Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Engineering
Department of Energy and Process Engineering

Maren Øie

Comparing the environmental impacts of a physical vs. digital UN conference

Master's thesis in Energy and Environmental Engineering
Supervisor: Francessca Verones
June 2022

NTNU
Kunnskap for en bedre verden

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Disclaimer

The Office of the United Nations High Commissioner for Human Rights (OHCHR) intended to provide data as a starting point for the master's thesis. Due to the unforeseen events in Europe during the spring of 2022, they unfortunately did not have the opportunity to provide data to this project. Thus, the project is based on general data, assumed data and the Ecoinvent version 3.8 database.

Master agreement

This report has been written as a masters thesis at the Norwegian University of Science and Technology (NTNU). The project is conducted during the spring of 2022 under the Department of Energy and Process Engineering and counts as 30 credits.

NTNU

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Master`s Agreement / Main Thesis Agreement

Faculty	**Faculty of Engineering**
Institute	**Department of Energy and Process Engineering**
Programme Code	**MTENERG**
Course Code	**TBA4950**

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The Master`s thesis	
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Risk Assessment and Data Management

Will you conduct a Risk Assessment? **If "Yes", Is the Risk Assessment Conducted?**	**No** **No**
Will you Apply for Data Management? **(REK*, NSD**)**	**No**
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Topics to be included in the Master`s Degree (if applicable)

LCA

Guidelines – Rights and Obligations

Purpose

The Master's Agreement/ Main Thesis Agreement is an agreement between the student, supervisor, and department. The agreement regulates supervision conditions, scope, nature, and responsibilities concerning the thesis.

The study programme and the thesis are regulated by the Universities and University Colleges Act, NTNU's study regulations, and the current curriculum for the study programme.

Supervision

The student is responsible for

- Arranging the supervision within the framework provided by the agreement.
- Preparing a plan of progress in cooperation with the supervisor, including a supervision schedule.
- Keeping track of the counselling hours.
- Providing the supervisor with the necessary written material in a timely manner before the supervision.
- Keeping the institute and supervisor informed of any delays.
- Adding fellow student(s) to the agreement, if the thesis has more than one author.

The supervisor is responsible for

- Clarifying expectations and how the supervision should take place.
- Ensuring that any necessary approvals are acquired (REC, ethics, privacy).
- Advising on the demarcation of the topic and the thesis statement to ensure that the work is feasible within agreed upon time frame.
- Discussing and evaluating hypotheses and methods.
- Advising on literature, source material, data, documentation, and resource requirements.
- Discussing the layout of the thesis with the student (disposition, linguistic form, etcetera).
- Discussing the results and the interpretation of them.
- Staying informed about the work progress and assist the student if necessary.
- Together with the student, keeping track of supervision hours spent.

The institute is responsible for

- Ensuring that the agreement is entered into.
- Find and appoint supervisor(s).
- Enter into an agreement with another department / faculty / institution if there is an external co-supervisor.
- In cooperation with the supervisor, keep an overview of the student's progress, the number of supervision hours. spent, and assist if the student is delayed by appointment.
- Appoint a new supervisor and arrange for a new agreement if:
  - The supervisor will be absent due to research term, illness, travel, etcetera.
  - The student or supervisor requests to terminate the agreement due to lack of adherence from either party.
  - Other circumstances where it is appropriate with a new supervisor.
- Notify the student when the agreement terminates.
- Inform supervisors about the responsibility for safeguarding ethical issues, privacy and guidance ethics
- Should the cooperation between student and supervisor become problematic, either party may apply to the department to be freed from the agreement. In such occurrence, the department must appoint a new supervisor

This Master`s agreement must be signed when the guidelines have been reviewed.

Signatures

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10.01.2022
Digitally approved

Francesca Verones
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10.01.2022
Digitally approved

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26.01.2022
Digitally approved

Task description

In 2020 most international meetings and conferences had to be either cancelled or were moved online due the COVID-19 pandemic. This was also true for conferences and meetings of the United Nations (for example in Geneva or New York, two of the main hubs of UN conferences worldwide). Many of the planned conferences took place, but were either fully digital or were carried out in a hybrid form with limited physical presence.

The Missions of Switzerland in Geneva and New York are fully aware of the economic costs implications of virtual and hybrid conferences, while there is unclarity around the "environmental costs".

The objective of this master thesis is to asses the impact of a digital conference, versus the CO_2-emissions from a comparable conference (in number of attendees) that is conducted physically (for example in Geneva).

The full "life cycle" of the conference including e.g. the travel for physical meetings should be taken into account. The Missions of Switzerland to the United Nations in Geneva and New York stand ready to provide contact points within the United Nations for necessary data. The Office of the High Commissioner for Human Rights (OHCHR) was intended to provide data as a starting point for the master's thesis. Due to the unforeseen events in Europe during the spring of 2022, they unfortunately did not have the opportunity to provide data to this project. Thus, the project is based on general data, assumed data and the Ecoinvent 3.8 database.

Tasks

The following tasks are to be considered:

1 Define the scope of the study for comparing a physical and a digital conference

2 Define a suitable functional unit for the comparison and set the system boundaries for both systems

3 Building the system in Brightway software

4 Collection of data in Ecoinvent

5 Collection of data in literature

6 Analysing the results

The project work comprises 30 ECTS credits.

The work shall be edited as a scientific report, including a table of contents, a summary in Norwegian, conclusion, an index of literature etc. When writing the report, the candidate must emphasise a clearly arranged and well-written text. To facilitate the reading of the report, it is important that references for corresponding text, tables and figures are clearly stated both places.

By the evaluation of the work the following will be greatly emphasised: The results should be thoroughly treated, presented in clearly arranged tables and/or graphics and discussed in detail.

The candidate is responsible for keeping contact with the subject teacher and teaching supervisors.

Risk assessment of the candidate's work shall be carried out according to the department's procedures. The risk assessment must be documented and included as part of the final report. Events related to the candidate's work adversely affecting the health, safety or security, must be documented and included as part of the final report. If the documentation on risk assessment represents a large number of pages, the full version is to be submitted electronically to the supervisor and an excerpt is included in the report.

According to "Utfyllende regler til studieforskriften for teknologistudiet/sivilingeniørstudiet ved

NTNU" § 20, the Department of Energy and Process Engineering reserves all rights to use the results and data for lectures, research and future publications.

Sammendrag

I 2020 måtte de fleste internasjonale møter og konferanser enten avlyses eller gjennomføres digitalt på grunn av COVID-19 pandemien. Dette var også tilfellet for tusenvis av FN møter og konferanser. The Missions of Switzerland er fullstendig klar over de økonomiske kostnadene knyttet til digitale konferanser arrangert av FN, men det er usikkert hvilke miljøkostnader som er knyttet til de.

Resultatene av denne oppgaven viser at digitale konferanser har et lavere karbonfotavtrykk enn tilsvarende som gjennomføres fysisk. Digitale konferanser er imidlertid ikke fri for miljøpåvirkninger. Karbonfotavtryket ble beregnet for fem ulike scenarier av digitale og fysiske konferanser. Den funksjonelle enheten var en konferanseperiode på 3 uker med 47 deltakere. Resultatet viste at det å bytte fra en fysisk konferanse til en digital i gjennomsnitt reduserer karbonfotavtrykket med 90%. De potensielle reduksjonene er i hovedsak knyttet til redusert forhåndsprintet materiale, bruk av konferanselokalet og behov for transport og hotellovernatting. Analysen viser at lokasjonen til deltakerne av konferansen har stor innvirkning på det totale karbonfotavtrykket forbundet med en digital konferanse. Årsaken er at energimiksen som benyttes er avgjørende for utslippene knyttet til bruk av IT-utstyret som kreves på konferanser.

Basert på denne kunnskapen bør arrangører etterstrebe det å arrangere mest mulig bærekraftige konferanser ved å ta i bruk den digitale versjonen. Videre kan det å bytte fra en fysisk konferanse til en hybridversjon både beholde fordelene med fysiske konferanser, samt redusere behovet for transport og hotellovernatting. Dersom arrangøren også er bevist når det gjelder valg av lokasjon, frekvens på konferansene, dataoverføring og bruk at IT utstyr, vil det være et stort potensial til å redusere konferansens karbonfotavtrykk. En overgang fra fysiske til digitale eller hybride konferanser krever et omfattende paradigmeskifte i hele konferansebransjen.

Abstract

In 2020 most international meetings and conferences had to either cancelled or were carried out digitally due to the COVID-19 pandemic. This was also true for thousands of UN meetings and conferences. The Missions of Switzerland are fully aware of the economic costs implications of digital conferences, while there is ambiguity around the environmental costs.

The results of this thesis show that digital conferences have a lower carbon footprint associated than a comparable conference that is conducted physically. However, they are not without their share of impact on the environment. The carbon footprint was calculated for five different scenarios of digital and physical conferences. The functional unit was a conference period of 3 weeks with 47 participants. The result showed that making a conference digital instead of physical will on average reduce the carbon footprint by 90%. This reduction is mainly caused by less printed material and no need for transport of participants or hotel accommodation. In addition, the location of the participants will be of great importance for the overall carbon footprint associated with a conference. The reason is that the energy mix used is decisive for the emissions associated with the use of IT equipment required for conferencing.

With this knowledge in mind, organisers should strive to arrange a sustainable conference by adopting the digital version of conferencing. Furthermore, switching from a physical conference to a hybrid version could both retain the benefits of physical conferencing and reduced need for transportation and hotel accommodation. If the organiser is also proven when it comes to choose of location, frequency of conferences, data distribution and use of IT equipment, there will be great potential in reducing the carbon footprint associated with the conference. Such transformation from physical to digital or hybrid conferences necessitates more than just calling on individual participants to reduce their carbon footprint. It requires instead a comprehensive paradigm shift towards decarbonisation throughout the conference industry.

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Abbreviations

AGWP Absolute Global Warming Potential

CH Data from Switzerland

EDA Eidgenössiches Amt für auswärtige Angelegenheiten (The Swiss Federal Department of Foreign Affairs)

eq Equivalents

GHG Greenhouse Gas

GLO Global data

GWP Global Warming Potential

GWP100 Global Warming Potential over a time horizon of 100 years

HD High definition

IPCC Intergovernmental Panel on Climate Change

ICT Information and Communication Technology

ILCD The International Life Cycle Data

IT Information Technology

ISO The International Organisation for Standardisation

kWh Kilo Watt Hour

LCA Life Cycle Analysis

LCI Life Cycle Inventory

LCIA Life Cycle Impact Assessment

NTNU Norwegian University of Science and Technology

OECD Organisation for Economic Co-operation and Development

OHCHR The Office of the United Nations High Commissioner for Human Rights

SA Sensitivity Analysis

SD Standard Definition

SDGs Sustainable Development Goals

TH Time Horizon

UN United Nations

UNCTAD United Nations Conference on Trade and Development

UNFCCC United Nations Framework Convention on Climate Change

UNGA United Nations General Assembly

UNHRC United Nations Human Rights Council

1 Introduction

1.1 Background

The UN Intergovernmental Panel on Climate Change (IPCC) states that the observed increases in well-mixed greenhouse gas (GHG) concentrations since around 1750 are unequivocally caused by human activities (*1*). There are limitations to adaption and adaptive capacity for human and natural systems. The only way to avert a climate catastrophes is with human intervention. The Paris Agreement states that the natural system will adapt better to a global warming of 1.5 °C compared to 2°C (*2*). The goal of the Paris Agreement is therefore to limit global warming to well below 2°C, preferably to 1.5°C, compared to pre-industrial levels (*2*). To reach this goal, research on GHG reduction gets more and more relevant.

The importance of conferences has been underlined by numerous research projects which showed that conferences are highly important and indispensable for scientific debate, diplomatic negotiations, knowledge sharing, development of new projects, networking, new ideas and solutions (*3*). The size and scope of conferences and meetings are also increasing, not only in terms of participants, but also in terms of magnitude and extravagance. As the conference industry proliferates, it also leads to substantial GHG emissions. The carbon footprint per participant reaches up to 3000kg CO_2-equivalents (eq) as reported by previous studies (*4*). In order to understand the sustainability implications of future conferences and inform the policies, it is essential to quantity the environmental footprints of physical and digital conferences.

The International Organisation of Standardisation (ISO) recognised the importance of sustainability in the conference industry and published the ISO 20121 in 2012. This is a guidance and best practice to help manage an event and control its social, economic and environmental impact (*5*). ISO 20121 is applicable to all types of conferences and specifies the requirements of an associated sustainability management system. For almost two decades, there has been a increasing demand for mitigation of environmental impacts and carbon emission of scientific conferences for implementation of a sustainable conference (*3*). Despite this growing interest and the increasing attention from numerous institutions, as well as on sustainable conferences by no means a common practice. A study from 2017 concluded that only one of ten sustainability conferences promoted action to reduce its ISO standard environmental impact (*6*). Researchers and experts from the sustainability field should lead by example when it comes to sustainable conferences e.g. by transporting participants in a more environmentally friendly way. Fortunately, there are exceptions, such as The United Nations (UN) climate conferences organised by the United Nations Framework Convention on Climate Change (UNFCCC) in Paris, and recently in Bonn, that had a strong focus on sustainable conference management and achieving climate neutral status (*7*).

In recent decades, digital tools have developed enormously, opening up opportunities that previously did not exist. Digital communication technology is often seen as an attractive mechanism for reducing the environmental impact. In particular, digital solutions substituting physical processes with virtual ones, thus providing a more environmentally friendly alternative to conventional activities like a conference (*8*).

In recent years, several organisers have considered digital conferences or hybrid conferences up against the traditional physical ones. The drastic increase in the use videoconferencing was seen as a consequence of the corona pandemic. In this way, important conferences could be held without participants having to be exposed to infection through either travel or physical contact. It may be natural to think that such digital conferences then do not have an environmental footprint. However, videoconferencing is not entirely associated with zero environmental impacts (*8*). The many devices involved in the processing and transmission of information in a video conference consume electricity, and the generation of electricity has a considerable carbon footprint. In addition, significant environmental impacts also accrue from the life cycle of all these devices, including their production, deployment and disposal stages. A study conducted at the University of New South Wales showed that the actual carbon savings of video conferences over physical ones, might be reduced or even negated seen from a life cycle perspective (*8*). They further emphasise that conferences impose a time cost on participants, and while digital conferences may save travel time, they can last longer than physical meetings in order to achieve the same outcome. Thus, the time cost saved by digital versus physical conferences will also be uncertain.

Although digital conferences have been commonly advertised as a more climate-friendly alternative to physical conferences, surprisingly little research has been done in quantifying the actual energy savings and GHG reductions. Therefore, it is interesting to look at the previous literature that have looked at carbon emissions associated with video conferences.

A study from the University of Melbourne researched the carbon savings provided by telecommuting as a function of the percentage of reduction in car and air travel (*9*). Their calculations show that teleconferences reduce carbon emissions significantly. For example, a 5% reduction in car travel will save between 50 $kgCO_2 - eq$ and 160 $kgCO_2 - eq$ per household, depending on the video quality and the type of network (*9*). However, they did not include the energy and carbon contribution of end systems such as videoconferencing equipment and computers, and also omitted the life cycle cost of the devices involved. However, people most likely would have a laptop anyway, which implicate that the life cycle cost is not relevant for this comparison. Another study found that substituting physical conferences by digital reduces carbon emissions by up to 90% (*10*). The study also presented the trade-offs between distance and energy cost. Longer travel distances leads to increased carbon savings. However, they did not present details of their calculations and intermediate values in terms of the energy and carbon emissions for both the conference solutions. This makes it hard to scale their results to estimate the environmental impact for a generic conference in terms of distance, duration and number of participants.

In 2020 most international conferences and meetings had to either cancelled or were carried out digitally due to the COVID-19 pandemic. In addition to scientific conferences, almost all other types of meetings had to shift to an online version. And this was also the case for thousands of UN meetings in Geneva, New York and other places. Thus, a question arises about whether digital conferencing is better than the ordinary physical. The economic cost implications of digital conferences are researched and calculated, but there is less research on the environmental costs. Based on the increased number of digital conferences, the Swiss mission found it interesting to know about their environmental impacts, which led to the creation of this thesis topic.

1.2 Aim of the study

This master thesis is an extension of the project assignment with the same name, completed in the autumn of 2021. The results of the project are an identification of the systems for a digital conference and a comparable conference that is conducted physically. This includes a definition of the scope of the study, system boundaries and a functional unit. The preliminary project also aimed to familiarise with Brightway, which is the software to be used in this master thesis (*11*).

The aim of this master thesis is to quantify the carbon footprint of different scenarios of digital and physical conferences based on a typical UN conference taking place in Geneva in Switzerland. To assess the differences, five scenarios have been analysed. Based on the results, recommendations will be given for organisers to implement sustainability measures.

ISO proposes several approaches to assess the sustainability of a conference, one of which is Life Cycle Assessment (LCA) (*5*). LCA is a methodology standardised according to ISO 14040 which is a holistic approach that assesses the environmental aspects and potential impacts associated with the manufacture, use and disposal of an activity (*12*). The results of this thesis are the carbon footprint associated with the different scenarios of digital and physical conferences. In addition, a contribution analysis of the scenarios will be provided.

2 Methodology

2.1 Carbon footprint

Climate change represents a major sustainability challenge of our time. As a result, international authorities, local authorities and private companies monitor their impact on climate change. Impacts are estimated through the amounts of GHG emissions that are released into the atmosphere (*13*). In this connection, the term carbon footprint should be defined. Carbon footprint is a tool that is easy to use to monitor and quantify greenhouse gas (GHG) emissions that are released, as well as check mitigation and reduction programs at different scales and a time horizon (*13*). The carbon footprint is able to capture the total amount of GHG emissions directly and indirectly caused by an activity or accumulated over the life stages of a product. The carbon footprint makes all the GHGs comparable by converting the gasses to the common unit; CO_2 eq.

2.1.1 Global warming potential

All the GHGs degrade over time in the atmosphere, a period known as the gases "lifetime". The different gases have a different ability to trap heat before they degrade, known as "radiative efficiency". A GHG total ability to trap heat is known as global warming potential (GWP). This is the characterisation factor used to calculate the carbon footprint in this project.

The GWP express the amount of additional radiative forcing integrated over time caused by an emission of 1 kg of GHG relative to the additional radiative forcing integrated over that same time horizon caused by the release of 1 kg CO_2 (*14*). The amount of radiative forcing integrated over time caused by the emission of 1kg GHG is called the Absolute Global Warming Potential (AGWP). The characterisation factor for any GHG (x) and any time horizon (TH) can then be calculated as shown in Equation 1.

$$GWP_{x,TH} = \frac{AGWP_{x,TH}}{AGWP_{CO_2,TH}} \tag{1}$$

GWP is measured as CO_2 -eq, which means carbon dioxide equivalent. Carbon dioxide equivalents is a measure that was created by IPCC in order to make the effects of different GHGs comparable. By converting all type of GHG emissions into CO_2 -eqs, researchers can include all emissions, instead of only carbon, in their calculations. Other quantified environmental impacts such as the use of natural resources and waste generation can also be converted to CO_2 -eqs to provide a measurement for total environmental impact (*15*). This common standard unit of measurements allows comparisons among the impacts of different activities.

For any gas, the carbon dioxide equivalent is the mass of CO_2, which would warm the earth as much as the mass of that given gas. Thus, GWP is a measure of how much energy the emissions of 1 ton of a given GHG will absorb over a given period of time, relative to the emissions of 1 ton of carbon dioxide. The larger the GWP, the more a given gas warms the Earth compared to CO_2 over that time period. The time period usually used for GWPs is 100 years, often marked as GWP100 (*16*). For example, methane (CH4) is estimated to have a GWP of 36 over 100 years. That means that 1 ton of methane will have 36 times higher global warming potential than 1 ton of carbon dioxide. Further on in the paper, the term carbon footprint will be used for global warming potential. The results of the study will be the carbon footprint associated with various conferences, measured in kg CO_2-eq.

2.2 LCA methodology

The environmental evaluation of the different types of conferences is carried out using life cycle assessment (LCA). LCA is a method for assessing the environmental impact of activities, products and services. All life stages can be significant in terms of environmental impacts (*17*). Since an activity cannot exist without components, materials, transportation and energy, for instance, all stages need to be accounted for to obtain a realistic comprehension of the environmental impact. Environmental impacts in this context refer to adverse impacts on the areas of concern such as ecosystem, human health and natural resources (*18*). The LCA practice is illustrated in Figure 1. Another main characteristic of LCA is its multi criteria nature; as many elementary flows, as realistically possible are accounted for, including natural resources, emissions to water, air or soil (*19*).

The results of a LCA can assist in identifying opportunities to improve the environmental performance of activities and products at various points in their life cycle (*18*). Another application of LCA is to use the result to provide information to decision-makers in the industry or government.

The International Organisation for Standardisation (ISO) defined the principles and framework for LCA in the 14040 standard (*12*). Increasingly many international initiatives and regulations uses LCA to define the environmental performance of a product or service, among others: the GHG protocol, the EU taxonomy for sustainable activities or the EN 15804 standards (rules for environmental product declarations). (*19*). LCA is defined as a four step technique including; definition of the goal and scope, the life cycle inventory analysis (LCI) phase, the life cycle assessment (LCIA) phase and the life cycle interpretation phase. The four phases are illustrated in Figure 1 and will be explored in this section.

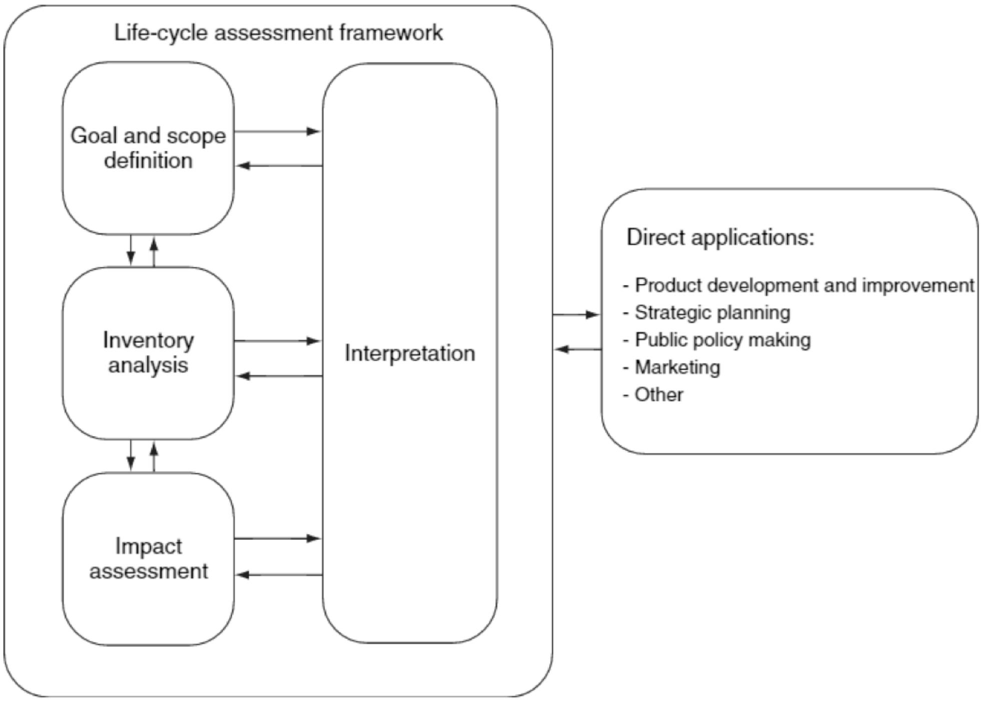

Figure 1: *Phases of an LCA (12)*

2.2.1 Goal and Scope

The goal of a LCA shall state the purpose for conducting the analysis, and specification of expected application. Defining the scope include definition of the characteristics of the study, such as system boundaries and functional unit. The scope definition also includes which impact categories to look at. In addition, this first phase should also consider assumptions, data requirements and limitations.

After the goal of the study is stated, the system needs to be defined and the functional unit needs to be determined. A system can have several functions and thus it is important to determine a functional unit based on the goal and the scope, to be able to compare and analyse the result in a fair way (*20*). In order to have a fair comparison, the system boundaries have to be described at a detailed level. The system boundaries should for example explain which activities that shall be included and which impact categories to evaluate. When setting the system boundaries, one should consider raw materials, transportation, manufacturing, use and maintenance of products, disposal and recovery of process wastes and products (*20*). Available life cycle data can limit the data collection, and these limitations must be specified, as well as included in the assessment when drawing the conclusion. Assumptions should also be considered to interpret an LCA, because they have an impact on what the results can be used for. The assumptions made can be tested to see if changes within reasonable limits affects the conclusion. This is called a sensitivity analysis (SA) and it is performed in the fourth phase of an LCA.

2.2.2 Inventory Analysis

The second phase is the Life Cycle Inventory (LCI). This involves data collection and calculation procedures to quantify relevant inputs and outputs of the entire system defined within the system boundaries (*21*). LCI starts with collecting data to determine the quantitative inputs and outputs of materials and energy associated with the activities and products in the study. In general, data categories under inputs include raw and ancillary materials and energy used in the system, while outputs include products, co-products, by-products and emissions to air, discharges to water and soil and waste (*18*). All input and outputs shall be accounted for in relation to the functional unit defined in the first phase. Data category is a collection of parameters that actually measure the magnitude of the data. The parameter is often called an inventory parameter because data collection in the context of LCA is called life cycle inventory analysis (*12*).

Despite the fact that data collection can be a significantly time-consuming process as various providers and information sources often need to be involved, it is important that the data used is relevant, accessible and credible (*17*). Relevant in terms of time, technology and geography. Available in terms of a republishing option and credible in form of consistent, precise and documented. Limitations in the data collection must be specified, as it can have a major impact on the result of the study (*22*).

Allocation is also significant in the inventory analysis, as most industrial processes yield more than one product and aim to recycle used materials to gain raw materials as input in other processes (*12*). Thus, environmental impacts should be allocated between products and co-products. Allocation is one of the most difficult components of an LCA study (*18*). A general challenge in allocation is that the results can vary based on the allocation method. It is therefore important to specify which allocation method is selected. In addition, allocation might be resource-intensive and should be considered at the beginning of the LCA (*12*).

2.2.3 Impact Assessment

The purpose of Life Cycle Impact Assessment (LCIA) is to turn the inventory from LCI to information about environmental impacts deriving from emissions and resource use (*17*). The LCIA consist of four elements; classification, characterisation, normalisation and weighting. Normalisation and weighting are considered optional, while classification and characterisation is mandatory elements (*22*). Figure 2 shows the relationship among the elements in LCIA.

