See the world or see the screen

A comparative LCA of three business meeting cases

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Group 3

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Abstract

Evaluating and limiting environmental impacts is becoming increasingly important in several areas of society. Business travel exists in the intersection of two large-impact sectors: business and transportation. Limiting business travel has become easier since the emergence of online meetings as a functional alternative. The aim of this LCA is to compare the environmental impacts of 25 meetings that are 4 hours long and 4 person attending the business meetings between Stockholm and London, depending on whether the meetings are held online or face-to-face. Two travel options will be studied: train travel and air travel. The LCA modelling is conducted in SimaPro. The results show that video meetings have markedly lower environmental impacts than both of the travel options. However, there is no real conclusion about whether flying have smaller impacts than train travel for this particular case.

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1. Introduction

1.1 Background

In today's society there are a lot of discussions about the environmental impacts of actions, both on individual level and from companies. Knowing that there are environmental impacts, and which actions have the greater impact, is getting more important for companies (Länsstyrelsen, 2010). Some companies go beyond what is required by both laws and regulations to show the public that they are working for a better environment.

According to Eurostat (2016a) transportation is one of the key driving factors of greenhouse gas (GHG) emissions in Europe. It was the only sector that increased its emissions between 2000 and 2009. The increase is mainly due to increasing transport volumes combined with the lack of a shift to more sustainable modes and fuels (Eurostat, 2016b). Between 2013 and 2014, the transport of passengers by airplane increased in all EU member states, with an average of 4.4%. GHG emissions from travelling are also one biggest impacts that larger companies have (Kolari & Tolkacheva, 2012).

The travels by train have increased during the last years, between 2013 and 2014 travelling by train increased by 1.5% within the EU member states (Eurostat, 2016c). To travel by train is known as one of the most environmental friendly way to travel (DSB, N.D.) but the emissions from the train depend on the electricity mix (Kolari & Tolkacheva, 2012).

Using videoconferences as an alternative is one way to reduce the travel distance (Videokonferenser, 2012). However, it is important to avoid the short-sighted assumption that ICT options are without environmental impact, since the services provided are not physical. Videoconferences have environmental impacts. To have a video meeting is more than just the construction of a computer. It also includes parts such as the Internet and infrastructure around the Internet (Chen, 2005).

In this report we are going to compare the environmental impacts of having three kinds of meeting: a video meeting or a physical meeting where the participants has travelled either by train or by airplane. While it might be presumed that the environmental impacts of flying will be larger than the trains and the train will be larger than having video meetings, it is interesting to visualise the impact difference. Further, it will be interesting to see the impact category hotspots and where in the supply chains the impacts are sourced.

1.2 Previous research

Making comparative LCA: s about transportation options compared to online meetings is not ground-breaking. Several different LCA: s have been done with this purpose. These have been studied both separately and as comparisons. Several studies have been performed about trains as well. Here will we discuss some of the most relevant comparisons.

Takahashi et al. (2006) compares video meetings with face-to-face meetings, for “one meeting for multiple attendances”, and only for CO_2 emissions. They found that the CO_2 emissions from video meetings were 80% less than flying. Quack and Oley (2002) have done a simplified LCA on environmental advantages of a video conference and they found out that if you are travelling a distance of 1 000 kilometres and had ha conference for 4 hours, the primary energy that needed for video conference was 1% of a flight and 5% of a ride by train. They also state that including the production phase could change the outcome.

Borggren et al. (2013) have done a similar setup comparison like our, but includes cars and use a different functional unit focuses mainly on the GHG emissions while we are not selecting a particular impact category to be our primary one. One of the most interesting conclusions here is that rarely and poorly used ICT have similar emissions to train travel, while the other options are worse. Bouwman & Moll (2002) compares different transport forms, for example depending on energy use. Here trains are evaluated as having less impact than flying.

Based on these results, the research gap that our study fills is that it has a business travel focuses, that it compares the three options of travelling by train, flying or having video meetings, and that we are modelling a larger number of environmental impacts, instead of just GHG emissions or energy.

1.3 Goal of the study

The research question for this project will be:
What are the comparative environmental impacts of three different business meeting scenarios: flying to a meeting, taking the train to a meeting and having a video meeting?

The aim of this project is to make a comparative and attributional life cycle assessment between having a video meeting and having a meeting face-to-face, with two different transport cases for the face-to-face option. This study is looking at a case when three persons are staying in London and one person either needs to fly from Stockholm or staying in Stockholm and attending a video meeting.

The objectives are:

- To model build a model for a video conference in SimaPro
- To compare and visualise the environmental impacts of the alternatives
- To analyse the differences between the three alternatives and the impact hotspots within them

The intended application of this study is for use by companies when deciding on meeting traveling policies. The intended audience is therefore companies which has meetings that employees travels to. The ILCD Handbook (European Union, 2010, p. 38) states that if the study is used for decision support for a small scale decision an attributional LCA should be conducted. This is the case for this study. Additionally, the attributional LCA suits the problem since it is not change oriented.

1.4 Scope of the study

1.4.1 Functional unit

The functional unit in this report is 25 meetings, each 4 hours long and with 4 people attending. This equals 100 hours of meeting time.

This functional unit has several parts which impacts the final result. The intention is to reflect an average business meeting. We have based the information about the meeting on a survey conducted among some employees at Atlas Copco in Nacka. The result of the survey was that their average business meeting is 4 hours long and 4 people are attending it (see Appendix 1).

The functional unit is based on the assumptions that 25 meetings conducted by video are equal to 25 face-to-face meetings in function. Some aspects that can be unequal between video and face-to-face meetings are those that a face-to-face meeting could make it easier to discuss with several people, and that signatures and agreements can be easier to manage in person (Takahashi et.al. 2016). Another aspect is relationship building and socializing, whether it is with clients or different parts of the same company (Enqvist, 2016). One aspect that is in advantage to the video meeting is time, since time requirements outside the meeting themselves are close to zero for video meetings. From an economic perspective it is also cheaper to conduct video meetings, at least once the technology is in place (Reichard, 2016).

1.4.2 System boundaries

This LCA is a cradle-to-grave LCA and therefore we are looking at the whole process. It is assumed that this LCA is about the systems as they exist in year 2015. While the future waste scenarios are not very detailed, it does not exclude any future processes because they are future processes, and it includes long-term emissions in the graphs. However, most of the data used in this model is sourced from SimaPro, so the accuracy depends on the general age of the data. Since the system involves crossing geographical boundaries, setting them for the system is not intuitive. The priority was to aim for data from the appropriate European countries for each case as well as the train data for each country passed for the route. However, in practice, generalized data for Europe has been the most suitable available data. Global data has been selected when there is no European data available.

The main process in the created life cycles is the meeting itself, but then there are some differences among the three scenarios. For the video meeting, as seen in Figure 1., the processes of acquiring raw materials, process those and manufacture headphones, a computer and an Internet access device are included. Further, the waste management are included for all of these products. In Figure 2. the system for the air travel meeting can be studied. It includes the processes of acquiring the raw materials, refining those and manufactures the airplane fuel, the airplane itself and the airport. Further, the actual flight is included and the waste management is included. The meetings are set in Stockholm and London, and the flight goes between those two cities. For the flying alternative, we are including the travel from central Stockholm and central of London to each airport. This travel is assumed to be done by train. Figure 3. shows us the process of travel to meeting by train. There are processes that are raw material acquisition, process of materials and manufacturing of tracks, stations and fuel. The cradles for the three cases are the extraction of the raw material and the grave is the waste management.

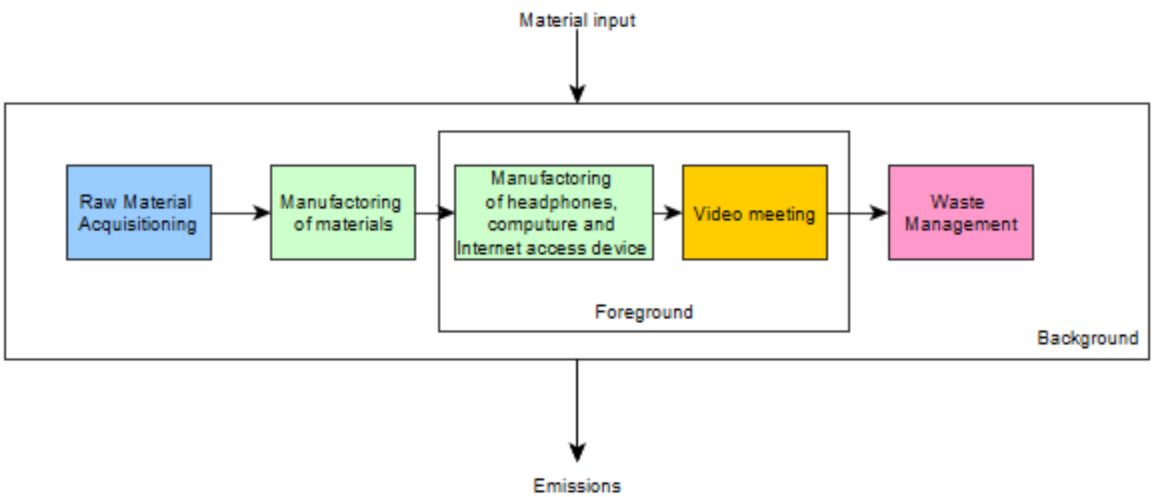

Figure 1. The initial flowchart of the video meeting system.

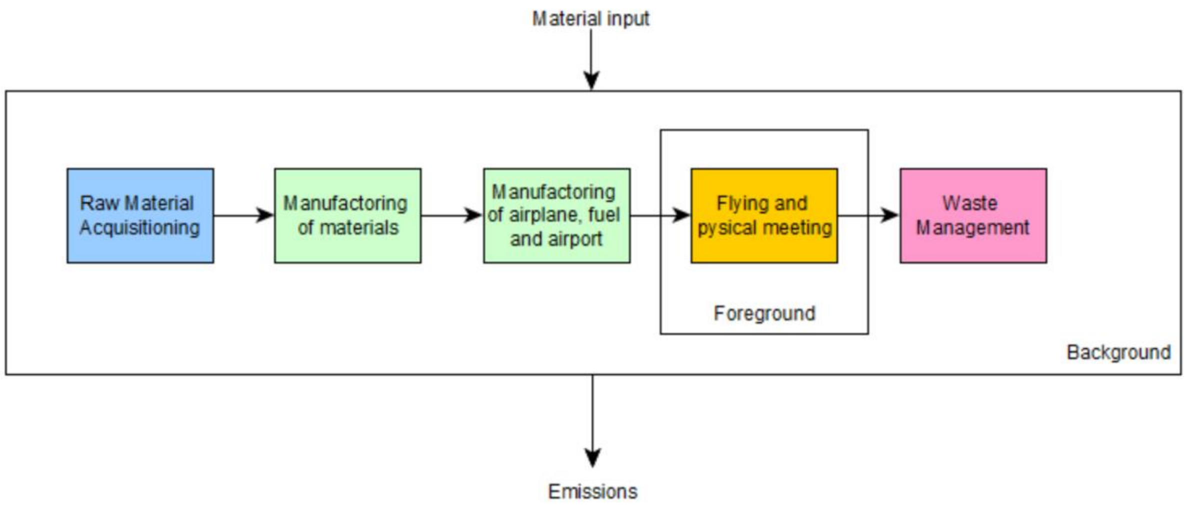

Figure 2. The initial flowchart of the air travel meeting system.

