Measuring the CO_2 footprint of the HZ University of Applied Sciences

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Executive summary

The HZ University of Applied Sciences wants to become more sustainable. In order to meet this goal it is important to know where you stand as a university. A good way to find out is by doing a CO_2 analysis. This resulted in the following research question: What is the best way to measure the CO_2 emission for the HZ? Consequently, the school also wanted that the actual CO_2 emission would be measured for the year 2015.

The research was started with literature research to get more information about how the CO_2 emission can be calculated and what activities produce CO_2. The topics of the importance of measuring CO_2 and data were also researched.

Desk research shows there are a substantial amount of different methods to measure the CO_2 emission. The most popular methods are called: GHGP, PAS2050 and CCC. The GHGP is the basis for all the other methods. It divides the greenhouse gasses in 3 scopes. The first scope contains all direct GHG emissions. The second scope is for all the indirect GHG emissions and consumption of purchased energy and the last scope contains all the left over emission categories. These scopes are the same for every measuring methods or protocol. The difference is in the emission categories within each scope. These differences are subtle and they make a certain method more suitable for specific industries.

After analysing the different methods in the literature review, it became clear that it was more beneficial to create a customized model for the HZ, since they do not need to measure all of the scopes. This means that some of the emission categories can be excluded from the model. After that, CO_2 emission reports were analysed from over 400 universities. This information was used in combination with the literature review and the interviews. All this resulted in the following model:

Scope	**Emission category**
Scope 1:	Direct transportation sources
Scope 2:	Purchased electricity
	Purchased heat
Scope 3:	Employee commuting
	Student commuting
	Employee travels
	Exchange student travels
	Water
	Waste

The CCC does not have a lot of guidelines for measuring the CO_2 emission. Because every university is different; however, they do have some general guidelines. These and the GHGP's guidelines were used to perform this case study.

The necessary data was collected with the help of several employees of the HZ. Not all of the data was complete so some assumptions had to be made and information was used from different universities and other third parties.

Secondly, the results were calculated. This resulted in the following:

Scope	Emission category	Co2 emission in kg	As % of total
Scope 1	Direct transportation	37.908,79	0,47%
Scope 2	Electricity	681.641,82	8,4%
	Heat	462.222,96	5,7%
Scope 3	Employee commuting	759.611,97	9,4%
	Student commuting	5.144.643,06	63,8%
	Employee travel	383.497,43	4,8%
	Exchange students	583.451,40	7,2%
	Water usage	1.628,26	0,02%
	Waste	14081,98	0,17%
Total		8.068.687,67	100%

The total CO_2 emission of the HZ is 8.068 tons CO_2 and this is equal to 1.837 kg CO_2 per student. The biggest contributor is the student commuting. This was expected since it is the biggest contributor for every university. However when comparing the CO_2 emission as a percentage of the total, the emission in scope 2 is 14,1%. This is high compared to the 4.7% of the HVA & UVA. The main reason being that the HZ does not buy green electricity and uses gas for heating.

Thirdly, a sensitivity analysis was performed to determine the level of uncertainty for the result per category. Scopes such as water usage and heat have a high certainty since all of the necessary data was available. However, for the results of student commuting the level of uncertainty is very high because the data was incomplete and assumptions had to be made.

HZ should understand that measuring the CO_2 emission is important, but actually reducing the CO_2 emission is more important. It is advisable that the HZ measures their CO_2 emission at least every three years. And they should measure the emission categories, which they are trying to improve every year. The following actions should be taken to reduce the emission:

Emission category	Actions to reduce CO_2 emission
Direct transportation	- Replace the diesel and gas cars with electric cars - Promote the use of public transport
Electricity	- Buy green electricity
Heat	- Stop using gas and switch to district heating
Employee commuting	- Support and promote public transport (NS business card) - Reinstate bicycle plan - Promote carpooling (create an app or system which shows who travels from where to the school on a certain day) - Paid parking area
Student commuting	- Paid parking area - Promote carpooling (create an app or system which shows who travels from where to the school on a certain day) - Promote public transport (give credits)
Employee travel	- Let employees travel by train to countries close to the Netherlands. - Support and promote public transport by giving employees a NS business card.
Exchange students	- Promote students travelling by train to countries close to/from the Netherlands. - Promote students carpooling to the airport.
Water usage	- Water-saving cranes
Waste	- Waste separation (this is already planned)

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1. Introduction

1.1 Introducing the HZ University of Applied Sciences

The HZ University of Applied Sciences(HZ) came to life in 1987 after a fusion of six different educational institutions from Zeeland. Currently, the school is still located in Zeeland. The HZ is a small university with 4,500 students including 400 international students. The University uses its small scale as an advantage by offering more personal contact with the students. This is also reflected in the mission statement of the school: "HZ specifically wants to be a community where every person counts and where every person is seen as an individual, where working together is high on the list of priorities and where there is mutual respect for the development possibilities of all involved." (HZ, 2014).

The HZ has six academies and they offer around 26 Bachelor programmes.

1.2 Problem statement

At the moment the HZ does not measure their carbon dioxide (CO_2) footprint. John Dane, who is a member of the board of directors has done a pledge during the climate change awareness week, which was organized in December by the HZ students to raise awareness about climate change and the need for sustainability practices and lifestyles. John Dane pledged his support for making the HZ more sustainable; however, in order to do this the HZ needs to measure their current CO_2 emission. Only then it is possible to set goals towards becoming more sustainable through reducing CO_2 emissions.

For executing a CO_2 zero measurement, a tool had to be created. It also had to be possible to keep measuring the CO_2 emission on a regular basis. By doing this, HZ management can actually see the impact that their decisions have on CO_2. There are a few important criteria for a CO_2 measurement tool, because it has to be useable in the future and it should be easy to include certain data in the tool. Furthermore it has to be comparable with the measurement criteria that other universities use.

Measuring the CO_2 emission is an interesting research topic, because there are several methods to measure CO_2 which have to be compared and decisions have to be made on what kind of CO_2 generating activities have to be included, such as waste and catering.

1.3 Research objectives

1. To assess how the school can best measure its CO_2 emissions.
2. To measure the current CO_2 emissions of the HZ also known as a zero-measurement
3. To assess how the HZ can best keep track of its CO_2 emissions in the future.

1.4 Research question

How can the HZ best measure and keep track of its CO_2 emissions?

1.5 Preliminary sub questions

1. Questions regarding other organisations
1.1 What kind of methods for measuring CO_2 emission are used by different organisations?
1.2 How often do most organisations measure their CO_2.
1.3 To which conditions should the measuring data comply?
1.4 In what kind of format should the measured data be saved and compared in order to measure the emission periodically?

2. HZ specific questions
2.1 What kind of CO_2 generating activities should be measured?
2.2 How can the data collection be improved by the HZ, in order to measure the school's CO_2 emission in a more practical and time-efficient way?
2.3 How should these CO_2 generating activities be measured?

The complexity of the research is finding which CO_2 generating activities, like electricity, transport, food and waste, will be included in determining the CO_2 emissions. Furthermore deciding on how to translate an amount of energy usage, transport, et cetera into a certain amount of CO_2 will be challenging.

Deciding how to measure the different CO_2 generating activities will also be challenging, because this process has to be realistic and reliable and it depends on how the HZ gathers its data of these activities.

The CO_2 emissions have to be measured periodically in order to monitor progress. This implies that the tool has to be relevant for the future so it has to be possible to add certain data while still being able to monitor year-to-year progress.

1.6 Relevance

The HZ is failing its social duty by not measuring their CO_2 footprint. Currently in the United States(U.S.) alone there are over 600 higher educational institutions measuring their CO_2 footprint(Aashe, 2016). For the Dutch universities a good benchmark to use is the Sustainabul, this list is maintained by Studenten voor Morgen and it is updated once a year. The organization ranks universities (including "HBO", hence universities of applied sciences) on how sustainable these schools are. They do this by measuring different aspects of sustainability and one of these areas is the CO_2 footprint(Sustainabul, 2015)

If the HZ wants to start competing in the Sustainabul, it is important for the school to score well in the CO_2 footprint category and this starts by measuring their CO_2 footprint.

Currently there is not a strong incentive for the school to start reducing their CO_2 emission, because of this every initiative to find a greener way of generating electricity fails. This is due to the fact that the HZ is a scale consumer, which means that they pay a really low price per kilowatt-hours. Furthermore the school does not have a policy on mobility so there is no incentive for students and employees to choose a more environmentally friendly way of transport.

Measuring the CO_2 footprint enable's the university to set short-term and long-term goals for the reduction of CO_2 and the HZ will be able to actually measure the progress that is being made. Moreover, if the long-term goals are managed correctly they might also be financially attractive. Furthermore by scoring well on the Sustainabul the HZ might become more attractive to new students and this could be an extra incentive for management to take sustainability seriously.

1.7 Scope

The HZ wants a model to measure their CO_2. This research will look at all the relevant literature available in order to answer the research questions and to provide a CO_2 measurement model in the end. The research will only look into CO_2 and not in other greenhouse gases. The actual CO_2 emission of the HZ will be measured and a recommendation will be given. But within this research no actions will be taken to lower the CO_2 emission. There are a few limiting factors such as the time available to execute this. Furthermore the research is only executed by one researcher, which means that there is a limit to the scope and broadness of the research since we also have to be realistic.

2. Theoretical framework

This chapter looks at the general literature around CO_2 and it will discuss and compare what has already been researched. The chapter starts by looking at the differences between CO_2 and carbon dioxide equivalents ($CO_2e_)$ its relation to climate change. Furthermore the types of CO_2 generating activities will be discussed and how they are measured. The chapter ends by looking at data quality issues.

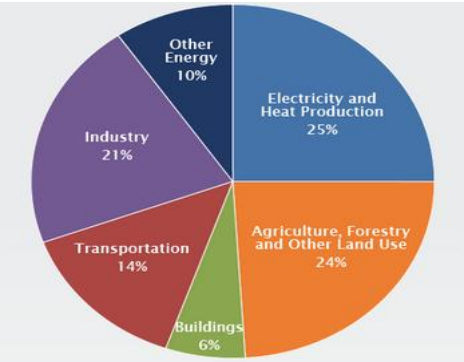
2.1 CO_2 and its relation to climate change

CO_2 consists of a carbon atom, which is attached to two oxygen atoms with a covalently double bond. CO_2 is a gas that is vital to life on earth because it is used by plants for the process of photosynthesis which produces oxygen and it can be found in volcanoes, hot springs, glaciers, rivers and sea water. In addition, it is produced by combustion of fossil fuels and wood (Senebier, 1796).

CO_2 is one of the greenhouse gases (GHGs), which are gases that absorb and emit radiation within the thermal infrared range. It is important to note that the term CO_2 is sometimes mistakenly used to refer to all the GHGs. But the correct way of describing all GHGs would be by referring to carbon dioxide equivalent (CO_2e). CO_2e is used to describe different GHGs in a common unit. Which means that for any amount and type of GHG, CO_2e says something about the amount of CO_2, which would have the same global warming impact (IPCC, 2007)

In other words instead of passing through the atmosphere and directly into space, some of the infrared radiation is re-emitted back towards the surface of the earth, increasing the temperature of the earth's surface to a comfortable 15 degrees Celsius (Arrhenius, 1927). Without this greenhouse effect life on earth would not exist as we know it today. However, due to human activities there is too much CO_2 in the atmosphere and this results in an increasing temperature (IPCC, 2005). In addition, this increasing temperature will have a lot of negative effects on the earth; the weather will become more extreme and ice caps will melt and sea levels will rise. Furthermore the pH level of the ocean will rise and this will have an effect on the species living in it. This effect will mostly be negative for most species; however, for some it will have a positive effect (Fischlin et al., 2007). In addition, the temperature changes have a very strong impact on the planet's biological system. Resulting in species moving to the north to find colder weather (Rosenzweig et al., 2007).

