Visualize the carbon footprint of MSG

Bachelor thesis: Industrial Engineering and Management

VISUALIZE THE CARBON FOOTPRINT OF MSG

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PREFACE

The thesis "Visualize the carbon footprint of MSG" is performed as a final assignment to graduate the Bachelor Industrial Engineering & Management at the University of Twente. The assignment is conducted with MSG Enschede with the purpose to get insight in the carbon footprint and options to reduce the emission towards a CO_2 neutral business.

First, I would like to thank my university supervisors, Sebastián Piest and Devrim Yazan. Sebastián Piest was my first supervisor. He has been very supportive and has a broad knowledge of the subject, which helped me a lot. His feedback was very helpful and clear. Devrim Yazan was my second supervisor. He provided a second opinion on my work.

Next to that, I would like to thank everyone at MSG. Especially Arjan Kleizen, my supervisor, has been very supportive and enthusiastic about the research. His guidance in the graduation process was very supportive and motivating.

Daniëlle Turkstra

MANAGEMENT SUMMARY

This thesis is conducted at MSG Enschede. MSG is a logistic, parcel and postal delivery company headquartered in Enschede. They have the goal to be CO_2 neutral in 2025. Currently, they have no insight into their carbon footprint and the reduction effects of specific actions to become CO_2 neutral. The goal is to create insight into the current situation, the existing carbon footprint, and the most optimal options to reduce it. This will be visualized in a dashboard.

First, the current carbon footprint must be calculated to create the dashboard. The literature study designates the GHG Emission Calculation tool as the best option for this case. More literature studies are conducted to decide on the KPI selection method for the dashboard and how the dashboard can be visualized in the most effective way.

To calculate the current footprint, the input for the GHG tool needs to be collected. After the tool's completion, the results of the GHG tool are analysed and will be used later in the study.

The effects on the carbon footprint of several actions MSG considers are important to reach the goal of becoming CO_2 neutral. These effects could be established with the needed emission factors and some calculations.

After collecting all the needed data for the dashboard, the selected KPIs provide MSG with the most relevant insights. The selection is made with the multi-criteria decision-making method Analytical Hierarchy Process (AHP) of Saaty (1988), together with the SMART criteria. Then, the outcome is filtered together with the management of MSG.

The dashboard is designed in Power BI. The needed data is gathered from Excel sheets with the GHG tool results and the calculations on the effects of specific actions. The dashboard contains two pages. The first page displays the current carbon footprint of MSG, and the second page shows the reduction effects of several sustainable actions on carbon footprint. To determine if the dashboard meets the expectations, the satisfaction of the MSG management is evaluated with the Unified Theory of Acceptance and Use of Technology (UTAUT) of Venkatesh et al. (2003). The answers are on a 1-5 Likert scale.

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CHAPTER 1 – INTRODUCTION

The first chapter introduces the company and describes the reason for the research. Also, the research methodology, research questions, and the scope are broadly defined.

CHAPTER 2 – THEORETICAL FRAMEWORK

The second chapter of this paper contains the three parts of theoretical framework. First, the carbon footprint methods and tools are discussed. Then, several selection methods of key performance indicators are outlined. Lastly, the visualization of a dashboard is considered.

CHAPTER 3 – RESEARCH IN THE COMPANY

In Chapter 3, the current situation is determined. The input for the selected carbon footprinting tool is described, followed by the analysis of the outcome of the GHG tool.

CHAPTER 4 – EFFECTS OF SUSTAINABLE ACTIONS

This chapter considers the effects on the carbon footprint of some selected actions. These calculations are based on the outcome of Chapter 3.

CHAPTER 5 – KPI SELECTION

Chapter 5 is intended to select the appropriate KPIs for the dashboard. The selection is done with the KPI selection method from Chapter 2 together with the MSG management.

CHAPTER 6 – DASHBOARD

The dashboard is explained in Chapter 7. The dashboard requirements, the tool selection, the data model and an explanation of the dashboard itself are elaborated.

CHAPTER 7 – ROADMAP

Chapter 7 discusses the feasibility of MSG's goal to become CO_2 neutral in 2025 and elaborates the roadmap towards the goal.

CHAPTER 8 – EVALUATION, CONCLUSION & DISCUSSION

This chapter concludes and evaluates the research. Next to that, the recommendations are provided to the company. Also, the study is discussed in this chapter.

1. INTRODUCTION

The first chapter of this paper will introduce the research. Section 1.1 starts with the introduction of the company; MSG. Section 1.2 describes the motivation for the study. Section 1.3 clarifies the problem identification. Then, in Section 1.4, the different stakeholders are analysed. Section 1.5 determines the research scope, and Section 1.6 discusses the research questions. At last, Section 1.7 describes the methodology behind the research.

1.1 INTRODUCTION TO MSG

MSG is a logistic, parcel and postal delivery company headquartered in Enschede. MSG stands for 'Makes Sending Great'. MSG started in 2012 by the fusion of a small express courier company from Enschede and the postal and courier department of DWC of 'Gemeente Enschede'. They expanded to Groningen and Noord-Brabant in 2016. MSG delivers (inter)national, focussing on the north- and east-Netherlands and Noord-Brabant. MSG focuses on the last mile solution for their customers. That means MSG concerns the last miles of the post and packages they deliver.

MSG focuses on social and sustainable entrepreneurship. The company has 500 employees, of which 73% have a distance to the labour market. Their mission is to work together in logistics to offer a sustainable solution for everyone. Their policy has four pillars: high quality, competitive price, social involvement, and personal contact (MSG, 2022b). MSG wants to take responsibility and act as an ambassador for sustainability in the regions where MSG is active. They do this by driving, planning, and sending more sustainably. MSG participates in sustainable projects and adjusts its building toward more sustainability (MSG, 2022a). All these aspects contribute to their goal: to be CO_2 neutral in 2025.

1.2 MOTIVATION

MSG is focussing on sustainability in the logistics field. Sustainability has started to get a higher priority for companies and consumers. MSG already took steps to reduce their carbon dioxide (CO_2) emission in the previous year. They bought six electric cars and compensated for their emission by planting their own MSG forest and other things (Msg et al., 2021). All these actions are one step closer to their goal.

The government set rules to make the centre of Enschede a zero-emission zone for order and freight vehicles in 2025. These rules are the initial reason MSG started to focus more on sustainability. Nowadays, they want to take responsibility for their emission and act as an ambassador in the regions where MSG is active. Therefore, MSG achieved the ISO 14001 certification in 2022. ISO 14001 is an international certifiable standard providing a systematic framework that helps firms control their environmental impact (Arocena et al., 2021).

To reach the goal, MSG must know what the most effective CO_2 reduction actions are and which step to take next. That brings us to the problem. The effects of the actions MSG take are unknown, but also the current overall CO_2 emission is unknown. As a result of this, there is no stepwise plan to reach the goal.

The purpose of this study is to visualize the CO_2 emission of MSG and give insight in the reduction effects of the sustainable actions MSG considers. A dashboard provides these insights for MSG. The dashboard needs data, but MSG has no overview of which data is available. This research will provide the data and process it in a dashboard. The management of MSG can use the dashboard to make better choices and show their performance to potential new clients.

1.3 PROBLEM IDENTIFICATION

The first sub-section of this section explains the problem in a structured way, with the help of a problem cluster. Figure 1 in Sub-Section 1.3.1 depicts the problem cluster. Based on this problem cluster, the action problem and the core problems are defined in Sub-Sections 1.3.2 and 1.3.3.

1.3.1 PROBLEM CLUSTER

Figure 1 shows the problem cluster for this specific problem. This cluster depicts the causal relations. The three action problems are at the bottom, and the two core problems are at the top. The lack of knowledge what data to use and lack of knowledge what data is available cause the absence of the current carbon footprint. Together with a policy that contains no actual calculations, there is no option to calculate reductions in the carbon footprint when implementing a sustainable action. Due to the unclear consequences of the actions MSG takes to become CO_2 neutral, there is ineffective decision making and no overview of how to reach the goal.

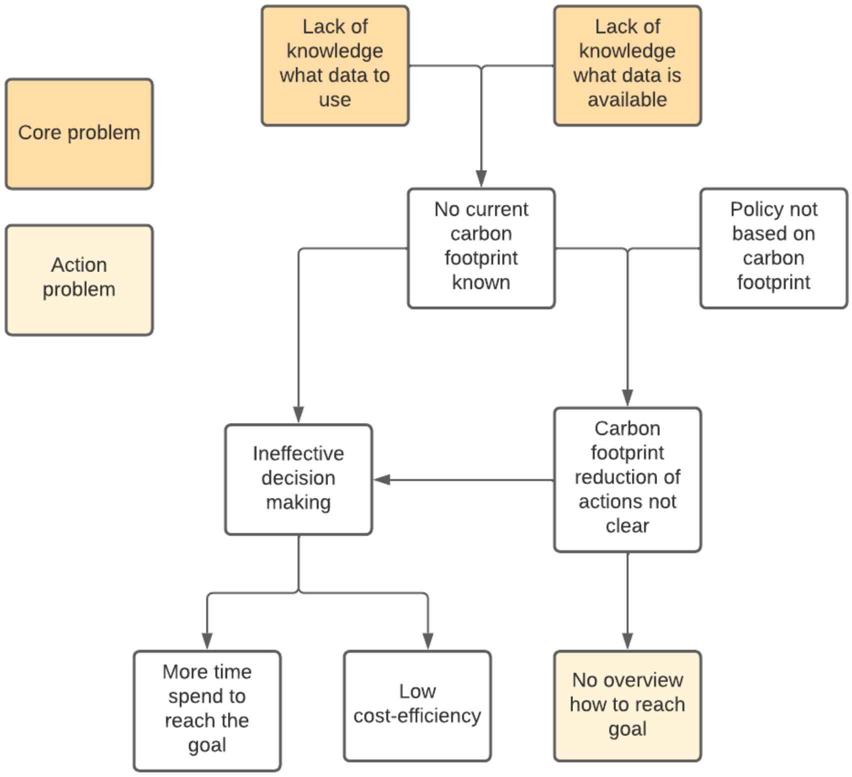

Figure 1 Problem cluster

1.3.2 ACTION PROBLEMS

The action problem is the gap between the norm and reality (Heerkens & van Winden, 2017). The action problem is the result of several problems leading to this action problem. In this case, MSG has three action problems. There is no overview of how to reach the goal, MSG spends more time to reach the goal, and there is a low-cost efficiency due to unknown consequences of investments. In this thesis, the focus is on one of the action problems, namely:

No overview of how to reach goal.

This action problem has the highest priority for MSG, and the expectation is that it will contribute to the solution of the other problems.

1.3.3 CORE PROBLEM

Figure 1 shows two core problems. The cluster defines the complete core problems as:

1. *Lack of knowledge of which data to use to perform carbon footprint measurements.*
2. *Lack of knowledge of which data is available for carbon footprint measurements.*

Data collection is needed to calculate the carbon footprint (Courier - Mailchimp, 2020). As explained in Sub-Section 1.3.1, MSG does not know what data to use and what data is available to calculate its carbon footprint. This lack of knowledge eventually leads to the fact that there is no overview to reach their goal. The policy MSG drafted contains some yearly steps, but the result is not measurable. Therefore, MSG will not be able to claim its CO_2-neutral status.

1.4 STAKEHOLDER ANALYSIS

The research impacts various stakeholders on micro, meso and macro levels. This means individual, organizational, and societal levels, respectively. In this section, the various stakeholders will be discussed, and placed in the stakeholder matrix. Figure 2 shows the stakeholder's matrix. The matrix consists of four boxes; manage closely, keep informed, keep satisfied and monitor. The power and interest matrix can be a helpful tool in assessing the feasibility of an activity. The matrix also focuses on how the activity should try to level the power of various stakeholders (Dfid, 2003).

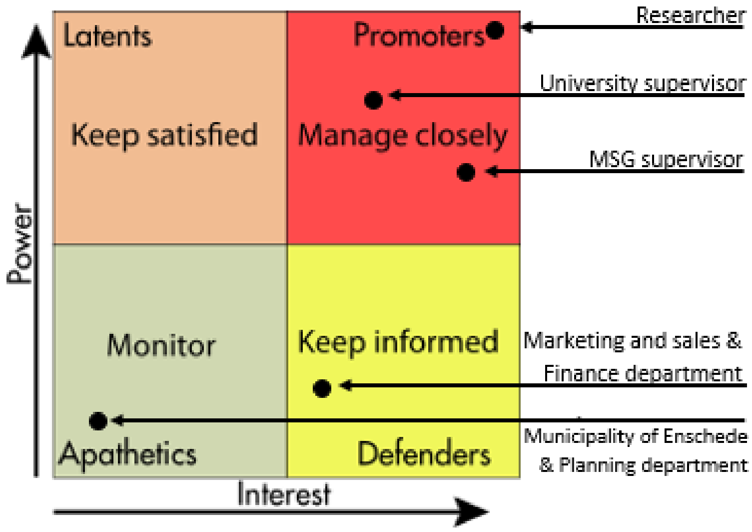

Figure 2 Stakeholder's matrix. Source: Wikimedia Commons, 2014

RESEARCHER – DANIELLE TURKSTRA

The researcher will perform the research and provide the deliverables for the University of Twente and MSG. My interest is high because with this research, I can finish my Bachelor. Besides, I want to receive a good grade and satisfy MSG and my university supervisors. My power is high because I make the decisions in the research and will do the execution of the research. I will make the research questions and set the scope with the university supervisor and the supervisor from MSG. In the stakeholder's matrix, I am in the 'manage closely' box.

UNIVERSITY SUPERVISOR – SEBASTIAN PIEST

The university supervisor, Sebastian Piest, will support me during my bachelor thesis. He has both high interest and high power in the research. His place in the stakeholder's matrix is 'manage closely'. It is in his interest that the research will meet all the requirements of the University of Twente. Further, he has the power to approve the project plan, provide the green light and grade the bachelor thesis. Therefore, it is also in his interest that the research executes appropriately. During the research, he will give me feedback with his specialism on this topic and have a weekly meeting to discuss the progress.

MSG SUPERVISOR – ARJAN KLEIZEN

The company supervisor, Arjan Kleizen, will be my guidance at the company. He has high interest and power, so he is placed in the 'manage closely' box. Arjan is the company's director and occupies with the sustainability goals. His interest is high because he will use the deliverables to decide which action to take next to reach the sustainability goal. Therefore, he will be one of the users of the dashboard. The power is high because he gives the list of the criteria for the dashboard. During the research, he is my first point of contact within MSG, and he will provide feedback. Next to that, he will provide information about MSG.

MARKETING AND SALES DEPARTMENT

MSG's marketing and sales department brings in new customers and keeps the current customers satisfied. Their interest in the deliverables is high because they want to use them to acquire new customers. The power is low because they have little participation in the research. The marketing and sales department is in the 'keep informed' box.

FINANCE DEPARTMENT

The finance department of MSG controls all the finance and pays for the sustainable actions MSG takes. The interest of the finance department is mediate. They are interested in a more structured overview of the actions' effects. Therefore, they will use the deliverables but on a low scale. Further, they have interest in new clients which make the profit higher. The power of the finance department is low. In the stakeholder's matrix, the department is in the 'keep informed' box.

PLANNING DEPARTMENT

The planning department of MSG has an overview of the fleet and manages the information about the fleet. The planning department provides this data in the form of Excel sheets. The power of the planning department is low, even as the interest. Therefore, the department is in the 'monitor' box. During the research, I have contact with the planning department about Excel sheets and discuss all the aspects that need consideration for the research.

MUNICIPALITY OF ENSCHEDE

The municipality of Enschede will have new rules on CO_2 emission in the inner city from 2025. So, this is the initial reason MSG wants to change. The genuine interest of the municipality of Enschede is low because if MSG does not fulfil the rules, a competitor will. The power of the municipality of Enschede is low for this individual research but high on a higher level. Therefore, the municipality is in the 'monitor' box of the stakeholder's matrix.