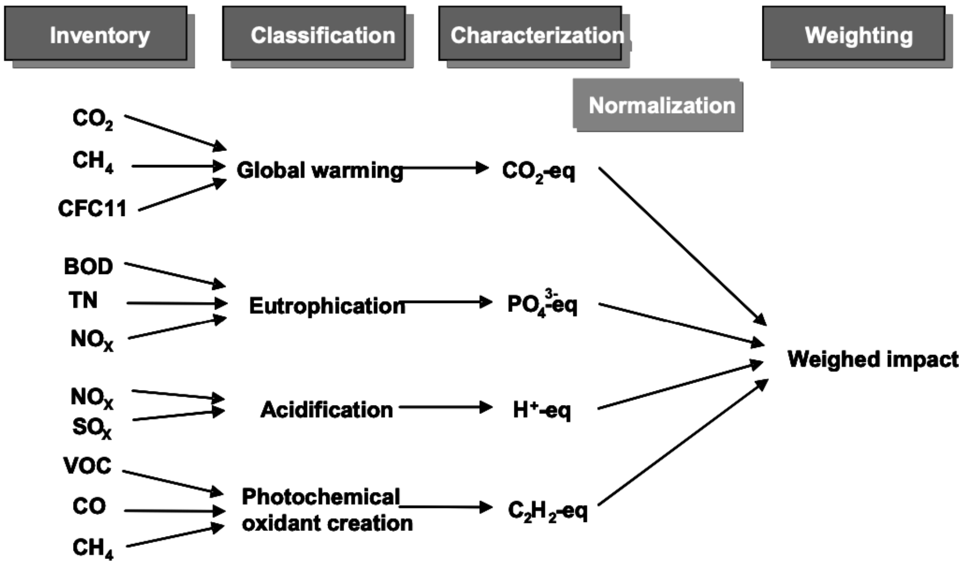

Figure 2: *Elements and relationship among the elements of LCIA (18)*

The first element is classification where inputs and outputs obtained in life cycle inventory (LCI) results are assigned to impact categories based on expected types of impact on the environment. Note that one parameter can affect more than one impact category. Methane will have an impact on both global warming potential and photo chemical oxidants creation for example. The different impact categories have different units in midpoint level, where for example global warming has the unit CO_2-equivalents, and acidification has the unit H^+-equivalents. This project will only focus on the impact category named "Global warming", measured in CO_2-equivalents, as explained in Section 2.1.1.

To be able to translate the LCI results into a limited number of environmental impact scores, the second phase of the LCIA includes characterisation factors. Characterisation factors indicate the environmental impact per unit of stressors (*23*). For example, per kg of resource used or emission released. The quantified impacts can be aggregated or added within the same impact category because all individual impacts have the same unit or dimension. Thus, the environmental impacts of a given impact category can be calculated. For example, the effect of different GHGs is converted the unit CO_2-equivalents, as explained in Section 2.1.1.

There are two main ways of deriving characterisation environmental impact factors; at midpoint or endpoint (*23*). These approaches differ in terms of objectives and robustness (*19*). A comprehensive LCA may display results using both the approaches to ensure that the conclusions remain the same.

Midpoint characterisation focuses on the potential environmental impacts associated with actual biophysical phenomena occurring through the emissions of substances (*19*). Characterisation factors at the midpoint level are located somewhere along the impact pathway, typically at the point after which the environmental mechanism is identical for all environmental flows assigned to that impact category (*24*). Midpoint indicators focus on single environmental problems, for this project it is the global warming. The International Life Cycle Data (ILCD) system proposes 19 categories commonly used in LCA to describe and model potential environmental impacts of activities with use of technology, using a midpoint approach (*19*).

Characterisation factors at the endpoint level aim at conveying the impacts and effects on the three areas of protection, which is human health, ecosystem quality and resource scarcity.

2.2.4 Interpretation

Interpretation is the last phase of an LCA and it is a key aspect in order to derive robust conclusions and recommendations. In this phase, the results of the LCI and LCIA is analysed. The purpose is to comprehend significant findings, and present them in an understandable manner. The first element in the interpretation is to identify significant issues based on the results of the LCI and LCA (*25*). The purpose of this element of interpretation is to analyse and structure the results of earlier phases in order to identify the significant issues. It is important to identify the main contributors to the LCIA results, for example the most relevant life cycle stages, processes and elementary flows and most relevant impact categories (*25*). In addition, it is important to look at the main choices that have the potential to influence the precision of the final results. These can be methodological choices, assumptions, inventories, LCIA methods as well as the normalisation and weighting factors. The second element in the interpretation is evaluation that consider completeness, sensitivity and consistency checks (*25*). This step is performed in order to determine the degree to which it is complete and whether the cut-off criteria has been met. Sensitivity checks have the purpose to assess the reliability of the results and the conclusions of the study (*26*). The consistency check is performed to investigate whether the methods, assumptions and data have been applied consistently throughout the study (*17*). The third and last elements i the interpretation are conclusions, limitations and recommendations. Conclusions can be drawn and recommendations made as to the environmental aspects of the product, activities, possible areas for improvement or key environmental information, all depending on the goal of the study (*21*). It is important to do the interpretation based on the assumptions, limitations and system boundaries chosen for the study.

The interpretation approach in this project is the contribution analysis. The idea of this approach is to decompose the aggregated results of inventory analysis, characterisation, normalisation or weighting into a number of constituent elements (*26*). For instance, one may wish to investigate the share of emissions associated with the different activities in a conference. Knowing the share of a certain process or life cycle stage in a certain emission or impact category may provide opportunities for the redesign of products or processes, or for prevention strategies at a more general level (*26*).

2.3 Cultural perspectives

ReCiPe is chosen as LCIA method, due to its implementation in the Brightway software. ReCiPe is a LCIA method that provides characterisation factors at midpoint and endpoint levels based on different groups of cultural perspectives. The groups are identified based on development scenarios and socioeconomic objectives and resource management strategies. The three cultural perspectives are the egalitarian, individualist and hierarchist. A link exists between stakeholder's interests and the aspects relevant to resource use. By defining multiple groups of different values based on cultural perspectives, the relevant impact pathways can be analysed (*27*).

Egalitarians are expected to prioritise the long-term availability of geological stocks for future generations by keeping extraction flows to a minimum level to reach global sufficiency (*27*). They view ecosystems as fragile and sensible to human interventions and are risk-adverse. The development scenario for egalitarians align on strong sustainability principles, entailing the protection of irreplaceable ecological functions that contribute to human welfare (*27*). Egalitarians will favour a parsimonious access to resources combined with an efficient use in order to meet human needs globally rather than local welfare.

Individualists position themselves before others, both in time and space and prioritise short term rather than long term. They aim for a maximal profitability for the current generation and locally (*27*). They are optimistic about the technological developments and the capacity of future generations to adapt, and believe resources to be abundant (*27*). Therefore, securing the welfare and maximising profits in the short term is prioritised. Individualists would most favour management practices that secure their own resource supply. Therefore, the political strategy archetype for individualists is business as usual.

Hierarchists are a middle ground between the egalitarian and the individualist's perspectives. They favour a positive and fair outcome for both current and future generations and they are optimistic on technological adaptation to sustain human welfare (*27*). Hence, hierarchists will maintain a balance between the development of the manufactured environment and environmental protection that tend to increase human welfare through space and time. The political strategy for hierarchists can be branded social justice through cooperation and development (*27*). Hierarchists prioritise to balance short term development goals such as SDGs with long term sustainability objectives.

The classification of the three different perspectives helps ensuring a more holistic coverage of the potential impacts related to mineral resource use fitting a specific view of the world (*27*). The different perspectives will have different weighting, which will give different LCA results.

The primary objective of the ReCiPe method is to transform the long list of life cycle inventory results into limited number of indicator scores. These indicator scores express the relative severity on an environmental impact category (*24*). Apart from "climate change", ReCiPe includes 17 other midpoint categories. Each midpoint indicator contains factors according to the three cultural perspectives.

ReCiPe is also based on the fact that there are different time horizons for both the impacts at the midpoint level and the endpoint level of climate change (*14*). The various GHGs have different atmospheric lifetimes, as explained, resulting in time-horizon dependent characterisation factors. The value choices for the time horizon are categorised by the three cultural perspectives, as summarised in Table 1.

Table 1: *Value choices in the modelling of the effect of GHGs (14)*

Choice category	Individualist	Hierarchist	Egalitarian
Time horizon	20 years	100 years	1,000 years
Climate-carbon feedbacks included for non-CO_2 GHGs	No	Yes	No[1]
Future socio-economic developments	Optimistic	Baseline	Pessimistic
Adaptation potential	Adaptive	Controlling	Comprehensive

The midpoint characterisation factor for climate change is the global warming potential (GWP), as described in Section 2.1.1. The time horizon used for the individualist perspective is 20 years, 100 years for the hierarchist and 1000 years for the egalitarian perspective. The GWPs for 20 years and 100 years are directly provided in the report from IPCC from 2013 (*1*).

2.4 Contribution analysis

Based on the objectives of this study, a contribution analysis was conducted to better understand the sources of significant life cycle processes associated with arranging a conference. Contribution analysis examines the relative contributions of different inputs to a product system to the overall life cycle impact associated with the system (*28*). In this way, contribution analysis can highlight those factors that contribute most significantly to the overall impacts from a conference. The analysis can be used both for learning, in order to improve performance, and accountability, as well as several other monitoring and evaluation purposes (*29*). The contribution from the different activities can be expressed in percentages that add up to 100.

For instance, one may wish to investigate the share of electricity production in the total carbon dioxide emissions of a product life cycle. A contribution analysis points out those elements that make the highest contribution to a certain emission or impact category (*30*). This will help assist in identifying opportunities to improve the environmental performance of activities and products at various points in their life cycle, which is one of the main goals for an LCA (*18*). Another use of the contribution analysis is for testing the results against what one would intuitively expect

(*30*). If the LCA of a flight transport is dominated by the use of the speakers in the cabin, there is probably a severe error in one or more data entries.

A contribution analysis can be used at different level of inventory analysis, characterisation, normalisation and weighting (*30*). At the inventory level, one may investigate the contributions of the various unit processes that form the life cycle (*30*). For example, the contribution of the conference preparation to the overall impact from a conference. In addition, one may assign all unit processes to a smaller number of life cycle stages in order to decompose the inventory results into the contributions of those life cycle stages.

At the characterisation and normalisation level, there is one other direction of decomposition (*30*). One may investigate the share of unit processes or the share of elementary flows in a category result. Thus, one may decompose the global warming potential into contributions of electricity production or heat production.

At the weighting level, there is even one more direction; decomposition into the contribution of impact categories (*30*). Here it is possible to investigate the share of unit processes in the weighted index. Combining the three directions, one may investigate the share of electricity production associated with CO_2 emissions causing climate change in the weighted index. This is a more detailed and advanced version of contribution analysis, than the one used in this study.

In this study, contribution analysis will mainly be used to determine the proportion of the total impacts associated with the different phases of a conference. This is the inventory level. In addition, contribution analysis will be used to study the proportion of impact from the activities related to the three phases of the conference. These are activities such as transport of participants, use of IT equipment and distribution of data.

2.5 Brightway

In conjunction with a PhD course, the Brightway software was introduced as a new alternative framework for conducting an LCA. Brightway is a Python based software written during the PhD of Chris Mutel (*11*). According to Chris, this software is small and not a complete LCA program, but it is a set of tools to do advanced LCA calculation and visualisation (*31*).

The Brightway software is modular, meaning that instead of one big gelatinous mass of a program, each set of functions is split into a package (*31*). These packages are not completely independent, but the most important functions and methods are written to accept generic inputs, to make it easier to understand and test. Modularity dramatically decreases the activation energy needed for someone to contribute to this open source project.

In addition to being small and modular, Brightway is agile (*11*). Each database is just a file and it is trivial to copy a database, or email it to a colleague. The data in a database is pure Python, so it is possible to easily add or remove attributes, reduce and map the data or apply whatever transformation (*31*).

The main purpose with Brightway is to be a useful software library or tool for doing advanced LCA work, act as a reference implementation of interesting LCA calculations and be a simple tool for everyday LCA practitioners. Brightway is still in a development phase, where Chris Mutel and his colleagues are making continuous adjustments to customise and optimise the software.

2.5.1 Construction

The construction of data in Brightway is structured in a hierarchy, where projects are at the top level (*11*). Each project is independent of other projects, with its own copy of data, methods, calculations, assumptions, metadata and user preferences. Inside a project, there are objects or sets of databases that store data and LCIA methods. Figure 3 shows the construction of a project within Brightway. Most of the data inside a project are inventory databases and impact assessment methods (*11*).

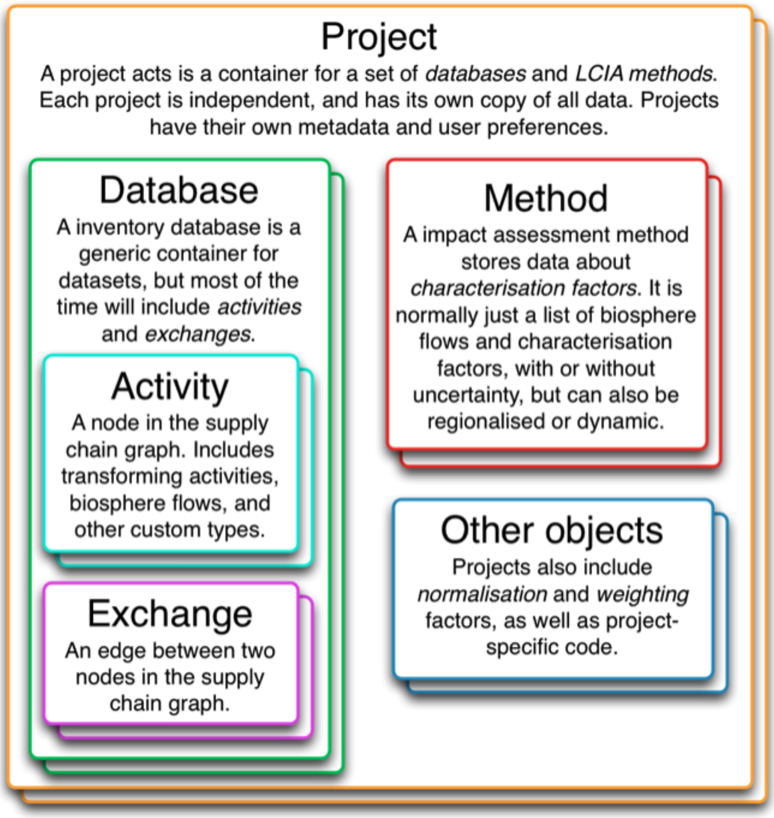

Figure 3: *Visualisation of a project in Brightway (11)*

The inventory database consists of activities and exchanges, and is the object used to organise the activities and exchanges in a life cycle inventory graph. This graph shall show the industrial supply chain and natural world (*11*). Activities are nodes in the supply chain, including transforming activities, biosphere flows and other custom types, for example steel production.

Exchanges are edges between nodes, which defines the connection between activities. Figure 4 visualise the relation between nodes and edges. An edge could describe the input of a product to a transforming activity, or an emission of a biosphere flow by an activity or the amount of a product produced by the given activity. A biosphere exchange is a consumption of a resource or an emission to the environment associated with an activity (*11*). This could be the CO_2 emissions associated with production of 1kg steel. A technosphere exchange is a process input from the industrial economy, for example the amount of steel needed to produce a car.

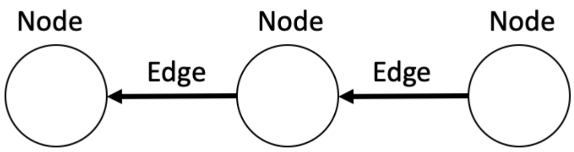

Figure 4: *Visualisation of nodes and edges in Brightway*

An inventory database can consist of hundreds of numbers, but also as a single dataset. The databases can have links to other databases, but they can also be independent. Databases can be created, modified, copied, iterated over, searched and deleted (*11*).

The impact assessment method documents are lists of biosphere flow references, characterisation factors and locations. Some of the methods in Brightway can handle regionlisation, though the default installed methods only provide global characterisation factors (*11*). The regionalisation included is essentially what distinguishes Brightway from other LCA software. The ability to calculate regionalised results is one of the main motivations for developing Brightway and will be explained in detail in the next section.

The last category inside a project is other objects, that could include normalisation factors, weighting factors and other specific data for the given project. Differently from classification and characterisation, which are mandatory steps in an impact assessment, normalisation and weighting are optimal (*5*). There is a risk that misunderstandings or malpractice in applying normalisation and weighting due to for example the potential biases and value choices they are respectively associated with and the consequent commercial concerns (*32*).

2.5.2 Regionalised LCIA methods

LCA is frequently used to quantify the environmental impacts of a product or activity throughout its entire life cycle (*17*). Life cycle assessment (LCIA), described in section Section 2.2.3, turns the inventory from LCI to information about environmental impacts deriving from emissions and resource use. Developers of this method, have long recognised that, for many impact categories, the impact of a given elementary flow depends on where that flow occurs, and have therefore provided site-dependent characterisation factors. Thus, the impact of, for example, water use will be different in a dry climate such as a desert and in a rain forest. Regionalised LCIA methods are calculating environmental impacts based on regional characterisation factors. Regionalised methods are important for almost all of the impact categories such as freshwater and acidification, eutrophication, pollution, respiratory effects from particulate matter, water scarcity and related impact on human health and ecosystem, land use, biodiversity and soil quality, toxicity and exposure effects, as well as overarching methods (*33*). Such regionalised models and methods include spatial inputs from fields such as climatology, geology, hydrology, ecology, human geography, and environmental engineering (*34*).

In theory, maps of regionalised LCIA characterisation factors can be combined with site-dependent LCI to produce more accurate and less uncertain LCA results. In practice, such regionalised LCA methods can be limited by a lack of standardisation in regionalised LCIA data formats, a lack of widespread software support and poor site-dependent inventory data availability. Regionalised normalisation and weighting also present a separate set of challenges, primarily due to data quality and availability (*34*). The three main LCIA methods released in last few years are ReCiPe 2016, Impact World+, and LC-IMPACT (*33*). All three of these included at least some degree of regionalisation, but only IMPACT World+ provides characterisation factors in any standardised format (*33*). The other two methods, and the Ecoinvent centre themselves, all provide characterisation factors in custom spreadsheets and Geodatabase. Spreadsheets cannot conveniently include spatial data, which is important for regionalised LCA methods.

LCA studies have shown that site-dependent impact assessment gives more accurate and realistic results than site-generic assessments (*33*). Brightway as a LCA software is an approach that allows for detailed geographic life cycle impact assessment results, because it is based on data packages, as described above (*33*).

In most cases, regionalisation shows different total scores, different processes of high importance, and varying geographic distributions of environmental impacts. As Brightway as a tool require no additional input other than the geographic information already in existing LCA databases, it can be used routinely. Better and more consistent geographic information in life cycle inventory databases and impact assessment methods, tailored to the specific spatial range of all environmental effects considered, would be beneficial (*33*). For this study, regionalisation will be used to be able to calculate the carbon footprint associated with conferences based on different locations as a starting point. In addition, regionalised data for electricity production will be used.

2.6 Data collection

To be able to compare the different types of conferences, a system with system boundaries and functional unit needs to be defined. The system definition is based on the previous project assignment. To set system boundaries and a functional unit, data is collected from literature, information on general UN conferences. Secondary sources for the calculations are retrieved from Ecoinvent version 3.8 database described in Section 2.6.2.

2.6.1 UN conference

Data collected about a generic UN conference are retrieved from meetings with EDA, during the pre-project for this thesis. The information regarding the conferences were based on assumptions of a typical medium UN conference in Geneva, in Switzerland arranged by The United Nations Human Rights Council (UNHRC). The Office of the High Commissioner for Human Rights (OHCRH) was ready to provide specific data for a typical conference. Due to the unforeseen events in Europe during the spring of 2022, they unfortunately did not have the opportunity to provide data to this project. Thus, the project is based on general data for a UN conference arranged by UNHRC and assumed data.

The United Nations Office in Geneva is a centre of multilateral diplomacy that provides a dynamic platform for collaboration, action on global priorities and dialogue (*35*). The centre is the representative office of the Secretary-General in Switzerland and the second largest UN duty station, with more than 1600 staff representing 120 nationalities (*36*).

The name of the centre is Palais des Nations and this is the place for over 12 000 meetings and conferences every year with nearly 128 000 delegates and visitors annually (*35*). The delegates are the foundation of UN and their task is to negotiate agreements and coordinate with their own home country. In that way, they embody the values, which the UN stands for (*36*). For the type of meetings studied in this thesis, delegates usually live in Geneva and represent their countries in a conference or meeting at the UN, unless a politician of higher rank is represented. It is assumed that delegates are appointed by their home country and have the task to speak and vote on behalf of their country. This is also the case for conferences arranged by The United Nations Human Rights Council (UNHRC).

UNHRC is a UN body whose mission is to promote and protect human rights around the world (*37*). The council has 47 members elected for tree-year terms on a regional group basis (*38*). The headquarters of the Council is in Geneva in Switzerland. UNHRC investigates allegations for breaches of human rights inn UN member states, and addresses thematic human rights issues such as freedom of expression, freedom of association and assembly, freedom of belief and religion, LGBT rights, women's rights and the rights of racial and ethnic minorities (*37*).

The member of United Nations General Assembly (UNGA) elect the members who occupy 47 seats of the UNHRC (*38*). Figure 5 shows the division of the members, where 13 are from Africa, 13 from Asia, 6 from Eastern Europe, 8 from Latin America and the Caribbean States and 7 from the Western Europe and other States (*39*). It is assumed that only these 47 participants will be present in the conference.

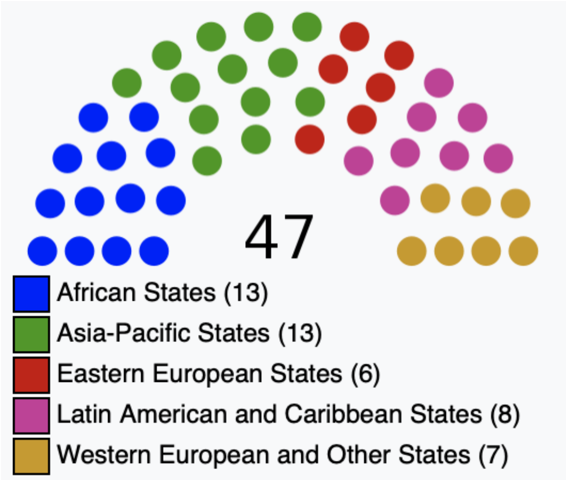

Figure 5: *Members of the United Nations Human Rights Council (39)*

The UNHRC holds regular sessions three times a year, in March, June and September (*40*). The regular sessions last at least ten weeks a year where four of the weeks are in March, three in June and three in September (*40*). If one third of the member states request so, the UNHRC can decide at any time to hold a special session to address human violations and emergencies (*39*). The latest UNHRC conference was held from 28 February to 1 April 2022 (*41*). The conference title was *"Situation of human rights in Ukraine stemming from the Russian aggression"* and was arranged as a hybrid between physical and digital (*41*). Figure 6 show the programme for the conference period.

Day	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5
	28 February	7 March	14 March	21 March	28 March
MONDAY	09.00 – 12.00: **ITEM 1** Opening of session High-level segment (HLS) 12.00 – 15.00: **HLS** (cont'd) 15.00 – 16.00: **HLS** (cont'd) 16.00 – 18.00: ANNUAL HIGH-LEVEL MAINSTREAMING PANEL (UNIVERSAL PARTICIPATION) (res. 16/21) *accessible*	09.00 – 10.00: - ID on OHCHR written update on Sri Lanka (con't) 10.00 – 12.00: **MEETING ON TECHNICAL COOPERATION IN PROTECTING HUMAN RIGHTS OF VULNERABLE PERSONS IN AND AFTER COVID-19 PANDEMIC** (res. 46/13) 12.00 – 15.00: - ID on HC report on Nicaragua (res. 46/2) - EID on HC oral update on the Sudan (res. S-32/1) 15.00 – 18.00: - ID on HC report on Afghanistan (res. S-31/1) - ID on HC oral update on Tigray (Ethiopia) (res. 47/13)	10:00 – 13.00: **ITEM 3** - ID with SR disabilities *accessible* - ID with SR food 13.00 – 15.00: **BREAK** 15.00 – 16.00: - ID with SR food 16.00 – 18.00: ANNUAL DEBATE ON RIGHTS OF PERSONS WITH DISABILITIES (res. 7/9 and 43/23) *accessible*	10.00 – 13.00: - ID on HC report on Myanmar (res. 46/21) - ID with SR on DPRK 13.00 – 15.00: **BREAK** 15.00 – 18.00: - ID with SR on Myanmar - Presentation of HC oral update on DPRK (res. 46/17) followed by **General debate**	10.00 – 12.00: DEBATE ON RACIAL DISCRIMINATION (GA res. 76/226) 12.00 – 13.00: **General debate on ITEM 8** (cont'd) 13.00 – 15.00: **BREAK** 15.00 – 18.00: **ITEM 9** Presentation of report of IGWG on DDPA, followed by **General debate**
	1 March	8 March	15 March	22 March	29 March
TUESDAY	10.00 – 13.00: **HLS** (cont'd) 13.00 – 15.00: **BREAK** 15.00 – 18.00: **HLS** (cont'd)	09.00 – 12.00: **ITEM 2- HC oral update, followed by** - ID on HC oral update on Tigray (Ethiopia) (cont'd) **a presentation of** reports on OHCHR activities in Colombia; Guatemala; and Honduras: and other reports and oral updates (Cyprus, Eritrea), **followed by General debate** 12.00 – 15.00: **General debate on ITEM 2** (cont'd) 15.00 – 18.00: **General debate on ITEM 2** (cont'd) **ITEM 3** - ID with SR cultural rights	10:00 – 13.00: - ID with SR counter-terrorism - ID with IE albinism 13.00 – 15.00: **BREAK** 15.00 – 18.00: - ID with SRSG on violence against children - ID with SRSG on children and armed conflict	10.00 – 12.00: PANEL ON PUBLIC POLICIES ON COVID-19 (res. 46/10) 12.00 – 15.00: **General debate on ITEM 4** (cont'd) 15.00 – 19.00: **General debate on ITEM 4** (cont'd) **ITEM 3** - ID with SR minorities	10.00 – 13.00: **ITEM 10** - Enhanced ID on oral updates on Democratic Republic of the Congo (HC and the expert team on Kasai, res. 48/20) - ID with SR on Cambodia (oral update) 13.00 – 15.00: **BREAK** 15.00 – 18.00: - ID on HC report on South Sudan (res. 46/29) - ID with IE on Mali
	2 March	9 March	16 March	23 March	30 March
WEDNESDAY	10.00 – 13.00: **HLS** (cont'd) 13.00 – 15.00: **BREAK** 15.00 – 18.00: **HLS** (cont'd)	10.00 – 12.00: ANNUAL DISCUSSION ON RIGHTS OF THE CHILD (res. 7/29 and 45/30) *accessible* 12.00 – 13.00: - ID with SR cultural rights (cont'd) 13.00 – 15.00: **BREAK** 15.00 – 16.00: - ID with SR cultural rights (cont'd) - ID with SR sale of children 16.00 – 18.00: ANNUAL DISCUSSION ON RIGHTS OF THE CHILD (res. 7/29 and 45/30) *accessible*	09.00 – 12.00: - Presentation of report of IGWG on TNCs; report on intersessional meeting on 2030 Agenda; HC/OHCHR/SG thematic reports, followed by **General debate** 12.00 – 15.00: **General debate on ITEM 3** (cont'd) 15.00 – 18.00: **General debate on ITEM 3** (cont'd) **ITEM 3** -ID with SRSG on children and armed conflict (cont'd)	09.00 – 12.00: **ITEM 6 - UPR outcomes (Hungary, Suriname, Samoa, Greece, Saint Vincent and the Grenadines, Papua New Guinea, Tajikistan, United Republic of Tanzania, Eswatini, Antigua and Barbuda, Trinidad and Tobago, Thailand and Ireland)** 12.00 – 15.00: **ITEM 6 - UPR outcomes** 15.00 – 18.00: **ITEM 6 - UPR outcomes**	10.00 – 13.00: - High-level ID on human rights situation in the Central African Republic - ID with FFM Libya 13.00 – 15.00: **BREAK** 15.00 – 18.00: - ID on HC oral report on Ukraine - Presentation of HC country report (Afghanistan), HC annual presentation on technical cooperation and report of Board of Trustees of Voluntary Fund Technical Cooperation **followed by General debate**
	3 March	10 March	17 March	24 March	31 March
THURSDAY	10.00 – 13.00: **HLS** (cont'd) **General segment** 13.00 – 15.00: **BREAK** 15.00 – 18.00: Urgent debate on the situation of human rights in Ukraine stemming from the Russian aggression	09.00 – 11.00: PANEL ON ACCESS TO COVID-19 VACCINES (res. 46/14) *accessible* 11.00 – 12.00: **ITEM 3** - ID with SR sale of children (cont'd) 12.00 – 15.00: - ID with IE foreign debt - ID with SR freedom of religion 15.00 – 18.00: - ID with SR freedom of religion (cont'd) - ID with SR privacy - ID with SR environment	10.00 – 13.00: **ITEM 3** - ID with SR housing **ITEM 4** - ID on OHCHR report on Belarus (res. 46/20) 13.00 – 15.00: **BREAK** 15.00 – 18.00: - ID on OHCHR report on Belarus (cont'd) - ID with SR on Islamic Republic of Iran - ID on HC oral update on Bolivarian Republic of Venezuela (res. 45/20)	10.00 – 13.00: **ITEM 6 - UPR outcomes** **ITEM 5** – Presentation of Reports of Forums on Human Rights, Democracy, Rule of Law; Minority Issues and Social Forum; SG report on prevention; Annual report CC of SPs followed by **General debate** 13.00 – 15.00: **BREAK** 15.00 – 18.00: **General debate on ITEM 5** (cont'd) **General debate on ITEM 6**	10.00 – 13.00: **General debate on ITEM 10** (cont'd) 13.00 – 15.00: **BREAK** 15.00 – 18.00: **ITEM 1 Decisions and conclusions**
	4 March	11 March	18 March	25 March	1 April
FRIDAY	10.00 – 13.00: Urgent debate on the situation of human rights in Ukraine stemming from the Russian aggression (cont'd) **ITEM 2** ID on HC report on OPT (res. 46/3) 13.00 – 15.00: **BREAK** 15.00 – 18.00: - ID on oral update by SR on Eritrea - ID on OHCHR written update on Sri Lanka (res. 46/1)	10.00 – 13.00: **ITEM 3** - ID with SR environment (cont'd) - ID with SR torture 13.00 – 15.00: **BREAK** 15.00 – 18.00: - ID with SR torture (cont'd) - ID with SR defenders	10.00 – 13.00: **ITEM 4** - ID on HC oral update on Bolivarian Republic of Venezuela - ID with FFM Venezuela (oral update) - ID with Commission on South Sudan 13.00 – 15.00: **BREAK** 15.00 – 18.00: - ID with Commission on South Sudan (cont'd) - ID with Commission of Inquiry on Syrian Arab Republic - EID on SG report on Myanmar (res. 46/21)	10.00 – 13.00: **ITEM 7** - ID with SR on OPT - Presentation of HC/SG reports **followed by General debate** 13.00 – 15.00: **BREAK** 15.00 – 18.00: **General debate on ITEM 7 (cont'd)** **General debate on ITEM 8**	09.00 – 12.00: **Decisions and conclusions** (cont'd) 13.00 – 15.00: **Decisions and conclusions** (cont'd) 15.00 – 18.00: **Decisions and conclusions** (cont'd) Appointment of mandate holders Adoption of session report