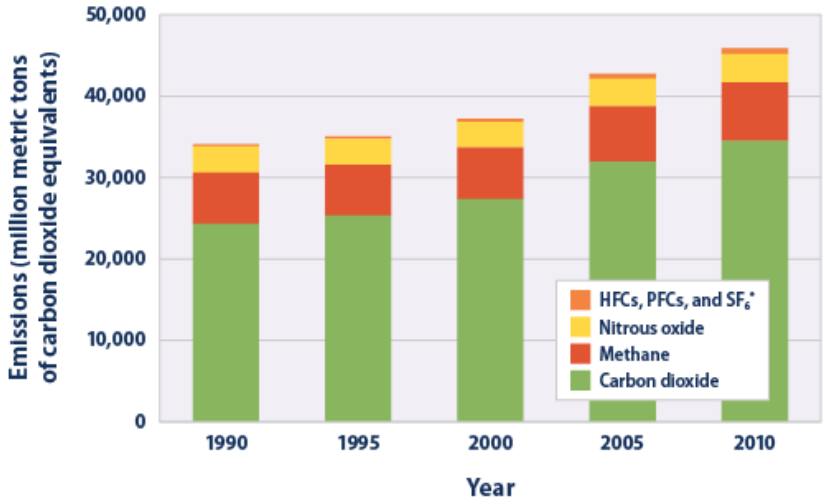
Figure 1: Shows the global greenhouse gas emission per sector



Note. IPCC. (2010). ghgemissions. Retrieved from EPA: https://www3.epa.gov/climatechange/ghgemissions/global.html

Figure 1 shows the global greenhouse gas emission per sector. It is clear that electricity and heat production sectors are the biggest contributors to GHG emission.

Figure 2: Global greenhouse gas emissions 1990 to 2010



Note. WRI. (2014). global ghg emissions. Retrieved from EPA: https://www3.epa.gov/climatechange/science/indicators/ghg/global-ghg-emissions.html

CO_2 is the most important greenhouse gas and the reason for this is shown in figure 2. The data shows that CO_2 is the biggest contributor to global warming of all the greenhouse gases; it should be noted that these totals include emission from land-use change and forestry.

2.2 Importance of measuring CO_2

Policy

In Europe big companies fall under the Emission Trading System (ETS). The ETS puts a cap on the total amount of GHG that can be emitted by companies. The companies have allowances, which allows them to emit a certain amount of GHG. If a company reduces its emissions, it can sell these allowances or it can save them for the next year. When a company emits more GHG than its allowances then the company will be fined. (EC, 2016)

In the Netherlands there is an organization called Urgenda, which is an association of Dutch corporate executives, entrepreneurs and scientists aiming to speed up the transition to a sustainable society. In 2013 Urgenda sued the Dutch government, Urgenda demanded that the government should implement a sufficient climate change policy. A few years later in 2015 the court agreed with Urgenda and stated that the government has to come up with an effective climate changed policy to reduce the CO_2 emissions. The Dutch government has decided to go in appeal against the verdict. The result of this is that there is no strict CO_2 emission policy at the moment and this will stay unchanged until the case against the Dutch government is done (Urgenda, 2016).

Companies

According to Susanne Stormer, who is Novo Nordisk's[1] vice president of corporate sustainability the difference between a company having a sustainability program and actually being sustainable is measurement. She believes that it is important for companies to measure and to publish the emission numbers in order to keep the company accountable. In this way sustainability becomes a priority instead of just a nice story to tell.

When sustainability is taken seriously by a company it can attract investors and be profitable in the long term. Susanne wants the company to be sustainable, but this also means that it still exists in 100 years. For this to work the company has to look at what does society look like in 100 years(Business Insider, 2012).

Encord represents a group of global construction companies. They believe just like Susanne Stormer that companies must manage their GHG risks if they want to be successful in the long-term. Being able to manage your GHG inventory is seen as good management practise. Furthermore they also mention the importance of sustainability in order to attract new investors, according to them it has become a part of their investors decision making process which is similar to Susanne's view. In addition, Encord prioritizes sustainability very high because it is also becoming a part of the contractor selection processes (Encord, 2015).

The UK department for Environment Food and Rural Affairs lists a few reasons for businesses to measure CO_2. They are a little more straightforward compared to the previous two. However, there are some similarities. According to The Department it helps to save money by reducing energy usage and by reducing costs you will become more competitive and generate new business (Defra, 2013). Furthermore they also mention that it is important to be able to provide this kind of information because it is becoming more and more important for the procurement process, as was also mentioned by Encord. Lastly it is important to do your bit for society.

Universities

The previous subchapter described the importance of measuring CO_2 for businesses. This chapter will compare this to the importance of measuring CO_2 for universities, while highlighting some facts on how many institutes actually measure their CO_2.

According to Studenten voor Morgen, students want to identify themselves with an educational institute that has a good sustainability image and measuring CO_2 is a part of this (StudentenvoorMorgen, 2015).

Harriet Kingaby is a consultant who works for Futerra a company which specializes in helping business to become more sustainable. Harriet believes that carbon management will increase the efficiency of resource use and it will also save costs which is beneficial for universities. This opinion is also shared by John Bailey, sustainability officer at the University of Greenwhich. He implies that universities should invest in a green agenda and thus measure carbon even when there is not a big budget. Because in the end these investments will pay off. In this regard some of the reasons for universities to measure their CO_2emissions are the same as for businesses (The Guardian,2011).

[1] Novo Nordisk is a Danish multinational pharmaceutical company.

Harriet Kingaby also recognizes the fact that students expect more from a university nowadays and measuring CO_2 and being sustainable is one of these things.

Pauline van der Meer Mohr, former chairman of the Board of Directors at Erasmus University Rotterdam believes that schools have a social duty to fulfil, not only in the way that they conduct business, but also to give important values to employees and students since they are the leaders of the future (Meer Mohr, 2015). The Erasmus University of Rotterdam has an extensive sustainability program and they also measure their CO_2 emission not only because of the financial and environmental benefits, but also to lead by example.

It is hard to find data on how many higher educational institutions actually measure their CO_2. However, there are a few ways to get a rough estimate. In the U.S. there are two major ranking systems for sustainability. These ranking systems are monitored by institutes and they have certain guidelines and rules that must be followed in order to be ranked. Every few years the participating institutes have to submit a report and in this report they also have to mention their CO_2 emission.

The first ranking system is called Sustainability Tracking, Assessment & Rating system (STARS) which was founded in 2006. A total of 753 universities are participating in this program of which 636 are located in the U.S.. Furthermore 56 are located in Canada and the remaining 61 are spread over the rest of the world (Aashe, 2016).

Secondly Second Nature was established in 1993 and they have been maintaining a ranking system for higher educational institutions to measure their sustainability performance since 2008. Furthermore they have over 643 participants and all of them are located in the U.S..
The main difference between both rating systems is the fact that Second Nature focuses mainly on CO_2 emissions, where STARS rates everything that is connected to sustainability (Second Nature, 2016). Both ranking systems have an overlap between participants; however, not all of them are represented in both ranking system.

In the Netherlands there also is a ranking system for higher educational institutions. The ranking system is called "de SustainaBul" and it is organized by Studenten voor Morgen. Every year the participating universities fill in a questionnaire and they deliver evidence to support their answers. The questions show how the school is performing in the field of sustainability. The Sustainabul looks at different topics such as: CO_2 emission, sustainability courses, research in the field of sustainability. For every topic a university can score a certain amount of points and this gives a total score. Currently 21 schools are participating in the ranking.

2.3 Types of emission

The Greenhouse Gas Protocol (GHG) is a tool that is used by businesses and governments to understand, manage and measure greenhouse gas emissions. It was developed by the World Business Council for Sustainable Development (WBCSD) and World Resources Institute (WRI) and their goal was to create an internationally accepted standard to measure greenhouse gases. The latest version of the GHG protocol was released in 2004. (WBCSD & WRI, 2004).

The GHG protocol divides greenhouse gases into 3 scopes:

Table 1: Shows the GHG protocol scopes.

Category	Definition	Examples
Scope 1	All direct GHG emissions.	Emission from company owned assets. Emission from company cars, Physical/chemical processing.
Scope 2	Indirect GHG emissions. Consumption of purchased energy	Purchased electricity, heat, cooling.
Scope 3	Other indirect GHG emissions.	Everything that is not mentioned in scope2. For example: Emission from cars that are not owned by the company, waste disposal.

Note. WRI. (2008). *ghg emissions*. Retrieved from ECY: http://www.ecy.wa.gov/climatechange/2008CATdocs/IWG/sepa/082808_3c_ghg_emissions_mitigations.pdf

Table 1 shows the differences between the scopes. Scope 1 contains all the direct GHG emission except for direct CO_2 from biogenic sources. So if a company produces electricity, steam or heat then this would fall under scope 1. Furthermore CO_2 that is released during the manufacturing process of cement or aluminium are also part of scope 1 (WBCSD & WRI, 2003).

Scope 2 is all about the indirect GHG emissions which is emission that comes from purchased electricity for example. For a lot of organizations this is where the biggest part of their total emission comes from. So reducing the emission in scope 2 could be a good goal for a lot of businesses (WBCSD & WRI, 2003).

The last scope is defined as other indirect GHG emissions that are not mentioned in scope 2. This includes purchased goods and services, waste and business travel.

2.4 Ensuring data quality

DAMA UK Working Group (DAMA, 2013) defines data quality dimensions as something (data item, record or database) that can be measured or assessed in order to understand the quality of the data. The data quality dimensions are used to assess the quality of the data that is used in research.

DAMA defines the following dimensions:

Completeness: Compares the measured data versus the stored data.
Uniqueness: The same thing cannot be measured twice when comparing it to the real world
Timeliness: How the data represents reality from the required point in time.
Validity: Does the data conform to the right format, type and range.
Accuracy: How well does the data reflect the real world.
Consistency: No difference between the same data in different data sets or databases.

Most factors can be checked by assessing the data itself; however, the accuracy of data can only be checked by checking the actual thing it represents or by assessing the data against a reference set.

Even if the data complies with all the above dimensions you should still ask yourself some questions such as:

- Can the data be acquired easily and is it maintainable?
- Is the data format comparable to other data and can the data be changed?
- Is the data protected?
- How expensive is it to get the data and is it worth the costs?

The GHG Protocol, has the following guidelines to ensure data quality. The data should be checked against the following criteria (BSI, 2008):

- Temporal specificity: How old is the data and within what time period has it been collected.
- Geographical specificity: From where is the data collected.
- Technological specificity: Is the data associated with one technology or a mix.
- Reliability: Can the data be trusted (assessment of the sources of data, collection methods).
Completeness: Does the set of data represent the population of interest.

