Advise on methods to reduce and compensate CO_2 emission of RUG staff commuting and RUG flight travel under 700 kilometers

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Abstract

Global warming caused by the greenhouse effect is a substantial problem in current society. One of the gasses that constitute the greenhouse effect by forming atmospheric traps preventing heat from escaping is CO_2 emission. The Rijksuniversiteit of Groningen(RUG) desires to limit their negative impact on the environment and, therefore, strives for CO_2 neutrality by 2020. Operations that contribute to their CO_2 footprint are RUG staff commuting and RUG flight travel under 700 kilometres. This study provides recommendations on reduction and compensation methods for RUG staff commuting and RUG flight travel under 700 kilometres to strive for CO_2 neutrality. The current CO_2 footprint of staff commuting calculated over 2017 is 3000 tonCO_2 and for RUG flight travel under 700 kilometres 87 tonCO_2. Recommended is to eliminate the staff commuting CO_2 footprint of the total RUG CO_2 footprint. Other recommended reduction methods for commuting are; realizing a shift away from car use to other transport methods, promoting sustainable car use and advocating the methods with a behavioural campaign. Furthermore, reduction methods advised for RUG flight travel under 700 kilometres are; a shift to either teleworking or railway travel and if inevitable fly as efficient as possible. Lastly, recommended is to compensate the unavoidable CO_2 emission with a carbon offset company. Conclusively, the methods provided in this report can reduce and compensate the CO_2 footprint of RUG flight travel under 700 kilometres and RUG staff commuting by 2020.

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1. Research Topic

This research and design topic is based on the emerging fields of energy sciences and environmental sciences. These disciplines acknowledge the rapid evolving of our energy system and face challenges like long-term energy supply and the transition from finite energy sources like fossil fuels towards sustainable energy sources like wind turbine farms. This research and design topic investigates the energy system of the RUG, focusing on reducing and compensating the CO_2 emission of staff commuting and RUG flight travel under seven-hundred kilometres. Analysing this system requires knowledge and fundamental principles of those disciplines. It requires an interdisciplinary approach, and aims to contribute to environmental and sustainable quality. This knowledge helps understand how individual technologies contribute to the entire energy system.

2. Problem Analysis

2.1 Problem Context

In current society, climate change caused by global warming is a trending topic. The current global warming trend is a result of the “greenhouse effect”. The “greenhouse effect” is global warming resulting from atmospheric traps preventing heat from escaping and, thereby, warming up the earth. Certain gases form the basis of those traps and CO_2 is one of those gases [1]. Global warming already has significant influence on the earth shown by ice cores drawn from Greenland and Antarctica, the warming of the earth and sea level risings.

Those significant effects have concerned the world about the consequences on the earth and civilization if we would continue our CO_2 emission in this matter. Fossil fuel burning is a significant cause of CO_2 emission. As reported in Raupach et al [2] fossil fuel burning results in sixty-three percent of the total atmospheric climate change and the CO_2 emission of fossil fuel burning is rising with a global scale of three percent per year. Within the transportation sector fossil fuels are dominant fuel sources. Therefore, understanding the causes and effects of CO_2 emission caused by transportation is important. This knowledge will provide insight on methods to reduce the CO_2 emission and, thus, reduce “the greenhouse effect”.

Currently, several agreements and policies amongst countries have been set to reduce the CO_2 emission and prevent further damaging of the earth. One of those policies is the Kyoto Protocol. The Kyoto Protocol is an international treaty, which extends the 1992 United Nations Framework Convention on Climate Change(UNFCCC) that commits state parties to reduce greenhouse gas. Furthermore, the European Commission has also implemented a policy in which they strive for a low-carbon economy in 2050. According to this policy Europe strives to reduce their CO_2 emission by eighty percent in 2050 compared to 1990 [3]. Those policies have stimulated countries to tackle and decrease their CO_2 emission and has reduced the CO_2 emission ceiling. In addition, such policies create awareness among companies and individuals about the damaging effects of generating high CO_2 emissions.

Moreover, a motivation to reduce CO_2 emission for especially companies is the positive image associated with sustainable and environmental strategies. Several studies argue that sustainable strategies result in a competitive advantage and an increase in financial benefits. Porter and Van der Linde [4] state that environmental standards can construct new developments leading to a reduce of cost and an increase in product’s value.

2.2 Problem context; The Rijksuniversiteit Groningen (RUG)

The Rijksuniversiteit Groningen is aware of the importance of sustainable and environmental policies within the organization. They comprehend the effects of their operations on the planet and realize that sustainable actions will conceive a positive image. Accordingly, two year ago they have established the Green office. The Green office initiates and coordinates projects related to sustainability within the University. It is also an advisory body for the Board of the University concerning sustainability. One of their sustainability goals is to strive for CO_2 neutrality in 2020. CO_2 neutrality is defined as having a net zero carbon footprint. This is achieved by balancing the amount of emission released with an equal amount of offset. Offset can be accomplished by buying carbon credits or investing in carbon offset projects. For the RUG to become CO_2 neutral they must firstly reduce their CO_2 emission and secondly compensate their left-over emission. Reduction is preferred over compensating, since it will prevent harmful gasses from reaching the atmosphere which is better for the environment than compensating them. Currently, no compensation methods for RUG operations are applied.

The current carbon footprint of the RUG calculated over 2017 is around 58000 ton CO_2. This CO_2 footprint calculation is based on the RUG Energie Rapport van A tot T [5]. To calculate the CO_2 footprint of the RUG, the greenhouse gas protocol calculation tool is used. This tool divides the CO_2 footprint of the RUG into different scopes. The following scopes are defined:

Scope 1: Direct emission
Direct emission is CO_2 emission from sources that are owned and controlled by the RUG. This includes natural gas used to heat RUG buildings, refrigerants used for maintenance of RUG installations and company transport. The current CO_2 footprint of scope one is approximately 9000 ton CO_2.
Scope 2: Indirect emission
Indirect emission is caused by indirect energy producing CO_2 emission. This includes purchased electricity which is determined by the total energy consumption of the RUG. Furthermore, it incorporates purchased heat which concerns heat supply. The current CO_2 footprint of scope two is 24000 ton CO_2.
Scope 3: Emission that are a consequence of RUG operations but not controlled by the RUG:
This emission includes employees and students commuting, RUG flight travel, water consumption, paper and cardboard consumption, residual waste and food. The current CO_2 footprint of scope three is 25000 ton CO_2. Figure 1 portrays the different scopes.

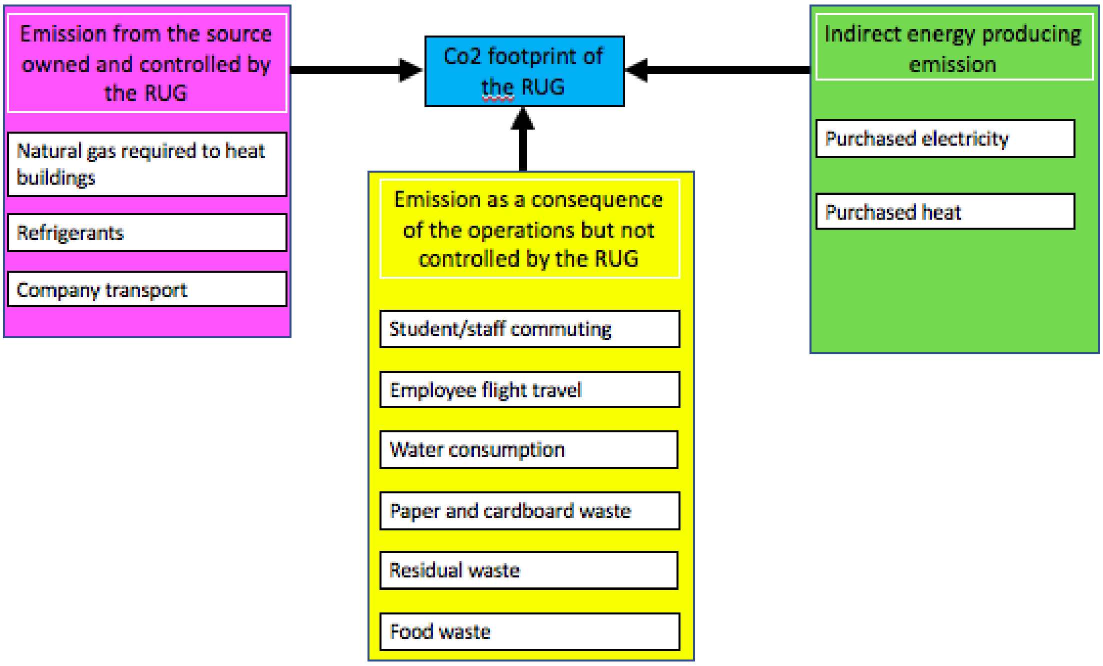

Figure 1: The operations constituting the CO_2 footprint of the RUG

Currently, efforts of the University to reduce their CO_2 emission has primarily been focused on scope one and scope two. For those scopes, it is easier to measure the impact of methods implemented to reduce the CO_2 emission and these scopes are easier to control. Scope three, however, is more difficult to control and to acquire data since the emission is a consequence of the operations of the RUG but is not controlled by the RUG. Since the Board of the University desires to be CO_2 neutral in 2020 this scope must also be decreased. Therefore, this project will focus on reducing and compensating the CO_2 emission of staff commuting and RUG flight travel under seven hundred kilometres. Currently, there are no or little efforts executed by the University to reduce the emission of these operations and as previously mentioned no compensation methods are applied. The current CO_2 footprint of staff commuting is 3000 ton CO_2 and of the total RUG flight travel is 6416 ton CO_2.

An important note is that this report will focus on reducing and compensating the CO_2 emission of the RUG trying to reach CO_2 neutrality but this does not make the University climate neutral. Other greenhouse gasses like methane and nitrogen dioxide also negatively influence the greenhouse effect and, therefore, the environment. Thus, climate neutrality is not equivalent to CO_2 neutrality [6].

2.3 Problem owner

The Board of the University has given the Green office the assignment to strive for CO_2 neutrality by 2020 by creating sustainable projects. The program manager of the Green office is Dick Jager and he is the problem owner of this integration project. Dick Jager initiates projects and methods to reduce the CO_2 footprint of the RUG and assigns Green office employees and students to work on those projects. Consequently, he constructed this integration project as part of the pathway to become CO_2 neutral. He desires that the result of this project will provide methods that reduce the CO_2 footprint of the RUG.

2.4 Problem statement

By 2020 the RUG strives to be CO_2 neutral and to achieve CO_2 neutrality they must balance the amount of emission released with an equal amount of offset. Currently no or little efforts have been carried out to decrease the emissions of staff commuting and RUG flight travel under seven hundred kilometres. Furthermore, no compensation methods are applied to achieve CO_2 neutrality.

2.5 Stakeholder analysis

The reduction and compensation methods will have effect on several stakeholders and successive implementation depends on the behaviour and decisions of those stakeholders.

The first stakeholder is Casper Albers a member of the University counsel. The University counsel is a representative body for the employees of the RUG. The employees will be affected by the possible methods implemented and must change their habits accordingly. To avoid problems and implement the changes effectively, understanding if they are willing to change their routines and behaviour is, therefore, important.

The second stakeholder is Jan de Jeu; the vice president of the Board of the University. Jan de Jeu will determine whether the established methods are possible to be implemented or not. He must approve of the methods and decides if it fits within the executive plan of the Board. Therefore, choosing methods that are possible to be implemented within the University and methods that are sustainable and reliable is critical.

2.6 System description

This integration project is derived from the sustainable target set by the Board of the University and executed by the Green Office. The Green office, thereby, constituted this integration project. The system that reduces the CO_2 footprint of the RUG staff commuting and RUG flight travel under seven hundred kilometres to seek for CO_2 neutrality depends on the type of traveling by employees for example by plane, car or train as well as the distances travelled and the time travelled. Those factors will determine the CO_2 emission and, therefore, the indented output that must be reduced. The reduced CO_2 output can, thereafter, be compensated by CO_2 compensations methods. Furthermore, the methods found must be implementable within the University. Therefore, the methods must comply to social, financial and reliable factors. Figure 2 describes this system.

