2

The Carbon Footprint of Travelling to International Academic Conferences and Options to Minimise It

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Introduction: Transportation as an Important Field of Action Against Global Warming

Science is clear on this matter: The increase in greenhouse gas (GHG) emissions over the past 100 years must not only be stopped but must be reversed, in order to minimise global warming. The 2018 IPCC special report estimates that a net-zero of global CO₂ emissions has to be reached already between 2040 and 2060 in order to limit global warming to a maximum of 1.5 °C as compared to pre-industrial age. Even a limitation at this level, however, would have severe consequences for natural systems (e.g. habitats in arctic regions or warm water coral fields) and human life on earth due to extreme weather events, coastal floodings and long-lasting droughts (Masson-Delmotte et al., 2018). Yet, all these risks would be significantly higher in a scenario where global warming exceeds the 1.5 °C threshold.

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In order to achieve this goal, change requires emission cutbacks throughout all spheres of human society, from major industries to public infrastructure, as well as individual lifestyle. According to a study based on the 2018 IPCC special report, personal lifestyle carbon emissions must be reduced to 2.5 t of CO₂ equivalents per capita by 2030, 1.4 t by 2040 and 0.7 t by 2050 in order to reach the 1.5 °C scenario (IGES, 2019). In 2017, a study highlighting the four highest impact actions to reduce personal emissions within highly developed societies achieved worldwide attention (Wynes & Nicholas, 2017). The authors found that the biggest potential for CO₂ reduction lies in having fewer children (one child fewer being equivalent to 58.6 t CO₂-eq per year). This specific aspect has been subject to methodological criticism for double counting (van Basshuysen & Brandstedt, 2018), as well as to ethical criticism, since family planning is a human right (Pedersen & Lam, 2018). Nevertheless, the basic idea of the study is compelling: the authors argue that it is most meaningful to primarily push forward the actions with the highest impact on reducing GHG—instead of those that are often promoted by government agencies, NGOs and also in science textbooks for students as eco-friendly behaviour (e.g. upgrading to power-saving light bulbs or reusing shopping bags), but which in fact have a relatively low impact on emission reductions. Apart from the recommendation to have one child less, the three other recommended actions received little attention. According to Wynes and Nicholas, these actions are: ‘living car-free (2.4 t CO₂-eq saved per year), avoiding airplane travel (1.6 t CO₂-eq saved per roundtrip transatlantic flight) and following a plant-based diet (0.8 t CO₂-eq saved per year)’ (Wynes & Nicholas, 2017, p. 1). These numbers show that a significant part of personal CO₂ emissions in developed countries results from travelling. Thus, the intensity of a person’s mobility and the chosen mode of transportation are two of the most relevant factors for reducing a person’s individual carbon footprint—and are incidentally also factors that can relatively easily be changed in an individual’s life.

Conferences as Part of the Academic World

In the life of an academic, conferences often play a significant role. Not only do they provide the opportunity to disseminate one's own research to interested peers, but they also allow researchers to catch the newest developments within a discipline. Furthermore, academics have the chance to exchange views and ideas face to face with their colleagues from around the world at conferences and congresses. These social gatherings may also help to build new research networks. Critics of the growing conference tourism argue instead that the professional, that is scientific, benefit of these events is minimal. A recent study reiterates this point by showing that scholars who fly much do not have more academic success (e.g. measured by the H-index adjusted for age and discipline) than those who stay on the ground. Nonetheless, one difference between these two groups becomes apparent: the frequent flyers have higher average salaries (Wynes et al., 2019). With the scientific added value of conferences being questionable, critics believe, most academics participate in conferences and congresses for two other reasons: they either travel to conferences in order to boost their symbolic capital¹ or they take the chance to enjoy a short holiday trip, which in some cases they even get paid for by their home university or a research fund (Hoyer & Naess, 2001). Many conference organisers even actively promote tourist activities such as guided tours or bus trips to nearby landmarks. And it has been shown empirically that 'sightseeing and social events' are significant pull factors for conference participation comparable in their effect size to the push factor 'career development' (Veloutsou & Chreppas, 2015, p. 117). Regardless of these points, it clearly has to be acknowledged that in today's academic sphere, conferences occupy a significant amount of researchers' time. This leads to the somehow curious fact that scientists, sometimes even those working in a field related to environment and climate change, exhibit a much higher average carbon footprint than non-scientists. For example, a study at the University of Montreal showed that professors travel more than 33,000 km per year, generating about 11 metric tons of CO₂ (Arsenault et al., 2019), whereas the average Canadian is estimated to

produce about 13 tons of household CO₂ emissions per capita (Maraseni et al., 2015).

As a result, more and more researchers, particularly from disciplines related to climate and ecology, have questioned the practice of flying long distances to attend academic conferences in the past years (Grémillet, 2008; Holden et al., 2017). Firstly, they criticise the very high GHG emissions of scientists as a result of their frequent work-induced flights, even if they otherwise lead low carbon lives (Fox et al., 2009; Grémillet, 2008). This can also be framed as an ethical debate about climate justice at the individual level, with academics representing the privileged societal groups that emit much more GHG than less privileged groups which will be more intensely affected by the effects of global warming. Secondly, they criticise the fact that a high carbon footprint from flying to conferences significantly reduces climate researchers' perceived credibility among the general public (Attari et al., 2016).