When comparing the data quality indicators used by GHGP to those of DAMA we see some similarities such as the completeness of data, which indicates, how much of the relevant data is actually used to draw a certain conclusion. Furthermore temporal specificity and the timeliness of the data both mean the same thing, which is the timing of the data: so when was the data measured and is this data still relevant for now?

There are some differences between the methods as well, since the model that is used by GHGP also includes the geographical specificity of the data and it looks at the source of the data. When we compare this to the DAMA model we see that the DAMA model chooses to disregard these factors and instead looks at the format of the data and how accurately the data describes the real world.

2.5 Methods for measuring CO_2

The GHG protocol was discussed to get a better understanding of the different types of emission and what kind of activities generate them. In this paragraph a few standards will be introduced and then the two most relevant methods will be discussed in depth. It is important to note that these standards mainly focus on GHG and not just on CO_2. Most of the standards use the GHG Protocol as their basis because the GHG protocol is widely used to categorise the different types of CO_2 generating activities and it is accepted as a standard. Differences between the different standards are mostly found in the kind of data that is measured and some measurement tools focus on certain sectors.

Some popular CO_2 measuring methods are: the GHG Protocol, PAS2050, EpE-protocol, SKAO CO2-prestatieladder, Campus Carbon Calculator (CCC). PAS 2050 is a method that is used to measure the life cycle GHG emissions for goods and services (PAS 2050, 2013). It is used to calculate the carbon footprint of products and it helps with finding weak areas in the supply chain that could be improved. The EpE-protocol is also based on the GHG Protocol; however, it has been modified for the waste management industry (EpE, 2013). The SKAO CO2-prestatieladder and GHG Protocol are similar since they both focus on organizations. However, the SKAO CO2-prestatie ladder is for Dutch companies and they try to set a standard for CO_2 emission factors. In this way Dutch companies are able to compare their CO_2 emissions. This increases competition between companies to score well on the ladder.

2.5.1 GHGP

The GHG Protocol is mainly used for organizations to calculate their CO_2 emission. Companies who want to use the GHG Protocol should take the following steps to implement it successfully.

1. Set boundaries
2. Identify GHG emissions sources
3. Select a GHG emissions calculation approach
4. Collect activity data and choose emission factors
5. Apply calculation tools
6. Roll-up GHG emissions data to corporate level

In the first step the company has to set organizational and operational boundaries. In order to define the inventory boundaries, which define what the company wants to measure. Firstly, the GHG Protocol suggests choosing one of two approaches to setting organizational boundaries. First there is the control approach: within this approach the company measures all the operations over which they have practical control. The other approach is known as the equity share approach, which means that a company should measure the emission for facilities that are partly or fully owned by the company. Secondly, it is important to decide on which emission sources to measure. These boundaries are important in order to define the scope for the project.

The second step is to identify GHG emission sources. These sources have been discussed in chapter 2.3. However, Putt del Pino & Bhatia who both work for the WRI created a guide for offices (WRI, 2002). They define the different emission sources per scope a little differently (see table 3).

Table 2: Shows the different emission sources per scope.

Category	**Example**
Scope 1	Business travel (company cars), Combustion in furnaces
Scope 2	Generation of bought electricity, heat
Scope 3	Business travel in personal cars, trains. Production of office supplies that are used by the organization Outsourced activities

Note. WRI. (2002). *ghg scopes*. Retrieved from ECY: http://www.ghgprotocol.org/files/ghgp/tools/working9-5.pdf

As shown in table 2 these categories are defined a little differently making them more suitable for an office. As a third step a GHG emission calculation approach should be chosen (UNEP, 2011).

Putt del Pino & Bhatia are not very specific when talking about the calculation approach. One option is the direct monitoring of emission by concentration and flow rate. However, this technique is really expensive and hardly ever used. A more viable option is to use documented emission factors and used fuel data. In addition the IPCC does have several guidelines on calculation approaches, but these are for very specialised sectors and not for offices. In the fourth step, activity data should be collected and emission factors have to be chosen.

Table 3: Shows the different data types.

Data type	Explanation
Primary data	Data from processes owned or controlled by the organization and they should be measurable
Secondary data	External and average data

GHGP defines two types of activity data as shown in table 3 (WBCSD & WRI,2003). Primary activity data is data such as the kilowatt-hours of electricity and secondary data is data that cannot be measured for some reason. For secondary data, different sources are available. GHGP recommends the use of GHGP verified data sources. Such as data from government sources and they also refer to some databases which can be used.

Calculations

So far the processes that should be followed for GHGP have been discussed; however, the calculations were left out. The GHG protocol uses the following equation (PAS 2050, 2011) (WBCSD & WRI, 2003):

CO_2 emission = activity data * emission factor

Activity data has already been explained; however, emission factors have not been explained. An example of an emission factor is: Diesel car 0,168 kg/km (co2emissiefactoren, 2016). This means that if someone has driven a diesel car for 100km. The calculation would be as follows: 100*0,168= 16.8kg CO_2. This means that 16.8kg CO_2 has been released into the atmosphere.

Emission factors consist of primary and secondary information as well. Primary emission factors would actually be measured and secondary emission factors are averages. GHGP has listed some emission factors and they also refer to lists and institutes such as the IPCC who provide emission factors (WBCSD & WRI, 2003). These emission factors play an important role when trying to compare two companies and studies have showed that there are big differences between these emission factors (Herold, 2003).

GHGP describes its process in details and it can be applied to different kinds of organizations; however, when using GHGP to actually calculate the total emission then it becomes more complicated. The main reason being that the protocol itself is made for a lot of different types of businesses. Using one general approach to calculate the CO_2 emission for companies in different sectors is difficult. That is why WBCSD & WRI have different tools on their website (WBCSD & WRI, 2003).

Earlier the guide from Putt del Pino & Bhatia was mentioned which is perfect for offices. Furthermore the WBCSD & WRI website contains cross sector tools to calculate: GHG emission from purchased electricity, stationary combustion and transport. Companies are obliged to use multiple tools in order to calculate their total CO_2 emission, but this will often be primary data. Furthermore WBCSD & WRI also has sector specific tools to calculate the emissions from the production of ammonia or cement.

2.5.2 Campus Carbon Calculator.

This chapter will zoom in on literature about calculating the CO_2 emission for universities.

It is important to introduce Second Nature, which is an organization that helps to develop the principles of sustainability fundamental in higher education (Second Nature, 2016). Second Nature is partner of the American College & University Presidents' Climate Commitment (ACUPCC), which was founded in 2006.

ACUPCC has created a network of colleges and universities who are committed to neutralizing their GHG emissions. In 2016 there are 643 universities and colleges working together with the ACUPCC. All these institutions have agreed to measure their GHG footprint and to create an action plan in order to reduce the GHG emission. They wrote a guide with rules for measuring and reporting the GHG footprint.

The guide states that different calculating methods are allowed as long as it follows the GHG Protocol. However, they do suggest that you use the Campus Carbon Calculator (CCC), which is based on the GHG Protocol. It was developed by Clean Air Cool Planet, but in 2014 the Sustainability Institute at the University of New Hampshire (UNH) acquired ownership. CCC is being used by thousands of institutions in the world, including around 90% of all colleges and universities in the US that report their emissions publicly (UNG, 2014).

The ACUPCC recognizes the strength of the GHG protocol and this is also the reason why they keep referring to the GHG Protocol in their guide (CCC, 2014). However the CCC does have its own guide as well. This guide explains the process for measuring the CO_2 emission by using the CCC.

Process:

- Create a team
- Set boundaries
- Collect data
- Calculate emission
- Analyse and summarize the results

First of all a team should be created and it is important to include different departments such as: sustainability office, facilities department and academic departments, which you might need.

After surrounding yourself with the right people it is important to set organizational and operational boundaries. This step is the same as described by the GHGP and the CCC also refers to the GHGP about this topic. The CCC has made some changes in the different emission scopes, which changes the operational boundaries.

Table 4: Shows the different GHG scope defined by the CCC.

Category	Examples
Scope 1	- Fugitive emissions from refrigerants - Emission from all fuels used by vehicles owned by the schools - Emission from agriculture
Scope 2	Emission from purchased cold water, electricity, steam
Scope 3	- Emission from managing waste - Transport financed by the university, but not in university owned vehicles - Emission from regular transport by staff and students - Emission from students flying to study abroad - Energy lost while transporting the items from scope 2 - Direct financed purchases such as emission from food, paper, school supplies.

Note. WRI. (2014). *CCC scopes*. Retrieved from UNH: http://www.sustainableunh.unh.edu/calculator

Table 4 shows how the CCC defines the three scopes. The category names have stayed the same, but the examples have changed compared to the GHGP (WBCSD & WRI, 2003)(CCC, 2014).

When comparing the different scopes from CCC to those of the GHGP a few things stand out. In scope 1 not a lot has changed, but it is safe to assume that a school will not have a lot of physical or chemical processing. But universities are big buildings that have a lot of heating and air-condition so this could be a big contributor to CO_2 emission. Additionally for agricultural universities a definition has been added which falls under scope one.

In scope 2 not a lot has changed the CCC mentions cold water, which the GHGP and PAS2050 did not. In scope 3 the CCC mentions emission from regular transport by staff and students and the guide talks about this in more detail. They define this transport part as travelling to and from campus every day by the students and staff (CCC, 2014).

According to GHGP scope 1 and 2 should be reported and scope 3 is optional. However, the ACUPCC wants scope 3 emissions from transport and direct financed air travel to be reported to the extent that data is available (CCC). For the other emission sources the ACUPCC encourages institutions to report the one's that can be measured precisely, who have a large emission and can be changed in a positive way.

The CCC guide does not say a lot about data collection. Mainly because there is no set formula for this because all schools are different. And depending on what kind of university and how the university is organized your process will change. It is important to keep a data collection journal. This journal should give an overview on who was contacted for what type of data and it should mention the date. Furthermore it should summarise the meeting in one or

two sentences. Data can be recorded on paper or in an excel document before entering it in the CCC.

Calculation
The CCC uses an excel file to calculate the total emission of a university. The document contains four data entry sheets. When the data is entered into the sheets the calculations will be done automatically.

The fact that the CCC has a tool that only needs input data sets it apart from GHGP. Because for the GHGP you need different excel files. Furthermore the CCC uses the same formula as the GHGP to calculate the emission, but it is a lot more detailed and a lot of work has been done already.

The emission factors used in the excel file are all taken from U.S. government research documents. It's possible to change these emission factor values if more reliable emission factors are available and the CCC guide also encourages you to do so.

2.5.3 Practical findings
GHGP is mainly used by businesses and it is not specifically made for one sector (WRI & WBCSD, 2003). This makes it useful for a lot of companies. However, its strength is also its weakness because it is necessary to use different excel models to calculate the total CO_2 emission and not all models are available. Furthermore the GHGP does have a good guide and it is easy to use.

The CCC (CA-CP, 2010) is created to measure the emission for universities and thus not only for CO_2 emission. It is based on the GHGP and it is actually very much the same as the GHGP. It also has a very detailed guide on how to apply and use the CCC. The scopes are also very similar to those of the GHGP. And only a few changes have been made to make them more suitable for universities.

The CCC does have a complete excel calculation model. This can be used to calculate the CO_2 emission of a university. The model also has build in emission factors, but these are not updated. For some scopes you can fill in all the necessary information. However, for scopes like waste and water the input information is very limited so the results will not be very precise. And in the emission category of commuting there only are a few travel options.

