PLEA

PLEA Conference Footprint:
Participant Travel Carbon Footprint

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Summary

The PLEA conference unites academics and practitioners of architecture and design in order to share, discuss, and expand knowledge on sustainable architecture and urban design. Due to the rising attention among society worldwide on climate change, there has been a trend of concern among the scientific community of the environmental impact of their own activities. The PLEA conference is one such institution. This study creates a baseline estimate of the carbon dioxide emissions associated with travel of participants to and from the PLEA conference. This baseline is calculated according to the conventional and most time effective travel method: flying. As such, it is a worst-case scenario as it is likely some participants already travel by alternative transport such as rail. It calculates the carbon footprint of each conference by using participant origin data of the five most recent physical conferences. It finds great variation on total emissions and emissions per person for each conference. Further, it finds some regions contribute much more of the total emissions than the number of participants they contribute, as they are far away and involve a much larger flight distant. The overall emissions of the PLEA are slightly higher than other European conferences, due to its high international character, but smaller than other international scientific mega-meetings. Based on these calculations and findings, it proposes a series of strategies that can be used to reduce travel emissions of the PLEA conference. These include: (1) putting a cap on the number of participants; (2) optimize conference location; (3) promote train/other alternative travel among in-region participants; (4) shift the conference (or a smaller regional version of it) to a vacation period and promote slow travel across all participants; (5) hold regional conferences; (6) hold virtual conferences; and (7) reduce the conference frequency. These findings can be combined to create scenarios of what the future of the PLEA conference format could look like. This is a joint report, and a two-part study. While this report focuses on estimating a travel caron footprint, a follow-up study (Consalvo, 2020) will take a closer look at specific alternative conference formats and the benefits and drawbacks associated with their implementation.

1. Introduction

The PLEA (Passive and Low Energy Architecture) conference is a almost-yearly event on sustainable architecture and urban design born in 1981 (PLEA, 2020b). It does not have a fixed location – rather, it alternates consistently between European and abroad locations at each of the conference's instances (PLEA, 2020b). It is an autonomous and non-profit association open to all who study or work in the field of architecture and the built environment and who share the sustainability views and objectives of the PLEA (PLEA, 2020a). As such, it is an interdisciplinary forum where different professionals and experts share conferences, workshops, and papers in order to promote research, practice, and education regarding sustainable design (PLEA, 2020a).

Due to the international nature of the conference and it's concern for sustainability and the environment, it is only natural that the PLEA conference should become concerned with its own carbon footprint (that is, the amount of CO2 emissions it causes). After all, participants travel from all corners of the globe to share experiences and learning about sustainable design - and while this learning is valuable and helps promote sustainability, it also causes negative environmental impact via the CO2 emissions such large scale international travel inevitably creates. This concern of the negative environmental impacts scientific conferences attempting to promote sustainability create is not isolated to the PLEA. Rather, it is an emerging concern not only for sustainability or environment related conferences (Bossdorf et al., 2009; Neugebauer et al., 2020), but also conferences of other fields, ranging from political science (Jackle, 2019) to medicine (Achakulvisut et al., 2020; Roberts and Godlee, 2007; Yakar and Kwee, 2020).

These pre-existing studies already find helpful recommendations to reducing the footprint of a scientific conference event. These include vegetarian meals (Neugebauer et al., 2020), incorporating geography into the meeting selection process (Ponette-González and Byrnes, 2011), promoting train travel instead of air travel (Neugebauer et al., 2020), alternating large international meetings with smaller regional ones (Ponette-González and Byrnes, 2011), and switching partially or entirely to an online format (Abbott, 2020).

The PLEA conference already attempts to increase regional attendance via alternating its conference locations, but as all these conferences are large international conferences, it still causes a large amount of travel emissions. Travel is the main source of environmental impact of a scientific conference, with a total footprint over five times that of the execution of the conference itself (Neugebauer et al., 2020). For this reason, in order to truly fulfill its sustainable and pro-environmental goals, the PLEA conference must examine its own carbon footprint and implement mitigation strategies to address it.

This study will calculate and examine the travel carbon footprint of recent PLEA conferences. It will do so by calculating sample footprints based on participant origin data provided by past conference organizers. Based on this information, it will explore different strategies that could be implemented to reduce the travel footprint associated with the conference. This study focuses on travel specific activities and their carbon footprint or footprint reduction potential. This is a joint report, and a two-part study. While this report focuses on creating an estimate of the travel carbon footprint, a follow up study (Consalvo, 2020) will take a closer look at specific alternative conference formats and the benefits and drawbacks associated with their implementation.

2. Methodology

The following section outlines the methodology used to calculate the reference footprint for each participant and its underlying assumptions.

2.1 Participant data

The first step of the methodology involved obtaining participant number and origin data. For this, the 5 most recent conferences were selected for three reasons. First, data availability: each PLEA conference has a different organizing committee, so there is no central participant data bank. The organizing committee of the most recent conferences is more likely to be involved with the conference or in touch with its current board, as well as most likely to still have data than the organizing board of a conference that occurred 20 years ago. Secondly, more recent PLEA conferences are inherently more representative of the current pool of PLEA attendees than those of the 1980s, when the PLEA had just begun. Lastly, as the conferences alternate between Europe and abroad, selecting the last few conferences (rather than just 1) ensured a more representative and broad view of the PLEA conference participation.

The conferences selected include:

- 2018 Hong Kong
- 2017 Edinburgh
- 2016 Los Angeles
- 2015 Bologna
- 2016 Ahmedabad

Data was obtained by contacting the chairs of the organizing committee of each conference, respectively. As the data was provided slightly differently for each conference, these files were translated into a summary of the number of participants per country of origin for each conference. Next, each country of origin was assigned a region (Appendix 1), based on which the participants of each conference were divided by region of origin. Islands counted as separate locations of origin than the country they are part of, to account for the fact that these might be located in different regions than the country they are part of. Reunion, for example, is a French territory, but is located in the Africa region.

2.2 Carbon footprint calculation

After obtaining the participant data, the next step in the methodology was the base carbon footprint calculation. For this, a few assumptions had to be made in order to ensure the calculation method was systematic and consistent. The conference requires working professionals and students to travel, so the first assumption is that the participants will choose the fastest route to the conference, which in most cases will include flying, and in all cases means cars (as confirmed by the methodology steps listed below). The flight and car combo makes the calculation a worst-case scenario, where all participants take the most conventional and highest emitting forms of transform – this was done for consistency and to remove guesswork (as participant travel data was not collected by conference organizers). Some participants likely already travel by train – this point will be reviewed in the discussion.

The second assumption is that the starting point of each participant's trip is the capital city of their country of origin (listed in Appendix 1). As city of origin data was not available, this assumption was necessary to avoid the selection of arbitrary start points that may advantage some participants or location over the others. The specific location within the capital city corresponded to the central location determined by google maps (that is, where the capital city pin fell within the city). This start point assumption was held consistent for all locations of origin, including the country of the conference itself (see Appendix 1). The arrival location was set at the conference venue – and in cases that multiple venues were in use, the venue listed for the first event of the first day was selected.

Travel during the conferences themselves (between locations) was not included, as it is dependent on where the participants were accommodated and the schedule of each individual conference, making it subject to guesswork and small complexities while at the same time being minor in value compared to the travel to and from the conference. Thar is, travel within the city is small distance but also more likely to happen with other forms of transportation (such as trams, walking, bus, etc.) dependent on the location.

The round-trip journey carbon footprint calculation involved the steps listed below. This held true for all start and end points, including the countries where the conferences were being held.

1. Flight route designation via Google Flights (Google, 2020).

The start city was set as capital city of country of origin, end location as conference city. Date set for January 1, 2020 for all flights. The flight selected was the first flight with least connections in the “best departing” flight selection (3-5 flights selected as most convenient and price effective by the website). This means that the first flight in the list was selected, unless a flight lower in the best departing list had fewer connections (as fewer connections meant a shorter/faster travel route, and was thus most consistent with the base assumptions). This was repeated for every country of origin for each of the five conferences (Appendix 3).

A few small assumptions had to be made for select travel paths. Palestinian travel was assumed to go via Jordan. Venezuelan travel to Los Angeles was assumed to go via Panama (PTY), as it is a common connection for countries in that region and it is not possible to calculate direct Venezuela to United States given current political conditions. Lastly, Liechtenstein travel was assumed to go via Zurich, as Liechtenstein does not have an airport.

2. Flight CO_2 footprint designation.

This was done using the carbon footprint calculator of the International Civil Aviation Organization (ICAO), a United Nations Organization (ICAO, 2016). Start and arrival airports input selected based on the flight paths resulting from Step 1 (Appendix 3). The calculator accounts for a calculation accounting for a greater number of variables than flight distance and fuel burn/CO2 emission per unit of distance. Rather, it included aircraft type typically associated with the specified route, passenger load, cargo load (where freight and mail cargo emissions were removed from passenger emissions), and cabin class (full equations and details at ICAO, 2018). Besides the start and arrival airport data, the remaining input categories were kept constant for all calculations: all journeys were set as roundtrip, second class, and for 1 passenger.