In order to better understand the relevance of travelling to academic conferences for scientists' overall carbon footprint, verifiable estimations are needed. Surprisingly, there are still only a few analyses in this regard. Some studies estimated the carbon footprint of scientific conferences in total (Desiere, 2016; Kuonen, 2015; Nathans & Sterling, 2016), per attendee, or the average emissions for presenting a single scientific paper (Spinellis & Louridas, 2013). However, it is surprising that the number of these works is still very limited, and that they are restricted to certain disciplines (e.g. ecological climatology or geography). This study updates an article published in 2019 which, at that time, was the first study that analysed not a single but a series of annual academic conferences of a major scientific organisation in terms of their carbon footprint (Jäckle, 2019).

The Example: ECPR General Conferences 2013–2020

In order to study the carbon footprint of scientific conferences, this analysis uses the example of the General Conference of the European Consortium for Political Research (ECPR GC). This academic conference can be regarded as a typical case of a major international scientific conference in many ways. The seven ECPR GCs that took place between 2013 and 2019 had an average of about 1630 participants, coming from all around the world—however, researchers from Europe dominated the meetings.² In comparison to other conferences in the field of political science, the ECPR GC is one of the bigger annual events. Only some conferences in the United States, such as the annual conferences of the International Studies Association (ISA), or the meetings of the American Political Science Association (APSA), both with more than 5000 participants, are larger. But within Europe, the ECPR GC is clearly the major meeting of the field. Of course, ECPR GCs are relatively small when compared to gigantic conferences in other scientific fields, such as the American Geophysical Union Fall Meeting (ca. 25,000 participants) or the annual meeting of the Society for Neuroscience (more than 30,000 participants). Nevertheless, due to its size and the geographic structure of its participants, ECPR GCs can nevertheless be regarded as relatively representative for major scientific conferences in many disciplines.

In order to estimate the travel-induced carbon footprint of ECPR GCs, I collected the publicly available information on paper presenters and their home institutions from the online conference programmes that are available at the ECPR website for the GCs from 2013 to 2019. Since the online programmes are not necessarily completely congruent to the list of actual attendees (some scholars may have been listed in the programme but did not show up, while others may have attended without presenting a paper), they are not a perfect source to determine who actually attended the conferences. Nevertheless, they are the best data available. Thus, every paper presenter mentioned in the online programme is counted as an attendee. In the rare case that more than one presenter is listed for a single paper, I expect all presenters to have attended the

conference. Due to the COVID-19 pandemic, the 2020 conference took place virtually. For this virtual conference, a new observer registration was introduced, which boosted participation numbers significantly. ECPR provided me with attendance data for this event. Table 2.1 gives an overview of all eight conferences in terms of presenters, papers and home institutions.

Method

Distinguishing between three modes of transport (airplane, coach, train) and assuming that each participant only uses one means of transportation for travelling to the ECPR GC, participants’ travel-induced carbon footprints (cf) can be estimated using the following formulas:

cf_{plane} = 2 \times (d_{greatcircle} \times 1.2 \times e_{plane})

Table 2.1 Overview of the last eight ECPR general conferences

Conference	Papers	Participants total	Independent scholars and participants with unknown affiliation	Home institutions
Bordeaux 2013	1681	1654	64	460
Glasgow 2014	1613	1541	45	449
Montreal 2015	1351	1174	14	421
Prague 2016	1902	1663	14	502
Oslo 2017	1785	1613	6	469
Hamburg 2018	2125	1930	7	493
Wroclaw 2019	1786	1810	5	437
Virtual 2020 *		2208**	5	575

Annotation: Own calculation based on data from the ECPR website (for 2020 attendance data was provided by the ECPR central services). * No data available, ** 1920 standard/student registrations (i.e. paper presenters) + 288 observer registrations

$$cf_{coach} = 2 \times (d_{roads} \times e_{coach})$$

$$cf_{train} = 2 \times (d_{railway} \times e_{train})$$

The distances from attendees' home institutions to the conference location (d) are multiplied with the average greenhouse gas emissions a certain means of transportation has per km (= emission factor e). The resulting value is doubled to get the emissions for a return trip.

Calculating the Travel Distances

Based on the lists of participants, I started measuring the travel distances (d) by web scraping longitude and latitude of the attendees' home institutions from Wikipedia. In a GIS program (QGIS), these coordinates were then used to calculate the distances travelled by airplane, (long-distance) coach and train between home institutions and conference locations. For the air travel distance, the formula of the great circle was applied (see Fig. 2.1). Yet, to use *raw* great circle distances would result in estimated emissions that would be systematically too low. In many cases, there are no direct flights from the participants' home towns to the conference

Fig. 2.1 Airplane and land-bound routes to the ECPR General Conference in Wrocław

locations which necessitate stopovers and thus longer travel distances. Furthermore, often airplanes do not take the shortest route but fly more inefficient detours in order to pass predefined navigational points. Kettunen et al. (2005) found that the actual distances aviated by airplanes are between 6 and 10 per cent longer than the great circle routes between the departure and the destination airports themselves. In addition, particularly at large airports, airplanes have to fly extra loops before they are allowed to approach the landing runway, which adds extra lateral flying to the total distance. Once arrived, the taxi time on the ground consumes fuel as well.³ Moreover, airports are often relatively remote from the city centres, so that travelling to and from the airports adds another portion to the GHG emissions of airline passengers. In order to account for all these factors and obtain more realistic numbers, the great circle distances are multiplied by a factor of 1.2. Second, I calculated the fastest times for a journey by car, as well as the respective routes from the presenter's home institutions to the conference venue for each conference, using the Openrouteservice API (<https://openrouteservice.org/>). The cartographic data underlying this endeavour comes from OpenStreetMap (<https://www.openstreetmap.org/>). Since Openrouteservice limits the routing to distances below 6000 km, this street-based calculation has only been performed for those home institutions within this limit. Thus, driving times and distances could be calculated for all locations within Europe (for the conferences in Europe) and the North American institutions for the 2015 conference in Montreal. Third, I calculated the shortest path between the home university and the conference locations based on a network of all existing railroad tracks. The vector data for this railroad network comes from <https://www.naturalearthdata.com/>. Figures 2.1 and 2.2 show the three distance measures: great circle for flying, the fastest route by car (which can also be used for journeys by coach) and shortest route by train for the example of the conference in Wrocław 2019.