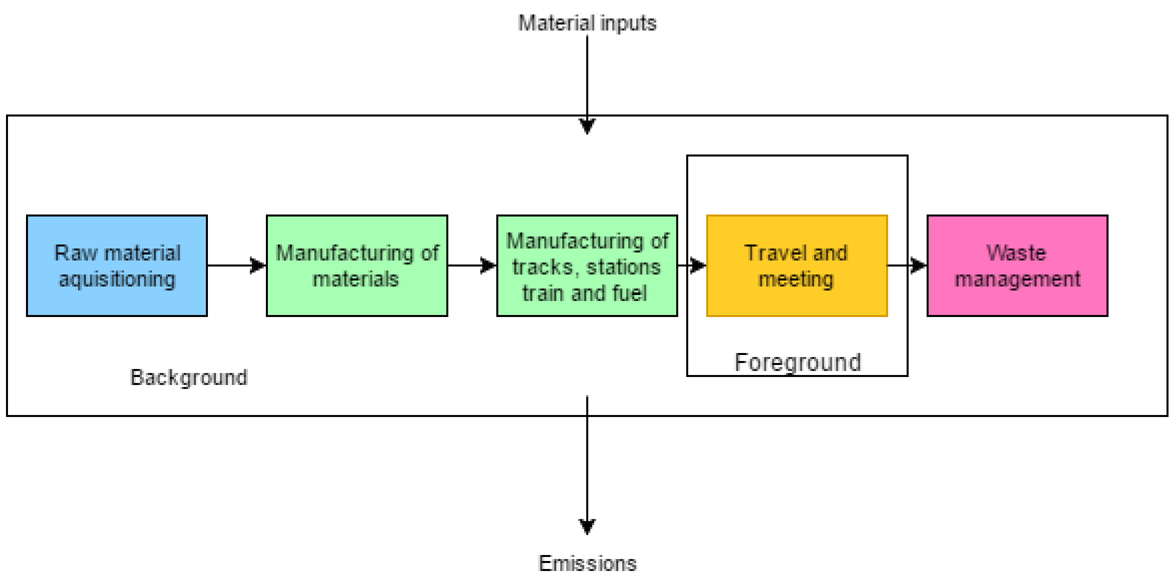

Figure 3. The initial flowchart of the train travel meeting system.

1.4.3 Allocation

Looking at the videoconference allocation problems, we could find both open loop and multi output allocation problems. The laptop, headphones and the Internet access device provides the users with more functions than just the video conference, this gives us a multi-output allocation problem. Further, some of the electronic devices are assumed to be recycled which gives an open loop allocation problem. The amount of time the laptop, headphones and Internet access device is used for the video meetings in relation to the total use time will also be the allocation factor. It is assumed in chapter 1.4.1 that the average meeting at Atlas Copco is 4 hours, and that one such video meeting is held every week. The average working week in Sweden is 40 hours (Arbetsmiljöverket, 2016), which gives us an allocation factor of 0.1 according to Equation 1.

$$\frac{Time\ used\ for\ video\ meeting}{Total\ use\ time\ for\ the\ computer} = \frac{4\ h}{40\ h} = 0.1 \tag{1}$$

Further it is assumed that there will be recycling of electronic devices used in the video meeting, with recycling rate of 10%. From this assumption, there will be an open loop allocation problem. To solve this problem the method of avoided burdens will be used. Both of these allocation problems are available to be used in SimaPro with the databases that are going to be used in this LCA.

There is no known allocation problem regarding flying and going by train to the meetings because these processes are already manufactured in SimaPro.

1.4.4 Assumptions and limitations

There are several exclusions done in the systems. Some of these exclusions are done because the LCA is comparative. For example; assuming that the four small rooms needed for the video meetings are equals to one larger room that is needed for the face-to-face meetings, and that all participants are using the same equipment to take notes on in all three cases, means that these processes can be excluded. Others, such as the video meeting application and the detailed manufacturing of headphones, were excluded due to data gaps and modelling difficulties. Yet some are outside the scope of our project. Since the air and train travel are not built from scratch but are slight modification of existing SimaPro processes, what is included from these processes are also excluded from our LCA.

1.4.5 Impact categories and impact assessment method

The impact assessment method used in this LCA is the ReCiPe Midpoint (H). This choice is valid for several reasons. One is simplicity: it is available in SimaPro. Another is that the midpoint option gives us more robust information about a larger amount of categories than the endpoint option (ReCiPe, 2009). Since there is a lack of multi-category LCA: s for cases similar to ours, this helps close our research gap. The (H) stands for a “hierarchist” perspective. This option is neither optimistic nor cautious, compared to the alternative (I) and (E) perspectives (Goedkoop et. al 2008). This makes it a balanced perspective suitable to our case.

This LCA model all impact categories in ReCiPe Midpoint (H). This is because studying all categories means closing an existing research gap, and because there is no real reason to exclude any categories.

1.4.6 Normalisation and weighting

Normalization shows the impact category indicator results linked to a reference value in the impact assessment. It also makes the impact categories into the same unit so that it is convenient to compare and focus on the main categories (Goedkoop et el., 2013). Normalisation is conducted in this study in order to see which of these three meeting types have the largest environmental impact compared to the impact of an average European for a year.

In this study weighting will not be done, mainly due to the high uncertainties regarding the development of weighting factors.

1.5 Meetings at Atlas Copco

Atlas Copco has a policy about when to travel to a meeting and when to use video or phone conferences (Reichard, 2016). They have a model for calculations of the costs of travel compared to having a video or phone conference, which depends on from which countries they are travelling to and from.

The travel also depends on your position within the company. The CEO could travel from Sweden to China for an important that is going on for one hour, while an ordinary employed need to have longer meetings or conferences to be allowed to fly (Wesling, 2016). It is easier to be allowed to fly to a meeting if you are combining it with a conference or study visit. During a project a specific amount of face-to-face meetings could be approved, but any additional meetings are must be video or phone meetings. The advantages with video meetings are that they can be shorter and held more often. With video meetings the contact between project groups has been better and they do not need to wait for next face-to-face meeting to show the progress to each other or ask for help.

Some people are not big fans of video conferences because of the loss of personal relations and having the chance get to know the other persons in a project that much (Enqvist, 2016). They are arguing for that the informal meetings that are coming natural during breaks when you have face-to-face meeting are a great basis for the decisions.

Another aspect for the company is the time it takes to travel to the meetings. Taking the train from Stockholm to London takes around one day and three hours (Google Maps, N.D.). This is too long for business travel, but trains are not excluded as an option for shorter distance like travel within Sweden (Reichard, 2016).

2. Life cycle inventory analysis [1]

This chapter cover the flows charts of the different life cycles, explains the data used and the data gaps. The first subchapter focuses on the video meetings and the second is combining the air and train travel meetings.

2.1 Video meeting

2.1.1 Flow chart

Figure 4. shows the flowchart for the video meeting and the processes that are included in the model in SimaPro. This flowchart is, in difference to the air and train travel flowcharts explain in chapter 2.2, constructed by the authors of this study.

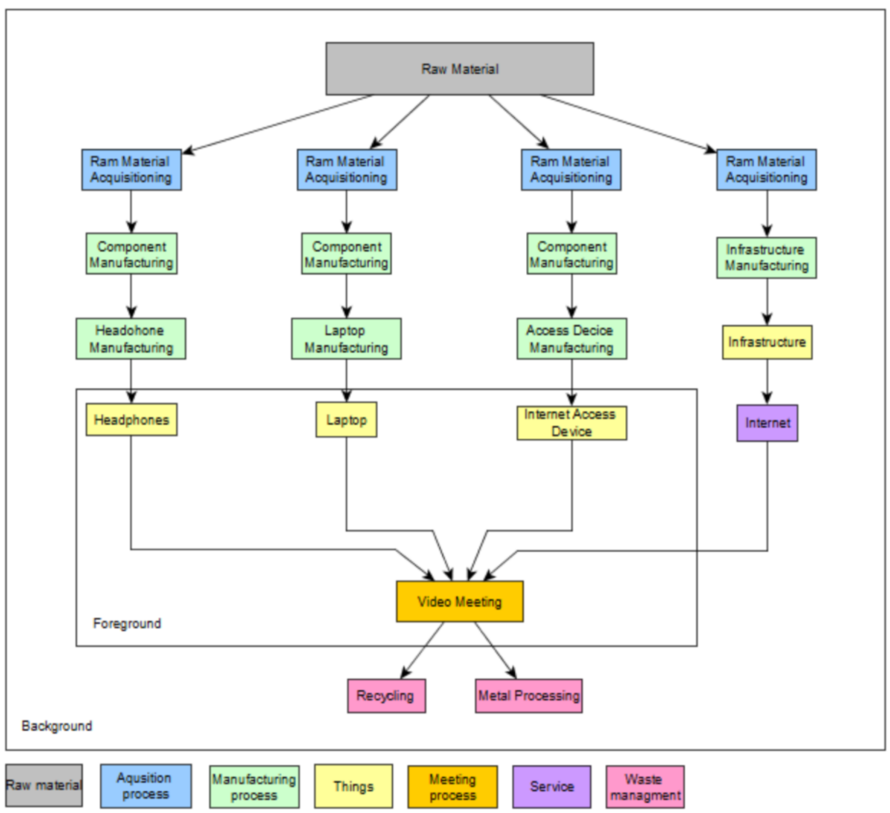

Figure 4. Flowchart for the video meeting

2.1.2 Collected data and data gaps

The data collected for the video meeting life cycle are mainly for the headphones. For the headphones, we have used the Urbanears Plattan On-ear headphones as a base example. The

1

weight and the known used materials are based on information about these headphones. However, the exact material compositions and fractions for these headphones is not known. Therefore, it some of the materials has been based on online information from company representatives, assumed common headphone materials where there was no information available, and mapped these factors to different parts of the headphones by weight. The sources for the materials information are primarily questions answered by the manufacturer, as in Urbanears (2015a), Urbanears (2015b) and Urbanears (2016).

For example, the cable was known to weigh 6 g and to be made out of copper, and covered by fabric. Thus, it has been assumed that 1.5 g was unknown fabric and 4.5 g was copper. Further, assumptions about the fabric composition were made based on the options available in SimaPro. The largest data gap for the headphones are the one of the processes used in the manufacturing, and the assumptions of which processes that are being used has not been well supported by any sources. For more information about the weight detailed, Table 2A. respectively Table 2B. in Appendix 2.

2.2 Modelling train travel and air travel

2.2.1. Flow charts

The flowchart of the train travel meeting is presented in Figure 5. and for the air travel meeting in Figure 6., and shows the processes included in the modelling for this study.

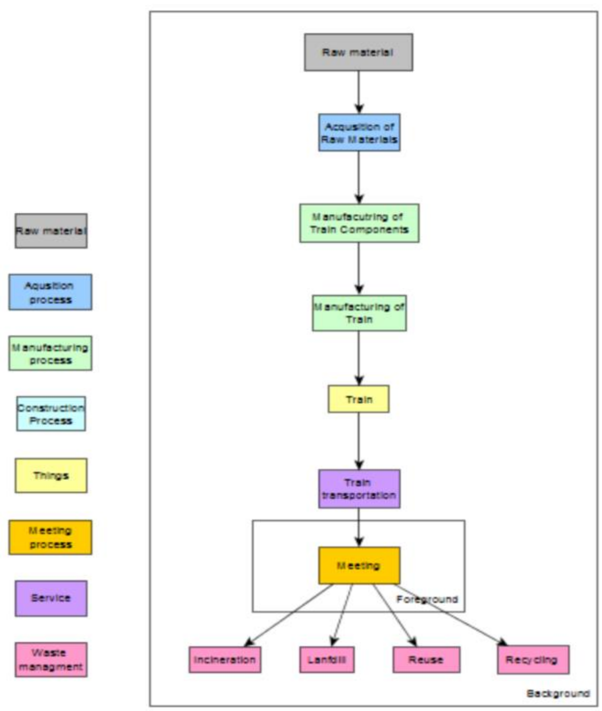

Figure 5. Flow chart for the train travel meeting.

