released by the United Nations Environment Programme reveals that there has been a consistent annual increase of approximately 1.5% in global emissions over the past decade. This upward trajectory is primarily driven by the escalation of CO₂ emissions from the energy sector and industry, which experienced a notable 2% surge in 2018 alone. Consequently, the report underscores the critical significance of two key strategies: decarbonizing the energy sector and transitioning end-use activities to electrification. These measures are deemed indispensable for achieving a successful transition towards a low-carbon society (Olhoff and Christensen, 2018).

2.4 Options to decarbonize the production

In fact, within industry there are different sectors of activity whose processes can be very different, so it is not easy to find solutions that are suitable for all sectors. Decarbonization is then a difficult challenge, not only because of the diversity of processes, but also because of the relative lack of low-carbon options available for “hard to decarbonize” industries such as iron and steel, cement, and chemicals (the three highest-emitting industries) (Griffiths, Sovacool, Kim, Bazilian, and Uratani, 2021; Couchy, 2023).

In a recent study Nurdiawati and Urban (2021) examined the technological pathways and essential policies for reducing carbon emissions in Swedish energy-intensive industries and delineate six primary decarbonization approaches to mitigate emissions from these industrial sectors. These approaches encompass:

- Demand-Side Measures: These involve actions such as optimizing product design and promoting reuse to reduce the demand for energy-intensive processes;
- Energy Efficiency Improvement: This approach focuses on improving the efficiency of industrial processes to minimize energy consumption and emissions;
- Replacement of Fossil Fuels and Feedstocks: Transitioning from carbon-intensive fossil fuels to low-carbon sources like biomass and renewable hydrogen can significantly reduce emissions;
- Electrification of Processes: Electrifying industrial processes using low-carbon energy sources helps lower emissions by reducing reliance on fossil fuels;
- Carbon Capture Utilisation and Storage (CCUS): technologies capture and store carbon emissions, preventing them from entering the atmosphere;
- Negative Emission Technologies: These include strategies like Bioenergy Carbon Capture and Storage (BECCS), which not only mitigate emissions but also remove carbon dioxide from the atmosphere.

Certainly, as mentioned by numerous research endeavors, it is important to utilize each of these potential mechanisms in order to attain a completely decarbonized industrial sector. Within this context, energy efficiency enhancements assume a crucial role in mitigating GHG emissions within the industrial domain. This is particularly significant given that, unlike measures such as demand reduction and specific forms of material efficiency, energy efficiency improvements align with the strategies of established companies. They serve the dual purpose of curbing costs and emissions, without conflicting with the revenue-generating

business models of these companies. Nevertheless, it is worth noting that various studies have established that relying solely on efficiency improvements is insufficient to achieve the requisite reductions in emissions (Couchy, 2023).

2.5 Barriers and Challenges for Decarbonization

According to Oberthür, Khandekar, and Wyns (2021), the six main barriers and challenges for deep decarbonization of Energy-Intensive Industries (EIs) include:

- Lack of Mature Low-CO₂ Technologies
 - Most technologies for eliminating greenhouse gas emissions from EIs are still in early development stages;
 - Existing technologies only offer limited decarbonization potential;
 - More research and development, especially in electrification, carbon capture, and non-fossil fuel feedstocks, are needed.
- Limited Research and Development (R&D) Investment
 - EIs have relatively low R&D investment compared to other sectors;
 - Smaller new entrants in these industries face challenges in accessing markets and funding for innovative solutions.
- High Capital Expenditures and Long Investment Cycles
 - EIs facilities require substantial upfront capital investment;
 - These investments have long life cycles, leading to carbon lock-in;
 - New, unproven technologies face high financial risks during demonstration and commercialization.
- Costs and Competitiveness
 - Low-carbon technologies often have higher operational costs, especially during development;
 - These costs can negatively impact the competitiveness of EIs products in global markets.
 - Without supportive policies, these higher costs may not be passed on to consumers.

- Complex Global Value Chains
 - Globalization has made EILs value chains more intricate;
 - Global competition and internationalization make it challenging to track and control product end use.
 - Recycling and up cycling efforts are hindered by this complexity, as well as labor-intensive product design.
- Lack of Adequate Policy Frameworks
 - Effective policy frameworks to promote EILs decarbonization are lacking;
 - Policies such as R&D support, subsidies, carbon pricing, and product standards are needed;
 - The global nature of EILs requires international cooperation to prevent carbon leakage and ensure the success of such policies.

2.6 Energy Efficiency

This project will mainly focus on energy efficiency improvements in order to decarbonize the production so it makes sense to review more in depth in this topic.

2.6.1 Definition

According to Patterson (1996), the term "energy efficiency" is quite general, and there is no single, definitive way to measure it. Instead, a number of indicators can be relied upon to quantify changes in energy efficiency. Essentially, energy efficiency means getting more out of the energy used, in the form of services or useful outcomes. In industry, for example, energy efficiency can be measured by how much energy is needed to produce a certain amount of a product. Therefore, energy efficiency is often defined using a simple ratio that is expressed in Equation 2.1.

$$\text{Energy Efficiency} = \frac{\text{Useful Output of a process}}{\text{Energy Input into a process}} \quad (2.1)$$

2.6.2 Advantages

The significance of prioritizing energy efficiency as a policy goal is intertwined with several advantages, including enhancing commercial and industrial competitiveness, energy security, and, more notably, contributing to environmental benefits by reducing CO₂ emissions (Patterson, 1996).

According to the Ryan and Campbell (2012) from International Energy Agency (IEA), there are several socioeconomic outcomes due to energy efficiency improvement at an individual, sectoral, national and international level:

- Individual Level
 - Health and well-being benefits: Improved energy efficiency leads to better building conditions and air quality, positively impacting public health.
 - Poverty alleviation: Lower energy costs for low-income households enable access to more essential services and needs.
 - Increased disposable income: Energy savings result in more money available for households, individuals, and businesses.
- Sectoral Level
 - Industrial productivity and competitiveness: Energy efficiency reduces resource use and pollution, boosting productivity and competitiveness.
 - Energy provider benefits: Enhanced efficiency allows energy providers to offer better services while reducing costs.
 - Asset value appreciation: Buildings with better energy performance command higher rents and property prices.
- National Level
 - Job creation: Investments in energy efficiency create jobs, supporting green growth strategies.
 - Reduced public expenditures: Lower energy costs for the public sector and reduced subsidies benefit national budgets.
 - Energy security: Energy efficiency enhances the security of energy systems by reducing risks.
 - Macroeconomic impact: Energy efficiency positively affects Gross Domestic Product (GDP) (a key economic indicator that represents the total monetary value of all goods and services produced within a country's borders during a specific period), trade balances, national competitiveness, and employment, mainly through increased spending and lower energy costs.
- International Level

- Reduced greenhouse gas emissions: Energy efficiency measures cut emissions by reducing fossil fuel demand.
- Stabilized energy prices: Lower energy demand can lead to more stable prices.
- Sustainable resource management: Energy efficiency eases pressure on resources.
- Development goals: Improved energy efficiency supports economic and social progress, benefiting developing and developed nations alike.

2.6.3 The rebound effect

The term "rebound effect" (or "take-back effect") is used to explain how increased energy efficiency, leading to reduced energy service costs, influences consumer behavior (Fronzel, 2004; Cleveland, 2004). In simple words, when individuals experience reduced energy expenses due to efficiency improvements, they often respond by using more energy services, such as leaving lights on longer or enjoying a higher level of comfort from heating. This phenomenon is like taking back some of the energy savings in the form of increased energy consumption. Cleveland (2004) gave the follow example to explain the rebound effect: the replacement of a 75-watt incandescent bulb with an 18-watt compact fluorescent bulb, theoretically saving 75% of energy, in practice, people may leave the light on longer because it costs less to run. This tendency is more pronounced in households facing "fuel poverty" where previous energy services like heating were considered insufficient. In such cases, efficiency improvements may result in higher comfort levels, effectively allowing consumers to enjoy a warmer home without increasing their energy expenses. These rebound effects have been observed and documented in real-world studies.

2.6.4 Costs and Challenges

Providing incorrect cost information, relying on outdated data, and making inaccurate predictions about the market can lead to skepticism about the effectiveness of renewable energy and energy efficiency measures in reducing emissions (Kamal, Al-Ghamdi, and Koc, 2019). Morrissey, Meyrick, Sivaraman, Horne, and Berry (2013) cited the "timeline dilemma", that refers to the situation where environmental policies involve immediate short-term expenses but offer significant long-term advantages.

Not accurately assessing the advantages of energy efficiency often leads to insufficient investments in this area. The missed benefits represent the "opportunity cost" when energy efficiency investments are not prioritized. This missed opportunity can be substantial, especially in a world where global demand is rising, resources are under pressure, and climate issues are of extremely importance (Ryan and Campbell,

2012).

According to Grueneich (2015), there are five main challenges in relation to energy efficiency:

- There is a need for a significant increase in the scale of energy efficiency savings.
- There is a need of diversification sources from which energy efficiency savings are derived.
- Establishing consistent methods for measuring and maintaining energy efficiency savings should become standard practice.
- Energy efficiency achievements should be seamlessly integrated into a framework aimed at reducing carbon emissions.
- Energy efficiency should be recognized and appreciated as an integral component of a constantly evolving energy grid that includes large-scale renewable energy sources, distributed energy resources (DERs), and substantial variations in energy demand.

2.7 Science Based Targets

2.7.1 History and Definition

In 2015, global leaders reached a historic milestone by adopting the Paris Agreement during the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change. Together, they pledged to mitigate the most severe consequences of climate change by constraining the increase in global temperatures to well below 2°C, with a special focus on limiting the rise to 1.5°C.

In the previous year, in 2014, was founded the Science Based Targets initiative, representing a collaboration involving the non-profit organization Carbon Disclosure Project (CDP), the United Nations Global Compact, the World Resources Institute (WRI), and the World Wide Fund for Nature (WWF).

The SBTi was established with the aim of mobilizing the private sector. Its goal was to encourage businesses to establish emission reduction objectives that align with climate science, enabling them to actively contribute to the monumental global endeavor to combat climate change (Science Based Targets initiative, 2021).

To summarize, the SBTi offers ways and recommendations for businesses to match their self-imposed targets for reducing emissions with the climate objectives outlined in the Paris Agreement (Schweitzer, Bach, Holzapfel, and Finkbeiner, 2023).

The SBTi must cover company's scope one and two emissions which are direct and indirect emissions, respectively (Bhatia et al., 2004). Scope one emissions are direct emissions from owned/controlled sources, for example, if the company burns gas to produce heat inside of the factory, that means that gas is a scope one emission source. Scope two emissions are known as indirect emissions such as the emissions from energy purchased from the grid. Scope three emissions refer to indirect greenhouse gas emissions that are generated as a result of a company's operations, but originate from sources that the company neither owns nor controls. Such emissions may occur upstream in the supply chain, such as those related to the extraction of raw materials used in the manufacturing of a company's products (Schweitzer et al., 2023). In contrast to scope one and two emissions, scope three emissions are only obligatory to be included in near-term targets if they represent more than 40% of total emissions, however, in long-term targets they are always mandatory (Science Based Targets initiative, 2023a). It should be noted that near-term targets for emission reductions, whether absolute or intensity-based, should span a minimum of five years and a maximum of ten years from the moment they are submitted to the SBTi for validation. Long-term targets should establish a target year no later than 2050 (Moreno, 2023).

2.7.2 Method

Typically, methods for establishing science-based targets consist of three key elements:

- A carbon budget, which delineates the total allowable greenhouse gas emissions to constrain global warming to 1.5°C or significantly below 2°C;
- An emissions scenario, which outlines the scale and timeline for emissions reductions;
- An allocation methodology, which specifies how the carbon budget is distributed among individual companies.

The main elements of methods for setting the SBTs are summarized in Figure 5.

