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Towards Climate Sustainability of the Academic System in Europe and beyond

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Towards Climate Sustainability

of the Academic System in Europe and Beyond

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Executive summary

The urgency of the climate crisis is made abundantly clear by the Sixth Assessment Report from the Intergovernmental Panel on Climate Change (IPCC). The academic system is making an important positive impact by (i) research into the climate crisis and its impact; (ii) research into mitigation and adaptation strategies and technologies; (iii) education of the general public as well as students; (iv) science-based policy advice. In the present report, **we focus on the academic system's negative impact on the climate through its own operations**. As with essentially every sector of society, a thorough transformation is necessary to achieve climate sustainability. In the case of the academic system, this need is accentuated by the following point: **academic institutions provide knowledge on the climate crisis and potential solutions and mitigation strategies, and therefore should also act on that knowledge**. In this way they can also play a leading role in showing how a sector can successfully transition to climate sustainability. **Data on greenhouse gas (GHG) emissions indicates that significant changes are necessary for the academic system to reach climate sustainability** (see Box 1).

For the academic system to reach climate sustainability, a change in culture is required, where individuals and institutions become aware of their climate impact and act to reduce it. Such a change in culture also requires a change in the framework conditions. Even the first steps towards climate sustainability require coordinated actions by various stakeholders in the academic system. Firstly, **the most central component of the academic system are universities and research institutes, and their GHG emissions come from various parts of their operations**. Furthermore, universities and research institutes set standards and framework conditions for students and academics. Secondly, **substantial input to framework conditions and in particular to shaping the current mobility culture in the academic system comes from conference organisers, academies and learned societies**. Thirdly, funding organisations produce GHG emissions in their own operations, but, more importantly, **funding organisations can set incentives for researchers to conduct research in a more climate-sustainable way**. In particular, in their support of prominent and highly visible individuals and research projects, they can set trends towards climate sustainability in the broader academic community. Fourth, **ranking agencies set incentives in a more indirect way and fifth, policy-makers set the larger framework conditions in the academic system.** Finally, **individual people, including students, make up the academic system and through their behaviour and choices can avoid or reduce GHG emissions.**

Some stakeholders are now beginning to engage with the topic of their GHG emissions and are even implementing first steps to reducing them. Additionally, some stakeholders have set reduction goals for the coming years and decades.

As a common theme across all stakeholders, we find that the current evidence base needs to be extended. In this report, we collect examples from across different stakeholders in the academic system in Europe, providing an indication of the climate impact of the academic system. **Where climate reports exist, they are often incomplete, leading to an underestimation of emissions.** This affects, for example, universities, where, with very few exceptions, climate reports are not

Box 1: Selected examples of greenhouse gas (GHG) emissions from the academic system *(additional data can be found in the main report)*

GHG emissions from European universities are reported to range from 1 t to more than 30 t CO_2-equivalent emissions per employee. This large variation is mainly due to the inclusion of different sources of emissions. Universities at the lower end of this range tend to include fewer sources, often focusing on emissions from electricity consumption and heating, whereas universities reporting higher emissions typically include more sources of emissions, for example transport, supply chain emissions and emissions related to building activities.

GHG emissions have been reported from several individual research institutes and are often directly tied to the research activities. For instance, in astronomy, one research institute reports about 18 t CO_2-equivalent emissions per researcher. The main sources are air travel and electricity use, the majority of which is related to computing. As a second example, two laboratories in the life sciences report about 4 t CO_2-equivalent emissions per researcher. The main sources are air travel and electricity use.

For individual academics, air travel to conferences can be an important source of GHG emissions. On average, about 1 t CO_2-equivalent emissions per participant arise for an international in-person conference.

Funding organisations do not yet report the GHG emissions associated with the funded research. From their own operations, examples exist regarding grant interviews. For an international panel of referees and international group of applicants, GHG emissions can amount to more than 1 t CO_2-equivalent emissions per interview.

comprehensive across all scopes of emissions. There is no common standard for the reporting of emissions, either for universities or, more broadly, for academic institutions.

Climate reports do not exist for all stakeholders. For instance, we are not aware of a funding organisation that has published even a rough estimate of the GHG emissions of the funded research.

Therefore, extending the evidence base is critical to ensure that steps are being taken towards climate sustainability do indeed target the most significant sources of emissions.

It is important to remember that climate reports are only a means towards the end – they can typically show where reductions are easily achievable and they also facilitate medium-term plans for those emissions that are more challenging to eliminate. Climate reports can also make it possible to set meaningful and quantitative reduction goals. However, it is critical that the extension of the evidence base proceeds in parallel with concrete actions that reduce GHG emissions.

From the examples that exist, it is clear that air travel is a major source of GHG emissions within the academic system. This is perhaps not surprising, because air travel is relevant to the current typical modes of work for all stakeholders in the academic system and across all disciplines. Because physical mobility and internationalisation are key aspects of academic life, finding a solution to the problem of these emissions is particularly challenging.

At the same time, emissions from air travel may not necessarily be the most significant source of GHG emissions for a given organisation. Climate reports from stakeholders that have measured their GHG emissions in all scopes, primarily some universities, show that other sources, such as buildings, electricity and supply-chain emissions, may be equally or more important emission sources. Reaching climate sustainability will therefore require focusing on a broad range of emission sources. Reducing some of these emissions can be achieved by individual stakeholders, whereas others require coordinated actions among many stakeholders, and even with other actors in society.