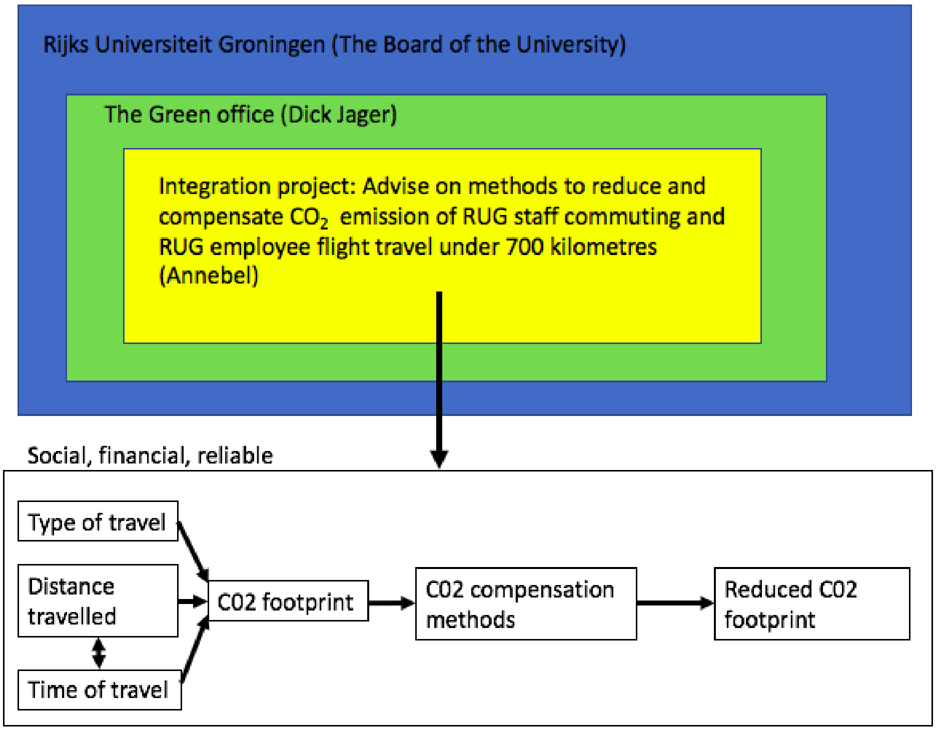

Figure 2: Scope and system of the project

2.7 Goal of research

Reduce the CO_2 footprint of the RUG to strive for CO_2 neutrality by providing recommendations of methods that reduce the CO_2 emission of RUG staff commuting and RUG flight travel under seven hundred kilometres and compensate the CO_2 emission of RUG staff commuting and RUG flight travel under seven hundred kilometres.

2.8 Research question and Sub questions

By how much tonCO_2 can the current CO_2 footprint of the RUG be reduced by applying methods that reduce the CO_2 emission of RUG staff commuting and RUG flight travel under seven hundred kilometres and by introducing CO_2 compensation methods by 2020?

Sub questions:

- What is the current CO_2 footprint of RUG staff commuting?
- What is the current CO_2 footprint of RUG flight travel under seven hundred kilometres?
- What are possible methods to reduce the CO_2 emission of RUG staff commuting?
- What are possible methods to reduce the CO_2 emission of RUG flight travel under seven hundred kilometres?
- What are possible compensation methods?
- Can those reduction and compensation methods be effectively implemented at the University?

Effectively depends on the following factors:

- Costs of the methods per tonCO_2
- The effects and reliability of the methods; how much tonCO_2 will be reduced and will the methods indeed reduce and compensate the tonCO_2.
- The efforts of the University; what is the implementation effort for the Green office and the adaption efforts of the employees?
- The feasibility of the methods; are the methods possible to be enforced by the University?

The methods in this report will be assessed on those factors.

3. Environmental effects of the transport sector

As earlier mentioned in this report fossil fuel burning accounts for about sixty three percent of the total atmospheric climate change. Within the transportation sector oil is a dominant fuel source and contributes for eighty-one percent of the total energy within this sector [7]. Transportation accounts for twenty-three percent of the total CO_2 emission and those shares will rise in the future [8]. Aviation and car use are the main contributors of this sectors CO_2 footprint. This depicts the great influence transportation has on the greenhouse effect and, thus, the atmospheric climate change. The Kyoto protocol understood that transportation was one of the main factors contributing to climate change and, therefore, since the start of the treaty political agendas of the countries who signed the agreement have been focused on transport. Unfortunately, at the beginning of the treaty they did not recognize the harming effects of the aviation sector and the upcoming growth, thus, this sector was left out of their political agendas [9].

3.1 Commuting

Commuting consist out of different transport methods. The most common ones used are cars, buses, trains and bikes.

3.1.1 Cars

In the transportation sector, car use is the second biggest contributor to greenhouse emission gasses and continuous to grow [7]. In the past decade car vehicle ownership, has risen rapidly. The annual growth of car ownership in OECD countries is 1,8% while in the rest of the world this is 4,5%. This reflects the relationship between income and car ownership [10]. The demand of car use is expected to grow as per-capital income continuous to grow. Although new alternative fuels like LPG and natural gas increase in popularity they are still carbon-based fossil fuels and considering the expected vehicle ownership growth, the CO_2 footprint of transportation is expected to grow if no reduction methods will be applied. Furthermore, car users find having a car convenient and eighty nine percent of the current car users would have difficulties living a lifestyle without one [11].

3.1.2 Buses

The bus is the most common alternative transport mode compared to the car, although, bus transport is still a very small percentage of the total transport sector [12]. The bus is a flexible transportation method and can quickly response to changing demands, furthermore it can be easily infused into the current infrastructure [7]. Currently, most buses are powered on diesel also producing CO_2 emission. However, considering a single bus can hold about forty-nine citizens, the CO_2 footprint per person will significantly decrease compared to a car. Table 1 portrays the emission per seat of buses and a normal sized car [12].

Table 1: CO_2 emission of different transportation modes

Mode	Seats	Kg CO_2 per km	Gram CO_2 per seat
Medium-sized car	5	3,5	78
Single Deck Bus	49	14,2	33

Table 1 clearly shows that the CO_2 footprint of a single person will decrease while using the bus as transport. Furthermore, buses are a tool to tackle congestions. Congestions is a cause of considerable CO_2 emission, since the engines are blowing but the car is not moving. The bus allows more people to make the same journey while generating less traffic and, thus, reducing congestions [13]. Conclusively, buses compared to cars are less polluting and is a more sustainable transport mode.

3.1.3 Railway

According to Shaw et al [14] railway is a real, reliable and safe alternative for the car. Railway is the most sustainable mode of transport, besides cycling and walking. It is considered four times more efficient than road transport and an ecological solution for short flights [7]. Moreover, it reduces road congestions and, thereby, CO_2 emission. Railway can be the solution for the high CO_2 footprint of the transportation sector. The use of oil to power railway travel has been decreasing over the last few years and the use of renewable energy and electricity has tripled [15]. In the Netherlands, the railway is fully sustainable and emission free [16]. Currently, a record number of passengers use the train and this trend must continue. To continue this movement behavioural stimulation is necessary and the rail infrastructure must be able to handle the increase in demand [17].

3.1.4 Cycling and walking

Cycling and walking produce a zero-carbon footprint and are the friendliest solutions for personal transport. This transport mode is, however, decreasing over the last twenty years due to recent car movements and can only be used for short distances. The upcoming trend of Ebikes is, however, a great alternative for bikes.

3.2 Aviation

Aviation is a cause for environmental concern. Aviation is essential for the world's economic system and the economic growth has been the main factor for an increase in business flights and results in more money for holidays [18]. New airport regulations in Europe has led to a sharp expansion of budget airlines serving short distance flights [19]. The highest quantity of CO_2 emission is during the ascent, which means that shorter flights will emit more CO_2 per kilometre than longer flights. Therefore, the increase of short distance flights has led to an increase of CO_2 emission within the aviation sector. Furthermore, airplanes emit gases such as CO_2 and NOx directly into the upper and lower stratosphere. Those gases influence the atmospheric chemistry resulting in climate change due to radiative forcing [20]. The impact on the environment is dependent on the latitude of the aircraft. CO_2 emissions are equally harmful at all height levels and mix with the atmosphere. Other gases like NOx do not mix with the atmosphere resulting in radiative forcing. The latitude of the aircraft determines the effect of the radiative forcing. For example; NOx emissions in the upper troposphere will have a stronger effect on radiative forcing than at the surface [7]. Conclusively, the emission of CO_2, the emission of other harmful gases causing radiative forcing and the rapid growth of flight departures makes the aviation sector a relevant environmental concern.

4. Analysis of the current CO_2 emission generated by RUG staff commuting and RUG flight travel under seven hundred kilometres

4.1 Analysis of the current CO_2 emission generated by RUG staff commuting

Over 2017 the CO_2 footprint of staff commuting is determined to be 3000 tonCO_2. Unfortunately, while working with the calculation tool to analyse the data of staff commuting different CO_2 footprints resulted from the same input zip codes of the employees. The zip codes used were the same zip codes inserted for the calculation of the 3000 tonCO_2, thus, assumed was that this number would have followed, however, while repetitively filling in the same zip codes different outcomes appeared. Those differences were up to 84%. This is inaccurate and not correct. Pieter Tjabbe, the manufacture of the CO_2 footprint calculation tool of the University is working on solving this problem. Advised is to check the calculation tool on its correctness, this will be explained in *chapter 5*. Unfortunately, due to the inconsistencies of the calculation tool no correct quantitative analysis on the CO_2 footprint of staff commuting can be executed, however, still a qualitative advice on reduction of CO_2 emission for commuting can be provided. In *Appendix A (Calculation of the RUG staff commuting CO_2 footprint)* the calculation of the RUG staff commuting CO_2 footprint over 2017 is explained.

4.2 Analysis of the current CO_2 emission generated by RUG flight travel under seven hundred kilometres

The current CO_2 emission of RUG flight travel over 2017 is calculated based on the available data of all RUG flights in 2017. In 2016 the University decided to book all flights at the travel management agency; ATPI. Consequently, the University can request detailed information about all flights booked at the agency providing data about all RUG flights. The data provides information about; the departure airport, destination airport, the faculty booking the tickets, the amount of tickets booked, the number of miles per flight, the number of kilometres per flight, the routing and the CO_2 emission per flight. This data is provided in an excel sheet.

4.2.1 Calculation of the total CO_2 footprint of RUG flight travel

To calculate the CO_2 footprint of RUG flight travel, the data is split into three categories; flights under 700 km, flights in-between 700-25000 km and flights above 25000 km. The data is split into those categories because the compensation factor differs at different distances. Short flights are more polluting than longer flights and, therefore, emit more CO_2 per kilometre. Thereupon, different compensation factors are established. Table 2 provides data on the total kilometres per category and their corresponding tonCO_2.

Table 2: CO_2 footprint of RUG flight travel

Category	**Kilometres**	**Compensation factor (kg/km)**	**tonCO_2**
<700km	292055	0,297	87
700km-25000km	30320955	0,2	6064
>2500km	1800689	0,147	265
Total	32413699	-	6416

4.2.2 Calculations of the CO_2 footprint of RUG flight travel under seven hundred kilometres
The total tonCO_2 of flight travel under seven hundred kilometres is 87 tonCO_2, which is 1,35% of the total CO_2 footprint of RUG employee flight travel. The number of flights that construct the total number of kilometres under seven hundred kilometres is 555. To analyse the CO_2 footprint of RUG employee flight travel under seven hundred kilometres, the total corresponding flight are divided into three categories:

1. Departure flights from Amsterdam, Eindhoven or Groningen airport
2. Arrival flights at Amsterdam, Eindhoven or Groningen airport
3. Other RUG flights under seven hundred kilometres

Those categories are established since it is easier to influence the behaviour and transport method of RUG employees if they depart and arrive at Dutch airports. Other RUG flights under seven hundred kilometres are for example flights from Shanghai to Being. Figure 3 portrays information about RUG flight travel under seven hundred kilometres and the corresponding categories.