Figure 6: *Meeting plan for the 49th regular session of the Human Rights Council*

A typical day at a UN conference

Based on Figure 6, a typical day at a physical and digital UN conference will be outlined. The first part of a conference day lasts 3 hours from approximately 10:00 AM to 01:00 PM. Then follows a break from approximately 01:00 PM to 03:00 PM. Catering serving during the break is not included in the system analysed here, but large conferences will often have various cakes and coffee serving during the break. In this project, it is assumed that participants will bring their own food or buy food in a canteen, as in a regular office. In addition to eating, the delegates will use the breaks to communicate and discuss resolutions with other delegates, write reports for their country and possibly attend less official events. The second part of the conference day begins at 03:00 PM, and lasts three hours until 06:00 PM. It takes place in the same way as the first part. A conference day is thus 6 hours divided in two blocks, with the opportunity for discussion between the blocks.

A typical day at a UN conference requires a preparation, which may have started many months in advance. UN includes different under-organisations that have an annual agenda where the conferences needed is roughly planned and stated (*36*). Further the preparation of a given conference is carried out by UNs "planning and coordination" committee, who is responsible for planning who will be there and what will be reviewed of various topics. The committee's preparation and planning is assumed to be carried out the same way both for a physical and a digital conference, but the planning meetings will be digital for digital conferences and physically for the physical. Before a conference, the committee will present an agenda, plan and other information to the delegates. This often includes reports, booklets, proceedings and other attachments that are useful in connection with the topic to be discussed in the given conference. This information is assumed to be sent by email to the delegates for both types of conferences. Thus, the amount of data distributed in the preparation phase is assumed to be the same for the physical and digital conferences.

Given that most countries have delegates located in Geneva, transportation to conferences will mainly be by car, bus, train and bicycle for a physical conference. Digital conferences naturally do not contain any transport of participants, as it is assumed that everyone is at home. The preparation for a physical conference will also include transport by air and hotel overnight stays for the delegates living outside Geneva. The United Nations centre, Palais des Nations is located north of the city centre of Geneva, 3km from the city centre and 4km from the airport (*42*).

A typical physical conference day starts at 10:00 AM, with a gathering of all participants or delegates. At the entrance, all delegates are assumed to receive pre-printed material in hand, which includes resolution, reports, proceedings, agenda and other attachments. After the opening of the conference, each delegate sits down with his own computer, microphone, headset and telephone. The computer is assumed to be used for writing speaking notes and reporting, while the telephone is used for communication with their home countries and other delegates. Given that there are participants from many different countries, the headset is assumed to be used to hear translation, if needed.

For a digital conference, the morning starts with a online gathering of all participants. All the delegates sit in their own home and are connected via the internet to the digital meeting. The norm is that all delegates use their own camera constantly. The equipment needed is still a computer, a microphone and a headset and a telephone. Unlike physical conferences, all the preparation materials will be sent by email, and no paper will be physical distributed. Thus, it is up to each participant to print the resolution, reports, agenda, proceedings and other attachments, if needed.

The leader of both types of conferences is the chairman. Chairmanship is the art of managing meetings (*43*). The chairman is the person who takes all necessary decisions as outlined in the program and has accepted responsibility for ensuring that the debate during a conference is orderly (*43*). The Chairman is supported, in varying degrees, by all delegations as well as by the secretariat, but he carries primary responsibility for the conduct of business in the conference. The Chairman gives the floor the delegates by choosing whose microphone is turned on and off. This way, each delegate can present their country's proposals regarding the topics being discussed.

Using the headset, all delegates will receive a live translation of chairman and the other speakers. All considered conferences are assumed to include interpreters who are responsible for providing a live translation of the conference. A typical UN conference arranged by the Office of the High Commissioner for Human Rights is assumed to be translated into 6 different languages, which is English, Chinese, Spanish, Arabic, French and Russian. For each of the languages, there will be at least two translators to ensure proper translation.

The digital conference itself is conducted the same way as the physical ones, where The Chairman gives the floor to delegates. As for the physical meetings, delegates will use the break to communicate and discuss resolutions with other delegates and write reports for their country. Whether there is as much communication between the delegates during the breaks for a digital conference is a topic for the discussion section.

Support personnel will also be needed for both physical and digital conference execution. The technical staff will ensure that everything is technically in order, such as The Chairman's technical equipment and the microphones of all delegates. This task holds for both physical and digital conferences. For the physical, there is also a need for security personnel that must ensure that the correct delegates have access to Palais des Nations, and remaining not.

After the conference, the delegates return home from the physical conference, and log off the digital one. An important task for the delegates is to summarise and report the conference results to their home country. It is assumed that there are no dinner or after-party after a regular day at a conference. The Chairman and the UN organisation will distribute summary of proposals, reports, and conclusions by email to all the participants. The size of this data distribution will vary a lot based on the topic of the conference.

System boundaries of a physical conference

Based on a typical day at a conference, both physical and digital conferences are divided in phases to systematise all the activities included. Figure 7 shows the three phases of a physical conference. The conference preparation includes all environmental burdens associated with the general preparation and planning. These activities refer to conference committees, the transportation of participants, the data distribution and the previous prepared materials. Activities of the conference committee include the review process of periodic meeting for planning and organising the conference. Previous prepared conference materials refer to the program booklet, the proceedings, additional printed materials and other dispatch. Transportation of participants to the conference local comprise travel by car, bus, train and bicycle/walk, whereby the latter does not contribute to the overall environmental impact. If there are participants from outside of Geneva, the conference preparation also include transport by air and hotel overnight stays.

The conference execution includes the environmental burdens from information technology (IT) equipment, computer usage, conference local and infrastructure. Infrastructure refers to interpreters, technical support, security support and The Chairman. The IT equipment needed per participant is a computer, a microphone, a headset and a telephone. The third and the last phase is after the conference, which includes transportation of participants and distribution of materials.

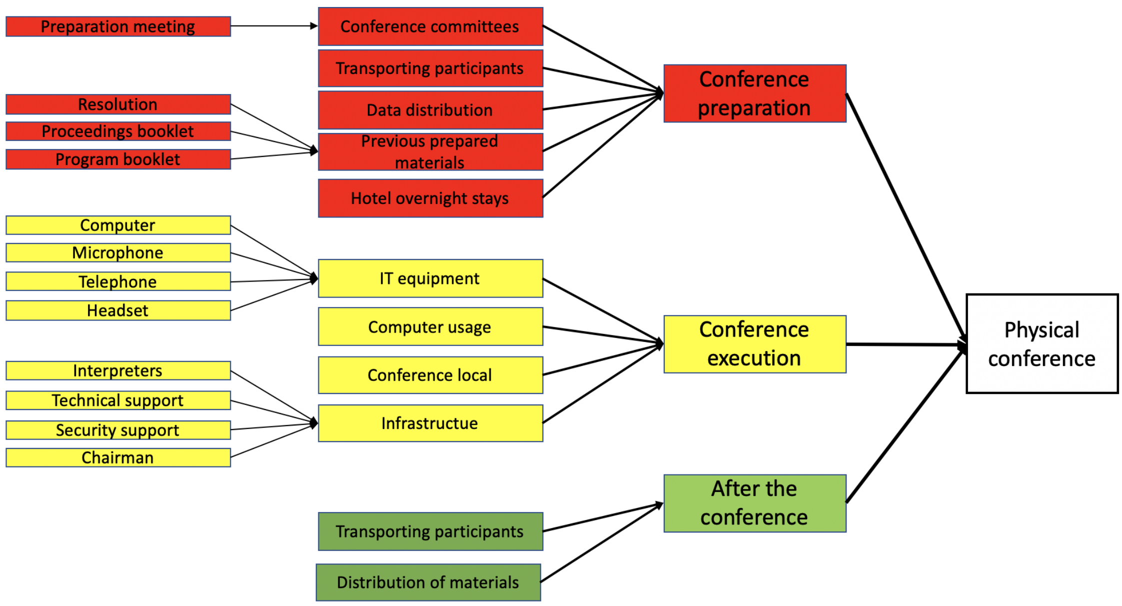

Figure 7: *Scope of the physical conference with the three phases shown in red, yellow and green*

System boundaries of a digital conference

A typical digital conference will have the same phase division as the corresponding physical one. Figure 8 shows the activities in the three phases for a digital conference. The conference preparation includes activities associated with the conference committees and the distribution of data. The conference execution will include the use of IT equipment, computer usage and infrastructure needed. In addition to computer, microphone, headset and telephone, a camera is needed for digital conferencing. The infrastructure will be the same as for physical conferences with the exception of security personnel. The only activity for after the conference is distribution of materials.

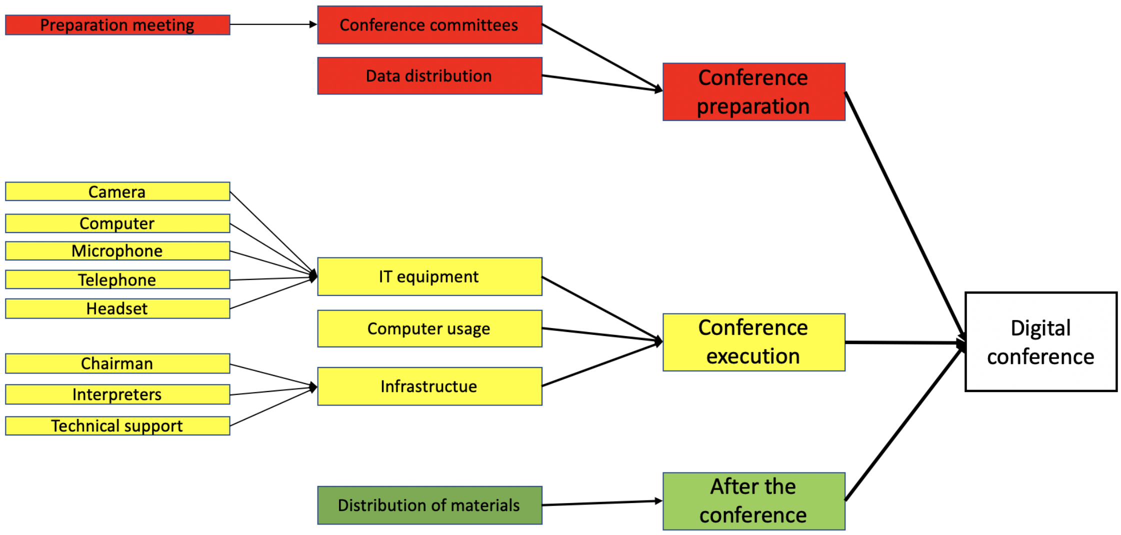

Figure 8: *Scope of the digital conference with the three phases shown in red, yellow and green*

2.6.2 Ecoinvent version 3.8 database

The database used for background data in this project is the Ecoinvent version 3.8 database. The Ecoinvent database is a Life Cycle Inventory (LCI) database that supports various types of sustainability assessments (*44*). This database enables users to gain a deeper understanding of the environmental impacts of their activities (*44*). It is a repository covering a diverse range of sectors on regional and global level. It currently contains more than 18 000 activities, otherwise referred to as 'datasets', modelling human processes or activities (*44*). The complete list of all datasets is available at *www.ecoinvent.org* (*45*). The datasets contain information on the agricultural or industrial process they model, measuring the natural resources withdrawn from the environment, the emissions released to soil, water and air, the products demanded from other processes and the products, co-products and wasted produced (*44*).

The Ecoinvent database is updated annually to include new and updated data, as well as technical improvements (*46*). Data quality is maintained by a rigorous validation and review system (*45*). The version used in this project is the Ecoinvent version 3.8 database, that focus on user comfort and includes enhanced documentation and expands the sectoral coverage (*46*).

Data from Ecoinvent version 3.8 are often location specific. There exists a column in the database that describes the location for the given data. In this study, mainly data from Switzerland are used, abbreviated with "CH". Table 34 in the appendix shows an overview of the given abbreviations for geographical areas.

2.6.3 Functional unit

In order to compare digital conferences with a comparable conference that is conducted physically, a functional unit was defined. The functional unit was chosen on the basis of a typical UN conference arranged by the United Nations Human Rights Council (UNHRC).

The functional unit for this analysis is one entire conference period for 47 participants, where the physical is carried out in UNs conference locals in Geneva in Switzerland (*42*). One conference period lasts for 3 weeks with 6 hours conferencing per day between Monday and Friday for both physical and digital versions. Notice that the weekends in between the conference days, are excluded from the study. The results will thus be in the form kg CO_2 -eq per conference period for 47 participants. To better understand the results, it will also be calculated kg CO_2 -eq per conference period per person and kg CO_2 -eq per conference day per person.

2.7 Scenario Analysis

In order to explore the total environmental impacts of conferencing, several scenarios were created. A conference is assumed to consist of a conference preparation, conference execution and activities after the conference. The scope of the different scenarios are visualised in Figure 9, Figure 10, Figure 11, Figure 12 and Figure 13 for scenario 1, 2, 3, 4 and 5, respectively. The figures show which activities are included in each of the three phases. Some scenarios were created to compare a physical conference with a digital, others to study the impact of the participants location. In addition, some scenarios are created to compare the carbon footprint associated with different hotel standards. The different scenarios are described in Table 2.

Table 2: *Description of the scenarios analysed*

Scenario	**Description**
Scenario 1	All participants live and attends physically at a conference in Geneva
Scenario 2	Participants from all over the world attends physically in Geneva, staying at a budget hotel
Scenario 3	Participants from all over the world attends physically in Geneva, staying at a luxury hotel
Scenario 4	All participants live in Geneva and attends a digital conference
Scenario 5	Participants from all over the world attends a digital conference

2.7.1 Scenario 1

The scope of scenario 1 is shown in Figure 9, with red, yellow and green for the conference preparation phase, conference execution phase and after the conference, respectively. To understand the importance of the participants location, scenario 1 will assume that all participants reside in Geneva. Part of the preparation includes printing the program booklet, the proceedings, additional materials and other dispatch. Table 4 show an overview over assumed data for the amount of prepared materials and other assumptions regarding the conference preparation. Given that all the participants reside in Geneva, there is no need for hotel overnight stays and transport by air. The travel habits of the participants are assumed to be similar statistics for commuters in Switzerland as described in Section 2.8.1. More detailed descriptions of the transport habits and distances in Geneva is shown in Table 17 for the participants and in Table 21 for the service personnel.

All the electricity used for the IT equipment is assumed to be produced in Switzerland. Thus, it is the Swiss electricity mix that is used, described in Section 2.8.1. The physical conference is assumed to take place at the UN headquarters in Geneva, called the Palais Des Nations. The energy needed to operate the conference location is described in Table 25 in the appendix. It is assumed that the conference execution requires 43 support persons. The detailed assumptions regarding the amount of service personnel is given in Table 20. Assumptions regarding the tap water production for a conference day is described in Table 23. Assumptions associated with the operation of the building, support personnel and other infrastructure is summarised in Table 6. Activities after the conference include transport of the participants and data distribution. The assumptions for these activities is summarised in Table 27, which is found in the appendix.

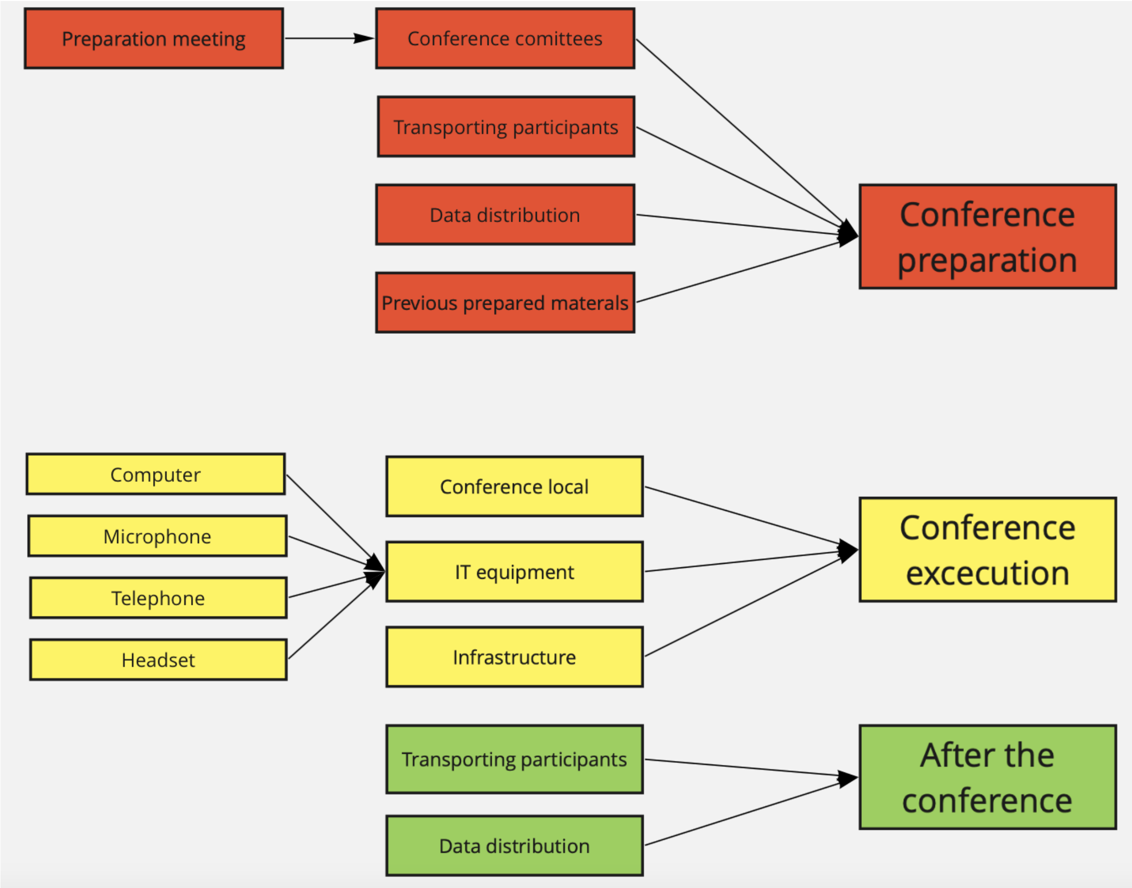

Figure 9: *Scope of scenario 1 with the three phases shown in red, yellow and green*

2.7.2 Scenario 2

The scope of scenario 2 is shown in Figure 10. The second scenario is also assumed to be a physical conference, but in this case the participants are from all over the world. This means that all the participants are travelling by air from their home country to attend physically at the conference in Geneva. It is assumed that there are 47 participants. The starting point is the locations of the 47 members of UNHRC. Figure 5 shows that 13 of the members are from African States, 13 are from Asia-Pacific States, 6 are from Eastern Europe States, 8 are from Latin America and Caribbean States and 7 are from Western European and Other States. The calculation of the average transport distance is detailed described in Section 2.8.1.

For this scenario, hotel overnight stay is an important activity in the conference preparation, shown in Figure 10. In scenario 2 it is assumed that all the participants stay at a budget hotel in Geneva for the hole conference period. This means that the conference preparation include transport by air for all participants and hotel overnight stay for 3 weeks. It is assumed that the weekends are excluded. Thus, a conference period last for 15 days. The assumptions for the activities for the conference preparation is summarised in Table 4.

The conference execution proceeds in the same way as for scenario 1, where the assumptions associated is summarised in Table 6. After the conference, the participants are taking the same route back to their home country.

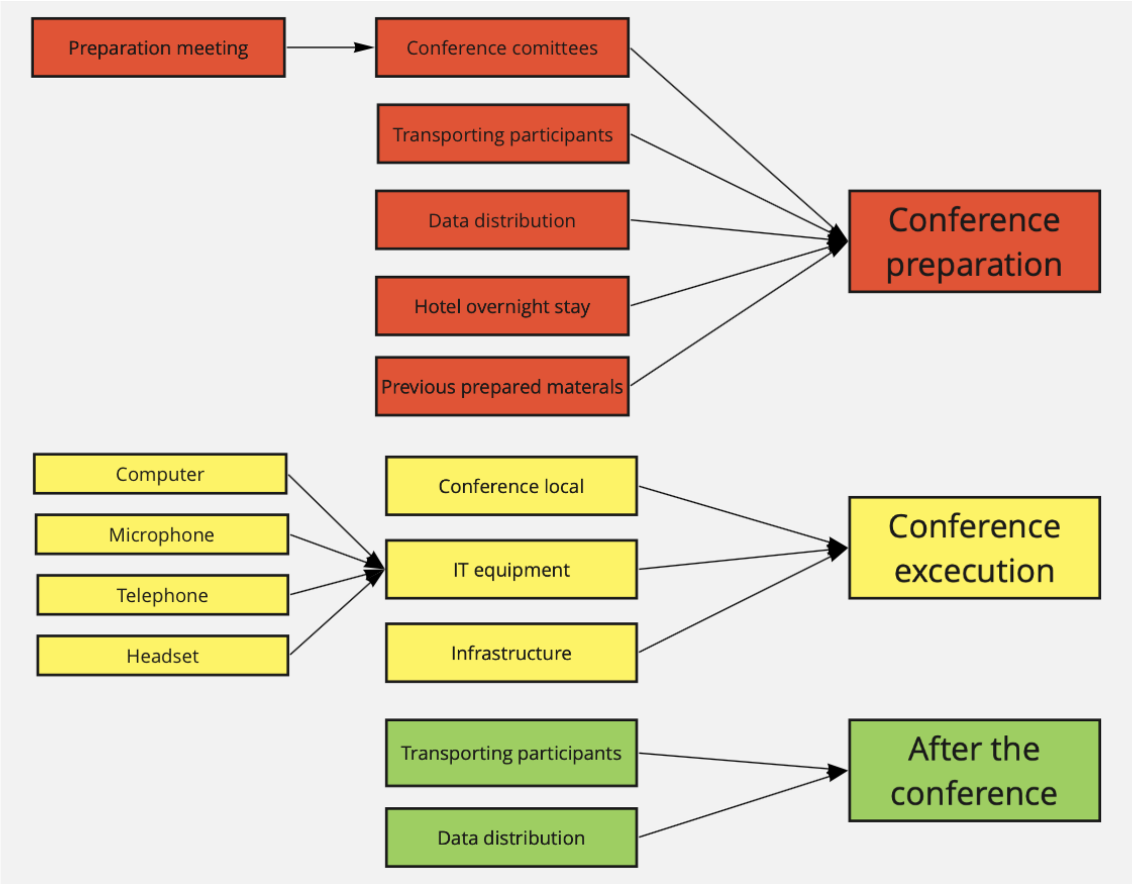

Figure 10: *Scope of scenario 2 with the three phases shown in red, yellow and green*

2.7.3 Scenario 3

The scope of scenario 3 is shown in Figure 11. To be able to calculate the difference between the hotel standards chosen for the participants, scenario 3 has the same activities as scenario 2, but in this case, all the participants are living on a luxury hotel. The data for a guest night at a luxury hotel is from the Ecoinvent version 3.8 database, and based on a global luxury hotel, because there is a lack of hotel data from Switzerland. All the assumptions regarding the conference preparation are summarised in Table 4.

For the conference execution, the assumptions are described in Table 6, and the activities after the conferees in Table 6 in the appendix. Notice that the assumptions regarding the travel by air are still based on the distribution of the participants in the UNHRC, shown in Figure 5, more detailed described in Table 5.

