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Carbon Footprint of Conventional and Online Alternatives of National Scientific Student Conference in Hungary

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The carbon footprint shows the total - direct and indirect - greenhouse gas emissions of a person, organization, event or product in terms of CO_2 equivalent. The carbon footprint of the alternatives of the Economics Section of the 35th National Scientific Student Conference in Hungary was examined. Environmental inventory data was collected in two event formats – conventional and online – via the activity and process approach. The main processes were mobility, accommodation, catering, energy, materials used, transport, and waste. The carbon footprint of the conference alternatives was calculated to compare the versions and to study and interpret CO_2 savings. The methodology of the "MyClimate Foundation - The Climate Protection Partnership" was employed for the calculation. It can be concluded that the implementation of the online conference resulted in a saving of 90.57 % in terms of CO_2 equivalent. The analysis indicates the critical points for the main processes. The transport of the participants (68 %) was the most significant contribution to the carbon footprint in the conventional conference, while in the case of an online conference, it was the self-catering (97 %). If catering is excluded, which was considered to be the same for both online and offline, the energy needs for the operation of electronic devices form the most significant part of the carbon footprint (98 %).

1. Introduction

A footprint is a quantitative measure, an indicator that expresses the extent of humanity's impact on nature (Hoekstra and Wiedmann, 2014). According to the United Nations Environment Programme/ Society of Environmental Toxicology and Chemistry (UNEP/SETAC) (2009) definition, a footprint indicates the impacts on different elements in the pursuit of sustainability goals. Many research studies currently focus on the different footprints (e.g. ecological, water, carbon, energy, material, biodiversity, chemical), the comparison of footprints, and the assessment of the combined impacts of and the relationships between them. By quantifying the exposure of specific environmental mediums (earth, water, air, or living beings, including human beings), they provide invaluable information to shareholders, politicians, business partners, competitors, civil organisations, and market operators. Whether separately or combined, footprints also serve to characterise progress toward sustainability, which makes them appropriate tools for the benchmarking of environmental performances (Tóthné Szita, 2018). Their identification and definition are therefore also important for the Sustainable Development Goals (SDGs) (Klemeš et al., 2022).

Carbon footprints, which address carbon dioxide or, simply, carbon, are a measure of the environmental impact of human activities. Carbon footprints can be connected to air pollution and climate change, and they indicate the total – direct or indirect – greenhouse gas (GHG) emissions caused by an individual, organisation, project, event, or product expressed in terms of carbon dioxide equivalent. The larger the carbon footprint of an activity, individual, community, or society, the higher the global warming impact (Tóthné Szita, 2018).

The organization-level and event-level calculations of carbon footprints consider all the direct impacts and indirect components of events, which include operational emissions and vehicle emissions of a company; emissions generated by electricity, steam, and heat; transported and purchased products and services; carbon dioxide and greenhouse gas emissions of waste generation; and water supply. At a national level, all direct greenhouse emissions, as well as indirect supply chain emissions, have to be included (Tóthné Szita, 2018).