1.5 RESEARCH SCOPE

Bhatia et al. (2012) of the Greenhouse Gas (GHG) Protocol team describes three scopes of emission. Figure 3 shows the Diagram of Scopes and Emissions across the Value Chain. Scope 1 are the direct greenhouse emissions from sources owned and operated by the company. This scope includes all 'within firm' activities and operations, including facilities. Scope 2 accounts for the greenhouse emissions arising from purchased energy. The GHG Protocol requires companies to account for and report all scope 1 and 2 emissions. Companies get flexibility in whether and how to account for scope 3 emissions, which includes all indirect emissions of the whole value chain. This research focuses on direct activities based on the available data and the limited time of 10 weeks. The selected method is determinative in which scopes are covered.

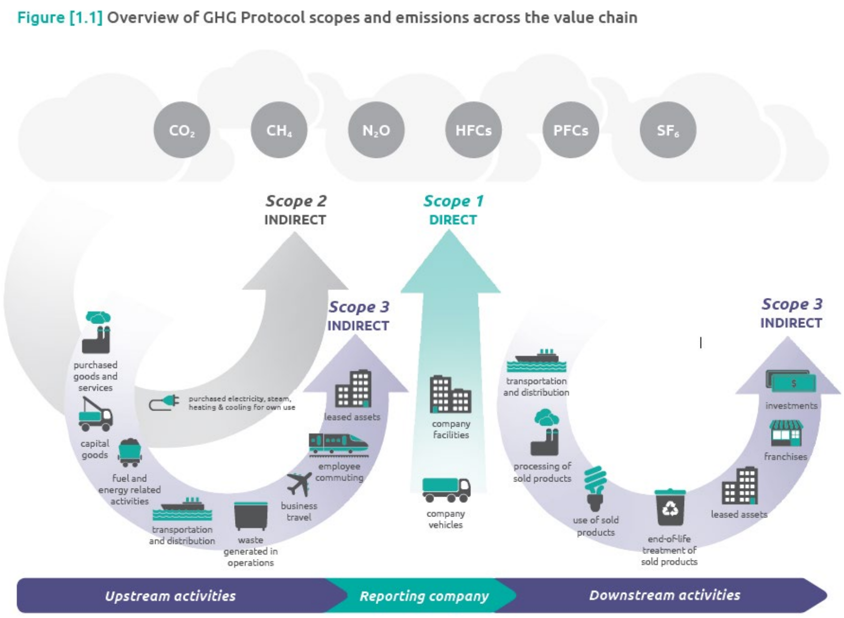

Figure 3 Diagram of Scopes and Emissions across the Value Chain. Source: (Callahan et al., n.d.)

MSG has multiple locations in the Netherlands. The main office is at Enschede, but other locations are Stadskanaal, Tilburg and Geldrop. This research will only focus on the location Enschede. MSG Enschede accounts for approximately 75% of the revenue, but the national projects are all invoiced and organised by location Enschede. In practice, location Enschede accounts for about 50% of MSG. The carbon footprint considers the complete location. The footprint includes all rides registered under location Enschede and in-house processes.

1.6 RESEARCH QUESTIONS

This section formulates the main research question and sub-questions. These questions are all provided with an explanation.

The main research question of this thesis is:

'How to measure and visualize the emission effects of the sustainable actions MSG takes to achieve their goal to be CO_2 *neutral in 2025?'*

The question splits into several sub-questions to answer the main research question. All these sub-questions cover a part of the main research question.

1. *How can the carbon footprint of MSG be calculated?*

Chapter 2 answers this knowledge question. There are multiple tools to calculate the carbon footprint of a company. The study will conclude which tool is best suited for MSG. The tool needs to consider the logistic emissions of MSG and the energy use of the office in Enschede.

2. *What data is needed to calculate the current footprint?*

Chapter 3 addresses this research question. The current situation must be clear to know the effects of the sustainable actions MSG takes. Also, calculating this gives more insight into the influencing factors of the carbon footprint. Data gathering is needed to provide a carbon footprint and result in the dashboard.

3. *What are the reduction effects of sustainable actions?*

A part of the main research question is the effect of sustainable actions. It is necessary to determine the influence of specific actions on the carbon footprint. Chapter 5 handles this research question.

4. *How to visualize the current carbon footprint in combination with the reduction in carbon footprint caused by the actions MSG takes?*

To be able to deliver a dashboard, a way to visualize the results of the research must be clear. Therefore, the research question divides into two knowledge questions.

4.1 How to select KPIs related to carbon footprint for MSG?

The used carbon footprinting tool provides the carbon footprint, but the dashboard needs to show more than only that. MSG wants a clear overview of which actions have which consequences. Therefore, we must make a proper KPI selection. In Chapter 2, a literature study will provide KPI selection methods. Chapter 6 carries out the most appropriate method.

4.2 How to visualize the KPIs?

When the KPIs are selected, they need visualization. The goal is to give MSG insight on their carbon footprint and how they can improve it most effectively. The dashboard must be clear for all involved. Therefore, the literature study in Chapter 2 will address the importance of correct visualization.

1.7 METHODOLOGY

This section is concerned with the methodology used for the research. Section 1.7.1 provides the various phases of the research methodology. Then, Section 1.7.2 elaborates on the literature review method that will be used. Section 1.7.3 sets the limitations of the research. The deliverables of the research are described in Section 1.7.4. At last, the reliability and validity are described in Section 1.7.5.

1.7.1 PROBLEM SOLVING APPROACH

The managerial Problem-Solving Method (MPSM) of Heerkens & van Winden (2017) answers the main research question of this thesis. The method provides a step-by-step framework for a solution. The problem-solving approach consists of seven phases.

PHASE 1: DEFINING THE PROBLEM

The problem-solving approach starts with the problem identification. In this phase, the researcher identifies the exact problem and makes a problem cluster. Based on this problem cluster, a core problem is chosen. In this research, the problem identification is given in Section 1.3.

PHASE 2: FORMULATING THE PROBLEM-SOLVING APPROACH

The second phase of the MPSM drafts a project plan. The project plan must be based on the D3 (Do, Discover, Decide). The researcher needs to describe all activities and knowledge required and choose from the various options within the approach (Heerkens & van Winden, 2017). Therefore, this phase chooses the carbon footprint method. The method will be done with the literature research in Chapter 3. Sub-Section 1.7.2 elaborates the literature methodology. Also, this phase of the MPSM establishes the KPI selection criteria.

PHASE 3: ANALYSING THE PROBLEM

In this phase, we reconsider the problem cluster an re-examine the problem identification. The problem will become more concrete. Therefore, the data of MSG will be used and analysed. This phase calculates the current carbon footprint of MSG.

PHASE 4: FORMULATING SOLUTIONS

After inventorying all information about the problem, the formulation of the solution starts. In this stage, we formulate the effect measurement. The measurement takes into account all actions MSG considers.

PHASE 5: CHOOSING A SOLUTION

When finishing the list with KPIs for the dashboard, a choice must be made based on the criteria collected in the literature research. Phase 5 sets the concepts the dashboard should display.

PHASE 6: IMPLEMENTING THE SOLUTION

In this phase, we build the actual dashboard. All previous stages are designed to get the best result in this stage. It is important to keep user-friendliness in consideration in this phase.

PHASE 7: EVALUATING THE SOLUTION

The last phase of the MPSM evaluates all previous phases of the MPSM. The adjusted situation and desired situation are compared. The evaluation concludes and reflects on the research. Next to that, we make some recommendations for MSG

1.7.2 LITERATURE REVIEW METHODOLOGY

Wolfswinkel et al. (2013) offers a systematic and rigorous literature review approach. We use the Grounded Theory of Glaser & Strauss (1967) as the base for the methodology. Wolfswinkel et al. (2013) is a guideline through the Grounded Theory method and explains the technique behind the method. Figure 4 depicts the construction of the Grounded Theory method. The method consists of five stages, of which some stages have their own steps.

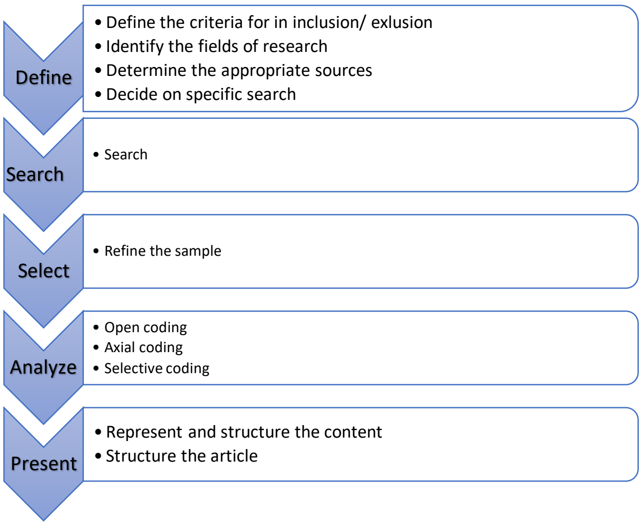

Figure 4 Construction of Grounded Theory method

The main databases used in the literature research are Google Scolar, Scopus and SpringerLink. Further, there were sources recommended by the involved stakeholders, sources as the GHG Protocol and TNO. In addition, some papers are retrieved from citations in an initial paper.

1.7.3 LIMITATIONS

This research has several limitations: data availability, time restraints and carbon footprint tools available.

The first limitation is the data availability of MSG. There was no earlier calculation of the carbon footprint, so it is unclear if all the data is available. The data availability is a determining factor for the whole research because every step after setting the current carbon footprint continues that.

The second limitation is the time restriction of this bachelor thesis. There are ten weeks available to prepare the research, followed by ten weeks of actual research. The time constraint limits the scope and depth of the research. For this reason, the carbon footprint calculation is with an existing tool.

To continue on the tool, the next limitation is which tools are available. Most of the tools specify on one specific sector or country. There are also some general tools, but those tools might not include every single factor of emission. The last limitation is the scope of emission. The scope also depends on the tool for carbon footprinting.

1.7.4 DELIVERABLES

The deliverables of this research are:

- The carbon footprint of MSG.
- The AHP method with SMART criteria for selecting KPIs and the operationalisation of it.
- A dashboard which shows the current situation and the effects of the sustainable actions MSG takes.
- A manual how to use the dashboard and add new data. This written report is delivered to the company and is not a part of this thesis.

1.7.5 RELIABILITY AND VALIDITY

Reliability has to do with accuracy, precision, and consistency. Validity means the extent to which a test measure aligns with what we wish to measure (Cooper & Schindler, 2014). There are three major forms of validity: external, internal, and construct validity.

The reliability of this research depends on the carbon footprint tool and data used. The tool must provide the same result when the input does not change, regardless of a valid outcome. The tool's source is the GHG Protocol, which is a trustworthy source. The tool has one disclaimer; it is still a beta version. For this reason, medium-high reliability for the tool in this experiment. The GHG Protocol offers other tools to calculate this uncertainty. They developed a measurement and estimation uncertainty tool and an uncertainty calculation tool. Due to the time limitations of this research, we do not use those tools.

Most of the data is reliable if the data is complete and accurate. Some data might be inaccurate because it is raw emission data without sensor data. In this research, the data will only be used if it is reliable because it can make a wrong estimation of the carbon footprint. Therefore, there is always an analysis of the data before using it.

External validity is the data's ability to generalise across different situations and groups. A selected carbon footprint tool is the basis for this research. This tool can be used in other situations. The data we use as input is completely based on MSG, so not applicable to other situations. One of the deliverables is a dashboard. This dashboard is also not applicable to other situations. Therefore, the external validity is low.

Internal validity means the degree to which the study determines the cause-and-effect relationship between the treatment and the outcome (Slack & Draugalis, 2001). This is based on the input used for the measurement. The input must be clear for everyone so there can be adjustments. All data needed for the tool will be as complete as possible, but there is no complete guarantee for internal validity in this research.

Construct validity is the degree to which a research instrument can provide evidence based on theory (Cooper & Schindler, 2014). This research aims to give MSG insight into the carbon footprint reduction that occurs when they implement specific sustainable actions. The selected KPIs in the dashboard show the effects of those actions. The KPI criteria select the eventual KPIs. Therefore, the construct validity is strong.

2. THEORETICAL FRAMEWORK

The first chapter introduced the problem and the problem approach. The study outlines several knowledge questions. A literature study answers all these knowledge questions using the method of Wolfswinkel et al. (2013) based on the Grounded Theory of Glaser & Strauss (1967). Section 2.1 answers knowledge question 1. Then, Section 2.2 answers the knowledge question 4.1 and Section 2.3 answers question 4.2. Lastly, Section 2.4 summarizes the literature studies.

2.1 CARBON FOOTPRINT CALCULATION

This section answers the knowledge question: "*How can the carbon footprint of MSG be calculated?*". The question is divided into four sub-questions:

- *What is the definition of a carbon footprint?*
- *What do the different scopes mean?*
- *What methods can be used to determine the carbon footprint?*
- *What tools are available to determine the carbon footprint?*

2.1.1. DEFINITION

In the new global economy, carbon footprint has become an important concept in response to the increasing public awareness of climate change (East, 2008). Therefore, a lot of studies are done since the start of the century. There is a large volume of published studies describing the definition of the carbon footprint. Carbon footprint is stated by (Wiedmann & Minx, 2008) as: "a measure of the exclusive total amount of carbon dioxide emissions that is directly and indirectly caused by an activity or is accumulated over the life stages of a product." Other statements are: "The carbon footprint is the full extent of direct and indirect CO_2 emissions caused by your business activities."(Energetics, 2007) or "the 'Carbon Footprint' is a measure of the impact human activities have on the environment in terms of the amount of greenhouse gases produced, measured in tonnes of carbon dioxide."(ETAP, 2007). In all cases, the carbon footprint shows the contribution of human actions on the climate change. These actions produce certain gaseous emissions, which increase climate change. For companies, carbon footprinting creates opportunities to understand the reduction potentials and implement those options (TNO, 2019). Figure 5 shows this continuous improvement cycle.

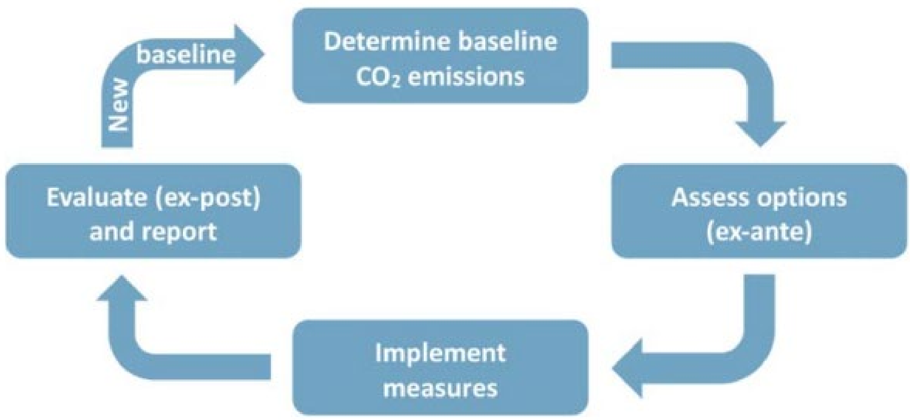

Figure 5 Positive decarbonisation loop through complete visibility of emissions. Source: (TNO, 2019).

2.1.2 SCOPES

The GHG Protocol (n.d.) corporate standard divides a company's emissions into direct and indirect emissions. Next to that, there are three different scopes of emission. The first scope contains the direct emissions, and the second and third scopes contain the indirect emissions. These scopes ensure there are no double emissions and only one company accounts for the emission within scope 1 and scope 2.

The first scope contains direct emissions. So, the emissions from operations that are owned or controlled by the reporting company. Scope 2 reports the indirect emissions generated during the process. The reporting company's electricity, steam, heating, or cooling consumed are all included in scope 2. Then, the third scope holds all other indirect emissions that happen in the value chain of the reporting company. This includes the upstream and downstream emissions.

2.1.3 METHODS

Calculating a carbon footprint involves several steps. First, the purpose of the footprinting investigation must be clear. This will help in further research to decide the accuracy and the acceptable level of accuracy (East, 2008). A company can use the carbon footprint for marketing and communication but also to inform the business decisions of the emitter. Between those extremes are combinations possible.