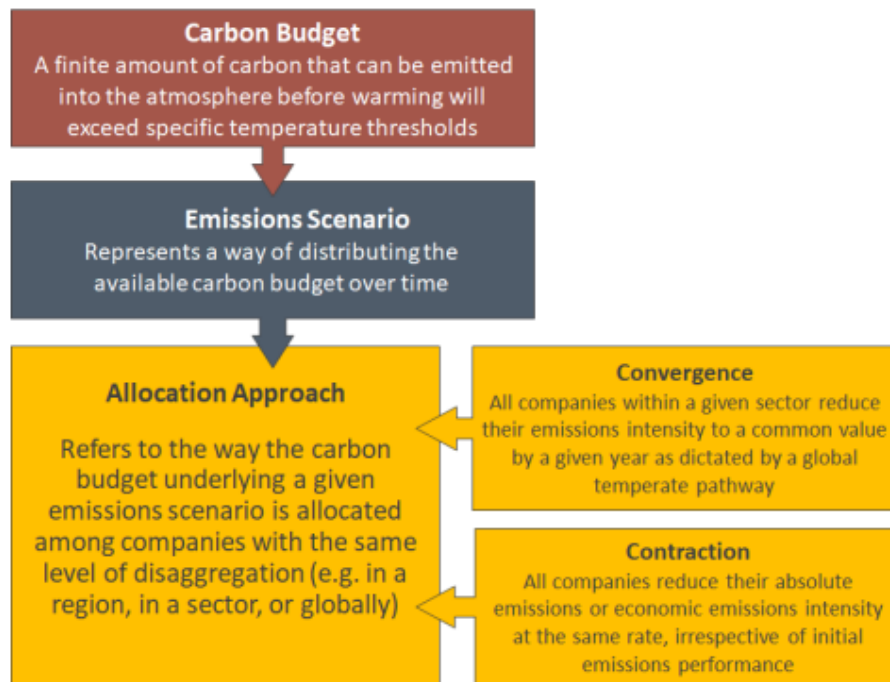


Figure 5: Main Elements of Methods for Setting SBTs. Retrieved from (Science Based Targets initiative, 2020)

2.7.3 Approaches

According to Schweitzer et al. (2023), today is possible to choose between two different strategies in order to achieve the near-term and long-term science-based targets (SBTs) that cover both scope one and two which are the Absolute Contraction Approach (ACA) and the Physical Intensity Convergence Approach (PICA) .

Absolute Contraction Approach

The ACA mandates that a company reduces its overall emissions by a consistent percentage each year. To meet the 1.5°C target, near-term goals necessitate an annual reduction of at least 4.2% (Science Based Targets initiative, 2019). For long-term objectives, a universal pathway, relevant to all industries, requires emissions to decrease by at least 90% compared to the base year.

Physical Intensity Convergence Approach

The PICA was developed to help businesses set emission reduction goals based on sector-specific scenarios and characteristics. It considers emissions, activities, and sector-specific factors, allowing companies to align their targets with sectoral trends and potentials. The PICA uses global sectoral data and is adaptable for scope three emissions. It also accommodates companies with different emission profiles within the same sector (Science Based Targets initiative, 2019).

It should be noted that, to make sure all of the companies within a sector attain a uniform reduction in their emission intensity in the long term they should follow the PICA. On the other hand, to set near-term SBTs using PICA, the SDA must be used (Science Based Targets initiative, 2023a).

In order to summarize the two strategies to achieve the near-term and long-term (SBTs) and having Schweitzer et al. (2023) as an inspiration, the Table 1 was created.

Table 1: SDA vs PICA

Approach	ACA	PICA
Fundamental Principle	Yearly linear emissions reduction vs. target year	Unique decarbonization trajectories tailored for sectors, considering anticipated market shifts
Method Output	Uniform reduction of absolute emissions for all companies regardless of initial emissions levels	Reduction of a company's emissions in relation to specific output, translated into absolute emission reductions based on emission intensity
Underlying Tenet	Past emissions carried forward as future allowances	Alignment toward a shared emission intensity goal for all sector companies, assuming major global sectors will harmonize emission intensities by 2050
Sector Availability	All Sectors	Apparel, cement, finance, forestry, ICT, maritime, power generation, transport, buildings, iron and steel, aluminum, pulp and paper
Target Range	Near- and long-term	Long-term

Companies are provided with two distinct SBTi methodologies to select from. SBTi encourages companies to opt for the most ambitious path for reducing emissions while still allowing them the freedom to choose their preferred method. Notably, the power sector is the only one mandated to utilize the sector-specific PICA approach (Schweitzer et al., 2023).

2.7.4 Companies involved

The adoption of SBTs by companies and financial institutions continued to surge in 2022. A total of 1097 companies had their targets validated, surpassing the cumulative count of the previous seven years. A significant majority (76%) of companies with science-based targets publicly disclosed their progress towards

these goals in various forms. In 2022, more than half of these companies (53%) provided comprehensive reports on their advancement regarding both near-term and long-term targets. Additionally, approximately a quarter (23%) of these firms reported progress on at least one specific target (Science Based Targets initiative, 2023b).

2.7.5 Challenges and Limitations

In fact, some authors have noticed that the attention given to the SBTi in existing academic literature is limited, with only a few studies addressing its effectiveness. Many studies focus on reporting standards, revealing a disconnect between target ambition and scientific requirements for emissions reduction. As of July 2020, there were few publications on SBTs, and none offered a comprehensive quantitative assessment of progress. SBTi lacks an integrated monitoring system, relying on self-reporting (Giesekeam, Norman, Garvey, and Betts-Davies, 2021).

According to Worthington and Lovell (2018), SBTs have gained attention and are useful for policy-making and portfolio-level climate action but their effectiveness at the individual company level is questionable. The concern lies in SBTs potentially setting a low bar for carbon reduction, with some companies benefiting from external factors like grid decarbonization, rather than implementing substantial emissions reductions. Real estate organizations, for instance, may find it relatively easy to meet SBTs without making meaningful changes. Investors interested in climate-conscious investments should consider SBTs compliance as a baseline requirement and focus on clear and time-bound plans for achieving net-zero carbon emissions. Ultimately, SBTs should serve as a starting point rather than a mark of full responsibility in addressing climate change.

Chapter 3

Company Presentation

This chapter introduces the company where the internship took place and which allowed the development of this project, Decathlon.

3.1 Company's History

Decathlon was founded in 1976 in Englos, France, by Michel Leclercq and six teammates who shared a passion for sports and wanted to create a new concept, a store dedicated to all sports under one roof. Today, Decathlon is at the forefront of sport retailers and, according to the latest information, is present in 59 countries with 1751 (company-owned, without franchises), as shown in Figure 6.



Figure 6: International presence of Decathlon's shops. Information from company documentation.

The company has 36 different brands, specialized in different sports areas, requiring a team of professionals responsible for the different phases of the products, from design to in-store sales. For this reason, the company has R&D centers in different locations in France (Figure 7), so that each sport can be offered in the right place and under the right conditions.

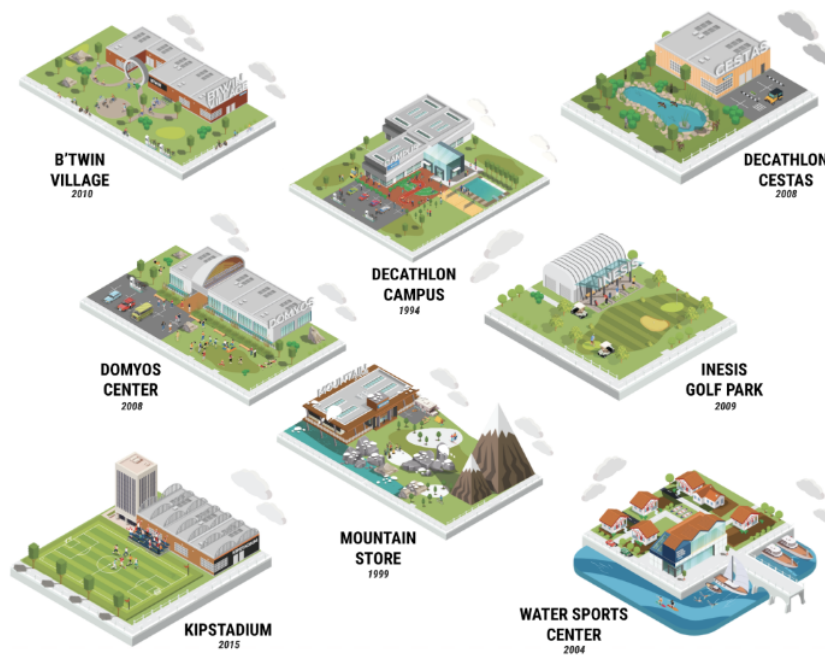


Figure 7: Decathlon's R&D facilities. Information from company documentation.

3.2 Values and Purpose

Decathlon is very demanding when it comes to partners, employees or suppliers, making sure they all align with the values Vitality, Responsibility, Generosity and Authenticity and a clear purpose: move people through the wonders of sports.

3.3 Decathlon Production Portugal

In 1992, Decathlon Production Portugal (DPP) was founded, and a few years later, in 1998, the production of bicycles began. Nowadays, Portugal owns the production of bicycles, helmets, ping pong tables, basketball tables, shoes and other products that have similar processes. In addition, Decathlon also has suppliers in Spain, which are also managed by the Portuguese office.

The production office is divided into teams for industrial processes, human resources, finance and logistics. Each industrial process consists of a group of Production Leaders who oversee the operations of their suppliers. These Production Leaders have specific responsibilities including quality control, supply management, industrialization and development. Each team is led by the respective Production Team Manager. Nowadays DPP has 11 teams:

- Cross Operations & Transformation;
- Bike - Finish Good Quality;
- Bike - Finish Good Supply;
- Bike - Components Quality;
- Bike - Components Supply;
- Metal;
- Plastic + Helmet;
- Footwear Industrial Division - Quality & Supply;
- Textile;
- Finance and Logistics.

This work was integrated with the Transformation Team, as sustainability is a cross-cutting issue for all teams. However, contact with all teams of the different industrial processes was required to engage with the supplier panel established for this project.

Part II

Core of the Dissertation

Chapter 4

Environmental Compliance and Decarbonize Manufacturing

Decathlon designs products and services that require the extraction of raw materials and the transformation of those materials into components. The components are assembled into products and the products are transported to warehouses and stored. The products are sold to customers who use them, and finally the products are recycled, repaired, incinerated, or end up in landfills. This entire chain impacts the environment, in the form of the carbon footprint.

When analysing the company's breakdown of greenhouse gas emissions by stage in the product life cycle (Figure 8), it can be seen that the main impact is due to the extraction of raw materials and production.

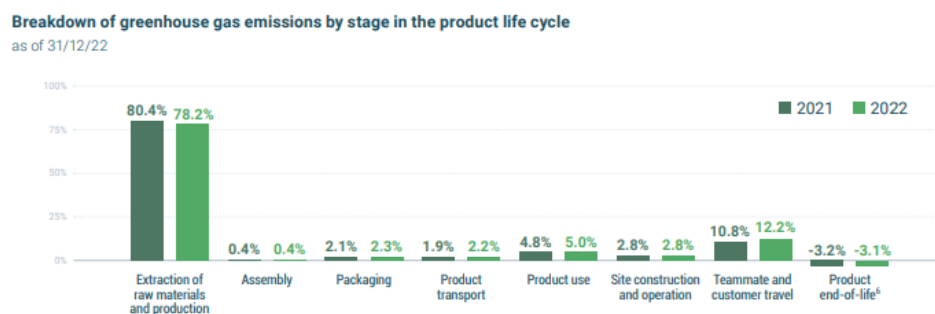


Figure 8: Decathlon breakdown of greenhouse gas emissions by stage in the product life cycle. Information from company documentation.

For this reason, the company must focus the main solutions on the products: on the one hand, on sustainable raw materials through eco-design of the products and, on the other hand, on the transformation of the energy used in production.

Today, the company has some difficulty evaluating the results of these actions. Indeed, for sustainable commodities, Decathlon uses eco-design key performance indicators (KPIs) and for renewable energy in production, the tools and data are difficult to manage and the company needs to work harder to manage them efficiently and appropriately. For the two main decarbonization strategies (Sustainable Materials and Processes and Low Carbon Energy Suppliers), data is key and Decathlon needs support and acceleration as it is not available or reliable enough.

Focusing in the solution "Suppliers Low Carbon Energy", the "Decarbonize The Production" project was launched at Decathlon in 2019 and aimed to promote the reduction of CO₂ emissions in Decathlon's supplier group. This project was divided into three main phases as shown in Figure 9.