Emission Factors

The second important factor necessary for estimating the carbon footprint is how much GHG⁴ is emitted per passenger and per kilometre for

different means of transportation. Various scientists, as well as governmental and non-governmental agencies, publish these so-called emission factors. Since their calculation is based on a multitude of choices and assumptions, it is no surprise that we find significant variation in emission factors between the different sources. One crucial aspect for all means of transportation is the average passenger load factor, since per capita emissions are certainly higher if a higher percentage of the seats remains empty. When it comes to railway travel, it is significant which kind of electricity mix is assumed to power the trains, whereas with travel by airplane, one major aspect is the extent of radiative forcing that describes the fact that the same amount of CO₂ emitted by an airplane at a high altitude has a more significant climatic effect than if emitted on the earth's surface.

Nevertheless, the exact magnitude of this radiative forcing index (RFI) is still a matter of the scientific debate. A recent meta-study estimates the

Fig. 2.2 Airplane and land-bound routes to the ECPR General Conference in Wrocław

effect of CO₂ in the higher atmosphere to be 5.2 times higher than on the ground. When adding all airplane CO₂ emissions for a flight (considering all altitudes the plane flies at during one flight), the authors of this study conclude that an average RFI of 2.0 should be used in carbon footprint estimations (Jungbluth & Meili, 2019). In general, long-haul flights reach higher altitudes (= higher RFI), whereas the high-emission take-off and landing phases make up a bigger proportion of the total emissions in short-haul flights. In order to absorb potential biases from the use of emission factors that are based on unrealistic assumptions, I will use four different sources for the emission factors: (1) UBA: the German Federal Environmental Agency (*Umweltbundesamt*) publishes emission factors based on the Transport Emission Model TREMOD 6.03 (Allekotte et al., 2020)⁵; (2) EEA: the European Environment Agency published emission factors for different vehicle types in its 2014 Transport and Environment Reporting Mechanism (TERM) report⁶; (3) UK: the Government of the UK provides a yearly data set including the latest conversion factors for GHG reporting which also include emission factors for different modes of travel⁷; and (4) NTM: The Network for Transport Measures, ‘a non-profit organisation, initiated in 1993, aiming at establishing a common base of values on how to calculate the environmental performance for all various modes of traffic, including goods transport and passenger travel’.⁸ Table 2.2 shows the differences between the emission factors of these three sources. Although the table points out some major differences, the overall pattern becomes clear: Travelling by airplane is by far the most climate-damaging mode of mass transportation, whereas travelling by coach or train emits between 3.7 and 20 times less GHG than flying.⁹ Only travelling by car can, at least in some instances (e.g. large petrol car with only the driver inside), produce even higher emissions. Furthermore, the biggest net differences among the four sources in the emission factors concern travelling by plane which means that the estimations based on the four sources can also be interpreted as lower and upper bounds for the carbon footprint.

Table 2.2 Emission factors per passenger-kilometre in g CO₂ equivalents

Vehicle	UBA	EEA	UK	NTM
Car	147	104–158 ^a	137–278 ^b	90–210 ^d
Coach (long distance)	29	68	27	30
Train (high speed)	32	14	37	38/0.6 ^e
Aeroplane (radiative forcing included)	230	285	146/424/585 ^c	280/300/440 ^f

Annotations: UBA: *Umweltbundesamt* (German Federal Environmental Agency) TREMOD 6.03, 2018, EEA: European Environment Agency TERM-report, 2014, UK: Government of the United Kingdom conversion factors, 2019, NTM: Network for Transport Measures. (a) dependent on size (small car vs. large car); (b) dependent on size (small car vs. large car) and fuel type (diesel vs. petrol); (c) long haul to/from UK in economy class/business class/first class; (d) dependent on occupancy (1.13–1.7) and fuel type (diesel vs. petrol); (e) EU average electricity/EU green electricity; (f) regional (< 785 km)/continental (785–3600 km)/intercontinental (> 3600 km), RFI = 2.0

A Realistic Estimation: Who Flies, Who Travels by Coach or Train?

It is not possible to deduce with perfect certainty which means of transportation a participant uses when merely looking at the data at hand. In order to estimate the carbon footprint, it is therefore necessary to make an assumption about which attendee uses which means of transportation. While a researcher from Australia probably has only one option, attendees from Europe can choose between a variety of vehicles: airplane, coach or train. I assume that participants base their decision primarily on the duration of the journey ahead. As I have calculated the journey times by car (which can be assumed to be proportional to the travel times by long-distance coach), for the baseline estimation I assume that attendees travel land-bound if they can reach the conference venue within five hours. Otherwise, they would take the airplane. For shorter travel times, the saving of time by the high flight velocity would not compensate the longer waiting times for security checks and boarding and the on average longer travel times for reaching the airport compared to train and coach stations which are located more often in the city centres. The following estimations will also show what impact it would have if presenters chose to travel land-bound, even if it takes them considerably longer than five hours.