3. Methodology

This chapter will outline the strategy behind the research, which means that it will explain the overall structure of the research. Furthermore it will explain the choices that were made in order to make sure that the research is done in an efficient, scientific and logical way.

In chapter 1, the research question and several sub questions were defined. The sub questions are there to break up the research question in smaller parts. When I am able to answer each sub question I will also be able to answer the research question.

3.1 Research Strategy

There are different research strategies to give structure to your research. The best type of strategy for a certain research takes into account factors such as: the purpose of the study, what kind of data is needed and how is this data analysed (Saunders et al, 2009).

The purpose of this study is prescriptive because it is used to prescribe a certain solution (Robson 2002:59). And the overall research strategy is known as design based research, which is suited for this research because there is a problem, which needs to be solved. The research results are in the form of prototypes and the knowledge gained from the research does not only look at the current situation, but its main focus is on future improvement. Doing research and developing the final model are parallel to each other to some extent (van Aken en Andriessen 2011).

Furthermore, the research questions are open questions. Mixed methods will be needed to answer these questions because some have qualitative components and others have quantitative components. This makes the research approach a mixed method because qualitative and quantitative data is analyzed and presented separately (Creswell & Tashakkori, 2007). In the subparagraphs Data collection and Analysis, I will go into more detail on why both data collection techniques and analysis procedures are needed.

3.2 Preliminary research

The research was started with a preliminary literature review to give an insight on important general topics such as:

- Why should organisations and universities measure their CO_2?
- What should you actually measure when calculating a CO_2 footprint?
- What methods are there to calculate the CO_2 footprint?
- What are prerequisites for data collection?

The following sources were used to execute the research:

- Newspapers
- Books
- Scientific papers
- Websites

Firstly, research was done on websites such as Google scholar and Sciencedirect. The main and sub questions were used to find related literature and while progressing in the research the

search queries were made smaller and smaller. In addition, the synonyms of keywords were used and some more general topics were researched for background information.

Secondly, Google was used to find books on the topic of CO_2 and to find more scientific papers that were missed in the previous search. Lastly, institutional websites were searched for information regarding standards for measuring carbon. This preliminary research provided critical information and it allowed me to come up with a good methodology.

3.3 Data collection

The next step is data collection, more data was needed in order to answer all of the research questions. Table 2 gives an overview of the different types of data and data collection methods that are needed to answer each sub question and these types of data will be discussed in this chapter.

Table 5: Shows the types of data and collection methods needed for each sub question

Sub Question	Quantitative	Qualitative	Desk research	Semi-Structured interviews
What kind of methods for measuring co2 emission are used by different organisations?				
How often do most organisations measure their co2.				
What kind of co2 generating activities should be measured?				
To which conditions should the measuring data comply with?				
How should these co2 generating activities be measured?				
In what kind of format should the measured data be saved and compared in order to measure the emission periodically?				
How can the data collection be improved by the HZ, in order to measure the school's co2 emission in a more practical and time-efficient way.				

There are two types of data that can be collected. Firstly, there is primary data, which is new data and collected by the researcher. Secondly, secondary data is already collected by others (Saunders et al, 2009). In addition, quantitative data was collected this is data that deals with numbers and it can be measured. Furthermore qualitative data which is data that is in text and often deals with descriptions was also used; however, the qualitative data was not quantified when analysed and vice versa. This means that this research uses Mixed-Methods (Tashakkori and Teddlie, 2003). There are different ways of collecting data, which will be discussed below.

3.3.1 Desk research

Desk research was used to build further on the preliminary research and for collecting secondary data. The data provided information on how different organisations measure their CO_2 footprint and how frequently. This was done by looking at studies about measuring CO_2. Furthermore it was also important to research the differences between CO_2 measuring methods and this was be done in the same way. In addition, CO_2 emission reports from universities were collected to look at aspects such as emission factors and frequency of measuring. In addition for the case study emission activity data was needed. Most of this information was gathered through desk research.

3.3.2 Semi-Structured interviews

Apart from just desk-research, semi-structured interviews were conducted. A semi-structured interview is a good way to obtain data when the order of questioning may vary and when the questions are complex or open-ended (Easterby-Smith et al. 2008; Jankowicz 2005). Input from experts was necessary to answer some of the sub questions. The experts have experience with measuring CO_2 at universities. The questions for the interview were derived from the sub-questions and the literature review. The following people were interviewed:

- Jan-Cees Jol, Sustainability & Energy Coördinator, Erasmus
- Marie Ernst | Advisor Sustainability, Energy and Climate, Arcadis
- Ewout Doorman, Policy Employee Sustainability and Innovation UVA & HVA

3.3.3 Questionnaires

Lastly, a questionnaire was administered. Structured interviews were held to collect the commuting data from the HZ employees. This approach is suitable for the target group since the employees were more willing to answer the questions when meeting in person.

3.4 Analysis

After having collected all the data it needed to be analysed. As explained in the previous chapter there were two data types.

3.4.1 Qualitative

For qualitative data there is no real standardised procedure to analyse it (Saunders et al, 2009). For analysing the semi-structured interviews a structured approach was chosen. The interviews were coded and labelled. Then the important parts from each interview were analysed in chapter 4. This resulted in a summary with the most important findings per subject.

3.4.2 Quantitative

Quantitative data was used because during the desk research emission reports from different universities were collected. This allowed for measuring the frequency of measuring CO_2 emission per university. Furthermore this also gave an insight on how many universities measure a certain CO_2 emission source. This is important because the HZ wants to be able to compare itself to other universities when it comes down to their CO_2 footprint.

The quantitative data was analysed with a rather simple table, by measuring the frequency of the different factors within each emission scope and the most popular time interval on measuring CO_2 emission. The analyses of both data types explained what type of CO_2 emission sources should be present in the CO_2 footprint calculation model for the HZ. Furthermore the data from the questionnaires was analysed with a quantitative approach since only averages and frequencies were necessary.

3.5 Case study

In the case study the model which was created after analysing the results was used to calculate the CO_2 emission of the HZ. The following steps were taken:

- Collecting the necessary data.
- Checking and changing the format of the data.
- Putting the data in Excel.
- Calculating the emission.

The case study used data from the desk research and from the questionnaires. This was necessary in order to make precise calculations. The case study showed how the model works when put into practice and it was a learning experience. It also showed that the end product is suitable and useful for the HZ.

3.6 Validity

It is important for the research to answer the research questions with good answers. To ensure that this happened it was important to focus on the reliability and validity of the research. Reliability says something about how your way of collecting data and analysing procedures will result in consistent findings. The following three questions help to assess the reliability (Easterby-Smith et al. 2008:109):

- Will the measurements get the same results on a different occasion?
- Will other observers reach the same observations?
- Is the raw data analyses process transparent?

Measurement validity is very important because often when data is used you will find that the data just does not match the data that you really want (Jacob 1994). Of course this is a big problem for the research because the answers will be invalid (Kervin 1999).

The methodology in this research has been structured with having these criteria in mind. Furthermore triangulation was used in order to counter measurement bias, which can occur due to deliberate distortion of data, and because of changes in the way the data was collected (Kervin 1999). This was done by using different types of data from different sources to answer the same questions as explained in the data collection chapter. In addition, the CARS checklist was used to check the credibility, accuracy, reasonableness and support of the sources. (see Appendix 1)

Lastly, in subchapter 3.4 a case study was discussed. The main reason for doing this case study was to ensure that the collected data and the conclusion drawn from it are applicable to the HZ's CO_2 emission model.

3.7 Sampling

This subchapter will briefly discuss the different sample sizes for each data collection type. Sampling is an important tool for researches since often is impossible to collect data from every case. A lot of researchers even believe that it improves the accuracy of the research since it saves time (Henry, 1990)

3.7.1 Desk research

As explained previously data from CO_2 emission reports was collected. It was too time consuming to find out how many universities measure their CO_2 emission. That is why a sample size was necessary.

There are 23729 universities in the world and the goal was to maintain a 5% margin of error. This means that 378 CO_2 emission reports were needed (Saunders et al, 2009). However as mentioned before the total population is actually every university that measures its CO_2 emission and not just every university. Meaning that the margin of error is most likely to be lower. Furthermore the simple random technique was used to select the universities in the sample size. STARS has a database with CO_2 emission reports and every university listed on this website got a number and then a random number generator was used to select the samples.

3.7.2 Semi-Structured interviews

For this type of interview there is not a standard sampling method. Non-purposive sampling was used since only experts were interviewed (Saunders et al, 2009).

3.7.3 Questionnaires

The university has 433 employees, which means that 204 responses were needed to stay within the 5% margin of error. Every office, the cafeteria, front desk and library were visited. Whoever was present on that day, he or she has been interviewed. Thus sampling was done randomly.

4. Analysis

This chapter is divided in two parts. In the first part the results of the database are discussed. And after that a summary with the most important findings from the semi-structured interview will be given.

4.1 Database

In order to see what other universities are doing in the field of CO_2 measurement I compared CO_2 measurement information for each university. The STAR website has a database which gives an overview of all the participating universities. Per university you can see what kind of information has been submitted. The database contains over 700 different universities; however, for some universities the data was limited so some other resources such as Second Nature had to be used in order to get the right sample size. In the end data from 387 universities was filed into the database.

For this research a few indicators were very important such as: What scopes were measured, How often does the university measure its CO_2 emission and did the university use a third party to measure this information?

Firstly, the scopes were divided into scope one, two and then scope three was divided even further in business travel, commuting, purchased goods/services, capital goods, fuel and energy related activities and waste.

The main reason for this is that scope 1 and 2 are mandatory. Furthermore scope 3 is not mandatory and universities have a lot of freedom on what they want to include. This information was easy to find since the STAR database has an overview for each universities and it shows what kind of scopes and emission factors were measured.

Secondly, the frequency of measuring was measured. It was important to find out if universities measure every year or once every four years. This was also easy to find because you can find the reports for every year. However if a university only just started measuring its CO_2 emission then it was impossible to find out.

Lastly, universities also had to fill in if they used a third party to measure the CO_2 emission or if a third party had checked their results.

Table 6: Shows an overview of the results from the database.

	Scope 1	Scope 2	Business travel	Commuting	Purchased goods	Capital goods	Fuel- and energy - not included in Scope 1 or Scope 2	Waste generated in operations
Filed in the data	387	387	386	386	386	386	385	386
Cover ing the scope	384	385	270	284	94	14	90	247
Uni's covering the scope as %	99%	99%	70%	74%	24%	4%	23%	64%

As shown in table 6 scope 1 and 2 are measured by 99% of all universities that were include in the research. Business travel is measured by 69,9% of all the schools. Furthermore student and employee commuting from and to the school are included by 73,6% of all the universities. The table also shows that 94 out of 386 universities measured the CO_2 emission from purchased goods.

Capital goods was measured a lot less since it is measured by 14 universities. Furthermore fuel and energy related activities that were not mentioned in scope 1 or scope 2 are measured by 23,4% of all universities included in the study. Lastly, waste generated operations are measured by 64% of all the schools.

Table 7: Shows the results from frequency of measuring.

Time interval between measurements (in years)	Amount of universities
1	35
2	35
3	73
4	31
5	7

As shown in table 7, 73 universities measure CO_2 emission every 3 years. And only 7 universities measure CO_2 every 5 years. This type of data was found for a total of 181 universities. The rest did not have this type of data available.