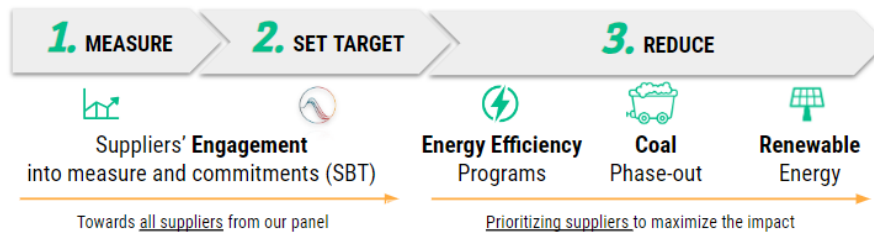


Figure 9: Decathlon Decarbonize Project. Information from company documentation.

The various phases required different actions and objectives:

- Phase 1 - Measurement: Suppliers were asked to measure their CO₂ emissions, and software was provided to enter their consumption data, which would then display the CO₂ calculation. The indicator used to monitor this process was the percentage of data quality rate;
- Phase 2 - Setting Targets: Suppliers were asked to sign up for the SBTi so that Decathlon could be sure they would take effective actions to reduce emissions. In this phase, various indicators were used to monitor the process, such as the percentage of SBTs validated, the percentage of trajectory validations, and the percentage of realized gap versus commitment;
- Phase 3 - Reduction: The goal of this phase is to reduce emissions through energy efficiency programs, completely eliminate the use of coal (which is no longer applicable in Portugal and Spain), and transition to renewable energy sources. The indicators chosen to monitor this phase are the percentage of maturity level and the percentage of maturity survey deployment.

This project was implemented as part of Phase 2 and Phase 3 of the Decarbonization Project. In a first step, it was requested to follow up on the actions that the suppliers had committed to fulfil when signing the SBTs. In a second step, the reduction phase, was requested to start through energy efficiency programs. This project was not launched in the entire panel of suppliers but only at some of Decathlon's suppliers as a strategic measure. The company intends to focus decarbonization efforts on suppliers that have the greatest impact. These include suppliers that emit the most or with whom they have a large turnover. In Portugal, the list of eligible suppliers included fourteen companies in the footwear, textile, plastic and metal components, and bicycle assembly sectors. In Table 2, information on the activity, emissions and turnover of the eligible suppliers was compiled based on data from a consumption tracking platform that

Decathlon provides and requires suppliers to keep up to date. Please note that the names of the suppliers as well as the percentage of turnover for Decathlon have not been disclosed for confidentiality reasons.

Table 2: List of eligible suppliers

Supplier	Process	Total tons of CO₂ (t)	Carbon Intensity (kg CO₂/kWh)	Turnover for Decathlon (%)
A	Bikes	2103	0,367	-
B	Bikes	1970	1,340	-
C	Helmets	1413	1,191	-
D	Plastic Composite	893	0,255	-
E	Bikes	1022	0,242	-
F	Footwear Industry Process	472	0,245	-
G	Metal	222	0,294	-
H	Metal	150	0,313	-
I	Bikes	342	0,284	-
J	Footwear Industry Process	118	0,301	-
K	Textile	249	0,278	-
L	Bikes	488	0,273	-
M	Footwear Industry Process	113	0,294	-
N	Woven	29	0,176	-

4.1 SBT Actions - Follow Up

Decathlon confirmed its track record with the SBTi organisation and therefore also sought to engage its suppliers in the initiative. In this way, the suppliers of the list were internally motivated to sign a science-based CO₂ target committing to reduce 4.2% of their CO₂ emissions in a linear way, as this is the minimum value to be reconciled with the scenario of a maximum temperature increase of 1.5 degrees Celsius. In addition, suppliers were asked to provide a road-map of planned actions, explaining what measures would be taken to reduce CO₂ emissions. At the beginning of this project, the SBTs were already signed with all of the suppliers presented in the list but, at that time, it was necessary to check which of the suppliers had wrote a road-map with actions and the status of those actions. So, one of the goals of this project was to understand whether or not the measures described by the suppliers were being complied with.

Ascertaining the status of the actions contained in the SBTs required reading these documents, as well as the proposed actions for each of these fourteen suppliers. In this way, it was possible to take advantage of the visit to the suppliers in the context of the energy efficiency programmes (explained in detail in subsection 4.2) to understand the status of the actions. In this way it was possible to map whether the supplier has written an action plan and what the status of these actions is in Table 3. For confidentiality reasons, the actions in question cannot be described, but only the percentage of actions that have not yet been started ("To Do"), that are in progress ("In progress") and those that have already been completed ("Done") is presented.

Table 3: SBT Actions - Follow Up

Supplier	Percentage of Actions		
	To Do	In Progress	Done
A	0%	25%	75%
B	0%	22%	67%
C	-	-	-
D	0%	40%	60%
E	0%	0%	100%
F	-	-	-
G	40%	0%	60%
H	-	-	-
I	14%	0%	71%
J	-	-	-
K	-	-	-
L	-	-	-
M	-	-	-
N	0%	0%	80%

From this analysis it was possible to conclude that seven of the suppliers on the list (C, F, H, J, K, L and M) have not written a road-map with actions. Furthermore, of the total actions that have been written, 7% have not yet been started, 11% are in progress, 76% have already been implemented and are completed and 6% of the actions were not included in any of the statuses as the suppliers did not know what they were about.

4.2 Energy Efficiency Programs

This project focused mostly on phase 3, named reduction, more specifically on energy efficiency programs.

4.2.1 Energy Efficiency Survey

The company decided that, for the list of selected suppliers, it was important, as a first step, to ascertain the level of maturity in energy efficiency and then, if necessary, to outline an action plan to improve energy efficiency. At the beginning of the internship, the company already had a survey to determine the level of maturity in energy efficiency of suppliers but it had not yet been publicised to them. The survey is divided into 5 chapters:

- Chapter 1 - Basic Information of the company
- Chapter 2 - Policy Planning and Management
- Chapter 3 - Data Measurement and Management
- Chapter 4 - Energy Intervention Investments
- Chapter 5 - Measurement and Verification

The questions in chapters 2, 3, 4 and 5 are mostly multiple answer questions, making it easier to attribute points and consequently a classification.

According to the survey, the supplier can be classified as "Not Mature", "Progressing" or "Mature" in terms of energy efficiency. A supplier classified as "Not Mature" is one that does not have an energy efficiency policy and does not perform any type of mapping of the energy it uses (no data collection or analysis). Suppliers classified as "Progressing" may already have a policy and are creating energy maps, but their investment in energy efficiency is not yet very high and they still have a lot of room for progress. Finally, suppliers classified as "Mature" have, as the name implies, already taken many energy efficiency measures, and their practises are an example to others.

The distribution of the surveys' points and respective ranking is summarised in Table 4.

Table 4: Classification of the survey chapters

Chapter	Points	Score
2	[0;36]	Not Mature
	]36;55[	Progressing
	[55;71]	Mature
3	[0;20[	Not Mature
	[20;45[	Progressing
	[45;79]	Mature
4	[0;10[	Not Mature
	[10;28[	Progressing
	[28;33]	Mature
5	[0;10[	Not Mature
	[10;40[	Progressing
	[40;45]	Mature

The final score includes a different weighting of the score for each chapter, as shown in Equation 4.1.

$$\text{Total Points} = 0.50 \times \text{C2 Points} + 0.25 \times \text{C3 Points} + 0.15 \times \text{C4 Points} + 0.10 \times \text{C5 Points} \quad (4.1)$$

Chapter 2 (C2) has a weight of 50%, chapter 3 (C3) has a weight of 25%, chapter 4 (C4) a weight of 15% and, finally, chapter 5 (C5) a weight of 10%. Similarly to the chapters, the supplier is also categorised according to total score into "Not Mature", "Progressing" or "Mature", as shown in Table 5.

Table 5: Final classification of the survey

	Points	Score
Final Score	[0;25[	Not Mature
	[25;50,6]	Progressing
	]50,6;64,7]	Mature

4.2.2 Energy Efficiency Maturity Survey Procedure

Another of the major objectives of this project was then to launch the survey in all the list of suppliers, being that, at the beginning of the internship, it had not yet been launched in any. In order to share the energy

efficiency survey with the list of fourteen suppliers, a Standard Operating Procedure (SOP) was created. This SOP (Figure 10) was designed to provide clear instructions and guidelines for the procedure. By doing so, it ensured that the survey dissemination process was well-structured and easily understandable for all parties involved.

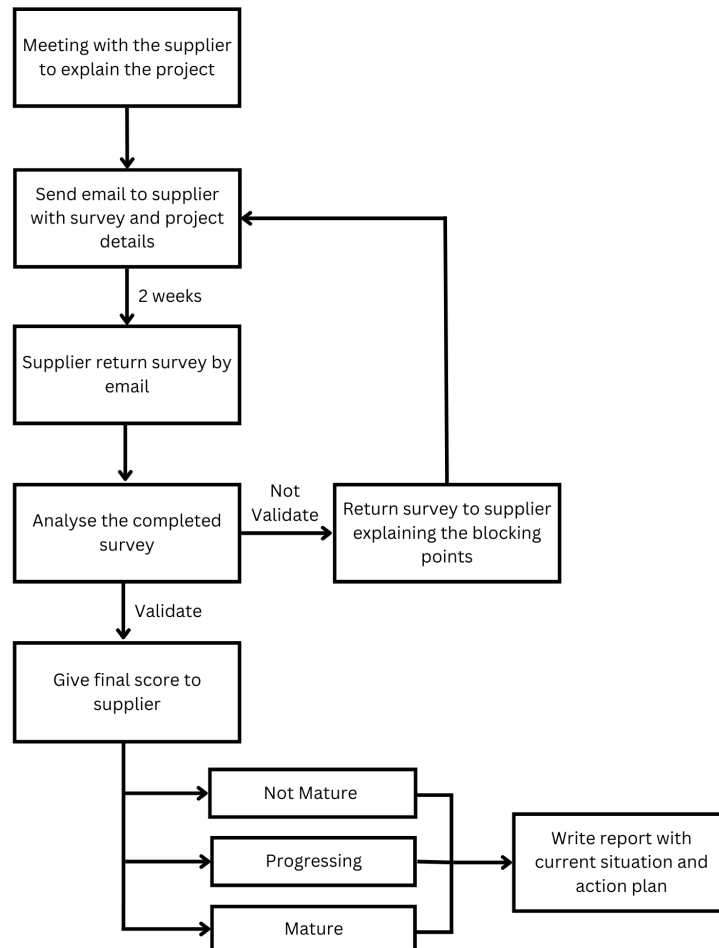


Figure 10: Energy Maturity Survey Procedure (SOP)

In this way, the survey was presented to each of these suppliers (which required a face-to-face visit to the majority of them) and they were given two weeks to complete it independently. The support slides used to explain the motivation of the project are in Appendix A.

During these two weeks it was necessary to provide support and clarify doubts. When the supplier returned the completed survey, it was necessary to analyse it and decide whether it was validated or not. When the survey was not validated it was because it had missing information or incorrectly filled in fields, in which case it was returned to the supplier for correction. This process allowed the company to obtain an initial picture of the state of maturity in energy efficiency of the supplier panel. Subsequently, it was possible to

outline an action plan to enhance this maturity.

4.2.3 Supplier Maturity Assessment

After presenting the survey and managing the survey validation process, it became possible to create a supplier ranking based on the scores obtained (Figure 11), along with the aforementioned rating .

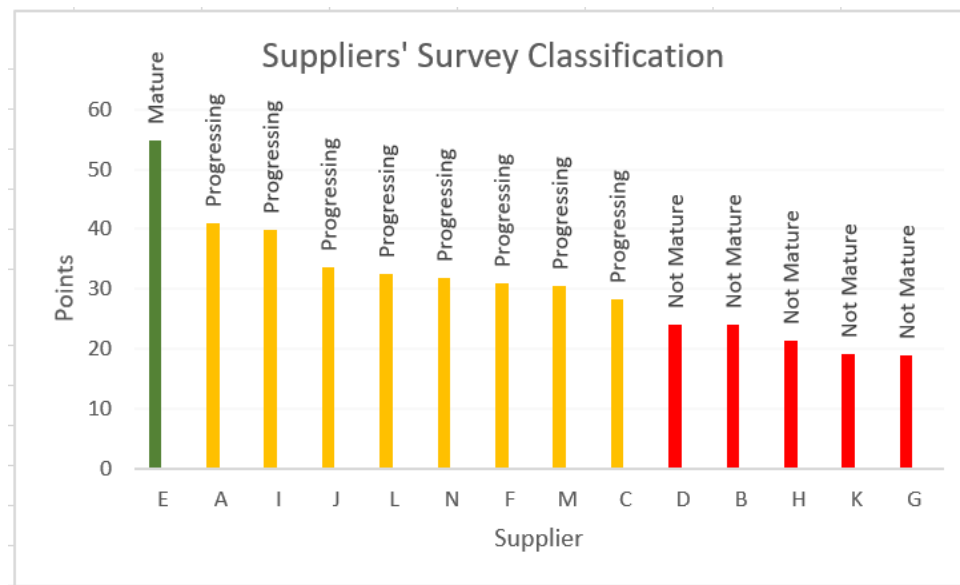


Figure 11: Suppliers' Survey Classification

Thus, only one of the company's suppliers was found to have reached maturity (supplier E), eight of the suppliers were rated as progressing (suppliers A, I, J, L, N, F, M and C), and five of the suppliers were still classified as not mature (suppliers D, B, H, K and G).