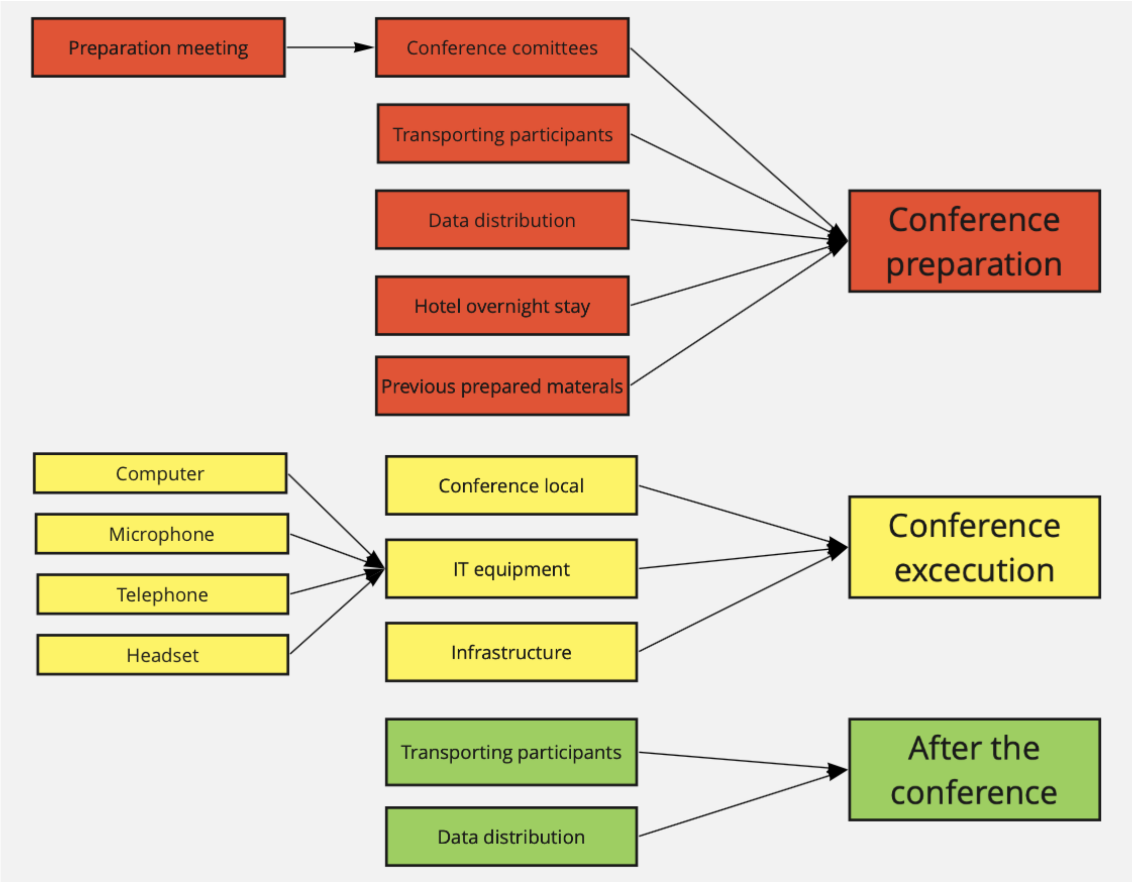

Figure 11: *Scope of scenario 3 with the three phases shown in red, yellow and green*

2.7.4 Scenario 4

The scope of Scenario 4 is shown in Figure 12. This scenario is based on a digital conference, where all the participants are assumed to live in Geneva. The conference preparation will thus only include conference preparation and data distribution. It is still the Swiss energy mix that is used for all electronic equipment. Notice that transport of participants and hotel overnight stay is not relevant for this scenario. The assumptions for the preparation activities are summarised in Table 4.

For the execution, there are in addition to telephone, microphone and headset, also use for camera, as shown in Figure 12. The conference execution will therefore have one extra IT equipment compared to the previous scenarios. For this digital conference, there are no need for a conference local or transport of the service personnel. Assumptions regarding the conference execution activities are summarised in Table 6. After the conference, there are only one activity, the distribution of data. Detailed description can be found in Table 27 in the appendix.

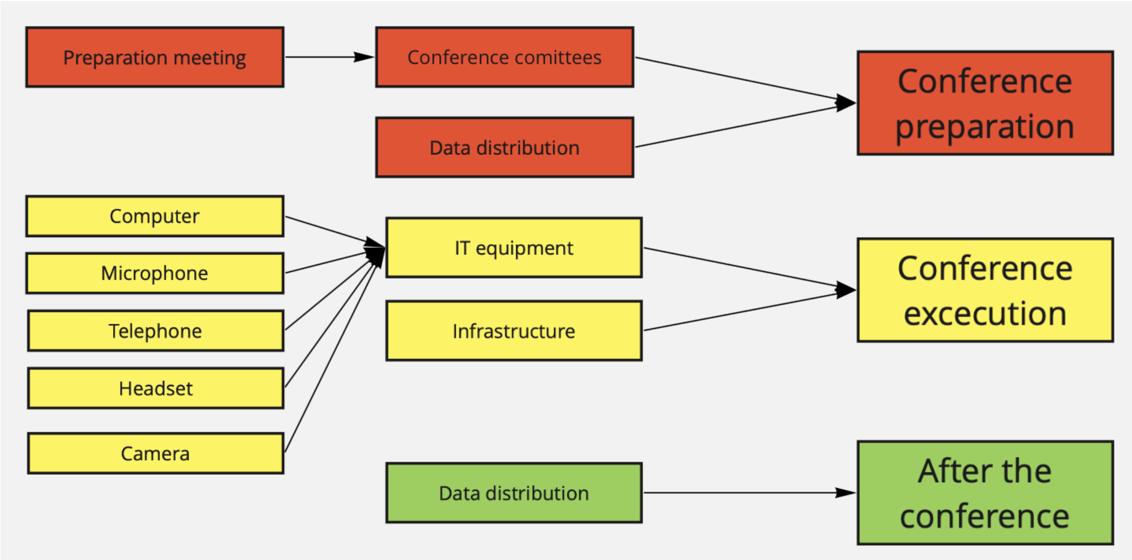

Figure 12: *Scope of scenario 4 with the three phases shown in red, yellow and green*

2.7.5 Scenario 5

The scope of scenario 5 is shown in Figure 13. The fifth and last scenario is also based on a digital conference. Note that scenario 5 include the same activities as scenario 4. In this case, it is assumed that the participants lives all over the world, with the same distribution as for scenario 2 and 3, showed in Figure 5. This scenario is designed to see how the energy mix of different locations plays a role in the total emissions associated with a digital conference.

The conference preparation include conference preparation meeting and data distribution, described in Table 4. For the conference execution, the IT equipment will use a different energy mix than for the previous scenarios. The assumptions regarding the energy production and other assumptions associated with the conference execution are described in Table 6. Even if the participants IT equipment uses different energy mixes, data distributed after a conference will be based on the Swiss energy mix. Assumptions regarding the data distribution after the conference is shown in Table 27 in the appendix.

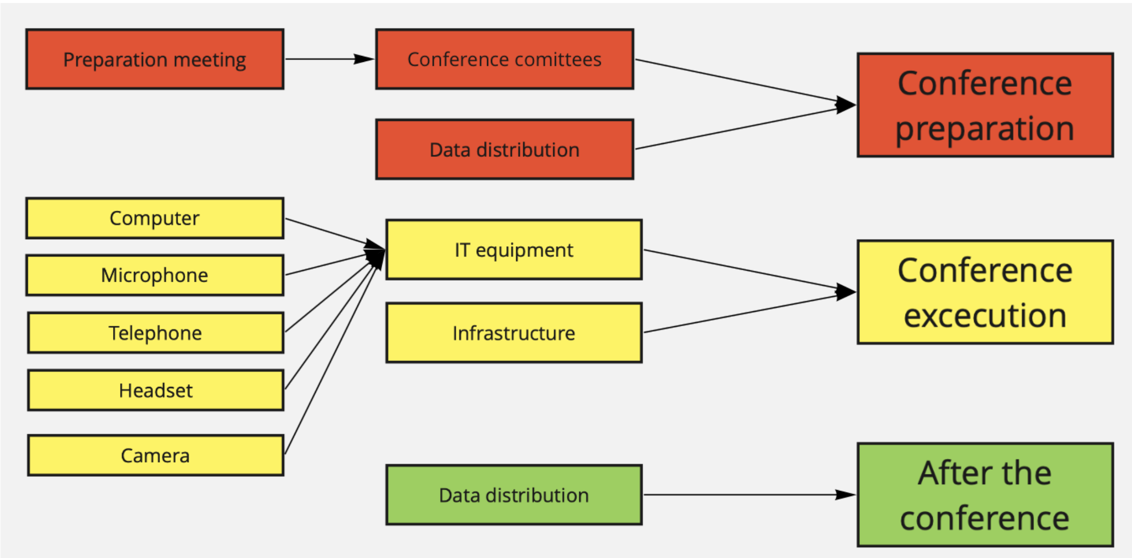

Figure 13: *Scope of scenario 5 with the three phases shown in red, yellow and green*

2.8 Assumptions and limitations

As the study has a prospective character and requires a large amount of data, several underlying assumptions have been made to define the system. The general assumptions made for the different scenarios are listed in Table 3. More detailed descriptions of assumptions for the different scenarios are given under Section 2.7.

The tables for general assumptions and assumptions for the three phases are set up in the same way. The name of the scenarios is abbreviated to only the number of the given scenario. This means that scenario 1 will be noted with only the number 1. The crosses in the table mean that there is a assumption for the given scenario. If it is not marked with a cross, it means that the assumption is not true for the given scenario. The column named "amount" shows the assumed value for the given assumption, and the unit is given in the column to the right.

The column where it says "loc" is a column where the location of the data is stated. There are not all factors where the location is interesting, but for location-specific data, the location will be noted in this column. The advantage of regionalised data in Brightway is described in Section 2.5. Geographic location for data in Ecoinvent is explained in Section 2.6.2 and the different location abbreviations are listed in Table 34 in the appendix.

Table 3: *General assumptions for the different scenarios*

Factor	**Description**	**Amount**	**Unit**	**Loc**	**1**	**2**	**3**	**4**	**5**
Functional unit	The unit to base the comparison on	-	Per conference period for 47 participants	-	x	x	x	x	x
Conference day	The length of a conference day	6	hours	-	x	x	x	x	x
Conference period	The weekends are excluded	15	days	-	x	x	x	x	x
Number of participants	The amount of participants at a general conference	47	persons	-	x	x	x	x	x
Electricity mix	The electricity is produced in Switzerland	-	-	CH	x	x	x	x	
	The electricity is based on the global energy mix	-	-	GLO					x
Previous prepared materials	Are distributed by hand	-	-	CH	x	x	x		
	Are distributed by email	-	-	GLO				x	x
Support personnel	Translators included	12	persons	-	x	x	x	x	x
	Chairman included	1	persons	-	x	x	x	x	x
	Technical staff included	20	persons	-	x	x	x	x	x
	Security personnel included	10	persons	-	x	x	x		
After party	After party is not included	-	-	-	x	x	x	x	x
Catering	Catering not included	-	-	-	x	x	x	x	x

The physical UN conference is assumed to be located in Geneva in Switzerland. The main reason is that because the UNHRC have their conferences here. In addition, there exist a large inventory database retrieved from Switzerland through Ecoinvent, which is the database used for the calculations. Note that the scenarios have the same functional unit, which makes it possible to compare them on a fair basis. Furthermore, assumptions related to the three different phases of a conference will be explained in detail.

2.8.1 Conference Preparation

For the conference preparation several assumptions were needed for the different scenarios, summarised in Table 4 and detailed described further below.

Table 4: *Assumptions regarding the conferees preparation for the different scenarios. All assumptions is given per conference period (3 weeks) for 47 participants*

Factor	Description	Amount	Unit	Loc	1	2	3	4	5
Conference preparation meeting	Physical at Palais des Nations in Geneva	-	-		x	x	x		
	Digital	-	-					x	x
	Computer operation	100	hours	CH	x	x	x	x	x
	Electricity	1 000	kilowatt hour	CH	x	x	x	x	x
Transporting participants	Passenger coach	1 100	person kilometer	CH	x	x	x		
	Passenger train	317	person kilometer	CH	x	x	x		
	Regular bus	254	person kilometer	CH	x	x	x		
	Electric bicycle	56	person kilometer	CH	x	x	x		
	Passenger aircraft	325 500	person kilometer	GLO		x	x		
Data distribution	Computer operation	50	hours	CH	x	x	x	x	x
	Operation of internet access equipment	50	hours	CH	x	x	x	x	x
Prepared materials	Paper production	99	kg	CH	x	x	x		
	Paper printed	99	kg	CH	x	x	x		
	Operation printer	99	kg	CH	x	x	x		
	Treatment of sludge from paper production	99	kg	CH	x	x	x		
Hotel overnight stay	Operation of budget hotel	705	guest night	GLO		x			
	Operation of luxury hotel	705	guest night	GLO			x		

Conference preparation meeting

For preparation of both a physical and a digital conference, it is assumed that the conference committee consists of people who are permanent residents of Geneva. For the physical conference, the committee meetings are conducted in Palais des Nations and digital for the digital conference preparation. It is assumed that the conference preparation meeting includes computer operation for both digital and physical conferences. In addition, electricity is needed for the physical preparation meetings. All assumptions regarding the conference preparation meeting are summarised in Table 4.

Energy mix

Almost all human activities require energy. To meet this energy requirements, each country uses the types of energy available to it, in differing proportions (*47*). This is called the energy mix. This term refers to the combination of the various energy sources used to meet energy needs in a given geographic region. The composition of the energy mix varies from country or region to the next and can change significantly depending om the period. Factors that will have an impact of the energy mix are the availability of useable resources domestically or the possibility of importing them. Also, political choice determined by economic, historical, social, demographical, geopolitical and environmental factors can have an impact (*47*).

Energy production accounts for around three-quarters of global GHG emissions (*48*). The main source for energy production is burning fossil fuels. The energy mix in Switzerland is one of the cleanest in the world (*47*). Electricity in Switzerland is mainly generated by hydropower (59,9%), nuclear power (33,5%) and conventional thermal power plants (2,3%, non-renewable) (*49*). Worldwide, only 16% of primary energy came from low-carbon sources, nuclear and renewables in 2019 (*48*). This is a small share compared to 93% primary energy from low carbon in the same year in Switzerland (*49*).

For this study, it will therefore be important to take into account how the energy mix is composed for given locations. For physical conferences, it is assumed that the location is Geneva in Switzerland. Thus, it is the Swiss energy mix that is used to arrange these conferences. This applies also for digital conference where all participants live inside of Geneva, but attend a digital conference. For a scenario where the participants come from all over the world and participate in a digital conference, it will be important to look at the different energy mixes for the given locations.

Thus, the location of the participants could constitute large emission differences based on the energy mix of the given location. Especially because digital conferencing includes the use of video, which requires more data transfer and thus more energy (*8*). General assumptions regarding the energy mix are listed in Table 3. All the scenarios, except scenario 5 is assumed to use the Swiss energy mix. For scenario 5, it is the global energy mix that is used.

For this study, it is mainly the IT equipment that needs energy in the form of electricity. In addition, the physical conferences will require electricity to operate the conference building. Assumptions regarding the energy use are provided in Table 6. Energy consumption in the conference local is described under section Section 2.8.2.

Data distribution

Data distribution is included as an activity for both a physical conference and a digital conference. The amount of data distributed will vary, as a portion of the material is printed for the physical conference. For both types of conferences, data will be distributed digitally after the conference. Most of the data are stored, managed, and distributed by data centres. Data centres require a tremendous amount of energy to operate (*50*). The global electricity demand of data centres represented about 1% of the total global electricity demand in 2018 (*50*). In addition, large amounts of water are also required to operate data centres, both directly for liquid cooling and indirectly to produce electricity. The geographic location and the local energy mix are strong determinants of a data centres carbon footprint. In the same way as the use of IT equipment, the carbon footprint of data distribution will depend on the location's electricity mix (*19*).

The data distribution both before and after a conference is assumed to be distributed from a laptop in Geneva, using the Swiss electricity mix. The number of computer operation time is assumed to be 50 hours before the conference and 50 hours after the conference in total for the hole conference period. This assumptions holds for all the five scenarios. Other assumptions regarding the data distribution before a conference are provided in Table 4 and assumptions regarding the data distribution after a conference in Table 27 in the appendix.

Transport of participants

Transporting participants to a conference will cause emissions that are directly related to the event and thus these emissions are specific to the given conference. In Switzerland, transportation represented 41% of CO_2 emissions from energy combustion in 2016 (*51*). 98% of the transport CO_2 was emitted on the roads, where private passenger vehicles account for two thirds of these emissions (*51*). Thus, both distances and transport methods will be important in finding the total emissions associated with a conference.

It is natural that transport of participants is not included in a digital conference, but for the physical there are several assumptions that must be made. If all participants live in Geneva and are attending a physical conference, transportation by air will not be required. For such a situation, transport distances and methods can be based on the business travel habits for the inhabitants of Geneva. In 2020, eight out of ten employed persons in Switzerland were commuters, i.e people who leave their dwelling to get to their place of work (*52*). 52% of the commuters used the car as main means of transport for their commute (*52*). 27% used public transport to go to work and 17% travelled by foot or by bike. On average, commuters covered 14km during one way to work, taking them 29 minutes (*52*). For the scenario where all participants live in Geneva, the study will be based on these travel habits, summarised in Table 17 in the appendix. To find the total number of person kilometers needed to transport all the participants to a conference, it is assumed that they are using the same transport method every day during the conference period.

It is worth noting what the UNHRC recommend the use of public transport from Geneva airport to the conference local; "The Palais des Nations". Both access by bus, tram and train that are mentioned and well explained on their website (*53*). Assumptions regarding the distance each participant need to travel are made using google maps, provided in Table 17 in the appendix.

Transport by air will only be included when the participants do not live in Geneva, but come from outside the city. Note again that all emissions associated with travel will be specific to the given conference. A life cycle analysis of a flight explains why the emissions are specific (*54*). This study concluded that the largest GHG emissions contribution for a flight is the operation phase (*54*). The operation phase consists of the landing and take-off cycle and the cruise phase of vehicle operations. The operation is the most significant aspect of passenger air transport in terms of environmental impacts because of the direct energy requirement of large commercial planes and global demand for air transport (*54*). There are several factors that affect the dispersion of emissions into the environment during the operation phase due to the dynamic nature of both technology used and the environmental conditions observed throughout its use, such as the engine used, load factors of the vehicle, design, weather and atmospheric conditions (*54*). The results showed that between 78% - 84% of the life cycle shares of total GHG emissions was emitted during the operation phase (*54*).

To calculate the emissions associated with travelling by air, an average distance by air is estimated. The average travel distance by air is estimated based on Figure 5, that shows the division of the members of the UNHRC. Table 5 summarise the assumed data to calculate the average travelling distance per person. The average distance from the different locations of the participants to Geneva, are found using google maps. The distances are assumed to be from the middle of the different continents, ie a rough estimate. Furthermore, passenger kilometres can be calculated based on the estimated distance and number of participants from the specific locations. By summing up all the passenger kilometres for all 47 participants, it becomes a total of 325 500 person kilometres. By dividing this distance by the 47 participants, the average travel distance by air is estimated to be 6 926 km to Geneva.

Table 5: *Travel distance by air to Geneva for the participants based on the division of the UNHRC members shown in Figure 5*

Location	**Average distance from Switzerland [km]**	**Number of participants [person]**	**Person kilometers [Person * km]**
African States	10 000	13	130 000
Asia-Pacific States	8 000	13	104 000
Eastern European States	1 500	6	9 000
Latin American and Caribbean States	9 000	8	72 000
Western European and Other States	1 500	7	10 500
Total		**47**	**325 500**

Hotel overnight stay

For physical conferences where participants arrive from outside of Geneva, it is important to consider the hotel overnight stay as an activity related to the conference. Hotels and buildings themselves make a considerable contribution to global environmental impacts (*55*). The building sector produces 20-30% of the global carbon footprint (*56*). The most significant burdens stem from primary energy consumption with consequent GHG emissions arising from different activities in operating a building over its long lifespan. Hotels are one of the most demanding energy consumers among all categories of the building stock due to their multi-usage functions and round the clock operations. This is because of the variety of facilities and functions provided (*55*). A carbon footprint analysis of hotels in UK showed the carbon footprint from different activities included in the life cycle of a hotel overnight stay (*13*). The functional unit was per 1 guest night stay. Although the share of the hotel buildings operation is dominant with 60-70% of the total carbon footprint, the contribution of catering and laundry services is nevertheless significant and should not be ignored. The study indicated that catering and laundry services make up 30-40% of the overall energy consumption of hotels (*55*). The average carbon footprint is calculated to be 9,95 kg CO_2 -eq per 1 guest per night (*55*). Thus, the hotel overnight stay is a significant activity that will have a large contribution in the total carbon footprint of a physical conference.

The assumptions regarding the hotel overnight stay are based on data from the Ecoinvent version 3.8 database and summarised in Table 4. The number of guest nights required for the participants at a physical conference is assumed to be the number of participants times the number of conference days, which is assumed to be 15. Thus, the total number of guest nights is 705 for the scenarios including hotel overnight stay.

Notice that Ecoinvent version 3.8 only provides data for operating hotels on global basis. Because there is no specific data for operation of a hotel in Switzerland, this will be a valid source of error that is important to discuss. To include another aspect of hotel overnight stays, this study will compare a situation where the participants stay in a budget hotel with a situation where they stay in a luxury hotel.

According to the travel guide Avenago, a luxury hotel has more and better facilities to offer (*57*). In a luxury hotel, you can expect room service, ironing and dry cleaning and concierge service, bigger beds, as well as dining and living areas and even kitchenettes and additional attached rooms, in some cases (*57*). Most budget hotels will not offer these amenities. Looking at the carbon footprint associated with a night at a hotel, it is natural to think that it is higher for a luxury hotel than for a budget, given the extra facilities. A study of the carbon footprint of hotels show that the lowest global warming potential (GWP) values are recorded for hostels and budget hotels (*58*). The highest GWP values are attributed luxury hotels. The hotel study is based on hotels in Brazil and Peru, but the results pinpoint correlation between hotel comfort category and GHG emissions, which is in line with the literature (*58*). Another study from Spain has showcased how the carbon footprint per guest night in hotels increases with the level of comfort they offer (*55*).

Material preparation before the conference

The use of hard copy references as books, articles and magazines versus the use of online references of those same hard copies, there are divided options among scholars and industries (*59*). An increasing concern has been rising based on the fact that both paper production and the electronic production require the use of natural resources. It is natural to think that the production of paper has greater emissions associated than producing the same document on a computer. Paper production require natural resources as plants and a series of mechanical and chemical processes, with associated emissions to the environment (*59*). The majority of adverse impacts in paper production is from the process stages and energy consumption rather than deforestation (*59*). On the other hand, electronic production, more specifically massive computer and laptop production involves not only the extraction of rare metals, but also more energy intense. Furthermore, the manufacturing and user stages are responsible for high CO_2 emissions (*59*). Juan Arango at the University of Oklahoma did a comparison of the environmental impacts of paper handouts versus online handouts from a life cycle assessment perspective. Under the assumptions made, the use of paper handouts had higher environmental impacts, than the use of an online handout (*59*). Among the evaluated processes in the paper handout, paper production had the highest environmental burden (*59*). For the online handouts, the activity with the highest environmental impact was the use of the laptop (*59*). The study wanted to emphasise that laptop users should use their device up to its maximum life span. Otherwise, the use of a computer will become an unsustainable practice. In addition, the time of use of the computer and the location plays a vital role in the environmental impacts. Thus, the discussion around different electricity mixes in different countries is also relevant in this connection.

In this study, materials prepared before the conference include reports, booklets, proceedings and other attachments that are useful in connection with the topic to be discussed in the given conference. For the physical conference, all the prepared materials are assumed printed to all the participants. For the digital conference, the materials are sent by email. Given an average weight per page of 5g (*60*), the total kilogram paper printed per person is calculated to be 2,1kg. Thus, the total amount of printed paper is assumed to be 98,7kg for the conference period for 47 participants. The total All the assumptions regarding the materials printed before the conference are provided in Table 18 in the appendix.

2.8.2 Conference execution

For the conference execution several assumptions were needed for the different scenarios, summarised in Table 6 and detailed described further below.

Table 6: *Assumptions regarding the conference execution for the different scenarios. All assumptions is given per conference period (3 weeks) for 47 participants*

Factor	**Description**	**Amount**	**Unit**	**Loc**	**1**	**2**	**3**	**4**	**5**
Computer	Computer operation	4 230	hour	CH	x	x	x	x	
	Operation of internet access equipment	4 230	hour	CH	x	x	x	x	x
	Operation computer video conference	4 230	hour	CH				x	
	Operation computer video conference	4 230	hour	RoW					x
Microphone	Electricity	2 115	kilowatt hour	CH	x	x	x	x	
	Electricity	353	kilowatt hour	CN-SGCC					x
	Electricity	353	kilowatt hour	CN-CSG					x
	Electricity	353	kilowatt hour	QA					x
	Electricity	353	kilowatt hour	UA					x
	Electricity	353	kilowatt hour	BY					x
	Electricity	353	kilowatt hour	JO					x
Telephone	Electricity	2 115	kilowatt hour	CH	x	x	x	x	
	Electricity	353	kilowatt hour	CN-SGCC					x
	Electricity	353	kilowatt hour	CN-CSG					x
	Electricity	353	kilowatt hour	QA					x
	Electricity	353	kilowatt hour	UA					x
	Electricity	353	kilowatt hour	BY					x
	Electricity	353	kilowatt hour	JO					x
Headset	Electricity	2 115	kilowatt hour	CH	x	x	x	x	
	Electricity	353	kilowatt hour	CN-SGCC					x
	Electricity	353	kilowatt hour	CN-CSG					x
	Electricity	353	kilowatt hour	QA					x
	Electricity	353	kilowatt hour	UA					x
	Electricity	353	kilowatt hour	BY					x
	Electricity	353	kilowatt hour	JO					x
Camera	Electricity	2 115	kilowatt hour	CH	x	x	x	x	
	Electricity	353	kilowatt hour	CN-SGCC					x
	Electricity	353	kilowatt hour	CN-CSG					x
	Electricity	353	kilowatt hour	QA					x
	Electricity	353	kilowatt hour	UA					x
	Electricity	353	kilowatt hour	BY					x
	Electricity	353	kilowatt hour	JO					x
Conference local	Electricity	145 800	kilowatt hour	CH	x	x	x		
Infrastructure	Passenger coach for support personnel	1 006	person kilometer	CH	x	x	x		
	Passenegr train for support personnel	19	person kilometer	CH	x	x	x		
	Regular bus for support personnel	232	person kilometer	CH	x	x	x		
	Electric bicycle for support personnel	52	person kilometer	CH	x	x	x		
	Tap water production	3 375	kilogram	-	x	x	x		
	Computer operation for support personnel	2 970	hour	CH	x	x	x	x	x
	Operation of internet access equipment for support personnel	2 970	hour	CH	x	x	x	x	x
	Operation computer video conference for support personnel	2 970	hour	CH				x	x

IT equipment

A typical conference will require large amounts of IT equipment, such as a computer, microphone, telephone, camera and headset. Furthermore, it is assumed that all participants are owners of this equipment. Therefore, IT equipment is not something they acquire specifically for a specific conference.