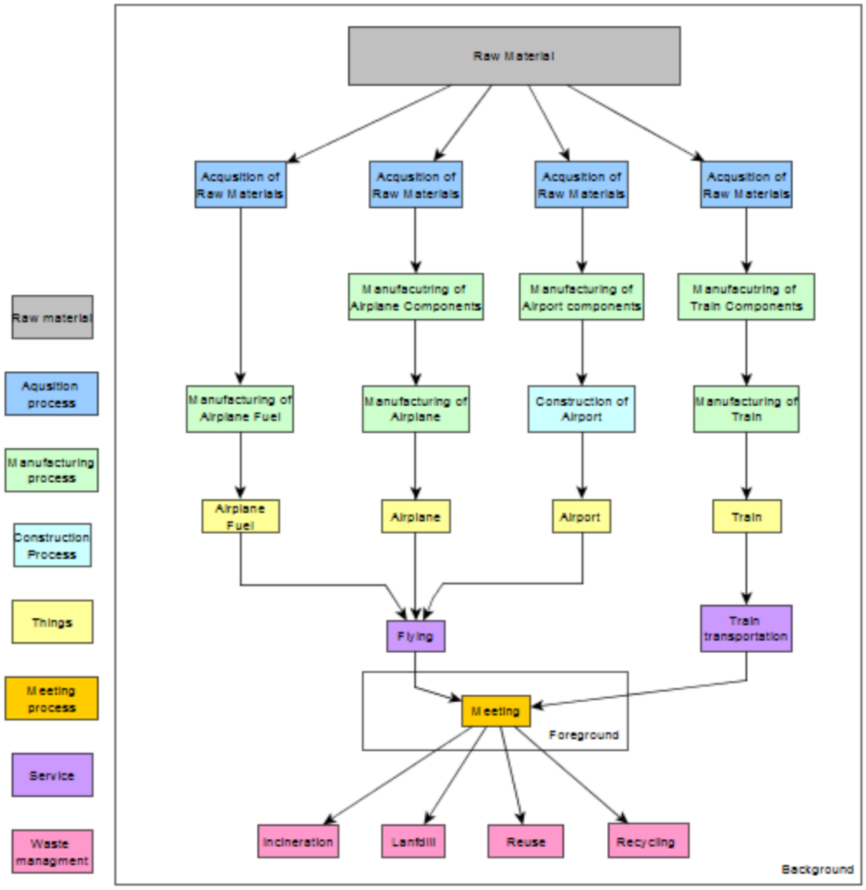

Figure 6. Flow chart for the air travel meeting.

2.2.2 Collected data, data gaps and calculations

There are several assumptions made about the two traveling life cycles. There is going to be 25 trips from the Central station in Stockholm to the Central station in London and back which gives the total number of 50 single trips. The distance by air is assumed to be 1433 km (Distance Calculator, 2016). Further, it is assumed that the traveller is traveling by train to the Central station of London and Stockholm from respective airport. The distance travelled from London Central Station to Heathrow is assumed to be 27 km and from Stockholm Central Station to Arlanda Airport is assumed to be 36 km (Figure 7.). For the train it is assumed that it is a trip without any stops or changes to either bus, boats or another train. Further, the distance from Stockholm Central Station to London Central Station by train is assumed to be 1900 km (Figure 8.).

Further, there are data gaps for the train travel for Sweden and England and for the flying inside Europe. In order to tackle this, a new air and train travel process were constructed which can be studied in Table 2C. respectively Table 2D. in Appendix 2. These processes are the global average processes that exist in SimaPro, but the non-European contribution was removed.

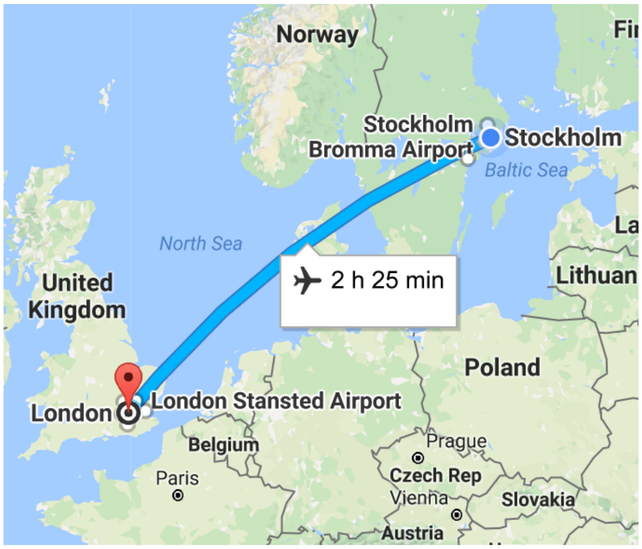

Figure 7. Flight map (Google maps).

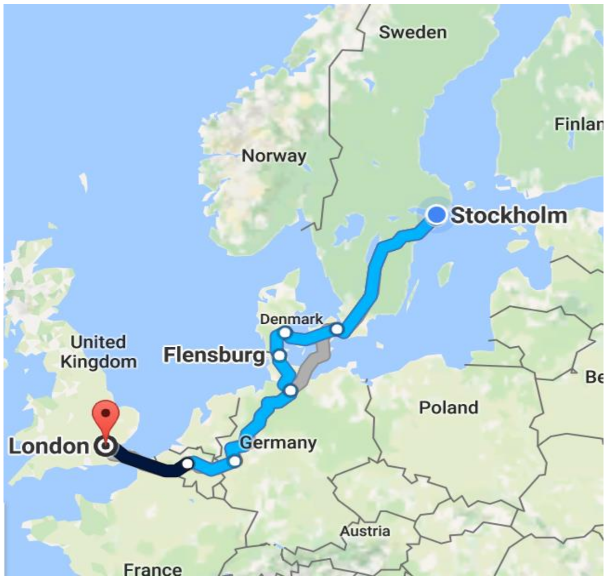

Figure 8. Train route map (Google maps).

3. Life cycle interpretation

3.1 Comparison of the three life cycles

The air travel meeting has the greatest impact for the eleven of the eighteen categories and the train travel meeting has the greatest impact in the remaining seven, which can be studied in Figure 9. The video meeting has the lowest impact in all categories, but are about the same as the train travel meeting for two of the impact categories. When studying the normalized results in Figure 10., the different impacts of the life cycles can be divided into three different categories; high, medium and low. The only category that is a high impact is the natural land transformation from the air travel meeting, which is significantly larger than the rest. The train travel meeting has a medium impact in four impact categories; freshwater eutrophication, human toxicity, freshwater ecotoxicity, marine ecotoxicity and natural land transformation. For these impacts, the normalized value is between five and eight. The video meeting has a low impact in all categories compared to the others.

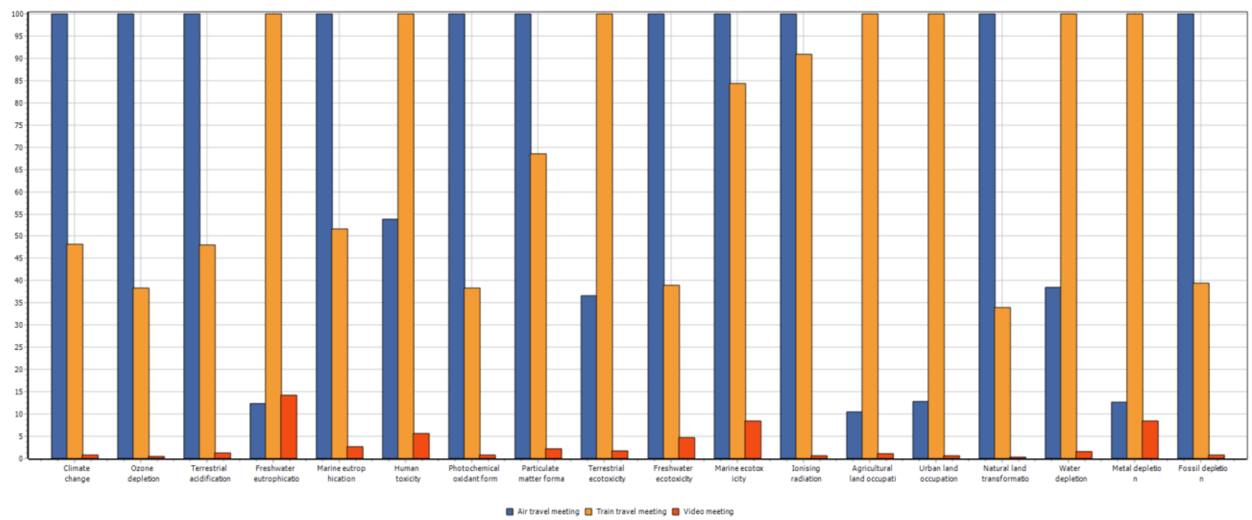

Figure 9. The comparison of the characterization of the three life cycles.

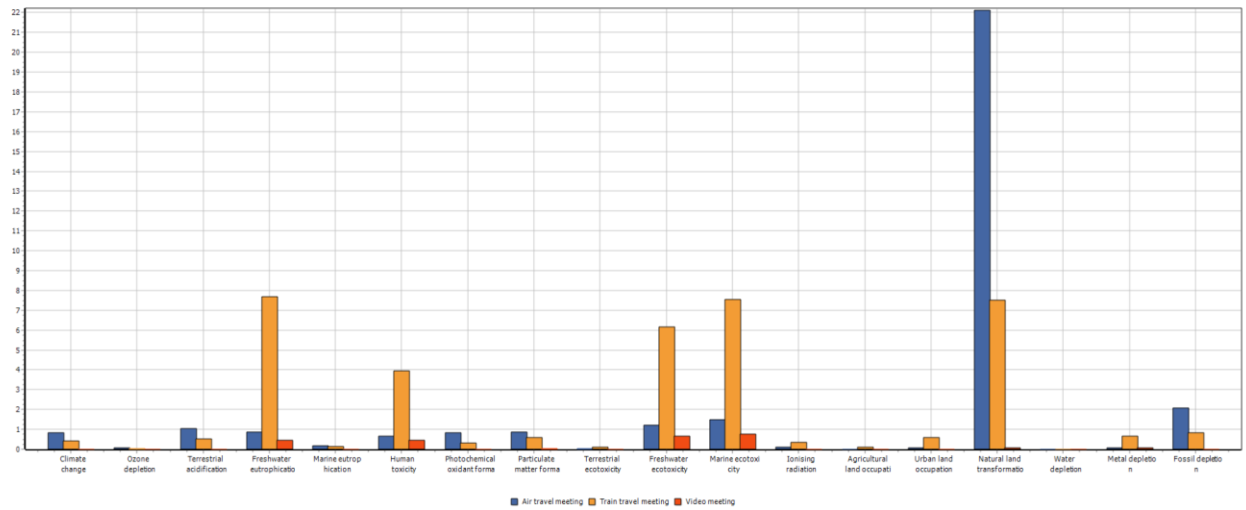

Figure 10. The comparison of the normalization of the three life cycles.

3.2 Characterization and normalization

3.2.1 Video meeting

The most significant contributor to the different impacts are the combined headphones, computer and Internet access device, which can be studied in Figure 11.. Further, the lowest impact contributor is the operation of the Internet access device. When the results are normalized, which can be studied in Figure 12., marine ecotoxicity, freshwater ecotoxicity, human toxicity and freshwater eutrophication are the most significant impacts. Further, natural land transformation, metal depletion, fossil depletion and particulate matter forma have a low impact contribution and the other impact categories have close to none.