4.2.4 Cross-Sector Actions Already Implemented in the Supplier Panel

As already mentioned before, the submission of the survey to the fourteen selected suppliers required face-to-face visits to the majority of them and an analysis of the survey responses. In this way, it was possible to determine that most of the suppliers surveyed had already implemented some measures, such as the presence of solar panels that cover a small percentage of energy consumption and the possession of Green Electricity Contracts, issued by the energy supplier. Green Electricity Contracts are documents that prove that the electricity consumed by a facility comes from renewable energy sources. The purpose of these certificates is to promote and support sustainable energy production methods that help reduce greenhouse gas emissions and global warming. For consumers, especially businesses, having a renewable

energy certificate serves as proof that the energy they use comes from sources that do not emit greenhouse gases. This supports their commitment to environmentally friendly practises.

4.2.5 Cross-Sector Problems in the Supplier Panel

In the same way that the visit to the suppliers and the analysis of the surveys made it possible to understand what actions had already been taken, it was also possible to ascertain the biggest problems/faults, related to energy efficiency.

From **Chapter 2**, related to policy planning and management, it was possible to conclude that, in the majority of the suppliers there was:

- No real energy policy - The supplier does not have a formal document that defines, at a minimum:
 - a long-term energy reduction objective;
 - a long-term energy efficiency objective;
 - makes available human and capital resources to achieve those objectives;
 - energy data gathering to build targets;
 - commits the supplier to energy efficiency investments;
 - verifies energy savings;
 - is signed by top management.
- No energy/water reduction plan - The supplier does not have an energy/water reduction plan and target.

From **Chapter 3**, entitled Data Measurement and Management, it was found that in a large proportion of suppliers there was:

- No internal energy review.
- No daily record of energy intensity (energy consumption per piece).
- No electricity submeters and/or steam meters.
- No control of the boilers.
- No control of chiller system or air conditioners.

From **Chapter 4**, about Energy Intervention Investments, it is difficult to summarise the issues common to most suppliers as this chapter has specific questions depending on the supplier's activity. For this reason, it is easier to compile the issues by activity:

- Textile - It was verified that in the suppliers K and N:
 - There were induction motors in sewing machines;
 - There were sewing tables that weren't being used, but there was still lighting on top of them;
 - Part of the lighting was still done with fluorescent lights.
- Footwear - The suppliers F, J and M, who produce footwear, did not:
 - Manage the temperature setting of heat ovens;
 - Install variable frequency controllers for each set of air compressors;
 - Have temperature difference of the supply and return of hot oil/thermal oil of more than 15 degrees Celsius, in the production of soles.
- Plastic - Supplier D was the only one with processes related to plastic sector and it did not:
 - Record the proportion of water output on a daily basis;
 - Use the cooling water from the cooling tower to cool the mould in the factory.
- Metal - Suppliers with processes related to metal industry, which are suppliers G and H, did not:
 - Have a frequency conversion control system on the exhaust fans used for the welding and polishing equipment;
 - Record the daily defective rate of finished products;
 - Install thermal insulation or coil heating on the barrels;
 - Have written requirements for regulating the temperature of the cooling system in the different seasons of the year.
- Other - Suppliers with activities that did not fit into the aforementioned sectors were included in the "other" category. Most of these suppliers did not:
 - Capture heat resulting from processes requiring high temperatures;

- Have an SOP for the maintenance and control of the Heating, Ventilation and Air Conditioning (HVAC) or cooling system;
- Test the efficiency of the cooling system, HVAC or boiler with the Coefficient of Performance (COP);
- Monitor the combustion efficiency of primary fuel used anywhere in the facility.

From **Chapter 5**, the last one, related to Measurement and Verification, it was possible to conclude that in the majority of the suppliers there was:

- No financial feasibility study for energy efficiency investments.

4.2.6 Supplier B - A detailed analysis

When analysing the results of the energy efficiency survey, it was possible to identify five suppliers with the lowest classifications which was given the title of "Not Mature" suppliers (Figure 11). Crossing that information with information on the company's carbon intensity and turnover, only one supplier was selected for further investigation. In Table 2, it can be seen that supplier B has the highest value of carbon intensity (1,340 kg CO₂/kWh). It was also found that this supplier has the highest turnover for Decathlon. For this reason, this supplier was further analysed in terms of energy efficiency.

Supplier B is one of Decathlon's bicycle suppliers and is therefore responsible for rim manufacturing, painting and bicycle assembly services.

Energy Information

Supplier B uses four energy sources: electricity from the grid, electricity from solar panels, natural gas and diesel. Most of the supplier's machines are powered by electricity, natural gas is used in the paint line, and diesel is used in only one of the company's vehicles. The consumption tracking platform provided by Decathlon allowed access to the consumption of the four energy sources in 2022, but in order to understand which type of energy was used the most, it was necessary to convert the energy from different sources into a common unit, the kWh. Thus, natural gas and diesel, which are measured in m³, had to be converted to kWh.

- Natural Gas

According to EDP (2018), to convert gas in m³ to kWh, the volume in m³ should be multiplied by a Volume Correction Factor (VCF) and by Gross Calorific Value (GCV) as shown in Equation 4.2.

$$\text{Energy from natural gas (kWh)} = \text{Volume (m}^3\text{)} \times \text{VCF} \times \text{GCV} \quad (4.2)$$

According to the information from the supplier, it should be considered for the value of VCF 0,96759 and for the value of GCV 11,598418 kWh/m³. Then, the calculations for the conversion were made based on the Equation 4.3.

$$\text{Energy from natural gas (kWh)} = \text{Volume (m}^3\text{)} \times 0.96759 \times 11.598418 \quad (4.3)$$

- Diesel

According to Portgas (n.d.), it is possible to convert diesel in m³ to kWh by multiplying the volume in m³ by a conversion factor of 10020 kWh/m³, which means that the conversion was made according to Equation 4.4.

$$\text{Energy from diesel (kWh)} = \text{Volume (m}^3\text{)} \times 10020 \quad (4.4)$$

Thus, it was possible to construct the graph presented in Figure 12 with all sources of energy expressed in the same unit.

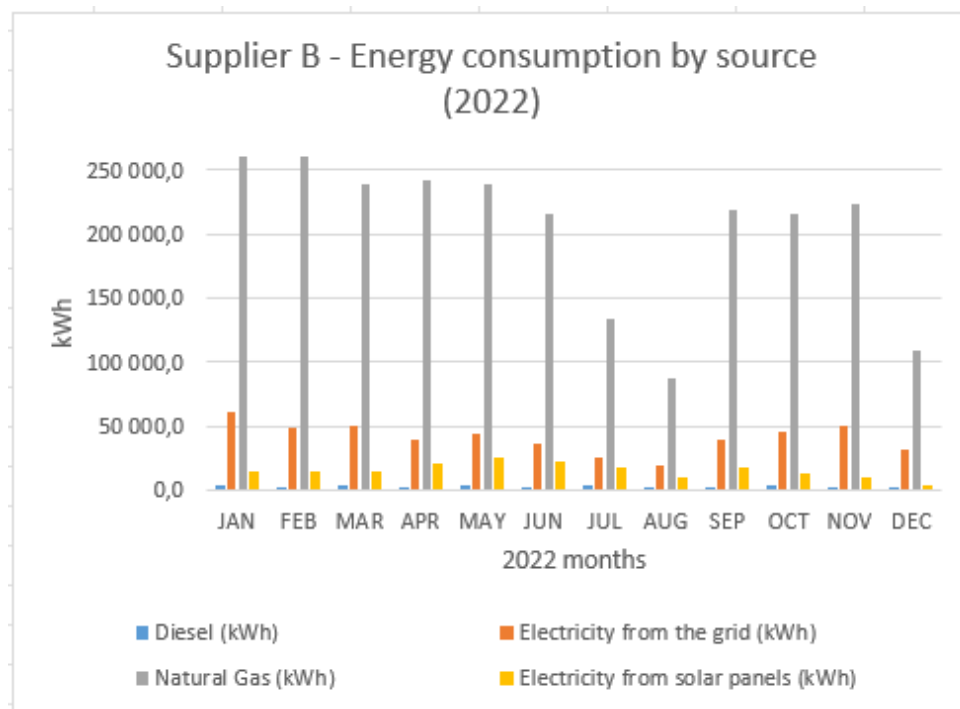


Figure 12: Supplier's Energy consumption by source (kWh) in 2022

Since the energy from all sources were expressed in the same unit, it was easy to understand that natural gas was the most used one. However, to understand which of these sources of energy had the greatest

impact on the carbon footprint, a new conversion was made between the different sources of energy and tonnes of CO₂. The Table 6 shows the conversion factors used, according Decathlon guidelines.

Table 6: CO₂ conversion factors

Energy Source	CO ₂ (kg)
Diesel (l)	3,070
Electric Power (kWh)	0,255
Natural Gas (m ³)	2,270

Once the conversions have been made in terms of the impact of CO₂ emissions, it was possible to obtain the graphic presented in Figure 13.

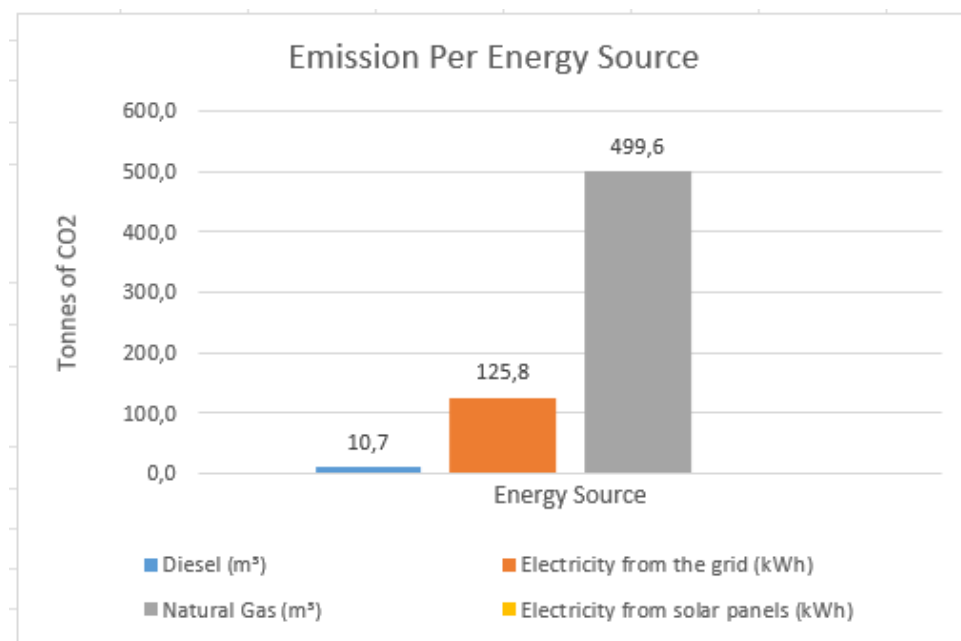


Figure 13: Supplier's CO₂ emissions per energy source

Thus, it can be concluded that, in addition to being the most widely used energy source, natural gas is also the source of energy with the greatest impact on the carbon footprint, that is, the one that emits the most tonnes of CO₂.

Shop Floor Description

As a first step, a revisit to the supplier was conducted to record the significant energy users (SEUs). A sketch of the factory floor is shown in Figure 14.