Estimation of Carbon Footprint: Baseline Results

Total Emissions

Figure 2.3 shows the total GHG emissions of travelling to the seven ECPR GCs between 2013 and 2019, using the four different sources for the emission factors under the assumption that attendees travel by long-distance coach if they can reach the conference venue within five hours. For those participants with no affiliation available (see Table 2.1), the average individual GHG emissions of the participants with an affiliation were used to calculate the total GHG emissions. This estimation will be referred to as *baseline estimation* in what follows.

For all the conferences within Europe, the lowest estimation is based on the UK governmental emission factors. According to these numbers, travelling to each of these conferences emitted at least 905 tons CO₂-eq. The NTM and EEA emission factors produce the upper limits, which are between 1825 and 2325 tons CO₂-eq. To set these numbers into comparison: According to Eurostat data,¹⁰ an average ECPR GC lasting three

Fig. 2.3 Total GHG emissions of travelling to ECPR General Conferences (journeys < 5 h travel time: by coach; > 5 h: by airplane)

to four days has about the same carbon footprint (just from the travel-induced emissions) as 120–310 average British persons within a whole year. The Montreal conference with estimated total emissions of 2050–4000 t CO₂-eq is clearly standing out. Even though this conference had the lowest number of participants (1174), the fact that all European attendees had to travel by plane to Canada made it by far the conference with the highest carbon footprint.¹¹

Figure 2.4 depicts the comparison between long-distance coach and train in terms of total emissions. Assuming that average travel times are similar between coach and high-speed train (a fully functional high-speed train network is not available everywhere in Europe and train passengers probably need more time for transfers), the group of attendees being able to reach the conference venue within five hours by car/coach is also used for the comparison with travelling by train.¹² The figure shows that for the conferences in Bordeaux, Montreal and Oslo, it virtually did not make any difference if participants who could reach the conference venue land-bound within five hours would travel by coach or by train. The biggest differences can be seen looking at the Hamburg conference when

Fig. 2.4 Comparison of total GHG emissions for travelling by coach or by train (journeys < 5 h travel time: coach or train; >5 h: by plane)

applying the EEA emission factors which state relatively low numbers for the train emissions. This is because Hamburg is well connected to the European high-speed train network and is located quite centrally. Thus, a bigger proportion of presenters is able to reach the conference venue by train. Yet, compared to the total emissions of 1770 tons CO₂-eq (EEA emission factors), it is evident that the decision whether attendees who travel land-bound choose the train or a coach is only of marginal relevance for the total carbon footprint of a conference. This picture might change substantially, if a higher proportion of participants abstained from flying and if trains were operated exclusively based on green electricity.

Emissions Per Participant

The average GHG emissions per attendee can easily be compared to country-specific average per capita emissions or to the average global life-style per capita emission needed to reach the 1.5 °C goal. Figure 2.5 depicts the average GHG emission of participants as compared to the 2.5, 1.4 and 0.7 tons of CO₂-eq which every human, on average, should maximally emit per year in the long run (by 2030, 2040 and 2050 respectively) to limit global warming to a maximum of 1.5 °C (IGES, 2019). This estimation is again based on the assumption that everyone who can reach the conference venue within five hours, relying on the street network, uses the long-distance coach, while the other attendees travel by plane.

Compared to the conferences which took place in Europe, the 2015 conference in Montreal stands out with its estimated per capita carbon footprint of up to 3.4 tons CO₂-eq. Even the lowest estimation for this conference, based on the UK governmental emission factors, presents a picture in which, by travelling to this Montreal ECPR GC, an average attendee emitted nearly 80 per cent of the GHG a single person would on a global average be allowed to emit by the year 2030 to limit global warming to 1.5 °C. The conferences within Europe, instead, had carbon footprints between 500 kg and 1.4 tons CO₂-eq, which correspond roughly to the estimated yearly per capita budget for personal lifestyle

Fig. 2.5 Average GHG emissions per attendee of travelling to ECPR General Conferences (journeys < 5 h travel time: by coach; > 5 h: by plane). The IGES estimation is based on the IPCC special report 2018. (IGES, 2019; Masson-Delmotte et al., 2018)

emissions allowed for the years 2040 and 2050. Compared with today's average citizen's carbon footprint, even the lowest limit of GHG emissions we found (ca. 500 kg) accounts for about 3 per cent of an average US American, 7 per cent of an average British and 21 per cent of an average Indian footprint in 2016 (World Resources Institute, 2019). Earlier studies, estimating the carbon footprint for conferences in other disciplines, came to somewhat lower values. The GHG emissions per attendee of the 14th Congress of the European Association of Agricultural Economists, in Ljubljana in 2014, were estimated between 308 kg and 322 kg (Desiere, 2016), and for the case of the European Geography Association Annual Congress 2013 in Wasilkow (Poland), Kuonen (2015) came to an estimation of 401 kg CO₂-eq per participant. The differences to the results in this study can partly be attributed to the use of different emission factors, methodological differences in the estimation process (e.g. the calculation of the land-bound travel distances) and to the fact that, contrary to the ECPR conferences, participants of both of these meetings came solely from European scientific institutions.