A key ingredient of the transition to sustainable academia relies on virtual interactions to maintain international exchange while reducing physical mobility. Many lessons have been learned over the past two years of the COVID-19 pandemic and the development of new formats adapted to the opportunities and challenges of virtual interactions continues. **We envision in-person, hybrid, hub-based and fully virtual events to coexist in the future, with a careful choice of format depending on the goals and participants of a given event. This comes with an important side benefit – the easier inclusion of researchers with care responsibilities and researchers from the Global South.**

An important challenge and simultaneously opportunity in the transition to a climate-sustainable academic system is the high degree of autonomy inherent and important to the academic system. While this can be an impediment to top-down approaches to reforming the academic system, it is at the same time a big opportunity. As group leaders, referees, committee members and science managers, academics set their own framework conditions and thus share the responsibility for implementing more sustainable practices in their respective spheres of action. This is part of the larger cultural and systemic change required for a transition to a climate-sustainable academic system.

At the end of our report, **we provide a list of recommendations that aims to be very concrete, instead of just advancing overarching principles and general guidelines.** There are recommendations that pertain to the academic system as a whole. Additional recommendations are specific to individual stakeholders; several recommendations also require cooperation between different groups of stakeholders in order to be implementable.

We consider the implementation of these recommendations as a first step for the academic system to become more climate-sustainable, but invite all stakeholders to engage in a dialogue in which a vision for a fully climate-sustainable academic system is developed, together with pathways for reaching it.

Guide for the busy reader

This report is structured as follows:

» The **Introduction** (Chapter 1) explains the **aim and context of the report** and addresses specifics of climate sustainability in the academic system.

» Chapter 2 introduces the stakeholders, the **three emission scopes**, reporting standards in the academic system and methods used in compiling the report.

» Chapters 3–11 discuss **individual stakeholders.** Each chapter on an individual stakeholder contains an introduction which **explains the relevance of the stakeholder to climate sustainability** in the academic system. The second part of each chapter contains, where available, **data on GHG emissions** from the stakeholder group and **current practices** of engaging with climate sustainability.

» **Recommendations and further considerations** are provided in Chapters 12 and 13. Chapter 12 focuses on several overarching topics, such as the importance of an evidence base and the choice of meeting formats. Chapter 13 focuses on individual stakeholders as well as groups of stakeholders.

» The **recommendations** are based on and founded in Chapters 3–11, which discuss GHG emissions of individual stakeholders and current practices of engaging with climate sustainability. The recommendations can be read without reading the previous sections. However, an explanation for many of the recommendations can be found in the discussions in Chapters 3–11.

» In addition to the Executive summary, **summarised information** can be found at the start of Chapters 3–11 on each individual stakeholder in the form of a **synopsis**.

» Readers interested in **universities** can turn to Chapter 3 (introduction and current practices) and 13b (recommendations). The climate impact of **research activities**, some of which are conducted at universities, is addressed more specifically in Chapter 4, with recommendations in 13c. Further, **students** and **individual academics** are discussed separately in Chapters 5 and 6, with recommendations in 13d and 13e.

» Readers interested in **research institutes** can turn to Chapter 4 (introduction and current practices) and 13c (recommendations).

» Readers interested in **students** can turn to Chapter 5 (introduction and current practices) and 13d (recommendations).

» Readers interested in **individual academics** can turn to Chapter 6 (introduction and current practices) and 13e (recommendations).

» Readers interested in **funding organisations** can turn to Chapter 7 (introduction and current practices) and 13f (recommendations).

» Readers interested in **conference organisation** can turn to Chapter 8 (introduction and current practices) and 13g (recommendations). Additionally, **virtualisation of meetings** and a **mix-and-match approach to meetings** are discussed in the recommendations in Chapter 12.

» Readers interested in **academies and learned societies** can turn to Chapter 9 (introduction and current practices) and 13h (recommendations). Readers interested in academies and learned societies as conference organisers can turn to Chapter 8 and 13g.

» Readers interested in **academic air travel** can find discussions in Chapter 3 (universities), Chapter 4 (research institutes), Chapter 5 (students), Chapter 6 (individual academics), Chapter 8 (conference organisers) and the corresponding recommendations in Chapters 13b, c, d, e and f, as well as recommendations on meeting formats in Chapter 12.

1. Introduction

The Sixth Assessment Report from the IPCC emphasises the rapid progression of the human-made climate crisis, which contributes to many observed changes in weather and climate extremes. The impact of the climate crisis affects virtually every region on the planet, increasing the likelihood of extreme weather events such as hot extremes, heavy precipitation and droughts (IPCC 2021). Consequences of the climate crisis include the partial or complete loss of ecosystems and biodiversity, dangers to multiple inhabited regions from raised sea levels, negative impacts on crop yields, food security and water resources, and dangers to human health and impact on livelihoods (IPCC 2014a; 'Summary for Policy-makers'). To meet the Paris Agreement and limit global warming to 1.5°C or at most 2°C, swift and transformative change needs to happen across all sectors of society, industry and politics.