In the (rare) cases where data was not available for round trip calculation, the one-way calculation was made instead and multiplied by 2. Only one airport was found to be unavailable, the German BER. In flight paths requiring this airport (see Appendix 3), it was substituted by SXF airport, which is also in Berlin and therefore would only have minor differences in terms of effect on the overall footprint.

3. Center to departing airport and arrival airport to venue commute.

This was calculated using NTMCalc Basic 4.0, the free version of the environmental performance calculator of the Network for Transport Measures (NTM, 2020). The calculator takes the best path between two locations as given by google maps and calculates the carbon dioxide released according to vehicle type, number of passengers, and other vehicle specifications. The vehicle specifications were left to default, while the vehicle set to car and the passenger number set to 2. This was done in order to include the presence of a driver in the calculation. The total carbon dioxide given by this calculation was then doubled, in order to give the round-trip value of CO2 emissions. As stated at the start of this methodology section (2.2), car travel was selected over train or other travel modes as it is the quickest form of travel (which was confirmed by this step).

4. Roundtrip total footprint summation.

The car commute and flight results from the two previous steps were summed up in order to create the total (round)trip footprint of a passenger coming from that country of origin. This was done for all countries of origin for each conference.

5. Total and regional conference footprint calculation.

The per passenger round trip footprint of each country of origin given by step 4 was multiplied by the number of participants coming from that respective location. The resulting country footprint of each country of origin was then summed together in order to create a regional total and an overall total carbon footprint for that conference.

6. Conference footprint per person.

The total conference footprint given in step 5 was divided by the total number of participants in the conference in order to determine the conference footprint per person. This controlled the results so that the number of participants was not the main influencing variable, allowing better scrutiny of the emission intensity of participant travel per conference

3. Results & Analysis

The following section details the results obtained from the participant (3.1) and carbon footprint (3.2) analyses, respectively, given by the procedure listed in the methodology (section 2).

3.1 Participant Analysis

There is a wide variety in the total attendance of each conference, ranging from just under 300 in the 2015 Bologna conference to nearly 1000 in the 2014 Ahmedabad conference (full list of number attendees from each origin country for each conference available in Appendix 2). For this reason, the total number of participants per region was converted into percentages for easy comparison, as shown in Table 1. The region with the greatest proportion of participants is always the region in which the conference is held. The region with the lowest proportion is always Africa or South America.

Table 1. *Total number of participants and percentage of participants originating from each region for each conference. Grey square represents highest percentage in each column.*

	2018 Hong Kong	**2017 Edinburgh**	**2016 Los Angeles**	**2015 Bologna**	**2014 Ahmedabad**
Africa	0.7%	1.8%	4.1%	2.1%	5.1%
Asia	44.6%	19.9%	15.5%	18.9%	44.9%
Europe	34.5%	54.2%	30.2%	61.9%	26.9%
North America	10.1%	11.2%	39.3%	6.2%	10.4%
Oceania	4.2%	2.8%	2.1%	1.4%	3.0%
South America	5.9%	10.2%	8.8%	9.6%	9.7%
Total (100%)	307	725	341	291	973

Figure 1, however, shows that while most represented, the home region does not always constitute a majority (that is, over 50%) of participants. The proportion of participants coming from within the conference region ranges from 39.3 to 61.9%. The proportion of participants coming from outside the conference region ranges from 38.1 to 60.7%.

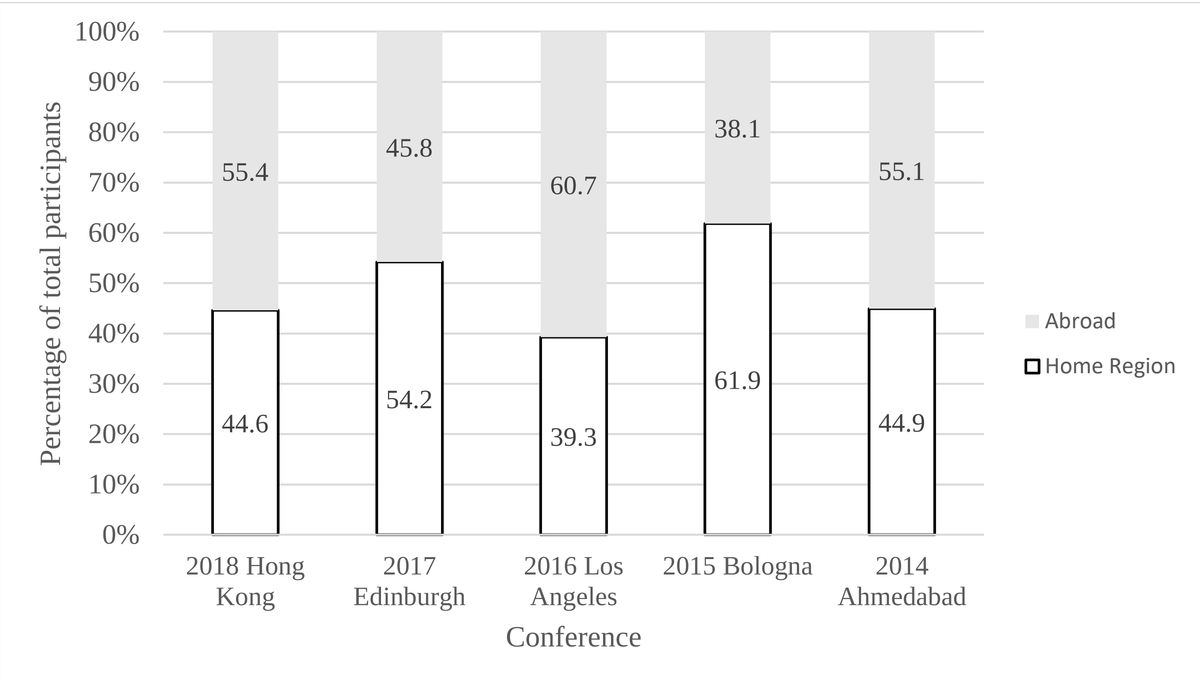

Figure 1. *Proportion of participants coming from the conference's own region (white) versus proportion of participants travelling from abroad (grey).*

3.1 Carbon Footprint Analysis

Similar to the total attendance of each conference, the total footprint also varies widely. Table 1 shows that the total roundtrip participant travel footprint ranges from 158 thousand kg CO_2 in the least attended Bologna conference to 855 thousand kg CO_2 in the most attended Ahmedabad conference. The roundtrip footprint per person varies between 544.5 kg CO_2 in Bologna and 965.6 kg CO_2 in Ahmedabad.

From the numbers given in Table 2, we can determine **the average PLEA conference** total footprint is 402 thousand kg CO_2, while **the average footprint per participant** is 750 kg CO_2. The greater part of this footprint (over 95%) is comprised of flight travel, rather than the car transport required to reach the airports in either direction (Appendix 4-6).

Table 2. *Round trip travel footprint (kg CO_2) per conference, total (all participants) and average contribution per participant.*

	2018 Hong Kong	**2017 Edinburgh**	**2016 Los Angeles**	**2015 Bologna**	**2014 Ahmedabad**
Total	233,311.2	435,357.0	329,272.8	158,445.5	855,510.7
Per Peron	760.0	600.5	965.6	544.5	879.3

Table 3 shows how the relative amount of CO_2 participants from each region contributed to each conference's total footprint. The greatest proportion is always represented by Europe for abroad conferences and Asia for European conferences. The lowest contribution percentage is always either Africa or South America.

Table 3. *Percentage of footprint contributed by participants from each region per conference. Grey square represents highest percentage in each column.*

	2018 Hong Kong	**2017 Edinburgh**	**2016 Los Angeles**	**2015 Bologna**	**2014 Ahmedabad**
Africa	1.1%	2.1%	7.1%	3.1%	4.9%
Asia	21.5%	32.9%	22.4%	31.5%	22.6%
Europe	42.1%	19.5%	33.9%	26.0%	27.3%
North America	14.1%	14.6%	24.1%	12.7%	16.0%
Oceania	4.5%	10.5%	3.1%	5.6%	4.1%
South America	16.8%	20.6%	9.4%	21.1%	25.2%

Figure 2 (below) demonstrates that the home region of the conference constitutes approximately $1/5^{th}$ to $1/4^{th}$ of each conference's total footprint, always contributing a significant amount to the conference footprint. The majority of the footprint is contributed by attendees from outside the region (Figure 2). The largest home region footprint is that of the Bologna 2015 conference, while the smallest from the Edinburgh 2017 conference. However, the difference between the amount the home region footprint contributes to the total conference region footprint is not excessively large or particularly informative, given the flight assumption behind the calculation (will be further addressed in the Discussion section). Rather than small differences between conferences, figure 2 is most important in its showing the proportion of the total footprint constituted by the home region travel (as mentioned in the first line of this paragraph).