The second step is to clarify the methodology we use for the measurement. The method often depends on the purpose of the enquiry and the availability of data and resources (Wiedmann & Minx, 2008). There are many different standards and methods for carbon footprinting. The first harmonized standard was the European EU 16258 standard (TNO, 2019). EN 16258 is an agreement on how to calculate the carbon footprint. In addition, there are the ISO 14067 and the EU FP7 COFRET standard, among others. Some methodologies are the GLEC Framework, Objectif CO_2 and the SmartWay methodology (TNO, 2019). Those methodologies are all based on standards to calculate carbon emissions. Tools to calculate the carbon footprint are based on a methodology.

The next step is to identify the measurement boundaries. Identification includes defining the emissions and timeframe to be quantified (East, 2008). The emissions are classified as direct or indirect during this stage. The accuracy of this stage depends on the purpose determined in the first step. At last, the actual carbon footprint is calculated by using the available data. Most measurement processes need assumptions, averages, and estimates to simplify the measurement (East, 2008). For this measurement, several tools are available.

2.1.4 TOOLS

The first tool is the Ecological Transport Information Tool World (ETW), developed by the IFEU, the Rail Management Consultants GmbH and several European rail companies. The ETW uses the GHG standards for their calculations. It calculates the ecological impacts of transport based on the origin and destination over the world. To calculate this distance, ETW provides a global traffic network for each type of transport route (LEARN project, 2019). The ETW does not consider the emission of the offices owned by the company.

The Greenhouse Gas Protocol provides one of the most accurate standards for calculating the carbon footprint (van der Aalst et al., 2010). Based on those standards, they developed several carbon footprinting tools. These tools enable companies to develop comprehensive and reliable inventories of their carbon footprint (*Calculation Tools | Greenhouse Gas Protocol*, n.d.). It has four sections of tools:

- Cross-sector tools
- Country-specific tools
- Sector-specific tools
- Tools for countries and cities

First, we analyse the sector-specific tools for a logistic tool. The sector-specific tools are for products as cement, wood, aluminium, iron, and steel. The country-specific tools are specializations in China, India, and Mexico. The tools for countries and cities specific are not applicable to a company. The cross-sector tools consist of seven tools. The two stationary combustion tools do not apply to MSG; the same applies to the tool for refrigeration and air-conditioning equipment and the tool for combined heat and power plant. Then, here are two tools which mainly focus on uncertainty. This thesis needs a tool that focusses on determining the baseline. Overall, two tools might be suited to use:

- GHG emissions from transport or mobile sources

The tool calculates CO_2, CH_4 and N_2O from vehicles, public transport by road, air, and water, mobile machinery (Institute, 2015). The fuel use and distance-travel data are needed to use this tool. The tool does not consider the emission of the office.

- GHG emission calculation tool

The tool covers stationary combustion, mobile combustion, and fugitive emissions from the air conditioning of the first scope. The fuel type, fuel usage and units for usage data are needed to calculate scope 1. Further, the total fuel, distance travelled, and fuel efficiency of each vehicle are needed together with the refrigerant information. The second scope covers purchased electricity and purchased heat or steam. Therefore, the energy source, energy usage and kWh for electricity from the local utility are needed. The third scope covers transportation and distribution, business travel, and employee commuting. For this scope, we need the method of travel, the travel distance, units/weight distance, units/passenger distance and unit. The tool disclaims that it does not necessarily cover all the relevant sources for the user. There is a recommendation to calculate other emissions when appropriate.

The GHG tools provide two possibilities to calculate the CO_2 emissions in the logistic sector: the fuel-based method and the distance-based method (van der Aalst et al., 2010). Ideally, there is fuel data on the actual litres consumed per vehicle available (Smart Freight Centre, 2021). If this data is not available, we use the distance-based method. This method calculates the absolute fuel consumption (AFC) with the distance travelled and the average fuel consumption. The average fuel consumption is based on the fuel consumption of different vehicle types (Smart Freight Centre, 2021). Equation 1 shows this calculation.

$$Absolute\ fuel\ consumption = distance\ traveled * average\ fuel\ consumption$$

Equation 1 Absolute fuel consumption. Source: (van der Aalst et al., 2010)

The CO_2 emission in the fuel-based method is based on the heating value of the fuel, oxidized carbon in combustion, and carbon content of the fuel. Equation 2 shows the correlation for the CO_2 emission.

$$CO_2\ emissions = AFC * heating\ value * emission\ factor$$

Equation 2 CO_2 emission for fuel-based method. Source: (van der Aalst et al., 2010)

The distance-based method is used when the AFC is missing (van der Aalst et al., 2010). Now, distance-based emission factors are required. Equation 3 gives the correlation for CO_2 emission.

$$CO_2\ emissions = distance\ traveled * emission\ factor$$

Equation 3 CO_2 emission for distance-based method. Source: (van der Aalst et al., 2010)

The last method for the transport calculation is used in the standard for scope 3 emissions (van der Aalst et al., 2010). Equation 4 shows this calculation, which is activity-based.

$$CO_2\ emissions = transported\ weight * distance\ traveled * emission\ factor$$

Equation 4 CO_2 emission for scope 3 emissions. Source: (van der Aalst et al., 2010)

These different calculation methods ensure there is always an option to calculate the CO_2 emission for a company.

Overall, the GHG emission calculation tool is more elaborated than the GHG emissions from transport or mobile sources tool. For that reason, we use the GHG emission calculation tool for this research.

2.2 KPI SELECTION METHOD

To visualize the carbon footprint emission of MSG and the carbon footprint, we use environmental KPIs. The KPIs provide businesses a measurement tool to reflect on their environmental performances (*Metrics for Continuous Improvement of the Supply Chain Performance 2*, n.d.). KPIs are also useful for deciding the new strategy to achieve their objectives, goals, and targets (Brockett & Rezaee, 2012). The KPI selection must be a considered choice that requires a deep understanding of the business or operation for the correct implementation (Meyers & Hester, 2011).

Various studies have assessed the efficacy of several KPI selection methods. This thesis will discuss the AHP method, the method of Horst & Weiss (2015) and the KPI Assessment Method (KAM).

First, we discuss the Analytic Hierarchy Process (AHP), developed by (Saaty, 1988). The AHP is a multi-criteria decision analysis. The method is used by Podgórski (2015) together with the SMART criteria. Table 1 elaborates the SMART method (Podgórski, 2015).

CRITERION	MEANING
SPECIFIC	The name of the KPI should precisely define the research and should be comprehensive to all users.
MEASURABLE	It should be possible to technically measure the KPI.
ACHIEVABLE	The KPI should be achievable under given conditions and in the foreseeable period.
RELEVANT	Measurement using the indicator should contribute to accomplishing the general goal: becoming CO_2 neutral.
TIME-BOUND	It should be possible to measure the KPI in the given time.

Table 1 The meaning of SMART criteria

The AHP consists of four steps. The first two steps consist of the five criteria that must be compared with each other and get a ranking. The ranking is done with the basic rating scale on an integer-valued 1-9 scale for pairwise comparison (Winston & Goldberg, 2004). Table 2 shows the interpretation of the basic rating scale.

VALUE	INTERPRETATION
1	Objective i and j are of equal importance.
3	Objective i is weakly more important than objective j.
5	Experience and judgment indicate that objective i is strongly more important than objective j
7	Objective i is very strongly or demonstrably more important than objective j.
9	Objective i is absolutely more important than objective j
2, 4, 6, 8	Intermediate values—for example, a value of 8 means that objective i is midway between strongly and absolutely more important than objective j.

Table 2 Interpretation of Entries in a Pairwise Comparison Matrix

The third phase is a pairwise comparison of the KPIs concerning the individual criteria and generating the local weight vectors. The last phase is determining the overall priority of the criteria (Podgórski, 2015).

Another KPI selection method is the method developed by Hester & Weiss (2015). The method consists of seven steps. The first step is the selection of effectiveness criteria and the feasible KPIs. The criteria rank a predefined list on a 1 to 10 scale in the second step. The third step is to score the KPIs on each criterion. The next step is to calculate the overall KPI score. The fifth step is to reconsider if the KPI sets are balanced. Step six is to compare the normalized scores for these KPI sets. The last step is implementing the set with the highest score (Horst & Weiss, 2015).

Then, we have the KPI Assessment Method (KAM) of Hester et al. (2017). The method focuses mainly on the manufacturing process, but it is a broadly used method. Therefore, it is considered for this research. The method consists of eleven steps for the assessment of KPIs. Figure 6 depicts these steps. First, the targets will be clarified, together with the stakeholders and potential KPIs.

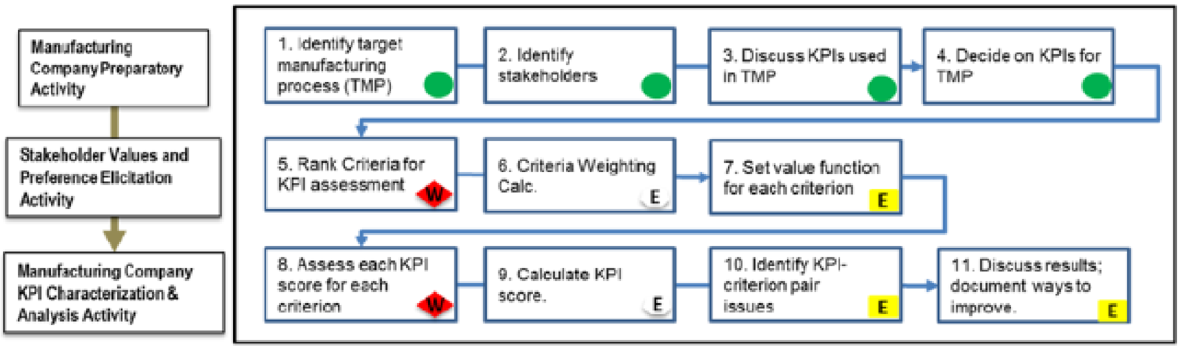

Figure 6 KPI Assessment Method. Source: (Hester et al., 2017)

Then, step 5 ranks the criteria for the KPI assessment. The criteria are a predetermined list of 20 criteria identified by Horst & Weiss (2015). The criteria are aligned (using different levels of KPI), balanced, standardized, valid, quantifiable, accurate, timely, predictive, actionable, trackable, relevant, correct, complete, unambiguous, automated, buy-in, documented, comparable, understandable, and inexpensive. After that, the criteria are weight with Equation 5 in step 6.

$$w_i = \frac{K + 1 - r_i}{\sum_{=1}^{K} K + 1 - r_j}$$

Equation 5 Rank Sum Method. Source: (Hester et al., 2017)

Where r_i is the rank of the i^{th} criterion, K is the total amount of criteria, and w_i is the normalized ratio scale weight of the i^{th} criteria.

The next step is to set a value function for each criterion. Followed by that, the assessment of each candidate KPI is done for each criterion. With these scores, the final KPI score can be determined with Equation 6.

$$v_{ik} = \frac{\sum_{j=1}^{M} \overline{w_j} v_{ijk}}{\sum_{j=1}^{M} w_j}$$

Equation 6 KPI score per stakeholder. Source: (Hester et al., 2017)

Where M is the number of criteria and v_{ik} is the i^{th} KPI score from the k^{th} stakeholder. Then, v_{ijk} is the i^{th} KPI core, from the k^{th} stakeholder for the j^{th} effectiveness criterion. The stakeholder average weight of the j^{th} criterion is given by $\overline{w_j}$.

At last, identifying the issues of the KPI-criterion pair and the discussion of the results can be conducted in steps 10 and 11.

2.3 VISUALIZATION OF KPIS

An effective dashboard needs visualizations that convey the message of the data clearly, are easy to interpret, avoids excessive use of space, are attractive and legible, guides the user and allows the user to achieve the goal they have (Smith & Salvendy, 2011). So, in this section we answer the research question: "*How to visualize the KPIs?"*. There are several guidelines for the design of a dashboard, what will be discussed in Sub-Section 2.3.1. Then in Sub-Section 2.3.2, the different chart types are elaborated for a good interpretation of the dashboard.

2.3.1 DESIGN GUIDELINES

To make the dashboard effective for MSG, we state several design guidelines for the design of a dashboard.

- Most people look instinctively at the upper left-hand corner first. Therefore, the most important information should be in the left upper corner (Ellen Nadelhoffer, 2016).
- The most important must be accentuated. The user must immediately see the most important information (Power BI | Microsoft Docs, 2022).
- Limit the number of views. Too many views take the attention from the goal of the dashboard (Ellen Nadelhoffer, 2016).
- Avoid overuse or misuse of colours. Colours can distract users and have adverse effects on decision-making. The decision time can be longer when too many colours are used (Bera, 2016).
- Studies prove that symmetry is eye-catching, so objects should be symmetrically aligned to each other (Bhatt et al., 2015).
- All filters should be placed together on the left or right side of the dashboard (Bhatt et al., 2015).

2.3.2 CHART TYPES

The chart type determines which information it provides to the user. Therefore, the right charts must be chosen to analyse the data correctly.

Cleveland & Mcgill (1984) published a study on the hierarchy of graph types. The study outlines the visualizations that are the easiest and most accurate to understand. Pie charts appear to produce more errors than lines because humans are less good at interpreting angles. Even worse is the interpretation of volume and curvature. Therefore, bubble charts and 3D charts might look attractive but can cause confusion about the story behind the data.

Based on the study of Cleveland & Mcgill, Evergreen (2017) studied the best chart type for the story the data must tell. These stories are divided into eight categories. For each category, the designer can adjust a few chart types. Figure 7 shows the different chart types per story.

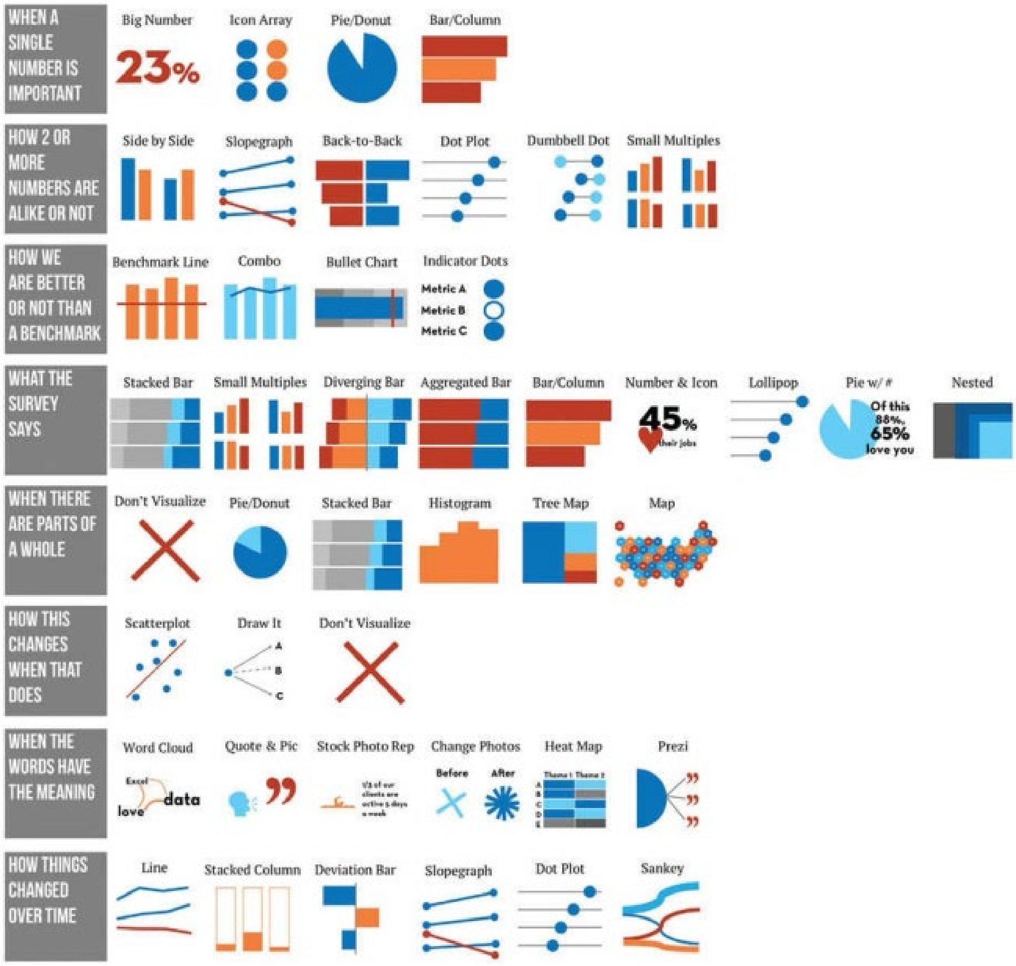

Figure 7 Chart types per story. Source: (Evergreen, 2017)

Next to the importance of the storytelling, there is also the need for analysation. There are three ways to analyse data in BI tools: comparison, transition, and composition (Bhatt et al., 2015). BI dashboards commonly use the comparison of two different items. This story complies with the second, third and fourth categories in Figure 7. Although, the most appropriate charts to use are a bar chart or a column chart (Bhatt et al., 2015).