A study conducted at the School of Engineering and Technology National University in San Diego calculated the total contribution to GHG emissions from a laptop computer (*61*). The conclusion of the study was that the manufacturing process contributed with over 90% of the total emissions of a laptops lifetime. Another study showed that the total life cycle contribution of a computer laptop was 422,5 kg CO_2 -eq (*62*). They assumed that the lifetime of a computer is 4 years. The analysis was divided into production, use and end of life. The carbon footprint during production of a laptop was 331 kg CO_2 -eq, which is over 75% of the total emissions over the lifetime (*62*). The carbon footprint during the use of a laptop was 32 kg CO_2 -eq, which corresponds to 8% of the total contribution (*62*). The conclusion is that the largest contributor to the carbon footprint of a laptop is during the manufacturing process. It is assumed that all participants already own a computer before attending the conference. Thus, we assume that the emissions from the production associated with using a computer 6 hours at a conference can be neglected.

This conclusion also holds for the other types of IT equipment. In the modern society, it will be natural to own a telephone, a computer, a headset, a microphone and a camera. It is therefore assumed that all emissions associated with the production of the IT equipment are not specific activities associated with a conference. The participants at the conference are also delegates who have these equipment's as part of their everyday work all year round. It is assumed that all the participants own a computer, a telephone, a headset and a microphone to be used at the physical conference. For the digital conference, it is also assumed that the participants have their own camera. All assumptions for the IT equipment are listed in Table 6.

Note that emissions associated with the operation of the IT equipment are not neglected. Based on the location, the IT equipment will use energy to operate, where the emissions depend on the energy mix for the location, explained in Section 2.8.1. Electricity in Switzerland is mainly generated by hydropower (59,9%), nuclear power (33,5%) and conventional thermal power plants (2,3%, non-renewable) (*49*). Using energy to operate IT equipment in Switzerland will thus have different emissions associated compared to using the same equipment in, for example, China. The electricity mix in China is based on 66% coal, 23% renewables. 5% nuclear power and 3% gas (*63*).

The total number of energy used by the IT equipment is calculated based on the energy use per device per hour, number of hours in use and number of participants. The assumption is that the microphone, telephone, headset and camera all consume 3kWh (*64*). Detailed calculation regarding the energy use for the different IT equipment is listed in Table 26 in the appendix.

The total number of computer operation time required for the conference period is 4 230 hours, found by multiplying 6 hours per conference day by 47 participants and 15 conference days in a conference period. Table 26 shows a detailed calculation of the total energy consumption of an IT unit for the entire conference, which is found in the appendix.

Catering

Despite the fact that the catering has a large share of the total carbon footprint for a hotel overnight stay, the food intake is excluded from this study (*58*). It is assumed that the food intake is not associated with the conference activity per se, but would have been consumed as well in daily life. Some participants will probably eat and drink more in a physical conference, while having long lunch breaks with other participants. On the other hand, a study of dietary changes during the COVID-19 pandemic showed that working from home was associated with increased intake of food and snacks (*65*). This implies uncertainties associated with the participants changes in diet given a physical or digital conference.

An environmental assessment of catering services in hotels may be methodologically cumbersome to perform. Hotels are usually not capable of providing information on the number of food covers served to their guests along with the energy amounts needed to prepare the food (*55*). Hotels with in-house restaurants rarely have a separate energy bill for their catering facilities, which makes it difficult to estimate how much energy consumed by dining services compared to other services in the hotel (*55*). In addition, in-house restaurants in hotels may serve food to other than the hotel guests.

Another diet related aspect is related to the type of food served in the canteen at Palais des Nations. Are the food managers concerned about the environmental footprint of the food served? What is the percentage of vegetarian food served? And which transport distances are associated with the food? Global food production is identified as a great threat to the environment, and dietary change could reduce GHG emissions and land use demand up to 50% (*66*). The understanding of dietary change as a measure for more sustainable food system is more recognised than before, but this aspect is excluded from this study. With more data available, it would be interesting to study how types of food serving could affect a conference's environmental footprint. But this aspect is not relevant for this study.

Conference location

The conference location is Palais des Nations, in Geneva for the physical conference. As explained in Section 2.8.1, the building sector produces 20-30% of the global carbon footprint (*56*). Thus, it is natural to include the emissions associated with both the construction phase and the operation of the conference room. Given that there are large uncertainties related to the proportion of the building's lifetime and operation that can be linked to a specific 3-week conference, these emissions are not included in this study. The most significant burdens stem from primary energy consumption with consequent GHG emissions arising from different activities in operating a building over its long lifespan (*56*). For the Palais des nations, the operation will mainly be conferences, where the emissions associated are related to the production of electricity for all of the IT tools needed to conduct a conference. Table 6 describes the energy required for the different scenarios. The energy use per square meter is assumed to be 180 kWh (*67*) and the square meter required per person $0,6m^2$ (*68*). Assuming that the physical conferences have 47 participants and 43 service personnel, the conference room have to be $54m^2$. Thus, the total energy required to operate the conference local is 145 800kWh for the hole conference period. Detailed calculation of the energy consumption in the conference local is shown in Table 25 in the appendix. This energy consumption includes activities such as maintaining a normal room temperature, air purification and lighting (*67*).

Infrastructure

When it comes to infrastructure required for a conference, there are many activities that can be included. In this study, activities under infrastructure will involve the transport of support personnel and tap water. It is assumed that all persons drink 2,5 litres each day of the conference (*69*). Thus, the total amount of water needed is 3 375 kg per conference period. Table 23 in the appendix summarise the assumptions and calculations regarding the total number of litres water required. The amount of service personnel needed are assumed to be 43 for the physical conference and 33 for the digital, described in Table 20 in the appendix. It is assumed that for the physical conference, the service personnel trend to have the same travel habit as the commuters in Geneva, described in Table 21 in the appendix. Service personnel are assumed to live in Geneva, and will therefore not need hotel accommodation for the conference. It is assumed that both the interpreters, the Chairman and the technical staff will use a computer during both the digital and the physical conference. The food intake of the personnel will, as for the participants, be assumed to be independent of the conference, and therefore neglected. The electricity required to power the computers for the personnel is summarised in Table 22, also in the appendix.

2.8.3 After the conference

The assumptions for the activities after the conference are listed in Table 27 in the appendix. It is assumed that the participants use the same method of transport back, as they used for the conference. In addition, it is assumed that 150 operating hours will be used after the conference to prepare reports and other documentation files.

2.9 Potential for reducing in carbon footprint of a UN conference

There will be a potential to reduce the carbon footprint associated with a physical conference. The scope of a physical version of a conference is visualised in Figure 7. To find the potential, the impact reduction potential for a UN conference will be identified. This will be done by reducing various activities that may be avoided in a physical conference. Four sub-scenarios of scenario 1 have been created, described in Table 7, where also scenario 1 and 4 are included. By calculating the carbon footprint of the sub-scenarios, the goal is to see if the sub-scenarios will be preferable to the digital scenario 4, with respect to the carbon footprint. Activities that are reduced in the sub-scenarios are transportation of participants, printed materials and energy use in the conference local.

Table 7: *Description of scenarios for potential carbon footprint reductions*

Scenario	**Description**
Scenario 1	All participants live and attends physically at a conference in Geneva
Scenario 1A	Scenario 1, without transportation of participants
Scenario 1B	Scenario 1, without prepared materials and transportation
Scenario 1C	Scenario 1, without prepared materials and transportation. The energy use in the conference local is 50% of the consumption in scenario 1
Scenario 1D	Scenario 1, without prepared materials and transportation. The energy use in the conference local is 25% of the consumption in scenario 1
Scenario 4	All participants live in Geneva and attends a digital conference

3 Results

All results presented in this report are found using Brightway software, as explained in Section 2.5. The code formulated in Brightway can be found in Section E in the appendix.

3.1 Overall results

The results for the five different scenarios and three different cultural perspectives are provided in Table 8, Table 9 and Table 10. The tables have the same relationship between the scenarios, given by different functional units. Thus, the overall results are the same for all the tables. Note that the carbon footprint is rounded off to integers and that the results presented are the average over the three cultural perspectives.

The result of the analysis shows that scenario 4 has the lowest carbon footprint with an average of 441 kg CO_2 -eq per conference period, 9 kg CO_2 -eq per person for the conference period and 1 kg CO_2 -eq per person per conference day. The scenario with the second lowest carbon footprint is scenario 1, with an average of 3 382 kg CO_2 -eq per conference period, 72 kg CO_2 -eq per person for the conference period and 5 kg CO_2 -eq per person per conference day. Furthermore, scenario 5 has an average carbon footprint of 6 076 kg CO_2 -eq per conference period, 129 kg CO_2 -eq per person for the conference period and 9 kg CO_2 -eq per person per conference day.

Scenario 2 has the second highest carbon footprint associated with it, with an average of 73 911 kg CO_2 -eq per conference period, 1 573 kg CO_2 -eq per person for the conference period and 105 kg CO_2 -eq per person per conference day. Scenario 3 clearly performs worst, with an average of 87 359 kg CO_2 -eq per conference period, 1 859 kg CO_2 -eq per person for the conference period and 124 kg CO_2 -eq per person per conference day. The average carbon footprint for the five scenarios are visualised in Figure 14.

Table 8: *Carbon footprint for the different scenarios per conference period (3 weeks) for 47 participants*

Scenario	**Egalitarian [kg CO2 eq]**	**Hierarchist [kg CO2 eq]**	**Individualist [kg CO2 eq]**
Scenario 1	2 834	3 225	4 086
Scenario 2	69 766	72 504	79 462
Scenario 3	82 867	85 824	93 386
Scenario 4	384	423	516
Scenario 5	5 542	5 891	6 795

Table 9: *Carbon footprint for the different scenarios per conference period (3 weeks) per participants*

Scenario	**Egalitarian [kg CO2 eq/person]**	**Hierarchist [kg CO2 eq/person]**	**Individualist [kg CO2 eq/person]**
Scenario 1	60	69	87
Scenario 2	1 484	1 543	1 691
Scenario 3	1 763	1 826	1 987
Scenario 4	8	9	11
Scenario 5	118	125	145

Table 10: *Carbon footprint for the different scenarios per person per conference day*

Scenario	Egalitarian [kg CO2 eq/person/day]	Hierarchist [kg CO2 eq/person/day]	Individualist [kg CO2 eq/person/day]
Scenario 1	4	5	6
Scenario 2	99	103	113
Scenario 3	118	122	132
Scenario 4	1	1	1
Scenario 5	8	8	10

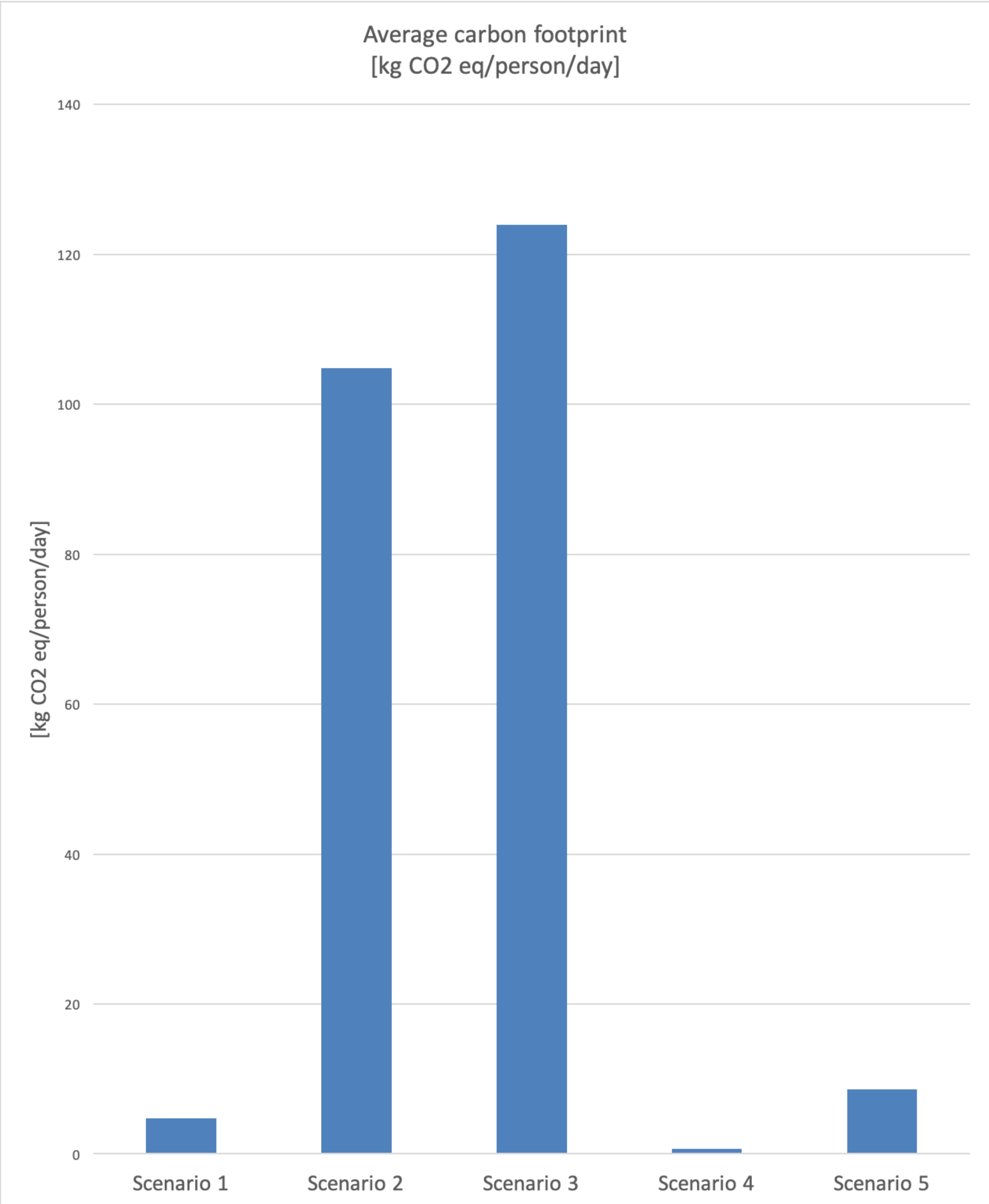

Figure 14: *The average carbon footprint per person per conference day over the three cultural perspectives for the five scenarios*

3.2 Contribution analysis

This section shows the result of the contribution analysis for all scenarios. For each scenario, the contribution from the three different phases; preparation, execution and after are given. Detailed information about the contribution analysis can be found in Section 2.4. All the three cultural perspectives are taken into account in the results. The cultural perspectives are explained in detail in Section 2.3. The contribution results presented are the average over the three cultural perspective.

Furthermore, each scenario has a bar graph that shows the distribution of the impact from the different subcategories associated with a conference. The graphs visualise the differences between the different cultural perspectives. A more detailed contribution analysis on in tabular form can be found in the appendix in Table 28, Table 29, Table 30, Table 31 and Table 32 for scenario 1, 2, 3, 4 and 5, respectively.

3.2.1 Scenario 1

The contribution analysis results at the inventory level for scenario 1 are provided in Table 11. Here, all participants are assumed to live in Geneva and attend a physical conference. The largest share of the contribution to the total carbon footprint is the conference execution, with an average of 84%. The conference preparations contribute 13% on average between the perspectives of the carbon footprint, while activities after the conference lead to 3% of it.

By studying Figure 15, it is mainly the operation of the conference local that has the largest contribution to the total footprint for this scenario. In addition, prepared printed materials and transportation of participants will have a significant proportion of the carbon footprint associated with it. Table 28 in the appendix shows that the operation of the conference local accounts for an average of 77% of the total carbon footprint, while prepared materials accounts for 10% and transportation 6%.

Table 11: *Contribution analysis results at inventory level for scenario 1 with the three different cultural perspectives*

Factor	Egalitarian	Hierarchist	Individualist
Conference preparation	17 %	14 %	8 %
Conference execution	80 %	83 %	89 %
After the conference	3 %	3 %	2 %

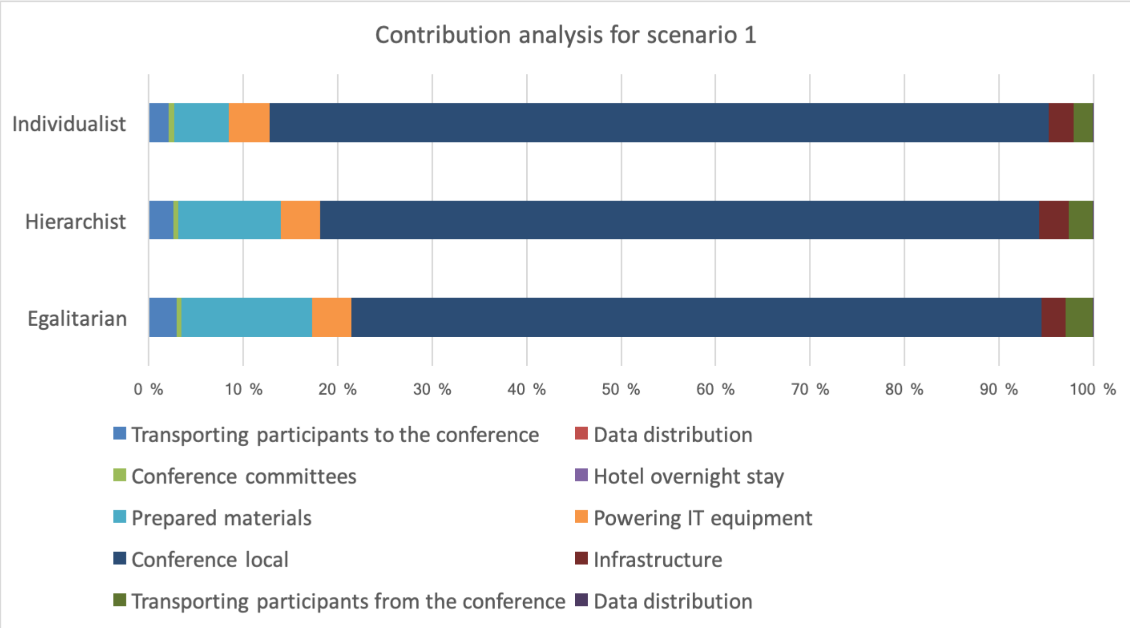

Figure 15: *Contribution analysis on activity level for scenario 1 for the three different cultural perspectives*

3.2.2 Scenario 2

The contribution analysis results at the inventory level for scenario 2 are provided in Table 12. All participants are assumed to live all over the world, and attend a physical conference in Geneva. The total carbon footprint is approximately divided between the conference preparations and activities after the conference. The conference preparations contribute an average of 53% of the total carbon footprint, while activities after the conference account for 43%. The execution itself contributes only 3% of the total.

Looking at Figure 16, it is mainly the transport of participants before and after the conference that contribute to the total footprint for this scenario. Table 29 in the appendix shows that transportation contributes a total over 86% of the total carbon footprint for this scenario. In addition, hotel overnight stay at a budget hotel will contribute with an average of 9% of the carbon footprint. The remaining carbon footprint is mainly due to the use of the conference local, which contributes with an approximate 3%.

Table 12: *Contribution analysis results for scenario 2 with the three different cultural perspectives*

Factor	Egalitarian	Hierarchist	Individualist
Conference preparation	51 %	52 %	55 %
Conference execution	3 %	4 %	5 %
After the conference	45 %	44 %	41 %

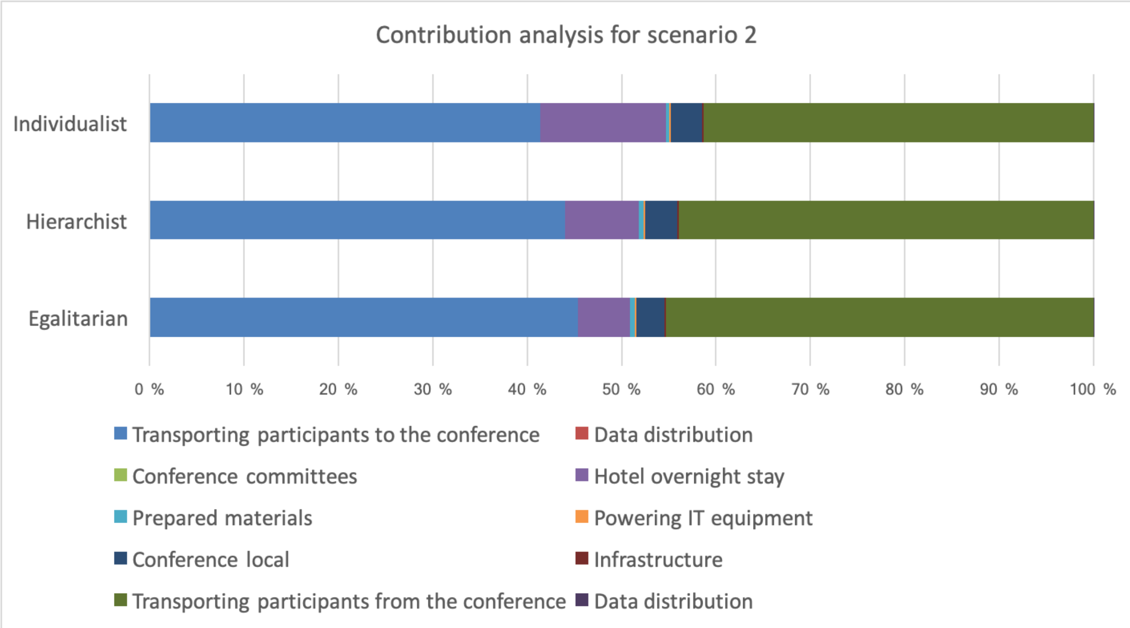

Figure 16: *Contribution analysis on activity level for scenario 2 for the three different cultural perspectives*

3.2.3 Scenario 3

The contribution analysis results at the inventory level for scenario 3 are provided in Table 13. All participants are assumed to live all over the world, and attend a physical conference in Geneva. The total carbon footprint is approximately divided between the conference preparations and activities after the conference. The conference preparations contribute an average of 58% of the total carbon footprint, while activities after the conference account for 37%. The execution itself contributes only 3% of the total.

By studying Figure 17, the carbon footprint is almost divided between three activities; transport of participants before and after the conference and hotel overnight stay for the participants. Table 30 in the appendix shows that transportation accounts for an average of 74% over the cultural perspectives of the total carbon footprint, while hotel accommodation accounts for an average of 23%. Note that it is assumed that the hotel holds the standard of a luxury hotel.

Table 13: *Contribution analysis results for scenario 3 with the three different cultural perspectives*

Factor	**Egalitarian**	**Hierarchist**	**Individualist**
Conference preparation	52 %	60 %	61 %
Conference execution	3 %	3 %	4 %
After the conference	38 %	37 %	35 %

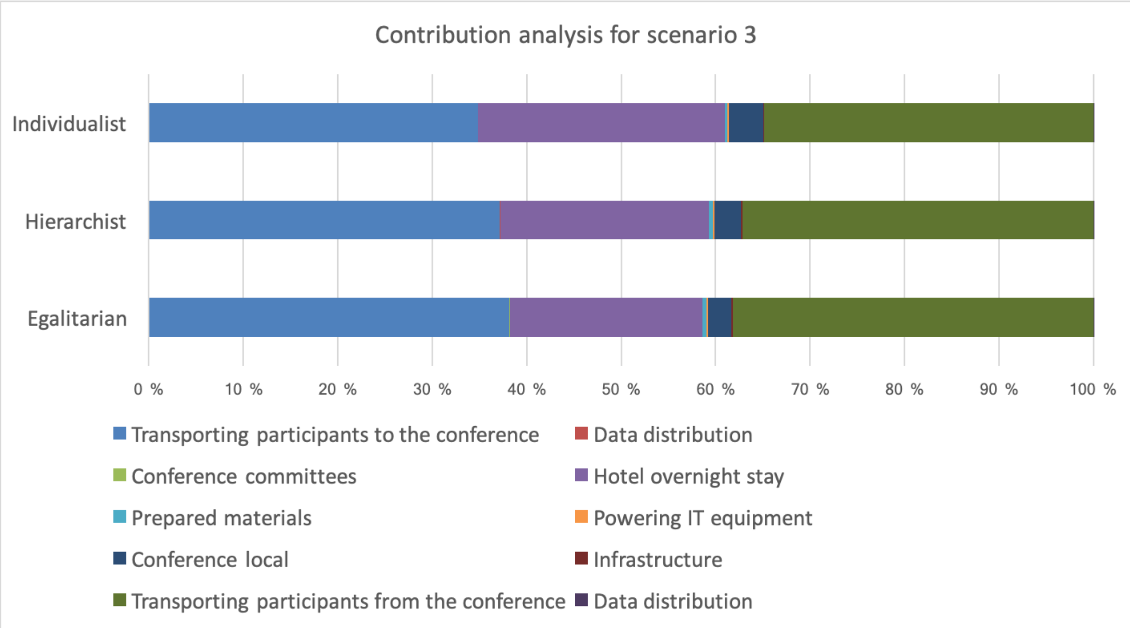

Figure 17: *Contribution analysis on activity level for scenario 3 for the three different cultural perspectives*

3.2.4 Scenario 4

The contribution analysis results at the inventory level for scenario 4 are provided in Table 14. All participants are assumed to live in Geneva, and attend a digital conference. The total carbon footprint is mainly caused by the conference execution. The contribution from this phase has an average of 96%. The rest of the share come from the preparation phase, with 4% of the total carbon footprint.

By studying the different activities in Figure 18, the carbon footprint is almost divided between two activities; powering IT equipment and infrastructure. In addition, conference committees will have a small contribution to the total carbon footprint. Table 31 in the appendix shows that powering IT equipment accounts for an average of 71% over the cultural perspectives of the total carbon footprint, while infrastructure accounts for an average of 26% and conference committees an average of 4%.