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The annual CO_2 emission per capita of Hungary in 2018 was 6.55 t CO_2-equivalent/capita/y. As a comparison, a sustainable carbon footprint should be about 2-2.5 t CO_2-equivalent/capita/y globally (EEA, 2020).
The sustainable management of events and conferences has moved increasingly into the foreground as a top priority in the effort to expand awareness. Knowing the carbon footprint of an event draws participants' attention to the global problem of climate change and illustrates the evolution and main components of emissions as well as the scope for reductions. Several studies have calculated the carbon footprint of conferences or meetings and proposed solutions to neutralise them for sustainable development. Neugebauer et al. (2020) were the first to conduct research that examined the holistic environmental impact of a conference in the field of sustainability research and which covered all phases of the conference. Hischier and Hilty (2020) investigated how to achieve a smaller environmental impact during the organisation of a conference without harming scientific development and personal relationships. Our analysis indicates that electricity consumption of events is not a critical point. On the other hand, the transport of participants and the services provided to them are critical points. The environmental impact of transport strongly depends on the origin of the participants and the location of the conference (Nevrlý et al., 2020). Milford et al. (2020) examined the relationship between the distance travelled by the participants and the size of the carbon footprint in the case of six medical conferences. Based on research, the most decisive factor is not the distance but the type of travel, as the carbon footprint of the conference can be potentially reduced if, for example, it is possible to travel by train (Tao et al. 2021). A significant number of participants travel to international conferences by plane (Yakar and Kwee, 2020), which increases the share of travel in the total carbon footprint. An et al. (2023) came to a similar conclusion, with a transport share of between 50-90 % of the total carbon footprint. Bossdorf et al. (2010) determined this at 66 %. The researchers' opinions differ on the catering and accommodation of the conference. Bossdorf et al. (2010) suggest 18 % and 13% of the total carbon footprint for accommodation and catering, while according to Astudillo and AzariJafari (2018), these account for only 1 % and 2 % of the total carbon footprint. This knowledge contributes to the application of practical solutions as well as to the development of environmental consciousness at both the individual level and the organisational level. The COVID-19 coronavirus epidemic has shifted the emphasis from conventional on-site events to online video conferencing events in virtual space. The question arises as to how this affects the evolution of carbon footprints of events. Jäckle (2019) showed that the carbon footprint could be reduced by 75-90 % if the conference was held online. In the case of a large international conference (nearly 1,500 people), this can mean up to 55 times less carbon emissions (Periyasamy et al., 2022).
In our research, the carbon footprints for the organisational alternatives of the Economics Section of the 35th National Scientific Student Conference were analysed. Based on the international literature, carbon footprint calculations are becoming increasingly important and widespread for achieving sustainability. However, carbon footprint calculation for conferences is not yet widespread in Hungary. The aim was to identify the most relevant processes and compare them with international results. We also examined the correlation between the calculated values of the domestic conference and the values of international literature.
The national conference was examined in both conventional and online formats. It aimed to calculate the carbon footprint of the conference alternatives by comparative analysis and interpret CO_2 savings.

2. Methodology

The present study calculated the carbon footprint of the Economics Section of the 35th National Scientific Student Conference (Sopron, Hungary). It aimed to complete a comparative analysis of the environmental impacts conventional and online event alternatives had on climate change expressed in CO_2 equivalents. The GHG data are transformed into CO_2-equivalent using conversion factors, e.g. provided by the Intergovernmental Panel on Climate Change (IPCC) (Pandey and Agrawal, 2014).
The analysis required the collection of descriptive as well as characteristic input environmental data. The result on the output side of the calculation was the carbon footprint values (kg CO_2-equivalent), on the basis of which the environmental impact assessment was performed. The formula for the calculation of carbon footprint (CF) is given by Eq(1):

$$CF\ [CO_2\ equivalent] = data\ of\ activity\ [unit] \times CO_2 emission\ factor \left[\frac{CO_2\ equivalent}{unit}\right] \quad (1)$$

This approach is the problem-oriented (midpoint) method (Tóthné Szita, 2018), which stops prior to the endpoint and assigns the environmental inventory data (in this case, environmental factors) to environmental problems (global warming as a midpoint). The methodology of the "MyClimate Foundation - The Climate Protection Partnership" was employed for the calculation. This is an internationally recognised analytical framework that is often used to determine the carbon footprint of events.

2.1 Descriptive data and system boundaries

The conference consisted of presentations held over three days (22-24 April 2021) in a total of 50 sections. The conference also included formal opening and closing sessions, daily coordination of the jury, and additional programs (e.g. sustainability corner, evening concert). In total, 1,060 people participated in this highly visible national conference. Due to the COVID-19 pandemic situation, instead of organising the traditional on-site conference (original alternative), the organisers decided to implement it online. The environmental inventory data was collected in two event formats – conventional and online – via the activity and process approach, and the system boundaries of the analysis were determined. The main processes involved in data collection according to conference format were as follows: mobility, accommodation, catering, energy, materials used, transport and waste. The environmental data of additional related product systems and background processes were not collected (e.g. the environmental impacts of fuel production for transportation fuel were not included in the input data). In the case of the conventional alternative, the most significant environmental input data from the perspective of the environmental impacts of the conference were determined.