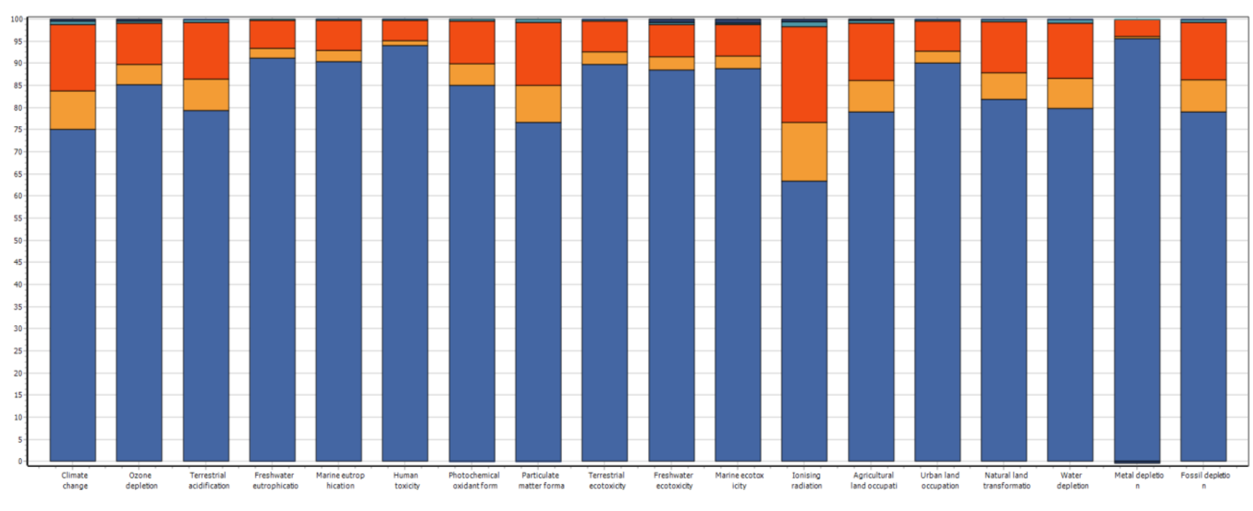

Figure 11. Characterization for the video meeting life cycle, with long term emissions.

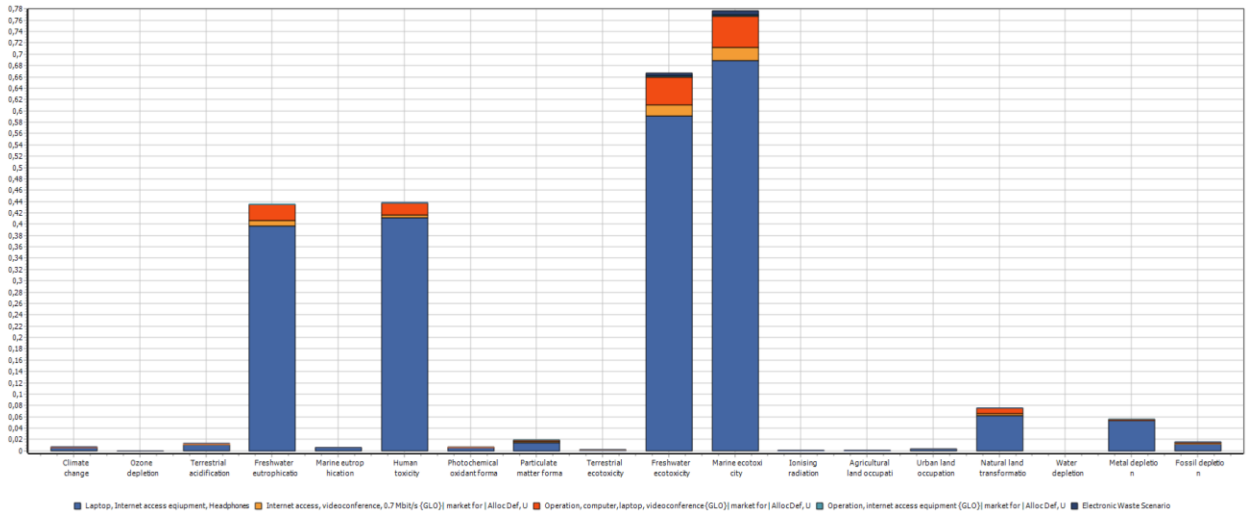

Figure 12. Normalization of the video meeting life cycle, with long term emissions.

3.2.2 Air travel meeting

As seen in Figure 13., the flying case contribute the most to all impact categories. However, the train travel to and from the airport contributes between 10% and 25% for some impact categories. Those categories are freshwater eutrophication, human toxicity, terrestrial ecotoxicity, freshwater ecotoxicity, marine ecotoxicity, agricultural land occupation, urban land occupation and metal depletion. The normalised results in Figure 14. shows that natural land transformation stands out as the single most significant environmental impact. Fossil depletion as the second most significant, however it is several times lower than natural land transformation.

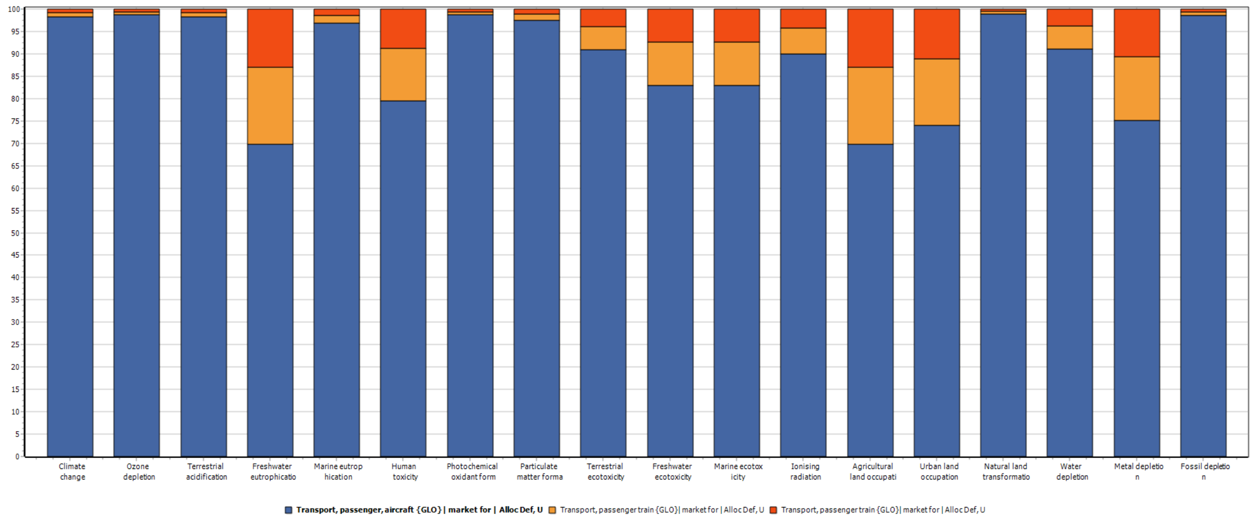

Figure 13. Characterization results of the Air travel meeting.

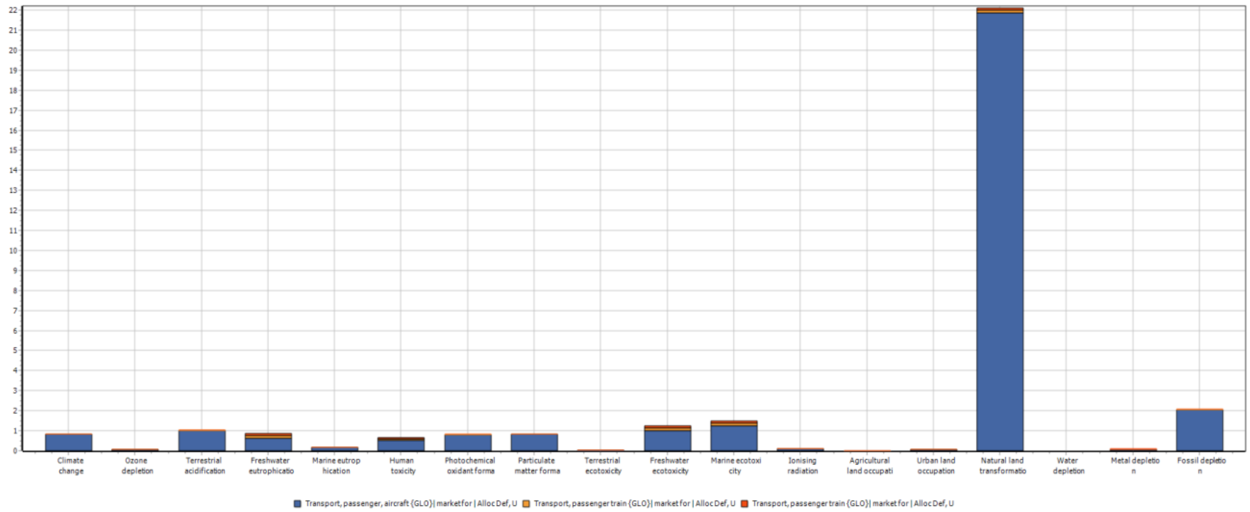

Figure 14. Normalization result of the Air travel meeting.

3.2.3 Train travel meeting

Because there is only one process for the train travel, the characterisation results are not interesting for to study. However, for the normalised results in Figure 15., five impact categories stand out; Freshwater eutrophication, human toxicity, freshwater ecotoxicity, marine ecotoxicity and natural land transformation. All the other impacts are low or close to zero.

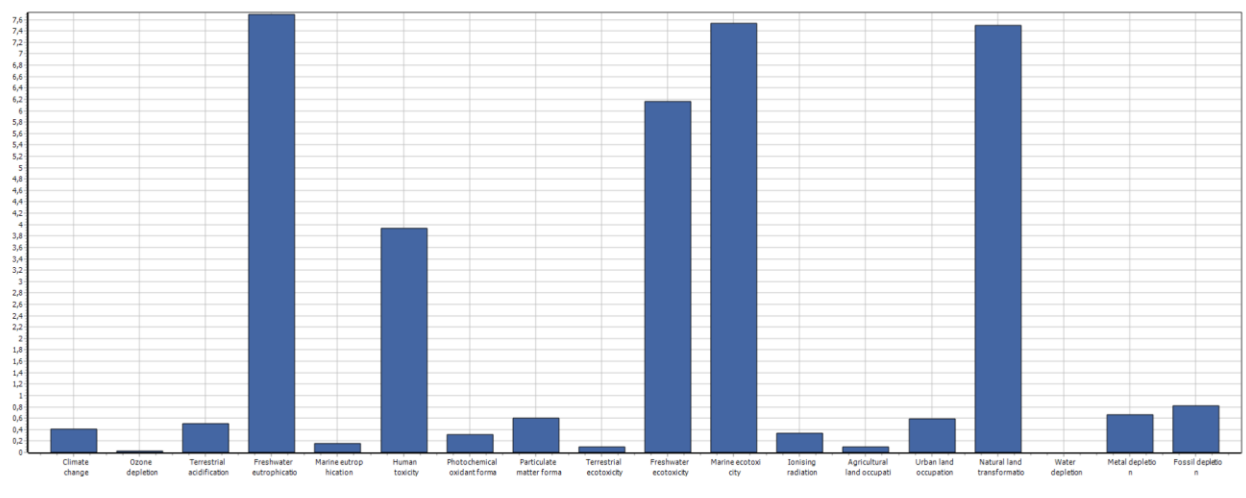

Figure 15. Normalised results of the train travel meeting.

3.3 Hotspots for the three life cycles

Figure 16. shows the impact contributions from the two largest contributor processes onto the five largest normalized impact categories for the air travel and train travel meetings. The green bars represent the portion of the "Train travel impact" in the respective categories which is derived from the SimaPro process of "Spoil from lignite mining {GLO} - treatment of, in surface landfill - Alloc Def, U". Lignite is a form of coal, and the spoils are a form of mining waste (Doka, 2009). Studying the process as modelled in SimaPro reveals emissions of a number of

heavy metals, which are likely the reason for the toxicity. It is notable that this process is the largest contributor in the four distinct categories in which the train performs the worst out of the three cases. The purple parts of the bars represent the impact on the travel options for the category natural land transformation, from the SimaPro process “Onshore well, oil/gas {GLO} - production - Alloc Def, U”. This means that the land uses from onshore oil or gas wells are the most important contributors to environmental impacts for flying, more so than climate change.