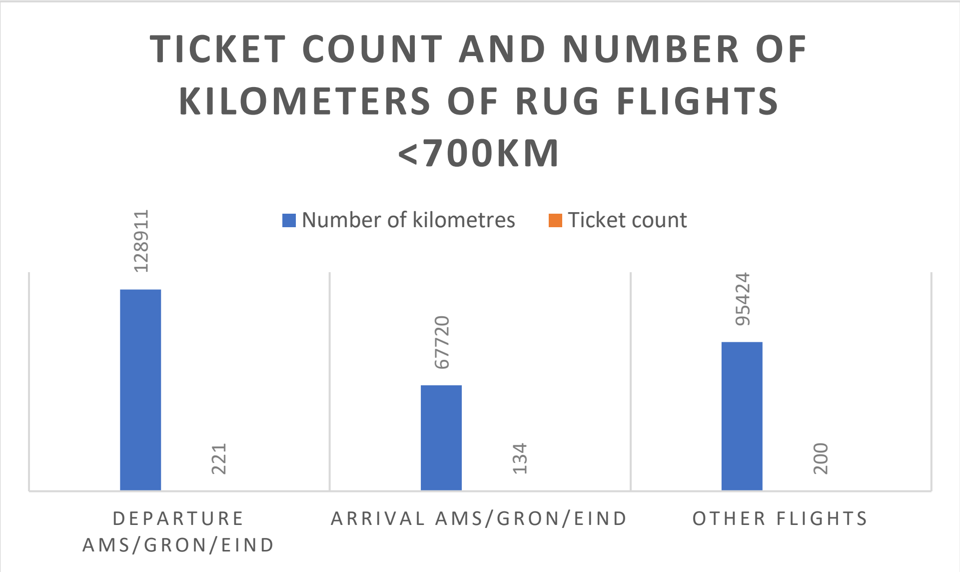

Figure 3: ticket count and number of kilometres of RUG flight travel under 700 kilometres

Departure from Amsterdam Airport
As observed in figure 3, flights that depart from Amsterdam, Eindhoven or Groningen hold the largest number of kilometres and amount of flights. The 221 flights that depart from Amsterdam, Eindhoven or Groningen visit twenty-four different cities. In *Appendix B (Flight information on RUG flights under seven hundred kilometres that depart from Groningen, Eindhoven and Amsterdam airport)* all flights are depicted. The percentage of flights that depart from Eindhoven and Groningen is just six percent and, therefore, neglected in this research. For analysis of this category, the flights are divided based on their destination. The destinations with five or more flights incoming from Amsterdam are evaluated and all destinations with less than five flights are combined into one category: others. In figure 4 the number of kilometres and ticket count per destination for the flights that depart from Amsterdam airport are depicted.

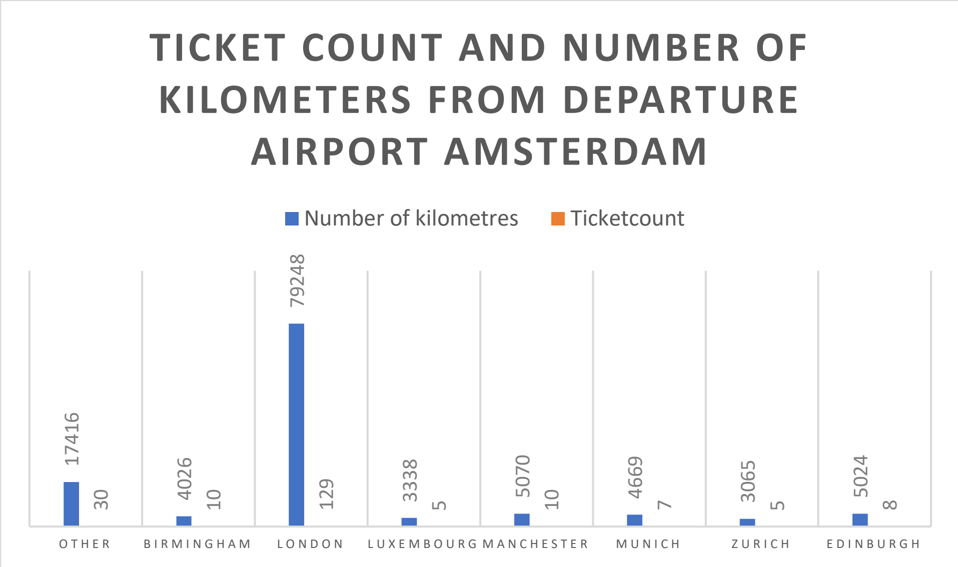

Figure 4: Ticket count and number of kilometres per destination that depart from Amsterdam airport

Figure 5 depicts information about the percentages of number of kilometres per destination that depart from Amsterdam airport. This portrays that London is the top destination of RUG flights under seven hundred kilometres that depart from Amsterdam.

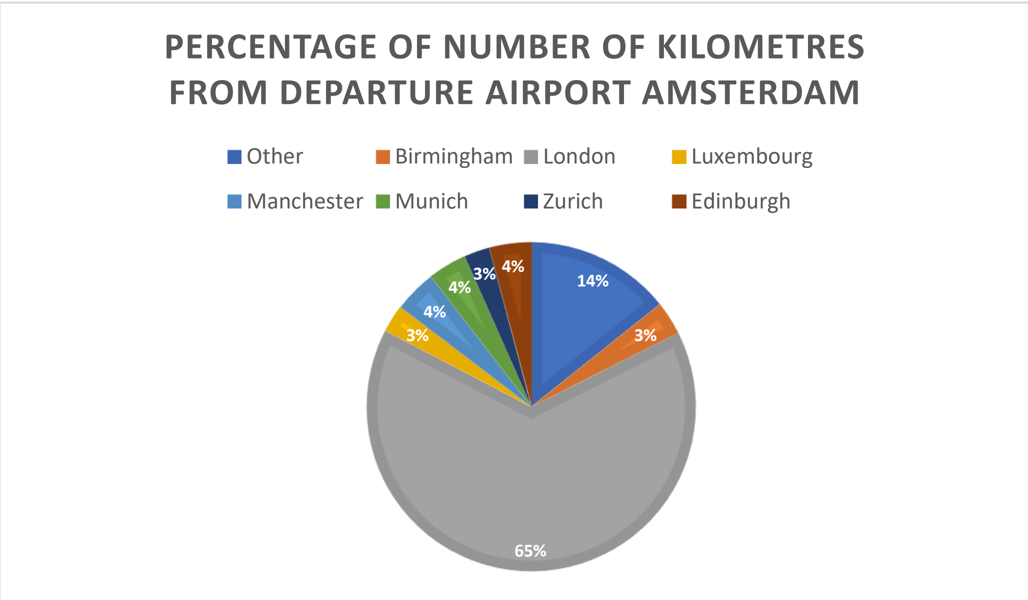

Figure 5: The percentages of number of kilometres per destination that depart from Amsterdam.

Arrival at Amsterdam Airport
As observed in figure 3, flights that arrive at Amsterdam, Eindhoven or Groningen hold the smallest number of kilometres and amount of flights. In *Appendix C (Flight information on RUG flights under seven hundred kilometres that arrive at Groningen, Eindhoven and Amsterdam airport)* all flights are depicted. Just like departure flight, the arrival flight that arrive at Groningen and Eindhoven is a small percentage and, therefore, neglected. The flights are divided into categories based on their destination. The arrivals with five or more flights

arriving at Amsterdam, are evaluated and all arrivals with less than five flights are combined into one category: others. In figure 6 the number of kilometres and ticket count per destination that arrive at Amsterdam airport is depicted.

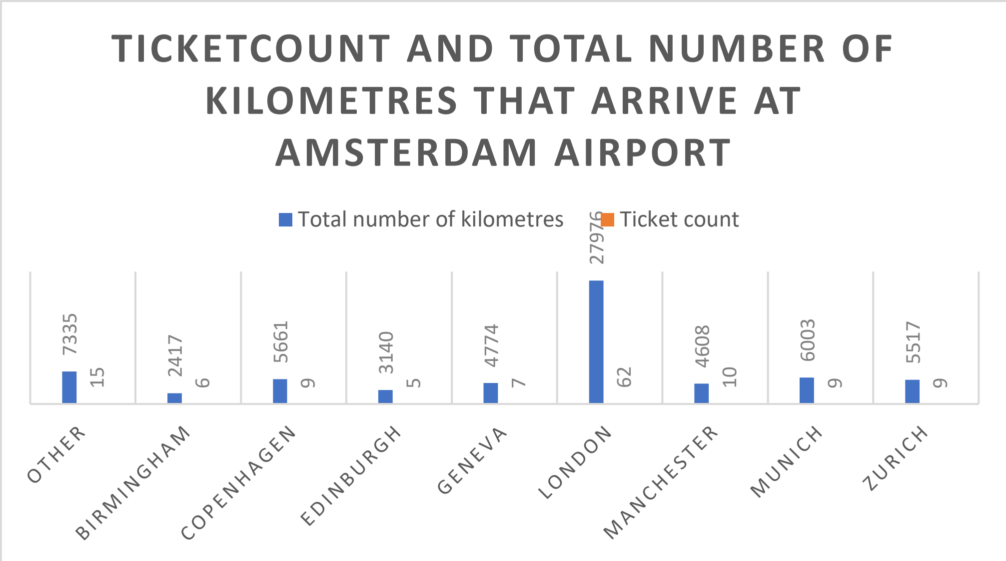

Figure 6: The percentages of number of kilometres per destination that arrive at Amsterdam.

In figure 7 the percentages of kilometres per destination that arrive at Amsterdam airport are depicted. Hereby, it is shown that especially many flights arrive at Amsterdam that depart from London airport. The rest of the cities are equally divided.

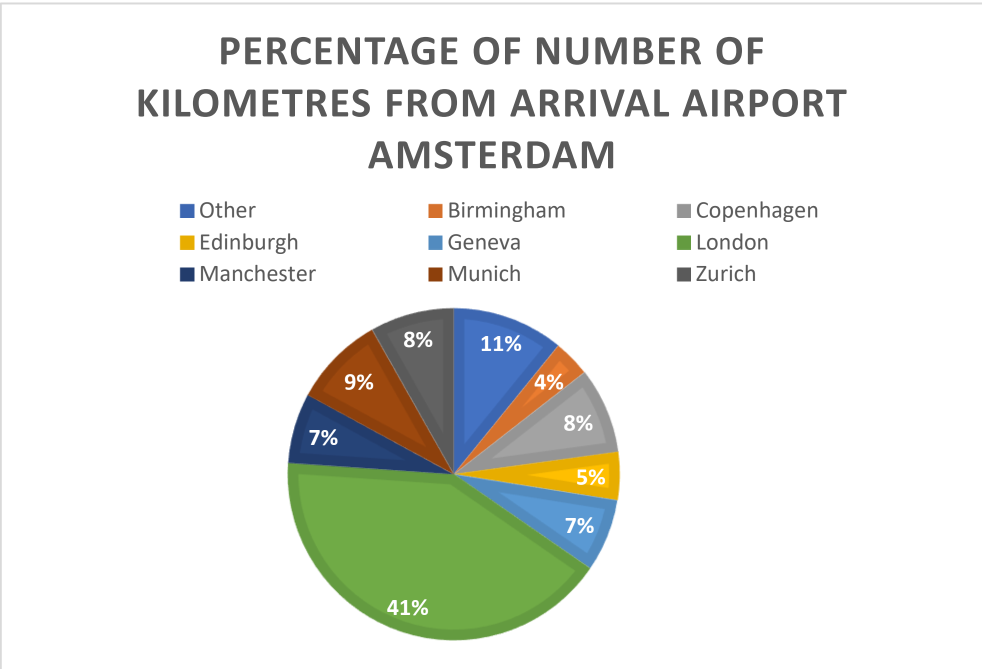

Figure 7: The percentages of number of kilometres per destination that arrive at Amsterdam.

Other RUG flight under seven hundred kilometres

The other flights of the RUG, that do not arrive or depart from Dutch airports are less useful to analyse because most of those flights are unique. All flights with a specific departure and destination airport and booked more than five times are shown in table 3. The other unique flights make up a ticket count of 138. Those 138 flights consist out of unique inland flights in all different continents.

Table 3: Information on other RUG flight travel under 700 kilometres

Departure	Destination	Ticket count	Number of kilometres
Yantai	Beiing	25	11374
Being	Yantai	22	12925
Yantai	Changhai	7	4837
Other	Other	138	62419

The table portrays that Yantai ←→ Being is a commonly used flight route for RUG flight travel.