The conference location matters not only when comparing Montreal to the five European locations but also regarding a comparison of the conferences which took place in Europe. For example, the average per

capita GHG emissions for the Hamburg conference were estimated between 219 kg and 430 kg lower than for the preceding event in Oslo. A more centrally located conference venue can, therefore, contribute to a significant reduction in GHG emissions.

However, the presented average numbers can be misleading since there is a large variation between the participants' carbon footprints (see Fig. 2.6). The Lorenz curves show that a comparatively small number of participants account for most of the emissions. Apart from the Montreal conference, where only a small number of participants had the possibility of travelling land-bound, all distributions are heavily skewed. Between 13 per cent (Oslo) and only 7 per cent (Hamburg) of the participants accounted for 50 per cent of the total emissions. To give an example, the largest carbon footprint for a participant (from the University of Canterbury, NZ) at the 2018 conference was estimated at 6.4–12.5 tons CO₂-eq, which is about three to five times the per capita emissions

Fig. 2.6 Distribution of GHG emissions among participants

allowed per year by 2030 to reach the 1.5 °C goal. This also indicates that if the total carbon footprint of conferences shall be reduced, focusing on these heavy emitters has high potential.

Estimating the Impact of Carbon Reduction Measures for Academic Conferences

The preceding estimations have shown how significant the GHG emissions from travelling to the ECPR GCs have been in total and per attendee. Compared to per capita emissions that experts regard to be necessary in order to limit global warming to about 1.5 °C, the carbon footprints of these conferences are very high. In the following paragraphs, I will present ideas on how conference organisers could contribute to the cutback of emissions of scientific meetings and estimate how significant the potential for GHG reduction of the respective measures is.

Choosing More Central Conference Venues

The estimations above have shown that the location of a conference is important for the size of its carbon footprint. The GC 2015 in Montreal is an outstanding example, but there were also significant differences in the GHG emissions for those conferences that took place in Europe. Thus, a more centrally located conference venue, 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. In order to see how big this potential is, I performed the same estimations as above, again using the four different emission factors but changing the conference venue for all conferences to Frankfurt (Germany). Frankfurt is quite centrally located in Europe and is very well connected to the European high-speed train network, which makes it a suitable comparison for the real conference venues.¹³ Figure 2.7, presenting the minima and maxima of the possible reductions (dependent on the different emission factors), demonstrates that if the conference venue had been in Frankfurt, the GHG emissions for each of the

seven ECPR GCs would have been significantly lower. Even a relatively small relocation from Hamburg in northern Germany to Frankfurt in central Germany—the distance between the two cities is only about 400 km—results in up to 4 per cent lower emissions.

Promoting Low-Emission Travel Options

The estimations showed that particularly flying is a bad option. Travelling by coach or by train would both be an improvement in terms of the carbon footprint. All the above estimations assumed that only presenters who can reach the conference venue in less than five hours using the street network would choose not to fly. Stimulating the attendees to choose land-bound travel options, even if this increased their travel time compared to flying, could result in significantly lower carbon footprints. In order to estimate the possible emission reduction, I recalculated the emissions under the assumptions that attendees choose to travel by coach or train for journey times below 10 h/15 h/20 h. Figure 2.8 again shows

Fig. 2.7 Potential reduction of total GHG emissions if the conferences had taken place in Frankfurt (in percent of baseline estimation from Fig. 2.3)

the minimum and maximum possible total reductions in the percentage of the baseline estimated emissions. While the effects are negligible for the Montreal conference, where most of the participants arrived by airplane from Europe, accepting longer travelling times by coach and train would have reduced the total GHG emissions for the other conferences considerably. Yet, there are substantial differences. For the conferences in Bordeaux, Prague, Hamburg and Wroclaw, all 15-hour estimations result in a reduction of 15–25 per cent, while the same estimations only make up 5–15 per cent for the two more remote European conferences in Oslo and Glasgow. This shows that a more central location which is easy to reach by coach and/or train can in combination with the promotion of low-emission land-bound travel options result in a significant reduction of the carbon footprint. Figure 2.8 also reiterates the fact that with a higher number of attendees choosing to travel by coach or train, the question of which of the two land-bound means of transportation is better in terms of carbon emissions, becomes more significant (which of course also depends on the way they are powered).

Hybrid Conferences as an Alternative to Regular Attendance

As Fig. 2.6 has shown, a relatively small group of participants accounts for a large part of the total emissions. Thus, one obvious option for reducing the carbon footprint of scientific conferences would be to reduce the number of participants who come from far away (for the ECPR GCs: e.g. everyone travelling there from outside Europe). Modern communication solutions such as remote conferencing services make it possible for panelists to attend a conference from home. They could present their research and take part in discussions just as any regular attendee. From a technical perspective, such hybrid conference solutions are possible and work well, particularly if not too many panellists join virtually. Within a conventional panel-structure with 3–4 paper presenters per panel it should be no problem to have one or two presenters joining online. The presentation and the discussion of papers as well as a Q&A time can be put into

Fig. 2.8 Potential reduction of total GHG emissions if attendees accept longer travel times than 5 h by coach or train (in percent of baseline estimation)

Fig. 2.9 Potential reduction of total GHG emissions if those participants with a flight distance > 4000 km attend the conference online (in percent of baseline estimation)

practice. Figure 2.9 shows the potential for reducing the travel-induced carbon footprint if those participants whose flying distance is longer than 4000 km attended the conference online. Except for the special case of the Montreal conference, where 77.5 per cent of the participants would have attended virtually under these circumstances, only between 7 and 15 per cent of the participants came from a place further than 4000 km away regarding all the other conferences. Figure 2.9 shows that if these persons did not travel to the conference venue in person, this would mean an estimated reduction of 43–57 per cent compared to the baseline estimation, depending on the respective conference and the source of emission factors.