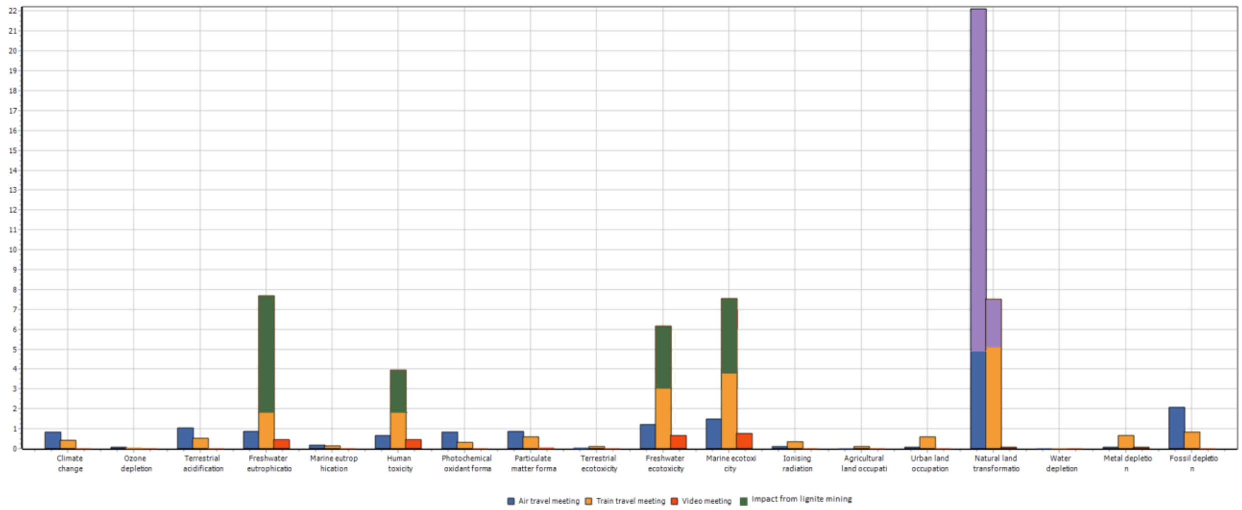

Figure 16. The normalized results of the comparison, with the hot spots marked.

In graph figure 17. the green impacts show the contributions to the environmental impacts of the laptop from the SimaPro process “Sulfidic tailing, off-site {GLO} - treatment of - Alloc Def, U “. The sulfidic tailings are a kind of mining waste which can cause outflows of acidic water if not managed properly (Nehdi, 2007). While the video meeting’s environmental impacts are smaller than the others, there is still room for improvements within the hotspots.

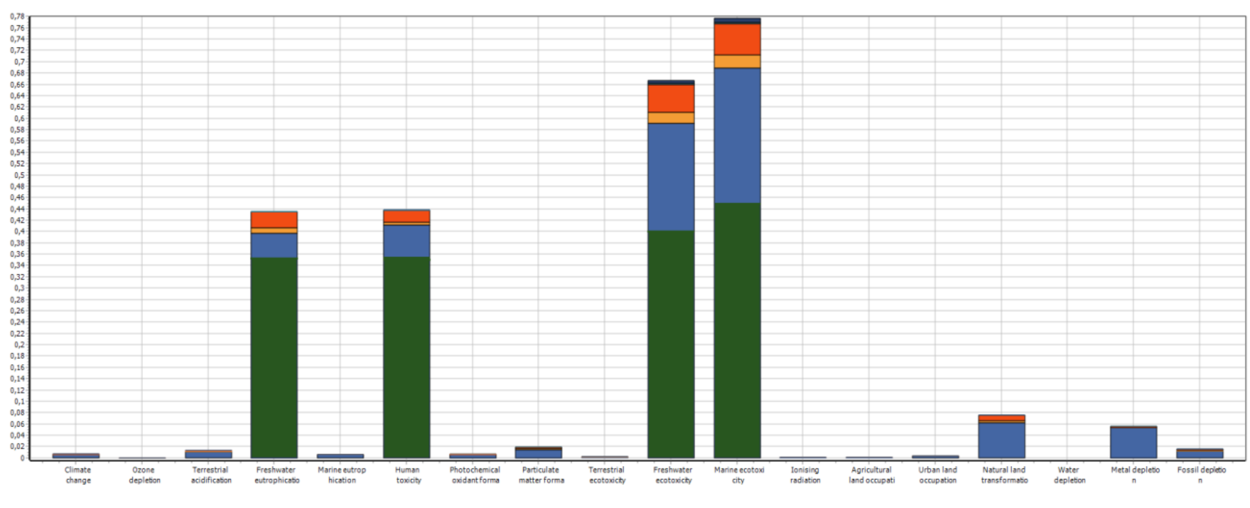

Figure 17. The normalized results of the video meeting, with the hot spots marked.

There are two ways to interpret these graphs. They either show that these are the key hotspots to improve in order to reduce impacts, or that there is some error in the existing SimaPro modelling for these functions, since they have an exceptionally large impact. Since the oil drilling and mining industries are well known for contributing to large environmental impacts, the former explanation is determined as likely.

3.4 Flow charts

3.4.1. Video meeting

Figure 18. shows the network of the SimaPro model for the video meeting. In chapter 3.3 sulfidic tailing was a hotspot for the video meeting case, and that originated from the laptop. When studying this flow chart, it can be confirmed that the laptop is responsible of the largest contribution of the impact compared to the other materials and processes in the life cycle.

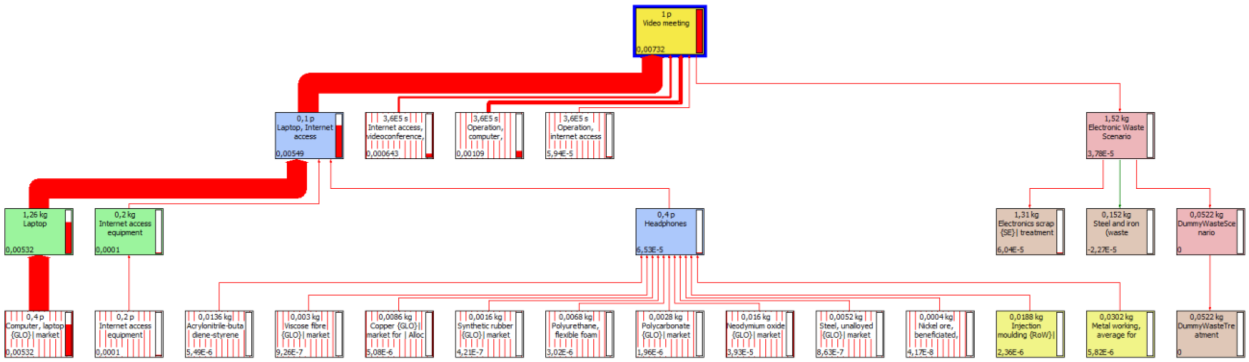

Figure 18. Network of the Video Meeting Life Cycle from SimaPro with 0 % Cut-off.

3.4.2. Air travel meeting

Figure 19. shows network the case with travelling by airplane, with the modified air travel process. As seen, the airport and the fuel are the most important impacts but they are however not dominating in the total contribution.

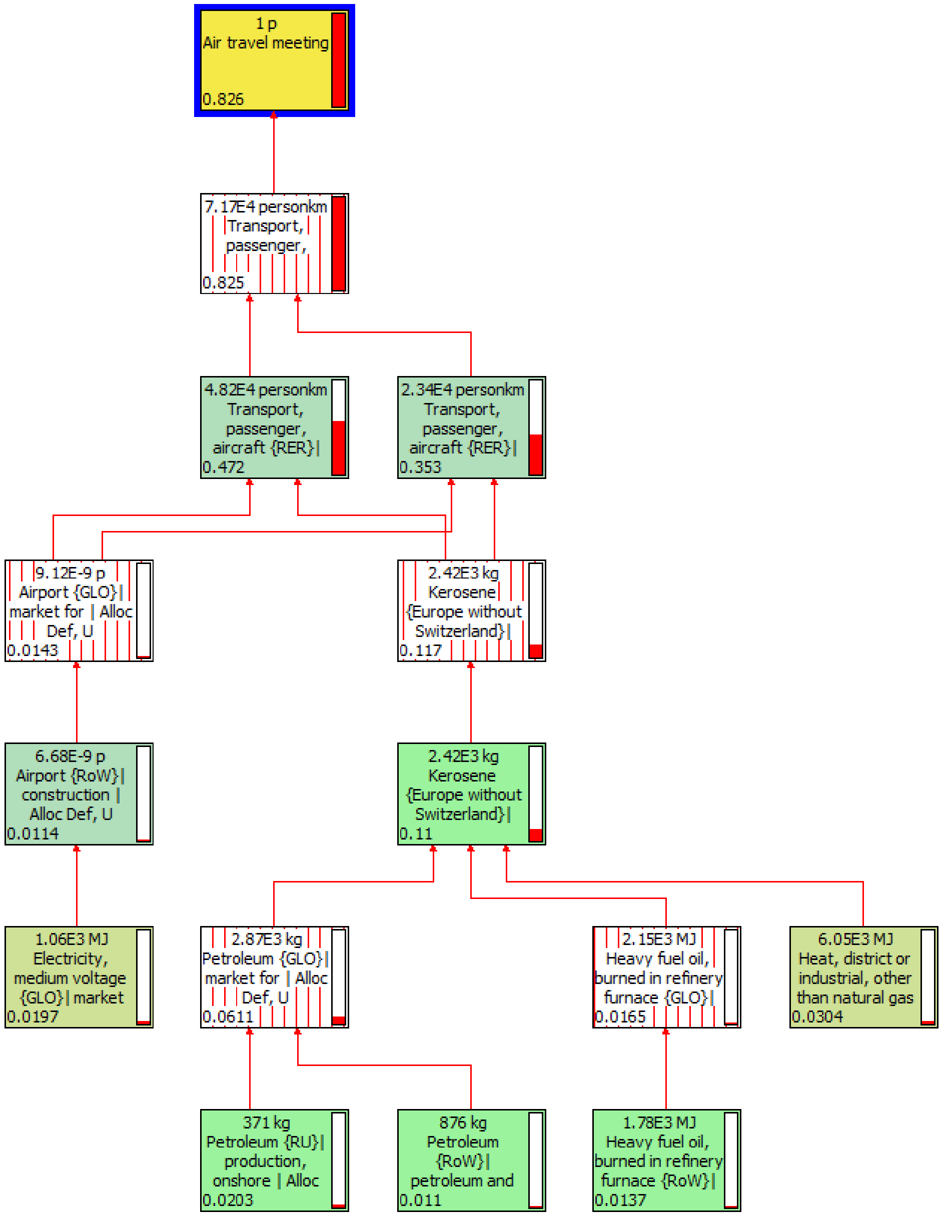

Figure 19. Flow chart of the modified air travel process.

3.4.3. Train travel meeting

Figure 20. shows the network of the train travel life cycle in SimaPro, with the modified train transport process. The electricity use is identified as a large contributor to the total impacts of this life cycle.