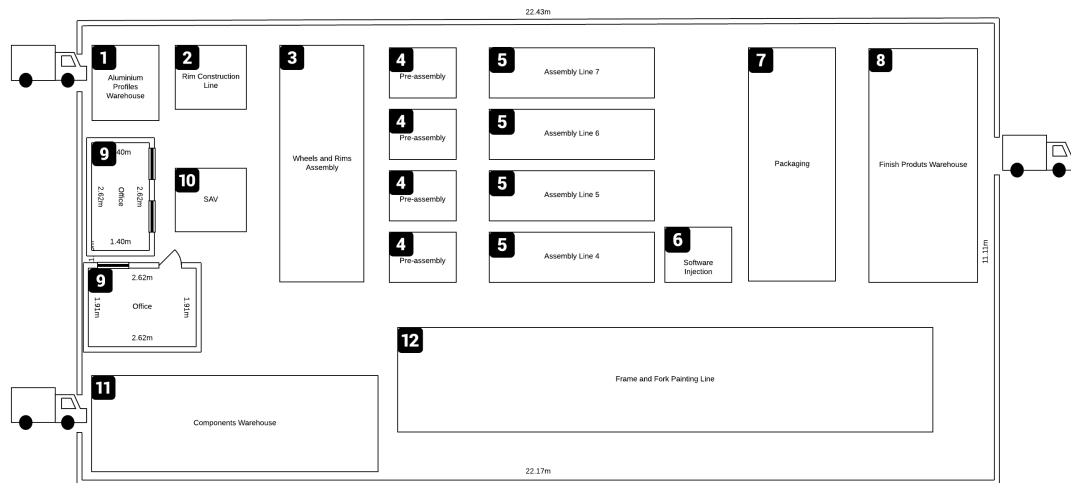


Figure 14: Supplier's Shop Floor

Each area of the factory floor was numbered to facilitate identification of the area and the SEUs used there.

- Area 1 - Aluminium Profiles Warehouse

This area is intended to store the aluminium profiles used in the construction of the rims. Thus, two electric forklifts are used to move the material in the warehouse.

- Area 2 - Rim Construction Line

Several machines connected to the electric current are needed to build the hoops. Thus, on this area there is one profile rolling machine, one cutting machine, one rim crimping machine and one rim shaking machine.

- Area 3 - Wheels and Rims Assembly

In order to obtain the wheels of the bicycle, a series of processes must be carried out. Thus, in this area nine mechanical rooting machines, three spoke stretching machines, twelve wheel straightening machines, three banding machines and four tyre fitting machines are used.

- Area 4 - Pre-Assembly

Before the bike is assembled on the production line, there is a pre-assembly of some components that also require machinery support. Thus, in this area, four machines for placing boxes and cones and one machine for cutting and scarfing are used.

- Area 5 - Assembly Lines

Bicycle assembly lines only use spanner wrenches, hot air guns and a conveyor belt to fit the bike. The wrenches used vary in type and can be electric, battery powered or connected to a compressed air system. From the observation of line four, it can be concluded that there were six compressed air spanners, ten battery spanners and one electric spanner (it will be assumed the same values for the other lines). As for the hot air gun, it was found that there was one per line.

- Area 6 - Software Injection

Software injection is present whenever electric bicycles are assembled. As a rule, line four is where this is done, however, the other lines can also do it if the needs require it. If there is then software injection, two computers are needed per line. As most of the time only electric bikes are assembled on line four, only two computers will be assumed for the listing.

- Area 7 - Packaging

In packaging, the finished bike is lifted and placed inside a cardboard box and then each pack of three boxes is placed on the pallet. Thus, in this area it was verified that in each line there was one machine to lift the bicycles, one machine to place staples and one machine to lift the boxes.

- Area 8 - Finish Products Warehouse

In this area the bicycles are ready and packaged for distribution and only two electric forklifts were used here.

- Area 9 - Offices

In the two offices there are three air conditioners and eighteen fixed computers.

- Area 10 - SAV

The SAV area is for the manufacture of wheels that do not go between production lines but go to the shops for repairs and replacements. In this area there is one wheel straightening machine and one mechanical rooting machine (similar to the machines used in area 3).

- Area 11 - Components Warehouse

There are ten electric forklifts in the components warehouse.

- Area 12 - Frame and Fork Painting Line

The frame and fork painting line consists of a "carousel" that transports these components, one washing machine, one drying machine, one painting booth and two ovens.

Electricity Consumption Calculation

During the visit to the factory floor, it was possible to list all the energy-consuming devices, as well as their model and quantity. Thank you to this information, it was possible to make an approximate calculation of the daily electricity consumption of each machine and consequently of each area.

It should be noted that this calculation is an approximation and that it was assumed that all equipment is in operation during the duration of the daily eight-hour shift. Although it is known that some equipment does not operate for eight hours at a time, it was not possible to estimate the time during which it would consume energy because even when equipment is "at rest" there are inherent energy costs. As mentioned above, for area 5, which corresponds to the assembly lines, information was collected on the equipment on line 4 because it is the most complex and has the most operations, and then this equipment was multiplied by the four lines.

In this way, using the model of each device, it was possible to access its performance and thus determine the daily electricity value using the formula presented in Equation 4.5.

$$\text{Consumption Base (kWh)} = \frac{\text{Number of Equipments} \times \text{Power (W)} \times \text{Daily Operating Time (hours)}}{1000} \quad (4.5)$$

In this way, the information about the type of device, the quantity, the power and the corresponding energy cost was compiled in Table 7.

Table 7: Considerable energy users on the shop floor

Area	Equipment	Number of equipments	Power (W)	Consumption Base (kWh)
1	Forklift	2	3000	48
2	Profile Rolling Machine	1	28000	224
	Cutting Machine	1	32000	256
	Rim Crimping Machine	1	11000	88
	Rim Shaking Machine	1	2500	20
3	Mechanical Rooting Machine	9	13000	936
	Spoke Streching Machine	3	1900	45,6
	Wheel Straightening Machine	12	2500	240
	Banding Machine	3	2000	48
	Tyre Fitting Machine	4	6000	192
4	Placing Boxes and Cones Machine	4	1500	48
	Cutting and Scarfing Machine	1	3500	28
5	Compressed Air Spanner	24	1000	192
	Battery Spanner	40	425	136
	Electric Spanner	4	320	10,24
	Hot Air Gun	4	1450	46,4
6	Computer	2	150	2,4
7	Lift Bycycles Machine	4	13000	416
	Place Stamples Machine	4	2600	83,2
	Lift Boxes Machine	4	9000	288
8	Forklift	2	3000	48
9	Air conditioner	3	12000	288
	Fixed Computer	18	150	21,6
10	Wheel Straightening Machine	1	6500	52
	Mechanical Rooting Machine	1	13000	104
11	Electric Forklift	10	10000	800

Area	Equipment	Number of equipments	Power (W)	Consumption Base (kWh)
12	Carousel	1	17000	136
	Washing Machine	1	18000	144
	Drying Machine	1	23000	184
	Painting Booth	1	27000	216
	Oven	2	60000	960

Thus, by adding up the electricity consumption of the machines that make up each of the areas, it was possible to obtain Table 8 and, consequently, draw up the graph in Figure 15.

Table 8: Electricity Consumption per Area

Area	Consumption (kWh)
1	48
2	588
3	1461,6
4	76
5	384,64
6	2,4
7	787,2
8	48
9	309,6
10	156
11	800
12	1640

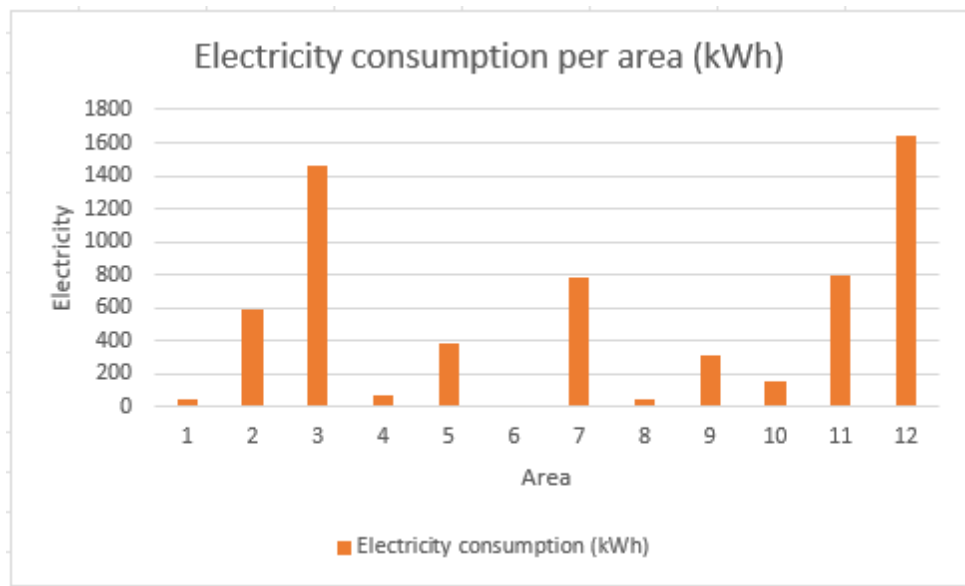


Figure 15: Daily Energy Consumption per Area

It is therefore easy to conclude that area 12, corresponding to the paint line, is the area that consumes more electricity. This conclusion seems to make sense since this area is home to equipment with high energy consumption, such as industrial ovens and paint booths.

In addition, area 3, where wheels and rims are assembled, also consumes a significant amount of electricity, which also seems to make sense as there are many machines in this area.

These conclusions are important for the supplier, particularly when it comes to setting priorities for action and choosing improvement actions, since the areas with the highest consumption should be prioritized.

Chapter 5

Presentation of the Improvement Proposals

The analysis of the surveys of the fourteen suppliers allowed the writing of fourteen reports with the current status of the supplier as well as a possible action plan. Just as it was possible to compile the most common issues in the supplier panel in the Chapter 4, this chapter will also present the solutions that were proposed for most suppliers. In addition, this chapter will also include the specific solutions for supplier B, which was analysed in more detail compared to the others.

5.1 Cross-Sector Action Plan in the Supplier Panel

To improve energy maturity, Decathlon suppliers should start an action plan with some critical items such as developing an energy policy and an energy and water reduction plan. In addition, an internal energy audit should be conducted to understand which are the most critical loads on site, and the installation of submeters would be extremely necessary. Boilers and HVAC systems are known to be large consumers, so suppliers should perform a detailed audit here as well. The actions are presented more specifically below.

5.1.1 Development of an Energy Policy

Suppliers should first develop a top-down energy policy, i.e., a formal document (signed by top management) in which the supplier establishes, at a minimum, long-term energy conservation and efficiency goals and the resources required to achieve those goals. In addition, this document should include energy data collection and the supplier's commitment to energy efficiency investments so that energy savings can be verified. To assist suppliers in creating an energy policy, an example was created and is shown in Figure 16.

Energy Policy - Example



This organization is committed to environmental sustainability and strives to reduce energy waste by all financially feasible means. We are committed to improving our energy performance by implementing an energy management system that includes the following:

- We will develop **long-term energy objectives** and targets to improve our energy performance;
- We will **provide the necessary resources** (qualified personnel, financial resources, etc.) to achieve our energy objectives and targets;
- We will **purchase energy efficient products** and services when financially feasible;
- We will take steps to demonstrate and **make visible energy performance**;
- We will ensure that **all employees** involved in energy management are appropriately trained;
- All new energy efficiency or energy saving projects will be reviewed to ensure that energy consumption is as low as possible following these measures;
- If necessary, improvements are made to all energy measures;
- We will comply with all legal and other requirements that apply to our use of energy.

This policy will be updated each year to ensure that it continues to reflect our ongoing commitment to SBT . It will also be communicated to all employees of this organization.

Date: 19 January 2019

Signed by: AAA

CEO / Owner/ Chief Sustainable Officer / Factory Manager

This organization

Figure 16: Energy Policy - Example

5.1.2 Development of an Energy and Water Reduction Plan

It would be very important for suppliers to have an energy and water reduction plan. At a minimum, this plan should include the following:

- A definite start and an end date of the target;
- The measurement unit;
- The baseline consumption;
- A reduction target expressed as a number or a percentage;

- An energy/water audit or assessment done by internal/external party identifying energy/water reduction opportunities;
- A list of specific implementation projects with start and end dates and progress of each project.