If the development of the data over a particular time is important, the data transition is analysed. A line or area chart fits best for this kind of data analysis (Bhatt et al., 2015). These charts comply with the sixth and eighth categories in the overview of Evergreen depicted in Figure 7. This data analysis requires a continuous data set to get the optimal result.

Then there is the composition of data. In some cases, it is important to get insight into the different elements of a value. Pie or scatter charts can be used for this data, as shown in categories four and five of Figure 7.

2.4 CONCLUSION

In this chapter, the three knowledge questions of this research are answered. We will use the GHG emission calculation tool to calculate the carbon footprint. This tool aligns with the situation of MSG. To select the right KPIs for the dashboard, we use the AHP method with SMART criteria. This selection method is more elaborated than the method of Horst & Weiss and a better fit for the situation than Hester's method. The eventual KPIs need optimal visualization in the dashboard. Therefore, the visualization of the dashboard must meet certain design guidelines to make the dashboard accurate and attractive. The chart type is important to provide the correct information to the user.

3. RESEARCH IN THE COMPANY

This chapter outlines the current carbon footprint at MSG. Section 3.1 describes the current situation, with first an explanation of the sustainable activities of MSG, followed by answering research question 2 "*What data is needed to calculate the current footprint?"*. The section provides an explanation of the input for the GHG Tool to calculate the carbon footprint. Section 3.2 reports and analyses the outcome of the GHG tool. Section 3.3 concludes the findings of the research in the company.

3.1 CURRENT SITUATION

3.1.1 SUSTAINABLE ACTIVITIES

The GHG tool calculates the current carbon footprint. Therefore, data on the emissions is needed. Several data measurements have been done over the last few years. They need the information to retain their ISO certificate. Further, MSG has used 'EnergiePartners' for the last three years. This application provides an overview of electricity and gas use. It also provides options of actions MSG could implement to lower their electricity and gas use. MSG has no smart gas meter, so the periodical use cannot be measured. MSG measures the data on gas use by hand yearly. The dashboard provides insight into the amount of gas saved by their actions. We implement the data of 'EnergiePartners' in the GHG emission calculation tool.

MSG keeps track of the number of kilometres driven by each car. Besides that, they implemented a tracking system in the car that observes the driving behaviour. These tracking systems are not in all cars yet and are insignificant in this research. Therefore, the information is omitted.

3.1.2 CURRENT CARBON FOOTPRINT

The current carbon footprint is calculated with the GHG emission calculation tool. The tool has five input factors. Figure 8 and Figure 9 depict the Scopes 1 and 2, respectively.

SCOPE 1 - STATIONARY COMBUSTION

The stationary combustion includes the fuel consumption at a facility to produce electricity, steam, heat, or power. The combustion of fossil fuels by natural gas boilers, diesel generators and other equipment that emits GHG into the atmosphere. To calculate the stationary combustion, the data of the fuel type, fuel usage and the unit of usage is required. Equation 7 provides the general formula for emissions.

$$Emissions_{GHG,fuel} = Fuel\ Consumption_{fuel} * Emission\ factor_{GHG,fuel}$$

Equation 7 General formula for emissions

The stationary combustion does not apply to MSG because the company does not generate their own electricity, steam, heat, or power.

SCOPE 1 - MOBILE COMBUSTION

The mobile combustion includes the fuel usage by vehicles owned or leased by the company. Combustion of fossil fuels contributes to the GHG emissions into the atmosphere. To calculate the emissions, at least two of the following are required: total fuel used by each vehicle, total distance travelled by each vehicle and the fuel efficiency of each car. The last two requirements are available.

An Excel sheet provides the data on travelled distance. The Excel sheet contained some errors, so the data needed recalculation first. Then, the data can function as input. The fuel efficiency is based on the type of car. Together, they reproduce the emission of mobile combustion.

The research includes all the cars owned or leased by the location Enschede from 2019 to 2021. Next, MSG has subcontracts for several routes or parts of routes. The driven kilometres by those third parties are not included in the research because MSG has no access to the data.

The electric cars produce no emissions in this factor because it is included in the purchased electricity. Equation 7 and Equation 1 show the calculation for the average emission factors for each vehicle type provided by the GHG tool.

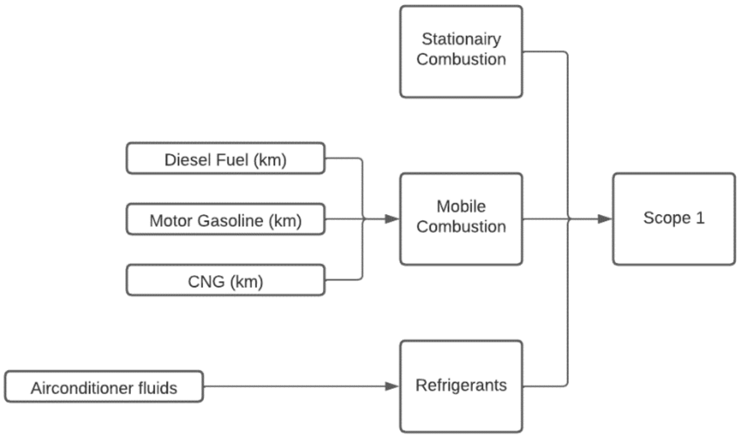

Figure 8 Overview of Scope 1 emissions of MSG

SCOPE 1 - REFRIGERANTS

The refrigeration and air conditioning are considered because several damaging substances are used in this sector. These emissions result from the manufacturing process, from the leakage over the operational lifetime, and from the disposal of the end of useful lifetime of the equipment. These gases have 100-year global warming potential 140 to 11700 times that of carbon dioxide. So, there is a significant impact on the climate change. The emission from manufacturing, operation and disposal phase are considered.

The tool offers reporters two approaches based on data availability and the level of accuracy required. First, there is the sales-based approach. This can be used by manufacturers, or by the users who maintain their own equipment. This approach estimates emissions based on the amount of refrigerant purchased and used by the equipment manufacturer of user. The required data should be available from entity purchase and service records. Second, there is the life-cycle stage approach for those who have contractors to maintain their equipment. The required information should be provided by the contractor. The sales-based approach is most accurate and easy approach to use.

MSG outsources the maintenance of air conditioners. There are yearly reports that include all the refrigerant fluids that were needed. These values are included in the GHG tool.

SCOPE 2 - PURCHASED ELECTRICITY

The electricity and other sources of energy purchased form the local utility is included in the purchased electricity. The data of the energy source, energy usage and units of usage are required to calculate the scope 2 emissions. The tool offers two options: location-based and market-based emissions. Location-based scope 2 emission factors are not available for EU countries. Therefore, we work with the market-based emissions. The yearly used electricity and the yearly gas usage are the input for the purchased electricity. The electricity data generated by the information from 'EnergiePartner' and the by-hand measured gas use serve as the input data.

MSG already replaced their fleet partly. They bought electric cars to replace some diesel fuel cars. Also, all gasoline mopeds supplanted for electric (cargo) bikes. Together with the electricity use of the building, it is the whole electricity consumption.

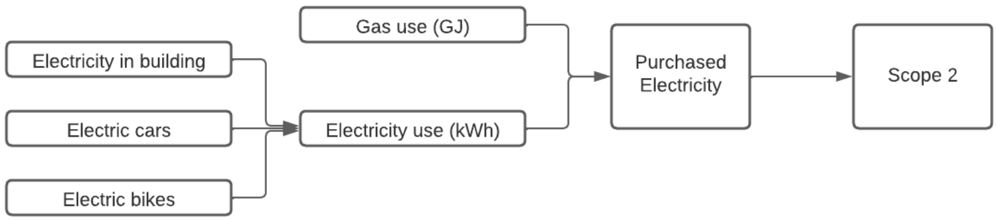

Figure 9 Overview of Scope 2 emissions of MSG

SCOPE 3 - TRANSPORTATION

The transportation represents scope 3 emissions. The scope includes the fuel consumption by vehicles used to conduct company-financed travel. Therefore, the method of travel and the travel distance and units/weight distance and units/passenger distance and units are required. This study does not include scope 3 emissions.

3.2 CARBON FOOTPRINT

Figure 10 shows the result of the GHG Emissions Calculation tool. The result is expressed in CO_2 -equivalent (CO_2e). CO_2 e includes other GHG as nitrous oxide (N2O), methane (CH4) and fluorinated gases (F-gases). The total carbon footprint is not directly on the screen. By adding “Scope 1 - total” and “Scope 2 - market based + heat based”, we calculate the total carbon footprint. Table 3 shows the total annual carbon footprint.

Figure 10 shows the highest emission from mobile combustion. This is the company’s main activity, so this result was expected. The emissions of the refrigerants are almost negligible overall. Only in 2021 there is a small emission of the refrigerants.

Year	**Carbon footprint (tonnes CO_2e)**
2019	643.62
2020	518.20
2021	542.69

Table 3 Annual carbon footprint

GHG Emissions Summary

Name of Busines: MSG
Prepared By: Danielle Turkstra

Boundary for res: Company
Year (optional): 2020

Scope	Activity Type	2018	2019	2020	2021	2022	2023
Scope 1	Stationary combustion	0.00	0.00	0.00	0.00	0.00	0.00
	Mobile combustion	0.00	541.75	427.61	442.07	0.00	0.00
	Fugitive emissions from air-conditioning	0.00	0.00	0.00	0.06	0.00	0.00
	Other fugitive or process emissions						
	Scope 1 - Total	**0.00**	**541.75**	**427.61**	**442.13**	**0.00**	**0.00**
Scope 2	Purchased electricity - location based	0.00	0.00	0.00	0.00	0.00	0.00
	Purchased electricity - market based	0.00	49.18	45.99	49.60	0.00	0.00
	Purchased heat and steam	0.00	52.70	44.60	50.97	0.00	0.00
	Scope 2 - Location based + heat a	**0.00**	**52.70**	**44.60**	**50.97**	**0.00**	**0.00**
	Scope 2 - market based + heat and	**0.00**	**101.87**	**90.59**	**100.56**	**0.00**	**0.00**
Scope 3	Purchased goods and services						
	Capital goods						
	Fuel-and energy-related activities (not included in scope 1 or scope 2)						
	Upstream transportation and distribution	0.00	0.00	0.00	0.00	0.00	0.00
	Waste generated in operations						
	Business travel	0.00	0.00	0.00	0.00	0.00	0.00
	Employee commuting	0.00	0.00	0.00	0.00	0.00	0.00
	Upstream leased assets						
	Downstream transportation and distribution						
	Processing of sold products						
	Use of sold products						
	End-of-life treatment of sold products						
	Downstream leased assets						
	Franchises						
	Investments						
Scope 1 (Biogenic)		0.00	0.00	0.00	0.00	0.00	0.00
Scope 2 (Biogenic)							
Scope 3 (Biogenic)		0.00	0.00	0.00	0.00	0.00	0.00

Figure 10 GHG tool outcome

Remarkable is the increase in CO_2e from 2020 to 2021. The increase in purchased electricity is explicable by purchasing electric cars and e-bikes. In fact, electricity consumption has almost doubled since purchasing electric cars in November. Figure 11 shows this increase.

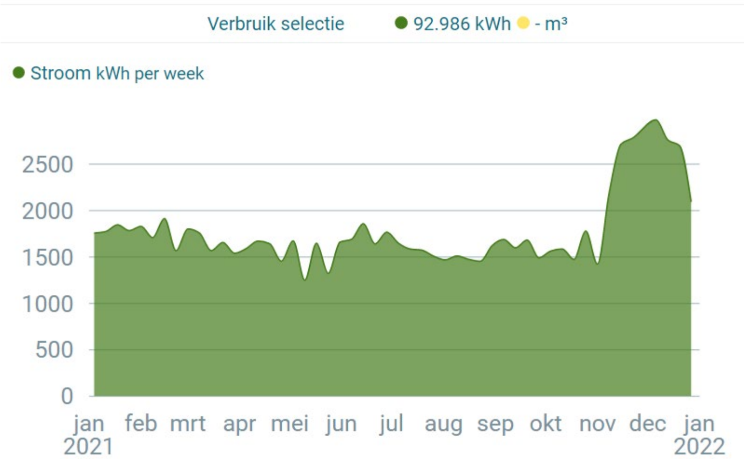

Figure 11 Electricity use 2021. Source: (Energiepartner Energieplanner, n.d.)

Another increasing point between 2020 and 2021 is the gas use that could be explained by the temperature difference between the years. Also, the mobile combustion has a growth of 3.4%. This growth is understandable because of the extra kilometres driven under the name of MSG Enschede. The complete company of MSG has a certain number of cars in use. MSG registers the cars under the name of the branch they drive for the most. In 2020, there were ten cars less than in 2021. Furthermore, the cars were more divided between the different locations.

Nevertheless, MSG improved the GHG emission in 2021 by -15.7% relative to 2019. Despite the increase in purchased energy for electric cars, the yearly energy use did not increase. There could be concluded that they have already made some steps towards less energy purchasing. Else, the consumption would be much higher.

The result of the tool does not include the planted EcoTree trees that compensate for some of the GHGs. In 2021, EcoTree planted 128 trees for MSG. That makes a total compensation of 3.2 tonnes of CO_2. This only covers 0.56% of the total emission. For MSG, every compensation contributes to their goal to be CO_2 neutral. However, to reach the goal, they should make big steps to reduce their largest emissions.

3.3 CONCLUSION

By answering and implementing research question 2, the study could identify the carbon footprint of MSG over the years 2019, 2020 and 2021 with the available data on MSG. The results of this research support the idea that MSG does not know the impact on the emissions of their sustainable actions. This chapter provides insights that enable MSG to reduce their CO_2 emission on their biggest emitter, the mobile combustion.

4. EFFECTS OF SUSTAINABLE ACTIONS MSG

Chapter 4 discusses several sustainable actions MSG is taking into consideration and therefore answers research question 3 "*What are the reduction effects of the sustainable actions?*". Section 4.1 describes the selected actions. Subsequently, Section 4.2. measures the reduction effects of these actions on the carbon footprint. Lasty, Section 4.3 briefly concludes the findings of Chapter 4.

4.1 ACTION SELECTION

Together with the management of MSG, we select several sustainable actions for effect measurement. The first action is the purchase of electric cars. MSG already bought six electric cars in November 2021. Their annual plan states to replace a quarter of the fleet every year, but they did not calculate the emission reduction. Further, the effect of solar panels and a heat pump on electricity consumption are considered. Although, MSG does not own the property, they might want to negotiate with the owner if the results make a significant difference. Next to that, we take HVO into consideration. HVO diesel lowers the CO_2 emission up to 90% of regular diesel. Lastly, there are options to compensate for emissions. One of these options is to plant trees. MSG already does this on a small scale. MSG considers an MSG forest to compensate for all the emissions.

4.2 EFFECTS

4.2.1 ELECTRIC CARS

To measure the reduction effects of an electric car on the emissions of MSG, we need the average kilometres driven by a car. Therefore, Table 4 shows the yearly average kilometres of cars used every month in 2019, 2020 and 2021. For ease of calculation, the average is rounded to 51505 kilometres per year.

Year	**Av. Per car**
2019	57363
2020	53356
2021	43797
Average	51505.33333

Table 4 Average kilometres per car (year)

The average energy consumption of the electric cars of MSG is approximately 25.7 kWh/100km. The energy consumption depends on the weather conditions, terrain, use of climate control and driving behaviour (EV Database, n.d.). Equation 8 calculates the yearly energy consumption.

$$\frac{51505 * 25.7}{100} = 13236.785\ kWh$$

Equation 8 Average yearly energy consumption of electric car

When filling in the average kilometres of a car on a yearly basis, as calculated in Table 4, the GHG tool calculates an emission of 20170 kg CO_2. By filling in the electricity consumption in the GHG tool, the emission is 7059.95 kg CO_2. Table 5 shows these outcomes.