5. Recommendations for the RUG on reduction methods

5.1 Validate Calculation tool

Firstly, to reduce and compensate CO_2 emission of an organization it is essential that the CO_2 footprint is calculated correctly to acknowledge how much CO_2 emission must be reduced and compensated. While working on this project, I have already faced several mistakes concerning the calculation tool. As explained in *chapter 5*, the calculation tool used for commuting provides different CO_2 footprint outcomes, while using the same zip codes, thus, the same distances. I have also identified a mistake concerning the CO_2 footprint of RUG flight travel resulting in a footprint of 6416 tonCO_2 instead of 5463 tonCO_2. This is a considerable difference of 953 tonCO_2. For the final calculations of RUG flight travel, the University assumed that all flights arriving at a certain destination airport, departed from a Dutch airport. Thereafter, they determined the distance of those flights and categorized them based on the following distances; 700km, 700-25000km and above 25000 km. This was not correct because not all flights departed from Dutch airports but also from other airports within the world. This resulted in different kilometres per category, which culminated in a different CO_2 footprint because of the different compensation factors per category. Therefore, advised is to either ask an expert to validate the calculation tool again and solve the mistakes or ask a carbon offset company to recalculate the CO_2 footprint of the RUG using their own professional calculating tools. One of these options is necessary to solve the miscalculations and to prevent wrong calculations of the CO_2 footprint in the future.

5.2 Reduction methods for commuting

Commuting is a worldwide phenomenon. Citizens need to get from home to work and desire this transportation method to be quick and cheap. Most of the inhabitants around the world, believe the car is the most convenient commuting transportation method. Fifty-one percent of the citizens that choose the car as transport method also have easy access to public transport [21]. Among citizens, car use is perceived more positively compared to public transport. Public transport is commonly perceived negatively or neutral. Even citizens that hardly drive a car, prefer a car over public transport [22]. Unfortunately, car use is a very polluting transport method as explained in *chapter 3* and contributes to the high CO_2 footprint of the transportation sector. Therefore, reduction methods must be applied to counteract those high emissions.

As explained in *chapter 4* the calculation tool of commuting was not valid and, therefore, no quantitative analysis on the data could be performed. Therefore, the advice given on reduction methods will mostly exist out of incentives and policies the University can implement to reduce the emission of staff commuting rather than a quantitative analysis based on the factors described in *chapter 2*. Furthermore, advised for the University is to remove the commuting CO_2 footprint of their total CO_2 footprint. The CO_2 emission of staff commuting fits within the personal CO_2 footprints of their employees just like buying groceries and going to the gym fits within their own CO_2 footprint and not contributes to the CO_2 footprint of the grocery job or gym. Recommended is to keep calculating the CO_2 footprint of staff commuting to see if the incentives and policies inserted reduces CO_2 emission but not to use it for calculating their own CO_2 footprint. General commuting reduction methods are described in *Appendix D (General reduction methods to reduce CO_2 emission of commuting).* Several of those reduction methods can be implemented by the University and they are described below. Some of these methods are also inspired on the report "CO_2 effects of different transport methods"[23]. This reports describes and interpreters results of commuting reduction methods applied by forty large NGO's like NUON, Deloitte and Shell. Therefore, advised for the RUG is to read this report because it will provide detailed information and results of commuting reduction methods.

5.2.1 Shift to other transport methods than car use

A shift to other transport methods than car use will decrease the commuting CO_2 emission. Insertion of reduction policies can form as an incentive for employees to use other transport methods than cars. This can be achieved by making car use less attractive or conceiving a shift towards bike travel or public transport

Make car use less attractive

By making car use less attractive other transport modes will become more attractive. Parking costs and parking policies are approaches that might achieve this. Inserting parking costs for employees might motivate employees to use public transport. For the forty NGO's this policy was very effective and decreased the CO_2 emission by nine percent. Inserting this policy might create resistance of the employees. Therefore, inserting this method with a reduction mechanism is advised. Thus, for example provide forty percent free parking the first year after inserting parking costs and thirty percent free parking the next year until it is decreased to zero. This way the method will be less radical for employees. If this method will result in less parking spaces needed, the left-over space can be used alternatively. Since, the possible reduction of parking spaces is generated by sustainable reasons, recommended is to also use the left-over space for sustainable purposes like setting up more sun panels. Furthermore, less maintenance costs for parking spaces is needed and the parking costs provides money. Recommended is to use this money to provide free public transport for employees or invest in sustainable energy projects. In the "CO_2 effects of different transport methods" report is examined that on average one OV 2nd class under fifteen kilometres is estimated to be the same costs as providing one employee with a parking place, thus, this will be a great alternative. Furthermore, reducing the amount of parking spots or extending the number of kilometres at which employees are eligible for a parking place form the same incentive. Currently, employees receive a parking place at Zernike if they live more than eleven kilometres away and in the city centre if they live more than seven kilometres away, the University can increase this to decrease parking spaces and decline car use. Furthermore, a limit on the maximum distance for receiving a parking spot for example fifty kilometres will also reduce parking spaces, thus, advised is to also set a maximum distance for receiving a parking sport.

Shift to bicycle use

Another method is promoting bicycle use. The shift to bike travel is preferred, since this is the least polluting transport method. Several policies may be inserted to achieve this. Firstly, providing bike services is an option. The University already provides bike services for their employees. Moreover, it also provides several e-bikes for example the Green office is equipped with an e-bike. Advised is to provide the employees with more e-bikes. If employees have an important meeting in the city centre and must quickly transport from Zernike to Groningen city centre, employees might prefer to take public transport or the car. The e-bike is the solution for sustainable but quick and free transport. Furthermore, advised is to promote interest-free loans for bikes or electrical bikes. "Het nieuwe fietsplan" gives companies the opportunity to provide employees with a bike allowance of nineteen cent per kilometre tax free [24]. The employees are able to pay of their bike or e-bike with the bicycle compensation they receive from the University. This initiative provides the University with the opportunity to pay a fixed amount of money per month to the employees based on the amount of days an employee works and the distance an employee travels, thus, no difficult administration is necessary. The interest-free loan also has no specific conditions of the government; thus, the University is free to provide it to the employees. This will form as a great incentive for bike travel.

Shift to public transport use.
A shift to public transport use can be achieved by providing cheap or free public transport for the employees. The NS (Nederlandse Spoorwegen) currently provides the NS-business collective. The NS- business collective provides unlimited train travel for a fixed amount. It, thus, accommodates unlimited travel for the employees, both for work and private use. This forms as an incentive for employees to personally take the train more often reducing their personal CO_2 footprint. No administration burden is necessary because of the fixed amount per year. The price for the upcoming year is calculated based on how much the company has spent on public transport the previous year. You will, however, never pay more than the distance travelled by train, thus, if travelled less than the fixed amount, money will be returned. An unlimited travel card monthly costs 333 euros and multiplying this by 10 working months will result in 3330 euros per employee. This will cost the University 3330* 5898 about 19.5 million euros per year. The fixed cost might, however, be different while working with the NS-business collective and setting up a contract. Therefore, advised for the University is to contact the NS for this offer. Based on investigation a sixty-six percent increase of train use by employees is created by the NS- business collective. This option is obviously too expensive to be inserted for all employees, therefore, other NS-discount cards might also be a possibility. An option is the trajectory based NS card, which provides free travel for a specific trajectory, which in this case will be the commuting route of the employees and forty percent discount for other routes. The price of a trajectory discount card will be based on the distance of the free trajectory. At the moment, the University provides a trajectory discount card for the area Drenthen this can be extended to other trajectories. The last option is a ‘normal’ discount card providing twenty percent discount at peak hours and forty percent at non-peak hours. This costs 22 per month thus 220 per year, resulting in 1.3 million euros per year for all employees. Conclusively, providing all employees with discount or free NS cards is still expensive. Therefore, advised is to offer this to specific employees. For example; if the University decides to limit parking spaces for employees that live further than sixteen kilometres away and closer than for example fifty kilometres away, the employees that do not receive a parking spot receive a discount NS card and the employees that receive and want a parking spot do not. If parking costs are inserted this also provides part of the money for discount cards. This can be calculated based on the number of employees that receive a parking spot and multiplied by the parking costs. Thus, the University must decide which employees are eligible for receiving a discount card for railway travel and if it is financially possible. Furthermore, it can also increase the allowances for public transport commuting. Currently the employees receive between four and six cents for both car commuting and public transport commuting. Recommended, is to increase the allowance for public transport commuting, forming an incentive to use public transport.

5.2.2 Sustainable car use
If employees, after the reduction methods above still decide to commute by car, the University must try to make them travel more sustainable. Providing more charging points for electrical vehicles will stimulate electrical vehicles use by employees. Moreover, recommended is to insert a fuel budget for the employees. If the employees stay below this budget they earn a reward. This will stimulate them to drive more sustainably. This reward might be in the form of a certain price per litre spared. Currently, the University has five company cars. Replacing those five company cars with electrical cars or if financially not

possible with newer and more sustainable cars will reduce CO_2 emission. This does not fit within commuting, but it is a method to reduce organizational CO_2 emission.

5.2.3 Behavioural campaign
The results of the methods described above all rely on awareness of employees about the methods. Therefore, awareness must be created and this can be achieved by behavioural campaigns. In those campaigns the importance of sustainability must be made clear and the employees must understand that small behavioural changes will have great effects. In those campaigns the possible reduction methods which the University offers should be explained like the possibility of a bicycle loan or the fuel budged. Described in the "CO_2 effects of different transport methods" report all the results of the reduction methods implemented are better while advocating it with a behavioural campaign. Furthermore, those campaigns can also inform the employees on the positive effects of carpooling or promoting teleworking, both are methods that also reduce CO_2 emission. Behavioural campaigns should not only be used for the reduction of commuting emission but also for the University's own company transport.

5.3 Reduction methods for employee flight travel under seven hundred kilometres
Aviation is considered a very polluting transport method. Airplanes do not only emit CO_2 gases, but also emit other damaging gases causing radiative forcing. The economic and social dependence on the aviation sector and the rapid growth make it an even bigger issue. To diminish the harmful accoutrements of the aviation sector, either the CO_2 emission per passenger must be reduced or limits on air travel must be set. A method to limit air travel emission was introduced during the triennial meetings of the UN Civil Aviation Organization(ICAO). During this meeting in Montreal an agreement was set in which the international aviation sector will be compensating the increase in CO_2 emission with effect from 2020. All major aviation countries like the US, China and European countries participate in this agreement [25]. This method, however, does have flaws. The agreement is on voluntary basis, which does not obligate the parties to honour it. Therefore, more reduction methods must be applied to counteract the damaging emission caused by aviation. Other general reduction methods for flight travel are described in *Appendix E (General reduction methods to reduce CO_2 emission of flight travel)* The advice provided for the University is based on those methods. The applicable methods are described below.

5.3.1 Optimize air capacity and improved technology
The University cannot directly influence the air capacity and improve technology of airplanes. It can, however, book flights at airlines that fly most efficiently. Several reports on airline efficiency have been released over the last few years. Atmospheric Airline index 2017 is one of those reports [26]. In this report airlines are ranked based on their efficiency. The airline with the highest efficiency will emit the lowest CO_2. The efficiency is ranked from classes; A to G. Airlines that fall in class A are most efficient and in glass G least efficient. The efficiency ranking is based on the following weighted factors: the type of airplane, engine, wing structure, seating capacity, cargo capacity, cargo occupancy and seat occupancy. Air occupancy and the type of airplane are the highest weighted factors with thirty-one and forty-eight percent influence and the wing structure and engine the lowest with two and three percent influence. In this report the flights are divided upon length. One of the categories is short haul flights up to 800 kilometres. For short haul flights up to eight hundred kilometres the best airlines fall in class C. All airlines that are the most efficient airlines for flights under eight hundred kilometres are depicted in Appendix C. For short haul flights; China West

airways and TUI fly are the best options. They fly with very efficient aircrafts and have high occupancy rates. Recommended for the University, therefore, is to fly with one of the airlines depicted in *Appendix F (Most efficient airlines for flight travel under eight hundred km)* for flights under seven hundred kilometres.