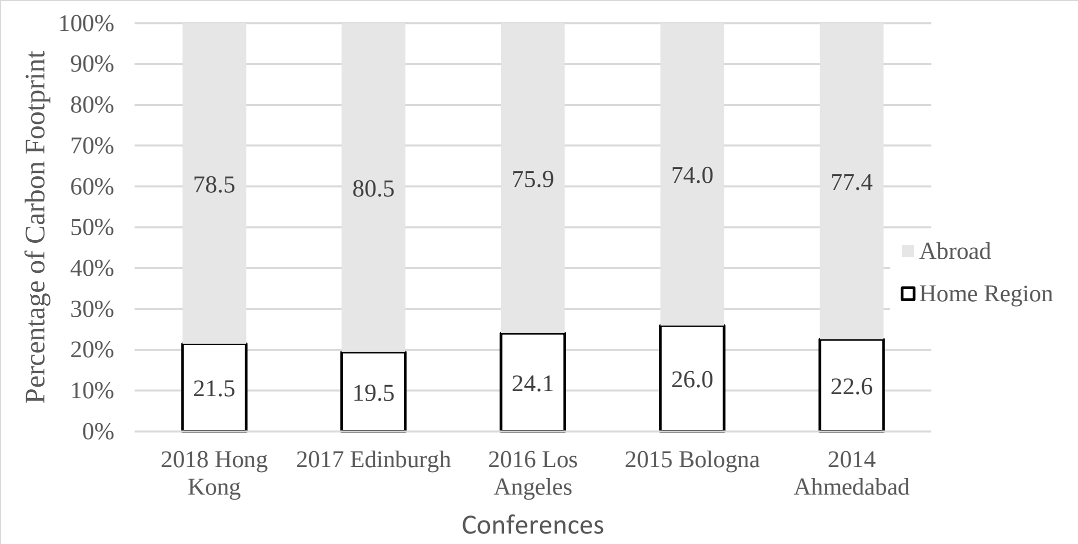

Figure 2. *Proportion of footprint resulting from participant travel from within the conference's own region (white) versus from participants travelling from abroad (grey).*

Finally, the mismatch between the proportion of participants from each region and the proportion of the total carbon footprint resulting from travel from each region is fully illustrated for all conferences in Figure 3. This figure illustrates the distribution of the percentage participant and footprint per region for all five conferences in a box and whisker chart. This allows us to see a regional profile for the participants and footprint contribution of each conference. For instance, Europe contributes between 19.5 and 42.1 of the footprint while representing between 26.9 and 61.9 of participants (exact numbers taken from Tables 1 and 3). Meanwhile, South America gives between 9.4 and 25.2% of the footprint with just 5.9 to 10.2% of participants.

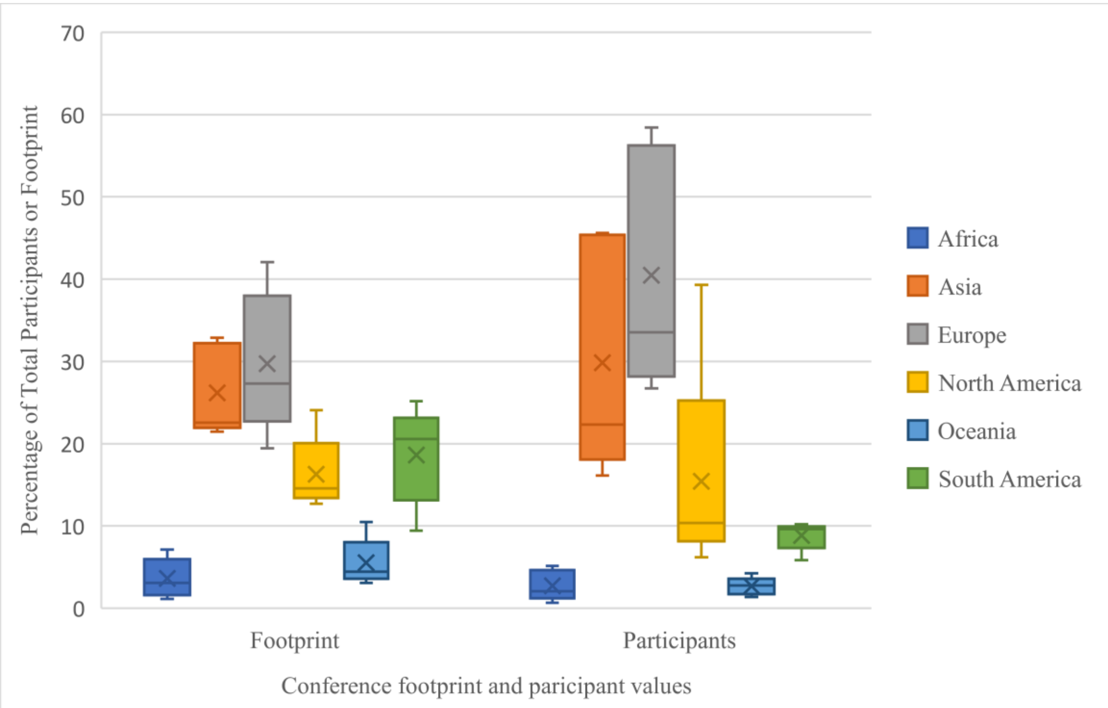

Figure 3. *Box and whisker chart showing the difference between the percentage each region contributes to the total participants and total footprint across all five examined conferences. As in other such plots, the top and bottom whiskers represent maximum and minimum, x represents the mean, the line in the center the median, and the box edges the first and third quartiles.*

4. Development of Carbon Reduction Strategies

Based on the previous results, a number of carbon reduction strategies can be developed to lower the carbon footprint of the conference. These are divided into two categories: strategies that would allow for the conference to maintain its current frequency and format, and strategies that would require such a change. It is important to note that while these **strategies** are noted separately, they do not need to be applied in isolation. Rather, two or more of the strategies can be combined in order to create different emission reduction plans for the PLEA conference, creating different potential **scenarios** for the future of PLEA conference organization. These scenarios will be explored in a subsequent report (Consalvo, 2020), considering the strengths and weaknesses of difference conference features and formats.

4.1 No change to conference format

Strategy 1: Cap on participant number [Medium impact]

The title of this strategy is self-explanatory. The easiest way to contain the conference's footprint without changing how it is organized or carried out is to limit the number of participants who will attend it. For instance, as shown in Table 1, at 291 participants the Bologna 2015 conference had 29.9% the number of attendees of the Ahmedabad 2014 conference– and at the same time, only 18.5% of the latter's footprint (Table 2). While the number of participants alone does not determine the footprint (the data clearly shows the region of origin of the participants plays and important part as well), limiting the amount of people travelling to the conference undeniably reduces the travel footprint associated with it. If the PLEA only accepted circa 300 participants per conference (as was the case in 3/5 conferences examined, see Table 1) rather than letting the number rise to 700 or 900 participants, the average PLEA conference total footprint would significantly lower. In order to illustrate, the average footprint of the five conferences is 402 thousand kg CO_2, while the average footprint of the conferences with approximately 300 participants is nearly half of that value, at 240 thousand kg CO_2. The impact of this measure varies on the situation, being most impactful in cases with most potential participants and less impactful in cases when there are less participants or the conference organizers do not want to shrink the attendee list. This is why this strategy has been classed as medium impact. This would be an easy strategy to apply in practice, but would also mean a smaller PLEA network and the resources and knowledge that would have been contributed by those missing participants. It could mean a slight reduction in the PLEA's international character, but this is not necessarily the case, as Table 1 and Figure 1 show that a smaller number of participants does not necessarily make a conference less diverse.

Strategy 2: Optimize conference location [Low impact]

Another possible strategy is selecting the optimum location depending on the provenance of the participants, so it is located at a location that presents least overall travel necessity. One sample tool which can make such a selection simple is ICAO's Green Meetings Calculator (ICAO, 2020). This tool suggests the least impactful conference location (in terms of flight emissions) depending on how many participants are coming from each location. However, the tool is not suited to such a large-scale international conference and easily crashes after 30 locations are input. Further, it also does not reduce the conference footprint as much as other suggested measures, for which reason it is marked as low impact. Moreover, it is realistically impractical, as conference location is a determining factor in attendance for participants, as the distance also determines feasibility and trip cost. Therefore, even if participants agree to a random location, it is not surprising they may drop out if such location is too inconvenient. It is also important to note that conference organization is a month, if not year, long process which involves not only securing a location, but funding, events, papers, among other factors, for which reason this could be impractical for conference organizers. However, this strategy points us towards rethinking how conferences are reorganized entirely, rather than just its travel or other such high environmental impact activities symptom of the current methods. This is a useful concept or mindset to carry on in the attempts to innovate scientific conferences and give them a more sustainable and carbon free future, despite the impracticality of this strategy itself in the current context. An easier, simpler version of this strategy is to put conferences in regions that are highly accessible by rail or other alternative travel methods, which can be combined with Strategy 3 to promote alternative travel.