Lastly, from the database was found that 233 universities mentioned if they had used a third party or not and 113 universities said that they did use a third party.

4.2 Semi-Structured interviews

As explained in the methodology three experts were interviewed. All of them are experts in the field of sustainability and have experience with measuring and calculating the CO_2 emission for a university or company. The full interviews can be found in appendix 2. This subchapter will summarize the most important results from the interviews per category. Every interview has received a code, which is being referred to in this chapter.

Frequency of measuring CO_2:
The interviewees agree on the fact that the most important emission factors should be measured every year. Jan-Cees Jol stated "The plan is to start measuring the CO_2 emission every year from now on". Marie Ernst agrees with this statement because she said "Once a year is ideal and by measuring it more often you also get better at measuring and the process will improve" According to Ewout Doorman "The university started measuring the CO_2 in 2015 and so far we do not know when it will be measured again. I believe that you might not have to measure everything every year, but measuring the emission activities that you are trying to improve is a good idea."(B).

Reasons for hiring a third party:
The respondents agreed that hiring a third party can have its benefits. Jan-Cees Jol said the following "There is a lot of discrepancy between the emission factors stated by different groups. Furthermore another advantage of including a third party is that Arcadis organized a kick off meeting for Erasmus employees who are involved because they will deliver some of the activity data. This gives the employees an extra incentive to actually show up to the meeting. In the end this will result in them delivering the necessary data quicker. "(A). Ewout Doorman stated "The main reason for hiring IVAM was because we had no experience in measuring CO_2."(B). Marie Ernst gave the following reasons for hiring a third party "Experience is the best thing we have to offer. Furthermore we have a lot of experts and connections so we are able to solve a lot of problems that might occur during the process."(C).

Deciding what scope to measure:
All parties mentioned that the scopes were decided by discussing them with the third party or client. Jan-Cees Jol had the following to say "This topic was discussed with Arcadis and they listened to the wishes of Erasmus and they also gave advice on which scopes to include."(A). This was confirmed by Marie Ernst "This depends on the company their wishes We try to measure as much as possible in the time that we have."(C). Ewout Doorman experienced the same when deciding on what scope to measure "We told IVAM what we wanted and how far we wanted to go in measuring."(B).

Experience with measuring commuting:
All interviewees agreed that having a lot of data is key and it was advised to create a modal split. According to Jan-Cees Jol "The school used surveys to get the data for a good modal split. And this was used to calculate the CO_2 emission for commuting."(A). Marie Ernst agreed with this way of calculating the CO_2 emission for commuting and she stated the following "It is very important to measure commuting because a big percentage of the total CO_2 emission is located in this activity. We advise to use a survey to create a modal split."(C). Ewout Doorman stated "We had a lot of information in order to measure this and the HVA and UVA do not have parking spaces for employees. Thus most of the employees use public transport and this is more reliable to measure with the information that we had. However

commuting is still an estimate, but you do not need to measure this precisely in order to see that it has a huge contribution to the overall CO_2 emission."(B).

Did you take actions to improve the data collection process?
Both respondents are not taking any steps to improve the data collection process. According to Jan-Cees Jol "At the moment Erasmus is not taking any steps to improve the data collection process."(A). Ewout Doorman said "No because it was the first time that we measured the CO_2. And I don't think that it will have the priority to change processes in order to improve the data collection."(B).

Benefits of measuring CO_2:
Two respondents agreed that knowing which emission activities contribute the largest amount of CO_2 is the main benefit of measuring CO_2. Jan-Cees Jol states "The measurements are mostly used to know where the biggest improvements can be made. The data can also be used to improve other processes. And it improves the image of the school. In addition costs might have been saved, but this was not the main focus."(A). According to Ewout Doorman "The measurements are used to guide the improvements that can be made to make the university more sustainable. But there are not that many benefits because you could hypothetically look at the CO_2 of another school. To see where you need to focus, but at this time it is too early to say if costs were saved."(B). Marie Ernst said "It is important in order to know where the biggest amount of CO_2 emission comes from. Then this information can be used to reduce these categories. It is important to take responsibility and the information that is collected can be useful in other processes as well."(C).

4.3 Prototype model

In order to execute the case study a prototype model is needed. After doing literature research, analyzing the database information and interviews a model has been created. This paragraph will explain what emission activities are included in the model and why.

First of all the model will be based on the GHGP and CCC. It is impossible to just follow the GHGP since it was not created for universities. At first sight the CCC looked like a good calculator to use; however, after all the research a few downsides were found:

- The calculator is a lot more complicated than it should be and it is not as transparent:
    - The goal for the research is to only measure CO_2 emission, but the CCC was created to measure all GHG.
    - A few activities are included in the model, but these are irrelevant for the HZ such as: Waste water, Agriculture sources, Refrigerants & chemicals and on-campus stationary sources.

- On some fronts the CCC does not have all the options that are desirable such as:
    - Emission factors are out-dated.
    - Waste cannot be measured in different categories.
    - Under staff and student commuting there are only 4 transport types. This is not enough and no distinction has been made between a gasoline or diesel car.
    - The calculator does not take into account the following relationship:
    Increase in kilometres flown = decrease in CO_2 emission per kilometres.

All these reasons supported the idea of creating a custom, simple and transparent model for the HZ.

Table 8: Shows the prototype model.

Scope	Emission category
Scope 1:	Direct transportation sources
Scope 2:	Purchased electricity
	Purchased heat
Scope 3:	Employee commuting
	Student commuting
	Employee travels
	Exchange student travels
	Water
	Waste

4.4.1 Scope 1

After comparing the different CO_2 emission reports there was no doubt that this scope had to be included since 99% of all universities include it. However, not every category has to be measured. This scope only contains the emission category called direct transportation sources. This includes the emissions of the vehicles that are owned by the HZ. The CCC includes other categories such as: Agriculture, on-campus stationary sources and refrigerants & chemicals. However, the HZ does not have any agriculture or relevant on-campus stationary sources. They do have some solar panels, but these do not emit any CO_2.

Lastly, the refrigerants & chemicals calculated in the CCC are calculated in terms of CO_2e and not CO_2. And these are a very small percentage of the total emission so they were not included.

4.4.2 Scope 2

Again 99% of all the universities included scope 2 in their reports. This category is almost the same as defined by the CCC. It includes purchased electricity and heat. The only difference is that the CCC split heat in steam and water. However, this is not necessary for the HZ since they buy gas.

4.4.3 Scope 3

This scope contains a lot of emission categories. Almost every university measured scope 3. But there is a big difference between which emission categories are measured.

First of all wastewater and land filled water were excluded from the model because they only admit CO_2e. And land filled water is not relevant for the HZ anyway. In addition paper was not included either because this falls under the purchased goods, which was only measured by 24% of all universities. And capital goods were not included in the CCC because the database analysis showed that only 4% of all universities included this in their analysis.

Furthermore the CCC measures a lot of offsets, which are not necessary to measure for the HZ since hardly any university includes them and they will be very small in terms of emission. Business travel and commuting were both included because they were measured by 70% and 74% of all the universities. And from the interviews I learned that this often is the biggest emission source. The difference is that for commuting only a few travel options were listed in the CCC and this model will have a lot more. In addition business travel will be

calculated more precisely by making a distinction between gasoline and diesel cars. Different emission factors will be allocated for air travel based on the distance, this was mentioned as very important by Marie Ernst in the interview.

The model will also include exchange student travel. This means exchange students who studied at the HZ. Their travel to Vlissingen will be included and the same goes for HZ students who studied abroad. This is also included in the CCC, but in this model it is put under its own emission category. Water is included in the CCC and it is also in the prototype model.

Lastly, it is possible to measure the CO_2 emission for waste in the CCC, but the CCC does not make a distinction between different types of waste. The database showed that 64% of all universities included waste, which makes it fairly important. The result is that it is included in my own model with different waste types.

5. Case Study: HZ University of Applied Sciences

In the previous chapter a model has been created to calculate the HZ's CO_2 emission. This chapter will describe the process of using this model to calculate the CO_2 emission of the university.

Firstly, the data collection process will be described for each scope. Secondly, the calculations will be presented and explained. After that the results will be explained and compared to those of other universities. Lastly an overview of uncertainty will be given. The case study was executed for the year 2015. Daan Polderman helped me to get into contact with the right people for the necessary information.

5.1 Data Collection

In this chapter the data collection will be discussed.

5.1.1 Scope 1

As mentioned previously we only included the cars that are owned and used by the HZ.
The HZ has 10 cars and it was important to know how many kilometres every car has travelled in the year 2015. Wilma Moerings-Huiszoon send me the kilometres driven in the year 2015 for each car.

5.1.2 Scope 2

This scope contains two emission types called purchased electricity and heat. I contacted Marcel Capello who send me the amount of bought electricity and gas for the year 2015.

5.1.3 Scope 3

Scope 3 was the most challenging scope because it involves a lot of different emission factors and a lot of data is needed to calculate the CO_2 emission.

Employee commuting
To calculate the employee commuting a lot of data was needed. First of all it was necessary to know how many employees the HZ has and I needed the postcodes of every employee. Mariëlle Poleij works at P&OO and she supplied me with the postcodes of all the employees.

This allowed me to calculate the travel distance to the school for each employee by using a VBA[2] script in excel (see appendix 3). This script uses Google maps to calculate the distance between two postcodes. However, this was not enough because this still leaves several questions open such as: How many times a week are employees actually present at the HZ. And what are their travel habits in order to create a modal split.

To get an answer to these questions structured interviews were held as explained in the methodology. This gave information over a good sample size, which was used to draw conclusions for the total population.

[2] Visual Basic is a computer programming language , which allows users to create customized functions in office programs.

Student commuting
For student commuting the same type of data as for the employee commuting was needed. Firstly, I contacted Peter Olivier he works at the student office and he send me the postcodes of all the students and then I immediately knew how many students the HZ has. Secondly, it was important to know the travel habits of students and frequency of school attendance. For this a modal split was used from the University of Twente (Geurs et al., 2011). Mainly because their research was very complete and the university is located outside of the city, which makes its accessibility comparable to the HZ.

Exchange student travel
The exchange students coming to the HZ to study and the outgoing HZ students who were going for a semester abroad were also included. For this it was important to know where the outgoing students were going and from where the incoming students were coming. All of this information was made available by the people working at the international office. This would make calculating an estimate over the total CO_2 emission from the exchange students their travels possible. To calculate the flight distance the following website was used http://www.travelmath.com/.

Employee travels
Employee travels are divided in the following types of employee travel: flights, public transport, car. In order to calculate the CO_2 emission for the flights, flight information was needed. Wilma Moerings-Huiszoon from the international office provided the number of flights in 2015 and to which city and country. The website Travelmath was used again to calculate the distances. Secondly, for public transport not a lot of data was available. Only a total amount of declared euro's was available which was send by Mariëlle Poleij and the NS website was used to calculate the costs per kilometre. Thirdly, for the employee business travel by car Mariëlle Poleij send me the total amount of kilometres travelled and declared for the year 2015.

Water usage
This information was easy accessible after getting in contact with the Ludo Franken. He send an overview with the amounts of water used for each month in 2015.

Waste
Collecting this data was fairly easy because the HZ is in the process of full waste separation. Van Gansewinkel had done a case study for the year 2015. They measured the different types of waste and the total amount.