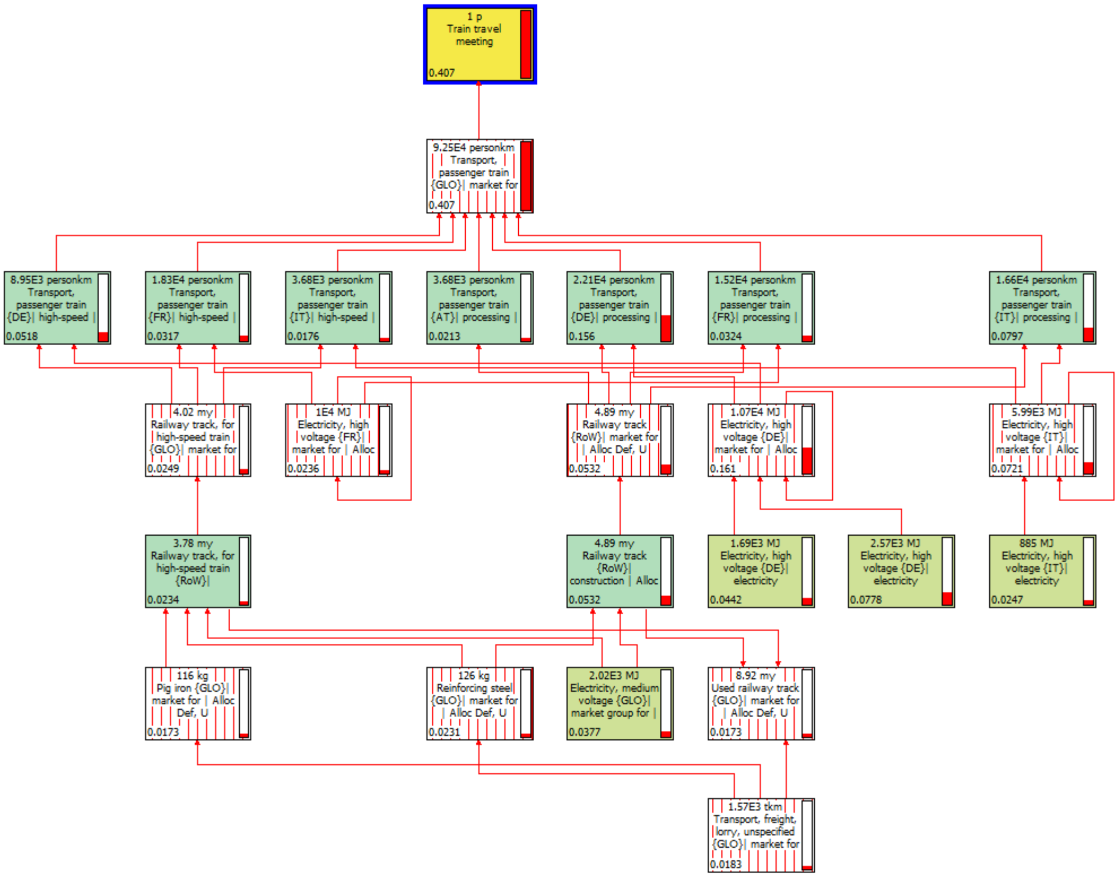

Figure 20. Flowchart of the modified train travel process.

4. Uncertainty and sensitivity analysis

There is also uncertainty within the travel selections. We have not chosen the shortest way to travel because we have chosen to take the train from Stockholm to London. In practice, this Travelling from Stockholm to London you could go by boat between Sweden and Germany, this is a shorter distance but not relevant for this comparison.

4.1 Uncertainty analysis

Our largest uncertainties are sourced in the functional unit, the headphone modelling and the allocation.

The functional unit of this report is relatively arbitrary. One of the uncertainties of this study is the choice of meeting time and frequency. It would also be valid to study 100 meetings with eight participants each. In the results of the survey, presented in Appendix 1, the meeting time varied between four and eight hours but only four hours has been used as the average meeting time. However, the largest impacts are from the travel options, so the main uncertainty, which will actually impact the results, is the travel distance. For this reason, sensitivity analysis will be done for the case of having only one meeting.

The most important allocation done in this report is the allocation of the computer and Internet access equipment. For the computer, 10% of the impacts were allocated to this process. However, if you were to allocate using the use time for our 100 hours compared to the entire life cycle use instead, the number would be closer to 1.16 percent. However, changing this allocation would only minimize the video meeting impacts even further. Another uncertainty comes from assuming that the same allocation is correct for the Internet access equipment. This is a complicated case to allocate, so this assumption was done. Another uncertainty is that we assumed that video meetings happens with laptops and headphones, and not in rooms with large screens and a computer only used for this purpose. Modelling this option is outside the scope of the project, but could impact the results.

For the headphones, there are several uncertainty factors. There are several fractions used that are hard to measure accurately without disassembly, such as the weight fraction of metal to fabric in the cord. Additionally, not all materials may have been correctly identified, or paired to suitable LCA materials. The attempt to model the manufacturing processes is also an uncertainty. This means that the headphone impact is small, but that the errors could be large.

One of the assumptions that affect the results is the assumption that only one person is travelling from Stockholm to London. However, the practical effects of more people travelling would be that the travel impacts were multiplied by the amount of people travelling. Since the result of this report already indicates that the Internet options have much smaller impacts, changing this would only solidify our results. There is also uncertainty within the travel selections. We have not chosen the shortest way to travel because we chose to take the train from Stockholm to London. In practice, this path is unlikely for ah business meeting, but it is still an interesting comparison to make due to it being a common way of business travel within Europe.

4.2 Meeting time and frequency analysis

In order to get an understanding of how this affects the results of the LCA, two scenarios have been modelled in SimaPro. The first scenario is assumed that only one meeting of four hours has been held, and the second one assumes that 25 eight-hour meetings have been held. In practice, the first case means that all travel is decreased by a factor of 25, the use hours for equipment reduced to four, and the computer allocation unchanged. For the second case, the equipment use hours have been doubled to 200.

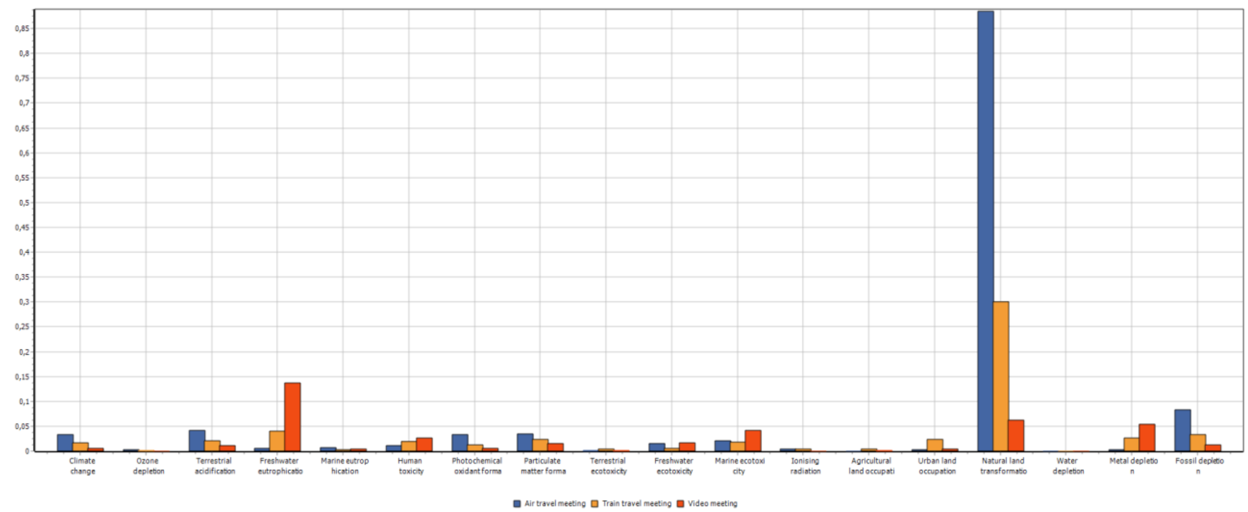

Figure 21. The normalisation results of the four hour, single meeting analysis.

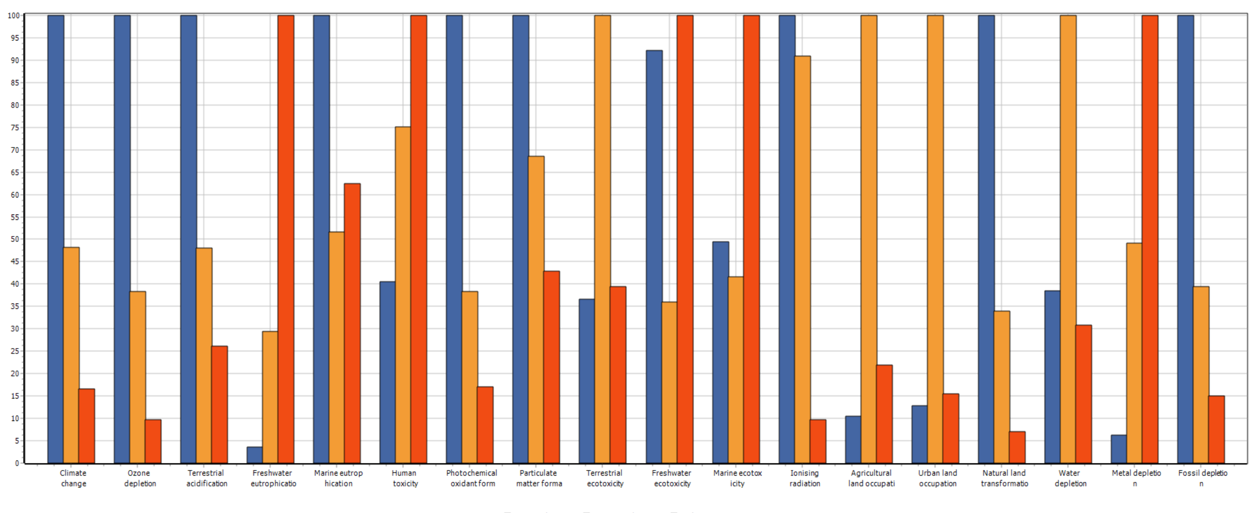

Figure 22. The characterisation result of the four hour, single meeting analysis.

The results above (Figure 21. and Figure 22.) show a marked increase in the environmental impacts of the video meeting compared to the travel scenario. This could be interpreted as meaning that video meeting only becomes the best option by far due to regular use.

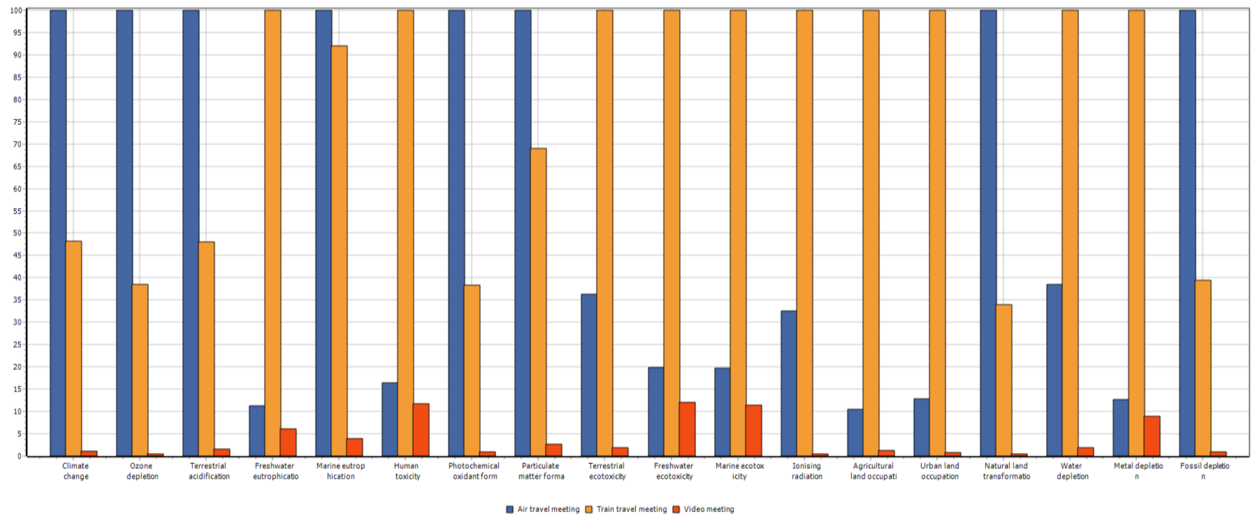

Figure 23. The characterisation result of the eight hour, twenty-five meeting analysis.