This report focuses on the role of the academic system in this transformation, as it pertains to the day-to-day operations and long-term strategy within the system. Research into the earth system and into technologies to mitigate the effects of climate change, cut greenhouse gas (GHG) emissions and reabsorb GHGs is critically important. This importance is widely acknowledged by governments, funding organisations, research institutes and universities and is not the subject of this report. Similarly, while education about sustainable development is a crucial area in which universities contribute to climate change mitigation, this aspect is not discussed in this report.

Instead we focus here on a third role of the academic system: on the GHG emissions from the academic system itself, which arise, for example, from energy used on university campuses and from academic mobility. To put these emissions into context, we should remember that the 2021 IPCC report estimates a carbon budget of 300 gigatons for an 83% chance of limiting global warming to below 1.5°C (IPCC 2021). In the academic system, per capita metrics are often used (to enable comparability across institutions of various sizes), for example to report GHG emissions of universities, research institutes or conferences. Therefore, a relevant comparison is to an estimated 1.1 t CO_2-equivalent emissions per capita per year until 2050.[1] This number is of course affected by a systematic uncertainty, and should therefore be viewed as providing a rough orientation, not an exact estimate. Nevertheless, the comparison with estimated per capita emissions within the academic system is highly informative, and indeed worrying: for instance, a low estimate of the average emissions across a number of European universities (typically neglecting several sources of emissions) amounts to more than 4 t per employee per year (see Chapter 3), a report from a research institute in astronomy estimates more than 18 t per researcher per year (see Chapter 4), a report from laboratories in the life sciences estimates 4 t per researcher per year (see Chapter 4), estimates from numerous conferences amount to 1 t on average per participant for a single conference trip (see Chapter 8), and estimates for the decision-making process of a European-level research grant amount to more than 1 t per interviewed candidate (see Chapter 7). These examples highlight a more general picture: the academic system is currently not climate-sustainable. The focus of this report is therefore three-fold: we collect data on GHG emissions from various organisations within the academic system, we review current practices aimed at reducing GHG emissions, and we formulate a set of recommendations.

Let us emphasise that while this report focuses solely on climate sustainability, we are aware of and concerned with other environmental crises such as water and land pollution, as well as the biodiversity crisis. We believe that academic institutions should also play an important part in addressing these issues as well, and that in many cases unified approaches may exist. These, however, go beyond the scope of the present report.

1 This estimate uses the population model underlying the equivalent estimate for 420 gigatons and a 66% change to remain below 1.5°C presented at https://www.atmosfair.de/en/green_travel/annual_climate_budget/

1a. Aim of this report

Achieving a climate-sustainable academic system is an important goal, driven by the urgent need to transform society as a whole in light of the climate emergency. As we pursue this goal with the utmost urgency, we must do all we can to ensure that the essential values we work towards realising in the academic system – including academic freedom, high-quality research and international collaboration, but also the aspirational values of fairness and equality of opportunity – are preserved during the transition period, and can flourish in the future climate-sustainable academic system.

Against this background, the aim of this report is to assess current practices and to critically examine current and proposed measures. Some measures that are designed with climate sustainability in mind could have unintended consequences and compromise core values like the freedom of research, quality of research, or equality of opportunities. Therefore, in order to deliver a transformation that preserves these values, an in-depth deliberation that critically examines arguments for and against certain measures is needed. Such a deliberation must also factor in that the academic landscape is diverse across geographical regions, even within Europe, the region this report will focus on.

1b. Systemic and individual change together enable cultural change

To facilitate a transition to climate sustainability in the academic system,[2] systemic change and individual change must go hand in hand. Attempts to implement systemic change are bound to fail if they do not find 'bottom-up' support from individuals and result in behavioural changes. Similarly, 'grassroots' initiatives on their own do not suffice to make the academic system climate-neutral.

To transition to net zero emissions in the academic system, the academic culture must change. All cultures are the sum total of individual behaviour, which is shaped by the framework conditions (some imposed by natural limitations, some human-made; some immutable and some open to change) in which the culture exists. The same is true for the academic culture when it comes to climate sustainability. Accordingly, this report will focus both on individuals and the changes they can implement, as well as organisations which determine the framework conditions for individuals (while they themselves are also both governed by individuals, and themselves constitute individual entities within a larger set of framework conditions). The report will discuss individuals[3] as well as organisations and structures (universities, research institutes, funding bodies, conference organisers, learned societies and academies, ranking agencies, and policy-makers and governance) as relevant stakeholders for a climate-sustainable academic system. As an important characteristic feature of the academic system, it is self-determined to a much higher degree than many other sectors in society: the framework conditions in the academic system are set by law, but within this framework, members of the academic system, e.g. presidents or rectors of universities, directors of institutions, presidents of academies and disciplinary societies, management of funding organisations, etc. have significant freedom to shape the academic system. Further, as referees and members of commissions or committees, many researchers have significant impact on decision-making processes in the academic system. This high degree of self-determination can be used to design and implement a process that will make the academic system climate-sustainable.

1c. Is the sustainability of the academic system a new issue?