Costs per tonCO_2

The costs for this method are difficult to determine. It is not possible to predict if the efficient airlines provide the desired RUG flights at the desired dates. In the future, the University desires to continue cooperating with ATPI because in the previous year's the collaboration was experienced successful. The University must ask or demand ATPI to book flights under seven hundred kilometres at the airlines described in *Appendix F (Most efficient airlines for flight travel under eight hundred km)*. The Atmospheric Airline index 2017 also provides information on the most efficient airlines of flight more than eight hundred kilometres, thus, this method can also be applied for those flights. Moreover, it is important that the price of those flight is not substantially more expensive than the flights ATPI would have booked otherwise, thus, requesting an offer for those alternative flights is important.

The effects and reliability of the method

The effects of this method are difficult to quantify. It is not possible to perfectly quantity the reduced CO_2 emission of flying with more efficient airlines since it also depends on the specific flight. For example, the specific occupancy of the flight will have effect on the CO_2 footprint per passenger.

The efforts of the University and employees

The efforts of the University are minimal. They only need to communicate the efficient airlines they desire to fly with. ATPI must, thereafter, put in some effort to book the flights at the corresponding airlines. The University must, however, keep track of the airlines the employees are flying with, thus, monitor if ATPI is booking the flights at those efficient airlines.

The feasibility

This method is feasible for the University. The airlines efficiency, however, might change over the years. Therefore, advised is to keep track of the most efficient airlines.

5.3.2 Emission ceiling

Emission trading is an incentive to reduce and minimize emission of countries and organizations. The University might be able to introduce emission trading within the University or set an emission ceiling for flight travel. Recommended is to introduce this for all flights and not just for flights under seven hundred kilometres because that will have minimum effect. Currently RUG flights emit 6416 tonCO_2, to become CO_2 neutral this must be reduced and compensated. The University strives for CO_2 neutrality by 2020, thus, it would be best to set goals on how much the CO_2 emission must be reduced by 2020. Table 4 shows an example of introducing an emission ceiling for RUG flight travel. This is just an example, since the University must decide what their reduction target will be. In this example, assumed is that the CO_2 footprint over 2018 is the same as over 2017. In case that the University has the goal of reducing RUG flights with 1500 tonCO_2 by 2020, the emission must be reduced by 750 tonCO_2 every year. This will provide emission ceilings for RUG flight travel for the upcoming years. The emission ceilings will be divided over the corresponding eleven faculties of the University. This is a voluntary emission ceiling and not binding for the faculties, however, this way they are aware that the University desires them reduce the emission. It is important that the faculties are aware of how much CO_2 is emitted per flight so that they recognize when they will reach their ceiling. Therefore, assigning an individual per faculty that keeps track of the total emitted CO_2 for flight travel is essential for this method to work. Trading or communication between faculties is also imperative. If a certain faculty believes it will cross their CO_2 ceiling they might contact another faculty asking for their credits. This method will create awareness among faculties of the RUG sustainability goals. To efficiently implement this method, the University should provide the faculties with an advisory document on how to decrease emissions for flight travel. Bartje Alewijnse's thesis and my own thesis can be used as an example to set up this document.

Table 4: Emission ceiling and trading system for RUG flight travel

Current CO_2 footprint over 2017/2018	6416 tonCO_2
Desired CO_2 footprint in 2019	6416-750= 5666 tonCO_2
CO_2 emission ceiling per faculty in 2019	515 tonCO_2
Desired CO_2 footprint in 2020	5666-750= 4916tonCO_2
CO_2 emission ceiling per faculty in 2020	447 tonCO_2

Costs per tonCO_2
This method requires zero costs.

The effects and reliability of the method
If the faculties are willing to put effort into this method and take the CO_2 ceiling seriously the effects of the method will be the reduction the University desires. For illustration, in the example shown in Table 4 a reduction of 1500tonCO_2 will be achieved by 2020. This ceiling, however, must be set by the University. If the faculties find it difficult to stay below the emission ceiling or if it is operationally not possible, the reduced CO_2 over 2018 can still be identified. The University can request the number of kilometres travelled over 2018 and calculate the emission per faculty showing the difference over 2018 compared to 2017. If a specific faculty enormously cross their ceiling, a consultation with this specific faculty must be set. In this consultation, the reasons for the high CO_2 emission can be discovered and possible reduction plans can be constructed.

The efforts of the University and employees
This method requires effort of both the University and the employees. The Green office must put in effort to correctly set up this method by creating a document that provides the faculties with reduction methods. Furthermore, good communication skills are needed to pursued the faculties of the importance of this method and to clarify it. Each faculty must assign an employee that keeps track of their flight CO_2 emission and that communicates with the Green Office. The employee also communicates with the faculty on the possible reduction methods and on the state of their CO_2 emission for flight travel. Conclusively, this method is time intensive for the Green office and some employees.

The feasibility
This method is feasible within the University; however, it does require good communication skills and an active approach of both the University and the employees.

5.3.3 A shift away from air travel to railway travel

A shift away from air travel towards railway travel will reduce the CO_2 footprint of RUG flight travel. Citizens are willing to take the train at a distance below seven hundred kilometres if it is not considerably more expensive or takes much more time [39]. Moreover, bus travel was also considered an alternative option for RUG flight travel, however, the duration of the shortest trip to London is 12 hours. A flight trip to London takes 6 hours, so taking the bus will take twice as long which is not feasible. Recommended for the University is to force employees to take the train if it is financially possible and durational attainable to reduce the CO_2 footprint. Table 5 depicts a table that provides the cost, duration and CO_2 emission of flight and railway travel from departing station Amsterdam Central to a specific destination. The destinations are chosen based on the findings of *chapter 4*. This section portrays the most popular arriving and departing airports that depart or arrive from Amsterdam. Unfortunately, the costs of the RUG flights could not be provided by the University so the costs are based on averages found on vliegtickets.nl. The costs of the train tickets are based on prices provided by the NS and Eurostar. Furthermore, the duration of the flight trips is calculated based on the duration of the flight, duration of the train ride from Groningen to Amsterdam and the duration of the flight procedure like passport control. The time for the train journey and flight procedure is estimated to be 5 hours. The duration of the train trip includes the train journey from Amsterdam to Groningen and the train journey from Amsterdam to the specific destination. The CO_2 emission is calculated based on the kilometres of the trip and the different conversion factors. For flight travel this factor is 0,297 and for railway travel 0,006.

Table 5: Comparison of train and railway travel for RUG destinations under 700 kilometres

Destination	**Average cost flight (euros)**	**Duration flight**	**Duration journey**	**CO_2 emission flight (ton)**	**Average cost train (euros)**	**Duration journey**	**CO_2 emission train (ton)**
London	60	01u 15m	06u 15m	0,20196	80	7u	0.00408
Birmingham	70	01u 15m	06u 15m	0,1188	130	13u	0,0024
Luxembourg	180	01u	06u	0,197802	80	8u	0,003996
Manchester	70	01u 20m	06u 20 m	0,136917	130	12u	0,002766
Munich	70	01u 30m	06u 30m	0,198099	70	10u	0,004002
Zurich	70	01u 30m	06u 30m	0,182099	100	12u	0,003678
Edinburgh	70	01u 30 m	06u 30m	0,186517	140	11u	0,003768
Copenhagen	100	01u 15m	06u 15m	0,13959	150	13u	0,00282
Geneva	100	01u 20 m	06u 20m	0,202554	120	11u	0,004092
	Average price: 88				Average price:100		

Table 5 depicts that railway travel for destinations; Birmingham, Manchester, Edinburgh, Zurich, Copenhagen and Geneva takes very long. The duration of the train journeys take twice as long compared to flight travel. Therefore, advised is to keep flying to those destinations. Moreover, Munich, Luxembourg and London are possible destinations that can be travelled by train. For Munich, train travel takes three and a half hours longer which is still is a considerable number and for London and Luxembourg it takes about one or two hours longer. In conjunction, working in a train is more functional than working while flying. Flying consists of more waiting lines, passport controls, possible bag check-ins that takes time away from operating. Table 6 depicts the total cost of flights and CO_2 emission for railway and aviation. The costs of flights are calculated based on the number of flight departing and arriving at the specific destination that departed or arrived at Amsterdam airport and multiplied by the average price given in table 5. The CO_2 emission is calculated based on the total kilometres per destination and the compensation factors.

Table 6: Costs and CO_2 emission on flight travel and railway travel for destinations: London, Munich and Luxembourg

	Flight travel	Railway travel	Difference
London			
Cost (euros)	11460	15280	
tonCO_2 emission	31,8	0,64	
Luxembourg			
Cost (euros)	900	400	
tonCO_2 emission	0,9	0,02	
Munich			
Cost (euros)	1470	1659	
tonCO_2 emission	3,2	0,06	
Total cost (euros)	13830	17339	3509
Total tonCO_2 emission	35,9	0,72	35,2

Costs per tonCO_2

As depicted in table 6 the total extra costs for taking the train for those destinations will be about 3500 euros. The University must decide whether this fits in their budget. The total costs might differ because the calculations are based on averages. The price will increase by twenty-five percent using railway travel compared to flight travel. The cost per tonCO_2 is, however, lower for railway travel since the CO_2 emission decreases with a factor of forty-nine and the price increase with factor of ¼.

The effects and reliability of the method

Using railway for trips to London, Luxembourg and Munich decreases the CO_2 footprint with 35,2 tonCO_2. The duration and price of the railway trips might differ per journey and become costlier in a specific season or at a specific time. Furthermore, the duration for some journeys might take longer or shorter due to inefficient or efficient changes. However, the same applies for flight travel. Thus, advised for the University is to first examine if railway travel is possible and if not use flight travel. Some rules concerning this decision must be set by the

University. For example; flight travel for those three destinations is only applicable if railway travel exceeds a duration of x hours and a price of x euros.

The efforts of the University and employees
The efforts of the University and employees are minimal. The extra effort is examining possible railway journeys to London, Luxembourg and Munich before contacting ATPI to book a corresponding flight if the journeys are not available.

The feasibility
The method is feasible, since it requires little effort and no substantial investment. Nonetheless, if the University compensates the 35,2 tonCO_2 it will only cost them about 140 euros. The 140 euros is calculated based on taking the average price of a Gold standard project which is four euros and multiplying it with 35,2 tonCO_2. Implementing this method will reduce the CO_2 footprint of flight travel under seven hundred kilometres with forty percent which is a high factor, however, if comparing it to the total CO_2 footprint of RUG flight travel it will only reduce it by a half percent. Therefore, the University must decide whether they find this method operable or too expensive and time intensive compared to the relatively small reduction. Advised for the University is to travel with the train if it is feasible for the employees and the University, since reducing CO_2 emission is always better than compensating. Compensating should primarily be used for unaccountable CO_2 emission. Especially for journeys to London, railway travel should be examined since for flight travel under seven hundred kilometres London is the most popular destination and the price and duration increase compared to flight travel is minimal as shown in table 6.

5.3.4 Communication technology
Communication technology might be able to replace some travel journeys for the University. Communication technology fully reduces the CO_2 emission of a specific journey, since it is a replacement for travelling. Firstly, the University must decide what appointments can be replaced by communication technology. For example, congresses might be difficult to replace by for example skype conferences but a business meeting of a few hours could. Furthermore, the University must make sure that the conditions for telecommunication are of good quality, otherwise, travelling will surely be preferred above communication technology. Therefore, the University must establish high quality technology and Wi-Fi network to skype without external interruptions. Several companies exist that provide help in video conferencing. An example of such company is Video Butler. Recommended, is to contact such a company to either ask for advice or cooperate with. Advised for the University, it to replace journeys that are possible to be reinstated by telecommunication because it will be economically and environmentally beneficial for the University.

Costs per tonCO_2
There are no costs per tonCO_2 because no CO_2 is emitted while using this method. Possible investments are an improvement of the communication technology within the University. Furthermore, the cost of travelling will be eliminated by this method.

The effects and reliability of the method
Communication technologies will totally reduce the CO_2 emission of travelling and, therefore, has significant effect on the CO_2 footprint of RUG flight travel under seven hundred kilometres. If in the upcoming years the replaced journeys by telecommunicating are monitored, the University can determine the reduction of the CO_2 footprint due to this method.

The efforts of the University and employees
There are no or little efforts for the University and employees. Furthermore, skyping will result in less time and effort for the employees concerning their appointment since travelling is eliminated. Travelling is exhausting and this time can now be spent on productive work or on preparation for their skype meeting.