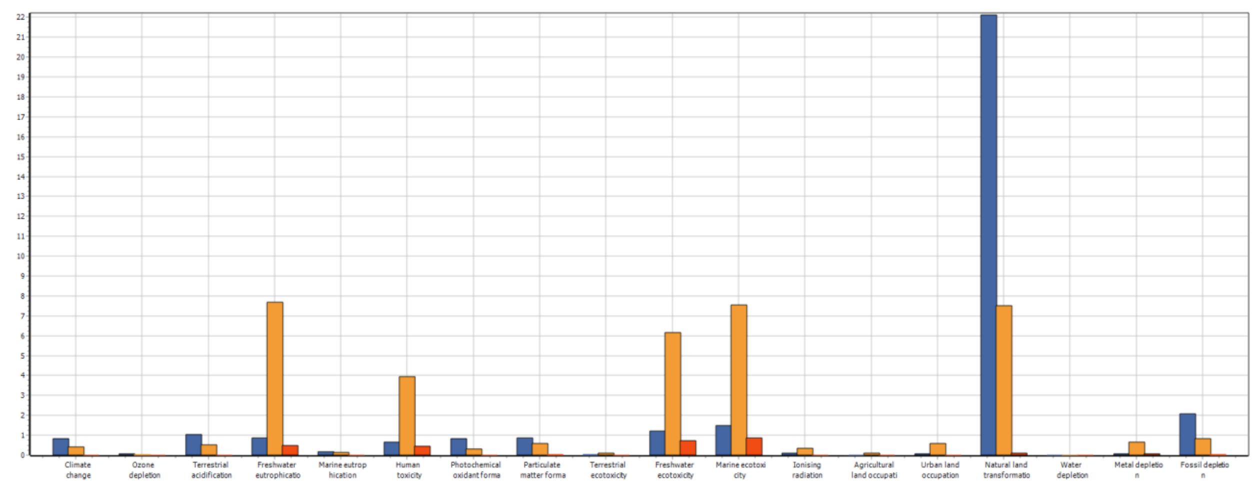

Figure 24. The normalisation results of the eight hour, twenty-five meeting analysis.

For the eight-hour meeting case described above, the results are very similar to the standard case. It can be concluded that assuming longer meetings does not impact the results.

4.3 Headphone analysis

Since the headphone model is very uncertain, one of the sensitivity analyses done was to multiply the number of headphones by 40, to see if the possible errors made in modelling would impact the results.

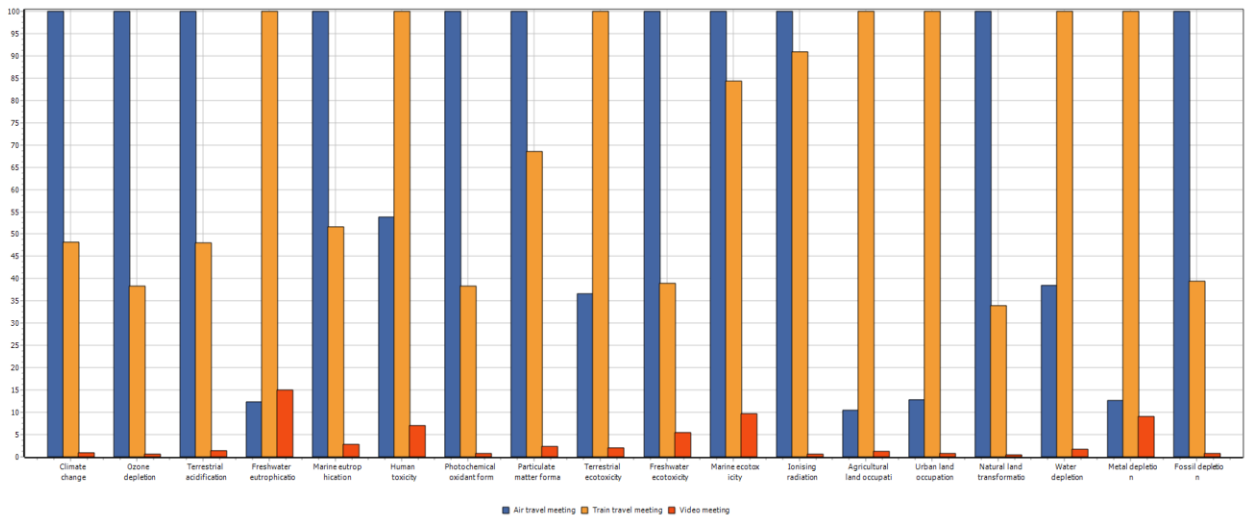

Figure 25. The characterisation result for the headphone analysis.

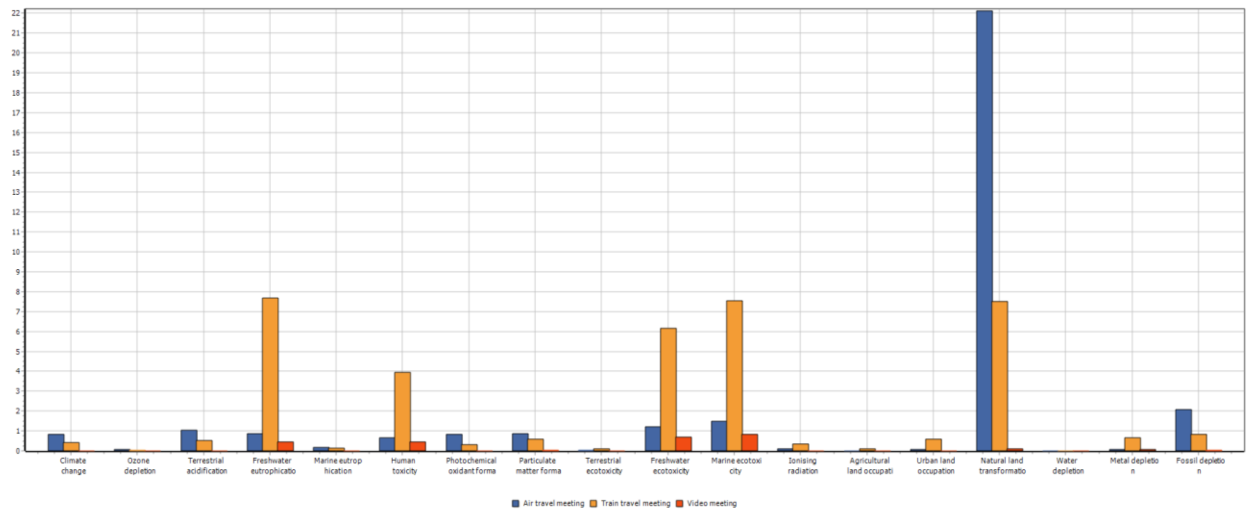

Figure 26. The normalisation result for the headphone analysis.

As seen in the graphs (Figure 25. and Figure 26.), even using 40 headphones instead of four does not lead to any large impact on the results.

4.4 Distance analysis

For this analysis, the travel distance was changed to see how that impacted the results. Instead of using the distance from Stockholm to London, the distance Stockholm-Gothenburg was used. The air travel distance was set to 400 personkm (Google maps, N.D.) and the train travel distance to 470 personkm (Ibid), and we assumed that the distance to and from the airports would be unchanged.

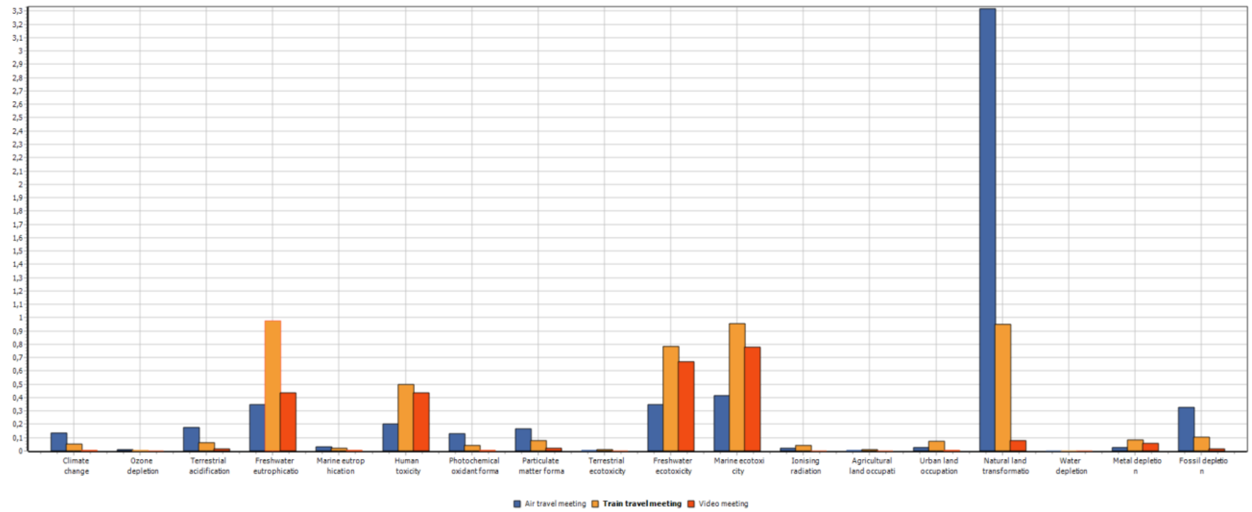

Figure 27. The normalisation result for the distance analysis.

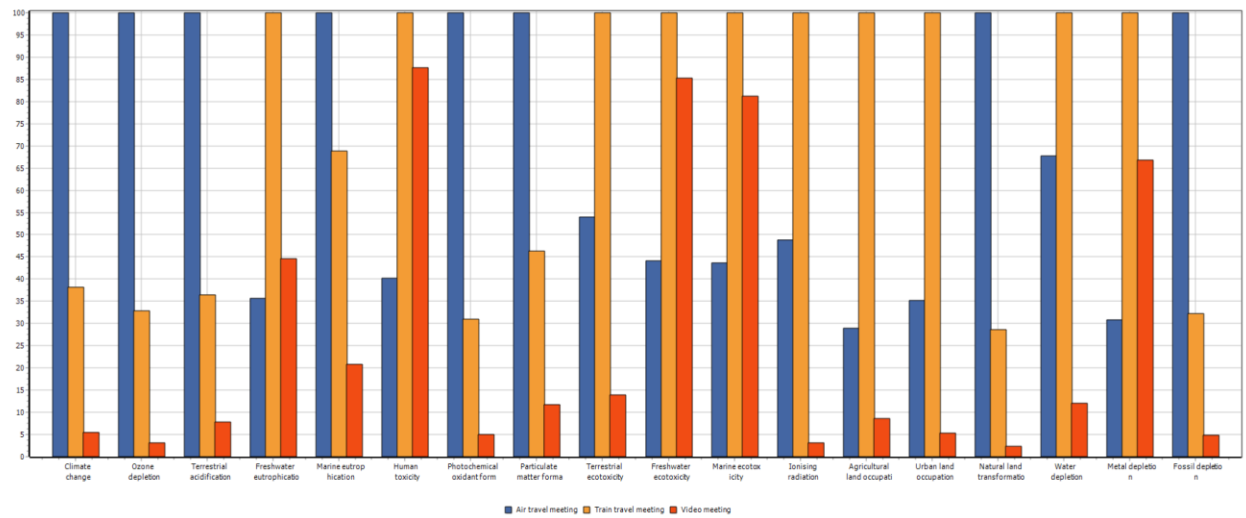

Figure 28. The characterization result for the distance analysis.

These results (Figure 27. and Figure 28.) shows that shortening the travel distance means that video meetings become relatively worse when compared to the travel options. The longer the travel distance is, the larger the benefits of video meetings become.

5. Discussion

The result shows us that both flying and going by train to meetings have greater impacts than video meetings. However, between the two travel models, the results are surprisingly equal. Of the three standout contribution processes, two are related to mining and one to oil. Mapping the in-depth connections between these processes and the studied services are outside the scope of the report. However, it is clear that mapping and working to replace these options are the best way to lower the most important impact for all cases. It seems more likely that it is possibly able to remove, replace or manage the mining impacts that are key for the train travel and the computer, rather than the oil for the train travel. If future analysis shows that this is the case, trains might be the better option in terms of environmental adaptability and potential to lower impacts.