Table 14: *Contribution analysis results for scenario 4 with the three different cultural perspectives*

Factor	Egalitarian	Hierarchist	Individualist
Conference preparation	4 %	4 %	5 %
Conference execution	96 %	96 %	95 %
After the conference	0 %	0 %	0 %

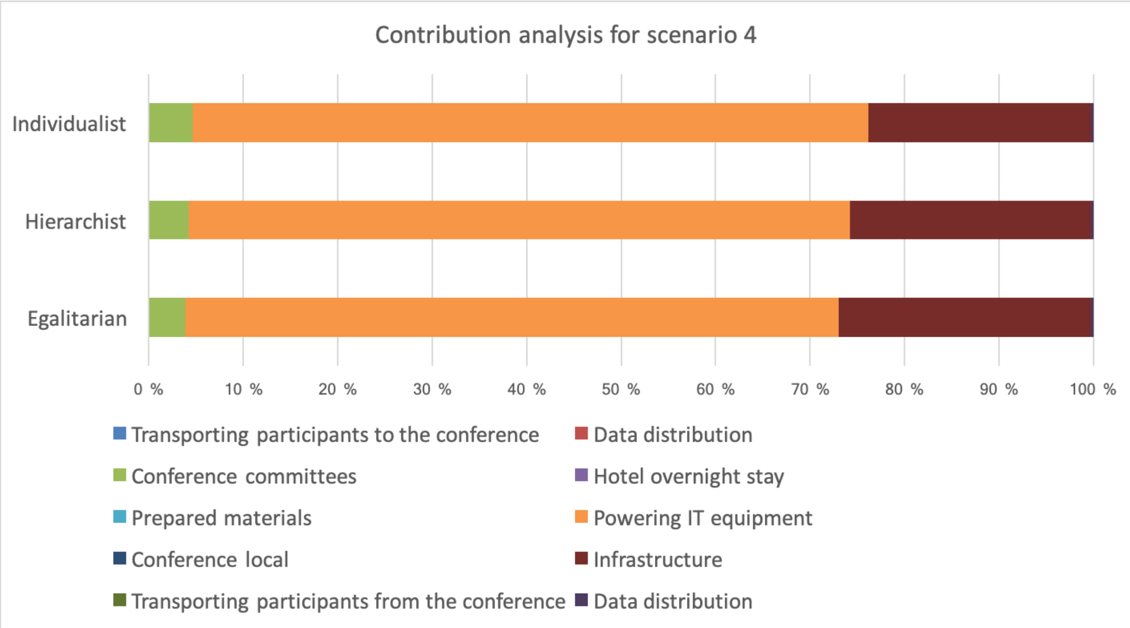

Figure 18: *Contribution analysis on activity level for scenario 4 for the three different cultural perspectives*

3.2.5 Scenario 5

The contribution analysis results at the inventory level for scenario 5 are provided in Table 15. All participants are assumed to live all over the world, and attend a digital conference. For this version of a conference, approximately the entire carbon footprint can be attributed to the conference execution, more specifically the powering of IT equipment. The only other activity that will contribute to a significant proportion of the carbon footprint is the infrastructure required for execution. Table 32 in the appendix shows that powering IT equipment accounts for an average of 99% over the cultural perspectives of the total carbon footprint, while infrastructure accounts for an average of 2%.

Table 15: *Contribution analysis results for scenario 5 with the three different cultural perspectives*

Factor	**Egalitarian**	**Hierarchist**	**Individualist**
Conference preparation	0 %	0 %	0 %
Conference execution	100 %	100 %	100 %
After the conference	0 %	0 %	0 %

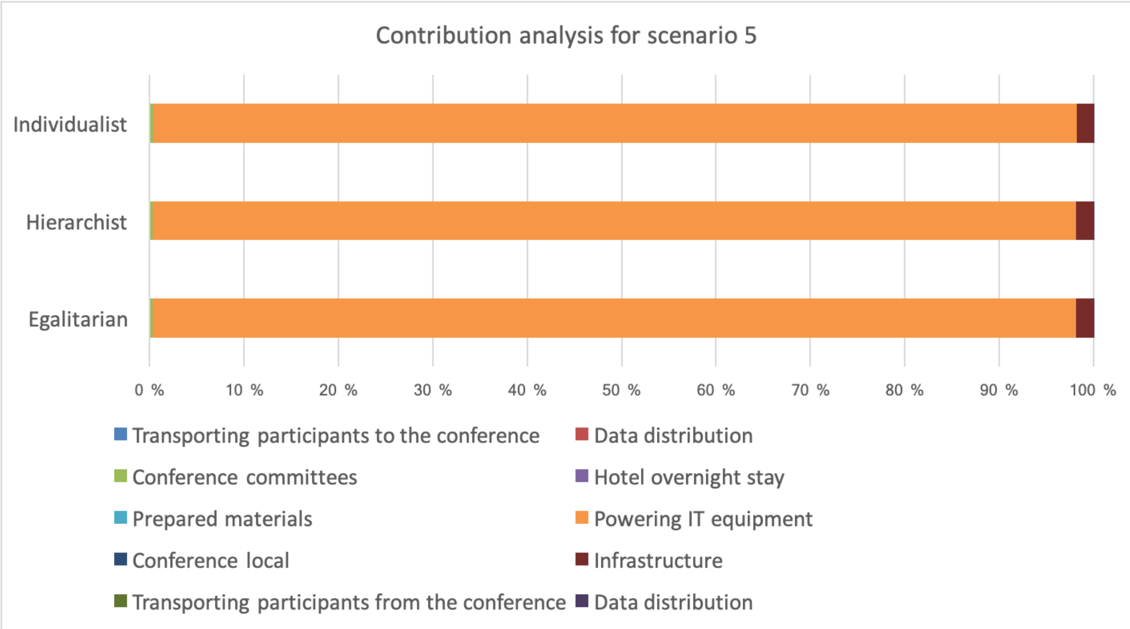

Figure 19: *Contribution analysis on activity level for scenario 5 for the three different cultural perspectives*

3.3 Potential for reducing the carbon footprint of a physical conference

This section shows the result of the potential carbon footprint reduction, which is described in Section 2.9. To find potential reduction in the carbon footprint for a physical conference, 4 sub-scenarios of scenario 1 have been created, described in Table 7. The carbon footprint of the three cultural perspectives for the different sub-scenarios are shown in Figure 20, detailed described in Table 33 in the appendix. The average carbon footprint per person per conference day is 4,5kg CO_2-eq, 4,1kgCO_2-eq, 2,2kg CO_2-eq and 1,3kg CO_2-eq for scenario 1A, 1B, 1C and 1D, respectively. None of the physical sub-scenarios will have a lower average carbon footprint than the digital version, described as scenario 4. The average carbon footprint of the three cultural perspectives is 0,6kg CO_2-eq per person per conference day.

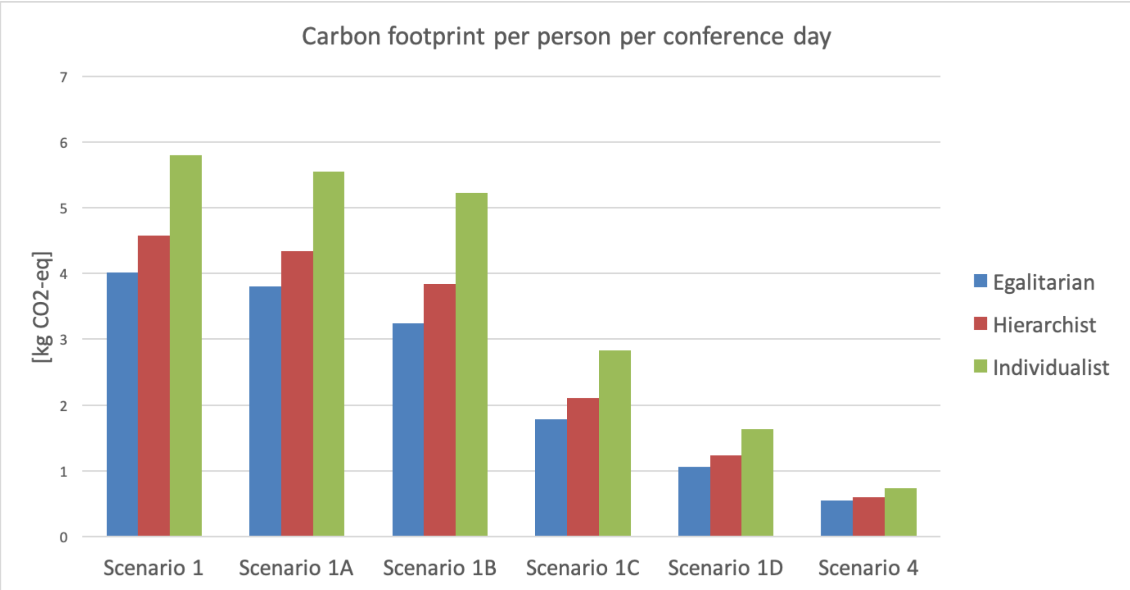

Figure 20: *Carbon footprint per person per conference day for the different scenarios, given for the three different cultural perspectives*

4 Discussion

The goal of this project was to calculate the carbon footprints different of physical and digital conferences. The study is based on a generic UN conference arranged by the UN Human Rights Council (UNHRC). In this section, the results of the study will be discussed to be able to give some general recommendations to conference organisers for implementing sustainability measures.

4.1 Conference location

The main objective was to base the system on a generic UN conference conducted in Geneva in Switzerland. The aspect of the conference location is important to discuss for the total environmental impact. All the findings in this thesis apply to the Switzerland conference case and the underlying assumptions of Geneva as the location that constitutes a very central place in Europe, with good reachability.

A meta-analysis for the physical case has shown that the location of a conference is important for the size of its carbon footprint (*70*). A more centrally located conference location, which can be reached via land bound means of transportation within a reasonable amount of time by a larger proportion of participants, has the potential to reduce the carbon footprint (*70*).

In addition, the energy mix for the given location contributes to the environmental impact. The results of the study showed that changing from the global energy mix (scenario 5) to the Swiss (scenario 4) would reduce the carbon footprint by 93%. The main source of energy in Switzerland are petroleum and other fuels (50,6%), followed by electricity (25%), gas (13%) and wood (4,4%) (*49*). The hydro power plants account for almost 60% of the total domestic electricity production (*49*). The rest of the electricity are mainly produced with nuclear power. If the electricity for a given location was mainly generated from coal power, both the use of the internet use and heating for the location would have a greater environmental burden.

4.2 Physical vs digital conference

Carbon footprint

The general results of this study show that there are large differences in the total total carbon footprint associated with a conference. Table 10 shows the CO_2-eq per person per conference day for the five scenarios analysed. Not surprisingly, it is the physical conferences that include both flights and hotel accommodation that have the highest total carbon footprint. The lowest carbon footprint is associated with the conference where all the participants live in Geneva, attending the conference digitally.

If the conference participants are assumed to live in Geneva, the carbon footprint associated with the conference can be reduced by an average of 87% by changing from a physical to a digital conference. This conclusion is drawn by comparing results for scenario 1 with scenario 4. These potential reductions are mainly caused by the fact that for the digital conference there is no need for printed materials or a conference location. The Plaias des Nations and other buildings is of course there regardless of whether a conference is held there or not. Thus, it might also be a question of allocation. Although the emissions associated with the construction phase are significant, there are large uncertainties related to the proportion of the building's lifetime that can be linked to a specific 3-week conference. Therefore, the carbon footprint associated with the construction of the building is neglected. Note that this fact can lead to great uncertainties in the results, and is an important source of error.

Figure 15 shows that the activities with the highest contribution are namely operation of the conference location and prepared materials for scenario 1. Note that the digital conference eliminates the need for transportation of participants, which is an activity with a significant proportion of the emissions associated with a physical conference. The discussion of potential of reducing the carbon footprint of a physical conference can be read under Section 4.7.

If the conference participants are assumed to live all over the world, the carbon footprint associated with the conference can be reduced by an average of 92% if the conference is conducted digitally rather than physically. This conclusion is drawn by comparing results for scenario 5 with scenario 2 and 3. Thus, the savings for moving a physical conference to digital will be greater if the participants are assumed to come from all over the world, than if it is assumed that they live in Geneva, where the potential reduction was 87% on average. For the situation where the participants live all over the world, a change from physical to digital will mean that transport by air is removed. As the contribution analysis for scenarios 2 and 3 in Table 29 and Table 30, respectively shows, there are large emissions associated with transport. Thus, it is natural that there is a greater potential reduction cut by moving a physical conference to digital, if one assumes that the participants come from all over the world.

In general, digital conferences will have a lower carbon footprint associated with a similar physical one. With this knowledge in mind, conference organisers should strive to arrange a sustainable conference by adopting the digital version. The fact that digital conferences have a lower environmental impact can be used in marketing, as green marketing is a trend that has sprouted up in recent years. Marketing a conference as environmental-friendly is bound to attract more participants, leaving a positive impression on the society (*4*).

It is interesting and important for making conferences greener to realise how much of an impact travelling has. The hotel standard, participants location and the energy mix used to power the IT equipment will be discussed later in this section.

Note that the a digital conference is preferable over a physical based on the carbon footprint associated. Other factors that can be discussed related to the choice between physical and digital conferences are economic costs, time costs, access, activity level and data collection. These factors are not quantified in this study, but will be interesting to discuss.

Economic costs

Physical conferences require many activities where there are costs associated. Hiring, renting local, booking accommodation for speakers and participants, supplying food and paying for transportation for example. Many of these costs are fixed and mandatory (*71*). Thus, large parts of the financial costs are ultimately wasted when putting together a physical conference, such as travelling costs. For a digital conference, a lot of these costs are significantly decreased. Another economic benefit is that digital conference can remain live year-round, thereby increasing the return on investment significantly (*71*). Hence, digital conferences are undoubtedly more cost-effective than physical conferences.

Time cost

A study conducted at the University of New South Wales showed that the actual carbon savings of video conferences over physical, might be reduced or even negated seen from a life cycle perspective (*8*). They further emphasise that conferences impose a time cost on participants, and while digital conferences may save travel time, they can take longer than physical meetings in order to achieve the same outcome. Thus, the time cost saved by digital conferences will also be uncertain. It is natural that the time perspective is important when an organiser plan a conference. Thus, it is of interest to discuss the time aspect between a physical and digital conference.

For physical conferences, the time cost represents the opportunity cost lost by participants while travelling to the conference location. Travel time unit cost will vary depending on the type of trip and travel conditions. There are two main trip types when it comes to conference trips. The first can be classified as a business travel, where one travel as a part of an employee's job, in which the business pays for the excess time cost. The second type of trips is personal or leisure travel. A study conducted, shows that business travel is valued at the rate of an employee's hourly income, while a personal travel is valued at 50% of that person's hourly income (*8*). Since travelling to and from a physical conference is generally considered as a part of a business trip, this is the type of trip that is most interesting in this discussion.

Digital conferences have no travel time cost, but it is natural to assume that it is less efficient to perform a task digital compared to physical conferences. In addition, remotely located persons suffer from weaker social ties and feeling of co-presence between participants as discussed in the part about connections and relations (*8*). Most of the body language, eye contact and coffee-meetings is lost in digital conferences, which affects the conversation flow and interpretation. Thus, digital conferences can disrupt the interaction between participants, which can be seen as a time cost. On the other hand, digital conferences can also provide networking opportunities through chat rooms and the possibility of video, audio and text. There will thus be a trade-off between the time cost saved by avoiding travel time and the time cost associated with the disrupted interaction, lower efficiency and weaker social ties associated with digital conferences.

It is assumed that the Internet's bandwidth will increase faster than its power consumption in the future, which implies that the energy intensity of data transfer is decreasing (*8*). However, this energy reduction does not necessarily translate into the equivalent energy savings of a digital conference versus the physical. One can similarly argue that the transportation will also become greener in the future, leading to reduced emissions from travelling.

Overall, when time costs are considered, the cost benefit that digital conferences have over physical ones been reduced because of the time overhead required to achieve the same functionality as a corresponding physical conference. As for the efficiency discussion, it is natural to discuss whether the selected functional unit is suitable for comparison of the two types of conferences. What if it takes twice as many hours to get the same outcome for a digital versus physical meeting?

The effectiveness of a physical conference versus a digital one is difficult to calculate concretely, but there are several factors that are interesting to discuss. Physical conferences take participants to a more focused environment with fewer distractions. As long as the participants are informed, the conference can probably have their attention for a longer time period than for a digital conference. When participants are attending from a place of their convenience, there are little control over other distractions that could reduce their attention span and take them away from the conference. Some studies show that 90 min is about the maximum amount of time someone can participate in a digital event without a break (*71*). For some participants, even 90 minutes will be too long to stay in focus.

Another interesting factor to discuss regarding the efficiency, is the information flow in the meeting. Conversations typically require back and forth information exchange and a high degree of interactions, while presentations consist mostly of information flow in one direction. For a conference with information flow mainly in one direction, i.e. that no major discussions are required, digital conferences could have the same outcome per time as physical ones. Video conferences are not similarly suitable for all types of meetings. In case of emotional discussions or conflicts, digital conferencing might not bring satisfying results (*8*). Likewise, for situations where the participants do not know each other. In order to build and strengthen important relationships, there will be many benefits to physical conferences. For such conferences, a digital versus a physical could require maybe four times as many hours for the same outcome. As a consequence, digital meetings could be used for replacing regular meetings among participants that know each other rather well or situations where there is no need to form relationship. In terms of efficiency, an organiser must take the goal of the conference as a starting point to decide whether it is most effective to conduct it physically or digitally.

The discussion about time cost is important to be able to compare in a fair way. Thus, this is something important to consider, but different to quantify. These time costs need to be in mind when making decisions based on the results of environmental assessments.

Access

Physical conferences require participants to travel to a specific location. Thus, the scale of the arrangement is often restricted by venue capacity and geographical boundaries. For physical conferences, it can be hard to find a venue that suits all the participants and speakers. Thus, there is a limiting factor in the number of participants that must be considered these conferences. This issue will not exist for digital meetings, where you can have an unlimited number of participants, as long as they have internet.

In addition to the fact that there are no restrictions in place digitally, one can also ensure that more nations can participate. For Geneva, that is the second largest UN duty station, where the most countries are represented by delegates, this is not the largest issue. But not all small countries are represented in Geneva.

Travelling to a specific location can be also be difficult for some, economic as well as geographically and logistic. A digital conference eliminated the transport of participants and could save a lot of time, cost and CO_2 emissions for everyone involved. It also makes it easier for those with disabilities or vulnerabilities and those with caring responsibilities to take part. Thus, digital conferences attract more participants and is accessible to all without geographical limitations. Digital conferences can also prevent jetlag and other travel related stress (*8*).

Digital conferences can be held for extended time frames which enables participation of participants from multiple time zones via live and recorded talks. Each participant only needs to log in to their computer because it does not require transport time. Recordings allows talks to be rewound or paused. Also since digital conferences often have lower registration fees, they are open to a much wider variety of participants (*71*). On the other hand, people have to work at potentially inconvenient times of the day. It can be limiting for social events and family time. Thus, digital conferences will be able to create a smaller boundary between working hours and leisure time. Physical conferences may not be that flexible because they have a finite time spots, but this fact can also be positive for the participants lives outside of work.

Activity level

Another perspective that may be relevant to discuss is whether the activity level of the participants is different between a digital and a physical conference. And what would happen to the activity level if the number of participants increased?

It is natural to think that the more participants, the less time there is for each participant to express their opinions and proposals. This is a fact for both digital and physical conferences. The overall activity level is probably higher for a physical meeting than a digital with the corresponding number of participants. Thus, one can assume that the activity level decreases both by making the conference digital, and by increasing the number of participants. How will a meeting with a lot of passive participants affect the outcome? The functional unit for this study does not include the activity level of the participants, and is therefore an own discussion.

Data collection

Most conferences will collect data during the event and survey after. Digital conferences allow organisers to gather participant feedback and data on demographers, level of networking and audience engagement, which would be hard to track during physical conferences. Data generated by digital conferences can be easily analysed to uncover crucial insights, which is highly valuable (*71*). These insight help improve upon the content and to away with the shortcomings during the next conference, thus improving the participants experience. The data can also be used by other organisers. With a lot of data from digital conferences, real-time reports and regulations can be made to improve the overall digital conference.

A number of digital conferences have incorporated virtual reality tools to create new conference environments (*71*). Other tools are apps and machine learning algorithms to match attendees of similar research interests into virtual discussion rooms, enabling networking and collaboration (*71*). Regarding the data collection during a conference, digital conferences will be preferable to physical.

4.3 Hotel

For physical conferences where participants arrive from outside the city, it will be necessary to include hotels as an activity associated with the conference. Some participants may have friends and acquaintances they can stay with, but most likely hotels will be the most relevant option. Especially because a conference period is supposed to last for 3 weeks. Both scenario 2 and scenario 3 include hotel overnight stays for the participants. Table 10 shows that there are large differences between the physical conference in scenario 1 vs scenario 2 and 3. Note that in addition to hotel overnight stay, scenario 2 and 3 also include travel by air. Going from scenario 2 and 3 to scenario 1, there is an average emission cut of 95% and 96%, respectively.

Table 12 and Table 13 show that the share from hotel overnight stays are relatively low compared to the transport of participants. Note that the contribution from the hotel is somewhat higher for scenario 3, where it is assumed that the participants live in a luxury hotel. This is natural, as the emissions associated with a luxury hotel are higher than the emissions associated with a budget (*57*). Note that hotel data are based on global averages. The Ecoinvent version 3.8 database does not provide data for hotels in Switzerland. Thus, this will be a source of uncertainty for the results of this study. Missing data and low data quality will generally be a source of error that is important to consider regarding the results.

Another fact that is worth noting is the difference between the different cultural perspectives for hotel overnight stays. The proportion of the total emissions is relatively similar across the cultural perspectives for most activities related to a conference. For hotels, overnight this is not the case. Both Table 12 and Table 13 shows that the cultural perspective chosen has a great significance for the contribution share to hotels. On a general basis, the inclusion of hotel overnight stay for participants will greatly contribute to increasing the carbon footprint associated with a conference.

4.4 Participants location

Table 10 shows that the carbon footprint per person per day is 25-30 times higher when the participants are assumed to travel from all over the world versus when they live in Geneva. The results of this study show that the carbon footprint of a conference depends heavily on the geographical scale of its participants.

The main reasons for the differences are that participants from all over the world are expected to require both air transport and hotel accommodation. As discussed in Section 4.3, it is mainly transport by air that makes the total carbon footprint much higher for these scenarios. For scenario 1, the use of conference local has the largest share of the total impact, compared to scenarios 2 and 3 where this contribution is almost zero.

By arranging a conference where the participants already live in Geneva, compared to a conference where the participants live all over the world, there is a large potential emission cut. Going from scenarios 2 and 3 to scenario 1, there is an average emission cut of 95% and 96%, respectively. The question of organising a conference for participants only in Geneva versus participants from all over the world would often not be relevant to an organiser. With a high probability, it will already be given where the participants live, and then the question is rather whether to arrange a digital or physical conference, as discussed in Section 4.2. Alternatively, the organiser can choose to arrange a hybrid conference, which will be discussed in Section 4.8.

Another option to reduce the carbon footprint associated with a conference is promoting low-emission travel options for the participants. Travel by air is a travel option with a high carbon footprint associated (*52*). Travelling by train or coach would both be an improvement in terms of the carbon footprint (*70*). To encourage participants to choose land bound travel options, even if this increased their travel time, compared to travel by air, could result in significantly lower carbon footprints. As mentioned, a more central conference location, which is easy to reach by coach, train and bus, if it is possible, can in combination with the promotion of low-emission land bound travel options result in a significant reduction of the carbon footprint associated with the transportation of participants.

Note again that the data for hotel overnight stays and transport by air is global data, and not specific to Switzerland. In addition, the distances with transport by air are based on assumptions, described in Table 5. The missing data and the assumed average travel distances leads to uncertainties and limitations related to the results of the analysis. Using specific data for both hotels and flights, the results would be more accurate. Given that Switzerland has a relatively green energy mix, the emissions associated with both hotels and aircraft are probably lower than the global averages. The use of global data will be a source of error that is important to consider.

4.5 Energy mix

As expected, the energy mix used could be a decisive factor in the total impacts associated with conferencing. A comparison of the scenarios for digital conferences will clarify this significance. For the digital conferences, it is assumed that all participants stay in their own homes and using the energy mix provided there. In scenario 4 the participants are expected to live in Geneva, where they use the Swiss energy mix. While the participants in scenario 5 live all over the world. Table 10 shows that the carbon footprint is almost ten times higher for scenario 5 compared to scenario 4. Thus, the potential carbon footprint reduction by using the energy mix in Geneva instead of the global is 93% on average. Despite major potential emissions cuts, the participants location will often be given, and not a choice the organiser can make.

Assumptions regarding the energy mix used are listed in Table 6. This result confirms the fact that the Swiss energy mix is one of the cleanest in the world (*49*). The result indicates that the environmental benefits of digital conferences are weakened if a large number of participants are located in regions without a strong penetration of renewables in the power grid. Nevertheless, with the increasing share of renewable energy in the power grid worldwide, gradual reductions in the environmental impacts of electricity production are promising (*4*).

4.6 New York as the conference location

Given the fact that the energy mix used is of great importance for the carbon footprint associated with conferencing, it will be interesting to make a qualitative sensitivity analysis with regard to the energy mix. In addition to Geneva, the UN is also headquartered in New York, Nairobi and Vienna (*72*). If the conference was held in New York, for example, how would it affect the carbon footprint? Is it still the best to have everyone digitally at home?

To be able to say something about this situation, it will be important to know how the energy mix in New York, or in the United States in general, is put together. Unfortunately, the Ecoinvent 3.8 database does not include data for electricity production in the US, which can be compared with data obtained from Switzerland. Thus, the sensitivity analysis must be based on information about the composition of the energy mix and electricity production for the US. With more and better quality of data, the result will be more accurate. It is important to keep in mind when discussing the results of this study.

The primary energy production sources in the US was natural gas (34%), crude oil (23,6%), coal (10%) and nuclear (8,2%) in 2020 (*73*). By comparison, the main sources of primary energy in Switzerland for the same year was petroleum (39,8%), nuclear (24,3%), hydro (12,3%) and gas (10,9%) (*49*). The CO_2 intensity was 1,6 and 2,3 kg CO_2 per kg of oil equivalent energy use in Switzerland and the US, respectively (*74*). The CO_2 intensity is CO_2 emissions from solid fuel consumption and refer mainly to emissions from use of coal as an energy source (*75*). The share of energy supply from renewable energy sources of the total was 81% higher in Switzerland than in the US in 2020 (*76*). Despite the fact that Switzerland is a much smaller country in terms of population, Switzerland produced 3 times as many kilo watt hours (kWh) of electricity from renewable sources compared to the US in 2020 (*76*).

Shifting from a physical to digital conference will require more electricity, due to the required use of a camera. Thus, for a conference in New York, there will not be as great savings by moving a physical conference digitally as for a Swiss conference, because the energy mix in America has greater emissions associated than the energy mix used in Switzerland.

Based on Geneva as the location for a conference, the results of this study showed that the alternative with the lowest carbon footprint is to hold the conference online for participants living in Geneva. Furthermore, it is interesting whether the same conclusion is drawn if the starting point for the conference is New York. From the contribution analysis, we know that both scenario 4 and scenario 5 have IT equipment as the activity with the highest share of the total carbon footprint. Powering the IT equipment accounts for 70% and 99% of the total carbon footprint for scenarios 4 and 5, respectively. Given that the carbon footprint for the use of IT equipment is only associated with the energy used to operate the devices, both scenarios 4 and 5 will be highly dependent on the energy mix used.

Thus, the American energy mix must be compared with the global one to understand how the results would have been for a situation where New York is the starting point for a conference. The electricity produced in 2021 in the US was based on 60,8% fossil fuels, 18,9% nuclear and 20,1% renewables (*77*). In comparison, global electricity was based on 58% fossil fuels, 10% nuclear and 29% renewables (*78*). Although the global and the American electricity mix have many similarities, the conclusion is that the American will most likely have greater carbon footprint per kWh. Thus, there will be greater emissions associated with the use of electricity in New York, compared to using the average global electricity mix. The conclusion is that for a situation based on New York as a conference location, the lowest carbon footprints are for a situation where all participants are spread all over the world.