Academic institutions have been involved in efforts to achieve sustainability for decades. A milestone was reached in 1990, when more than 500 university representatives from over 50 countries signed the international Talloires Declaration (Association of University Leaders for a Sustainable Future 1990),

2 Climate sustainability of an organisation (or a sector of society) is a vague term. It could mean net zero emissions, which could be reached through significantly reduced emissions compared to a baseline value (e.g. today) and where remaining emissions are offset or compensated (e.g. through natural carbon capture). It could also mean significantly reduced emissions, where the remaining emissions are compensated by other societal stakeholders, not by the organisation itself. Finally, it could also mean zero emissions. Which of these the academic system should fulfil is a question that societies and policy-makers in a given country or larger region (e.g. the EU) have to answer. Therefore, for the purposes of this report, we will not adopt any of these definitions. Because all three versions of climate sustainability require a very substantial reduction in emissions, the first steps towards climate sustainability are the same in all cases.

3 For the most part, our discussions of individuals focus on **researchers** and **students**. These discussions extend to other staff (non-research academic, managerial and support). Our extensive treatment of academic mobility is, however, specific to researchers.

which argued that higher education institutions had a responsibility to engage in urgent action to mitigate the drastic consequences of climate change as well as other environmental crises. Aside from its core role in providing sustainability education and research, the university was seen as a role model, which ought to demonstrate to society that a more ecologically responsible way of performing work is possible. The recommendations of the Talloires Declaration therefore included that universities engage in what became known as 'campus sustainability' activities such as recycling and conserving energy.

Three decades later, sustainability education as well as sustainability research and sustainability campus initiatives are more widespread and have become a prominent feature of higher education. However, new insights into the most harmful and beneficial practices of organisations and individuals have brought with them a new awareness of what sustainability in higher education entails. Recycling and energy conservation no longer suffice to be a 'green' university; areas like building construction and maintenance, procurement, food and mobility have come into focus as important contributors to a university's ecological impact which need to be addressed.

At the time of writing this report, climate sustainability of the academic system is being recognised more and more widely as an important goal, and various representatives from various groups of stakeholders have recently started to engage with this topic. These include, for example:

1. A growing list of universities setting GHG emission targets, including a number of universities aiming to reach climate neutrality on their campuses within the next decade or even by 2025.

2. Funding organisations, conference organisers and individual researchers engaging with virtual mobility as a tool to connect researchers internationally at a significantly reduced carbon cost.

3. Research fields with energy-intensive experiments and laboratories starting to consider GHG emissions as a major cost of research that can no longer be ignored.

4. Students demanding that universities not only ensure climate literacy through their teaching but become leaders in showing how large public enterprises can reach climate neutrality.

By now, initiatives aiming at climate neutrality of the academic system as a whole, i.e. beyond just universities, have spread to several countries in the European region. For instance, the Alliance of Science Organisations in Germany (which includes research institutes like the Max Planck Society, university representatives through the conference of university rectors, funding organisations like the German Research Foundation and the Humboldt Foundation, as well as academies like the National Academy of Sciences, Leopoldina), has recently declared its intention to reach climate neutrality by 2035 (Allianz der Wissenschaftsorganisationen 2021). In that context, it has called upon the federal and regional German governments to provide the regulatory framework and financial means to reach this goal.

Most recently, the 'Hamburg Declaration' (Global University Leaders Council Hamburg 2021) reaffirmed that "universities are uniquely positioned to lead society to a future of environmentally sustainable development and to promote mitigation of climate change". As one of its recommendations, the Hamburg Declaration calls on universities worldwide to "make plans for reaching carbon neutrality on [their] campuses at a specified date, appropriate for the university and [their] country".

Beyond these longstanding efforts there is currently, however, also a unique opportunity to implement systemic change. During the COVID-19 pandemic, universities were forced to transition to online teaching and key events such as conferences, seminars, collaboration and committee meetings could only be held virtually. Facing this challenge has boosted the technological developments and skills needed for efficient online communication, as well as awareness of the challenges involved. A new equilibrium will need to be sought once the world emerges from the emergency situation of the pandemic, and a deliberate approach to this provides a unique opportunity to, for example, deliberately retain some of the advantages of an increased digitisation of the academic system.

1d. Potential concerns and arguments for and against climate sustainability in the academic system

Is the academic system 'special' and therefore exempt from climate sustainability efforts?

Neither the academic system, nor any of its subfields, is a special sector of society that may be exempt from imperatives to operate sustainably. One might argue that the academic system should be exempt from imperatives to operate sustainably on the grounds of the special role it plays in the transition toward a sustainable society (Kreil 2021): the academic system produces knowledge and technology needed for the transition (and also for other challenges that society faces). Despite this important positive impact, we consider the academic sector to be one of several important sectors of society, none of which should be exempt from becoming climate-sustainable.

We also caution that asking for exemptions or special rules for the academic system would be difficult to communicate to a society in which there is already scepticism about science.

For these reasons, we think that the climate impact of the academic system deserves attention, although the benefits and harms of each proposition must be weighed carefully so as not to sacrifice core functions and values of the academic, as expressed in Section 1a.

Are existing market-based solutions not sufficient?