Strategy 3: Promote regional train or bus travel [Medium impact]

Flying is the most emission intensive form of travel. While a short haul flight emits circa 156 g of CO_2 per km, a bus emits 105 g (67.3%), and national rail travel only 41 g (26.3%) (Ritchie, 2020). The rail number is even lower in Europe, as a Eurostar train only emits 6 g of CO_2 per km (3.8%) (Ritchie, 2020). Even travelling by car could be more convenient, with a 2-person car ride emitting 96g (61.5%) (Ritchie, 2020). With this data, we could roughly estimate how much regional emission could be decreased if flying was swapped for alternative methods of transportation (Figure 4). These were calculated simply, by multiplying the home region footprint percentage of Figure 2 to the percentage of emissions each travel mode releases in comparison to flying (listed here). For instance, Home region travel represented 22.6% of emissions in the Ahmedabad conference. Since a bus emits 67.3% of the emissions of a short haul flight, we calculated potential bus travel emission to be 67.3% of the original home region emissions, giving a final value of 15.2%. This means bus travel could reduce home region emissions from 22.6% of the total to 15.2% of the total. The same simple calculation was done for the other home region emission for all modes of travel discussed here, and the results can be seen all together in the figure below. The only exception were train emissions for Europe, which were calculated with the lower Eurostar value. This is a very rough estimate intended only to illustrate the potential of this strategy, which is why it is not included in the report's main methodology and results. It does not account for number of flights, which means more emission intensive take-offs. Further, the national rail value is based on UK data (Ritchie, 2020).

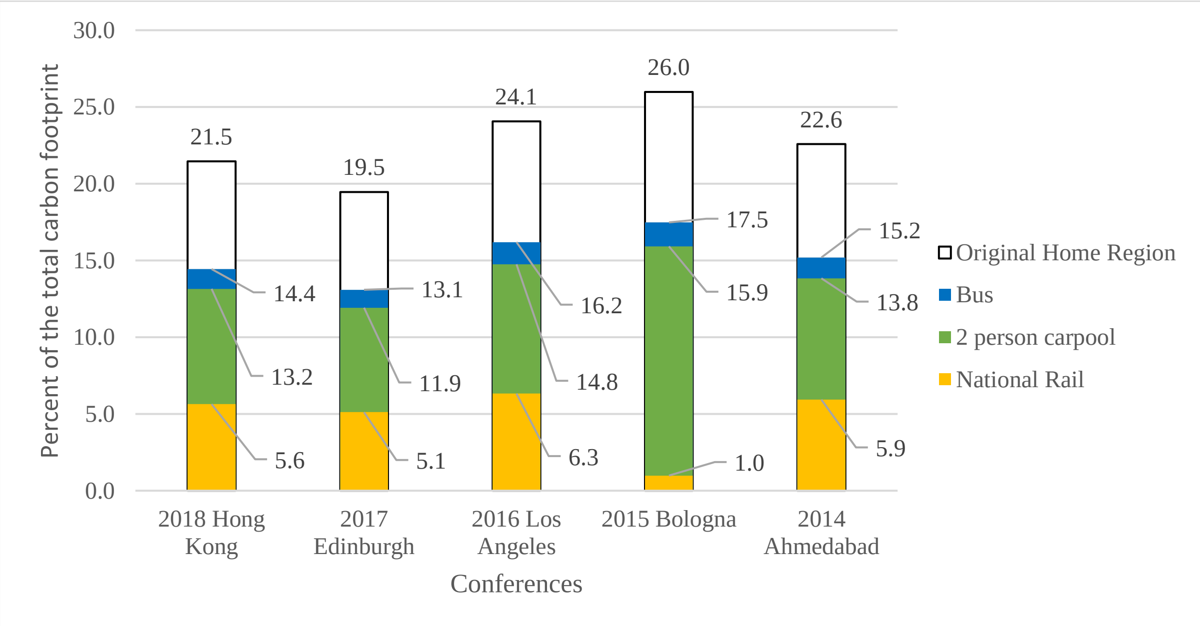

Figure 4. *Comparison of percentage of home emissions (flight) out of the total footprint versus the potential new percentage of relative home region emissions if home region travel was done entirely by bus, rail, and two-person car trip.*

This strategy can be more or less effective depending on the type of alternative travel selected and the number of participants that actually use those alternative methods. Therefore, it is limited to the original home region percentage – that is, it will never cancel out the home regions completely as there will always be home region participants, and these local participants must travel somehow. For these reasons it has been classed as medium impact. It is likely more than simply asking participants would be required to promote alternative travel methods, as these are time intensive and often more expensive than small flights.

Further, successfully changing participant's main travel mode to be rail or other such alternative slow travels may require shifting conference locations to only regions with high rail (or other alternative travel type) accessibility, so that it is actually easy and convenient for participants to make such a switch. In this way, this strategy would require some location optimization similar to that suggested in strategy 2, although to a much smaller and less radical degree. Many more participants would be willing to travel by train if they can easily reach and conveniently use a rail system, than if the conference is set in a country with few or disconnected railways. It would be unreasonable to expect participants to switch where there is insufficient railways, where they must take many connections, or where the travel time would take excessively long when compared to conventional (flight) methods.

Strategy 4: Set conference in vacation months and promote slow travel for all [Medium impact]

As an extension of the previous strategy, "slow travel" (that is, not flying) could be promoted across all participants rather than just local ones. This would require the conference date to be switched for conventional vacation months as per academic or national work calendars, as slow travel would require much more time for out of region participants. Further, it would require additional incentive, as further away participants will be less likely to want to attempt slow travel due to price, time intensiveness, and other such difficulties. It is important to keep in mind that these vacation months and associated practices would vary between countries and regions. For instance, some countries may not keep their academic institutions open during the vacation period, and others may have a practice of leaving the country entirely for vacation, or simply to not work due to unsuitable weather or climate conditions. Therefore, there are some impracticalities and caveats associated with selecting such a strategy. As such, it would likely be more effective in combination with other strategies, such as strategy 5, where such vacation month conference can take place in a smaller regional scale. In this manner, it would be less complicated to plan such alternative conference dates and match them across conference participants while at the same time finding a suitable location.

4.2 Change conference format

Strategy 5: Regional conferences [Medium-High impact]

One potential method to reduce overall average emissions would be to alternate international conferences with regional ones. In this manner, the footprint of that conference would be reduced. This would mean a significant reduction, although this would not necessarily cut emissions down to the home region footprint percentages as per Figure 2 – this is because while all participants will be for the home region, the regional character of the conference is likely to attract a greater number of participants from that region. Therefore, this strategy could be of high overall impact in reducing average PLEA emissions, but it depends on the number of participants that then attend, which is why it has been marked as medium-high impact. The major drawback of this strategy is that it would reduce the international character of the PLEA conference, which is why it is only suggested for alternate years rather than for all PLEA conferences or events.

Strategy 6: Online conference [High impact]

The last strategy would be to hold the conference online on selected alternate years, be this of regional or international character. This is high impact, as it completely cancels out travel for that year's conference and can drastically lower the average total conference footprint. For instance, an online conference every other year would mean a 50% reduction in the overall footprint, simply because of that cancelling out of the second year's footprint. If held every three years, a 33% reduction, and so on.

While it does depend on the frequency with which online conferences are adopted, they do have a full travel emission cut potential, which is why it has been marked as high impact. Of course, this does not imply online conferences would have no emissions. However, they would have no travel emissions, which is what this report is concerned with. It would not be relevant to compare the emissions of the digital conference (including energy use, internet use, and other such sources of emissions) to the worst case scenario travel emissions in this report for the simple reason that this report deals with travel emissions alone. Rather, such a comparison would be more useful if done against the on-site emissions (energy use, food, in-conference travel, among other sources). As travel to an online conference is not necessary, online conferences are simply accounted for as zero carbon emissions for the purpose of this travel-emission related report. If the PLEA conference was always online, it would cut 100% of participant travel to and from the conference, regardless of the emissions associated with computer use and other such online emission sources.

Strategy 7: Reduce conference frequency [High impact]

This last strategy is in line with strategy 6, with the exception that instead of having a virtual conference on alternate years, the conference simply not be held at all in those years, thus reducing its frequency. It is the simplest high impact conference format changing strategy.

4.3 Combine strategies into novel scenarios

As already indicated through the section, many of these strategies can be most effective when applied in combination with each other. For instance, combining the promotion of train travel to optimizing conference location, or combining promoting slow travel in vacation months with regional conferences. Combining such strategies not only makes them more effective but can facilitate their carrying out and allow the PLEA missions and values to be preserved. Strategies may be also alternated, in order to allow for PLEA's networking and international idea sharing component. These future strategy-combining and alternating plans for the PLEA are the **scenarios** for the future format(s) of the conference.

Potential future scenarios for the conference have been analyzed in detail in a subsequent report (Consalvo, 2020) which accounts for their strengths and weaknesses, and the advantages and disadvantages of selecting them for the future of the conference. These are of course not an extensive list of all the possible scenarios for the future of the PLEA conference format, but a promising selection developed by considering the research of this report and the available literature on alternative conference formats. While they will not be discussed at length in this report, they will be outlined for reference below (Table 4). Just as this is not an extensive list of potential future scenarios, the strategies included in them is not defined – they could be altered to include different combinations of strategies as best suited for the PLEA organization, both regarding its values and missions and the practical aspects of organizing the conference.