Table 9: Shows an overview of all the contacts per scope.

Scope	Emission Category	Name of contact	Departement
Scope 1	Direct Transportation	Wilma Moerings-Huiszoon	International office
Scope 2	Electricity, heat	Marcel Capello	
Scope 3	Employee commuting	Mariëlle Poleij	P&OO
	Student commuting	Peter Olivier	Student office
	Exchange student travel	Evelien Clemminck	International office
	Employee travels	Wilma Moerings-Huiszoon	International office
		Mariëlle Poleij	P&OO
	Water usage	Ludo Franken	Concierge service
	Waste	Robbert van Waes	Van Gansewinkel

5.1.4 Emission factors

The emission factors were taken http://co2emissiefactoren.nl/. This website is the standard for emission factors and it is updated every few months. To calculate the CO_2 emission for waste, Jan-Cees Jol provided emission factors for each type of waste. These factors can be used because Erasmus uses the same company for waste separation as the HZ. See appendix 4 for all the emission factors that were used.

5.2 Calculations

This chapter will show and explain the calculations for each emission category.

5.2.1 Scope 1

To calculate the direct transportation emission: I started by searching the engine type for each car to find out if they used diesel or gasoline. Then the kilometres per car were multiplied by the emission factor for gasoline or diesel.

5.2.2 Scope 2

The amount of electricity and gas bought was multiplied by the emission factors for these types of activities.

5.2.3 Scope 3

Employee commuting

Calculating the employee commuting was a little more challenging. The following steps were needed:

1. A modal split was created from the survey.
2. Calculated the distance for every employee from his house to the university. For this a VBA script was used, which used Google maps to calculate the distance.
3. The distances were filtered as shown in table 10 to see in which distance category they would fall.

Table 10: Shows the categories for distances from employee homes to their work.

1 to 6	6 to 16	16 to 31	31 to 39	39 to 55	55 to 87	87 to 500

4. Then all the distances were added per category. This gave a total of kilometres per category.
5. The distances for each category were multiplied by the modal split percentages. This gave a total of kilometres travelled per transport type.
6. These were multiplied by the corresponding emission factor and by the number 2 because the previous number was only one-way travel.
7. The survey showed that employees work an average of 4 days a week. So I multiplied it by 4 and by 42 for the number of weeks in a school year.

Student commuting
The only difference with calculating employee commuting is the modal split. The following steps were taken to calculate the student commuting:

1. Calculated the distance for every student from their house to the university.
2. The distances were filtered as shown in table 11 to see in which distance category every students travel amount would fall. These categories are different to the one's in the previous calculation. This is because they had to equal those used in the modal split.

Table 11: Shows the categories for distances from student homes to school.

1 to 5	5 to 10	10 to 15	15 to 25	25 to 50	50 to 100	100 or more

4. All the distances were added per category again. This gave a total of kilometres of distances per category.
5. The distances for each category were multiplied by the modal split percentages from the university of Twente. This gave a total of kilometres travelled per transport type.
6. These were multiplied by the corresponding emission factor and they were multiplied by two again.
7. The modal split also showed that students attend the university around 4 days a week. The data from step 6 was multiplied by 4 and by 38 for the number of schools weeks for the students.

Exchange student travel
The following steps were taken:
1. The data was split over 2 different documents. These were added together which gave a list of travel destinations and a number of students per location.
2. For each location the nearest airport was taken and used to calculate the flying distance to Schiphol airport. There was no data on what airport was used, so assumptions had to be made.
3. Then these distances were filtered and put into the following categories: Less than 700km, between 700 and 2500km's or more than 2500km's. This is important because there are different emission factors depending on the distance.

4. The distances were multiplied by the amount of people going to the same city.
5. After that all the distances per category were added together and multiplied by two to include the return flight.
6. The total amount of kilometres per category were multiplied by the matching emission factors and they were all added together.

For the following countries the assumption was made that students would travel by car:
Belgium, France, Germany, Luxembourg.
These were also included:
1. No exact locations were available. To deal with this a city in the middle of every country was used to calculated the distance to the HZ.
2. This was multiplied by the amount of people travelling to/from these cities.
3. And it was multiplied by the emission factor that is used when the type of car is unknown.

Of course students who fly would also have to travel to and from the airport; however, this would involve to many assumptions and guesses.

Employee travel
Employee travel is divided in travel by public transport, car and flights.

The following steps were taken to calculate the public transport part:
1. Only an amount of declared money was known. The price and distance for 10 different scenarios was calculated for the bus and train. This gave me the price per kilometre for the bus and train for each scenario.
2. The average price per kilometre for the train and bus was calculated.
3. I assumed that 90% of travel with public transport was per train and the other 10% was the bus.
4. This gave a total amount of money declared per transport type.
5 The amount of money spend on train travel was divided by the costs of travelling 1 km with the train. And then it was multiplied by the emission factor for train travel. The same was done for the 10% bus travel.

CO_2 for travel by car was calculated by doing the following:
1. For travel in this category employees used their own cars. From the employee survey I had learned that 80% owns a gasoline car and almost 20% owns a diesel car. These numbers were multiplied by the total amount of kilometres declared.
2. Both categories were multiplied with the right emission factor.

The same steps were taken to calculate the CO_2 from employee flights as for exchange student travel.

Water usage
The amount of water used was multiplied by its emission factor.

Waste
The amount of waste per category was already available so these numbers only had to be multiplied by their emission factors.

5.3 Results

Executing the calculations in the previous chapter, leads to the following end result:

Table 12: Shows the HZ's CO_2 emission per category.

Scope	Emission category	Co2 emission in kg	As % of total
Scope 1	Direct transportation	37.908,79	0,47%
Scope 2	Electricity	681.641,82	8,4%
	Heat	462.222,96	5,7%
Scope 3	Employee commuting	759.611,97	9,4%
	Student commuting	5.144.643,06	63,8%
	Employee travel	383.497,43	4,8%
	Exchange students	583.451,40	7,2%
	Water usage	1.628,26	0,02%
	Waste	14081,98	0,17%
Total		8.068.687,67	100%

Table 12 shows the CO_2 emission for the HZ University in 2015. The university has a **total emission of 8.068 tons of CO_2**. This means that **the emission per student is 1.837 kg's CO_2** per year. The biggest contributor to the total CO_2 emission is student commuting, as this was to be expected.

It is important to see where the HZ is standing compared to other universities. The HVA and UVA measured their CO_2 emission for the first time for the year 2015, which is the same year as used in this research. When comparing the HZ's emission to that of the HVA and UVA, we can see that their total emission was 73.516 tons of CO_2 in the year 2015.This is almost 10 times as much. However, the HVA and UVA have a combined total of 80,774 students and they have 910 kg's CO_2 per student. This is half the amount of the HZ's 1.837kg's CO_2 per student. If we further look at the CO_2 in percentages and compare these to the HVA and UVA, a few things are noteworthy. First of all, scope 2 accounts for a total of 14,1% of the total CO_2 emission. For the UVA and HVA scope 2 is only 4,7% of the total. This is because they buy green energy and use district heat instead of gas.

Furthermore, the HZ's employee commuting percentage is almost twice as much compared to the 5,9% of the HVA and UVA, even though the HVA and UVA's employees travel is 3% higher. When interviewing Ewout Doorman, I learned that the HVA and UVA do not offer parking spaces to their employees. The result is that almost every employee uses public transport.

The HZ was compared to the HVA and UVA because it was their first time measuring CO_2 emission as well. If we would compare the HZ to a top school in the field of sustainability such as the Hogeschool Utrecht, then the HZ performs even worse because the Hogeschool Utrecht emits 438 kg's CO_2 per student which is a quarter of the HZ's emission per student.

5.4 Uncertainty Analysis

The previous chapter explained the results from the case study. However, every emission category has been measured in different ways and it is important to understand the degree of uncertainty for every category in order to be able to fully interpret the results. This chapter will explain the uncertainty for every emission category.

We define 4 levels of uncertainty:
A: Very low uncertainty
B: Low uncertainty
C: Uncertain
D High uncertainty

Table 13: Shows the level of uncertainty per category.

Scope	Emission category	Level of uncertainty
Scope 1	Direct transportation	A
Scope 2	Electricity	A
	Heat	A
Scope 3	Employee commuting	C
	Student commuting	D
	Employee travel	C
	Exchange students	D
	Water usage	A
	Waste	A

5.4.1 Scope 1
As shown in table 13 the level of uncertainty for direct transportation is an A. For this scope all the information was available. And even knowing the type of cars was a bonus.

5.4.2 Scope 2
Scope 2 contains the emission categories electricity and heat. The level of uncertainty for both of these emissions is level A. This due to the fact that the data is actually measured and easy to get so the only uncertainty within these calculations would be the emission factors.

5.4.3 Scope 3
Employee commuting gets a C because a modal split was required in order to calculate the emission. Even though the survey has provided a lot of data about how the employees travel to work and how often. This in combination with the postcodes of the employees gave a lot of information. However, the calculations are still a rough estimate and can always be improved.

For the calculations of student commuting the same type of data was needed. However, a modal split is used from a different university, which makes it less reliable than employee commuting and this is why it gets a D for uncertainty.

The level of uncertainty for employee travel is C. A lot of data was needed and there are some limitations to the data. For example, only an amount of invoiced kilometres are available so assumptions are made on what type of car was used. In addition, for the travel by public transport only an amount of money was available; therefore, the price for travelling one

kilometre by train was used. But employees might temper a bit with the amount of money invoiced. Furthermore assumptions are made on what percentage of the total invoiced amount is allocated to trains or busses.

For calculating the CO_2 emission of the incoming exchange students and the outgoing HZ students, a lot of assumption are made as shown in the calculation part(see page 30). Only the home countries from the foreign students are available and the destination countries for the HZ students who were going abroad. So assumptions are made about what type of transport and what airfield was used. This makes the level of uncertainty a D for student commuting.

Water usage has a very low uncertainty because the amount of water used is actually measured. This means that the only mistake that could be made is with the emission factor and the same goes for waste.

6. Discussion

This research started with the question: How can the HZ best measure and keep track of its CO_2 emissions? This topic was researched by looking at different literature, followed by looking at what other universities are doing and conducting interviews with experts.

This research shows that it is important to measure the CO_2 emission and how this can be done. The literature review shows that different methods are available for different types of companies. But the expert interviews have shown that these methods are not specific enough since every university is different. All the literature is really focused around what specific activities should be measured. While executing the case study it showed that the biggest challenge actually is calculating the emission for each activity. And it leaves questions such as: What is the most reliable way of calculating the CO_2 emission for this activity and what would be the ideal data to have? The literature does not go into detail on these topics even though they are an important part of the CO_2 emission measuring process. All the experts in the interviews did talk about these topics because they also find them very important.

A model to measure the CO_2 emission has been developed in this research, which proved to be very useful in the case study. This is also how this research differentiates itself from other research mainly because the model is a useful product tailored to the needs of the HZ. The case study does not only prove the validity of the model. It also shows that the HZ's CO_2 emission is very high compared to other schools and this should be an incentive for the HZ. Furthermore, the case study also shows what activities are the problem areas for the school.

During the research I have kept an open-mind as much as possible. This has been shown in the methodology. The research structure is clear and the data gathering process has been transparent. Triangulation has been used this means that multiple research methods were used to answer the same question, this increases the validity and reliability of the results. Triangulation also helped in dealing with the bias of the interviewees, since the answers were compared to the literature review. This was important, because the sustainability experts might execrate the importance of measuring CO_2.