5.1.3 Carry out an Internal Energy Review

In order to understand what are the major consumers inside of the company, the suppliers should have an internal energy review. This review could include:

- A list of all major equipment and systems for the entire site;
- An energy balance of the entire site;
- The largest energy consumers on site;
- A ranking of the energy consumers based on considerable potential for energy performance improvement;
- All forms of energy;
- A ranking of the major energy users from largest to smallest.

5.1.4 Installation of Submeters

According to U.S. General Services Administration (n.d.) submeters are sensors that can be used to measure energy, liquid or gas consumption in more detail than is possible on a normal electric bill.

In fact, today there are already many options for installing submeters. Figure 17 is an example of one of these devices, which is available on the website of the company Genea, which offers a sales and installation service.



Figure 17: Example of a submeter. Retrieved from (Genea, 2019)

According to Energy Program at Washington State University (2019), these submeters come in a variety of designs, from mechanical meters that measure peak power at a specific time to advanced electronic meters that track energy, power quality, peak demand and more over time. Installing submeters allows for accurate measurement of energy use in specific areas or systems of a building, even when a general electric meter is in place for the entire site. The use of submeters is becoming increasingly important as more electrical equipment, such as heat pumps, are used that require more accurate monitoring. Submetering can result in benefits such as reduced energy and water consumption, more efficient buildings with lower operating costs, longer equipment life, increased occupant comfort, and resolution of building-related issues. In addition, submetering may be necessary to meet local and state regulations aimed at reducing carbon emissions and achieving low or no net energy consumption.

Submeter data have several practical applications, they can be used to compare a building's energy use, evaluate the impact of energy conservation projects, identify opportunities for improvement through data analysis, create energy budgets and reports, review project results, manage demand reduction strategies, select appropriate utility rates, validate utility bills, and facilitate cost allocation for shared spaces or tenants. However, it's important to understand that the mere presence of a submeter doesn't directly reduce energy consumption; rather, it provides valuable data that must be carefully analyzed to uncover actionable opportunities (Energy Program at Washington State University, 2019).

If a company wants to choose and implement a submeter, it's crucial to establish well-defined objectives and formulate a comprehensive submetering plan. Elements of the plan include setting goals, allocating resources, selecting areas for submetering based on criteria such as size and usage, and integrating the selected equipment into building systems. Data collection, analysis and implementation are critical steps,

and open systems integration is recommended for seamless device communication.

Ultimately, the key to successful submetering is a dedicated person responsible for reviewing data, identifying opportunities and suggesting appropriate actions. This person ensures that the data collected is used effectively, resulting in energy efficiency improvements.

It is difficult to put an exact price on the installation of this equipment because the price includes more than just the equipment itself. It is also important to count on labor costs for installation, which in turn depend on the type of submeter, location, communications equipment, etc.

5.1.5 Detailed Control of Boilers

A boiler is a closed vessel that allows the transfer of combustion heat to water, turning the water into either heated water or steam. Subsequently, the pressurized hot water or steam can be used to supply heat to a specific industrial process. However, only a portion of the heat content of the fuel is converted into valuable heat, while the remaining portion is dissipated through waste gasses, blowdown, and radiation losses (Shah and Adhyaru, 2011).

Industrial steam boilers, which are an essential part of manufacturing processes, play a crucial role in various industries. These boilers contribute significantly to energy consumption and emission generation, thus exerting a considerable influence. Approximately 30% of thermal energy consumption in the manufacturing sector is due to the operation of industrial steam boilers (M. Yang and Dixon, 2012; Hasanbeigi, Harrell, Schreck, and Monga, 2016; International Energy Agency, 2007).

For this reason, it is advisable to give priority to industrial steam boilers within the manufacturing sector when it comes to improve energy efficiency. Then are some actions that allow boilers to be controlled, such as:

- Install flow meters on the boilers in order to have access to the total steam production volume and steam meters so the facility could be able to provide daily records for individual steam boiler production;
- Testing equipment to measure the flue gas for Oxygen (O_2) and Carbon Monoxide (CO) and flue gas temperatures. According to Emerson Process Management (2015) flue gas analysis is a technique used by power plant operators to optimize the ratio of fuel to air. For this purpose, the content of excess oxygen and/or carbon monoxide (CO) in the flue gasses produced during combustion is determined. In this way, plant operators can determine the most efficient heating rate, reduce nitrogen oxide emissions (NO_x), and minimize greenhouse gas emissions. In theory, the optimum

point is reached when all the fuel reacts with the available oxygen in the combustion air and no un-reacted fuel or oxygen remains, however, this ideal condition is rarely achieved. The best operating point is usually at a slight excess of air (about 1-3%) and low levels of CO (0-200 ppm). This point varies for each boiler and must be adjusted periodically as burners wear and other firing conditions change over time.

Besides that, according to Chao, Ke, Yongzhen, Zhitong, and Yulie (2017), the temperatures of the incoming and outgoing gases also influence the efficiency and heat loss of the boiler. The temperature of the exhaust gases significantly affects the amount of heat lost through the exhaust in the boiler system. When the exhaust heat loss increases, it leads to a reduction in the overall thermal efficiency of the boiler, so it is really important to keep this information monitored regularly in order to keep the boiler's efficiency as high as possible. Ideally, the boiler testing should demonstrate that the boiler efficiency is at least 70% for coal boiler, 65% for biomass boiler or 88% for natural gas boiler;

- Measure boiler blowdown water. The water in a steam boiler isn't pure due to solid particles. So, before entering the boiler, the incoming water undergoes chemical treatment. The solids dissolved in the boiler water are referred to as Total Dissolved Solids (TDS). As water evaporates, especially near the surface, TDS concentration and water conductivity rise. If this conductivity surpasses the boiler manufacturer's set limit, foaming occurs on the water surface. This foam hampers evaporation, heat transfer, and shortens the system's lifespan. To maintain desired conductivity levels, solid materials must be removed from the water, done through a process called "Boiler Blowdown". Instead of using highly concentrated water, fresh feedwater is introduced, regulating the solid concentration. However, this process has two downsides regarding steam system efficiency. Firstly, chemically treated feedwater is used during blowdown, increasing production costs. Secondly, while condensate temperature is typically 70–80°C, feedwater is only 10–20°C, leading to significant heat energy loss for feedwater heating (Kocabaş and Savaş, 2021). So, measuring and managing boiler blowdown water effectively ensures that impurities are removed while minimizing unnecessary water and energy losses. This, in turn, contributes to improved energy efficiency, reduced operational costs, and prolonged equipment life;
- Recover of steam condensate. In systems where steam is produced, such as boilers, the steam that is sent to the necessary process at a specific pressure goes through partial condensation once it loses heat. These resulting steam condensates hold a considerable quantity of thermal energy

(European Commission, 2009). So, re-use of steam condensates increases the energy efficiency of industrial steam boilers (Jung-Min Yu, 2007);

- Search for and reduce energy loss or leakage in the steam, hot water or thermal oil distribution system. Regular maintenance and inspection of the boiler, for example through an SOP, can prevent leaks and consequently avoid energy waste. Figure B.0.1 shows an example shared with the suppliers in order to facilitate the development of an SOP.

5.1.6 Detailed control of Centralized Chiller System or HVAC Systems

The energy consumption of buildings, largely due to the operation of HVAC systems, accounts for more than 33% of the total energy usage and CO₂ emissions in both Europe and the U.S.. These emissions play a significant role in driving climate change (Pérez-Lombard, Ortiz, and Pout, 2008). To enhance energy efficiency, a variety of technological innovations are necessary. These solutions must not solely aid building experts in the appropriate selection and installation of heating systems, but they also need to continuously oversee these systems. This oversight involves the utilization of tools designed for detecting and diagnosing faults (Bonvini, Sohn, Granderson, Wetter, and Piette, 2014). Suppliers should:

- Change refrigerant at least once a year. The function of the refrigerants used in these systems is to absorb and release heat so changing the refrigerant regularly can help maintain the efficiency and effectiveness of the systems;
- Install VFD to control cooling and chilled water pumps. VFD are electronic devices that control the speed and rotation of heating, ventilation, and air conditioning motors by adjusting the frequency and voltage supplied to the motor to regulate the flow of water or air, resulting in lower energy consumption and greater energy efficiency (Teitel et al., 2008) ;
- Auto-control the frequency of cooling and chilled water pumps by the temperature difference of cooling and chilled water supply and return. The design and operation of a cooling system that maintains a significant temperature gap has attracted interest due to the idea of creating a highly efficient cooling system. This substantial temperature gap, referred to as the chilled water temperature differential, is quite different from conventional cooling systems, which typically operate with a supply temperature of 7 °C and a return temperature of 12 °C, resulting in a temperature differential of 5 °C. Increasing this temperature difference between the supply and return temperatures can result in a reduction in the amount of water circulated, lower energy consumption for

heat transfer, and an overall improvement in the efficiency of the cooling system (Dai, Lu, and Xu, 2021);

- Conduct a COP testing for chillers. COP is a performance indicator that allows the efficiency of chillers to be evaluated and defines cooling capacity in relation to power consumption, as shown in Equation 5.1:

$$\text{COP} = \frac{\text{Cooling Output}}{\text{Energy Input}} \quad (5.1)$$

The Cooling Output is the amount of heat removed or provided by the chiller and is usually measured in units such as kilowatts (kW) or British Thermal Units (BTUs) per hour. Energy Input is the electrical energy consumed by the chiller for operation. It's measured in kilowatts (kW) or another unit of energy. Thus, a higher COP means higher efficiency, and it makes sense to constantly analyze this performance indicator to continuously improve it;

- Install air conditioners with energy efficiency ratings above the Premium Efficiency IE3 standard. The International Electrotechnical Commission (IEC) developed a new test method and defined energy efficiency classes for single-speed three-phase motors, specifying voltage ratings, power ranges, pole numbers and duty cycles. Motors that met certain efficiency criteria were labeled IE3 (highest), IE2 (high) or IE1 (standard) motors (U.S. Department of Energy, 2014).

5.2 Specific Actions according to the Suppliers' Process

In addition to the actions suggested for Decathlon's entire panel of suppliers, it was also possible to point out some specific actions to improve energy efficiency, according to the suppliers' processes. The visits to each of these suppliers, as well as the analysis of the energy efficiency surveys, made it possible to see some shortcomings that were specific to the various sectors. Although the suppliers were listed at Chapter 4 and the process inherent to each one, not all of them fit perfectly into one of these processes. For example, supplier N has a very specific process for producing a mix of textiles and footwear, but it was decided that it would be included in textiles. So, together with the supplier, it was decided which process (Textile, Footwear, Plastic, Metal or Other) was most suitable and the suppliers were divided into the order showed in Table 9.

Table 9: Division of suppliers according to process

Process	Suppliers
Textile	K, N
Footwear	F, J, M
Plastic	D
Metal	G, H
Other	A, B, C, E, I, L

This division was very important as it made it possible to define more specific questions about each activity and to compile the problems by process. The failures/problems found in each sector are presented below.

5.2.1 Textile

Suppliers operating in the textile industry should:

- Replace induction motors by servo motors on the sewing machines. Servo motors are motors that consume energy proportional to the load: they consume only the energy required to perform the work in question. Compared to other types of motors, such as induction motors, servo motors offer superior energy efficiency, especially in situations where the load varies over time. They have low power consumption at rest: when the cutting machine is not actively performing an active cut, servo motors can go into an energy-saving mode or switch off completely, significantly reducing the energy consumption compared to other motors that continue to work at a fixed speed. Some servo motors also have the ability to regenerate energy during deceleration. Instead of dissipating this energy as heat, it can be returned to the power supply or stored in a battery.
- Install switches for individual lamps above each sewing table allowing the lights to be switched off when the tables are not in use;
- Replace all the fluorescent tubes by LED lamps since they are much more efficient.