While it was possible to estimate the potential impact of the strategies listed above, the same projected impact cannot be made for all the scenarios, given their combination of strategies and the many open factors that remain to be decided by the PLEA board. It is possible to infer the emission reduction potential of Scenario 3 – a virtual conference would cut all travel emissions, therefore the entire set of emissions given by this calculation study (100%). In order to calculate the emission reduction potential of conference's total emissions, it would be necessary to find such a total emission estimate. For this, it would be necessary to supplement this report's travel calculation with an estimate of on site (non-travel) emissions of a conference. Further, it would be relevant to calculate the streaming/digital emissions associated with a physical conference compared to those emissions associated with a virtual conference, where all participants will be on the screen at the same time. The total emission reduction potential for the entire conference emissions would then be dependent on the number of conference participants. This last point is the same reason why it is not possible to give a relevant estimate for Scenario 1 or 2 in total emission reduction potential or only travel emission reduction potential, as the first would depend on the number, frequency and size of regional events, and the second would depend on the number of participants streaming and the number and size of networking events on the last day.

Table 4: *Summary of 3 potential future scenarios for the PLEA conference's future format (as per Consalvo, 2020), including their name, a brief description, and included strategies of emission reduction included in their development and full length explanation*

Scenario Name	Brief Description	Included Strategies
Scenario 1: **Think Global, Act Local**	Alternating the large-scale international conferences (once every three years) with small-scale regional ones (in the two in between years)	• Strategy 2: Optimize conference location • Strategy 5: Regional conferences
Scenario 2: **At Last, A Quick On-site Meeting**	Virtual conference with one full day of in-person networking at the end	• Strategy 1: Cap on participant location • Strategy 2: Optimize conference location • Strategy 3: Promote regional train or bus travel • Strategy 6: Online conference • Strategy 7: • Reduce conference frequency
Scenario 3: **Virtual Sight, Virtual Mind**	Completely virtual format with different events and interactive activities	• Strategy 1: Cap on participant location • Strategy 7: Reduce conference frequency

5. Discussion

The first part of this study involved using participant data in order to create a sample travel carbon footprint calculation for the plea conference. This was done for the five of the most recent conferences, from Ahmedabad 2014 to Hong Kong 2018. Once an estimate for the carbon footprint of each conference was reached, an average conference total and per person footprint was calculated. The average total conference footprint *when all participants are travelling by plane* is approximately 402 t CO_2, and the average footprint per participant is 0.75 t CO_2. This value is slightly higher when compared to other Europe-based conferences, likely because it has a greater international character which implies both more participants coming from further locations and a smaller proportion of participants coming from in region (Desiere, 2015; Neugebauer et al., 2020). On the other hand, it is much lower than larger international mega-meetings, which can involve thousands of participants (Ponette-González and Byrnes, 2011). Therefore, its footprint is slightly large for a conference its size, but not disproportionately so in the contexts of scientific conferences. Examining the participant and footprint profile of each PLEA conference indicates that there are a few factors which are most impactful in shaping its travel footprint: participant number, participant origin, and travel mode.

Based on this examination and analysis, it was possible to create a number of strategies were devised targeting these three factors. These strategies are in line with what has already been recommended by previous studies (Abbott, 2020; Desiere, 2015; Neugebauer et al., 2020; Ponette-González and Byrnes, 2011), and include 3 main categories: strategies to lower participant number, strategies to promote alternative travel, and strategies that change conference format. These are not independent, and the strategies mentioned may overlap across them. The highest potential impact strategies are also in accordance with the literature, namely shifting to having smaller regional conferences in alternate years or reducing its physical frequency – be this alternating to online or not holding it as often (Desiere, 2015; Ponette-González and Byrnes, 2011). It is important to notice that this does not mean strategy 5 or 6 are simply the answer for the future of the PLEA conference – each conference has a different mission and character, and it may be necessary to combine different strategies in order to find which strategy/combination of strategies will most fit with the PLEA mission and goals. Two strategies found in the literature were not included: not including international participants, as this conflicts with the PLEA international character and can also be accomplished via regional meetings, and carbon offsets, which imply business as usual and is therefore not fully in line with the PLEA sustainability values (Ponette-González and Byrnes, 2011). Carbon offsets could be embedded into one of the strategies, however, or complement whichever path the PLEA choses – it is only as a standalone strategy that it conflicts with the idea of learning about and promoting sustainable change.

It is important to note that this study has some limitations. As participants were not surveyed during each conference, assumptions had to be made about their start location and travel modes. The start location was set as the city capital for consistency, which for some countries could add or take away from the footprint depending on the location of the capital relative to the closest international airport. In multiple conference instances, for example, Brazilians had to be allocated an extra short flight in order to reach the international airport from the capital. Given the subsequent flight was always a long one, this was not immensely impactful of the final calculation, but could mean some larger countries had potentially slightly larger footprint journeys than what was perhaps the case in real life. It is possible, for example, that Indians or Brazilians do not always fly within their territory and take trains or cars for many-hour road trips more easily than Europeans would over the same distance (travelling across Brazil or India would be equivalent to travelling across many European countries). However, this would mean assumptions on countries that the authors are not necessarily familiar with, and therefore the capital city consistency was the best choice given the lack of actual start point information. The case in which this situation is most limiting is for participants coming from the country where the conference is held, whish is where participants would be most likely to select alternative transportation methods. As flying within country remained both possible and the quickest form of travel, however, the consistency of the calculation was not changed for the home location. The only case where this was an issue was for the Hong Kong participants going to the Hong Kong conference. The emissions of these participants in particular was likely slightly over estimated, as while no flight was calculated, the distance to and from the airport were still included given the systematic nature of the calculation. However, as this extra travel emissions represented less than 0.5% of the total emissions for that conference, the overall calculations were not particularly affected.

Further, the choice of flight as default transportation mode can also be seen as a limitation, as it limits accuracy especially for conferences in region with high quality of transportation infrastructure. While the flight choice does limit accuracy, it prevents inconsistent assumptions in the same way the capital city choice does. Further, having the flight as a baseline calculation is not necessarily a weakness – in a case of data uncertainty, it provides a worst-case scenario. While it is not possible to go back and ascertain the travel modes taken by each participant, it is unlikely that the conference travel footprint could be any higher than what has been calculated here. This is particularly the case with home region footprints, as participants coming from the country or region where the conference will be held are much more likely to take alternative forms of travel simply due to the fact that they are closer. This is why the difference between home region footprint between the conferences is not particularly informative as calculated in this report (Figure 2). Rather, they would be much more interesting if based on the actual travel chosen by participants, as they might find more interesting differences, with some regions having more or less travel due to the quality of the infrastructure or the tendency of participants to choose alternative travel modes.

Lastly, another limitation is that the strategies proposed that change the conference format presume no rebound effect on participant number. That is, they presume that even though some conferences are held regionally, online, or not at all in alternate years, this will not result in an increase in the participant turnout when the international conference is held. This is an acceptable assumption for the regional and online alternatives, as the information and opportunity is still being provided, but is likely a riskier assumption in the case that the conference is simply not held at all on occasional years.

6. Conclusion

The PLEA conference attracts many participants from all over the globe, and this international character is why it has a relatively large travel carbon footprint. Particularly, this study shows that in its current format, with its highly international character, and presuming typical international travel modes (i.e., flights), the PLEA conference can have a higher footprint than European conferences of comparable size. However, this flight-travel calculation scenario is also a worst case scenario, as there is much room to reduce the footprint and there are many potential strategies that can be used to construct a greener future for the PLEA conference. Between non-conference format interfering strategies, such as controlling participant number or promoting slow travel, and higher impact conference format changing strategies, such as including regional or online alternatives, there is potential to make significant reductions in the current PLEA conference footprint. With combinations of these strategies, new PLEA conference future scenarios can be developed. These new scenarios will diverge in their proposed format and their benefits and drawbacks, but they will all contribute to a reduction of the travel carbon footprint and an increase in the sustainability of the PLEA conference.

7. Recommendations for future research

This research was done in a systematic way in order to create estimates of the PLEA emissions and based on these create some suggestions for its future. However, as discussed in the discussion, it was not a perfectly precise method. In order to create a better picture of how the PLEA travel emissions look like and how much can be reduced by promoting alternative travel, it would be useful for the PLEA board to administer a survey to participants of future editions, so that they may know where these participants came from and what modes of transportation they used for which parts of their journey. This would create a more detailed calculation of the PLEA conference participant emissions.

Further research can also focus on the outcomes of the conference, and survey participants of the 2020 Spain conference, held online, and see if the participants are satisfied with the learning, activities, networking, and other features of this alternative format. These outcomes can be analyzed in order to inform a suitable choice between the alternative future scenarios for the PLEA conference, or to see where these might have to be edited or fine tuned to better meet the PLEA missions and the participant expectations. It would be particularly interesting to compare such a survey with an equivalent survey of a regular on site international PLEA conference, if such conference is held again in the future.