The feasibility
Telecommunication for specific appointments of employees of the RUG is feasible. Some employees might find skyping less convenient than meeting in person. Therefore, a good explanation about the reasons for inserting telecommunication and the effects should be explained to the employees to create less resistant's' towards this method.

5.5 Conclusion on reduction methods for RUG flight travel under seven hundred kilometres
In conclusion, to reduce the CO_2 footprint of RUG flight travel under seven hundred kilometres the University must apply several reduction methods described above. Firstly, it must determine whether an appointment can be replaced by telecommunication instead of travelling. Secondly, if this is not possible examine if railway travel is possible for the specific journey and lastly if flying is necessary do it as efficient as possible. Thereafter, the emission of RUG flight travel under seven hundred kilometres that could not be avoided must be compensated. This decision process is described in figure 8.

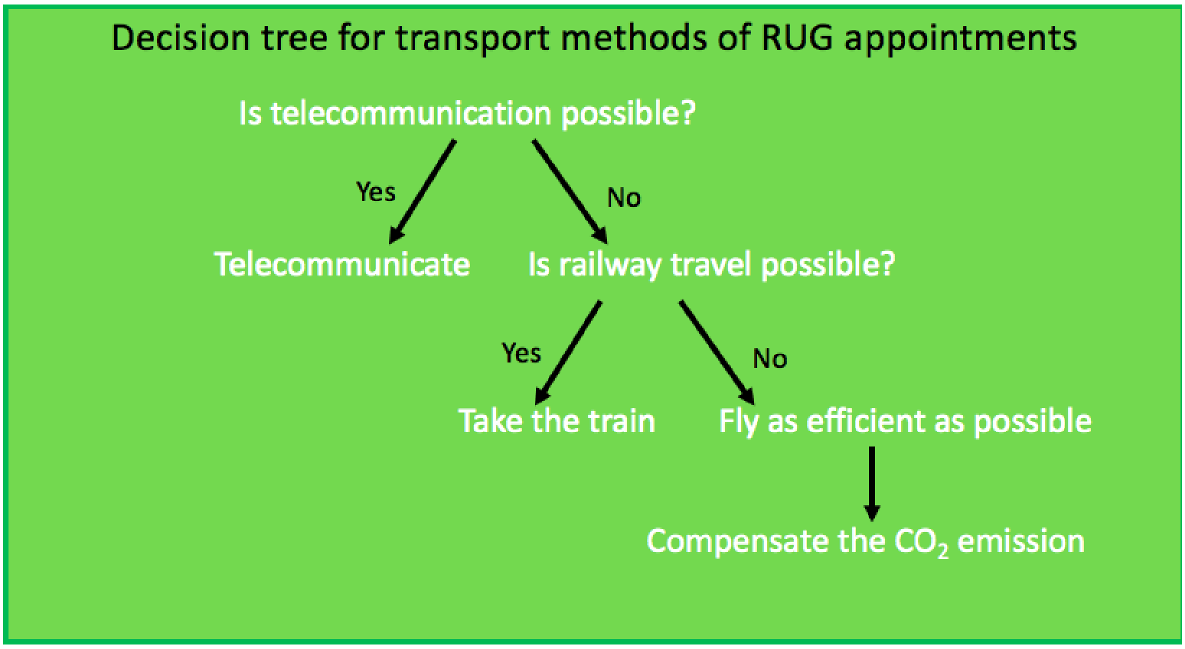

Figure 8: Decision tree for transport methods of RUG appointments

6. Recommendations for the RUG on carbon offsetting

Carbon offsetting is a way to take responsibility for an organization's own carbon emission. It involves financing methods that compensate the CO_2 emission of an organization or an individual. It should be used for CO_2 emission that cannot be reduced and should, therefore, not be used in place of CO_2 reduction methods. It is a response to counteract CO_2 emission and to become CO_2 neutral [27]. Carbon offsetting will provide an organization with a positive image among employees and external organizations, since those methods strive for a reduction of the greenhouse effect and illustrate environmental responsibility. The carbon market consists out of the carbon compliance market and the carbon voluntary market. Carbon offsetting is a complex industry that holds many different carbon projects providers, many different projects, different carbon standards and different prices. A thorough explanation about carbon offsetting and the carbon market is given in *Appendix G (Carbon offsetting).* The information given in Appendix G is also retrieved of an interview with Franka Bosman a representative of the carbon offset company; the South Pole Group.

To compensate the CO_2 emission of RUG flight travel several methods are viable. Compensating the CO_2 emission of commuting is not necessary because, as previously explained it is not part of the CO_2 footprint of the RUG. The RUG can either work together with ATPI that partners with the carbon offset company "Greenseat" or collaborate with an independent carbon offset company. Recommended is to collaborate with an independent carbon offset company. Setting up own CO_2 compensation projects is neglected, since this method is not viable without external expertise and a very large investment. Below the methods are explained and evaluated based on the factors defined in *chapter 2.*

6.1 Compensate by working together with ATPI

A possible compensation method is to collaborate with ATPI. ATPI has partnered with Greenseat; an independent carbon offset project developer. There are two ways that ATPI can compensate RUG flight travel CO_2 emission. Either by integrating offsetting into the reservation system, which will automatically include offset each time a flight is booked. Another option is offsetting based on calculations after travel. ATPI will provide Greenseat with an annual statement of RUG flights. Greenseat will based on those flights, calculate the offset and the corresponding cost. The RUG will, thereafter, receive the invoice and carbon certificates.

Costs per tonCO_2

The cost of compensating for this method is set at 1 or 2 percent per ticket. For RUG flights under 700 kilometres' an average price of 100 euros is estimated. For under 700 kilometres there are 555 flights resulting in 833 euros for carbon offsetting under 700 kilometres. The total emission of RUG flights under 700 kilometres is 87 tonCO_2. Dividing 833 euros by 87 ton results in 9,5 euro per tonCO_2. For longer flights this might differ, those findings will be interpreted in the Thesis of Bartje Alewijnse's. table 7 describes the calculation.

Table 7: Calculation of cost per tonCO_2 of RUG flights under 700 kilometres

Average ticket price	100 euro
Average offsetting price	1-2 euros
Total number of flights	555 flights
Total offsetting price	833 euro
Total emission	87 tonCO_2
Cost per tonCO_2	9,50 euro

The effects and reliability of the method
Greenseat works with VCS and Gold standards for their carbon offset projects. Those standards are full-fledge standards which assures quality. Therefore, this method is reliable. Furthermore, introducing this method for flight travel under seven hundred kilometres will result in a total compensation of 87 ton CO_2.

The efforts of the University and employees
For the University, no or little effort are required for this compensation method. The RUG only needs to set an agreement with ATPI concerning the two options for offsetting. Advised is using the reservation system option, since after the agreement is established the offsetting price will be included into the booked flights and no efforts are longer needed. For the employees, it requires zero efforts.

The feasibility
For flight travel under seven hundred kilometres this method is feasible, since it requires no or little efforts and a small investment.

6.2 Compensate by collaborating with an external carbon offset company
Within the Netherlands several offset companies are active. The most popular and most sold standards are the VCS and the Gold standard [28]. Therefore, preferable is to work with a carbon offset company that works with those standards. The Gold standard projects tackle poverty and try to improve health, while protecting the environment. The RUG also desires social responsibility and, thus, the gold standard will not only contribute to their environmental goals but also to their social responsibility plans. Thus, if financially possible the Gold standard would be the best fit.

Recommended for the University is to request quotations of three different offset companies. Three Dutch offset companies that work with VCS and Gold standards are: The South Pole Group, Climate neutral group and Fair Climate Fund. The South Pole Group took the time to skype with me and explain the complex offset market. They further informed me on the reasons for the different prices per project, the different standards and the types of projects. Per carbon offset company described above, I have provided the University with contact information to retrieve information about the prices and projects.

Costs per tonCO_2
The average cost of carbon offset projects is commonly between one euro and twelve euros. Some credits are more expensive, but those are mostly sold to individuals wanting to compensate for example; their flight to London. Those credits are more expensive, since the transaction and administration cost are relatively high for small compensations. The cost differs per project depending on the type of technology, standard and the country the project is developed in. The offset company can provide the University with offers of different projects ranging in price. It is up to the RUG to choose their preferred projects. A contract for more years might result in discounts. This will decrease the cost, therefore, recommended is to sign a contract for more years.

The effects and reliability of the method
The VCS and Gold standard assure quality and, therefore, promises reliability. For flight travel under seven hundred kilometres, 87 ton will be compensated. To become CO_2 neutral in 2020 they must compensate more than only flights under seven hundred kilometres. Together

with the offset company the RUG can debate on the amount of CO_2 they want to compensate the upcoming year and the corresponding costs.

The efforts of the University and employees
Little efforts are required for the University. They need to request quotations of different carbon offset companies and decide which company they prefer. Thereafter, a contract must be constructed with the corresponding company. Thenceforth, no effort is longer required. The University might be interested in following their projects, but the carbon offset companies have monitoring techniques that can easily provide this. No efforts are needed from the employees.

The feasibility
This method is feasible within the University, since no or little efforts are needed and the carbon offset companies have the expertise to in fact compensate CO_2 emission. Furthermore, compensating flights under seven hundred kilometres is defiantly feasible. Taking the average price of a carbon offset project which for Gold standard is set at four euros and multiplying it with 87 tonCO_2, will result in 348 euros. This is a small investment for the RUG. It is also feasible to compensate other CO_2 emission caused by the RUG by setting an annual contract with a carbon offset company.

6.3 Comparison of both methods
Costs comparison
Cooperating with an individual carbon offset company is cheaper than compensating through ATPI. Table 8 provides the cost of both methods. This shows that compensating through ATPI is relatively high compared to the range of costs for the projects carbon offset companies offer. Therefore, for financial reasons compensating by cooperating with a carbon offset company will be more beneficial.

Table 8: Cost comparison of compensation methods

Method	**Cost**
Compensating through ATPI	9,50 euro
Compensating through a carbon offset company	1-12 euros

The effects and reliability comparison
Both methods are equally reliable and can compensate the 87 tonCO_2 for RUG flights under seven hundred kilometres.

The efforts of the University and employees
Working with a carbon offset company will require more effort than compensating through ATPI, however, cooperating with a carbon offset company still does not desire much effort. Furthermore, an advantage of working with a carbon offset company is that it is possible to choose and prefer a specific carbon offset project. This will create more awareness among employees and students than anonymously compensating through ATPI and it makes it possible to invest in projects that the University has affinity with.

The feasibility
Both methods are feasible for flight travel under seven hundred kilometres. Therefore, for flight travel under seven hundred kilometres the RUG can become CO_2 neutral in 2020, however, the RUG strives for total CO_2 neutrality in 2020. Consequently, other CO_2 emission

than flight travel under seven hundred kilometres must also be compensated. This will solely be possible by cooperating with a carbon offset company since ATPI can only compensate flight travel. If we assume the average price of a carbon offset credit for a gold standard project to be four euros and the University emits 57000 tonCO_2, the cost of compensating all CO_2 emission will be 22800 euros. The price might differ and be either cheaper or more expensive depending on the company and type of project.

Conclusively, both methods are viable for flight travel under seven hundred kilometres. Nonetheless, if the University desires to be CO_2 neutral in 2020, it must also compensate other operations. Therefore, cooperating with a carbon offset company is a superior option compared to compensating through ATPI. Furthermore, it also provides the opportunity to elect preferable projects and is the cheaper option.

6.4 How to introduce an external offset company within the University

Recommended is to request quotations of the three carbon offset companies mentioned above, thereafter, decide with which company to cooperate with and finally start compensating. Advised it to set up a contract of multiple years to retrieve possible discounts and to bring about real changes. In 2022, the offset companies reckon a possible effect on the voluntary market due to the shift towards the Paris agreement. The possible effects are not identified yet but will probably be negative for the carbon offset companies. Therefore, advised is to set up a contract no longer than 2022 to make sure the University does not suffer from those changes.

Furthermore, to introduce compensating within the University it would be interesting to involve employees and students at the decision process of choosing the carbon offset projects. Firstly, the University must choose several projects themselves which are provided by the carbon offset companies. Those projects can be displayed to the employees and student and a vote for the top projects may be introduced. This way the employees and student are aware that the University is compensating and have direct influence on the way the University will be compensating. Furthermore, regularly informing employees and students on the state of the carbon offset project will keep them involved and informed.