Type	**Yearly CO_2 (tonnes)**
Diesel	20.170
Electric	7.05995

Table 5 Yearly CO_2 emission for diesel and electric car

Overall, the electric car ensures a 65% decrease in CO_2-emissions from a diesel car.

4.2.2 TREES

To compensate for the CO_2 emission, MSG started to work with EcoTree. A tree absorbs between 10 and 40 kg of CO_2 every year. On average, that is 25 kg CO_2 per year (EcoTree, n.d.). Based on 2021, MSG should plant $\frac{542690}{25} = 21707.6$ trees to compensate for their CO_2 emission.

The trees are planted in France now. MSG wants to do something for the inhabitants of Enschede and is thinking about planting a forest in Enschede. A forest of 1 hectare consists of approximately 2000 trees (Natuurpunt, n.d.). So, a 1-hectare forest compensates for 50-ton CO_2 per year.

4.2.3 SOLAR PANELS

There are different types of solar panels available on the market. The power of the solar panels is expressed in Watt peak (Wp), which is the maximum peak power of the panel. We use the peak power to calculate the annual yield of the solar panels. In the Netherlands, the average annual kWh yield is 90% of the system's capacity in Watt peak (Consumentenbond, n.d.). This calculation uses 400Wp solar panels.

The annual electricity consumption can be calculated with the average energy use for 2019, 2020 and 2021. However, the energy consumption in 2022 will be higher due to the purchased electric cars. Equation 9 shows there must be 227 solar panels on the roof to compensate for the yearly electricity use. Besides, if MSG decides to buy more electric cars, even more panels are needed to compensate.

$$\frac{1.1 * annual\ electricity\ consumption}{400} = \frac{1.1 * \frac{92196+86221+92986}{3}}{400} = 248.786\ panels$$

Equation 9 Solar panels needed to compensate for all electricity use

Table 6 depicts the annual yield of the solar panels. As mentioned in 5.2.1, the annual electricity consumption of an electric car is 13236.785 kWh. So, 37 solar panels of 400Wp could annually compensate for this car.

Solar panels	**Annual yield (kWh)**	**(tonnes) CO_2 reduction**
10	3600	1.92016
30	10800	5.76056
37	13237	7.06048
50	18000	9.60097
100	36000	19.20199
150	54000	28.80301

Table 6 Annual yield of solar panels

There could be concluded that solar panels can compensate for the electricity used, but only with a high purchase. However, the cost of the purchase will be very high. In the Netherlands, the average price for ten solar panels is €5880, - (Zonnefabriek, n.d.). Also, MSG will most likely purchase more electric cars, so the energy consumption will increase. The purchase of solar panels must be even higher to cover all energy consumption.

4.2.4 HVO

Hydrotreated Vegetable Oil (HVO) diesel is a new type of diesel fuel. It consists of waste vegetable oils and residual waste. HVO lowers the CO_2 emission to 90% of regular diesel and is highly biodegradable. The fuel is chemically identical to fossil propane, so that it can substitute it entirely (*Modeling and Analysis*, 2017).

HVO is a type of biodiesel that is less polluting to the environment. The produced emissions during combustion are recyclable. The CO_2 is released into the atmosphere and can be used by growing plants, which returns to biodiesel later in the process. However, there is also a downside to the process. Due to the high temperatures that are needed for the combustion, higher quantities of NO_2 are released (Coronado et al., 2008).

Neste Oil's Porvoo refinery in Finland conducted a fuel analysis. According to them and CO2 Emissiefactoren (n.d.), the emission factor of HVO is 0.314 kg CO_2 per litre, and the emission factor of normal diesel is 3.262 kg CO_2 per litre. To be consistent with the emission factors used, we will convert these factors to those in the GHG tool. Equation 10 provides the emission factor of diesel used in the GHG tool.

$$\frac{20170\ kg\ CO2}{51505\ km} = 0.391612\ kg\frac{CO2}{km}$$

Equation 10 Emission factor of diesel by GHG tool in kg/km

With this factor, we can reconcile the fuel consumption the GHG tool used for the calculation. Equation 11 computes the fuel consumption with the emission factor of CO2 Emissiefactoren (n.d.).

$$\frac{0.391612\ kg\frac{CO2}{km}}{3.262\frac{kg}{L}} = 0.12005\frac{L}{km}$$

Equation 11 Diesel fuel consumption by GHG tool in L/km

So, the GHG tool assumes a fuel consumption of 0.12005 L per kilometre driven. With this information, we can calculate the emission of HVO per kilometre. Equation 12 works out the emission factor of HVO.

$$0.314\frac{kg}{L} * \frac{0.12005L}{km} = 0.0376957\ kg\frac{CO2}{km}$$

Equation 12 Emission factor of HVO in kg/km based on GHG tool

HVO diesel emits only 9.6% of the regular diesel. For the goal of MSG to become CO_2 neutral, using HVO diesel could make a big difference on their highest emitter.

4.2.5 HEAT PUMP

The goal of a heat pump is to obtain the high-temperature heat of the heat source to make the system more efficient. The heat pump is an alternative to the gas boiler. Nowadays, there are three types of heat pumps. The heat pump obtains its energy from air, ground, or groundwater. A heat pump reduces the gas use to zero, but the electricity use will increase.

We chose not to measure the reduction effects of the heat pump. This has two reasons. The first reason is the lack of concrete numbers on the efficiency of a heat pump for an office like MSG Enschede. In addition, MSG Enschede is a rental property, which makes it beyond the control of MSG.

4.3 CONCLUSION

The effects on the carbon footprint of several actions MSG could take to reach its goal are considered in this chapter. Therefore, research question 3 can be answered. One interesting finding is that HVO reduces CO_2 emission more than an electric car. It could be argued that the electric car is still the more sustainable option because the needed electricity can be generated by green energy. This is an important issue for future research. Although, HVO could offer MSG a short-term solution for their high emission on mobile combustion. Further, the study concludes that the solar panels could function as a small addition, but it will not bring MSG the significant reduction in CO_2 emission they need. Then, the trees could function as the last reduction in CO_2 emission by compensating for the remaining emission.

5. KEY PERFORMANCE INDICATOR SELECTION

In this chapter, the KPIs are selected. Section 5.1 determines the criteria weights for the KPI selection. Then, Section 5.2 describes how the eventual criteria are chosen. Appendix E shows the final selection based on the used AHP method. In conclusion, Section 5.3 summarizes this chapter.

5.1 CRITERIA WEIGHTS

Several KPI selection methods are discussed in section 2.2. For this research, Saaty's AHP method with SMART criteria is used. This is conducted with the stepwise plan of Winston & Goldberg (2004), which is illustrated in Figure 12.

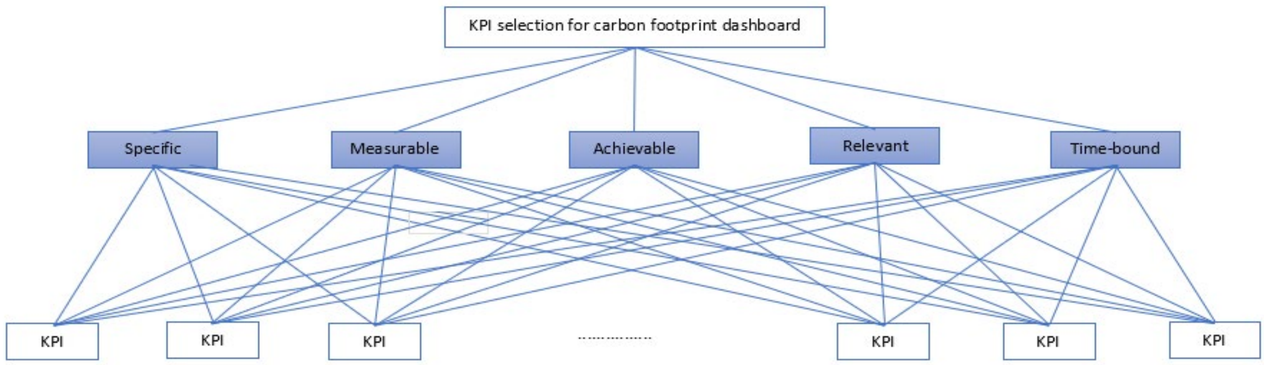

Figure 12 AHP method with SMART criteria

The first step is to compare the SMART criteria, explained in Table 1, with each other and indicate a score based on the basic rating scale (Table 2). Appendix A shows these matrices, one valued by the researcher and one by the management of MSG. Appendix A pictures the Matrix A of both participants. The next step is to create the normalized matrix A_{norm}. Appendix A presents this matrix A_{norm} and explains the calculations.

To combine the results of the researcher and the insights of MSG, an average A_{norm} matrix is made.

$$A_{norm\,(average)} = \begin{bmatrix} .0625 & .0579 & .0438 & .0789 & .0501 \\ .2188 & .2316 & .2842 & .1974 & .3008 \\ .2813 & .1703 & .1973 & .1974 & .2481 \\ .3125 & .4631 & .3948 & .3947 & .3008 \\ .1250 & .0772 & .0803 & .1316 & .1003 \end{bmatrix}$$

Using matrix $A_{norm\,(average)}$ the weights w can be calculated. $\sum w_i \neq 1.0000$ due to rounding. The consistency checks for both matrices are provided in Appendix B.1 and B.2.

$$w = \begin{bmatrix} .0586 \\ .2465 \\ .2188 \\ .3731 \\ .1029 \end{bmatrix}$$

The outcome of the SMART criteria weights can be elaborated. First, the specific criterion. The weight is low, namely 0.0586, because a KPI for this problem asks explicitly for certain values and focuses on the target. Then, the KPI must be measurable. To indicate the performance of the problem, the KPI must be measurable. Therefore, the measurability has a quite high weight. The KPI must also be attainable, which means KPI must be achievable. The weight is 0.2188 because carbon footprints and environmental issues can become very broad. Therefore, it is also important to set strict boundaries in the KPIs. The relevance is the most important criterion. MSG wants to be CO_2 neutral and wants to know how to reach that goal. The carbon footprint includes other gases, but extensive information about these gases is not relevant for this research. So, the KPIs should focus on the end goal: being CO_2 neutral in 2025. Lastly, the time-based criterion weights 0.1029. The constraint is less important than some other but also still important for research like this. The time for the research is only a few weeks, so not everything can be included in the research. This outcome is in line with MSG's point of view as the researcher's point of view.

5.2 KPI SELECTION

To get an insight in the progress of MSG, it is important to select appropriate KPIs. Therefore, a list with potential KPIs is prepared based on literature research, the GHG Protocol tool input and input from MSG. Appendix C shows the list of potential KPIs. From this list, we erased the doubles to complete it. Appendix D depicts the next step. The SMART criteria rank the potential KPIs. The KPI's total score is computed by the product of the score with the weight of the SMART criteria. Appendix D.1 shows the researchers ranking and Appendix D.2 shows the ranking by MSG. Then, Appendix D.3 depicts the average of these outcomes to validate the research. Of this outcome, every KPI above a weighted score of 8.00 is selected. With the management of MSG, another selection is made on the remaining KPIs. The selection is based on what is most useful and fits the pillar 'social involvement' the most. One extra KPI is added at the request of MSG. The final KPIs are explained below.

TOTAL NATURAL GAS USE

The natural gas use is the total gas use of the company. MSG has no smart gas meter, so they yearly calculate it by hand. The total natural gas use uses the by-hand generated data. This is the same input as in the tool for the purchased electricity. Therefore, the KPI purchased gas is merged with the total natural gas.

DIRECT GHG EMISSION (SCOPE 1)

The scope 1 emissions include all direct GHG emissions generated by the energy consumption within the freight transport sector (Tian et al., 2014). For MSG, this is the mobile combustion and the refrigerants, of which mobile combustion dominates.

INDIRECT GHG EMISSION (SCOPE 2)

Scope 2 emissions include the GHG emissions from electricity consumption. As mentioned in Section 3.1, MSG already uses 'EnergiePartners' as a dashboard to depict energy and gas use. Still, this KPI is in the dashboard to provide a clear overview of all aspects of the carbon footprint.

TOTAL DIRECT ENERGY USE

'EnergiePartners' measures the energy use of MSG accurately. Although, it is included in the dashboard to provide a complete picture of the emissions of MSG in one place. The purchased electricity is merged within this KPI. This is in line with the input for the GHG tool.

TOTAL RENEWABLE ENERGY USE

In this case, renewable energy use is the generated energy from solar panels.

LEVEL OF CO_2 EMISSION

The level of CO_2 emission is the total CO_2 emission minus the compensated emission. The goal of MSG is to be CO_2 neutral, which makes this KPI one of the priorities.

CO_2 PER TON KILOMETRES

The mobile combustion has the highest share of the total emission. Therefore, the CO_2 emission per ton kilometres is essential to indicate their progression on this major polluter.

PERCENTAGE OF ELECTRIC CARS

MSG’s percentage of electric cars in use is based on their total fleet in 2021.

EMISSION PER EURO REVENUE

MSG is a growing company, which reflects in its emission. To see whether MSG still reduces its emissions relatively, they want to add a KPI that indicates the emission in relation to the revenue. Therefore, the dashboard includes the emission per euro.

5.3 CONCLUSION

This chapter uses the AHP method with SMART criteria to select the appropriate KPIs for the carbon footprint dashboard. The criteria receive a value from the AHP method, which reduces the potential KPI list to the actual KPIs. With the management of MSG, nine KPIs are chosen to get the best insights in the carbon footprint and the reduction effects of the sustainable actions MSG takes. Also, the KPIs relate to one of the four pillars of MSG, the social involvement.

6. DASHBOARD

Chapter 6 first gives a brief overview of the requirements for the dashboard in Section 6.1. Section 6.2 elaborates the tool selection for the dashboard. Then, Section 6.3 provides the data model behind the dashboard. Section 6.4 explains dashboard design and how to use it. Finally, Section 6.5 summarizes the dashboard-making process.

6.1 REQUIREMENTS FOR THE DASHBOARD

The dashboard must provide insight into the carbon footprint and the action's effects. Therefore, the main functionalities of the dashboard are:

- Depict the current carbon footprint.
- Provide insight into the amount of emission per emission source.
- Calculate the effect on the carbon footprint of specific actions
- Give a quick overview of the actions MSG can take to reach their goal.

Next to that, there are a few needs for the use of the dashboard:

- The dashboard must be easy to use for the sales department.
- The data in the dashboard must be easy to understand for all departments.
- The dashboard must provide a clear overview of steps MSG can take toward carbon neutrality.

6.2 TOOL SELECTION

Multiple programs are available to design a dashboard, e.g. Tableau, Power BI, Qlik Sense, Qlikview, Excel and Google Looker. All the applications have their strengths, weaknesses, and unique selling points. For this thesis, Power BI is used to design the dashboard. Power BI is one of the market leaders and scores high in sharing the dashboard with other users because it is cloud-based (Bhatt et al., 2015). Besides, the management of MSG already purchased Power BI, so there are no purchase costs.

6.3 THE DATA COLLECTION

Section 3.1 already describes the initial data sources. The GHG tool outcome is represented in an Excel sheet. This excel sheet is not well ordered and could be hard to use for MSG to maintain the dashboard. Therefore, a new Excel file is created to which MSG can easily add data. Figure 13 depicts the data collection process for the Power BI tool.

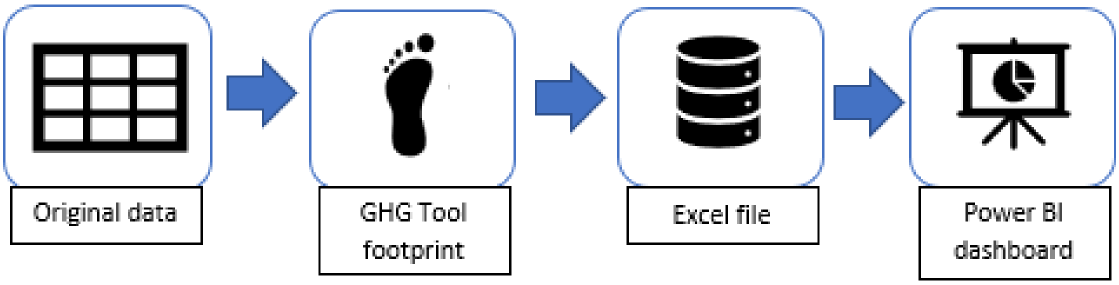

Figure 13 Data collection process for Power BI

There is no data available on the effect measurement. Therefore, we generate the data in an Excel file. Chapter 4 functions as the foundation for the calculations in the Excel file. Together with the data of the current footprint, the Power BI dashboard can be constructed.