For this estimation, I assumed that online participants to have zero emissions. While this is not entirely true, the next paragraph will show that emissions associated with online participation are indeed negligible compared to emissions from travelling. Before that, it will be shown to what extent a combination of the three measures discussed could lead to even lower carbon footprints than each measure individually.

Fig. 2.10 Potential reduction of total GHG emissions if all three actions are applied (in percent of baseline estimation)

Combined Effects of All Three Actions

Figure 2.10 compares the baseline estimation (see Fig. 2.3) for the maximum reduction case in which the conferences had taken place in Frankfurt, attendees travelled land-bound for travel times shorter than 20 h and all participants whose flying distance was greater than 4000 km did not attend in person but online from home. This maximum reduction scenario shows the vast potential for reducing the carbon footprint of ECPR GCs: depending on the source of the emission factors and on the conference venue, between 78 and more than 97 per cent of the travel-induced GHG emissions of these conferences could have been saved. In total numbers, this would mean that for example the GHG emissions of the Hamburg conference could have been reduced from 906–1825 to 177–379 tons CO₂-eq—or expressed as average emissions per participant: from 469–945 to about 92–196 kg CO₂-eq.

The Carbon Footprint of Online Conferences: The Example of the Virtual ECPR GC 2020

Due to the COVID-19 pandemic, ECPR decided to switch the 2020 GC to a virtual format using the online conferencing software, Zoom. Of course, also a virtual conference produces GHG. In order to get an

impression of the carbon footprint of this first-time online-only ECPR GC, I estimated the electricity consumption of online streaming as well as of the personal devices of the participants. Comparing these emission estimates to the emissions that would have been produced by travelling to the conference, if the conference had taken place in Innsbruck, Austria, as originally planned, exaggerates the vast potential of online conferences for the reduction of carbon emissions.

For an online conference, the GHG emissions can primarily be attributed to the electricity needed for such an event. The electricity consumption of an online conference, in turn, can mainly be ascribed to two factors. First, the electricity needed to power the participants' devices, and second, the electricity needed at servers to provide the necessary video and audio transfer. The virtual ECPR GC took place from August 24 to 28. In total, a maximum of about 40 hours of online activities was possible (including not only panels and round tables but also refreshers, pauses, virtual social gatherings and online sport exercises).¹⁴ Assuming that all 2210 participants using a desktop PC¹⁵ on average attended 60 per cent of the time of the online conference (which is probably a too high assumption), the overall electricity consumption ($EC_{devices}$) of the devices can be estimated as:

$$EC_{devices} = P \times A \times D \times EC = 2210 \times 0.6 \times 40h \times 0.2kW / h = 10,608 kWh$$

with $EC_{devices}$: total electricity consumption of all participants' devices for the overall conference in kWh, P : number of participants, A : attendance rate, D = total duration of conference in hours and EC : electricity consumption of device in kW/hour.

Similarly, the electricity consumption of the video and audio data transfer on the internet can be calculated as follows, applying an estimated average upload and download data usage of 1.35 GB for 1 hour at Zoom (720p quality),¹⁶ and assuming an average electricity intensity for internet transfers in 2019 of 0.015 kWh/GB¹⁷:

$$\begin{aligned} EC_{internet_transfer} &= P \times A \times D \times U \times I \\ &= 2210 \times 0.6 \times 40h \times 1.35GB / h \times 0.015kWh / GB \\ &= 1,074 kWh. \end{aligned}$$

with $EC_{internet_transfer}$: total electricity consumption of all data transfers in kWh, P : number of participants, A : attendance rate, D = total duration of conference in hours, U : data usage for one hour at Zoom and I : average electricity intensity of internet transfers in kWh/GB.

From the electricity consumption, it is possible to estimate the carbon footprint of the online conference. Of course, this depends very much on the way the electricity is produced. For example, data from the European Environmental Agency shows that in 2016 producing 1 kWh of electricity in France emitted ca. 58 g of CO₂, whereas producing the same amount in Poland led to 773 g of CO₂ emissions.¹⁸ More recent estimates report 233 g for the UK and 402 g for Germany.¹⁹ Table 2.3 presents the carbon footprint of the virtual ECPR GC 2020, using the (in the EU comparatively high) German numbers for the CO₂ emissions per kWh and compares it to the hypothetical case, in which the conference took place in Innsbruck, Austria, as originally intended. For the latter estimation, I use the same emission factors and assumptions as in the baseline estimations above. Even without including the higher heating, electricity and catering carbon emissions produced by hotels and conference centres compared to the location from where to join a virtual conference—at home or at the regular workplace (Balanzat, 2020)—the travel-induced carbon emissions are between 250 and 530 times higher than the emissions resulting from the online conference! In fact, the numbers could even be much more pronounced, given that much of the carbon footprint of the virtual conference must be attributed to participants’ devices.

Table 2.3 The carbon footprint of the virtual ECPR GC 2020 compared to the situation if it had taken place in Innsbruck as initially planned (in tons CO₂ eq)

Carbon footprint of	Virtual	Innsbruck (baseline estimation)
Participants’ devices	4.26	–
Internet transfers (Zoom)	0.43	–
Travel	–	1210–2493
Total	4.70	1210–2493

Since scientists nowadays primarily work with these electronic devices anyhow, it does not have any significant impact on the average day carbon footprint of a scientist, if he or she joins a virtual conference or works otherwise at the computer.