7. Discussion

By 2020 the University strives to become CO_2 neutral. This project provides advice on reduction and compensation methods for RUG staff commuting and RUG flight travel under seven hundred kilometres, to contribute to this sustainability goal. The CO_2 footprint over 2017 of RUG staff commuting was calculated to be 3000 tonCO_2 and for RUG flight travel 87 tonCO_2. The University can reduce and compensate the 87 tonCO_2 of RUG flight travel under seven hundred kilometres before 2020, by inserting the methods provided in this report and can, therefore, become CO_2 neutral for this operation. Furthermore, the University should neglect the CO_2 footprint of staff commuting, since it does not belong to their own CO_2 footprint but to the CO_2 footprints of their employees, thereby, also reducing the total CO_2 footprint of the University by 3000 tonCO_2.

The quantitative analysis on the reduction of CO_2 emission performed for several methods described in this report is based on the calculated CO_2 footprint of the RUG over 2017. During this project, several mistakes were discovered concerning the calculation tool of the CO_2 footprint. Consequently, the total CO_2 footprint calculated over 2017 is likely to be incorrect. Therefore, the calculation tool lacks credibility and the corresponding quantitative analysis that follows in this report also lacks integrity. Thus, the results found with quantitative analysis on the reduction of CO_2 emission should be considered an estimation of reality and not a representation of reality.

The reduction commuting methods described in this report provide possible policies and incentives the University can introduce. No quantitative analysis was conducted, since the staff commuting CO_2 footprint was inconsistent. Therefore, the University must further investigate if those methods are feasible to be implemented within the organization. Furthermore, the flight travel reduction methods described are evaluated based on the factors described in chapter 2, those factors establish if the methods are effectively implementable within the organization. Therefore, a more thorough advice is given compared to the advice on commuting methods. Nevertheless, the quantitative analysis on costs for flight travel reduction methods is primarily based on literature investigation. The University could not provide the data of the costs of flight travel and the costs of the other methods are also based on literature research. Therefore, the prices might differ slightly in reality. Conclusively, the reduction methods on flight travel provide comprehensive recommendations and assesses the strengths and weaknesses of the methods, however, lack strong quantitative backup.

In this report, advice is only provided on carbon offsetting concerning RUG flight travel under seven kilometres, however, carbon offsetting through carbon offset companies can also be applied for other operations of the RUG. The methods provided are based on literature research and interviews with experts, therefore, providing a clear and accurate description of the complex carbon offset market. The two methods described are both feasible for the University and the weaknesses and strengths are evaluated. The University is provided with contact information of different carbon offset project developers, giving the chance to evaluate the different services carbon offset companies offer. Conclusively, both the information provided in this report and the contact information of the different carbon offset companies, establishes tools to quickly start compensating in a responsible way.

Overall, the report provides clear policies and methods that may be introduced by the University. Unfortunately, the methods are not strongly backed-up by quantitative analysis, therefore, forcing the University to conduct further investigation on 100% reliability of the methods.

8. Final advice

The reduction and compensating methods described in this report, will help reduce and compensate the CO_2 emission of RUG staff commuting and RUG flight travel under seven hundred kilometres to strive for CO_2 neutrality by 2020. Firstly, the RUG must recalculate or revalidate the CO_2 footprint calculator of the University, since several mistakes were found during this project. This will prevent wrong calculations of the CO_2 footprint in the future. The University will, thereby, correctly comprehend how much tonCO_2 must be reduced and compensated to strive for CO_2 neutrality.

Furthermore, advised it to remove the staff commuting CO_2 footprint of the total CO_2 footprint of the University, since it does not belong within the CO_2 footprint of the RUG. It will reduce the total CO_2 footprint of the University with around 3000 tonCO_2. This, however, does not imply that the University should not try and reduce the CO_2 emission of staff commuting. Recommended is to insert parking costs and parking distance restrictions to discourage car use. The parking costs should be determined by the University and parking distance restrictions is advised to be set on sixteen un till fifty kilometres Moreover, suggested is to provide employees with free or discount tickets for public transport to encourage public transport or to increase the allowance on public transport. The parking costs could be used to finance this. To promote bike travel, the University should advocate interest free loans for bikes and e-bikes, which the employees can pay back with the help of a nineteen-cent bike allowance they are entitled to. To stimulate sustainable car use, advised is to insert more electrical charging points and to insert a fuel budget for the employees. All methods should be promoted with a behavioural campaign to increase the effects of the methods. Recommended is to further investigate the potential of the methods.

Moreover, the University can reduce and compensate the 87 tonCO_2 over 2017 by inserting the reduction methods described in this report. Firstly, the University is advised to promote and investigate the possibilities of telecommuting. Video Butler is a company that provides help in video conferencing, thus advised is to contact them. Thereafter, if teleworking is not possible, the University must determine if the journeys can be replaced by railway travel instead of flight travel. Railway journeys that are viable for popular RUG destination are London, Luxembourg and Munich. Therefore, advised is to switch from flight travel to railway travel for those destinations. Especially London is the most popular destination for RUG flight travel under seven hundred kilometres, thus, will have significant effect. Recommended is to further investigate the destinations of the RUG under seven hundred kilometres and constitute a list of destinations that are reachable by train. Lastly, if flight travel is necessary advised is to fly as efficient as possible. This is achievable by flying with the most efficient airlines described in this report. The unavoidable CO_2 emission must be compensated to become CO_2 neutral.

Recommended for compensation methods is to cooperate with a carbon offset company. A carbon offset company provides the opportunity to compensate more than just flight travel emission, which is necessary to become fully CO_2 neutral. Furthermore, it provides the possibility of choosing a specific CO_2 offset project. The carbon offset companies offer a range of projects for different prices, providing the University with the opportunity to choose a project they prefer and that is financially viable. Recommended is to involve the employees and students in the final decision making process on the carbon offset projects to create awareness. Furthermore, setting up a contract of multiply years is advised to experience real effects. Nevertheless, the contract should not exceed 2022 to prevent possible negative effects of the shift from the Kyoto Protocol to the Paris agreement.

Conclusively, this report provides recommendations of methods that can reduce and compensate the CO_2 emission of RUG staff commuting and RUG flight travel under seven hundred kilometres. Recommended is to further investigate the methods described in this report and establish which methods are introducible and how to most effectively implement them.

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10. Appendix

Appendix A: Calculation of RUG staff commuting CO_2 footprint

The calculation neglected employees that work less than four hours per week. The number of RUG employees that work more than 4 hours per week is 5898. A full-time employee(FTE) works eight hours per day and five days per week, resulting in thirty-six hours per week. On average RUG employees work 72 percent of FTE hours resulting in 165,6 full days per employee. Consequently, the calculations are based on 5898 employees traveling from work and back 165,6 times per year.

The commuting distance of the employees is calculated based on their zip codes and the zip code of the RUG. Commuting distances under sixteen kilometres are neglected since the CO_2 emission of those trips are very low and the calculation tool assumes that most employees below sixteen kilometres will take the bike. The largest distance an employee commute is two-hundred kilometres, thus the category between sixteen and two hundred kilometres is established and used for the calculations. The commuting kilometres are divided into categories; public transport and car/scooter use. The percentage of kilometres for car use and scooters is 86 percent and for public transport 14 percent. Those percentages are assumed based on the distance and location of an employee's home. The public transport sector is further divided into bus travel and railway travel. As previously explained in this report railway travel is more sustainable than bus travel and, therefore, has a lower CO_2 compensation factor. The percentage of bus travel is 59 percent and of railway travel 42 percent. The calculated CO_2 emission is multiplied by an extrapolation factor, since several assumptions are made resulting in the final CO_2 footprint of staff commuting of 3000 tonCO_2. Table A depicts the calculation. Since the total commuting distance in unknown due to the error in the commuting calculation tool a number X is used instead.

Table A: Calculation of the CO_2 footprint of staff commuting

	Compensation factor	Total
Total Commuting Distance	-	X
Total Car/scooter use distance travelled	86% of the total commuting distance	0,86 * X
Total public transport distance travelled	14 % of the total commuting distance	0.14 * X
Total railway use	42 % of the total public transport distance	0,14* 0,42* X
Total bus use	59 % of the total public transport distance	0,14 * 0,59*X
CO_2 footprint car/scooter use	0.220	0,220*0,86 * X
CO_2 footprint bus use	0.140	0,140*0,14* 0,42* X
CO_2 footprint railway use	0.006	0,006*0,14 * 0,59*X
Total CO_2 footprint staff commuting	-	Y= SUM of all CO_2 footprints
Total CO_2 footprint staff commuting extrapolated	Extrapolation factor:	Y* extrapolation factor= 3000 tonCO_2

Appendix B: Flight information on RUG flights under seven hundred kilometres that depart from Groningen, Eindhoven and Amsterdam airport

	Total number of kilometres	Amount of flights
Amsterdam	**121856**	**204**
Basel/Mulhouse	575	1
Berlin	1188	2
Bern	660	1
Birmingham	4026	10
Copenhagen	1258	2
Duesseldorf	712	2
Durham Tees Valley	673	1
Edinburgh	5024	8
Geneva	2728	3
Glasgow	1363	2
Hannover	1348	2
Humberside	1360	2
London	79248	129
Luxembourg	3338	5
Manchester	5070	10
Munich	4669	7
Norwich	1804	4
Nottingham	386	1
Paris	1279	3
Strasbourg	477	1
Stuttgart	1605	3
Zurich	3065	5
Eindhoven	**548**	**1**
Manchester	548	1
Groningen	**6507**	**14**
Aarhus	624	1
Copenhagen	4211	9
Southend	1672	4
Total	**128911**	**219**

Appendix C: Flight information on RUG flights under seven hundred kilometres that arrive at Groningen, Eindhoven and Amsterdam airport

	Total number of kilometres	Amount of flights
Amsterdam	**67431**	**132**
Basel/Mulhouse	1725	3
Berlin	603	1
Birmingham	2417	6
Bristol	486	1
Copenhagen	5661	9
Edinburgh	3140	5

Frankfurt	362	1
Geneva	4774	7
Glasgow	682	1
Hamburg	370	1
London	27976	62
Manchester	4608	10
Munich	6003	9
Newcastle	500	1
Nottingham	386	1
Paris	1788	4
Southampton	433	1
Zurich	5517	9
Eindhoven	**289**	**2**
London	-354	1
Prague	643	1
Groningen	**3869**	**8**
Copenhagen	2338	5
Gothenburg	695	1
Southend	836	2
Total	**71589**	**142**

Appendix D: General reduction methods to reduce CO_2 emission of commuting

Shift to other transport methods than car use

As previously cited in chapter 3, car use is more harmful for the environment than public transport or cycling. Buses and trains are more environmental friendly and emit less kgCO_2 per passenger. Therefore, a switch in transportation method will result in a lower CO_2 footprint of the transportation sector. To make this shift possible, either car use must be made less attractive or public transport and cycling must be made more attractive.

Make car use less attractive

There are several factors why commuters prefer a certain transportation method. Those factors include; speed, time, cost, flexibility, safety, and comfort. Therefore, influencing those factors negatively for cars, will form as an incentive to switch from transportation method [29]. Firstly, pricing policies on car use will increase the cost and decrease satisfaction. Possible pricing policies are; introducing road tolling, higher fuel prices and extra parking cost. The higher the increase of costs the greater the motive to switch to public transport or cycling. Furthermore, car users are fond of the flexibility of cars and enjoy being able to park close to their destination. Thus, limiting parking places close by large institutions or work will motivate a switch in transport method.

Make public transport more attractive

To motivate car users to switch to public transport, it is important to understand the most influential factors that determine the decision on a transport method. According to [21] the duration of the service and price are the dominant factors that determine the transport mode. Consequently, reducing cost and time of the public transport sector will increase popularity for this transport mode. To develop a faster service, the travel networks of public transport must be improved and the sector must prioritize routes with high level of traffic and supplement them with feeder routes. Secondly, reducing the costs of public transport will also result in more travellers. Moreover, information and marketing of the public transport sector is sometimes missing or incomplete. Consequently, individualized marketing helps motivate commuters to switch [29].