The carbon footprint calculation for the two versions of conferences considered the input data. The methodology of the ”MyClimate Foundation - The Climate Protection Partnership“ was employed for the calculation. The methodology also permitted the consideration of the scenario of substitution with 100 % renewable energy for the energy consumed (MyClimate Foundation, 2021). The calculation also conformed to the GHG Protocol Corporate Accounting and Reporting Standard (GHG, 2020).

2.2 Data of conventional alternative

Regarding the transport of participants - based on registration forms and data collected by the conference organisers - it was determined that 9.24 % of participants would utilise local, environmentally friendly transport alternatives such as cycling or walking. The ratio of participants who would utilise trains as a means of public transport is 43.4 %. 6.23 % would travel by bus, and 41.13 % would arrive by private car. By our estimation, the lecturers and companions would travel to the event in the same car. Thus, an average of three people would travel in one automobile. The jury members and VIPs would also travel in pairs. For reasons of simplification, we specified a distance of 300 km for the average zone of travel, which amounts to 600 km roundtrip (Koloszár, 2021). According to our calculations, the total distance travelled by public transport was 39,474 km (27,294 km by train, 12,180 km by bus), and the distance covered by cars was 97,800 km.

The number of meals provided to participants was as follows: 1,700 breakfasts, 3,400 warm meals and 850 gala dinners –70 % non-vegetarian, 30 % vegetarian. Coffee and mineral water were served at each meal. Wine, beer and spirits were only served for lunch and dinner. The total amount of dining waste plastics (PET) is 59.5 kg (100 % collected separately; 100 % recycled). Since the on-site and online versions of the event occurred in spring, the rooms (total of 1,250 m^2) required neither heating nor air conditioning. The energy consumed in interior lighting was negligible due to the nature of the event (projection). The on-site section presentations required 50 laptops and 50 projectors with an average operating time of 6 h. Each of the presenters produced an additional 4 h operating time by using their own laptops. The energy requirements for organising the conference were considered in the calculation. The conference also produced 1,000 printed copies of a 660-page publication, participation certificates, notebooks, and canvas bags (10.6 kg of textiles in total). Approximately 1,654.1 kg of paper was consumed. Polyethylene (PE) business card holders were used to identify the participants (a total of 5.3 kg, which were not collected and reused). With participant accommodation, the present study estimated a total of 1,900 overnight stays (mainly in student hotels), with a total of 68.4 kg of plastic waste (PET) generated (100 % collected separately, 100 % recycled) (Koloszár, 2021). Neither the conventional nor the online conference versions involved the need to transport participants to programs at external locations.

2.3 Data of online alternative

For the online alternative, it was assumed that all participants logged in at home, so the environmental impacts of transport and overnight stays could be omitted. The accommodation was considered as not directly linked to the conference, and even some research has already shown that online conference accommodation is not a necessary emitter (Faber, 2021). According to the model, online participants required the same amount of meals as in the conventional alternative. In addition, the same amount of waste from meals was taken into account as the amount of wastes from catering to the offline conference. Online presentations required 710 laptops, 350 PCs and 1,060 modems, with an average of 6 h of operation per presenter. Each participant's own device generated an additional 2 h of uptime (online programmes). The calculation also takes into account the energy demand of the conference organisation. The online version of the conference required no printed publications or gifts; only the certificates of participation were printed and distributed to the participants. Approximately 4.1

kg of paper was used to create the certificates. The online alternative also generated no conference-related plastic waste (Koloszár, 2021).

3. Results

The input environmental inventory data provided valuable information, which could be assessed from a general environmental aspect as well. In the conventional alternative, the site choice entailed a central location with suitable accessibility, which is ideal from an environmental point of view. The distribution of transport modes and the number of kilometres travelled reveal a preference for car travel. Fortunately, the cars that travelled to the event carried more than one passenger.

The choice of the spring date for the event made it possible to avoid heating and/or cooling the premises. The time of day and the nature of the event (projection) help to reduce unnecessary lighting on the premises. All catering waste was selectively collected. The local, high-quality catering service did not include single-use items and accurate registration eliminated waste and unnecessary portions. The use of seasonal goods, fair trade products, and the involvement and promotion of certified farms are all recommended for sustainable events. A higher proportion of vegetarian food is also environmentally friendly.