For Comparison: Other Possible Actions to Reduce Conference Emissions

Many scientific organisations have started to promote policies and programmes to reduce the carbon emissions caused by their conferences. Unfortunately, some of these measures are not very effective. One of these policies is eliminating printed conference programmes since the production of paper and the printing process itself has a considerable carbon footprint. ECPR, for example, offered the attendees for the 2018 GC in Hamburg to choose whether they wish to receive a printed conference programme in addition to the online version. Yet, as the following estimation shows, this action is mostly symbolic. The estimation of the carbon footprint of printing the conference programme is based on emission factors (per page) from a Finnish study (Pihkola et al., 2010) that applies a life-cycle approach—from paper production to disposal—to estimate the emissions for a heatset offset printed magazine (which is a similar print product as the ECPR GC conference programme). Figure 2.11 shows the potential reduction of GHG emissions if the ECPR completely abstained from handing out printed conference programmes. The emissions from the whole life-cycle of the 215 pages long Hamburg conference programme are estimated between 565 and 930 g CO₂-eq (mostly depending on whether recycled paper and green energy are used for production, and particularly whether it is recycled or comes to a landfill after usage). Abolishing the printed programme would have resulted in a GHG reduction of 1.1–1.9 tons CO₂-eq, which is about two times the average carbon footprint of an attendee at the Hamburg conference (baseline estimation). Thus, while every action taken to reduce the carbon footprint of conferences is very welcome (also from the point of raising awareness), the optional choice to not take a printed conference programme as offered by the ECPR indeed has a very limited impact on the emissions.

Fig. 2.11 Potential reduction of total carbon footprint by alternative approaches at the ECPR GC 2018 in Hamburg

Another option to reduce the carbon footprint of conferences could be to switch the catering to vegetarian or vegan. According to a British study, daily GHG emissions are 5.93 kg CO₂-eq for meat-eaters, 3.85 kg for vegetarians and 2.94 kg for vegans (Scarborough et al. 2014). Thus, if all 1930 participants of the Hamburg ECPR GC follow a strict vegetarian/vegan diet instead of eating meat during the entire four days of the conference, this would mean a GHG reduction of 16.1 t for vegetarian and 23.1 t for a vegan diet (see Fig. 2.11).²⁰ While the reduction potential of vegetarian/vegan catering is significantly larger than that of abolishing the printed conference programme, it would still have only a small impact compared to the 905–1825 t of CO₂-eq that participants emitted by travelling to the Hamburg conference.

Conclusion and Recommendations for Concrete Actions

In this article, I estimated the carbon footprint (total and per attendee) of the ECPR General Conferences as an example for major scientific meetings. It became evident that the pattern of today’s conference business is

far from being sustainable. Average emissions per attendee of 0.5–1.4 tons CO₂-eq (for the six conferences that took part in Europe)—not to mention the 1.7–3.4 tons for the Montreal conference in 2015—cannot be justified when climate experts tell us that every human is only allowed to emit about 2.5 t CO₂-eq per year in the medium run (by 2030), and even only 0.7 t by 2050, in order to limit global warming to 1.5 °C compared to the pre-industrial age.

The good news is that significant improvements are possible! My estimations have shown that a combination of three measures has the potential to reduce the travel-induced carbon footprint of ECPR GCs by 78–97 per cent. All these measures are not ECPR-specific but could also help to reduce GHG emissions of other conferences. These measures are: (1) selecting a more centrally located conference venue; (2) promoting low-emission land-bound travel options, so that attendees choose means of transportation that emit less carbon, even if this comes along with longer journey times; and (3) introducing the option of online participation in the form of hybrid conferences, particularly for colleagues from far away. Other disciplines already show that the goal of climate-neutral conferences is not a phantasm but can become a reality if the organisers take the problem seriously (Balanzat, 2020; Bankamp & Seppelt, 2013; Bossdorf et al., 2010).

According to the results above, I have the following recommendations for conference organisers:

1. While it may be unrealistic to have conferences only in very centrally located cities such as Frankfurt, the potential GHG emissions associated with the location of the conference venue should also be taken into account when organisers decide about where conferences should take place. For a European conference, such as the ECPR GC, venues taking place outside of Europe (as 2015 in Montreal), or on islands which require all participants to fly (as 2011 in Reykjavik), should be avoided, whereas cities well accessible via the European high-speed network should be prioritised.
2. Organisers should test the options of introducing hybrid formats and the opportunity of online participation at conferences. The estimations above have shown that online conferences produce only a negli-

gible amount of GHG compared to the travel-induced carbon footprint of regular conferences. Encouraging examples of workshops and panels with online attendance, and even conferences that take place entirely in the virtual sphere, have already existed for some years and can hence serve as examples to learn from (Avery-Gomm et al., 2016; Balanzat, 2020). With a great many conferences that had to switch to online due to the COVID-19 pandemic in 2020, organisers, as well as participants, were able to gather a multitude of experiences in that regard. Of course, this helps to further enhance these types of scientific meetings. Throughout one of these COVID-19-caused virtual conferences, many researchers might have experienced for the first time that—albeit not delivering the full experience of a regular in-person meeting—these online events work surprisingly well. Furthermore, switching to online or hybrid formats could not only reduce the carbon footprint enormously but could also promote the inclusion of non-European/non-North American researchers and non-funded junior scientists who otherwise would not have the opportunity to attend the conferences due to high travel costs. Of course, this argument also holds for researchers who are parents or family caregivers for whom travelling for a couple of days is often more challenging to organise. In these regards, online or hybrid conferences are perhaps also a means to advance diversity and equal opportunities within the academic world.