Carpooling
Carpooling is the sharing of a car by people that follow the same journey. For commuters, this journey will be to their workplace. Persuading people to carpool will result in less kgCO_2 per passenger. Furthermore, since more citizens use the same car as transport method it will reduce congestions. As previously stated congestions are very harmful for the environment and reducing this will, therefore, be beneficial

Teleworking
Teleworking is also called "home-sourced", it allows employees to work at home. Having employees work at home will eliminate commuting transport resulting in no CO_2 emission. Via communication technologies like conference and skype calls the organization can communicate with the employees that work at home. It will defiantly be beneficial for the environment but it also has effect on the organization itself. It will increase role ambiguity and the structure of the organization must change to successfully implement teleworking [30].

Technological change
There are several technological innovations that can reduce the CO_2 emission of car use. One of those innovations are sustainable cars. There are several existing sustainable cars; hybrid vehicles, electrical vehicles, hydrogen vehicles and compressed air vehicles [31]. The hybrid car combines two engines that incorporates fossil fuel and electricity, thereby, reducing fossil fuel consumption. The electric car eliminates fossil fuel totally and is powered on electrical stored energy created by chemical reactions in a battery. Furthermore, the hydrogen car uses hydrogen to power the car. The compressed air vehicles are still in development. It is an innovation in which an engine uses fuel in the form of compressed air that is carried in tanks. Another option are alternative fuels. Those alternative fuels are not fully environmental friendly since they still emit damaging gases but are an environmental improvement compared to gasoline or diesel cars. Alternative fuel options are; ethanol, natural gas, propane or biodiesel [32]. Lastly, vehicle weight reduction will also decrease CO_2 emission. The smaller the mass the less energy needed for a specific velocity. Weight reduction will produce greatest saving when mild steel is replaced by high-strength steel. Furthermore, it might be the solution for CO_2 reduction of car use [33].

Appendix E: General reduction methods to reduce CO_2 emission of flight travel
Kerosene taxation
Currently, due to international agreements no tax is pressed on kerosene. Several attempts of European transport and environment ministers to insert the taxation in consultation with the International Civil Aviation Organization have been unsuccessful. The ministers believe it will be a solution for the environmental impact of air travel [34]. The organization has declined the requests because it would have an economic down effect on the aviation sector. Presently, ongoing appeals are being pressed on taxing kerosene. If kerosene taxation would be approved and inserted, the CO_2 footprint of the aviation sector would decline.

Optimize existing air capacity
A fully booked aircraft emits less CO_2 per passenger than an aircraft that is not. The CO_2 emission per person is calculated by dividing the total CO_2 emission by the number of passengers on the plane, therefore, optimizing air capacity will reduce the CO_2 footprint per

passenger. Airplane agencies are continuously working on planning and scheduling models that optimize their network structure to carry their passenger flow at the lowest transportation cost [35]. This planning-decision making process is the main problematic issue of airlines. Agencies want their airplanes to be fully booked because over-sized aircrafts will result in more costs while under-sized aircrafts will form an incentive for their passengers to book flights at competitors [36]. Airplane agencies, therefore, also desire their aircraft capacity to be optimized. Furthermore, an incentive that will motivate the agencies to optimize their aircraft capacity is to increase the price on aircraft slots. This will pressure the agencies to increase income per flight.

Improved technology
More efficient air planes will reduce CO_2 emission. There are several ways to technically reduce the CO_2 emission. One way is to replace kerosene by environmental friendly fuels like cooking oil, sugar cane or biomass. It will cut greenhouse gases by eighty percent. Unfortunately, a large investment is necessary for biofuels to take over kerosene. Another technical method is to lighten specific airplane parts by using 3D printers. This will cut fuel use and, therefore, CO_2 emission. Experts predict this will be a method frequently used in the future [37]. Furthermore, an increased efficiency in the engines will result in lower emissions. Open rotor engine designs are possible new engines that have a propulsive engine efficiency of about ninety percent. Moreover, improving airplanes aerodynamics and reducing aerodynamic drag will create a higher efficiency. Aerodynamic drag will result in less energy used for floating, while improved aerodynamics will result in less energy needed to keep the plane in the air. Lastly, an enhanced wing-body configuration can be used to minimize drag. This will result in a change of the airplane’s infrastructure. Within the military sector those airplanes are already used. Expected, however, is that consumers will raise resistance towards those aircrafts. The aircrafts will have less windows and the passengers will encounter greater vertical movement when airplanes turn [8].

Emission permits and trading
Emission trading is a market used to control pollution and is also a central element of the Kyoto protocol. The market consists out of tradable pollution permits. It is a way of tackling greenhouse emission linked to climate change. An emission ceiling is set and thereafter permits are created up to the level of this ceiling and divided among international and domestic parties. One emission permit holds the emission of one ton of CO_2. The trading market puts a price on pollution and adds profit as an incentive for the reduction of CO_2 emission. The ceiling is set per year. In Europe, the Emission Trading System(ETS) is already the largest in the world. In 2012 the aviation sector is included within this system. All airlines operating in Europe are required to monitor, report and verify their emissions and surrender allowances [38].

Encourage a shift away from air travel
As previously stated in section *3.1.3 railway*, railway is the most sustainable transport mode aside from cycling and walking. Therefore, a shift from short haul flights towards rail travel will result in lower CO_2 emission. To realize this shift railway infrastructure must be improved. Moreover, behavioural stimulation is fundamental because according to [39] northern Dutch citizens consider the environment of minimal importance while planning an international trip. The price and duration of the transport method is from greater concern. They consider international trains to be too expensive and would only consider taking the train under 680 kilometres. Furthermore, northern Dutch citizens would not contemplate taking the train if it takes more than 138 min compared to flying.

Communication technologies
Communication technologies can serve as a replacement for especially business flights. Business meetings abroad, can be replaced by conference calls and skype meetings. This will automatically reduce CO_2 emissions within the aviation sector because it will reinstate air flights. This will, however, require good communication technology and a strong Wi-Fi connection. Furthermore, people prefer to meet in person and, therefore, behavioural stimulation towards communication technology is necessary.

Appendix F: Most efficient airlines for flight travel under 800 km

China West Airlines
TUIfly
TunisAir Express
Airways France
Monarch Airlines
Transavia
LATAM Airlines Brasil2
Virgin Australia Internationa
Shenzhen Airlines
Air Europe
Thai Airways International T
Hong Kong Airlines
Air Mauritius
China Southern Airlines
Qantas Airways
Air France
Japan Airlines

Appendix G: Carbon offsetting
Compliance market
In the compliance market carbon offsetting occurs under compliance schemes and voluntary programs. National, regional and international carbon reduction regimes regulate the compliance market. Every mandatory greenhouse gas reduction system has allowed the use of offset to meet compliance obligations [40]. Mandatory compliance regimes such as the Kyoto Protocol and the European Union Emission Trading System have been key drivers for creating reduction projects. One of the carbon offsetting methods is buying emission permits described in *appendix D.* Another method is buying carbon reduction certificates from the Clean Development Mechanism(CDM) established by the Kyoto protocol or buying reduction certificates from voluntary projects. The CDM creates reduction projects by for example investing in renewable energy sources or planting trees. A reduction credit equals the compensation of one ton CO_2. Those reduction projects must comply to standards and must demonstrate how and to what extend they reduces greenhouse gasses. The CDM executive board is the decisive factor in concluding if a project fits CDM standards. Large organizations like Greenpeace and the World Fond of Nature have criticized those standards. They believe that the projects lacked social influence of sustainable development and monitoring. Therefore, they have created the Gold standard. Gold standard projects focus on contribution of locals towards sustainability. They want to tackle poverty and improve health, while protecting the environment. Projects undergo a golden standards selection and if they pass, they receive a golden standard certificate [41].

Voluntary market and standards

Within the voluntary market there exists a large range in projects, standards and protocols. The voluntary market holds so many different projects that the quality of some projects might lack. Carbon market actors, therefore, have improved the standards of those projects and offset standard types grounded. Currently, several offset standards types exist. The most common ones used are the full-fledged carbon offset standard and the project design standard(PDS). The full-fledged carbon offset standard consists of three components:

1. Accounting standards
2. Monitoring, Verification and Certification standards
3. Registration and enforcement systems.

Registration and enforcement systems make sure that the credits are registered in a 'certification bank' so that the same credits cannot be sold more than once. The buyer 'owns' the credits now. The PDS standards consists out of the first two components but lack the registration and enforcement systems. These standards are useful for de development of new projects and may help secure funding, however, to receive a certificate the projects must also hold a full-fledged carbon offset standard. Different types of standards for the full-fledge carbon offset standards exist. Those standards are; the CDM standard, Gold standard, Voluntary carbon standard(VCS), VERX and CCX. Those standards assure quality for the buyer and the provider. They, however, provide different benefits. The Gold standard provides social, economic and environmental benefits while the VCS, CDM, VERX and CCX solely focus on the reduction of greenhouse gasses. [42] depicts the most popular standards, projects and prices over 2016. In this report the VCS and the Gold standard are most popular standards. The VCS projects hold a 76-million-dollar value and the Gold standard projects a value of 46 million in a market of 160 million.

The following information about carbon offsetting is based on an interview with Franka Bosman of the South Pole Group

Carbon offset providers and project types

Within the voluntary market project providers are acknowledged as brokers or project developers. Brokers are companies that buy carbon credits of project developers and sell them with a higher marge to customers. Project developers are companies that develop the carbon offset projects themselves. They provide different kind of projects. The most popular projects are renewable energy and forest and land use projects. The forest and land use projects have a value of 67 million dollar and renewable energy a value of 25 million (Hamrick and Gallant 2017). Other project types are methane projects, fuel efficiency projects, house hold device projects like clean cook stove distributions and transport projects.

The development of a carbon offset project

For the development of a carbon offset project, project developers work together with project owners in the country the project is constituted in. For example, consider a project for building sun panels which creates green energy in Thailand. The project owner in this case has the government as competitor, leaving them without any grants of the government. This project will not exist if no external investment is granted. Carbon offset developers are the investors that together with the local business start develop such a sustainable project.

The development of such a project must follow certain regulations to receive a standard and thereafter a carbon certificate. Firstly, the projects must be monitored and for example, the green energy generated must be measured and translated into an amount of reduced tonCO_2.

Secondly, those measurements must be checked and the projects undergo an inspection of the standard owners to receive the desired standard. For the Gold standard that would be the Gold standard foundation. Lastly, the projects must be verified by independent companies and thereafter the certificate is granted. Consequently, CO_2 credits given to the customers might be reduced CO_2 emission of a few years ago. Dependent on the type of project, projects might take a few years to be developed.

Pricing of carbon offset projects
The prices per carbon credit range from one euro to eleven euros with an average price of 2,50 euros. Different factors establish the price of one carbon credit or certificate. The credits are more expensive if the corresponding project is more expensive. The technology of a project has influence on the price. Forrest and land use projects and house hold devices projects hold the highest average price of around 4,5 euros while renewable energy like windmills projects hold an average price of 1,2 euros (Hamrick and Gallant 2017). This difference is due to higher CO_2 compensation compared to other projects. This results in more certificates making it possible to reduce the price of one certificate. Furthermore, the country of the project has effect on the price. Third world countries have lower wages resulting in lower prices. Moreover, the type of standard influences the price. Gold standard credits hold and average price of 4 euros, while VCS of 1 euro. The selection process of a Gold standard project is more intensive than for a VCS standard, resulting in higher cost. This, however, does not mean that the Gold standard is necessary better. People are willing to pay more for certain projects if they hold certain preference. For example; if they prefer a specific technology, standard or country.

Effects of the shift from Kyoto Protocol to the Paris agreement on the voluntary market
The shift from the Kyoto protocol towards the Paris agreement in 2020 will have effect on the carbon voluntary market. The Paris agreement is an agreement within the United Nations Framework Convention on Climate Change (UNFCCC) and will replace the Kyoto Protocol. Most projects created by carbon offset companies are developed in countries that are not part of the Kyoto Protocol. If the Paris agreement goes into motion, projects that are created in countries that are now part of the Paris agreement might claim the CO_2 reductions credits of those project since they are developed in their country. Unfortunately, the direct influence of the shift is not predictable and will be experienced when the Paris agreement is introduced in 2020. Carbon offset companies predict that it will influence their business around 2023.