Finally, it may also be interesting to compare on-site emissions produced by the organizing and carrying out of the conference itself and compare these to the footprint potentially associated to a digital conference, therefore looking beyond travel. This would be particularly relevant if the PLEA conference board opts for an online format, as such a format would mean travel would no longer be the main source of conference emissions.

These are only some potential future avenues of exploration the PLEA can take in order to learn more about the conference emissions and the effectiveness of alternative formats, as well as to learn about how to optimize these alternative future formats. Whichever format the conference takes on for the future, there are always potential avenues of research available to better inform or optimize the format or related emissions of the PLEA conference.

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Appendices

Appendix 1. List of all named countries of origins in all 5 PLEA conference data, and their respective capital cities and assigned regions

Country	Capital (Start Point)	Assigned Region
Algeria	Algiers	AFRICA
Argentina	Buenos Aires	SOUTH AMERICA
Australia	Canberra	OCEANIA
Austria	Vienna	EUROPE
Bangladesh	Dhaka	ASIA
Belgium	Brussels	EUROPE
Bosnia and Herzegovina	Sarajevo	EUROPE
Brazil	Brasilia	SOUTH AMERICA
Cambodia	Phnom Penh	ASIA
Canada	Ottawa	NORTH AMERICA
Chile	Santiago	SOUTH AMERICA
China	Beijing	ASIA
Colombia	Bogota	SOUTH AMERICA
Costa Rica	San Jose	NORTH AMERICA
Cuba	Havana	NORTH AMERICA
Croatia	Zagreb	EUROPE
Cyprus	Nicosia	EUROPE
Czech Republic	Prague	EUROPE
Denmark	Copenhagen	EUROPE
Ecuador	Quito	SOUTH AMERICA
Egypt	Cairo	AFRICA
Finland	Helsinki	EUROPE
France	Paris	EUROPE
Germany	Berlin	EUROPE
Greece	Athens	EUROPE
Hong Kong	City of Victoria	ASIA
Hungary	Budapest	EUROPE
India	New Delhi	ASIA
Indonesia	Jakarta	ASIA
Iran	Tehran	ASIA
Ireland	Dublin	EUROPE
Israel	Jerusalem	ASIA
Italy	Rome	EUROPE
Japan	Tokyo	ASIA
Jordan	Amman	ASIA
Kenya	Nairobi	AFRICA
Kuwait	Kuwait City	ASIA
Lebanon	Beirut	ASIA
Liechtenstein	Vaduz	EUROPE
Malaysia	Kuala Lumpur	ASIA
Malta	Valletta	EUROPE
Mexico	Mexico City	NORTH AMERICA
Mongolia	Ulaanbaatar	ASIA
Netherlands	Amsterdam	EUROPE
New Zealand	Wellington	OCEANIA
Nigeria	Abuja	AFRICA
Norway	Oslo	EUROPE

Oman	Muscat	ASIA
Palestine	East Jerusalem	ASIA
Pakistan	Islamabad	ASIA
Paraguay	Asuncion	SOUTH AMERICA
Peru	Lima	SOUTH AMERICA
Philippines	Manila	ASIA
Poland	Warsaw	EUROPE
Portugal	Lisbon	EUROPE
Reunion (FR)	Saint-Denis	AFRICA
Romania	Bucharest	EUROPE
Russia	Moscow	ASIA
Saudi Arabia	Riyadh	ASIA
Serbia	Belgrade	EUROPE
Singapore	Singapore	ASIA
Slovenia	Ljubljana	EUROPE
South Africa	Cape Town	AFRICA
South Korea	Seoul	ASIA
Spain	Madrid	EUROPE
Sri Lanka	Sri Jayawardenepura Kotte	ASIA
Sweden	Stockholm	EUROPE
Switzerland	Bern	EUROPE
Taiwan	Taipei	ASIA
Thailand	Bangkok	ASIA
Tunisia	Tunis	AFRICA
Turkey	Ankara	ASIA
Uganda	Kampala	AFRICA
Ukraine	Kyiv	EUROPE
United Arab Emirates	Abu Dhabi	ASIA
United Kingdom	London	EUROPE
United States of America	Lisbon	NORTH AMERICA
Uruguay	Saint-Denis	SOUTH AMERICA
Venezuela	Bucharest	SOUTH AMERICA
Vietnam	Moscow	ASIA

Appendix 2. Number of participants per region for all 5 PLEA conferences, total count per conference included

Country	2018 Hong Kong	2017 Edinburgh	2016 Los Angeles	2015 Bologna	2014 Ahmedabad
Algeria	0	1	4	0	19
Argentina	2	0	1	2	5
Australia	9	13	6	3	25
Austria	1	1	0	0	5
Bangladesh	0	2	6	1	21
Belgium	1	9	7	9	16
Bosnia and Herzegovina	0	0	0	0	1
Brazil	9	52	14	13	60
Cambodia	1	0	0	0	0
Canada	0	8	5	2	9
Chile	3	14	7	11	12
China	31	20	9	9	24
Colombia	0	5	5	0	12
Costa Rica	2	0	0	0	0
Cuba	0	1	1	0	0
Croatia	2	4	0	0	0
Cyprus	0	0	0	2	3
Czech Republic	0	2	0	0	0
Denmark	2	12	0	3	7
Ecuador	2	0	1	0	3
Egypt	0	10	3	4	18
Finland	0	0	1	2	1
France	4	21	2	4	16
Germany	14	22	11	12	33
Greece	2	5	1	3	7
Hong Kong	29	9	4	1	12
Hungary	0	4	1	4	1
India	18	24	6	10	260
Indonesia	1	7	0	1	4
Iran	0	1	1	0	11
Ireland	1	7	0	0	4
Israel	8	10	6	4	5
Italy	5	14	6	45	32
Japan	15	26	4	13	28
Jordan	0	3	0	0	0
Kenya	0	0	0	0	1
Kuwait	1	0	0	1	0
Lebanon	0	2	1	0	3
Liechtenstein	1	0	1	0	0
Malaysia	0	1	0	3	9
Malta	1	1	1	2	2
Mexico	7	10	13	4	16
Mongolia	1	0	0	0	0
Netherlands	4	14	2	3	8
New Zealand	4	7	1	1	4
Nigeria	0	0	0	0	4

Norway	0	5	1	3	4
Oman	1	0	0	0	0
Palestine	0	0	1	0	0
Pakistan	2	2	0	1	3
Paraguay	0	1	0	0	0
Peru	0	2	1	1	1
Philippines	5	0	0	0	1
Poland	4	4	1	2	2
Portugal	2	2	0	0	13
Reunion (FR)	0	0	1	0	1
Romania	1	0	0	0	1
Russia	0	1	0	0	0
Saudi Arabia	1	2	6	3	6
Serbia	0	0	0	0	4
Singapore	10	13	4	1	6
Slovenia	0	0	0	1	1
South Africa	0	0	3	2	5
South Korea	1	0	1	0	24
Spain	7	26	6	7	15
Sri Lanka	0	2	0	3	2
Sweden	3	1	2	10	2
Switzerland	7	12	14	11	14
Taiwan	3	6	1	1	2
Thailand	9	5	0	0	1
Tunisia	0	0	0	0	2
Turkey	0	1	2	2	7
Uganda	2	2	3	0	0
Ukraine	2	0	0	0	0
United Arab Emirates	0	6	1	1	5
United Kingdom	42	227	46	57	70
United States	22	62	115	12	76
Uruguay	1	0	0	1	0
Venezuela	1	0	1	0	1
Vietnam	0	1	0	0	3
Total	**307**	**725**	**341**	**291**	**973**

Appendix 3. Flight paths for participants coming from each country (start point capital city) to each conference city, listed for all five conferences. Missing flight paths correspond to when no participants from that country attended the conference