The same method can also be used to assess other locations, such as Vienna and Nairobi, which are also the headquarters of the UN (*72*). If the electricity mix for the given location is cleaner than the global one, it can be assumed that the best scenario is to let all participants participate digitally from the given location. On the other hand, if the electricity mix for the given location is not cleaner than the global one, it will be better if the participants are spread all over the world and participate digitally in the conference.

The general conclusion will therefore be that it is the digital conferences that have the lowest carbon footprints, regardless of location. Whether scenario 4 or 5 is preferred depends on the energy mix for the particular location.

4.7 Potential for reducing the carbon footprint of a physical conference

There will be a potential to reduce the carbon footprint associated with a physical conference. The question is, which reductions can be assumed to be realistic for conducting a physical conference?

In order to answer this question, four sub-scenarios of scenario 1 were identified, described in Table 7. Figure 20 shows the carbon footprint of the sub-scenarios for the three cultural perspectives. The results show that there are potential for reducing the carbon footprint by avoiding different activities. For scenario 1, it is mainly operation of the conference local, prepared material and transport of participants that contribute to the total carbon footprint, as seen in Figure 15.

In order to reduce the carbon footprint, scenario 1A assumes that the physical conference can be carried out without the use of transport. This means that all participants are assumed to walk or cycle to the conference. This assumption is likely if participants are aware of emissions associated with transportation and really want to help reduce the carbon footprint associated with transportation. By avoiding emissions associated with transporting participants, the average carbon footprint will be reduced from 4,7kg CO_2-eq per person per conference day to 4,5kg CO_2-eq. The difference is thus 0,2 CO_2-eq per person per conference day, which will be an improvement, but to reach the Paris agreement, we must strive for even greater carbon footprint reductions.

Furthermore, scenario 1B describes a physical conference where the transportation of participants and the printed materials are avoided. The probability is small that the participants miss getting printed material by hand. The digital development has made it common and possible to send large files by mail (*6*). Thus, scenario 1B will also be realistic for a physical conference. By avoiding the carbon footprint of transportation and the printed materials, the average carbon footprint is calculated to be 4,1kg CO_2-eq per person per conference day. Thus, scenario 1B will reduce the carbon footprint by 0,6kg CO_2-eq per person per conference day, compared to scenario 1.

The third factor that may be reduced is the energy associated with the conference local. Given that energy efficiency will improve in the next few years, it will be realistic to reduce energy consumption for the local (*56*). Scenario 1C sketch a physical conference where both transport of participants and printed materials are avoided. In addition, the energy use in the conference local is assumed to be only 50% of the assumed consumption in scenario 1. This reduction in energy use may be optimistic, but with both increased energy efficiency and a focus on energy use, it will be possible to implement. The results show that the average carbon footprint for this scenario is 2,2kg CO_2-eq per person per conference day. Compared to scenario 1, this sub-scenario will reduce the carbon footprint by 2,5 kg CO_2-eq per person per conference day. Thus, by implementing the reductions described above, there will be a potential to halve the carbon footprint. Despite the reduction in both transport, printed material and energy consumption, this sub-scenario will not be preferable to the digital version of conferencing, such as scenario 4, which which has a carbon footprint of 0,6 kg CO_2-eq per person per conference day.

If energy efficiency is assumed to improve drastically in the next few years, an very optimistic mindset will envisage a physical conference as described in scenario 1D. In addition to avoiding transportation and printed materials, this sub-scenario assumes that the energy use in the conference local is only 25% of the assumed consumption in scenario 1. Even with this optimistic scenario, the average carbon emissions associated with the conference will not be preferable to scenario 4. Figure 20 shows that the average carbon footprint for this scenario is 1,3kg CO_2-eq per person per conference day.

Thus, the conclusion is that the physical conferences will never have a lower carbon footprint than digital. Despite this fact, this analysis shows that there is great potential for reducing the carbon footprint associated with physical conferencing. In situations where a conference is required to be conducted physically, a focus on sustainability will make a big difference. It is not realistic for all conferences to be digital, so it is important that organisers of physical conferences take actions to reduce or avoid activities that greatly contribute to the carbon footprint.

Note that this conclusion is based on the carbon footprint calculated in this study. As discussed, there are also other factors to consider in choosing the type of conference. Challenges exist for digital conferencing, such as reduced body language, networking opportunities as in-person interactions and naturally flow in conversations.

4.8 Hybrid conference

To both get the interpersonal interactions from a physical conference and at the same time reduce transport, a hybrid version could be a solution. A hybrid conference combines the elements of both digital and physical conferencing (*4*). The conference is conducted at a central location, to which some participants travel, other stays at come and participate digital (*79*). Like a digital conference, a hybrid conference is open to anyone in the world, regardless of mobility (*79*). This type of conferencing will have many of the same benefits as digital conferencing, and at the same time some of the benefits of the physical. The decision of which participants should attend physically or digitally, should be made by the organisers based on the land bound public transport availability and travel distance. For instance, participants within 5 hours of travel time by land bound public transport could attend physically, while the rest attend digitally. Such a version of conference will reduce the carbon footprint associated with travelling, given that there is no need for transport by air. With regard to the carbon footprint, a hybrid conference will be preferable to a physical one, where participants have large travel distances.

On the other hand, hybrid conferencing will also have significant problems. At a hybrid conference, physically present participants have a very different experience from a digital participant. The participants that are at the conference physical, meet face to face and mix discussion with small talks, as a traditional physical conference. Thus, a hybrid conference offers them the additional benefit of digital presentations from participants or speakers who would not otherwise have been able to attend, and face-to-face local discussions (*79*). On the other hand, for the digital participants the entire event involves looking into a computer. Although technological developments have drastically improved electronic equipment, it will not compensate for the disadvantages of participating digitally (*80*).

In order, not to discriminate between participants who participate physically and digitally, multi hub-conferencing will be an option. A multi-hub conference is a conference distributed across several global locations (*81*). Participants meet personally at several hubs, spread across the planet. Such a conference is carried out by groups of participants being connected digitally, so that it feels as if everyone is in the same place (*81*). All participants talk at each hub are shared with the other hubs, either in real time or as video recordings (*81*). Social interaction among hubs happens at digital socialising sessions that also include face-to-face interaction. The conference has a conference chair at the centre of it all to manage the flow (*82*).

The conference is semi-digital, in two senses. First, it involves face-to-face communication with some participants and digital communication with others. Second, during the conference participants can repeatedly choose between digital or parallel real presentations. There will also be a possibility that participants do not travel to a hub, but participate digitally, but then the challenge of discrimination arise again.

Supporters of multi-hub conferences argues that such a form will reduce the carbon footprint, increase the number of participants and reduce the economic cost (*81*). In addition, participants can spend less time out of the office and join a hub closer to home, leading to less accommodation and less travel. Perhaps the largest benefit of the multi-hub conferences is the face-to-face part (*82*).

A disadvantage of multi-hub conference is that it requires complex organisational structure due to the need to coordinate activities across multiple platforms. Another weakness is that it is only local networking, so for an international organisation, where one of the key is to have international collaboration, then bringing the people from Germany together in Berlin is not going to help the international collaboration. The success of a multi-hub conference also depends crucially on the reliability of the technology (*81*). Both for the implementation of the conference itself, and for socialisation and networking between the hubs.

As the results of this study show, activities such as transport of participants and hotel overnight stay are activities that greatly contribute to the total carbon footprint for a conference. By arranging a hybrid conference, both the need for both of these activities will be drastically reduced. Based on the location of the participants, one can find an optimal number of hubs to be able to carry out the conference in an efficient way, while keeping the total carbon footprint low. For conferences organised by UN, one possibility would be to have a hub for each continent. In this way, air transport will be drastically reduced, although it will still be required to conduct the conference.

4.9 Cultural perspectives

The carbon footprint is calculated for the three cultural perspectives for all the scenarios. The same trend applies to all 5 scenarios, the egalitarian perspective has the lowest carbon footprint and the individualist's perspective has the highest. The definitions of three cultural perspectives are described in Section 2.3. Because the egalitarians are expected to prioritise the long-term availability of geological stock for future generations, it is natural that this perspective have the lowest carbon footprint. It is thus also natural that the individualists that aim for a maximal profitability for the current generation has the highest carbon footprint. Hierarchists are a middle ground between the egalitarian and the individualist's perspectives, and this also applies to the results of this study. The difference in carbon footprint between the cultural perspectives are more significant for some activities. This holds especially for hotel overnight stay. The share of the total carbon footprint is for scenario 2, 5%, 8% and 13% for egalitarians, hierarchists and individualists, respectively. Another activity with large differences between the perspectives is the prepared materials for scenario 1, where the contribution is 14%, 11% and 6% for egalitarians, hierarchists and individuals, respectively. The reason for the differences will be that the different perspectives weight events differently.

4.10 Impacts of information and communication technology

The innovations in the area of information and communication technology (ICT) has an important role for the economic and societal development in the 21th century. From the beginning of this century, it was expected that technological development would automatically lead to sustainable development, but this assumption is debatable (*80*). In addition to opportunities, there are as well risks and changes connected with the application of ICT.

The impacts of ICT can be differentiated in effects of first, second and third order (*83*). First order effects originate from the ICT themselves, for example production of hardware or operation of end devices. Second order effects comprehend the impacts of ICT applications, for example transport due to internet commerce. Third level effects are consequential and rebound effects, for example over compensation and changes in lifestyles and consumption patterns.

The effects of digital video conferences as an ICT can be studied on all the three levels. A study done by the Organisation for Economic Co-operation and Development (OECD), shows that video-conferencing systems effects concentrate on the first and second order effects (*83*). Although it is clear that third order effects also can lead to a change in travel patterns and overcompensate the positive effects. Digital conferences simplify the contact and collaboration between participants that work far apart, but as it is unsatisfying never to meet each other in person while working, one can expect some additional flights every year (*80*). This would mean that although there is a decrease at one point, the overall environmental burdens increase due to connected activities. This effect is called rebound effect and has been found in many other applications of ICT (*83*). Due to the complex circumstances with ICT, the impact is hard to calculate precisely, but the environmental performance can be improved by improving the energy efficiency of devices, networks, and data centres (*4*). Therefore, it is important to work with these critical factors for success that would help to increase the sustainable use of digital conferencing and another ICT.

Another perspective that is important to discuss is the lifetime of a device. Given all the materials needed to produce equipment and not least the energy used in production, it will be important to use the IT equipment up to its maximum life span. Extending the lifetime and delaying obsolescence of devices can significantly reduce their environmental and climate impacts (*84*). The life time of a unit can be extended by repairing, replacing materials and protecting it (*80*).

4.11 Sustainable Development Goals trade-offs

United Nations developed the Sustainable Development Goals (SDGs) as a response to increasing concern about the long term sustainability of human societies, shown in Figure 21. This includes a 2030 agenda, including 17 goals and 169 targets (*85*). With such plethora of goals and targets, both negative and positive interactions are expected. Possible interactions range from cancellation to indivisibility. Correlations between SDGs mainly points towards synergies, but also indicate trade-offs. In addition to driving mitigation of GHG emissions, climate change mitigation actions can deliver non-climate benefits, but can also have adverse side effects, working counter to other SDGs (*86*). For example, the trade-offs between electricity access and decarbonisation of energy supply. Another example is the trade-off across land use options in terms of increasing carbon stocks, and protecting biodiversity and contributing food security (*86*).

Figure 21: The 17 Sustainable Development Goals (SDGs) (*85*)

As shown in Figure 21 number one is about eradicating poverty in all its forms everywhere (*85*). Achieving this goal will require large resources that go to the detriment of the goals related to reducing environmental impacts. Although one can assume that increasing incomes above extreme poverty will increase the environmental pressure, the magnitude and location of these impacts caused by the global economy are rarely investigated (*87*). Another example is that spatial interactions may have enormous influence on progress towards SDGs in different locations (*88*). Efforts for achieving SDGs in location A may promote progress towards SDGs in location B. Also, impacts on SDGs may occur at local and regional levels. Furthermore, besides places with direct connections, other places may also be indirectly affected (*88*).

There is already a strong understanding that climate actions are linked, both positively and negatively, with achieving other SDGs (*86*). Figure 22 provides a visualisation of the links between emitting sectors, sectorally mitigation actions, co-impacts of mitigation actions and the SDGs. The inner circle represents the sectors where the climate mitigation action occurs, such as the energy sector and the transport sector. The second and blue circle shows different types of mitigation actions, with the small roman numerals mapping the sectors onto the mitigation actions (*86*). The third and green circle is divided according to the different domains where co-impacts are observed. The domains are climate resilience, economic, environmental, social, political and institutional (*86*). For each of the sectors, the different types of climate related co-benefits are shown with green letters and adverse side effects with red letters, that can be achieved. The final circle maps the different co-impacts domains to the SDGs.

To understand the figure, the energy supply sector will be discussed. Energy efficiency, renewable options and alternative fuels can provide affordable and reliable energy supply. In addition, sustainable harvesting of forestry resources can contribute to energy access in communities reliant on these sources for energy supply (*86*). On the other hand, reducing forest degradation and controlling illegal logging and land clearing could lead to increased hardship and reduced incomes for community's dependent on these activities.

Another SDG tradeoff occurs regarding air pollution. Alternative fuels, processes, feedstocks and renewable energy options can reduce air pollutant loads compared with fossil fuels. Although alternative feedstocks and processes may be less GHG intensive, than current options, there is a potential for greater local air pollutant impacts. An example is vehicles driving on diesel produced from fossil fuels, which have lower GHGs associated, but higher local air pollutants than petroleum vehicles. Switching from petroleum to ethanol will increase the ozone pollution (*86*).

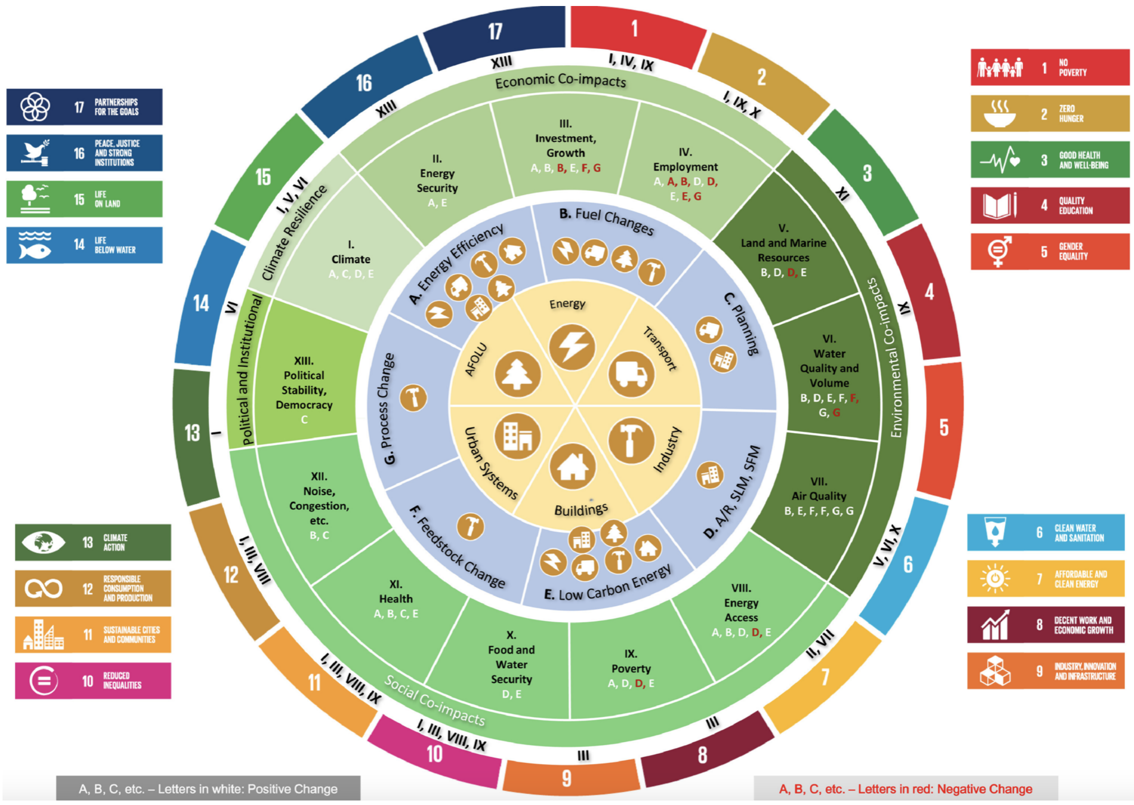

Figure 22: *Co-benefits and adverse side effects of mitigation actions with links to the SDGs. The inner circle represent the sectors where the climate mitigation action occurs, such as the energy sector and the transport sector. The second and blue circle shows different types of mitigation actions, with the small roman numerals mapping the sectors onto the mitigation actions (86). The third and green circle is divided according to the different domains where co-impacts are observed. The domains are climate resilience, II-IV economic co-impacts, V-VII environmental, VIII-XII social, and XIII political and institutional (86). For each of the sectors, the different types of climate related co-benefits are shown with green letters and adverse side effects with red letters, that can be achieved. The final circle maps the different co-impacts domains to the SDGs. (86)*

Applying a co-impact framing when examining climate change mitigation policies and actions has a number of advantages (*86*). Climate change decision making requires a comprehensive approach that accommodates ecological vulnerabilities and intersecting developmental needs. Assessment of co-impacts and tradeoffs is critical to ensuring support for any climate change mitigation action, but also to ensure maximum positive impacts for sustainable development.

In this project, the different conferences have only been assessed on the basis of carbon footprint. It is important to remember that other impact categories such as pollution and land use change have not been considered. A study from Chinese Academy of Sciences identified a trade-off between climate change mitigation and adaption in urban land use (*89*). The results showed that large urban cities play a significant role for reducing transport distances associated with conferencing, and thus reducing the carbon footprint. At the same time, the development of large cities leads to enormous use of land.

Coordinated integrated approaches to climate change mitigation policies, across sectors, are required to maximise synergies and manage trade-offs. Given the importance of the SDGs and their short time horizon, it is important that policy makers receive relevant and timely information to facilitate potential mitigation and adaptation policies on SDG trade-off.

4.12 Limitations of Ecoinvent version 3.8 database

The results of this study should be interpreted in the light of the limitations that exist. In addition to limitations related to the definition of the scope of conferences, there exist limitations related to data collection, which is manly based on Ecoinvent. There are mainly two types of limitations regarding the use of Ecoinvent version 3.8 database; uncertainty in the data and data availability.

There is uncertainty in all scientific data. Uncertainty is the quantitative estimation of error present in data. Thus, all measurements contain some uncertainty generated through systematic error or random error (*90*). There are two types of uncertainty for the data obtained from the Ecoinvent version 3.8 database; variation and stochastic error and uncertainty due to use of estimates (*45*). Variation and stochastic error of the values occurs because of e.g. measurement uncertainties, activity specific variations and temporal variations. This is expressed in the basic uncertainty. Uncertainty due to use of estimates, incompleteness in the sample or lacking verification would be reflected in the additional uncertainty in the dataset. Both basic uncertainty and additional uncertainty are taken into account in the Ecoinvent version 3.8 database. Two types of uncertainty that are not taken into account is the model uncertainty and mistakes imposed by human errors (*45*). Model uncertainty are connected with the model used to describe a unit process. Mistakes imposed by human errors may include human errors included in the information source used or errors made by the data provider during modelling.

In addition to uncertainties related to data available in Ecoinvent version 3.8 database, there are also limitation related to data available. Large amounts of data stored in the database are location specific to Switzerland (*45*). For scenarios where it is assumed that Switzerland is the location where the conference will be held, this fact is good news. For the sensitivity analysis based on other locations, the lack of data will be challenging. An example is data for hotel accommodation. Because only global data exist, there will be great uncertainty associated with these when used in Switzerland as a starting point. The same is true of location-specific data for electricity production in New York. It is possible to make good assumptions based on information sources, but it is a major limiting factor that there is no site-specific data for all locations studied in this thesis. Missing data and low data quality will generally be a source of error that is important to consider regarding the results. Future research may be based on more accurate location specific data.

4.13 Recommendations for conference organisers

Digital conference

Whenever possible, organise digital rather than physical conferences. Organisers should invest time in understanding how to optimise a digital conference based on the goal. In addition, invest in digital technologies needed for digital conferencing and technical support.

Conference location

If the conference needs to be conducted physically, the most central venue should be chosen based on the geographical locations of target participants. It is recommended to choose a central location which can be reached easily by land bound means of transportation within a reasonable amount of time by a larger proportion of participants. Venues taking place on islands which require all participants to travel by air should be avoided.

Material preparation before the conference

With physical conferences, printed materials are a massive contributor to the total carbon footprint. This printed materials that are usually distributed before and during events can easily be reduced by sending the materials digitally to the participants. If it is important to have some material printed, make sure to choose materials that have a lower carbon footprint. Organisers should also avoid other single-use items, such as plastic water bottles and lanyards.

Hotels

The results of the analysis show that hotel accommodation is the cause of a large proportion of the emissions associated with a conference. If for the purpose of the conference it is important to have participants who need hotel accommodation, choose budget hotels over luxury hotels.

Catering

Although catering is not included as an activity in this analysis, there will be significant choices in this category to reduce the overall environmental impact associated with a conference. First of all, the amount of food served can be reduced. Secondly, serving plant based foods is better because animal based foods tend to have a higher carbon footprint (*70*).

Transport of participants

The organiser should consider emission profile of participant travel. Most important of all is to reduce the transport needs associated with the conference, especially transport by air. The results of this study show that the carbon footprint of a conference depends heavily on the geographical scale of its participants. If it is important for the goals of the conference to have the participants physically present, the participants should be encouraged to choose land bound travel options, such as train, bus or coach. There is a great potential in reducing the carbon footprint by choosing land bound travel options instead of transport by air, although this will be at the expense of travel time. The conference organisers could also take concrete actions, such as giving simple information before the conference to raise awareness for the travel related carbon emissions and promote public transport.

Energy use in the conference local

Regarding the energy use in the conference local, there exist a large potential for carbon footprint reduction. In addition to improving energy efficiency, a focus on energy use will be important in making physical conferences more sustainable.

Hybrid conferencing

The conference organisers should consider the possibility of arranging a hybrid conference in situations where digital conferencing is not possible. This can be done by prioritising participants with small carbon footprints to physical attend the conferences. Based on the participants location, one alternative is that the participants who live close participate physically, while the rest attend digitally, as discussed in Section 4.8. Limiting the number of physical attendees can also be done by prioritising based on other factors than the participants home location, as age for example. Another alternative is to choose a multi-hub conference where there are hubs distributed across several global locations, which reduce long distance flights. Thus, participants travel to their nearest hub.

Data distribution

When it comes to data distribution, less will be better in terms of the carbon footprint. The participants camera and microphones can be turned off for those periods it is not necessary for the goal of the conference. Data files could be compressed to reduce the file size before sharing them with the participants. The same holds for any graphics, photos and videos uploaded onto the conference event website because transmitting larger files generally consumes more energy. The participants should be encouraged to watch video in Standard Definition (SD) instead of High definition (HD). In addition, the organisers should provide opportunities for participants to communicate via text based services instead of video.

Frequency of conference

The organiser should consider arranging the conference less frequently. Saving physical conferences to special situations where the connection, networking and two ways conversations are important is a good option to reduce the total carbon footprint in the long run. Alternatively, the conference can be arranged digitally and physically, alternately. Choosing a hybrid conference instead of a physical will also help to reduce the total carbon footprint. In addition, organisers should maximise the physical conferences by organising topical meetings next to plenary sessions to cover a full week for instance. Avoid short duration physical conferences with single goal.

IT equipment

Participants should be encouraged to prolong the lifespan of their IT equipment. Extending the lifetime and delaying obsolescence of devices can significantly reduce their environmental and climate impacts (*84*). Extending the life of equipment may involve maintenance, repairing, replacing materials and protecting it.

Create awareness of participants on carbon footprint reduction

Organisers can offer participants the option of carbon offsetting, to provide opportunity to invest in renewable energy and environment friendly projects. Another action to create awareness is to provide specific and practical environment conservation techniques. One example is to provide personalised carbon footprint computation to the participants. Another is to give assistance in booking train tickets or give discount vouchers from train companies.

Documentation

Finally, the conference organisers should document all the actions taken to reduce the carbon footprint of the conference. By monitoring and documenting activities, there will be greater potential for reducing the carbon footprint of future conferences. Even the small actions are important. Documentation will help to create awareness and transparency about emissions associated with conferencing, as well as sending out a strong signal to other organisers and the general public.

5 Conclusion

The shift to digital conferencing prior to, and increasingly during, the COVID-19 pandemic has provided an unprecedented opportunity to reform methods of organising conferences. Instead of flying over half the world to attend a conference is more likely to consider a digital option. It is crucial that the organisers examine the data generated from conferences, such as LCA to further improve the environmental impact of conferences. Mounting scientific evidence about the urgency of mitigating climate change suggests that mitigation is more important than maintaining the traditional conference experience.

The result of this analysis showed that making a conference digital instead of physical will on average reduce the carbon footprint by 90%. This reduction is mainly caused by less printed material and no need for transport of participants or hotel accommodation. With this knowledge in mind, organisers should strive to arrange a sustainable conference by adopting the digital version of conferencing. Despite the fact that digital conferences have their advantages, this does not mean that the physical conference disappear completely. Digital communication has had and will have major improvements in the coming years and decades, but it will probably never be able to have the same quality as face-to-face communication and handshakes.

By taking the goal of the conference, the participants need and further assessing what measures can be taken to reduce the total carbon footprint, conferencing can become more sustainable. The result may be that digital conferencing is the norm, while physical conferences are "saved" for special occasions where meeting face to face is important for the goal of the conference. Other factors that should be considered in the choice between physical and digital conferences are economic costs, time costs, access, activity level and data collection for future improvements. In the end, such transformation from physical to digital or hybrid conferences necessitates more than just calling on individual participants to reduce their carbon footprint. It requires instead a comprehensive paradigm shift towards decarbonisation throughout the conference industry.