5.2.2 Footwear

Suppliers operating in the footwear industry should:

- As mentioned above for the textile industry, in the footwear activity is also useful to install servo

motors in the cutting machines so that they consume energy on demand rather than in a linear fashion, thus saving energy;

- Manage the temperature setting of heating ovens using a SOP or other formal documentation, as showed in Figure B.0.1. The SOP or other formal document may describe recommended temperature settings that maximise oven efficiency and performance. By following these guidelines, energy can be used more effectively, allowing the oven to operate at maximum efficiency. For this reason, it may be important to have one of these documents;
- Install variable frequency controllers for each air compressor set. Frequency regulators allow precise control of motor speed so the compressor can operate at the required capacity without always running at full speed. By adjusting the motor speed according to the compressed air requirement, variable frequency controllers avoid the energy wastage associated with fixed speed compressors. This results in significant energy savings, especially during periods of reduced need;

5.2.3 Plastic

Suppliers with activities related to the plastic industry should:

- Record the proportion of water output on a daily basis. Plastic industry is known for using a significant amount of water at various stages of its production process so, a great measure would be to record the proportion of water output on a daily basis. Recording water outputs can be interesting for:
 - Identifying unusual peaks or drops in water use and detecting potential wastage.
 - Monitoring the efficiency of the plant's water distribution system. If certain areas or processes are using excessive water compared to others, this indicates potential areas for improvement or optimisation.
- Use the cooling tower water directly for cooling the moulds. In winter, the ambient temperature is usually lower, which means that the cooling tower water is already at a lower temperature compared to other water sources. By using the cooling tower water directly for cooling the moulds, it can take advantage of this naturally lower temperature and reduce the energy required for additional cooling. This can result in energy savings and lower operating costs. However, it is important to note that not all mould cooling systems allow or are suitable for direct tower cooling. The feasibility and effectiveness of this approach depends on the specific characteristics of the system, including the

cooling water temperature of the tower, the cooling temperatures required for the moulds and the capacity of the cooling system to handle the process needs.

5.2.4 Metal

Suppliers with metal processes should:

- Have a frequency conversion control system on the exhaust fans used for the welding and polishing equipment (on equipment with nominal power higher than 5.5 kW). It may be important to have a frequency conversion control system as this allows the fan speed to be adjusted according to the actual exhaust requirement. This allows the fan to operate at a lower speed when the need is lower, saving energy compared to a fixed speed system. In welding and polishing equipment, where the load can vary, this speed control can result in significant energy savings.
- Record the daily defective rate of finished products. In the metal industry, the number of defective products can be high, so a good measure could be to record the daily defective rate of finished products in order to be able to act quickly and reduce the use of energy on parts that have no value.
- Have thermal insulation or coil heating on the barrels. Ensuring that thermal insulation or coil heating is installed for all barrels can be important in terms of energy efficiency as it helps to conserve heat, control temperature, reduce energy wastage, improve equipment efficiency and realise cost savings. It is an effective measure to optimise energy use and promote sustainable practices within the facility.
- Have written requirements for regulating the temperature of the cooling system in the different seasons of the year. Having written requirements for temperature regulation allows to optimise the energy performance of the cooling system. During different seasons of the year, cooling needs may vary due to climatic conditions. By setting appropriate temperature limits for each season, you can avoid excessive energy consumption by reducing the cooling load when environmental conditions are more favourable.

5.2.5 Other

Finally, for the suppliers who didn't fit any of the previous sectors because they had different processes, it was possible to suggest:

- Capture heat in order to pre-heat fuel, water or air in systems such as boilers, furnaces, etc. Install heat capture devices such as economisers on your boilers, which capture heat to be used for pre-heating feed water in the boiler, or any other such device;
- Have an SOP for the maintenance and control of the HVAC or cooling system (Figure B.0.1 shows an example shared with the suppliers);
- Test the efficiency of the cooling system, HVAC or boiler with the COP regularly;
- Monitor the combustion efficiency of primary fuel used anywhere in the facility.

5.3 Supplier B - Detailed Action Plan

As mentioned above, Supplier B was selected for further analysis of energy efficiency. For this reason, and in consultation with the supplier, it was possible to come up with some proposals to improve energy efficiency. Some of the proposals require higher investments, but there are also some where the investments are zero. Although it was not possible to specify a particular investment for each proposal, a matrix of priorities for action was created. It is important to note that some of the ideas for the proposals were inspired by other suppliers at the time of the visits to each supplier. In addition, some of the ideas came from a brainstorming session with the environmental department staff at Supplier B and the Decathlon quality production leader responsible for that supplier.

5.3.1 Proposal 1 - Translucent roof

During the visit to the supplier, it became clear that the production area is lit almost exclusively by the lighting system and receives very little natural light, even though the supplier is located in a sunny area. Translucent roofs allow natural light to enter the interior spaces, reducing the need for artificial lighting during the day. This can significantly reduce electricity consumption and energy costs. This requires the choice of special materials to control the amount of heat entering the building, as well as a high-quality insulation materials and installation.

5.3.2 Proposal 2 - Sensor lights in offices and warehouses

During the visits to the supplier, it could be seen that the warehouse was visited only a few times a day and the lights there were always on. The same was true of the offices, which were sometimes empty for a few

hours but still lit. Sensor lights can automatically detect occupancy and adjust lighting levels accordingly. When areas are unoccupied, they can dim or turn off the lights, significantly reducing energy consumption. This can result in significant energy cost savings in large spaces such as warehouses and office buildings.

5.3.3 Proposal 3 - Installation of submeters

In fact, it would be very important to start collecting data from operations and understand which area or line is using more energy, what the daily energy records are, among other information that can be obtained with a submeter. Since the supplier had no submeters at the time of the visits, it was important to list all the major energy users and figure out which area was the most critical. That was made and described in the Chapter 4. Any way, this energy mapping to all of the energy significant users was really difficult, not precise and could change at any moment, so the submeters installation would be really important. Another Decathlon supplier who already had several submeters installed on the shop floor mentioned that the investment in this equipment was recouped in less than a year thanks to the correction of anomalies at various points in the factory.

5.3.4 Proposal 4 - Heat capture from the painting process and compressed air machine

During the visits to Supplier B, it could be noticed that the production hall is very hot, especially in summer. Since the painting process is carried out in an open environment right next to the assembly lines and two industrial ovens with high temperatures are used, it could be concluded that this contributes to the heat felt in the factory hall. Since moving the painting process to an environment isolated from the rest of the factory would be very expensive and perhaps not the best solution to the excessive heat, it would be interesting to capture the heat near the ovens and use it for processes that actually require heat, such as heating water, air conditioning other colder areas of the factory, and other activities.

In addition, bicycle assembly uses compressed air to a large extent, meaning that there is a compressed air distribution network throughout the factory floor and a machine that pumps the air through the pipes. It was found that there is a very high temperature near the machine that pumps the compressed air. This means that the compressed air machine is leaking and air with high temperatures is escaping into the factory hall, which also contributes to the heat that is present there, so it would be important to eliminate these leaks and, if this is not possible, to collect the heat released by the machine and use it for other measures, as described previously.

5.3.5 Proposal 5 - Repair of compressed air leaks

As mentioned above, most of the assembly processes for bicycles involve compressed air, which means that almost the entire length of the factory hall has a compressed air line. To find out if this system was efficient, a visit to the factory floor was made at the end of working hours, that is, when this equipment was no longer in use. During this visit, the sounds of air coming out of the equipment could be heard, so it was concluded that there are indeed compressed air leaks and that this system is not as efficient as it could be. It is therefore important to address the compressed air leaks and ensure that the system is not using more power than it needs to assemble the bikes.

5.3.6 Proposal 6 - Variable Frequency Drives in engines

As mentioned earlier, a VFD controls the speed and rotation of HVAC motors by adjusting the frequency and voltage supplied to the motor, so it could also be an interesting option to save energy.

5.3.7 Proposal 7 - Conversion of the service car to an electric one

Supplier B has only one company car for travel between production units, and this car is the only one responsible for diesel consumption. Since there is only one vehicle, it would therefore be interesting to convert this vehicle into an electric vehicle, which would completely eliminate the share of diesel fuel in the forms of energy used, and provide a charging station that could be used for the company vehicle or to charge the suppliers' electric cars.

5.3.8 Proposal 8 - Equipment designed for small production runs

The production volume is not linear and has decreased significantly in recent months, resulting in shorter shifts. Therefore, it would be interesting to develop another production line with smaller equipment that would be prepared for smaller productions and consume less energy. This would be a measure that would require a large investment but which, if production volumes were to continue to be lower than in past years, could bring energy savings.

5.3.9 Proposal 9 - Provision of electric bicycles for employees

The last proposal has no direct impact on the energy consumption of the factory, but could influence the habits of employees. Since Supplier B makes bicycles, including electric bicycles, some of these could

be made available to employees to use for short trips (to go home for lunch, to pick up something for the other production unit, etc.), encouraging them to use a sustainable source to get around while testing the equipment and helping the company make sure the bicycles don't have problems.

5.3.10 Action Priority Matrix

After the proposals were presented to the supplier, the task was to prioritize them according to the effort and impact they would have. Thus, an effort/impact matrix was created in which the various proposals were ranked according to the information available about them Figure 18.

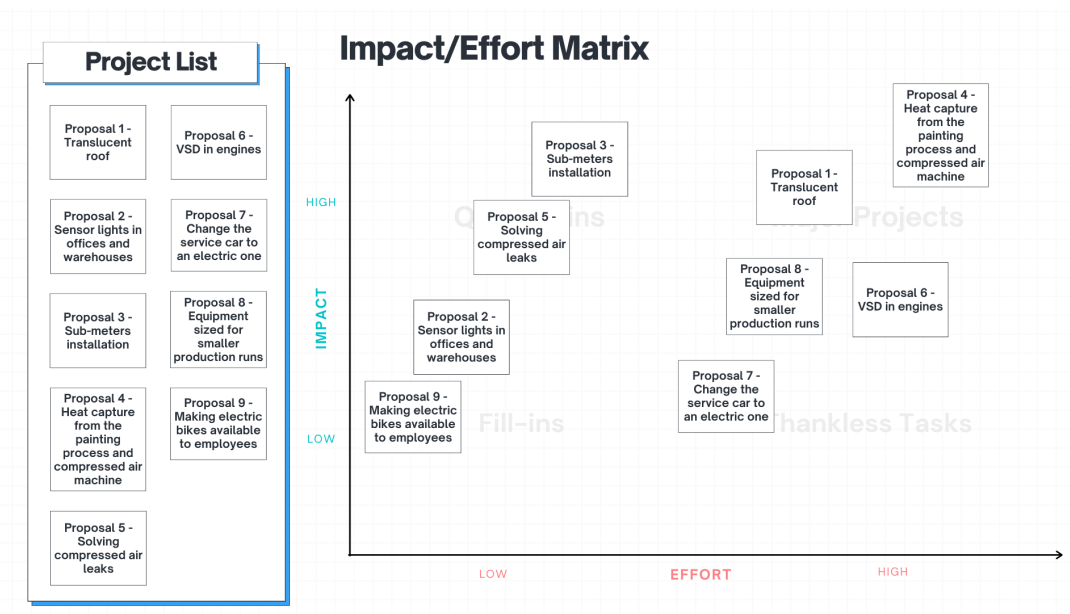


Figure 18: Impact/Effort Matrix - Supplier B

It should be noted that this matrix is an initial assessment based on estimates and that a more detailed analysis of each proposal would require more information that could not be obtained. In any case, it seems clear that the installation of submeters is the priority measure, since it requires little effort and will save a lot of energy.

Chapter 6

Conclusion

The purpose of this chapter is to summarize the process that was necessary to promote the decarbonization of production at Decathlon's suppliers, as well as any constraints and difficulties encountered during this process. It also makes some suggestions for future work to keep energy efficiency programs and follow-up SBTi as one of the main priorities, given their importance for a sustainable future.

6.1 Final Considerations

At the beginning of the project, Decathlon shared a list of fourteen suppliers with the aim of conduct an energy efficiency survey and follow up on the actions that the suppliers had committed to fulfil when signing the SBTs. For two of them, an on-site visit was not possible, so a virtual meeting was scheduled to explain the project. At all remaining suppliers, the facilities were visited and the project was presented. During the visits/virtual meetings, it was possible to ask the suppliers about the actions they had committed to implement when signing the SBTi, and even to confirm them by seeing some of them. Some visits were about confirming the installation of the solar panels and some documents were shown during the meetings as proof of the actions carried out. In the end it could be concluded that, within the list of suppliers analyzed, 7% of the total actions have not yet been started, 11% of the actions are in progress and 76% of the actions have already been completed. It was also possible to see that 6% of the total actions could not be included in any of the statuses indicated because they were actions that the suppliers did not know what they were about. Besides that, in all of them it was possible to launch the survey so that the 100% quota of completed surveys was reached.

The surveys were fundamental to achieving another objective outlined at the beginning of the internship, namely write action plans for improving energy efficiency in the supplier panel and also identifying and prioritizing actions by the most critical suppliers. In fact, an action plan was drawn up for each supplier, with simple actions that could make a difference in improving energy efficiency.