Country	2018 Hong Kong	2017 Edinburgh	2016 Los Angeles	2015 Bologna	2014 Ahmedabad
Algeria	-	ALG, CDG, EDI	ALG, CDG, LAX	-	ALG, DOH, AMD
Argentina	EZE, FRA, HKG	-	EZE, PTY, LAX	EZE, FCO, BLQ	EZE, GRU, DXB, AMD
Australia	CBR, SIN, HKG	CBR, SYD, DOH, EDI	CBR, SYD, LAX	CBR, MEL, DXB, BLQ	CBR, SIN, AMD
Austria	VIE, MUC, HKG	VIE, AMS, EDI	-	-	VIE, DOH, AMD
Bangladesh	-	DAC, DOH, EDI	DAC, DOH, LAX	DAC, IST, BLQ	DAC, SIN, AMD
Belgium	BRU, IST, HKG	BRU, EDI	BRU, AMS, LAX	BRU, BLQ	BRU, DOH, AMD
Bosnia and Herzegovina	-	-	-	-	SJJ, DOH, AMD
Brazil	BSB, GRU, ADD, HKG	BSB, GRU, LHR, EDI	BSB, PTY, LAX	BSB, LIS, BLQ	BSB, GRU, DXB, AMD
Cambodia	PNH, HKG	-	-	-	-
Canada	-	YOW, EWR, EDI	YOW, IAD, LAX	YOW, LHR, BLQ	YOW, YYZ, BOM, AMD
Chile	SCL, YYZ, HKG	SCL, LHR, EDI	SCL, LAX	SCL, MAD, BLQ	SCL, GRU, DXB, AMD
China	PEK, HKG	PEK, IST, EDI	PEK, HND, LAX	PKX, SVO, BLQ	PEK, SIN, AMD
Colombia	-	BOG, EWR, EDI	BOG, LAX	-	BOG, EWR, DEL, AMD
Costa Rica	SJO, YYZ, HKG	-	-	-	-
Cuba	-	HAV, CDG, EDI	HAV, MIA, LAX	-	-
Croatia	ZAG, MUC, HKG	ZAG, AMS, EDI	-	-	-
Cyprus	-	-	-	LCA, VIE, BLQ	LCA, DOH, AMD
Czech Republic	-	PRG, AMS, EDI	-	-	-
Denmark	CPH, IST, HKG	CPH, EDI	-	CPH, VIE, BLQ	CPH, DOH, AMD
Ecuador	UIO, DFW, HKG	-	UIO, PTY, LAX	-	UIO, GRU, DXB, AMD
Egypt	-	CAI, IST, EDI	CAI, SVO, LAX	CAI, IST, BLQ	CAI, DXB, AMD
Finland	-	-	HEL, SVO, LAX	HEL, AMS, BLQ	HEL, DOH, AMD
France	CDG, HKG	CDG, EDI	CDG, LAX	BVA, BLQ	CDG, AUH, AMD
Germany	TXL, IST, HKG	BER, EDI	BER, AMS, LAX	BER, BLQ	TXL, DOH, AMD
Greece	ATH, MUC, HKG	ATH, LHR, EDI	ATH, AMS, LAX	ATH, BLQ	ATH, DOH, AMD
Hong Kong	HKG	HKG, IST, EDI	HKG, LAX	HKG, SVO, BLQ	HKG, DEL, AMD
Hungary	-	BUD, EDI	BUD, MUC, LAX	BUD, MUC, BLQ	BUD, DOH, AMD
India	DEL, HKG	DEL, LHR, EDI	DEL, HND, LAX	DEL, SVO, BLQ	DEL, AMD
Indonesia	CGK, HKG	CGK, IST, EDI	-	CGK, IST, BLQ	CGK, SIN, AMD
Iran	-	IKA, IST, EDI	IKA, SVO, LAX	-	IKA, KWI, AMD
Ireland	DUB, MUC, HKG	DUB, EDI	-	-	DUB, AUH, AMD
Israel	TLV, HKG	TLV, GVA, EDI	TLV, SFO, LAX	TLV, FCO, BLQ	TLV, MUC, DEL, AMD
Italy	FCO, MUC, HKG	CIA, EDI	FCO, LAX	FCO, BLQ	FCO, DXB, AMD
Japan	HND, HKG	HND, IST, EDI	NRT, LAX	HND, IST, BLQ	HND, DXB, AMD
Jordan	-	AMM, IST, EDI	-	-	-
Kenya	-	-	-	-	NBO, AUH, AMD
Kuwait	KWI, DOH, HKG	-	-	KWI, IST, BLQ	-
Lebanon	-	BEY, IST, EDI	BEY, DOH, LAX	-	BEY, DOH, AMD
Liechtenstein	ZRH, HKG	-	ZRH, JFK, LAX	-	-
Malaysia	-	KUL, DOH, EDI	-	KUL, IST, BLQ	KUL, BKK, AMD
Malta	MLA, MUC, HKG	MLA, LGW, EDI	MLA, CDG, LAX	MLA, BLQ	MLA, FRA, DEL, AMD
Mexico	MEX, YVR, HKG	MEX, LHR, EDI	MEX, LAX	MEX, FRA, BLQ	MEX, SFO, DEL, AMD
Mongolia	ULN, HKG	-	-	-	-
Netherlands	AMS, HKG	AMS, EDI	AMS, LAX	AMS, BLQ	AMS, DEL, AMD
New Zealand	WLG, CHC, HKG	WLG, MEL, DXB, EDI	WLG, SYD, LAX	WLG, AKL, DXB, BLQ	WLG, SYD, SIN, AMD
Nigeria	-	-	-	-	ABV, IST, DEL, AMD
Norway	-	OSL, EDI	OSL, AMS, LAX	OSL, MUC, BLQ	OSL, DXB, AMD

Oman	MCT, BKK, HKG	-	-	-	-
Palestine	-	-	AMM, ORD, LAX	-	-
Pakistan	ISB, AUH, HKG	ISB, IST, EDI	-	ISB, IST, BLQ	ISB, AUH, AMD
Paraguay	-	ASU, GRU, LHR, EDI	-	-	-
Peru	-	LIM, EWR, EDI	LIM, LAX	LIM, MAD, BLQ	LIM, GRU, DOH, AMD
Philippines	MNL, HKG	-	-	-	MNL. BKK, AMD
Poland	WAW, IST, HKG	WAW, AMS, EDI	WAW, AMS, LAX	WMI, BLQ	WAW, DOH, AMD
Portugal	LIS, MUC, HKG	LIS, AMS, EDI	-	-	LIS, DOH, AMD
Reunion (FR)	-	-	RUN, MRU, CDG, LAX	-	RUN, MAA, AMD
Romania	OTP, DOH, HKG	-	-	-	OTP, DOH, AMD
Russia	-	SVO, BRU, EDI	-	-	-
Saudi Arabia	RUH, MNL, HKG	RUH, LHR, EDI	RUH, LHR, LAX	RUH, SAW, BLQ	RUH, DXB, AMD
Serbia	-	-	-	-	BEG, AUH, AMD
Singapore	SIN, HKG	SIN, IST, EDI	SIN, LAX	SIN, IST, BLQ	SIN, AMD
Slovenia	-	-	-	LJU, MUC, BLQ	LJU, FRA DEL, AMD
South Africa	-	-	CPT, DOH, LAX	CPT, AMS, BLQ	CPT, DOH, AMD
South Korea	ICN, HKG	-	ICN, LAX	-	ICN, DMK, AMD
Spain	MAD, IST, HKG	MAD, EDI	MAD, AMS, LAX	MAD, BLQ	MAD, DOH, AMD
Sri Lanka	-	CMB, DOH, EDI	-	CMB, SVO, BLQ	CMB, BLR, AMD
Sweden	BMA, HEL, HKG	ARN, EDI	ARN, MUC, LAX	ARN, MUC, BLQ	ARN, DOH, AMD
Switzerland	ZRH, HKG	ZRH, EDI	ZRH, JFK, LAX	ZRH, MUC, BLQ	ZRH, DOH, AMD
Taiwan	TPE, HKG	TPE, AMS, EDI	TPE, LAX	TPE, IST, BLQ	TPE, BKK, AMD
Thailand	DMK, HKG	BKK, DXB. EDI	-	-	DMK, AMD
Tunisia	-	-	-	-	TUN, DOH, AMD
Turkey	-	ESB, IST, EDI	ESB, IST, LAX	ESB, SAW, BLQ	ESB, DOH, AMD
Uganda	EBB, IST, HKG	EBB, AMS, EDI	EBB, AMS, LAX	-	-
Ukraine	KBP, DOH, HKG	-	-	-	-
United Arab Emirates	-	AUH, AMS, EDI	AUH, IST, LAX	AUH, SAW, BLQ	AUH, AMD
United Kingdom	LHR, HKG	LTN, EDI	LHR, LAX	STN, BLQ	LHR, DXB, AMD
United States of America	IAD, HKG	IAD, DUB, EDI	BWI, LAX	IAD, LIS, BLQ	IAD, AUH, AMD
Uruguay	MVD, PTY, SFO, HKG	-	-	MVD, EZE, AMS, BLQ	-
Venezuela	CCS, PTY, YYZ, HKG	-	CCS, PTY, LAX	-	CCS, PTY, FRA, DEL, AMD
Vietnam	-	HAN, DOH, EDI	-	-	HAN, CCU, AMD

Appendix 4. Roundtrip flight footprint (kg CO2) per participant by location of origin for each conference. Corresponds to flight paths listed in Appendix 3. Empty cells correspond to no participants coming from that location.