3. In order to promote land-bound travel options which in the estimations have shown to be much less climate-damaging than flying (whether participants choose a coach or a train, makes only a minor difference in contrast—at least as long as the electricity for the trains is not produced primarily by renewables), organisers could also take concrete actions. These actions could take on different forms, from giving simple information during the online registration to raise awareness for the issue of travel-induced carbon emissions, up to voluntary or even obligatory carbon-offset options. Awarding prizes to participants who make the most outstanding efforts in shrinking their carbon footprint of travelling to conferences could, on the one hand, be an additional option to incentivise attendees to choose carbon-neutral means of transportation. On the other hand, it would present

academics as truly caring about climate change and present science positively to the general public. Such a positive picture within the public is particularly relevant for our credibility as scientists.²¹

4. Finally, organisers should document all the actions they take to reduce the impacts on the environment of their conferences—even if these actions are minimal. This is also a matter of awareness and transparency and might help to send a strong signal out to other scientists as well as the general public (Holden et al., 2017).

Implementing these actions could help to reduce the impact of scientific conferences on climate enormously. However, in the end, this transformation can only be successful if we as scientists start to question our conference-hopping behaviour. To be clear: attending two to three international conferences per year in person—and most of us probably know colleagues for whom these numbers may even be too low—can never be sustainable in terms of the carbon footprint. These changes at the individual level will only happen if academia at large—meaning also the institutional level—moves forward in this direction. As a recent article reiterates: ‘we need to develop systems that allow academics to become more effective and efficient at doing their jobs in a less carbon intense way’ (Higham & Font, 2020, p. 7). In the end, such a transformation necessitates more than just calling on individual scholars to reduce their personal, academic footprint and also more than implementing some technical carbon reduction schemes at the department or university level. It requires instead a comprehensive paradigm shift towards decarbonisation in the ways that we cooperate as scientists, measure academic excellence and reward scholars for their academic activities.

Notes

1. Being accepted as a presenter at a prestigious conference is seen as an indicator for scientific achievements. That is also why we find conference participations as a prominent feature of most scientific CVs. In that sense academic conferences are important for scholars as they create ‘a reputation for competence and an image of respectability and honorability’ which is exactly how Bourdieu defines social capital.

2. At the ECPR GC in Hamburg 2018 for example, 3 participants came from home institutions in Africa, 75 from Asia, 29 from Australia, 15 from Central and South America, 76 from North America and 1725 from Europe.
3. See <https://www.transportmeasures.org/en/wiki/manuals/air/air-methods/extra-distance-taxi-time/>.
4. In accordance with the general usage of the term, I subsume not only carbon dioxide (CO₂) to GHG, but also methane (CH₄) and nitrous oxide (NO₂). The overall GHG emissions are presented in CO₂ equivalents.
5. https://www.umweltbundesamt.de/themen/verkehr-laerm/emissionsdaten#verkehrsmittelvergleich_personenverkehr.
6. <https://www.eea.europa.eu/publications/term-report-2014>.
7. <https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2020>.
8. <https://www.transportmeasures.org/en/about-ntm/>.
9. If trains are operated completely with green electricity (see NTM), or air passengers fly in business or first class (see UK), the difference between flying and coach or train rides is even bigger.
10. https://ec.europa.eu/eurostat/databrowser/view/t2020_rd300/default/table?lang=en.
11. The 2011 ECPR GC in Reykjavik had probably a similar or even higher carbon footprint. Yet, for this conference, as for the others before, no paper/presenter details were available.
12. In order to come to a more realistic estimate, it would be necessary to know the average speed of a train on a given route section of the railway network (just as Openrouteservice offers for the street network). Yet, such data is unfortunately not available.
13. A further argument for Frankfurt would be that it has one of Europe's largest airports (4th after London Heathrow, Paris Charles de Gaulle and Amsterdam Schiphol), which serves a lot of direct flights to major cities, thus minimizing the need for longer travel distances due to transfers.
14. Mo–Th 8:45–17:30, Fr 8:45–14:00.
15. A desktop PC consumes about 200 W/hour, Laptops only about 50–100 W/hour.
16. <https://www.whistleout.com.au/Broadband/Guides/How-much-data-does-Zoom-use?>

17. Aslan et al. (2018) estimate an average electricity intensity for internet transfer in 2015 of 0.06 kilowatt-hours per gigabyte. They also show that every two years this value is halved. So, for 2019 a value of 0.015 kWh/GB can be assumed. This value will also be used in this estimation for the year 2020.
18. <https://www.eea.europa.eu/data-and-maps/daviz/sds/co2-emission-intensity-from-electricity-generation-2>.
19. <https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2020>; <https://www.umweltbundesamt.de/presse/pressemittelungen/bilanz-2019-co2-emissionen-pro-kilowattstunde-strom>.
20. These estimates are probably too high, given the fact that a number of participants already are vegetarians or vegans (no more reduction possible), and that ECPR as the conference organiser only offers lunch catering and one reception, so that the majority of meals taken during the conference cannot be influenced by the ECPR.
21. Such a prize already exists at the Society for Conservation Biology, which in 2015 awarded the Swarovski Optik Green Travel Award to two researchers from England who travelled to the Society's conference in Montpellier (France) by boat and bicycle (Rosen, 2017).

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