The online alternative yielded several environmental savings, which were emphasised by the organisers. Plastic business card holders were used for the on-site presence event. The conference was organised with minimal printing. Nearly all communication was electronic. In the case of essential publications, the use of recycled paper and double-sided printing is recommended. The carbon footprint values observed in the main activity areas of conventional and online conferences are presented in Figure 1.

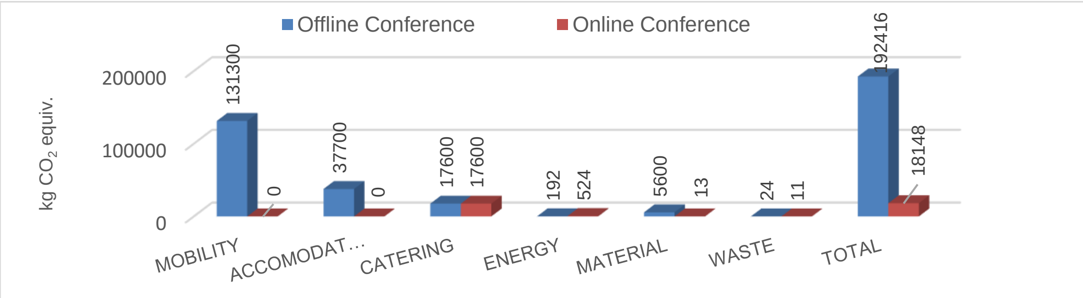

Figure 1: The carbon footprint of the main activities of the offline and online conference (unit: kg CO_2-equivalent)

The carbon footprint of the conventional conference was 192,416 kg CO_2-equivalent, while the carbon footprint for the online conference was only 18,148 kg CO_2-equivalent. The values clearly show high environmental savings in total and by sub-area (excluding energy). Participant transport, accommodation, catering, energy needs, materials used, and waste generated all need to be considered for the on-site format. The online event required no facilitative activities for the participants and consumed far less in terms of energy and materials. Figure 2 shows the relative proportion of carbon footprint values of the specific activity areas.

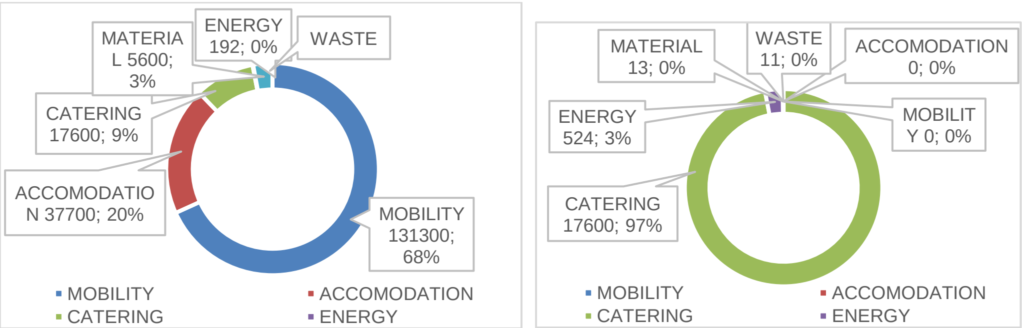

Figure 2: Carbon footprint proportion (unit: kg CO_2-equivalent and percentage) of the main activities of the conventional (offline) (a) and the online conference (b)

The transport of the participants (68 %) was the most significant contribution to the carbon footprint in the conventional, on-site conference. This is followed by the contribution of accommodation (20 %) and catering (9 %). Printed publications, materials used, and gifts account for only small proportion (3 %). The energy needs of the conventional conference include only the operation of electronic devices (the heating/cooling of the