In the case study the uncertainty has been discussed. Most of the total CO_2 emission is allocated in level C meaning that the calculations have a medium uncertainty on average. The most uncertain categories are the student commuting and exchange students emission. These two categories combined are responsible for 71% of the total CO_2 emission. It could be argued that if measured more precisely that the amount of emission would be different and this would have an impact on the total CO_2 emission of the HZ.

For student commuting the modal split from the University of Twente has been used. This university has the same accessibility as the HZ and most of the students do not live within cycling distance from the university. When looking at the total kilometres travelled by students only 5% of the total is allocated to people living within a travel distance from the HZ between 0 to 15km's. If there are differences between the modal split of the University of Twente and the HZ its students their actual commuting behaviour. Then this difference will need to occur at travel distances between 15km's and 100+km's in order to have a serious impact. When looking at these distance categories within the modal split of the University of Twente it shows that they allocate an average of 25% of the travel to travel by car, which seems reasonable. To see the effects of a different percentage of car travel at distances between 15km's and 100+km's. I used an average of 30% for car travel to calculate the effect.

This increased the percentage total of student commuting from 63.8% to 66.1%. When I lowered the average of car travel to 15% and thus increased public transport accordingly, the total for student commuting decreased to 60.9%.

Furthermore, for the exchange students, travel to the airport has not been included so this emission number is likely to be higher. CO_2 emitted from travelling to the airport will be small compared to emitted CO_2 from the flight. This will not be more than 10% of the total exchange student emission. When I increased the exchange students CO_2 emission by 10% it resulted in an increase of 0.7% as a percentage of the total. Therefore, the error of margin will be within 10%.

In the recommendation several ideas for reducing the CO_2 emission are discussed. It could be an idea for follow up research to see what the most interesting CO_2 emission activities are. The more complicated activities could be researched to see what options are available to reduce the emission. A study to determine the cost/benefit per activity could also be performed.

Limitations
This research has some limitations, which I will discuss here.

All the limitations are regarding the data that has been needed for the research. These limitations have influenced the calculations and the accuracy of the case study.

Firstly, to calculate the student commuting a modal split was needed. The best way to make a modal split for this group is by surveying them. However, due to time issues and the sample size for the student commuting it was impossible to survey the minimum amount of students.

I asked for help from the school, my idea was to send the survey from an official HZ email account. This would be more realistic than using my own email account, because students are more likely to reply to an official HZ email than to a spam email from a student.

Unfortunately the school did not want to cooperate with my idea. Which I find weird because from my interviews and other research I have found that a lot of universities send a mobility survey each year and I did this research for the HZ. This forced me to use a modal split, which makes the calculations less accurate.

Secondly, a lot of assumptions had to be made in the case study. I will not go into too much detail since this has already been discussed in the case study. But in the category of exchange student travel, assumptions had to be made about which airfield was used. The same goes for employee travel; assumptions had to be made about which airfield was used. And for employee travel by public transport only a total amount of money was available. All of these assumptions reduce the accuracy of the calculations.

7. Conclusion and Recommendations

This chapter will conclude the research by answering the research question and the sub questions. Furthermore recommendations will be given to the HZ.

7.1 Conclusion

1. Questions regarding other organisations.

1.1 What kind of methods for measuring CO_2 emission are used by different organisations?
The GHGP is used as a basis for every method that is used by companies. Some companies only use the GHGP. Others use more specific tools such as PAS2050 for production companies. And the CCC is used by a lot of universities. Other companies choose to use online calculators such as the Milieubarometer.

1.2 How often do most organisations measure their CO_2.
How often organisations measure their CO_2 depends on the type of company. Most industrial companies calculate it each year. According to Marie Ernst this is the case because they have the required data available anyways so it is not a lot of effort for them. Most universities measure their CO_2 emission once every three years.

1.3 To which conditions should the measuring data comply?
The data should comply with the data quality indicators as defined by GHGP.
These indicators are the following:

- Temporal specificity: How old is the data and within what time period has it been collected.
- Geographical specificity: From where is the data collected.
- Technological specificity: Is the data associated with one technology or a mix.
- Reliability: Can the data be trusted (assessment of the sources of data, collection methods).
- Completeness : Does the set of data represent the population of interest.

1.4 In what kind of format should the measured data be saved and compared in order to measure the emission periodically?
This depends on the type of organization. Most companies use an excel model because it is cheap and easy to use. For some companies and universities the Milieubarometer would be a good option and the CCC could also be used by universities. The HZ should use my model and if they want an online tool then they could use the Milieubarometer.

2. HZ specific questions.

2.1 What kind of CO_2 generating activities should be measured?
A prototype model was made based on the literature review, interviews with expert and the analysis of CO_2 emission report. This model was then tested in the case study where no problems were found in the emission categories so the following activities should be measured:

Table 8: Shows the prototype model.

Scope	Emission category
Scope 1	Direct transportation
Scope 2	Electricity
	Heat
Scope 3	Employee commuting
	Student commuting
	Employee travel
	Exchange students
	Water usage
	Waste

2.2 How can the data collection be improved by the HZ, in order to measure the school's CO_2 emission in a more practical and time-efficient way.

The data collection part went pretty good, since it was easy for me to collect all the data. The lack of data was more an issue than the data collection part. There were only two people who were slow in responding to my requests. The process could be improved by better communication between employees within the HZ, because the two delays that I had were because of unclear communication between employees.

Furthermore, all the data could be connected in an ERP system; however, the costs will not outweigh the benefits in this case. The costs of an ERP system depends on number of users, customization level and applications required. Even when you buy a simple ERP system it will costs more than €100,000.-. An ERP system can be very beneficial for an organization, but investing in such a system to improve the data collection to measure the CO_2 emission would be a bad investment. The school would be better off investing this money directly in making the HZ more sustainable.

2.3 How should these CO_2 generating activities be measured?

CO_2 generating activities can be measured by following the guidelines prescribed by the GHGP and the CCC. This means that the following process should be followed:

- Create a team
- Set boundaries
- Collect data
- Calculate emission
- Analyse and summarize the results

These steps should be executed as explained in the case study.

7.2 Recommendations

The following recommendations can be made, after conducting this research:

I recommend that the HZ uses the CO_2 model which was created in this research. I believe that hiring a third party is not within the HZ's budget. Although this is an assumption, so this assumption could be wrong. The created model in this research is complete, easy to use and it is free to use. Another option would be to use an online platform such as the Milieubarometer, which provides a calculation model and it updates the emission factors every few months. If the HZ would like to involve a third party, it is advised to do so every five years or so. The school could learn a lot from these experts and they can refine the measuring process, but hiring them every year is unnecessary and expensive.

Secondly, measuring the CO_2 emission is important, but it is a means to an end and not the other way around. The school should take measuring the CO_2 emission seriously, but make sure that the emphasis is on taking action to reduce the CO_2 emission and not on measuring as precisely as possible.

Thirdly, regarding the frequency of measuring. Measuring every CO_2 category every year does not add a lot of value, because the differences in emission will be small. That is why the HZ should measure all of their CO_2 categories every 3 years. If, for example, the university decides to stimulate their employees to use public transport more often, this category should be measured every year to see if their actions are working.

When reducing the CO_2 emission it is important to focus on the CO_2 category where most of the CO_2 emission is allocated. Some changes could be made to categories with a very low emission, but this is not as effective when looking at the bigger picture. Table 14 shows the actions that could be taken to lower the CO_2 emission per activity.

Table 14: Shows the action that should be taken to reduce the CO_2 emission.

Emission category	**Actions to reduce CO_2 emission**
Direct transportation	- Replace the diesel and gas cars with electric cars - Promote the use of public transport
Electricity	- Buy green electricity
Heat	- Stop using gas and switch to district heating
Employee commuting	- Support and promote public transport (NS business card) - Reinstate bicycle plan - Promote carpooling (create an app or system which shows who travels from where to the school on a certain day) - Paid parking area
Student commuting	- Paid parking area - Promote carpooling (create an app or system which shows who travels from where to the school on a certain day) - Promote public transport (give credits)
Employee travel	- Let employees travel by train to countries close to the Netherlands. - Support and promote public transport by giving employees a NS business card.
Exchange students	- Promote students travelling by train to countries close to/from the Netherlands. - Promote students carpooling to the airport.
Water usage	- Water-saving cranes
Waste	- Waste separation (this is already planned)

As mentioned in the conclusion to improve the data collection a big investment would be necessary. However, the benefits are too small since it will only make all of the data available in one computer program. The case study already showed that collecting the data was not a big problem. Therefore, I recommend some type of small information session to make the employees aware about the HZ's goal to measure and reduce its CO_2 emission. By communicating this clearly to the employees, they are more likely to cooperate when someone contacts them to ask for data that is needed to measure the CO_2 emission.

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Appendices
Appendix 1: CARS checklist

CARS-checklist					
Article = also website content, document, book, or report					
0 = Not applicable and/or accurate, 5 = Accurate and/or applicable					
	1	2	3	4	5
Credibility					
The article contains background information about the author or organization responsible for the contents of the site or document					
Quality control exists on the contents of the article, for instance content is reviewed before you are able to publish or post it to the portal, online magazine or publishing institute.					
The article is clearly structured.					
The article contains well formulated sentences without spelling or grammatical errors.					
The article is referred to by reliable sources or articles.					
Accuracy					
The article is recently updated.					
The article contains up to date information.					
The author has evidently tried to look at the subject from different angles or points of view.					
Reliability					
The article gives an objective opinion, which also includes reference to the points of view of opponents in the argumentation. The contributions of opponents are treated with integrity and respect. (honesty)					
It appears that the author has done his best to write as objectively as possible.					
Based on your own knowledge and experience, it can be concluded that the contents of your article is of acceptable quality.					
The objective of the author is to be scientifically informative, and not politically or financially coloured.					
Support					
The article clearly states the origin of the information.					
The article includes contact information of either the author or the company the author is connected with.					
At least two reliably sources confirm the article content or statements in the article.					

Appendix 2: Interviews

Interview code:	A
Date:	
Time:	
Contact type:	Visit
Interviewers:	Jan-Cees Jol
Interviewees:	Thierry Ars
Impression from contact:	Positive
Main issues or themes that struck me:	How much more can be done with the data that is gathered.

What is your function?
I am the sustainability coordinator at Erasmus University.
This means that I make sure that the university achieves the set goals for the mjaa's
This is one of my maintasks and I also guide some different programs all involving sustainability within the green office.

How often does the university measure its CO_2 emission?
This year (2016) it is the first time since 2012 that Erasmus is measuring its CO_2 emission. However, the plan is to start measuring the CO_2 emission every year from now on.

Did the university measure its own CO_2 emission or did they hire a 3rd party to measure the co2 emission and if so why?
In 2012 the university hired (check date) Climate neutral group. But now they are switching to Arcadis who are more up to date with the CO_2 measuring according to mr Jan-Cees Jol.
The main reason for the university to include a 3rd party is the emission factors.
Apparently there is a lot of discrepancy between the emission factors stated by different groups. Some use 50 for a certain source and other institutions use 100. But this is a difference of 100%. The university hires Arcadis to let them calculate the CO_2 emission. Erasmus delivers the data that is required. Furthermore another advantage of including a 3rd party is that Arcadis organized a kick off meeting and Erasmus employees who are involved because they will deliver some of the activity data were also invited. This gives the employees an extra incentive to actually show up to the meeting. And it makes them more involved in the whole process so they actually know what is going on. In the end this will result in them delivering the necessary data quicker.