At the level of the EU, the European Union Emissions Trading System (EU ETS) implements a principle of capping and trading of GHG emissions within the EU. Thus, one may wonder whether additional, sector-internal regulations and policies are required, and whether the academic system needs to be proactive, instead of trusting that the EU ETS will provide a market-based solution to GHG emissions, including those of the academic system. To this, we offer two responses: first, the EU ETS has been in place since 2005. During this period, carbon-intensive practices within the academic system have not significantly and comprehensively decreased.[4] While we are not aware of comprehensive data on the development of academic travel during this time, air travel emissions at large have grown immensely in this period (United Nations 2022), and what data exists gives no reason to assume a decrease in the academic sector (Medhaug 2021a; The University of Edinburgh 2022). A review of analyses of carbon pricing, including the EU ETS, finds a limited effectiveness of the EU ETS in general (Green 2021). Second, the EU ETS does not cover the academic system within the European area in countries that are not members of the EU.

A symbolic move?

All sectors of society, irrespective of the relative share of emissions, are needed to achieve a climate-sustainable society. An argument sometimes advanced against the need to make the academic system climate-sustainable is that the GHG emissions from the academic system as a whole are small compared to total global emissions. One may therefore view programmes and measures that aim to make the academic system climate-sustainable as symbolic. We object to this – climate neutrality requires that overall GHG emissions reach net zero, and no sector can continue 'business as usual'. There are close to 5000 higher education institutions in Europe (European Commission 2022a), with more than 17 million students and GHG emissions in the range of several tonnes per year per person are reported from many of those universities that track their GHG emissions. As examples in this report will highlight, per capita emissions in the academic system can be very high.

In addition, symbolic moves can be both necessary and powerful. Transitioning into a climate-sustainable society requires changes in policy and framework conditions, as well as social norms and individual behaviours. To bring about such a cultural change, which is driven by a shift in values, symbolic moves can be key. Their inspirational power can trigger larger changes. The academic system now has the opportunity to lead and inspire and make a symbolic move in the best possible sense of the word.

4 For instance, while some individual universities have decreased their reported GHG emissions, typically those linked to electricity consumption, e.g. University of Bournemouth, University of Copenhagen, University of Dublin, University of Ghent, University of Plymouth, many of these have seen intermediate increases in emissions, while others have not reported any decrease and many universities do not even evaluate their GHG emissions, nor take steps to reduce them. (See Appendix A for the corresponding references).

Is academic freedom in danger?

Academic freedom amounts to "the right, without constriction by prescribed doctrine, to freedom of teaching and discussion, freedom in carrying out research and disseminating and publishing the results thereof, freedom to express freely their opinion about the institution or system in which they work, freedom from institutional censorship and freedom to participate in professional or representative academic bodies" (UNESCO 1998). We believe that these freedoms have to be safeguarded. That said, these fundamental freedoms have always been subject to limitations. These include limitations of resources (financial and natural), as well as ethical regulations of research practices. The urgency of the climate crisis requires that climate sustainability be taken into account in research, dissemination and education, too.

The urgency of the climate crisis made clear through the academic system's reaction to it

A powerful way to show the urgency of a problem is to act on it.[5] The urgency of the climate crisis has been emphasised by climate researchers for many years, but the academic system as a whole has not acted upon it at the scale appropriate given the urgency. Instead, a certain complacency in the academic system's reaction to the climate crises can be observed. To the public, this may signal that the academic system is not taking the crisis very seriously.

We argue that even the effectiveness of scientific policy advice could (although by no means exclusively) depend on this. As an example, we take the COVID-19 pandemic, where scientific policy advice was followed closely in many countries. In this case, the academic community responded to the urgency of the crisis just like any other sector of society. For instance, universities and research institutes went into lockdown, scientists followed their own guidance regarding the use of masks, etc. This is in contrast to the climate crisis, where the academic community – although naturally best-disposed to understand the urgency of the crisis – has not responded in a similar way. We argue that the impact of science communication and scientific policy advice on the climate crisis will be higher, if the academic system becomes a sector of society that is leading in the transformation to climate sustainability. For this, it is crucial that actual and visible change happens in how the academic system operates, and there is no 'greenwashing' in place of meaningful change.

Proactive, self-determined change now vs externally determined rules and regulations later

Given the urgency of the climate crisis to which governments are starting to increasingly respond, the academic system can now make a decision: right now, the academic system can react proactively and self-determine how to change to become more climate-sustainable. This can be done in such a way that across-the-board rules are avoided, decisions are well deliberated and balanced and account for the needs of various disciplines, career stages and geographic regions. In short, we believe that a proactive, self-determined transition to climate sustainability can avoid harming research quality and international collaboration. Given its high degree of self-determination, the academic system is uniquely positioned to implement such changes, because many of its framework conditions are self-determined. In contrast, if the academic system does not undertake these steps now, policy-makers might decide at a later time to regulate GHG emissions from the academic system, with less opportunity for stakeholders to have an active say in how these regulations are imposed and who they affect. Thus, we consider it important for the academic system to now take proactive, self-determined steps to becoming climate-sustainable.

Compatibility of the transition with core values of the academic system

A change effort to achieve climate sustainability in the academic system should occur in accordance with core values achieved or aspired to within the academic system. It should further be mindful of the needs of certain groups within the academic system, who are perhaps especially vulnerable to a systemic change.

In particular, it is important to us as the authors of this report that the opportunities for early career researchers to develop their careers and deliver high-quality research are kept in mind as a key priority throughout any change programme.