6.4 THE DATA MODEL

The input data needs modelling. Figure 14 depicts the data model. The "S1-Mobile combustion" and "Purchased_Electricity" derive from the GHG Tool. "Carbon Footprint – Revenue" and "Results Summary GHG tool" derive from an Excel sheet. The "Fuel Source" table is made in Power BI. The four tables related to the effect measurement derive from another Excel sheet, especially for the actions. The data model contains five measurements. Appendix E provides the formulas of these measurements.

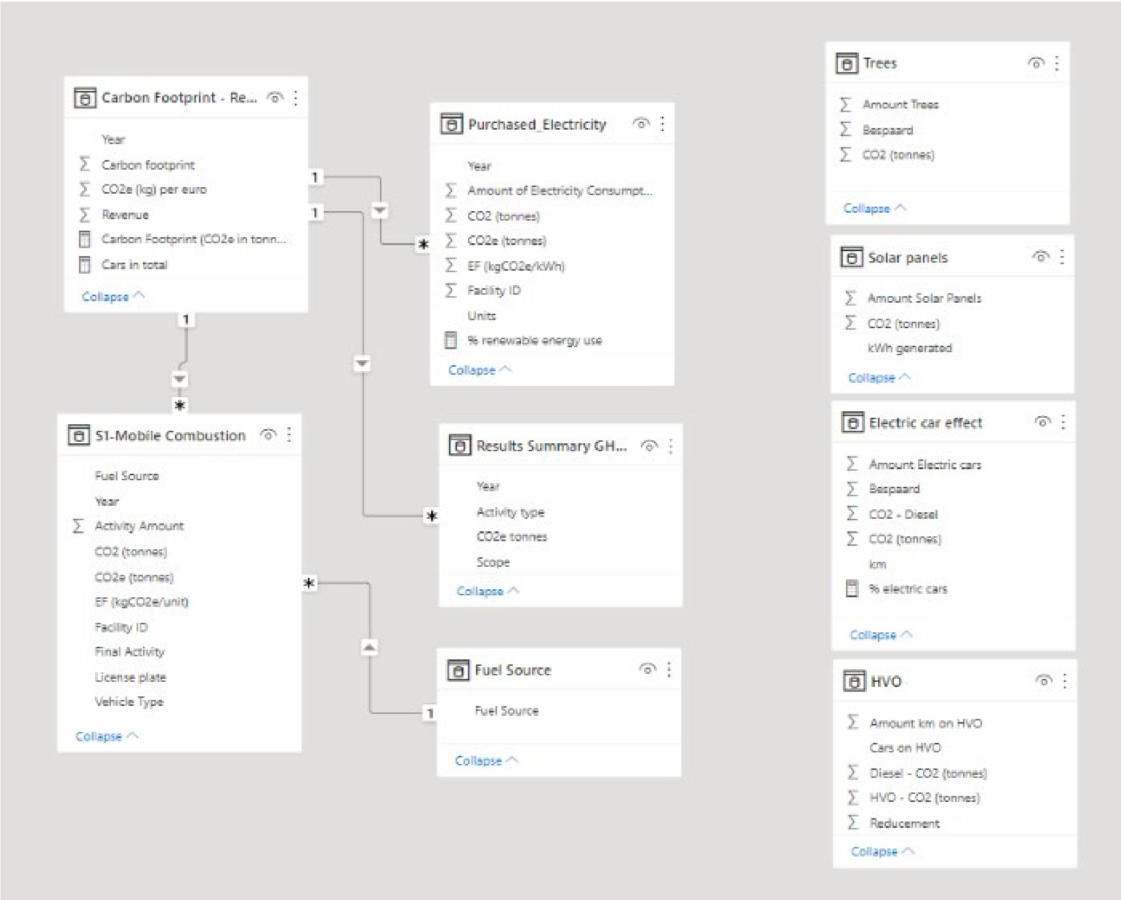

Figure 14 Power BI data model

6.5 THE DASHBOARD

The first page of the dashboard shows the situation for 2019, 2020 and 2021, as calculated in the GHG tool. Figure 15 shows the first page. The page gives an overview of the "Current" situation. All the data is derived from the initial data used for the tool. The left side displays the carbon footprint in CO_2e for 2019, 2020 and 2021. The immediate focus is on the "Total CO_2e tonnes by year". The graphic shows the type of emission on the total carbon footprint. All other graphs on the page address a part of the emission. "Activity Amount by Fuel Source in 2021" and "Activity Amount by Year and Fuel Source" provide more information on the mobile combustion, their largest emitter. Then, "CO_2e tonnes for scope 1 and 2 by Year" gives an overview of the emission per scope. "CO_2e (kg) per Euro Revenue by Year" provides insight in the emission per euro revenue. Lastly, the "Total natural gas by Year" and the "Total electricity consumption by Year" are displayed. The "Current" page depicts most of the required KPIs. Page 2 "Effects on Carbon Footprint" shows the remaining KPIs.

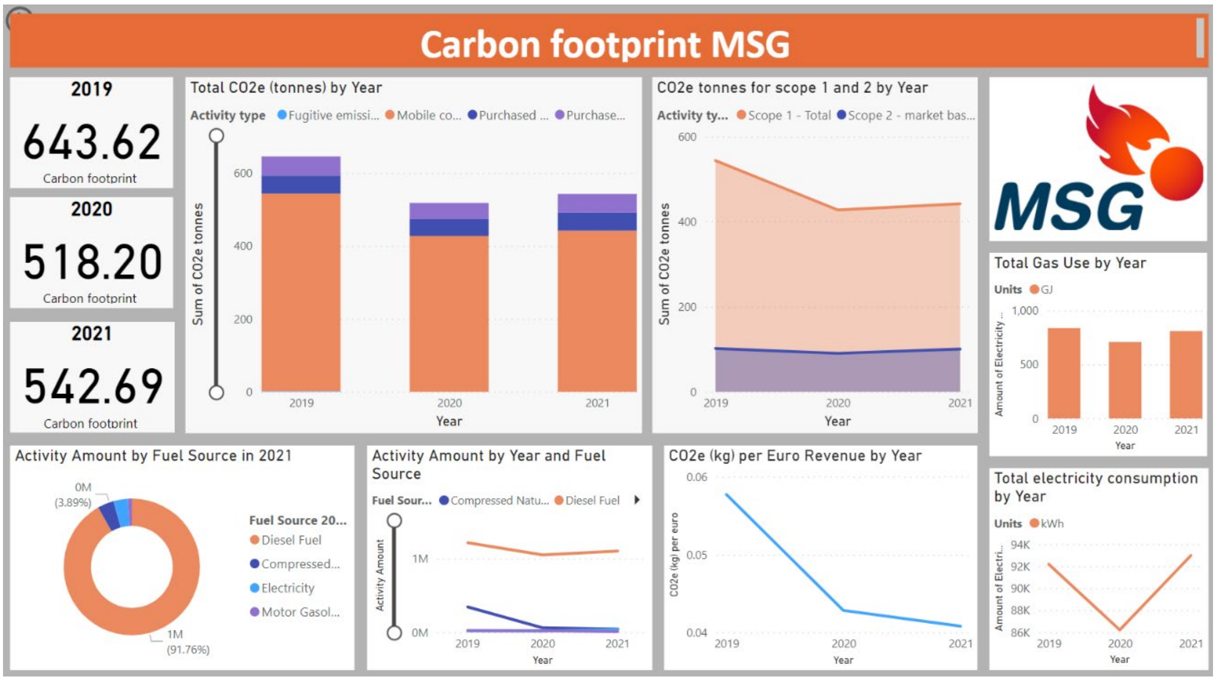

Figure 15 Dashboard "Current" page

On the second page, named "Effects", MSG can see the impact on their carbon footprint of the actions they consider. Figure 16 shows this second page of the dashboard. The carbon footprint is based on 2021. The value is lower than the value provided on page 1 and in Section 3.2 because the compensation of the planted trees is taken into account in this sheet. Beneath the carbon footprint, there are filters where MSG can choose the actions they want to take and in which amount. They can see what affects their footprint the most and make decisions based on these effects. The data for this page is derived from the GHG Tool and constructed from the calculations in Chapter 5 "Effects of sustainable actions".

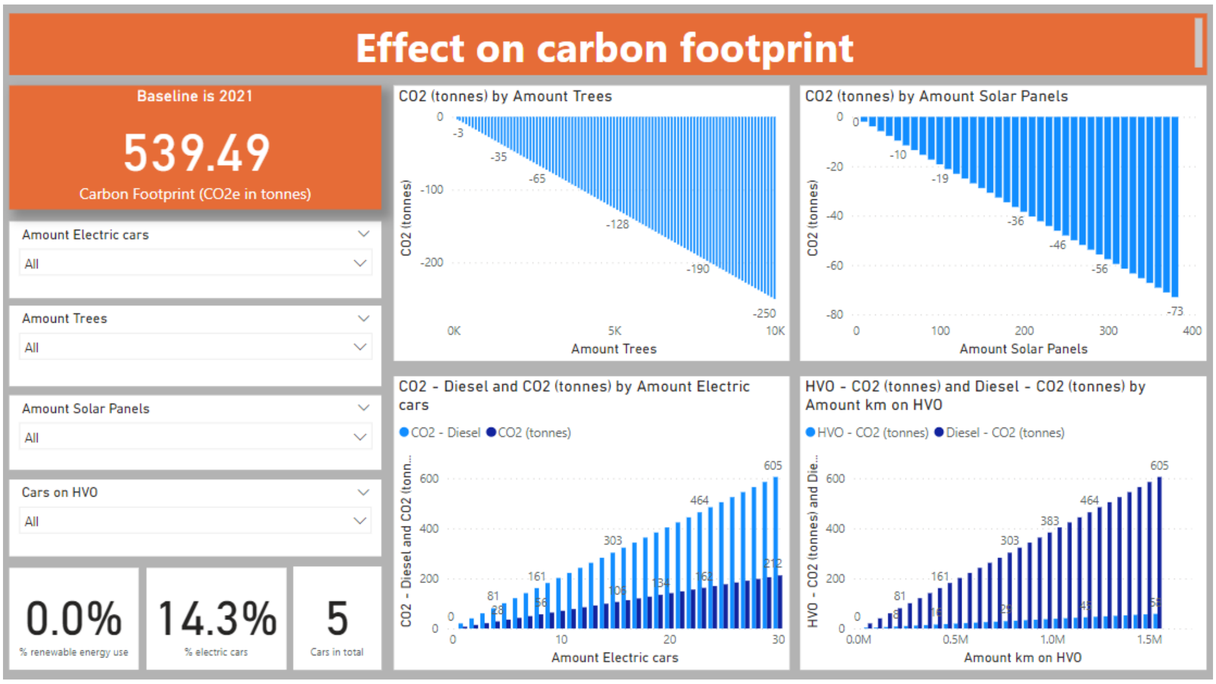

Figure 16 Dashboard page "Effects"

The "CO_2 (tonnes) by Amount Trees" depicts the decrease in tonnes of CO_2. The trees compensate for the emission; therefore, the carbon footprint decreases. The "CO_2 (tonnes) by Amount Solar Panels" shows the reduction in emissions by placing solar panels. The reduction is based on the generated energy that replaces the energy consumption from their energy supplier. The remaining two graphs make a comparison with the current situation. The "CO_2 – Diesel and CO_2 (tonnes) by Amount Electric cars" illustrates the emission of the electric cars (based on purchased electricity) and the emission of diesel fuel cars. When selecting the number of electric cars, the graph changes to a comparison between both emissions for the specific number of cars. The "HVO – CO_2 (tonnes) and Diesel – CO_2 (tonnes) by Amount km on HVO" works the same way. The graph presents the emission for a car driven a certain number of kilometres on diesel and HVO. A quick analysis of the effect can be done when selecting the number of kilometres driven. Figure 17 shows the graph where 500000 kilometres are driven. The difference is clear immediately.

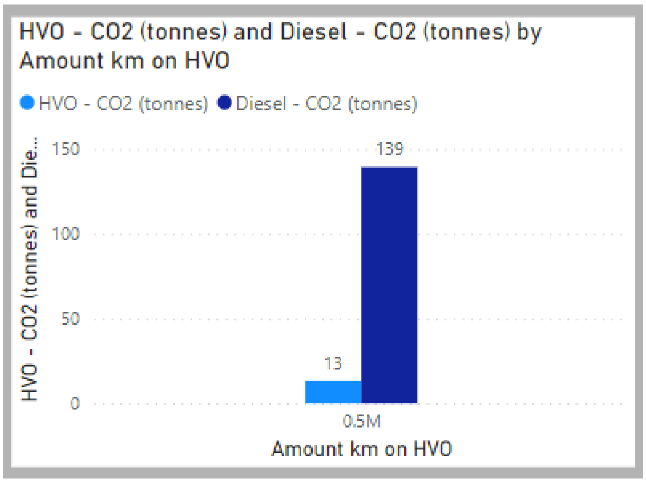

Figure 17 Dashboard amount of kilometres on HVO

At the bottom left, the two remaining KPIs are depicted. The "Percentage Electric Cars" and "Percentage renewable energy" indicate how far MSG is with their sustainability.

The box "Cars in total" has a starting value of 5. There are already five electric cars, so new electric cars or cars on HVO cannot replace these cars. When selecting a value in the "Amount Electric cars" or "Cars on HVO", the "Cars in total" depicts the total 'replaced' cars of MSG Enschede. In 2021, the fleet of MSG Enschede contained 35 cars. With this box, the dashboard user can see the number of diesel cars already replaced by electric cars or cars on HVO. If this number exceeds 35, there are more actions on cars than what is possible.

6.6 CONCLUSION

This chapter describes the dashboard-making process. The data is collected so that MSG can maintain the dashboard and add the new values to the Excel sheets. The dashboard provides information on all the desired KPIs. The visualization is done with the literature study and the requirements mentioned in Section 6.1.

7. ROADMAP

This chapter discusses options for a roadmap towards a carbon neutral MSG. Therefore, Section 7.1 discusses the feasibility of MSG's goal to be CO_2 neutral in 2025. Section 7.2 considers the steps MSG could take next.

7.1 FEASIBILITY

Based on the dashboard, there could be concluded MSG needs to take considerable steps to achieve their goal to be carbon neutral in 2025. These steps are high investments and will cost MSG a lot. If these needed resources are available, then the goal could be achieved. However, the year 2025 will soon be here and it will be difficult to make such big changes in such a short time.

7.2 ROADMAP

To become carbon neutral, a company should create awareness and obtain information about their emissions (TVM, n.d.). Also, the possibilities should be mapped and worked out. This study covers these steps. The next step is to make choices and work out those choices.

All the options included in the research decrease the carbon footprint. Based on Section 4.2, which is visualized in the dashboard, some conclusions about the impact of the options can be drawn. Planting trees on small scale has a minimum 'per piece' effect. In that case, it is only suitable for last compensation that is needed to achieve the goal. Although, it could make a considerable impact when planting a forest. A 1-hectare forest compensates for 50 tonnes CO_2 per year.

There are 2 options considering the cars of MSG. The first option is to replace diesel cars to electric cars. This ensures a decrease of approximately 13.1 tonnes CO_2 per year per car. The second option is to change the diesel in the cars with HVO. This ensures a decrease of approximately 18.2 tonnes CO_2 per year per car. When only looking at the numbers one might choose to change all diesel with HVO. This could be a helpful intermediate step to achieve the goal before 2025. Though, HVO is not zero emission, so it always needs to be compensated. An electric car drives on renewable sources. As shown in Section 4.2, an electric car still causes emissions. There is energy needed to produce electricity, which is the reason for this emission. The difference with HVO is that the needed energy for electricity can be generated naturally.