Did you have any input on what scopes were measured?
This topic was discussed with Arcadis and they listenend to the wishes of Erasmus and they also gave advice on which scope to include.

What was the most challenging activity to measure?
Commuting

How were these activities measured and what is you opinion on how they were measured?

Erasmus University has a professor who is specialized in transport economics. With him the school decided what data they needed to measure the business travel and employee/student commuting as accurately as possible. The school used surveys to get the data for a good modal split. And this was then used to calculate the co2 emission for commuting. I think this all went pretty well.

What could be improved?
Employee commuting could be improved in the future:
At the moment the university has a parking garage and employee have a school id card/badge. If they want to enter the parking garage they have to scan their badge and the gate goes open and this is the same for when they leave.

This card has the employee's personal information such as: name and home address. This information could be used to calculate the distance to their home and because of the check in and out system in the garage the university could monitor how many times they came to school with their car. This would make the measuring of the employee commuting a lot more reliable. Of course you still need to know if the car runs on gas or diesel. But this whole previously described process could be fully automatic. You would still need to find a way to measure the public transport more accurately and this could be a challenge.

Are you satisfied with the outcome of the CO_2 analysis?
Satisfied

How much did it cost?
Around €6000, -

Are you aware of any challenges that were encountered by the 3rd party when collecting the necessary data for measuring CO_2?
The third party does not collect the data. Erasmus collects the data.

If yes: Did you take any measures to improve the data collection process (or saving the data) in order to calculate the CO_2 emission easier or faster?

In the beginning the data collection process was a lot of work. Because employees sometimes said they would send the data but then they would not. Which resulted in the whole process taking longer than necessary. However, the data collection process is improving in a natural way mainly because the CO_2 is getting measured more often.
As a result the involved employees who have the data know that the sustainability department is going to need the data. So the departments will make sure that the data is ready for them when they need it.
In addition these departments also notice some extra benefits. The data can be used for the improvement of other processes as well.

Hopefully this process keeps improving. At the moment Erasmus is not taking any steps to improve the data collection process. However, the long-term goal would be to have all the data being send automatically to a system. And then this system would calculate the CO_2 emission at the end of the year.

How do you use these measurements?
The measurements are mostly used to know where the biggest improvements can be made.

Are there other benefits of measuring CO_2?
The data can also be used to improve other processes. And it improves the image of the school.

Did the university save costs as a result of measuring CO_2?
Maybe but this was not the main focus.

Do you have any tips for measuring co2 or things you wished you knew before you started measuring CO_2?
Be transparent in where the data comes from. Let someone advice you for the emission factors. Involve a 3rd party. Involve colleagues.

Interview code:	B
Date:	
Time:	
Contact type:	Phone
Interviewers:	Ewout Doorman
Interviewees:	Thierry Ars
Impression from contact:	Positive
Main issues or themes that struck me:	Doing something about the co2 emission is more important than measuring.

What is your function?
Policy employee sustainability and innovation.

Why and when did the university start measuring its CO_2 emisson?
The university started measuring the co2 in 2015 and so far we do not know when it will be measured again.

Could you tell me something about the process?

How often does the university measure its CO_2 emission?
2015 was the first time the university started measuring the CO_2. But it is not useful to do it too often. However, the university does measure energy every year. In addition I also believe that you might not have to measure everything every year, but Only the emission activities which you tried to improve.

Did the university measure its own CO_2 emission or did they hire a 3rd party to measure the CO_2 emission and if so why?
We hired IVAM which is a daughter company of the UVA. However, it is an independent company. And I functioned as the contact person between both institutes. The main reason for hiring IVAM was because we had no experience in measuring CO_2.

Did you have any input on what scopes were measured?
Yes we told IVAM what we wanted and how far we wanted to go in measuring.

What is your view on the way that the activities in scope 3 were measured?
Pretty good. We had a lot of information in order to measure this and the HVA and UVA do not have parking spaces for employees. Thus most of the employees use public transport and this is more reliable to measure with the information that we had. However, commuting is still an estimate, but you do not need to measure this precisely in order to see that it has a huge contribution to the overall CO_2 emission.

Furthermore we also included catering which was a lot of estimates as well.

Are you satisfied with the outcome?
Yes although I think we overdid it a little.

How much did it cost?
Between €10.000-€12.000 .

Did you encounter any problems when collecting the necessary data for measuring CO_2?
Data that was not up-to-date. Such as students postcodes which is from when they lived with there parents. Even though a lot of them moved since then closer to the university.

If yes: Did you take any measures to improve the data collection process (or saving the data) in order to calculate the CO_2 emission easier or faster?
No because it was the first time. And I don't think that it will have the priority to change processes in order to improve the data collection.

Are there benefits of measuring CO_2?
Not that many you could hypothetically look at the co2 of another school. To see where you need to focus.

What do you do with these measurements?
To guide the improvements that can be made to make the university more sustainable

Did the university save costs as a result of measuring CO_2?
Too early to say.

Do you have any tips for measuring CO_2 or things you wished you knew before you started measuring CO_2?
We could have used emission factors and milleubarometer.
The most important thing is to remember why you are measuring. Which is to lower the CO_2 emission of the university. So make sure that you put more effort into improving the CO_2 emission instead of just analysing and measuring. Action is more important than measuring.

Interview code:	C
Date:	
Time:	
Contact type:	Visit
Interviewers:	Marie Ernst
Interviewees:	Thierry Ars
Impression from contact:	Positive
Main issues or themes that struck me:	Measuring process keep improving.

What is your position in the company and what does this entail?
I am an advisor in sustainability, energy and climate. This means that I work together with clients to fulfill their wishes regarding CO2 analysis. And these clients are companies and schools.

Who are some of your clients?
Hogeschool Utrecht, University Erasmus and big industrial companies. However, Arcadis works in many industries.

Is there an increasing or decreasing trend in the amount of business who want to measure their CO_2?
This is definitely increasing. More and more companies are interested in measuring co2 and to actively decrease the CO2 emission of their company.

Why should companies measure their CO_2 emission?
It is important in order to know where the biggest amount of CO2 emission comes from. Then this information can be used to reduce these categories. It is important to take responsibility and the information that is collected can be useful in other processes as well.

How do you determine what scope to measure?
This depends on the companies wishes. We try to measure as much as possible in the time that we have. Furthermore the amount of time available or the project also determines the level of detail for measuring.

Does the company have any input?
Yes a lot.

Difference in measuring CO_2 for a university or a company?
Overall most companies that we work with have a lot more data. And the availability of the data is higher and more precise. The main reason for this is because these companies are obliged to have this data for other reasons.

How often should a company measure CO_2 ?
Once a year is ideal, but it depends on the company. And by measuring it more often you also get better at measuring and the process will improve.

What is the most challenging scope and why?
There is not one most challenging scope. For universities, commuting can be a real challenge, but for some big companies this is easy to measure if they run a good administration.

How important is this scope?
If we take the example of commuting. This scope is very important because a big % of the total CO_2 emission is located in this activity. And that is why you want to measure this scope precisely and often.

How do you advice universities to measure this?
Use a survey to create a modal split.
What are some common problems during the whole CO_2 measuring process?
Often data is not complete. Small mistakes or discrepancies can be found in the data and it can be a real challenge to correct these mistakes. To make sure that the calculations are reliable.

Advantage for companies of hiring a third party?
Experience is the best thing we have to offer. Furthermore we have a lot of experts and connections so we are able to solve a lot of problems that might occur during the process.

What does it cost?
Depends on what the clients wants. The pay for the hours of the people working on the project.

Future of CO_2 measuring developments?
It is hard to say. But from experience we know that the more times you run the process of measuring CO_2 small improvements will be made. This can be data collection improvements or the data might be more complete. Furthermore I do believe that in the far future CO_2 might be measured automatically by a computer program. However there are always improvements to be made.

Do you have any advice for me?
See where the biggest percentages of the total emission are located. Focus on these activities and measure them as precisely as possible. And then tackle the problem of reducing these emissions. Furthermore do not waste time on measuring a certain activity as accurately as possible when it is only 1% of the total CO_2 emission.

Appendix 3: VBA script

```
Public Function G_AFSTAND(start As String, eind As String, Optional vervoer As Variant,
Optional eenheid As Variant) As Variant

Dim Verv As String
Dim Eenh As String
Dim Link As String
Dim Bestemming As String
Dim Mode As String
Dim Taal As String


Link = "https://maps.googleapis.com/maps/api/distancematrix/json?origins="
   Bestemming = "&destinations="
   Mode = "&mode="
   Taal = "&language=nl"

If IsMissing(vervoer) = True Or IsEmpty(vervoer) = True Then
      Verv = "driving"
   Else
      If vervoer > 2 Then
        Verv = "driving"
      Else
        Select Case vervoer
          Case 0: Verv = "driving"
          Case 1: Verv = "walking"
          Case 2: Verv = "bicycling"
        End Select
      End If
   End If

If IsMissing(eenheid) = True Or IsEmpty(eenheid) = True Then
      Eenh = 0
   Else
      Eenh = eenheid
   End If

Set objHTTP = CreateObject("MSXML2.ServerXMLHTTP")
   URL = Link & Replace(start, " ", "+") & Bestemming & Replace(eind, " ", "+") & Mode &
Verv & Taal
   objHTTP.Open "GET", URL, False
   objHTTP.setRequestHeader "User-Agent", "Mozilla/4.0 (compatible; MSIE 6.0; Windows
NT 5.0)"
   objHTTP.send ("")

If InStr(objHTTP.responseText, """distance"" : {") = 0 Then GoTo Error
```

```
meters = Right(objHTTP.responseText, Len(objHTTP.responseText) -
InStr(objHTTP.responseText, """value"" : ") - 9)

kilometers = Right(objHTTP.responseText, Len(objHTTP.responseText) -
InStr(objHTTP.responseText, """text"" : """) - 9)

If Eenh = 1 Then
   G_AFSTAND = CDbl(Replace(Split(meters)(0), ".", ","))
   Else
   G_AFSTAND = CDbl(Replace(Split(kilometers, " km""")(0), ".", ","))
   End If
   Exit Function

Error:
   G_AFSTAND = -1


End Function
```

Appendix 4: Emission factors

Type of emission	Conversionfactor	Unit
Car (diesel)	0,195	Kg/km
Car (gasoline)	0,22	Kg/km
Train	0,055	Kg/km
Bus	0,12	Kg/km
Ebike	0,007	Kg/km
Scooter	0,113	Kg/km
Hybrid	0,171	Kg/km
Gas	1,882	kg/Nm^3
Grey electricity	0,526	MWh
Water usage	0,00034	kg/m^3
Air travel (<700)	0,297	Kg/km
Air travel (700-2500)	0,2	Kg/km
Air travel (2500>)	0,147	Kg/km
Rest waste	0,527	Kg/kg
Paper & cardboard	0	Kg/kg
Plastic	0	Kg/kg
Glas	0	Kg/kg
Swill	0,0001	Kg/kg
Construction waste	0	Kg/kg