After analysing all the returned questionnaires that, as already mentioned, contained information about the suppliers' energy efficiency maturity level, it was possible to identify the most critical suppliers, classified as "Not Mature". Among the suppliers with the lowest scores in the survey, information on carbon intensity and turnover for the company was cross-referenced and only one supplier was selected for further

investigation. In the case of supplier B, it was necessary to go on site a few more times to learn about the processes and make suggestions for improvement. After analysing all of the intensive energy users of the shop floor, it was possible to understand which was the most critical processes and to come up with nine proposals, prioritizing them by the impact that would have as well as the effort implied.

The process of launching the surveys was not an easy one, given the failure to meet the deadline set for returning them, the doubts that arose and the lack of openness on the part of some suppliers. In addition, it was sometimes difficult to create specific solutions for each supplier due to the lack of time to get to know each process and reality. It should be noted that the electricity calculation for supplier B's various areas is a theoretical calculation, prone to errors, given that at the time of the visits there were no devices of any kind to extract the energy data for each zone. Therefore, the process of collecting the machine models in order to calculate their energy consumption was very difficult and time-consuming.

But despite all the difficulties, the project's objectives have been met and Decathlon now has access to the energy efficiency maturity of its suppliers, knows whether or not they are complying with the actions they proposed in the SBTi and, finally, has action plans to motivate suppliers to improve their energy efficiency.

6.2 Prospect for future work

Indeed, it has become apparent that there is still much to be done in the area of energy efficiency among Decathlon's suppliers.

Ideally, an energy audit should be carried out at all suppliers, and it would be important to continue monitoring energy efficiency performance indicators and promoting the implementation of improvement measures.

Since the percentage of SBTs actions completed is not 100%, it would also be important to follow up on these measures in time to reach this value and motivate suppliers who do not have a roadmap with measures to create one.

For supplier B, it would be very important to focus on the painting line, as it is not only the biggest electricity consumer, but also contributes to the perceived heat in the workshop, which affects the comfort of the employees. In addition, the installation of submeters should be prioritized and done shortly.

It is also very important to point out that energy efficiency measures are very important, but not enough to change the trajectory of climate change, and that much more needs to be done to reduce CO₂ emissions and save the planet.

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Part III

Appendices

Appendix A

Presentation of the Project to Suppliers

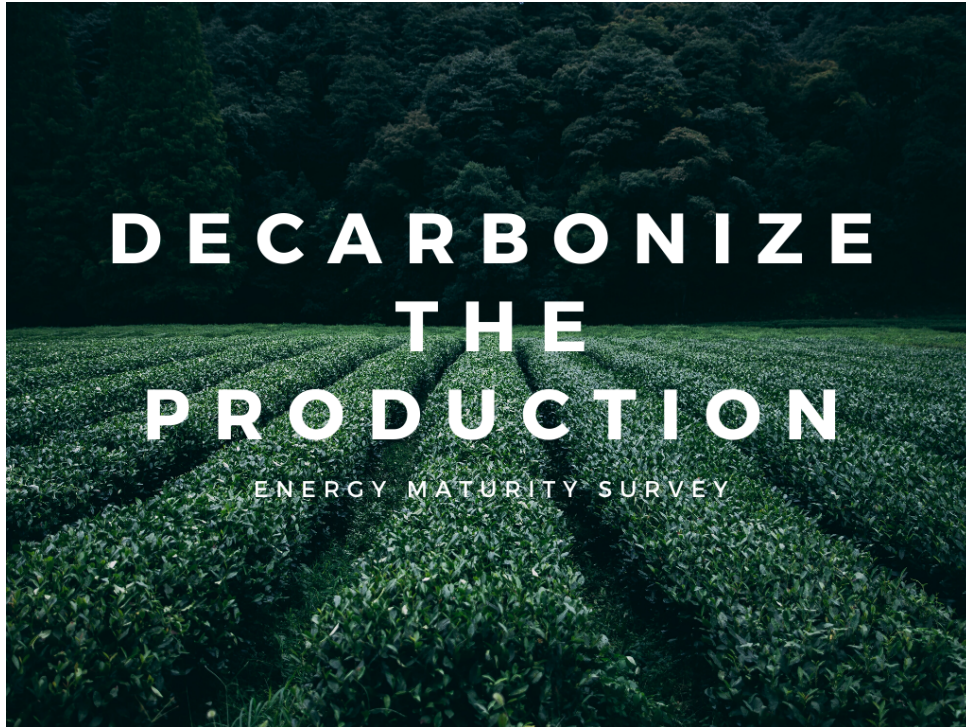


Figure A.0.1: Slides to support the presentation of the project to suppliers - Slide 1

1 CONTEXT

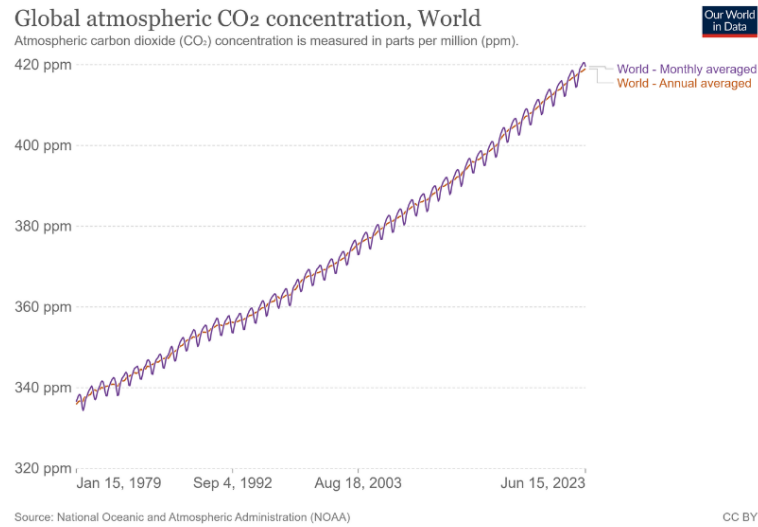


Figure A.0.2: Slides to support the presentation of the project to suppliers - Slide 2

1 CONTEXT

“The signs of global warming are everywhere, and are more complex than just climbing temperatures. All of these changes are emerging as humans continue to add heat-trapping greenhouse gases to the atmosphere.”
National Geographic



*ALL OF THE INFORMATION OF THIS SLIDE WAS RETRIEVED FROM NATIONAL GEOGRAPHIC SITE

Figure A.0.3: Slides to support the presentation of the project to suppliers - Slide 3

2 DECARBONIZE THE PRODUCTION PROJECT

Global greenhouse gas emissions and warming scenarios

Our World in Data

– Each pathway comes with uncertainty, marked by the shading from low to high emissions under each scenario.
– Warming refers to the expected global temperature rise by 2100, relative to pre-industrial temperatures.

Annual global greenhouse gas emissions
in gigatonnes of carbon dioxide equivalents

150 Gt

100 Gt

50 Gt

Greenhouse gas emissions up to the present

0

1990 2000 2010 2020 2030 2040 2050 2060 2070 2080 2090 2100

Data source: Climate Action Tracker (based on national policies and pledges as of November 2021).
OurWorldinData.org – Research and data to make progress against the world's largest problems.

Last updated: April 2022.
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No climate policies

4.1 – 4.8 °C

→ expected emissions in a baseline scenario if countries had not implemented climate reduction policies.

Current policies

2.5 – 2.9 °C

→ emissions with current climate policies in place result in warming of 2.5 to 2.9°C by 2100.

Pledges & targets (2.1 °C)

→ emissions if all countries delivered on reduction pledges result in warming of 2.1°C by 2100.

2°C pathways

1.5°C pathways

Figure A.0.4: Slides to support the presentation of the project to suppliers - Slide 4

3 ENERGY EFFICIENCY CONCEPT

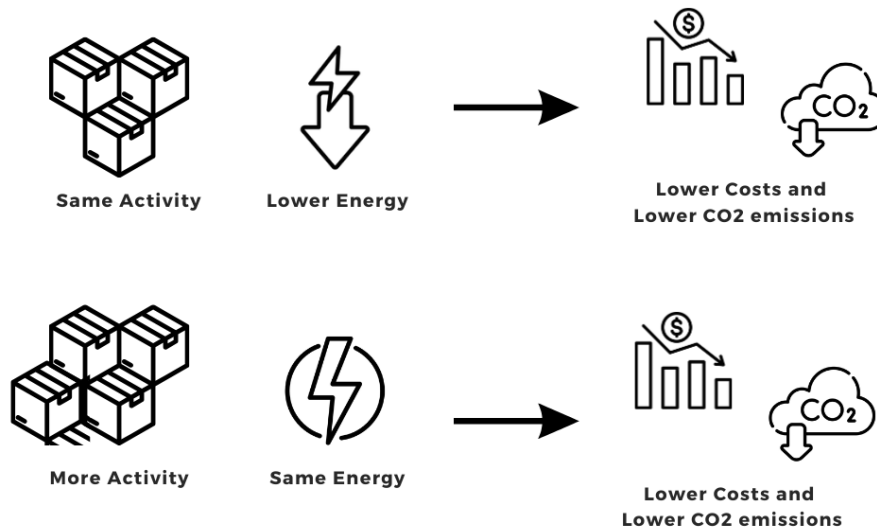


Figure A.0.5: Slides to support the presentation of the project to suppliers - Slide 5

4 ENERGY EFFICIENCY SURVEY

Purpose of the survey:

- Get an initial picture of the energy efficiency maturity of the supplier panel;
- Understand suppliers' biggest difficulties/failures;
- Proposing actions to improve energy efficiency.

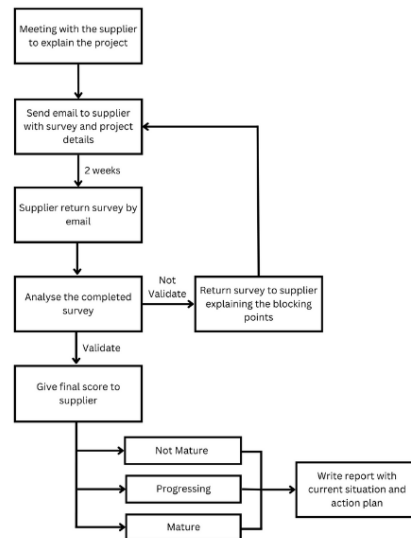


Figure A.0.6: Slides to support the presentation of the project to suppliers - Slide 6

4 ENERGY EFFICIENCY SURVEY



Figure A.0.7: Slides to support the presentation of the project to suppliers - Slide 7

Appendix B

Example of an SOP

Standard Operating Procedure (SOP)

(General Template)

Procedure: HVAC System / Cooling System / Boiler / Heating Ovens

Departments involved: Health and Safety department

Aim and Scope: This SOP outlines the procedures for the routine maintenance of HVAC systems/ Cooling systems/ Boilers/ Heating Ovens to ensure optimal performance and safety.

This procedure applies to all personnel responsible for the maintenance of the mentioned equipment at *This Organization*.

Equipment Description:

HVAC systems are used to control the indoor environment of a building or facility by regulating temperature, humidity, and air quality. They typically consist of components such as air handlers, chillers, heat pumps, ventilation fans, ...

Cooling systems are designed to remove excess heat from equipment, processes, or spaces. They use various methods such as refrigeration, air cooling, or water cooling to maintain temperature control.

Boilers are pressure vessels that use heat from a fuel source (such as natural gas, oil, or biomass) to generate steam or hot water. The steam or hot water is then used for heating, power generation, or other industrial processes.

Heating ovens are enclosed chambers designed to provide controlled heating for various purposes, such as baking, drying, curing, or annealing. They can use electric, gas, or other heat sources.

Maintenance Schedule: A routine check should be carried out at the beginning of each month.

Procedure:

1. **Safety Precautions**

- a. Before beginning any maintenance work, ensure that the equipment is safely shut down, and all energy sources (electricity, gas, etc.) are isolated
- b. ...

2. **Inspection**

- a. Visually inspect the equipment for signs of wear, damage, or leaks.
- b. ...

3. **Cleaning**

- a. Clean or replace air filters in HVAC systems.
- b. Clean and remove debris from cooling system condenser coils and evaporator coils.
- c. Remove sediment and deposits from boilers.
- d. Clean and remove residue from heating oven surfaces.

4. **Lubrication**

5. ...

Figure B.0.1: Example of an SOP