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Appendix

A Assumptions for the different scenarios

A.1 Assumptions for the conference preparation for the different scenarios

Table 16: *Transport habits for commuters in Switzerland (52)*

Transport	Percentages
Passenger car	52
Railway	15
Public road transport	12
On foot	10
Bicycle	7
Motorised two-wheelers	2
E-bike	2

Table 17: *Calculation of the person kilometers per transport method needed to transport the participants to the physical conference, based on the transport habits of the commuters in Switzerland (52)*

Transport	%	Number [person]	Average distance [km]	Person km [Person * km]
Passenger car	52	24,44	3	73,32
Railway	15	7,05	3	21,15
Public road transport	12	5,64	3	16,92
On foot	10	4,7	2	9,4
Bicycle	7	3,29	2	6,58
Motorised two-wheelers	2	0,94	2	1,88
E-bike	2	0,94	2	1,88

Table 18: *Calculation of the paper production per participant*

	Average amount of pages	Weight per page [g]	Amount of paper [kg]
Program booklet	20	5	0,1
Proceedings	200	5	1
Resolution	100	5	0,5
Other printed attachments	100	5	0,5
Total			2,1

	Amount	Unit
Participants	47	persons
Amount of paper	2,1	per person
Total kilogram paper	98,7	kg paper

A.2 Assumptions for the conference execution for the different scenarios

Table 19: *Calculation of the total amount of operation hours for computers for all participants during the hole conference period*

	Amount	Unit
Participants	47	persons
Hours of operation	6	hours per person per conference day
Total hours operation per day	282	hours per day
Amount of conference days	15	days
Total hours of operation	4 230	hours per conference period

Table 20: *Number of service personnel required to arrange a conference in the different scenarios*

	Amount	Unit	1	2	3	4	5
Interpreters included	12	persons	x	x	x	x	x
Chairman included	1	persons	x	x	x	x	x
Technical staff included	20	persons	x	x	x	x	x
Security personnel included	10	persons	x	x	x		
Total number of support personell		**persons**	**43**	**43**	**43**	**33**	**33**

Table 21: *Calculation of the person kilometers needed to transport the service personnel to the physical conferences*

Transport	%	Average distance [km]	Persons	Person kilometer [person*km]
Passenger car	52	3	43	67,08
Railway	15	3	43	19,35
Public road transport	12	3	43	15,48
On foot	10	2	43	8,6
Bicycle	7	2	43	6,02
Motorised two-wheelers	2	2	43	1,72
E-bike	2	2	43	1,72

Table 22: *Calculation of operation hours for the computers to the service personnel for the hole conference period*

	Amount	Unit
Personnel with a computer	33	persons
Hours of operation	6	hours per person per day
Total hours operation per day	198	hours per day
Amount of conference days	15	days
Total hours operation per conference period	2 970	hours per conference period

Table 23: *Calculation of tap water needed for the hole conference period*

	Amount	Unit
Participants	47	persons
Support personnel	43	persons
Water per person per day	2,5	kg
Total water per conference day	225	kg per conference day
Amount of conference days	15	days
Total water for the conference period	3 375	kg per conference period

Table 24: *Calculation of area at the conference local needed for a conference*

	Amount	**Unit**
Square meters per person	0,6	m2/person
Participants	47	persons
Support personnel	43	persons
Total area	54	m2

Table 25: *Calculation of the energy needed for to operate the conference local for the hole conference period*

	Amount	**Unit**
Energy per square meter	180	kWh/m2
Participants	47	persons
Support personnel	43	persons
Amount of square meters per person	0,6	m2/person
Amount of square meters	54	m2
Energy use	9 720	kWh per day
Amount of conference days	15	days
Total energy use for the conference period	145 800	kWh per conference period

Table 26: *Calculation of the total energy consumption per IT unit for the hole conference period*

	Amount	**Unit**
Energy consumption per unit	3	kWh
Amount of participants	47	persons
Energy consumption per conference day	141	kWh
Amount of conference days	15	days
Total energy consumption for the conference period	2 115	kWh

A.3 Assumptions for after the conference for the different scenarios

The name of the scenarios is abbreviated to only the number of the given scenario. This means that scenario 1 will be noted with only the number 1. The crosses in the table mean that there is a assumption for the given scenario. If it is not marked with a cross, it means that the assumption is not true for the given scenario. The colum named "amount" shows the assumed value for the given assumption.

The column where it says "loc" is a column where the location of the data is from. There are not all factors where the location is interesting, but for location-specific data, a location will be noted in this column. Geographic location for data in Ecoinvent is explained in Section 2.6.2 and the different location abbreviations are listed in Table 34.

Table 27: *Assumptions regarding the conference preparation for the different scenarios. All assumptions is given per conference period (3 weeks) for 47 participants*

Factor	**Description**	**Amount**	**Unit**	**Loc**	**1**	**2**	**3**	**4**	**5**
Transporting participants	Passenger coach	73	person kilometer	CH	x	x	x		
	Passenger train	21	person kilometer	CH	x	x	x		
	Regular bus	17	person kilometer	CH	x	x	x		
	Electric bicycle	4	person kilometer	CH	x	x	x		
	Passenger aircraft	325 500	person kilometer	GLO		x	x		
Data distribution	Computer operation	150	hours	CH	x	x	x	x	x
	Operation of internet access equipment	150	hours	CH	x	x	x	x	x

B Contribution Analysis

Table 28: *Contribution analysis for scenario 1*

Factor	Egalitarian	Hierarchist	Individualist
Transporting participants to the conference	3 %	3 %	2 %
Data distribution	0 %	0 %	0 %
Conference committees	1 %	1 %	1 %
Hotel overnight stay	0 %	0 %	0 %
Prepared materials	14 %	11 %	6 %
Powering IT equipment	4 %	4 %	4 %
Conference local	72 %	76 %	83 %
Infrastructure	2 %	3 %	3 %
Transporting participants from the conference	3 %	3 %	2 %
Data distribution	0 %	0 %	0 %

Table 29: *Contribution analysis for scenario 2*

Factor	Egalitarian	Hierarchist	Individualist
Transporting participants to the conference	45 %	44 %	41 %
Data distribution	0 %	0 %	0 %
Conference committees	0 %	0 %	0 %
Hotel overnight stay	5 %	8 %	13 %
Prepared materials	1 %	0 %	0 %
Powering IT equipment	0 %	0 %	0 %
Conference local	3 %	3 %	3 %
Infrastructure	0 %	0 %	0 %
Transporting participants from the conference	45 %	44 %	41 %
Data distribution	0 %	0 %	0 %

Table 30: *Contribution analysis for scenario 3*

Factor	Egalitarian	Hierarchist	Individualist
Transporting participants to the conference	38 %	37 %	35 %
Data distribution	0 %	0 %	0 %
Conference committees	0 %	0 %	0 %
Hotel overnight stay	20 %	22 %	26 %
Prepared materials	0 %	0 %	0 %
Powering IT equipment	0 %	0 %	0 %
Conference local	2 %	3 %	4 %
Infrastructure	0 %	0 %	0 %
Transporting participants from the conference	38 %	37 %	35 %
Data distribution	0 %	0 %	0 %

Table 31: *Contribution analysis for scenario 4*

Factor	Egalitarian	Hierarchist	Individualist
Transporting participants to the conference	0 %	0 %	0 %
Data distribution	0 %	0 %	0 %
Conference committees	4 %	4 %	5 %
Hotel overnight stay	0 %	0 %	0 %
Prepared materials	0 %	0 %	0 %
Powering IT equipment	69 %	70 %	72 %
Conference local	0 %	0 %	0 %
Infrastructure	27 %	26 %	24 %
Transporting participants from the conference	0 %	0 %	0 %
Data distribution	0 %	0 %	0 %

Table 32: *Contribution analysis for scenario 5*

Factor	Egalitarian	Hierarchist	Individualist
Transporting participants to the conference	0 %	0 %	0 %
Data distribution	0 %	0 %	0 %
Conference committees	0 %	0 %	0 %
Hotel overnight stay	0 %	0 %	0 %
Prepared materials	0 %	0 %	0 %
Powering IT equipment	98 %	98 %	100 %
Conference local	0 %	0 %	0 %
Infrastructure	2 %	2 %	2 %
Transporting participants from the conference	0 %	0 %	0 %
Data distribution	0 %	0 %	0 %

C Potential for reducing the carbon footprint of a physical conference

Table 33: *Carbon footprint per person per conference day for the different scenarios, given for the three different cultural perspectives*

Scenario	**Egalitarian [kg CO2 eq/person/day]**	**Hierarchist [kg CO2 eq/person/day]**	**Individualist [kg CO2 eq/person/day]**
Scenario 1	4,0	4,6	5,8
Scenario 1A	3,8	4,3	5,6
Scenario 1B	3,2	3,8	5,2
Scenario 1C	1,8	2,1	2,8
Scenario 1D	1,1	1,2	1,6
Scenario 4	0,5	0,6	0,7

D Ecoinvent 3.8 database

Table 34: *Abbreviations used in the Ecoinvent 3.8 database*

Abbreviations	**Geography classification**
GLO	Global data
CH	Switzerland
CA-QC	Canada, Québec
CN-SGCC	Asia, UN Region
CN-CSG	China
QA	North America
UA	Europe
BY	Belarus
JO	Jordan

E Code from Brightway

```
    .. code:: ipython3

    #Set-up notebook
    #import geopandas as gp
    import bw2data as bd
    import bw2calc as bc
    from pathlib import Path
    import numpy as np
    from warnings import warn
    import bw2io as bi
    import pandas as pd

    from bw2data import *
    from bw2calc import *
    from bw2io import *

.. code:: ipython3

    #Set-up project and reset project
    bd.projects.set_current("UN_conference_physical")

    if "UN_conference_physical" in list(bd.databases):
        del bd.databases["UN_conference_physical"]


.. code:: ipython3

    #Import ecoinvent from the path on this comupter which is:
    #"/Users/marenoie/ecoinvent 3.8_cutoff_ecoSpold02/datasets"
    #This is where I have saved the Ecoinvent database on this comupter
    #This will take a lot of time to import (8min) because it is a lot of data
    #r=raw string, helps to ignore the backslashes

    bi.bw2setup()

    dirpath = "/Users/marenoie/ecoinvent 3.8_cutoff_ecoSpold02/datasets"

    ei = bi.SingleOutputEcospold2Importer(dirpath, "ecoinvent 3.8_cutoff_ecoSpold02")

    ei.apply_strategies()
    ei.all_linked

    ei.write_database(overwrite=True)


.. parsed-literal::

    Biosphere database already present!!! No setup is needed
    Extracting XML data from 19565 datasets
    Extracted 19565 datasets in 190.01 seconds
    Applying strategy: normalize_units
    Applying strategy: update_ecoinvent_locations
    Applying strategy: remove_zero_amount_coproducts
    Applying strategy: remove_zero_amount_inputs_with_no_activity
    Applying strategy: remove_unnamed_parameters
    Applying strategy: es2_assign_only_product_with_amount_as_reference_product
```

```
    Applying strategy: assign_single_product_as_activity
    Applying strategy: create_composite_code
    Applying strategy: drop_unspecified_subcategories
    Applying strategy: fix_ecoinvent_flows_pre35
    Applying strategy: drop_temporary_outdated_biosphere_flows
    Applying strategy: link_biosphere_by_flow_uuid
    Applying strategy: link_internal_technosphere_by_composite_code
    Applying strategy: delete_exchanges_missing_activity
    Applying strategy: delete_ghost_exchanges
    Applying strategy: remove_uncertainty_from_negative_loss_exchanges
    Applying strategy: fix_unreasonably_high_lognormal_uncertainties
    Applying strategy: set_lognormal_loc_value
    Applying strategy: convert_activity_parameters_to_list
    Applying strategy: add_cpc_classification_from_single_reference_product
    Applying strategy: delete_none_synonyms
    Applied 21 strategies in 46.03 seconds
    19565 datasets
    629959 exchanges
    0 unlinked exchanges

    Vacuuming database


.. parsed-literal::

    Writing activities to SQLite3 database:
    0% [##############################] 100% | ETA: 00:00:00
    Total time elapsed: 00:01:07


.. parsed-literal::

    Title: Writing activities to SQLite3 database:
      Started: 05/23/2022 14:54:01
      Finished: 05/23/2022 14:55:09
      Total time elapsed: 00:01:07
      CPU %: 82.60
      Memory %: 41.02
    Created database: ecoinvent 3.8_cutoff_ecoSpold02




.. parsed-literal::

    Brightway2 SQLiteBackend: ecoinvent 3.8_cutoff_ecoSpold02



.. code:: ipython3

    #Using bw2io to create a core for the project
    bi.create_core_migrations()

.. code:: ipython3

    #Set-up database for the project
    db = bd.Database("UN_conference_physical")
```

```
    db.register()

.. code:: ipython3

    #Creating default LCIA methods
    bi.create_default_lcia_methods(overwrite=True)


.. parsed-literal::

    Applying strategy: normalize_units
    Applying strategy: set_biosphere_type
    Applying strategy: fix_ecoinvent_38_lcia_implementation
    Applying strategy: drop_unspecified_subcategories
    Applying strategy: link_iterable_by_fields
    Applied 5 strategies in 1.96 seconds
    Wrote 975 LCIA methods with 254388 characterization factors


.. code:: ipython3

    #Setting the path for the excel-file we want to import
    fp= "/Users/marenoie/Documents/1. Energi og Miljø/Masteroppgave/Excel
    dokumenter/Sensitivitetsanalyse/6maiScenario1.xlsx"

.. code:: ipython3

    #Import the excelfile from the path described above
    ei = ExcelImporter(fp)


.. parsed-literal::

    Extracted 1 worksheets in 0.49 seconds


.. code:: ipython3

    #Applying strattegies
    ei.apply_strategies()


.. parsed-literal::

    Applying strategy: csv_restore_tuples
    Applying strategy: csv_restore_booleans
    Applying strategy: csv_numerize
    Applying strategy: csv_drop_unknown
    Applying strategy: csv_add_missing_exchanges_section
    Applying strategy: normalize_units
    Applying strategy: normalize_biosphere_categories
    Applying strategy: normalize_biosphere_names
    Applying strategy: strip_biosphere_exc_locations
    Applying strategy: set_code_by_activity_hash
    Applying strategy: link_iterable_by_fields
    Applying strategy: assign_only_product_as_production
    Applying strategy: link_technosphere_by_activity_hash
    Applying strategy: drop_falsey_uncertainty_fields_but_keep_zeros
```

```
    Applying strategy: convert_uncertainty_types_to_integers
    Applying strategy: convert_activity_parameters_to_list
    Applied 16 strategies in 0.30 seconds


.. code:: ipython3

    #Matching the databae name fields
    #The names in the excel files should have the
    #exact same name as the activities in the Ecoinvent database

    ei.match_database(fields=['name'])


.. parsed-literal::

    Applying strategy: link_iterable_by_fields


.. code:: ipython3

    #Printing number of datasets, exchanges and unlinked exchanges
    ei.statistics()


.. parsed-literal::

    18 datasets
    47 exchanges
    29 unlinked exchanges
      Type technosphere: 15 unique unlinked exchanges




.. parsed-literal::

    (18, 47, 29)



.. code:: ipython3

    #Link unlinked flows to flows from ecoinvent
    ei.match_database("ecoinvent 3.8_cutoff_ecoSpold02", fields=["name", "location"])



.. parsed-literal::

    Applying strategy: link_iterable_by_fields


.. code:: ipython3

    #This import is for a single database,
    #but can also have project-level variables.
```

```
    #This means that we first have to add the project parameters explicitly.
    ei.write_project_parameters()

.. code:: ipython3

    #We then write the database, and choose to activate the parameters we have imported.
    #If we didn't activate them,
    #they would be imported as Database(name)['parameters'] and `Activity()['parameters'].
    ei.write_database(activate_parameters=True)


.. parsed-literal::

    Writing activities to SQLite3 database:
    0% [##################] 100% | ETA: 00:00:00
    Total time elapsed: 00:00:00


.. parsed-literal::

    Title: Writing activities to SQLite3 database:
      Started: 05/23/2022 15:06:31
      Finished: 05/23/2022 15:06:31
      Total time elapsed: 00:00:00
      CPU %: 50.30
      Memory %: 19.66
    Created database: UN_conference_physical


.. code:: ipython3

    #Calculating the LCA

    impact_categories_results={
        ('CML 2001 (superseded)', 'climate change', 'GWP 100a'): None,
        ('CML 2001 (superseded)', 'freshwater aquatic ecotoxicity', 'FAETP 100a'): None,
        ('CML 2001 (superseded)', 'land use', 'competition'): None,
        ('CML 2001 (superseded)', 'stratospheric ozone depletion', 'ODP 10a'):None,
        ('ReCiPe Endpoint (I,A)', 'ecosystem quality', 'climate change, ecosystems'):None,
        ('ReCiPe Endpoint (I,A)', 'human health', 'climate change, human health'):None,
        ('ReCiPe Endpoint (I,A)', 'resources', 'total'):None,
        ('ReCiPe Midpoint (H)', 'climate change', 'GWP100'):None,
        ('ReCiPe Midpoint (I)', 'climate change', 'GWP20'):None,
        ('ReCiPe Midpoint (E)', 'climate change', 'GWP500'):None

    }

.. code:: ipython3

    #Printing the result of the LCA
    for category in impact_categories_results:
        lca = bc.LCA(
        {('UN_conference_physical', 'conference'): 1}, # Func unit is one conference day
         (category),
        use_distributions=False,
        seed_override=None
        )
        lca.lci()
```

```
        lca.lcia()
        impact_categories_results[category] = lca.score

    print(impact_categories_results)


.. parsed-literal::

    {('CML 2001 (superseded)', 'climate change', 'GWP 100a'): 370.65,
    ('CML 2001 (superseded)', 'freshwater aquatic ecotoxicity', 'FAETP 100a'): 273.76,
    ('CML 2001 (superseded)', 'land use', 'competition'): 136.5802697921101,
    ('CML 2001 (superseded)', 'stratospheric ozone depletion', 'ODP 10a'): 4.98e-05,
    ('ReCiPe Endpoint (I,A)', 'ecosystem quality', 'climate change, ecosystems'): 7.98,
    ('ReCiPe Endpoint (I,A)', 'human health', 'climate change, human health'): 10.61,
    ('ReCiPe Endpoint (I,A)', 'resources', 'total'): 20.40,
    ('ReCiPe Midpoint (H)', 'climate change', 'GWP100'): 365.41,
    ('ReCiPe Midpoint (I)', 'climate change', 'GWP20'): 468.45,
    ('ReCiPe Midpoint (E)', 'climate change', 'GWP500'): 320.83}


.. code:: ipython3

    #Putting the endpoint results in a dataframe
    #This is the result for the study and shows
    #the carbon footprint per conference for 47
    #participants, which is the functional unit

    pd.DataFrame([
        {
            'Climate Change Egalitarians':
            impact_categories_results['ReCiPe Midpoint (E)', 'climate change', 'GWP500'],
            'Climate Change Hierachists':
            impact_categories_results['ReCiPe Midpoint (H)', 'climate change', 'GWP100'],
            'Climate Change Individualits':
            impact_categories_results['ReCiPe Midpoint (I)', 'climate change', 'GWP20']
        } for _, _ in zip(lca, range(1))
    ])




.. raw:: html

    <div>
    <style scoped>
        .dataframe tbody tr th:only-of-type {
            vertical-align: middle;
        }

        .dataframe tbody tr th {
            vertical-align: top;
        }

        .dataframe thead th {
            text-align: right;
        }
    </style>
    <table border="1" class="dataframe">
```

```
    <thead>
      <tr style="text-align: right;">
        <th></th>
        <th>Climate Change Egalitarians</th>
        <th>Climate Change Hierachists</th>
        <th>Climate Change Individualits</th>
      </tr>
    </thead>
    <tbody>
      <tr>
        <th>0</th>
        <td>320.837809</td>
        <td>365.412671</td>
        <td>468.45479</td>
      </tr>
    </tbody>
  </table>
  </div>
```

```
.. code:: ipython3

    #Now we want to a contribution analysis
    import bw2analyzer as ba
    from bw2analyzer import ContributionAnalysis

.. code:: ipython3

    #Printing the objects in the database
    #We can do a contribution analysis for all the activities,
    #but we want to find the main activity, which is the Physical conference,
    #id=87139
    for obj in bd.Database("UN_conference_physical"):
        print(obj.key, obj, obj.id)


.. parsed-literal::

    ('UN_conference_physical', 'microphone') 'Microphone' (unit, CH, None) 87151
    ('UN_conference_physical', 'preparation') 'Conferece_preparation' (unit, CH, None) 87140
    ('UN_conference_physical', 'local') 'Conference_local' (unit, CH, None) 87154
    ('UN_conference_physical', 'Transporting') 'Transporting_participants'
    (person kilometer, CH, None) 87145
    ('UN_conference_physical', 'meeting') 'Preparation_meeting' (unit, CH, None) 87144
    ('UN_conference_physical', 'Distribution') 'Data_distribution_before' (hour, CH, None) 87146
    ('UN_conference_physical', 'infrastructure') 'Infrastructure' (unit, CH, None) 87155
    ('UN_conference_physical', 'materials') 'Prepared_materials' (hour, CH, None) 87147
    ('UN_conference_physical', 'headset') 'Headset' (unit, CH, None) 87153
    ('UN_conference_physical', 'commitees') 'Conference_committees' (unit, CH, None) 87143
    ('UN_conference_physical', 'execution') 'Conference_execution' (unit, CH, None) 87141
    ('UN_conference_physical', 'hotel') 'Hotel' (unit, GLO, None) 87148
    ('UN_conference_physical', 'after') 'Conference_after' (unit, CH, None) 87142
    ('UN_conference_physical', 'conference') 'Physical_conference'
    (conference day, CH, None) 87139
    ('UN_conference_physical', 'computer') 'Computer' (unit, CH, None) 87150
    ('UN_conference_physical', 'telephone') 'Telephone' (unit, CH, None) 87152
    ('UN_conference_physical', 'distributionafter') 'Data_distribution_after'
```

```
(hour, CH, None) 87156
('UN_conference_physical', 'IT') 'IT_equipment' (unit, CH, None) 87149
```

```
.. code:: ipython3

    #Saving the physical conference as act, so we can use it later
    act = bd.get_activity(87139)
    act




.. parsed-literal::

    'Physical_conference' (conference day, CH, None)



.. code:: ipython3

    #Printing the supply chain for the activity: physical conference
    #Now we can see how the supply chain is but together
    ba.print_recursive_supply_chain(act)


.. parsed-literal::

    1: 'Physical_conference' (conference day, CH, None)
      1: 'Conferece_preparation' (unit, CH, None)
        1: 'Conference_committees' (unit, CH, None)
        0: 'Transporting_participants' (person kilometer, CH, None)
        1: 'Data_distribution_before' (hour, CH, None)
        0: 'Prepared_materials' (hour, CH, None)
        15: 'Hotel' (unit, GLO, None)
      15: 'Conference_execution' (unit, CH, None)
        15: 'IT_equipment' (unit, CH, None)
        1.5: 'Conference_local' (unit, CH, None)
        15: 'Infrastructure' (unit, CH, None)
      1: 'Conference_after' (unit, CH, None)
        0: 'Transporting_participants' (person kilometer, CH, None)
        1: 'Data_distribution_after' (hour, CH, None)


.. code:: ipython3

    #Giving name to different parameters to make
    #it easier to calculate the contribution analysis later

    #This is the ipcc, climate change method
    ipcc = ('IPCC 2013', 'climate change', 'GWP 100a')

    #This is the ReCiPe midpoint hierarchist perspective
    hir = ('ReCiPe Midpoint (H)', 'climate change', 'GWP100')

    #This is the ReCiPe midpoint individualists perspective
    ind = ('ReCiPe Midpoint (I)', 'climate change', 'GWP20')
```

```
#This is the ReCiPe midpoint egalitarian perspective
ega =  ('ReCiPe Midpoint (E)', 'climate change', 'GWP500')
```

.. code:: ipython3

```
#Results for Egalitarians
#act is the activity, which is the conference
#ega stands for egalitarians, which is the method used for this calculation
#max level is the level we want to calculate for, the higher the more data
#cutoff shows the smalest contribution we want to look at

#Fraction of score shows the contribution percentage of
#the total CO2 eq for the given level
#That is why the fraction of the score for the physical
#conference is 1 =100%
#Level 0 is only the activity itself
#Level 1 consist of the conference preparation,
#conference excecution and after the conference
#Level 2 is the underactivities to the conference preparation,
#conference excecution and after the conference.


results = ba.print_recursive_calculation(act, ega, max_level=2, cutoff=0)
results
```

.. parsed-literal::

```
Fraction of score | Absolute score | Amount | Activity
0001 | 320.8 |     1 | 'Physical_conference' (conference day, CH, None)
  0.0467 | 14.97 |     1 | 'Conferece_preparation' (unit, CH, None)
    0.0457 | 14.66 |     1 | 'Conference_committees' (unit, CH, None)
    0.000972 | 0.3118 |     1 | 'Data_distribution_before' (hour, CH, None)
  0.95 | 304.9 |    15 | 'Conference_execution' (unit, CH, None)
    0.642 | 205.9 |   1.5 | 'Conference_local' (unit, CH, None)
    0.309 | 99.07 |    15 | 'Infrastructure' (unit, CH, None)
  0.00292 | 0.9355 |     1 | 'Conference_after' (unit, CH, None)
    0.00292 | 0.9355 |     1 | 'Data_distribution_after' (hour, CH, None)
```

.. code:: ipython3

```
#Results for Hierachists
#act is the activity, which is the conference
#hir stands for hierarchists, which is the method used for this calculation
#max level is the level we want to calculate for, the higher the more data
#cutoff shows the smalest contribution we want to look at

#Fraction of score shows the contribution percentage of the total CO2 eq for the given level
#That is why the fraction of the score for the physical conference is 1 =100%
#Level 0 is only the activity itself
#Level 1 consist of the conference preparation,
#conference excecution and after the conference
#Level 2 is the underactivities to the conference preparation,
#conference excecution and after the conference.
```

```
    results = ba.print_recursive_calculation(act, hir, max_level=2, cutoff=0)
    results


.. parsed-literal::

    Fraction of score | Absolute score | Amount | Activity
    0001 | 365.4 |     1 | 'Physical_conference' (conference day, CH, None)
      0.0485 | 17.73 |     1 | 'Conferece_preparation' (unit, CH, None)
        0.0476 |  17.4 |     1 | 'Conference_committees' (unit, CH, None)
        0.000897 | 0.3278 |     1 | 'Data_distribution_before' (hour, CH, None)
      0.949 | 346.7 |    15 | 'Conference_execution' (unit, CH, None)
        0.672 | 245.5 |   1.5 | 'Conference_local' (unit, CH, None)
        0.277 | 101.2 |    15 | 'Infrastructure' (unit, CH, None)
      0.00269 | 0.9835 |     1 | 'Conference_after' (unit, CH, None)
        0.00269 | 0.9835 |     1 | 'Data_distribution_after' (hour, CH, None)


.. code:: ipython3

    #Results for Individuals
    #act is the activity, which is the conference
    #ind stands for individuals, which is the method used for this calculation
    #max level is the level we want to calculate for, the higher the more data
    #cutoff shows the smalest contribution we want to look at

    #Fraction of score shows the contribution percentage of the total CO2 eq for the given level
    #That is why the fraction of the score for the physical conference is 1 =100%
    #Level 0 is only the activity itself
    #Level 1 consist of the conference preparation,
    #conference excecution and after the conference
    #Level 2 is the underactivities to the
    #conference preparation, conference excecution and after the conference.


    results = ba.print_recursive_calculation(act, ind, max_level=2, cutoff=0)
    results


.. parsed-literal::

    Fraction of score | Absolute score | Amount | Activity
    0001 | 468.5 |     1 | 'Physical_conference' (conference day, CH, None)
      0.0515 | 24.12 |     1 | 'Conferece_preparation' (unit, CH, None)
        0.0507 | 23.75 |     1 | 'Conference_committees' (unit, CH, None)
        0.000791 | 0.3707 |     1 | 'Data_distribution_before' (hour, CH, None)
      0.946 | 443.2 |    15 | 'Conference_execution' (unit, CH, None)
        0.72 | 337.1 |   1.5 | 'Conference_local' (unit, CH, None)
        0.227 | 106.1 |    15 | 'Infrastructure' (unit, CH, None)
      0.00237 | 1.112 |     1 | 'Conference_after' (unit, CH, None)
        0.00237 | 1.112 |     1 | 'Data_distribution_after' (hour, CH, None)
```

NTNU
Kunnskap for en bedre verden