We are further aware that many suggested changes, such as increased virtualisation of conferences,

5 At the level of individual researchers, there is evidence that researchers who are seen to have small carbon footprints are more credible and effective in their public communication about needed climate change mitigation action (Attari et al. 2019; Sparkman and Attari 2020).

have deep implications for inclusivity and equality of access: they can increase accessibility for some groups presently facing disproportionate barriers to knowledge dissemination and networking (e.g. researchers with care obligations; researchers living with disability; researchers, in particular from the Global South, with no or insufficient access to travel funds). However, some of these researchers (as well as others) may not have access to high-level internet connections and the necessary hardware for virtual communication. Without solving the challenge of this 'digital divide', side benefits from increased virtualisation of conferences are more difficult to reap. This is only one example of a policy option that requires careful evaluation and tailoring.

1e. Two categories of emissions and focus on air travel

Academic institutions produce, broadly speaking, two categories of emissions. These fall into the three scopes of emissions (direct, indirect from energy consumption and indirect from other sources) that are commonly used to report emissions from organisations according to the GHG protocol. We will discuss the three scopes later; here, a different definition of categories specific to the academic system is important: the first category is similar to other private or public enterprises, and associated with building infrastructure and corresponding energy needs, supply of various goods such as office furniture and canteen food. The second category is specific to and/or deeply intertwined with research activities, including for instance, air travel linked to, for example, conferences, and discipline-specific emission sources, such as emissions from laboratories or experiments or emissions associated with (super)computing. Air travel is of course an activity not specific to the academic system; however, it is currently very closely connected with international exchanges of knowledge, international collaboration and international mobility, all of which are activities at the heart of the international academic community. We will call this category 'research-relevant' emissions in the following.

Many sources in the first category constitute a critical problem beyond the academic system, with significant research into solving these problems already existing or under way. In contrast, the second category is deeply intertwined with key needs of researchers, such as the need for international collaboration, the need to conduct experiments and the need to use computing power – for instance for climate modelling itself. This makes finding a solution to the problem of these emissions particularly challenging. Furthermore, this is a problem that is specific to the academic system and that other sectors of society do not share, or at least not in the exact same way. Therefore, we will place a particular focus on this second category in our report. Out of this second category, air travel in the academic system is already comparatively visible in discourses on climate sustainability; in this report, we will also highlight other emission sources in the research-relevant category.

From within this category, we in particular focus on air travel. The reason for this is three-fold: first, air travel is relevant (to a somewhat varying degree) to the current typical modes of work for all stakeholders in the academic system and across all disciplines. Second, air travel is a significant source of emissions for many stakeholders in the academic system (see, for example, Chapter 3 on universities and Chapter 4 on research institutes), often constituting one of the largest sources of emissions. Third, the emissions from laboratory experiments and computing are not relevant for all disciplines and understanding how to reduce them requires an in-depth understanding of the mode of operations and research topics as well as methods in the corresponding disciplines. We therefore mostly leave such more specific discussions to reports from within the corresponding disciplines; see, for instance, Bloom et al. (2022); Boisvert (2020); Matzner et al. (2019); Stevens et al. (2020); van der Tak et al. (2021).

2. Introduction to chapters on relevant stakeholders

In the following, we dedicate one chapter to each of the relevant stakeholders. We begin with universities as key stakeholders for a climate-sustainable academic system. They also exemplify institutions that are, on the one hand, part of the structures and framework conditions within which research operates and, on the other hand, individual entities within the larger context of the academic system's transition to climate sustainability. We subsequently discuss research institutes, which share some aspects with universities, while highlighting the problem of emissions from research-relevant activities.

Next, we discuss stakeholders that consist of individuals (researchers and students), before moving on to stakeholders who are part of the structures and framework conditions of research (funding bodies, conference organisers, learned societies and academies, ranking agencies and policy-makers).

In the first part of each chapter, we outline the role that the respective stakeholder plays in a transition toward a climate-sustainable academic system: we discuss how each stakeholder is implicated in carbon-intensive practices, their responsibilities and how they might influence the academic system; and we also pay attention to the specific needs and vulnerabilities each stakeholder may have when it comes to consuming carbon, which need to be kept in mind in order to design a socially fair and acceptable transition.

In the second part of each chapter on a stakeholder, we provide a semi-quantitative overview of the current status of GHG emissions in the academic system. We summarise available data on GHG emissions from various stakeholders and review current practices aimed at reducing those emissions.

At the time of writing, an increasing number of stakeholders are recognising the need to become climate-neutral and are either considering how to implement first steps or have already implemented them (see Section 1c). Given this current encouraging development, this report provides a snapshot of climate sustainability in the academic system in Europe at the end of 2021/beginning of 2022. This snapshot shows that a variety of initiatives exist across many of the key groups of stakeholders, but these initiatives have not yet converged towards a larger overarching strategy, in which the academic system as a whole puts the climate sustainability of its own operations on its agenda. We hope that this report can contribute to such a process of convergence by highlighting many initiatives across many groups of stakeholders and many regions. We further hope that the examples provided can inspire those individuals and organisations which are not yet engaging, or are only engaging to a limited extent, with this topic.