The electricity MSG uses for their building and cars can be generated by solar panels. A single solar panel reduces 0.19 tonnes CO_2 per year. MSG needs a lot of panels to cover all the electricity they use. When MSG decides to replace more of their fleet for electric cars, the electricity use will increase even more. Section 4.2 mentions that MSG needs 249 panels to cover the energy is in 2021. Thereby, for each electric car 37 extra panels are needed. MSG does not have the space to place that many solar panels. Also, it is a big investment to install solar panels.

MSG should consider all the options. When their plan of approach is made, the company must adjust to their new strategy. Possible additional charging stations, instruct employees and change plannings with deal with loading time or to pass the trucks by an HVO station, are examples of adjustments in the company that must be made. Then, MSG can experience the effects and gather new data to evaluate the actual impact of their choices (TVM, n.d.). The new data can provide the insight to decide whether the plan of approach is correct or whether some adjustments must be made. Eventually, MSG will reach their goal at the most effective way if they keep gather, process, and evaluate new data.

8. EVALUATION, CONCLUSION & DISCUSSION

8.1 EVALUATION

For evaluation of the dashboard, the Unified Theory of Acceptance and Use of Technology (UTAUT) of Venkatesh et al. (2003) is used. This method provides a valuable tool to assess the likelihood of success for new technology introductions. The questions, including the answers, are shown in Appendix F. The questionnaire asked to answer according to the Likert scale from 1 to 5.

The UTAUT consists of eight subjects. The first subject, the performance expectancy, scores the maximum score. The respondent indicates that the value of the dashboard is very high for MSG. The effort expectancy scores well. The dashboard is understandable without accompanying explanations. With the corresponding explanations, it is easy to use. The attitude towards using the dashboard is positive. The social influence scores are neutral overall. The respondent is a primary supporter of the dashboard. Therefore, the respondent is not influenced by others but wants to influence others. The respondent wants to make others in the organisation more aware of the CO_2 emissions. Next, MSG recognises that more specific data is needed to optimise the dashboard. This data is not available yet but will be in the future. The self-efficacy is high if a description is provided. The anxiety for the dashboard is very low. The last subject, the behavioural intention to use the dashboard, has the maximum score. MSG will use the dashboard, to understand where MSG stands and helps them to meet their goals.

8.2 CONCLUSION

This research answered several sub-research questions that make it possible to answer the main research question. This section concludes with the answers to the sub-research questions and the main research question.

1. *How can the carbon footprint of MSG be calculated?*

We conducted a literature study to answer this question. There are many ways to calculate the carbon footprint of a logistics company. Eventually, we chose to work with the GHG Emission Calculation Tool because this tool includes the driven kilometres but also the purchased electricity of the office.

2. *What data is needed to calculate the current footprint?*

For this research question, research question 1 needed an answer first. The tool calculates the footprint based on five input factors: stationary combustion, mobile combustion, refrigerants, purchased electricity and transportation. There is no stationary combustion at MSG, so no data is needed. The mobile combustion needed the yearly driven kilometres per car and the car types. Then, the purchased refrigerants for the air conditioners are asked, of which the information could be retrieved by the yearly maintenance reports. For the purchased electricity, electricity consumption and gas use are needed. The transportation concerns scope 3 emissions, which is outside the scope of this research.

3. *What are the reduction effects of the sustainable actions?*

To answer this question, a list of sustainable actions is made. Calculations based on emission factors and the GHG tool standard showed the effects of these actions. An electric car reduces the CO_2 emission with 65% in comparison with a car on diesel fuel. Driving a car on HVO emits only 9% of a car's emission on diesel fuel. Installing solar panels generates 360 kWh yearly, which reduces the carbon emission by 0.192016 tonnes CO_2 per year per panel of 400 Wp. Lastly, planting trees can compensate 25 kg of CO_2 very year for the remaining emission.

4. *How to visualize the current carbon footprint in combination with the reduction in carbon footprint caused by the actions MSG takes?*

The current carbon footprint, in combination with the reduction in carbon footprint caused by the actions MSG takes, can be visualized by selecting the most accurate KPIs and emphasizing the most important values.

4.1 How to select KPIs related to carbon footprint for MSG?

Literature study showed many KPI selection methods to choose the most appropriate KPIs for the research. We discussed the KPI Assessment Method (KAM) (Hester et al., 2017), the method of Horst & Weiss (2015) and the AHP method with SMART criteria (Saaty, 1988). The AHP method is chosen for this study because it is more elaborated than the method of Horst & Weiss (2015) and is more applicable to this situation than the KAM.

4.2 How to visualize the KPIs?

The literature study answered this question. The study outlined some design guidelines. These design guidelines are applied to the dashboard design. Next, the importance of selecting the correct chart for the correct data is studied. Every data needs to tell a story that must be analysed correctly, which the different charts can help with.

'How to measure and visualize the emission effects of the sustainable actions MSG takes to achieve their goal to be CO_2 *neutral in 2025?'*

To answer this question and come up with a deliverable that helps MSG to achieve their goal to be CO_2 neutral, the current carbon footprint had to be calculated first. Then, the measurement is based on this current situation. All these aspects come together in the dashboard to help MSG reach its goal. They have an overview of their emission and the source of the emissions. Further, the management of MSG has an overview of the effects of their sustainable actions on their carbon footprint.

8.3 RECOMMENDATIONS

In this section, the recommendations on different phases of the research are done. First, the recommendations on carbon footprinting method. The calculation of the mobile combustion will be more accurate with the fuel consumption. So, the first recommendation is to record the fuel consumption of every car and not only the kilometres. Then, MSG measures the gas use by hand every year. MSG is already exploring the options for a smart gas meter, and it is strongly recommended to continue this because it can give an insight into the small steps MSG is taking to reduce gas use.

The following recommendation is about the scope of the research. In this study, only location Enschede is included. MSG has multiple locations that merge into each other on several point. So, the recommendation is to include all locations in the scope to get an overview of the whole company.

Then there are also some recommendations on the dashboard. The dashboard contains data from 2019, 2020 and 2021. To get an insight in the progress of reducing the emission, it could be helpful to calculate the carbon footprint for the first few months of 2022. This could prevent unexpected emissions that keep MSG even further from its goal. Overall, the advice is to constantly update the dashboard to make it more accurate.

As the researcher, I also have a recommendation on which options MSG should invest in. If MSG wants to achieve their goal to become carbon neutral in 2025, the recommendation would be to change the fuel from diesel to HVO for as many cars as possible. This is a short-term solution. From this point, electric cars can be purchased. The compensation or generation for the needed electricity can be considered at the same time as the purchase. From the long-term point of view, the recommendation would be to invest mainly in electric cars. As mentioned in Section 7.2, the electric cars can be completely zero emission in contradiction to HVO. Also, a recommendation is to compensate for the last emission with trees. The trees can make the last influence to justify MSG's CO_2 neutral status. The last recommendation is on the solar panels. The solar panels are a difficult topic because MSG rents the building, so cannot decide about solar panels on their roof. Irrespective of that, the investment costs versus the impact on the total carbon emission make that the recommendation would be not to focus too much on the solar panels.

The last recommendation is about the whole process. The GHG tool is based on averages. The effect measurements are partly based on emission factors, partly on new averages and partly on the GHG tool. This study provides a good baseline for MSG, but MSG can expand and improve the accuracy of their carbon footprint. There are multiple businesses that are specialized in reducing the carbon footprint of logistic companies. The last recommendation would be to delve into the options on this market and cooperate with one of these companies to get a more accurate and frequent update on the carbon footprint.

8.4 CONTRIBUTION

8.4.1 CONTRIBUTION TO THEORY

This research is done for a logistic company that wants to include the emission of their vehicles, their largest emission, but also the emission the office produces. The lack of literature where both emissions are in consideration shows the importance of this research. Most of the studies are focussed on the logistic emissions or the emission within a building. This study shows the influence of the emissions produced by the activities and the building of a logistic company.

In the process, several methods are used: the literature review method of Wolfswinkel et al. (2013), the GHG carbon footprinting method, the AHP method with SMART criteria and the ATUAT. The contribution of the study is a case study to measure and visualize the carbon footprint and the reduction effects of certain specific actions from zero, with the help of several methods.

8.4.2 CONTRIBUTION TO PRACTISE

The dashboard will be used to analyse the actions' effects to the current carbon footprint. MSG can make deliberated decisions on which investments they will make to obtain their goal of being CO_2 neutral. With the dashboard, MSG can also show their potential customers the reduction in carbon footprint.

MSG rents the building of location Enschede. This dashboard can show the host the importance and benefits of solar panels. Together, they can get in a discussion about the installation of the solar panels.

Further, the carbon footprint provides MSG with an insight on the sustainability of the company. MSG claims to be a social company for the people and the planet. The reality is that they did not know how sustainable they were. This study gives them the opportunity to be completely open about their carbon footprint toward their customers.

8.5 DISCUSSION

There are several discussion points in the study. The main weakness of this study is the time constraint to execute this research. There are only ten weeks to determine the current carbon footprint, measure the effects of some actions MSG has in consideration and make a dashboard that contains all this information. The findings of the study may be somewhat limited in accuracy because of this.

Another discussion point is the quality of data. There was data needed from multiple different sources. The data is gathered from 2019 because, for some sources, there was no data from previous years. Also, there is only available data about the kilometres driven for the mobile combustion instead of the fuel consumption. This makes the research less accurate because we had to work with averages instead of absolute numbers.

The third discussion point is that the GHG tool is still in a beta version. There could be some adjustments to the tool that influence the current carbon footprint. It can be argued that is not a problem because carbon footprinting will always evolve, irrespective of this tool.

In Chapter 5, the KPI selection method is conducted. The first discussion point in this chapter is the KPI gathering. The literature provides many KPIs, of which most are irrelevant in this case. The KPIs from literature go into more detail on carbon footprinting, whereas in this case we want to map the broad outlines and provide an insight for MSG. The GHG Protocol provides KPIs that are also used in the tool. This is helpful because it says something directly about the input. Then there are some KPIs MSG recommends and would like to see in the dashboard. This study focusses on providing insight for MSG, so the KPIs must be clear, relevant, and understandable for every employee that will use the eventual dashboard. Therefore, the KPIs from literature are somewhat too complex and detailed to use. MSG is a company with a goal and the GHG Protocol sets standards to help reach that specific goal, so it is logical that those two are more aligned.

Next, the score per KPI with the SMART criteria are based on the student and the management of MSG. Other stakeholders could have another insight in this selection process. Also, there was another selection of the MSG management on the final list of KPIs. This selection is done to make the dashboard more accessible. Therefore, the importance of the selection method can be argued for this research.

Then, there is a discussion point on the dashboard. When selecting 30 electric cars, there can still be selected kilometres driven on HVO. This is not possible when there are no more cars that drive on diesel fuel. The user of the dashboard should take this in consideration when selecting those two actions. Therefore, the extra "Cars in total" box is added. Still, it could be stated that this influences the user-friendliness of the dashboard. Also, as mentioned before, the quality of data is poor. This data is processed in the dashboard, which makes the dashboard less reliable. Therefore, the findings will doubtless be much scrutinised. Though, MSG has an indication of their emission and what actions they can take.

The last point of discussion is the subcontractors of MSG. MSG outsources some parts of the routes. These emissions are scope 3 emission, so it is not included in the research. Though, these driven kilometres have a significant influence on the carbon footprint. Therefore, the recommendation is to map those emissions to make the carbon footprint more accurate.

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APPENDICES

APPENDIX A – SMART PAIRWISE COMPARISON MATRIX

The first 2 matrices are valued by the researcher of this thesis. The second 2 matrices are valued by the management of MSG. The matrices are n x n matrices. The entry in row *i* and column *j* of A, say a_{ij}, indicates how much more important objective *i* than objective *j* (Winston & Goldberg, 2004).

The Matrix A_{norm} is calculated with Matrix A, according the AHP. Each entry in column *i* of A must be divided by the sum of the entries in column *i*. The sum of each column in A_{norm} is equal to 1.

APPENDIX A.1 PAIRWISE COMPARISON MATRIX RESEARCHER

$$A = \begin{matrix} S \\ M \\ A \\ R \\ T \end{matrix} \begin{bmatrix} 1 & \frac{1}{4} & \frac{1}{4} & \frac{1}{5} & \frac{1}{2} \\ 4 & 1 & 2 & \frac{1}{2} & 3 \\ 4 & \frac{1}{2} & 1 & \frac{1}{2} & 2 \\ 5 & 2 & 2 & 1 & 3 \\ 2 & \frac{1}{3} & \frac{1}{2} & \frac{1}{3} & 1 \end{bmatrix} \qquad A_{norm} = \begin{bmatrix} .0625 & .0612 & .0435 & .0789 & .0526 \\ .2500 & .2449 & .3478 & .1974 & .3158 \\ .2500 & .1224 & .1739 & .1974 & .2105 \\ .3125 & .4898 & .3478 & .3947 & .3158 \\ .1250 & .0816 & .0870 & .1316 & .1053 \end{bmatrix}$$

APPENDIX A.2 PAIRWISE COMPARISON MATRIX MSG

$$A = \begin{matrix} S \\ M \\ A \\ R \\ T \end{matrix} \begin{bmatrix} 1 & \frac{1}{4} & \frac{1}{5} & \frac{1}{5} & \frac{1}{2} \\ 3 & 1 & 1 & \frac{1}{2} & 3 \\ 5 & 1 & 1 & \frac{1}{2} & 3 \\ 5 & 2 & 2 & 1 & 3 \\ 2 & \frac{1}{3} & \frac{1}{3} & \frac{1}{3} & 1 \end{bmatrix} \qquad A_{norm} = \begin{bmatrix} .0625 & .0545 & .0441 & .0789 & .0476 \\ .1875 & .2182 & .2206 & .1974 & .2857 \\ .3125 & .2182 & .2206 & .1974 & .2875 \\ .3125 & .4364 & .4418 & .3947 & .2857 \\ .1250 & .0727 & .0735 & .1316 & .0952 \end{bmatrix}$$

APPENDIX B – CONSISTENCY CHECK

Appendix B.1 – Consistency Check Researcher

STEP 1

$$Aw^T = \begin{bmatrix} 1 & \frac{1}{4} & \frac{1}{4} & \frac{1}{5} & \frac{1}{2} \\ 4 & 1 & 2 & \frac{1}{2} & 3 \\ 4 & \frac{1}{2} & 1 & \frac{1}{2} & 2 \\ 5 & 2 & 2 & 1 & 3 \\ 2 & \frac{1}{3} & \frac{1}{2} & \frac{1}{3} & 1 \end{bmatrix} \begin{bmatrix} .0586 \\ .2465 \\ .2188 \\ .3731 \\ .1029 \end{bmatrix} = \begin{bmatrix} 0.3010 \\ 1.4138 \\ 0.9688 \\ 1.9054 \\ 0.5360 \end{bmatrix}$$

STEP 2

$$\frac{1}{n}\sum_{i=1}^{i=n} \frac{i \text{ th entry in } A\mathbf{w}^T}{i \text{ th entry in } \mathbf{w}^T} = \left(\frac{1}{5}\right)\left\{\frac{0.3010}{0.0597} + \frac{1.4138}{0.2711} + \frac{0.9688}{0.1908} + \frac{1.9127}{0.3721} + \frac{0.5360}{0.1061}\right\} = 5.1014$$

STEP 3

$$\text{CI} = \frac{(\text{ Step 2 result }) - n}{n-1} = \frac{5.1014 - 5}{4} = 0{,}0254$$

STEP 4

Compare CI to the random index (RI) for the appropriate value of n, shown in Table 7 (Winston & Goldberg, 2004)

N	2	3	4	5	6	7	8	9	10
RI	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.51

Table 7 Values of the Random Index (RI)

For consistency, $\frac{CI}{RI} < 0.10$. In this case, $\frac{CI}{RI} = \frac{0.0254}{1.12} = 0.0226 < 0.10$. Thus, the pairwise comparison does not contain any serious inconsistencies.