What this LCA cannot take into account is the different behaviour that these two types of meeting (face-to-face and video meetings) are leading to. Even though we found out how long a typical meeting is for 20 of Atlas Copco's Swedish employees, the results showed that meetings that are flown to are often longer and combined with study visits. A face-to-face meeting have other important side effects too, such as knowing each other and the discussion outside the meeting give a lot of new ideas and relations. On the other hand, having the opportunity to have a video conference means that you could have meetings more often but shorter compared with when you are travelling. These are aspects that are not taken into account in the comparison but still have a great impact when companies choose to have a video or face-to-face meetings. That companies still choose travel despite it being worse based on time, environmental impacts and presumably money, shows that these informal and non-measurable aspects are very important to them.

The results of the sensitivity analysis show that the LCA results are solid. It also highlights some general trends. Manufactured but rarely used video meeting equipment may have larger environmental impacts than a single trip. The environmental savings of the video meeting equipment increase with travel distance and the time the equipment are used. The second of these results are also supported by Borggren et al. (2013). There are several avenues available for further research. Our LCA results could be challenged or adapted by doing a social life cycle analysis (S-LCA) or life cycle costing (LCC), for the same cases. Aspects that could be more important in these cases are conflict minerals, and economic aspects, and would together with the LCA give a better understanding of the sustainability of the different meetings.

The sources used in this study are mainly from between 2006 and 2016, with a few exceptions with sources that dates back to between 2000 and 2006. For some of the assumptions for the headphones, the customer service for Urbanears has been used and is considered to be a good source. Further, for the assumptions about traveling distance, Google Maps has provided with data that has been determined reliable. For the sources for the text, studies from renown authors, developers for SimaPro and ReCiPe and also authorities have been used where all are determined to be reliable. For the statistics, the European statistics site Eurostat has been the source which also is determined to be trustworthy.

6. Conclusion

The conclusion is that having a video meeting has lower environmental impacts compared to travelling between Stockholm and London for a face-to-face meeting by airplane or train. However, the decision between those two transport alternatives is ambiguous from an environmental perspective. For fewer meetings and shorter distances, video meetings are less superior, but still better. All three cases studied have large normalized contributions from just a few SimaPro processes. These are spoils from lignite mining in the case for the train meeting case and it is on-shore oil and gas well in case of both the train and air travel meetings. However, it is likely that it is easier to improve the ones connected to trains and video meetings, rather than the oil which is central to passenger travel.

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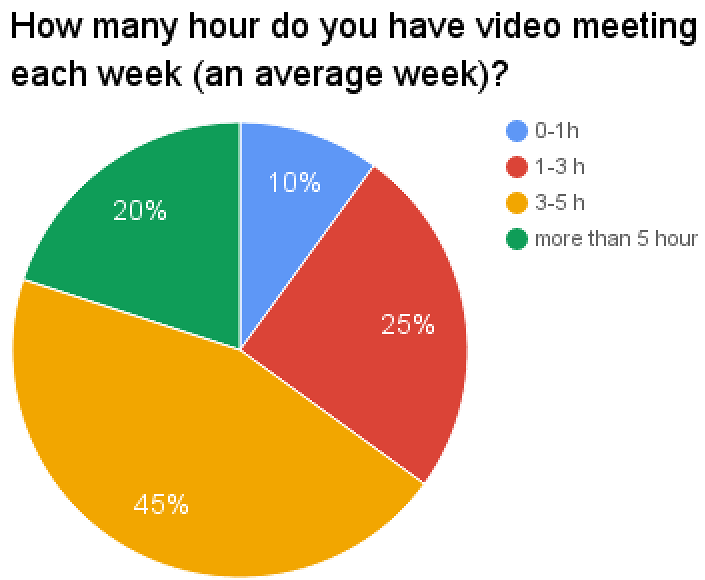
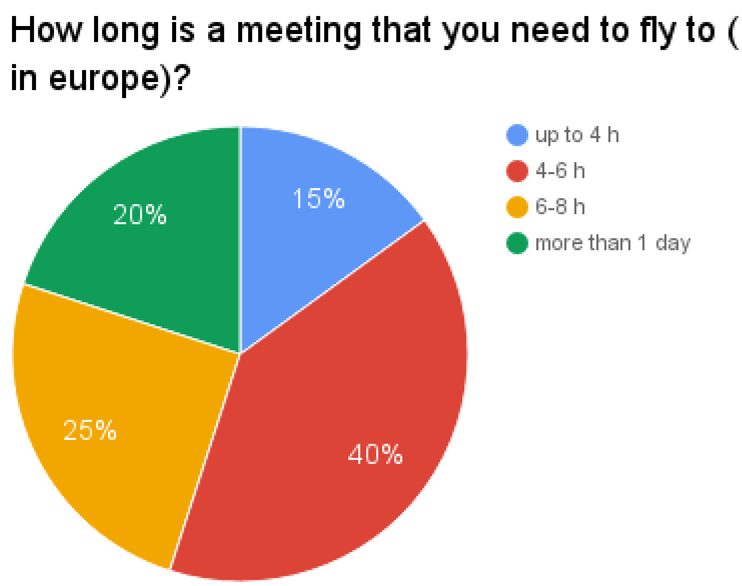
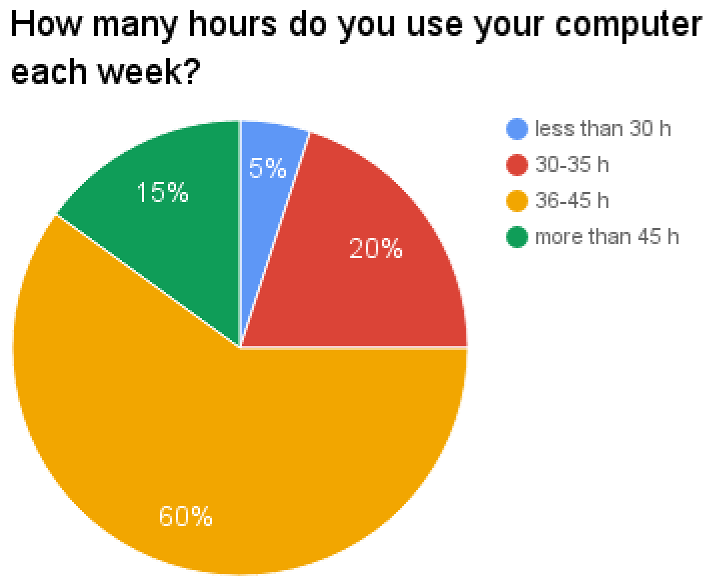
Appendix 1 - Atlas Copco survey

20 employees of Atlas Copco in Stockholm, Sweden, answered the questions.






How many hours do you use your computer each week?
less than 30 h
30-35 h
36-45 h
more than 45 h
5%
20%
60%
15%

Appendix 2 - Data reference

Table 2A. The data reference for the material used in the headphones

Component	Material	Ecoinvent Process	Amount	Data Source	Comment
Cable	Fabric	Viscose fibre {GLO} - market for - Alloc Def, U	1.5 g	Authors own estimation	
	Copper	Copper {GLO} - market for - Alloc Def, U	3,5g	Authors own estimation	
Jacks	Rubber	Synthetic Rubber {GLO} - market for - Alloc Def, U	4g	Authors own estimation	Urbanears (2015a)
	Copper	Copper {GLO} - market for - Alloc Def, U	7g	Authors own estimation	
	Nickel coating	Nickel ore, beneficiated, 16% {GLO} - market for - Alloc Def, U	1g	Authors own estimation	
Volume regulator	Hard plastics (ABS)	Acrylonitrile-butadiene-styrene copolymer {GLO} - market for - Alloc Def, U	3g	Authors own estimation	Urbanears (2015a)

	Copper	Copper {GLO} - market for - Alloc Def, U	1g	Authors own estimation	
Earmuffs	Foam	Polyurethane, flexible foam {GLO} - market for - Alloc Def, U	6g	Authors own estimation	
	Hard plastics (ABS)	Acrylonitrile-butadiene-styrene copolymer {GLO} - market for - Alloc Def, U	8g	Authors own estimation	Urbanears (2015a)
	Fake leather	Polyurethane, flexible foam {GLO} - market for - Alloc Def, U	6g	Authors own estimation	The closest that was found for fake leather
Headband	Steel	Steel, unalloyed {GLO} - market for - Alloc Def, U	3g	Authors own estimation	
	Hard plastics (ABS)	Acrylonitrile-butadiene-styrene copolymer {GLO} - market for - Alloc Def, U	12g	Authors own estimation	Urbanears (2015a)
	Foam	Polyurethane, flexible foam {GLO} - market for - Alloc Def, U	5g	Authors own estimation	
	Fabric	Viscose fibre {GLO} - market for - Alloc Def, U	3 g	Authors own estimation	The closest that was found to fabric

	Plastic (PC)	Polycarbonate {GLO} - market for - Alloc Def, U	7g	Authors own estimation	Urbanears (2015a)
Headphone core	Neodymium magnet	Neodymium oxide {GLO} - market for - Alloc Def, U	34g	Authors own estimation	It is assumed that this material is used in the magnet since it is used in another model (Urbanears 2015b)
	Hard plastics (ABS)	Acrylonitrile-butadiene-styrene copolymer {GLO} - market for - Alloc Def, U	17g	Authors own estimation	Urbanears (2015a)
	Steel	Steel, unalloyed {GLO} - market for - Alloc Def, U	10	Authors own estimation	
	Copper	Copper {GLO} - market for - Alloc Def, U	16	Authors own estimation	

Table 2B. The data reference for the processes used in the life cycle of the headphones

Component	**Process**	**SimaPro**	**Amount**	**Data Source**	**Comment**
All plastic components	Moulding plastics	Injection moulding {RER} - processing - Alloc Def, U	47	Authors own estimation	

All metal components	Working metal	Metal working, average for metal production manufacturing {RER} - processing - Alloc Def, U	75,5	Authors own estimation	

Table 2C. The data reference for the airplane traveling

Component	Process	SimaPro	Amount	Data Source	Comment
Travel by airplane	Transport, passenger, aircraft 1	Transport, passenger, aircraft {RER}| Intercontinental | Alloc Def, U	0.673	SimaPro	The amounts are based on % calculations from SimaPro data
	Transport, passenger, aircraft 2	Transport, passenger, aircraft {RER}| Intercontinental | Alloc Def, U	0.327	SimaPro	Same process as before, calculated separately

Table 2D. The data reference for the train traveling

Component	Process	SimaPro	Amount	Data Source	Comment
Train travel	German High-speed train travel	Transport, passenger train {DE}- high-speed - Alloc Def, U	0,096769115 personkm	SimaPro	The amounts are based on % calculations from SimaPro data
	French High-speed train travel	Transport, passenger train {FR}- high-speed - Alloc Def, U	0,1977053218 personkm	SimaPro	

	Italian High-speed train travel	Transport, passenger train {IT}- high-speed - Alloc Def, U	0,0398188704 personkm	SimaPro	
	Austrian High-speed train travel	Transport, passenger train {AT}- high-speed - Alloc Def, U	0,039755404 personkm	SimaPro	
	Belgium High-speed train travel	Transport, passenger train {BE}- high-speed - Alloc Def, U	0,0423654526 personkm	SimaPro	
	German High-speed train travel	Transport, passenger train {DE}- high-speed - Alloc Def, U	0,2392280695 personkm	SimaPro	
	French High-speed train travel	Transport, passenger train {FR}- high-speed - Alloc Def, U	0,1648593838 personkm	SimaPro	
	Italian High-speed train travel	Transport, passenger train {IT}- high-speed - Alloc Def, U	0,1794997638 personkm	SimaPro	