Country	2018 Hong Kong	2017 Edinburgh	2016 Los Angeles	2015 Bologna	2014 Ahmedabad
Algeria	-	459.4	1193	-	879.2
Argentina	2176.6	-	1384.6	1222.2	2418.5
Australia	708.6	2151.2	1400.5	2137.4	1150.6
Austria	995.6	173	-	-	732.4
Bangladesh	-	1007.7	1980.1	782.6	791.1
Belgium	1047.8	210	1129	231.6	847
Bosnia and Herzegovina	-	-	-	-	807.8
Brazil	2388.8	1232	1270.8	1072.2	2318.6
Cambodia	260	-	-	-	-
Canada	-	772	819.4	810	1363.6
Chile	1838.1	1078.6	837.8	1290.9	2512.8
China	313.8	1038.8	1067.8	815.8	953.2
Colombia	-	1143.8	591.4	-	1699.9
Costa Rica	1575.3	-	-	-	-
Cuba	-	1134.2	666.2	-	-
Croatia	1013.6	439	-	-	-
Cyprus	-	-	-	515.2	623.4
Czech Republic	-	355.6	-	-	-
Denmark	1025	214.8	-	372	865
Ecuador	1589.8	-	879.9	-	2698.8
Egypt	-	644.6	1377.8	488.4	610.8
Finland	-	-	1189.4	548.6	780.4
France	794.8	213.2	946.8	184.2	951.4
Germany	986.8	220.6	1212	184.4	853.8
Greece	1151.6	536.4	1399.4	246	708.4
Hong Kong	0	1117	926.2	994.4	655.9
Hungary	-	307.8	1387.2	310.5	796
India	487.8	708	1445.6	743.4	168.1
Indonesia	432.6	1243.8	-	1087.6	582
Iran	-	734.2	1313.4	-	551.2
Ireland	1144.6	83.6	-	-	922
Israel	729.6	669.3	1315	436.7	954.7
Italy	1055	317.8	1073.6	128.4	822.8
Japan	410.2	1176	733.6	1019.8	1226
Jordan	-	834.2	-	-	-
Kenya	-	-	-	-	800.6
Kuwait	877.8	-	-	577.4	-
Lebanon	-	601.8	1805	-	615.2
Liechtenstein	797.2	-	1233.5	-	-
Malaysia	-	1192.1	-	904.6	605.4
Malta	1148	516.6	1264	199.2	1043.7
Mexico	1446.9	1047.9	401.6	1471.4	1731.1
Mongolia	437.4	-	-	-	-
Netherlands	821.6	173	1047.4	266.4	945.2
New Zealand	938.9	2489.1	1644.4	2385.8	1475.7
Nigeria	-	-	-	-	1124.4
Norway	-	197	1275.2	406.4	887
Oman	752.5	-	-	-	-
Palestine	-	-	1303.5	-	-
Pakistan	893.6	792.5	-	636.3	592.6
Paraguay	-	1267.4	-	-	-
Peru	-	1317.8	732.8	1314.1	2653.6
Philippines	194.2	-	-	-	710.8
Poland	978.8	416.6	1291	214.4	772.2
Portugal	1234.2	502	-	-	943.6
Reunion (FR)	-	-	1990.6	-	865.7

Romania	1177.8	-	-	-	744.6
Russia	-	569.4	-	-	-
Saudi Arabia	1094.3	792	1580.8	624	451.2
Serbia	-	-	-	-	805.6
Singapore	344.2	1112.4	1237.2	956.2	421.8
Slovenia	-	-	-	292.2	950.3
South Africa	-	-	2273.1	1417	1083.3
South Korea	308.2	-	885.2	-	917.8
Spain	1101.8	324.8	1302.4	348	856.5
Sri Lanka	-	959.3	-	948.6	402.1
Sweden	618.6	275	1488.9	412.2	832.8
Switzerland	797.2	247.4	1233.5	268	746.4
Taiwan	162	945	862	991.6	744.4
Thailand	282.4	1315.2	-	-	453.4
Tunisia	-	-	-	-	794.6
Turkey	-	525.2	1196.4	383.2	656.4
Uganda	1268.8	929	1803.4	-	-
Ukraine	1169.6	-	-	-	-
United Arab Emirates	-	785.8	1491	705	287.2
United Kingdom	825	138.2	929.8	219.2	976.8
United States of America	847.6	707.6	564.8	1025.8	1255
Uruguay	2303.4	-	-	1277.8	-
Venezuela	1862.1	-	931.8	-	2104.3
Vietnam	-	1100.1	-	-	557.5

Appendix 5. Roundtrip city center to departing airport footprint (kg CO2) per participant by location of origin for each conference. Corresponds to first airport code in the flight path listed in Appendix 3. Empty cells correspond to no participants coming from that location.

Country	2018 Hong Kong	2017 Edinburgh	2016 Los Angeles	2015 Bologna	2014 Ahmedabad
Algeria	-	7.268	7.268	-	7.268
Argentina	14.454	-	14.454	14.454	14.454
Australia	3.13	3.13	3.13	12.536	3.13
Austria	12.536	12.536	-	-	12.536
Bangladesh	-	3.608	3.608	3.608	3.608
Belgium	6.462	6.462	6.462	6.462	6.462
Bosnia and Herzegovina	-	-	-	-	3.958
Brazil	2.678	2.678	2.678	2.678	2.678
Cambodia	5.358	-	-	-	-
Canada	-	5.76	5.76	5.76	5.76
Chile	7.588	7.588	7.588	7.588	7.588
China	13.078	13.078	13.078	13.078	13.078
Colombia	-	6.264	6.264	-	6.264
Costa Rica	7.756	-	-	-	-
Cuba	-	8.312	8.312	-	-
Croatia	6.652	6.652	-	-	-
Cyprus	-	-	-	22.32	22.32
Czech Republic	-	8.182	-	-	-
Denmark	3.17	3.17	-	3.17	3.17
Ecuador	17.54	-	17.54	-	17.54
Egypt	-	9.164	9.164	9.164	9.164
Finland	-	-	8.6	8.6	8.6
France	14.642	14.642	14.642	14.642	14.642
Germany	4.842	12.562	12.562	12.562	4.842
Greece	15.26	15.26	15.26	15.26	15.26
Hong Kong	16.72	16.72	16.72	16.72	16.72
Hungary	-	9.742	9.742	9.742	9.742
India	5.19	5.19	5.19	5.19	5.19
Indonesia	13.656	13.656	-	13.656	13.656
Iran	-	20.58	20.58	-	20.58
Ireland	4.816	4.816	-	-	4.816
Israel	22.9	22.9	22.9	22.9	22.9
Italy	13.148	6.674	13.148	13.148	13.148
Japan	10.026	10.026	34.08	10.026	10.026
Jordan	-	15.35	-	-	-
Kenya	-	-	-	-	7.578
Kuwait	8.894	-	-	8.894	-
Lebanon	-	3.334	3.334	-	3.334
Liechtenstein	51.36	-	51.36	-	-
Malaysia	-	25.26	-	25.26	25.26
Malta	3.97	3.97	3.97	3.97	3.97
Mexico	3.578	3.578	3.578	3.578	3.578
Mongolia	5.966	-	-	-	-
Netherlands	9.608	9.608	9.608	9.608	9.608
New Zealand	4.066	4.066	4.066	4.066	4.066
Nigeria	-	-	-	-	16.398
Norway	-	21.08	21.08	21.08	21.08
Oman	4.708	-	-	-	-
Palestine	-	-	107.58	-	-
Pakistan	12.384	12.384	-	12.384	12.384
Paraguay	-	4.556	-	-	-
Peru	-	5.182	5.182	5.182	5.182
Philippines	5.26	-	-	-	5.26
Poland	3.884	3.884	3.884	17.364	3.884
Portugal	2.518	2.518	-	-	2.518
Reunion (FR)	-	-	3.72	-	3.72

Romania	8.216	-	-	-	8.216
Russia	-	12.446	-	-	-
Saudi Arabia	16.036	16.036	16.036	16.036	16.036
Serbia	-	-	-	-	8.406
Singapore	10.242	10.242	10.242	10.242	10.242
Slovenia	-	-	-	11.272	11.272
South Africa	-	-	7.824	7.824	7.824
South Korea	25.98	-	25.98	-	25.98
Spain	6.444	6.444	6.444	6.444	6.444
Sri Lanka	-	16.674	-	16.674	16.674
Sweden	18.07	18.07	18.07	18.07	18.07
Switzerland	54.48	54.48	54.48	54.48	54.48
Taiwan	20.82	20.82	20.82	20.82	20.82
Thailand	11.488	11.488	-	-	11.488
Tunisia	-	-	-	-	3.518
Turkey	-	11.6	11.6	11.6	11.6
Uganda	21.06	21.06	21.06	-	-
Ukraine	15.798	-	-	-	-
United Arab Emirates	-	13.97	13.97	13.97	13.97
United Kingdom	11.302	23.68	11.302	27.6	11.302
United States of America	18.91	18.91	21.94	18.91	18.91
Uruguay	8.144	-	-	8.144	-
Venezuela	12.108	-	12.108	-	12.108
Vietnam	-	11.01	-	-	11.01

Appendix 6. Roundtrip arrival airport to venue footprint (kg CO2) per participant by location of origin for each conference. Corresponds to first airport code in the flight path listed in Appendix 3. Empty cells correspond to no participants coming from that location.

Conference	**Venue/Opening Event Venue**	**Kg CO_2 roundtrip**
2014 Ahmedabad	CEPT University	3.226
2015 Bologna	Palazzo Re Enzo	4.23
2016 Los Angeles	Baltimore Hotel	12.644
2017 Edinburgh	Edinburgh Castle	6.338
2018 Hong Kong	Yasumoto International Academic Park	18.17