Carbon, CO_2 and greenhouse gases

Throughout the report, we mostly refer to greenhouse gases (GHG), which include carbon dioxide (CO_2), as well as methane, hydrofluorocarbons and others. Emission reports typically report CO_2-equivalent emissions (CO_2-eq), which converts the warming potential of other GHGs into that of CO_2. We follow this practice, but also use the terms 'carbon footprint' and similar throughout the report, where this does not necessarily mean the emissions of CO_2 only, but typically refers to the footprint in terms of emissions of all GHGs, converted into a CO_2-eq.

Scope 1, 2 and 3 emissions

GHG emissions of organisations are typically categorised into three categories, which we will use in the subsections below, where appropriate. In particular, universities typically report their GHG emissions as Scope 1, 2 and 3.

Scope 1 includes all direct emissions from owned or controlled sources. For instance, if a university owns a fleet of vehicles, their emissions fall under Scope 1. Scope 2 includes so-called indirect emissions from the generation of purchased energy. For instance, this includes GHG emissions in electricity production and heating. Scope 3 are all so-called indirect emissions that are not included in Scope 2. This includes, for example, business travel, commuting to work and emissions generated along the supply chain of purchased goods, and GHG emissions from waste disposal and investments (e.g. if a university invests in endowment funds).

Agreed-upon standards in reporting GHG emissions and methods of calculating GHG emissions

In the academic system, there is currently no agreed-upon standard for reporting GHG emissions. For instance, among those universities that report their emissions, a varying range of sources is included in the reports; from Scope 1 and 2 emissions only, to parts of Scope 3 emissions and individual attempts to estimate all GHG emissions from Scopes 1, 2 and 3. Thus, a comparison of different institutions in the academic system is difficult and cannot be done reliably by simply comparing the reported GHG emissions, or the GHG emissions per full-time equivalent employee.

In addition, the calculation of GHG emissions from a given source can be difficult. For instance, the flights included in, for example, the reporting of an institution may contain only the flights of members of the institution paid for by the institution itself or may also include other categories such as staff travelling on third-party funding and the travel of guests. Similar ambiguities apply to (invited) speakers to a conference or travel associated with a particular grant or project. Moreover, emissions from air travel can vary depending on the type of plane as well as the route taken between two destinations, among other factors. However, not all reports take these variations into account to the same degree. Accordingly, GHG emissions reported by different institutions for the same type of source (e.g. employee air travel) can also vary in their level of accuracy. In summary, reported GHG emissions from institutions in the academic system should be understood as coming with a sizeable error bar, which itself is difficult to quantify.

Methods used in compiling this report

We are not aware of systematic reports on the GHG emissions from the academic system as a whole. GHG emissions from universities are reported by some individual universities; the same is true for research institutes as well as other organisations in the academic system. A focus of systematic research is on academic flying (De Jonge Akademie (2020); Hoolohan et al. (2021); also Bjørkdahl and Duharte (2022) and references therein), whereas a few studies consider climate sustainability of universities, but typically focus on selected examples; see, for example, McCowan et al. (2021). Omazic and Zunk (2021) conduct a semi-systematic literature review on the broader topic of sustainability in higher education institutions and identify a research gap on the topic of campus sustainability. In compiling this report, we have therefore proceeded as follows: sections that address academic flying draw systematically on the available literature, as well as the expertise represented within the working group. Sections that address the overall climate impact of various stakeholders largely focus on examples. We have not conducted a systematic study that allows us to claim that, for example, GHG emissions from those universities or research institutes we highlight are representative, in particular not of geographic regions not covered by the examples. We consider them as examples that provide a rough first understanding of the climate impact of the academic system, but highlight that a more comprehensive evidence base is needed. Within our report, we have largely focused on reports and papers in English, German, Danish and Swedish, with individual examples in Italian and Spanish. In addition, we have searched both in general for climate reports from universities in Central and Eastern Europe, as well as on the web pages of different universities in these regions. We have found little evidence that climate reports are released by universities in Central/Eastern Europe, but stress that this absence of evidence is not evidence of an absence.

3. Universities

Synopsis

- » Universities have a central role in society in generating knowledge as well as creating and enhancing individual, social and collective learning systems and are thereby positioned as a key player in fostering sustainable development.
- » Some universities have recently published their first reports on their own GHG emissions. These reports typically include a subset of GHG emissions and are typically not complete in Scope 3 emissions.
- » There is no agreed-upon standard for the reporting of emissions, which is a challenge to setting meaningful emission reduction goals.
- » University operations give rise to a variety of GHG emission sources, such as air travel, buildings, heating, electricity and purchasing of services and goods.
- » Those examples that exist from universities that have reported emissions in Scope 1–3 indicate that Scope 3 emissions are much more significant than Scope 1 and 2. Within Scope 3, transport (including air travel) is important, but emissions from the supply chain may be equally or more significant.
- » For air travel, long-distance flights account for the majority of emissions, even though they constitute a minor fraction of the total number of flights.
- » One specific best-practice example for a travel policy resulting in emission reductions focuses on the inclusion of researchers.
- » When reducing emissions from air travel, it is important to continue to support internationalisation, international exchange and collaboration.
- » Some universities have now started setting their own emission reduction goals but these are difficult to compare because, just like for reporting GHG emissions, there is no agreed-upon standard scheme for how this should be done. Many reduction goals come without a concrete pathway on how they will be achieved and what the role of offsetting is.
- » The academic freedom, the high degree of autonomy among individual researchers and decentralised structure of many universities may hamper the chances of university leadership enforcing effective top-down measures to reduce emissions from their own operations.