premises did not occur). The contribution rate was negligible (0.099 %). There was also no significant contribution from the selectively collected waste (0.012 %). Catering forms the most significant part of the carbon footprint (97 %) for the online conference, while energy needs for the operation of electronic devices, the printed participation certificates and waste account for only a small contribution (3 % and less than 1 %). In our case, no contribution to other areas of activity arose during the online conference. If we exclude catering, the energy needs would be the most significant part of the carbon footprint (98 %).
Overall, the quantity of CO_2-equivalent saved by the implementation of the online conference is 174,268 kg (90.57 % saving). This quantity could be avoided by converting the original conventional (presence) event into a purely online event. In the case of an online conference, energy demand (873.81 kWh, 524 kg CO_2-equivalent) is the only field that surpasses the conventional event (321 kWh, 192 kg CO_2-equivalent). The online event consumed 272 % more energy than the conventional event. However, considering total savings in the ultimate result, this resulted in only a slight surplus of CO_2-equivalent contribution in the energy activity area (online surplus: 332 kg) of the online alternative. Replacing fossil fuels with renewable energy might reduce a carbon footprint (Mekonnen et al., 2016). The applied methodology of carbon footprint calculation provided an opportunity to take into account the scenario for 100% renewable energy substitution regarding the energy used (MyClimate Foundation, 2021). If "green energy" completely supplies the energy required, the energy activity area results in 20 kg CO_2-equivalent when organising the conventional conference (172 kg CO_2 would be offset). This amount is 54 kg CO_2-equivalent in the case of the online alternative (470 kg CO_2 would be offset) (Table 1).

Table 1: Carbon footprint of conference types in the case of substitution of energy use with 100 % renewable energy (unit: kg CO_2-equivalent)

Main processes	Offline conference	Offline conference (100% renewable energy)	CO_2 avoided (offline conference)	Online conference	Online conference (100% renewable energy)	CO_2 avoided (online conference)
Mobility	131,300	131,300	0	0	0	0
Accommodation	37,700	37,700	0	0	0	0
Catering	17,600	17,600	0	17,600	17,600	0
Energy	192	20	172	524	54	470
Material	5,600	5,600	0	13	13	0
Waste	24	24	0	11	11	0
Total	192,416	192,244	172	18,148	17,678	470

The total value of the carbon footprint of the conventional alternative will be slightly less. In the case of the online conference by using renewable energy, the carbon proportion produced by energy demand could be further reduced by 90 %, which means a 2.59 % decrease in the total online CO_2 profile. If we disregard the inclusion of a weekday meal at the event - as we considered equal in online and offline form - the 90 % reduction in the carbon dioxide rate from energy demand already represents an 88 % reduction in the total online CO_2 profile. The question arises of how the obtained carbon footprint results can be interpreted, what the savings achieved mean in practice and how it would be possible to neutralise the actual carbon footprint (carbon offset analysis). The carbon footprint of the traditional conference corresponds to the average daily CO_2-emission of 10,722 Hungarian residents. With the online version of the conference, this value amounts to 1,011 residents (base year: 2018). The savings of the online version equals the average daily energy consumption of 9,711 people domestically. Calculated according to the globally sustainable daily carbon footprint value per capita, this saving could cover the energy consumption of 25,443 people on average. Had the online conference been realised from purely renewable energy resources, it could have covered the energy consumption of an additional 1011 residents and another 69 people in a globally sustainable way (Moran et al., 2018).

4. Conclusion

In conclusion, the carbon footprint and the share of each process of the examined conference are similar to the recently published research results. For the traditional conference, 68 % of the carbon footprint came from transportation, which falls within the range of the international literature values (50-90 %) or is almost the same as that (66 %). The results for the offline conference also correlate with the published values. Accommodation and catering account for 20 % and 9 % of the total carbon footprint. Concerning the evolution of the carbon footprint, the online version of the conference resulted in considerable environmental savings (90.57 %) when compared to the conventional version of the same event. This is close to the upper limit of the interval defined by other researches (75-90 %).

On the basis of a comparison of the carbon footprint of conference types, it is proposed that, due to the significant emissions impact of transport, in addition to the conventional conference there should be the possibility to participate in online, hybrid or external sessions. It must be to pay significant attention to sustainability, so it is recommended that the results of the research are also taken into account in the case of other conferences. In this way, further carbon footprint reductions, carbon dioxide emission avoidance and neutralization can be planned, not only in the future, but also in the present, during current and ongoing activities and events. This requires life-cycle thinking, which is a priority in achieving both external (comparative) and internal (efficiency) advantages.

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