Appendix B.2 – Consistency Check MSG

STEP 1

$$Aw^T = \begin{bmatrix} 1 & \frac{1}{4} & \frac{1}{5} & \frac{1}{5} & \frac{1}{2} \\ 3 & 1 & 1 & \frac{1}{2} & 3 \\ 5 & 1 & 1 & \frac{1}{2} & 3 \\ 5 & 2 & 2 & 1 & 3 \\ 2 & \frac{1}{3} & \frac{1}{3} & \frac{1}{3} & 1 \end{bmatrix} \begin{bmatrix} .0586 \\ .2465 \\ .2188 \\ .3731 \\ .1029 \end{bmatrix} = \begin{bmatrix} 0.2901 \\ 1.1364 \\ 1.2534 \\ 1.9054 \\ 0.4996 \end{bmatrix}$$

STEP 2

$$\frac{1}{n}\sum_{i=1}^{i=n} \frac{i \text{ th entry in } A\mathbf{w}^T}{i \text{ th entry in } \mathbf{w}^T} = \left(\frac{1}{5}\right)\left\{\frac{0.2901}{0.0586} + \frac{1.1364}{0.2465} + \frac{1.2534}{0.2188} + \frac{1.9054}{0.3731} + \frac{0.4996}{0.1029}\right\} = 5.0503$$

STEP 3

$$\text{CI} = \frac{(\text{ Step 2 result }) - n}{n-1} = \frac{5.0503 - 5}{4} = 0{,}0126$$

STEP 4

Compare CI to the random index (RI) for the appropriate value of n, shown in Table 7 (Winston & Goldberg, 2004).

For consistency, $\frac{CI}{RI} < 0.10$. In this case, $\frac{CI}{RI} = \frac{0.0126}{1.12} = 0.0112 < 0.10$. Thus, both pairwise comparison do not contain any serious inconsistencies.

APPENDIX C – POTENTIAL KPIS

SOURCE	KPI
(HŘEBÍČEK ET AL., 2007)	EN 17 Greenhouse gas emissions
	EN 19 Other significant air emissions by weight
	EN 23 Other relevant greenhouse gas emissions
	KPI 1 Greenhouse gases

	KPI 2 Acid rain and smog precursors
	KPI 3 Dust and particles
	KPI 5 Volatile organic compounds
	KPI 6 Metal emissions to air
	EN 3 Direct energy consumption broken down by primary energy source
	EN 4 Indirect energy consumption broken down by primary energy source
	EN 5 Percentage of total energy consumption met by renewable sources
	EN 6 Total energy saved due to conservation and efficiency improvements
	EN 7 Initiatives to provide energy-efficient products and services
	EN 8 Initiatives to reduce indirect energy consumption
	KPI 15 Natural gas
(*EUR-LEX - 52019XC0620(01) - EN - EUR-LEX*, N.D.; ZARZYCKA & KRASODOMSKA, 2021)	Direct GHG emissions (scope 1)
	Indirect GHG emissons (scope 2)
	All indirect GHG emissions (scope 3)
	GHG absolute emissions target (tons or %)
	Total energy consumption and/or production from (non)renewable energy (MWh)
	Energy efficiency target (%)
	Renewable energy consumption (% increase) and/or production target (% increase)
	Assets committed in regions likely to become more exposed to acute or chronic physical climate risks
(HŘEBÍČEK ET AL., 2011)	EN3 total direct energy use
	EN4 total renewable energy use
	EN16 total annual emission of greenhouse gases
	EN20a total annual air emission
	EN26 initiatives to mitigate environmental impact of products and services, and extent of impact mitigation expressed (number of initiatives)
KRAUTH ET AL. (2005)	Level of CO_2 emission
	Society satisfaction
	Employee satisfaction
	Wasting resources
	Recycling level
INPUT MSG	CO_2 per ton kilometres
	Emission reduced by electric cars
	The share of alternative fuels in total km
	NOx per ton kilometres

	Percentage on electric
GHG PROTOCOL	Kilometres driven
	Purchased electricity
	Purchased gas
	Purchased refrigerants

Table 8 List of potential KPIs

APPENDIX D – KPI SELECTION

APPENDIX D.1 – KPI RATING RESEARCHER

KPI	S	M	A	R	T	Total
Acid rain and smog precursors	4	1	2	2	1	1.7676
Dust and particles	2	1	2	2	1	1.6504
Volatile organic compounds	2	1	1	1	1	1.0585
Metal emissions to air	8	2	3	6	2	4.0626
Direct energy consumption broken down by primary energy source	4	6	2	1	4	2.9357
Indirect energy consumption broken down by primary energy source	7	6	2	1	4	3.1115
Total energy saved due to conservation and efficiency improvements	7	3	4	8	7	5.73
Initiatives to provide energy-efficient products and services	5	7	7	5	6	6.033
Initiatives to reduce indirect energy consumption	8	8	8	5	8	6.8799
Natural gas	5	7	9	9	9	8.2717
Direct GHG emissions (scope 1)	8	9	9	9	8	8.8376
Indirect GHG emissons (scope 2)	8	8	8	9	7	8.2694
All indirect GHG emissions (scope 3)	7	5	5	7	3	5.6571
GHG absolute emissions target (tons or %)	5	7	7	9	7	7.6283
Total energy consumption and/or production from (non)renewable energy (MWh)	8	7	8	8	7	7.6498
Energy efficiency target (%)	4	4	3	7	5	5.003
Renewable energy consumption (% increase) and/or production target (% increase)	5	7	5	8	6	6.7147
Assets committed in regions likely to become more exposed to acute or chronic physical climate risks	1	4	1	2	2	2.2154
total direct energy use	7	9	9	9	9	8.8819
total renewable energy use	7	7	6	9	7	7.5267
total annual air emission	7	6	5	7	3	5.9036
Level of CO_2 emission	8	9	7	9	9	8.5029
Society satisfaction	6	4	7	3	3	4.2972
Employee satisfaction	5	6	7	4	4	5.2076
Wasting resources	3	3	4	7	3	4.7109
Recycling level	7	2	2	5	2	3.4121
CO_2 per ton kilometres	9	9	8	9	9	8.7803
Emission reduced by electric cars	8	9	9	9	9	8.9405
The share of alternative fuels in total km	8	8	8	9	9	8.4752
NOx per ton kilometres	9	6	8	6	9	6.9215
Percentage of cars on electric	8	9	9	7	8	8.0914
Kilometres driven	8	9	9	8	8	8.4645
Purchased electricity	7	9	9	9	9	8.8819
Purchased gas	8	7	9	9	9	8.4475
Purchased refrigerants	5	8	6	4	7	5.7905

APPENDIX D.2 – KPI RATING MSG

KPI	S	M	A	R	T	Total
Acid rain and smog precursors	6	2	1	1	1	1.5394
Dust and particles	2	2	1	2	1	1.6781
Volatile organic compounds	7	1	1	1	3	1.5573
Metal emissions to air	7	2	2	3	2	2.6659
Direct energy consumption broken down by primary energy source	7	4	3	4	4	3.9566
Indirect energy consumption broken down by primary energy source	7	4	3	3	4	3.5835
Total energy saved due to conservation and efficiency improvements	6	4	4	7	5	5.339
Initiatives to provide energy-efficient products and services	9	9	8	6	8	7.5581
Initiatives to reduce indirect energy consumption	9	8	8	6	8	7.3116
Natural gas	6	8	6	9	9	7.9204
Direct GHG emissions (scope 1)	8	9	8	9	9	8.7217
Indirect GHG emissons (scope 2)	8	8	8	9	8	8.3723
All indirect GHG emissions (scope 3)	8	4	6	7	5	5.8938
GHG absolute emissions target (tons or %)	4	7	6	9	8	7.4538
Total energy consumption and/or production from (non)renewable energy (MWh)	9	6	7	8	7	7.2431
Energy efficiency target (%)	6	5	6	7	7	6.2289
Renewable energy consumption (% increase) and/or production target (% increase)	5	6	5	7	7	6.198
Assets committed in regions likely to become more exposed to acute or chronic physical climate risks	2	3	1	1	2	1.6544
total direct energy use	9	7	8	9	9	8.2873
total renewable energy use	7	7	8	9	8	8.0672
total annual air emission	5	2	6	5	6	4.5817
Level of CO_2 ***emission***	8	8	8	9	9	8.4752
Society satisfaction	7	6	7	7	5	6.547
Employee satisfaction	7	7	6	7	8	6.8834
Wasting resources	5	4	5	6	6	5.229
Recycling level	7	5	3	6	5	5.0522
CO_2 per ton kilometres	9	8	8	9	9	8.5338
Emission reduced by electric cars	8	8	9	8	8	8.218
The share of alternative fuels in total km	7	8	8	9	8	8.3137
NOx per ton kilometres	9	6	7	5	7	6.1238
Percentage of cars on electric	8	9	9	8	9	8.5674
Kilometres driven	8	9	9	7	9	8.1943
Purchased electricity	9	8	8	9	9	8.5338
Purchased gas	9	6	8	9	9	8.0408
Purchased refrigerants	6	7	6	6	8	6.4517

APPENDIX D.3 – FINAL KPI RATING

KPI	Total
Acid rain and smog precursors	1.6535
Dust and particles	1.66425
Volatile organic compounds	1.3079
Metal emissions to air	3.36425
Direct energy consumption broken down by primary energy source	3.44615
Indirect energy consumption broken down by primary energy source	3.3475
Total energy saved due to conservation and efficiency improvements	5.5345
Initiatives to provide energy-efficient products and services	6.79555
Initiatives to reduce indirect energy consumption	7.09575
Natural gas	8.09605
Direct GHG emissions (scope 1)	8.77965
Indirect GHG emissons (scope 2)	8.32085
All indirect GHG emissions (scope 3)	5.77545
GHG absolute emissions target (tons or %)	7.54105
Total energy consumption and/or production from (non)renewable energy (MWh)	7.44645
Energy efficiency target (%)	5.61595
Renewable energy consumption (% increase) and/or production target (% increase)	6.45635
Assets committed in regions likely to become more exposed to acute or chronic physical climate risks	1.9349
total direct energy use	8.5846
total renewable energy use	7.79695
total annual air emission	5.24265
Level of CO_2 ***emission***	8.48905
Society satisfaction	5.4221
Employee satisfaction	6.0455
Wasting resources	4.96995
Recycling level	4.23215
CO_2 per ton kilometres	8.65705
Emission reduced by electric cars	8.57925
The share of alternative fuels in total km	8.39445
NOx per ton kilometres	6.52265
Percentage of cars on electric	8.3294
Kilometres driven	8.3294
Purchased electricity	8.70785
Purchased gas	8.24415
Purchased refrigerants	6.1211

APPENDIX E – MEASUREMENT FORMULAS POWER BI

NAME	Formula
CARBON FOOTPRINT (CO_2E IN TONNES)	`average('Carbon Footprint - Revenue'[Carbon footprint ]) - value(MIN(Trees[Bespaard])) - SELECTEDVALUE('Electric car effect'[Bespaard])-SELECTEDVALUE(Trees[Bespaard]) + SELECTEDVALUE('Solar panels'[CO2 (tonnes)])-SELECTEDVALUE(HVO[Reducement])`
CARS IN TOTAL	`Calculate(calculate(count('S1-Mobile Combustion'[Fuel Source]),'S1-Mobile Combustion'[Year] = "2021"),'S1-Mobile Combustion'[Fuel Source]="Electricity")+SELECTEDVALUE('Electric car effect'[Amount Electric cars]) + SELECTEDVALUE(HVO[Cars on HVO])`
% ELECTRIC CARS	`(SELECTEDVALUE('Electric car effect'[Amount Electric cars])+ Calculate(calculate(count('S1-Mobile Combustion'[Fuel Source]),'S1-Mobile Combustion'[Year] = "2021"),'S1-Mobile Combustion'[Fuel Source]="Electricity")) / calculate(COUNT('S1-Mobile Combustion'[Fuel Source]),'S1-Mobile Combustion'[Year] = "2021")`
ALTERNATIVE FUELS	`(SELECTEDVALUE('Electric car effect'[km])+ SELECTEDVALUE(HVO[Amount km on HVO])+ calculate(calculate(sum('S1-Mobile Combustion'[Activity Amount]), 'S1-Mobile Combustion'[Year]= "2021"),OR('S1-Mobile Combustion'[Fuel Source]= "Electricity",'S1-Mobile Combustion'[Fuel Source] = "Compressed Natural Gas")))/CALCULATE(sum('S1-Mobile Combustion'[Activity Amount]),'S1-Mobile Combustion'[Year]= "2021")`
% RENEWABLE ENERGY USE	`IF(NOT((SELECTEDVALUE('Solar panels'[kWh generated]) /CALCULATE(AVERAGE(Purchased_Electricity[Amount of Electricity Consumption]),Purchased_Electricity[Units] = "kWh")) =0),(SELECTEDVALUE('Solar panels'[kWh generated]) /CALCULATE(AVERAGE(Purchased_Electricity[Amount of Electricity Consumption]),Purchased_Electricity[Units] = "kWh")),"0.0%")`

Table 9 Formulas in Power BI

APPENDIX F – UTUAT FORM

	Questions	1	2	3	4	5
1)	*Performance Expectancy*					
	I would find the dashboard useful in my job					X
	Using the dashboard enables me to accomplish tasks more quickly					X
	Using the dashboard increases my productivity					X
2)	*Effort expectancy*					
	My interaction with the dashboard would be clear and understandable				X	
	It would be easy for me to become skilful at using the dashboard				X	
	I would find the dashboard easy to use				X	
	Learning to operate the dashboard is easy for me				X	
3)	*Attitude towards using technology*					
	Using the dashboard is a good idea					X
	The dashboard makes work more interesting				X	
	I would like to work with the dashboard					X
4)	*Social influence*					

	People who influence my behaviour think that I should use the dashboard		X			
	People who are important to me think I should use the dashboard		X			
	In general, the organization supports the use of the dashboard					X
5) *Facilitating conditions*						
	I have resources necessary to use the dashboard					X
	I have knowledge necessary to use the dashboard				X	
	The dashboard is not compatible with other systems I use			X		
	A specific person (or group) is available for assistance with dashboard difficulties					X
6) *Self-efficacy*						
I could complete a job or task using the system…						
	If there was no one around to teel me what to do as I go				X	
	If I could call someone for help if I got stuck				X	
	If I had a lot of time to complete the job for which the software was provided		X			
	If I had just the built-in help facility for assistance					X
7) *Anxiety*						
	I feel apprehensive about using the dashboard	X				
	It scares me to think that I could lose a lot of information using the dashboard by hitting the wrong key		X			
	I hesitate to use the dashboard for fear of making mistakes I cannot correct		X			
	The dashboard is somewhat intimidating me	X				
8) *Behavioural intention to use the system*						
	I intend to use the dashboard in the next 6 months					X
	I predict I would use the dashboard in the next 6 months					X
	I plan to use the dashboard in the next six months					X

Table 10 UTUAT evaluation

Explanation per subject:

1) Jazeker gaan we het gebruiken voor onze CO_2 ontwikkelingen in de toekomst. Het heeft voor ons een grote waarde al is nog niet alle data even eenvoudig beschikbaar of accuraat maar ook daar werken we op andere vlakken aan waardoor het dashboard in de toekomst nog meer waarde gaat krijgen voor MSG.
2) Zonder de bijbehorende uitleg is het goed te begrijpen mits je een klein beetje van de materie afweet, met de bijbehorende uitleg is het voor iedereen eenvoudig te gebruiken.
3) Geen opmerkingen
4) Ik ben primair zelf voorstander van het dashboard en ben dus niet echt beïnvloed door andere mensen binnen de organisatie. Ik denk wel dat we met het dashboard anderen binnen de organisatie bewuster kunnen maken van onze CO_2 uitstoot en dat dat een gezamenlijke uitdaging is op vele vlakken
5) De data komen uit andere bronnen (binnen MSG) en die zijn nodig om het dashboard te laten werken, verder is er weinig extra kennis nodig
6) Volgens mij komen we er met de extra beschrijving altijd uit binnen MSG en is het niet nodig externe hulplijnen in te schakelen
7) Geen enkele angst voor een dashboard dat ons verder helpt inzichtelijk te hebben waar we staan om onze doelstellingen te helpen halen

8) We plannen het, we voorspellen het maar we gaan het ook gebruiken.