3a. Introducing universities as relevant stakeholders

We begin this report with a focus on universities, which are central organisational units in the academic system and also the most considerable part of it in many respects. Further, the Higher Education Act of many European countries emphasises a broad societal role of universities, which in our view places an imperative on universities to play a key role in climate sustainability.

Universities are relatively autonomous organisational entities with clear boundaries, and have internal policies, common infrastructure available to their employees and students, and their own funds, all of which university management can influence (if often through long and complex processes and within limitations, in particular when it comes to funding). They also represent relatively cohesive (and locally concentrated) social collectives, often with a historically grown sense of identity and purpose and a certain confidence in acting as a collective agent, which facilitates collective organising among individuals. These are two factors that make universities promising as agents – or, more accurately, vehicles and places – of change for climate sustainability in the academic system. The roles that universities can play in a positive transformation toward sustainability are manifold. They can pursue a holistic approach in which sustainability is considered in research and teaching, and reduce emissions caused by these activities at the same time; both aspects are mentioned for instance in Iyengar et al. (2021). Both of these processes can be pursued within the university, where they influence the decisions of many hundreds or thousands of staff and students. They can also be pursued in alliances with other universities, which together can set norms and influence yet other institutions – including higher-level structures such as learned societies, funding organisations and ranking agencies. While individual universities are presently constrained in their ability to reduce GHG emissions by systemic conditions, such alliances can begin to change these conditions and open up possibilities for transformation.

Given the role of universities in creating and enhancing individual, social and collective learning systems, they are positioned as a key player in fostering sustainable development, by boosting sustainability knowledge generation and transfer at different levels. Activities and tasks focused on sustainable development should be an inseparable part of a university's strategy and structure (Sedlacek 2013).

Many enterprises in society obviously face similar challenges in achieving carbon neutrality as universities do. For universities, the academic freedom and, as mentioned above, the high degree of autonomy among individual researchers, may pose an extra challenge. It has resulted in many academic settings having a decentralised structure. Although a decentralised structure can have many advantages in producing novel research findings, it can at the same time hamper the chances of university leadership enforcing effective top-down measures, especially if it has a negative influence on traditional research practice. This obviously creates a challenge for universities in reaching carbon reduction targets and, specifically, puts extra pressure on all levels of university leadership to act decisively and indeed dare to make uncomfortable decisions that may go against traditional academic practice and culture.

As a final note, we acknowledge that important work toward a climate-sustainable academia is also being done at the level of sub-units of universities, such as research laboratories, departments or divisions.[6] For brevity, we only discuss universities here, but many of the challenges and opportunities facing universities and their organisational sub-units are probably similar and can be generalised from this chapter. We also discuss research laboratories in Chapter 4, on research institutes.

6 See, for example, https://labos1point5.org/ and https://greenyourlab.org/ for corresponding initiatives.

Categories of GHG emissions

University operations give rise to a variety of GHG emission sources. Emissions from air travel are often a big part of the carbon footprint of universities as will be explored below; but major emissions are also connected to, for example, buildings, in particular those housing laboratories, heating/cooling, catering and purchasing services and goods (e.g. chemicals, IT equipment, but also office and teaching materials as well as food). To reach regional, national and international reduction targets, it is thus necessary to address all these various sources of emissions.

Thus, in this chapter of our report we will focus on two points: (i) we will assess emissions that universities have in common with most other public or private enterprises and discuss mitigation strategies; (ii) we will assess emissions that are research-related, focusing on emissions from air travel in this chapter and discussing emissions that are related to experimental facilities, laboratories and scientific computing in Chapter 4 on research institutes below.

We include emissions related to air travel in the second category (the research-specific emissions), despite overlap with business practices in other sectors, because they are so tightly linked to the way in which research is conducted today. They are linked to the internationalisation of universities, including mobility on the part of students and researchers to study, teach and collaborate, and the international exchange of ideas. Although physical mobility is often the mode in which this mobility of ideas is achieved, engendering a large amount of GHG emissions, virtual mobility may often provide suitable alternatives. Online teaching reduces commuting, power consumption on campuses, etc. (see Filimonau et al. 2021), while online conferences reduce emissions related to long-distance travel (Burtscher et al. 2020).

3b. Data on GHG emissions

Universities contribute to society's struggle against a warming planet with valuable input in the form of new research findings and well-educated students. The need for new knowledge and solutions from universities to combat the climate crises is perhaps greater than ever, but at the same time, we believe that the emissions of GHGs from their operations should decrease significantly and rapidly. This naturally poses a major challenge for universities in the coming decade: the following quotation both emphasises the importance of achieving net zero emissions at universities and highlights the challenges associated with the underlying evidence base: “Universities, as innovation drivers in science and technology worldwide, should be leading the Great Transformation towards a carbon-neutral society and many have indeed picked up the challenge. However, only a small number of universities worldwide are collecting and publishing their carbon footprints […].” (Helmers et al. 2021). The case for universities to reduce their GHG emissions is made even more clearly in Borgermann et al. (2022): “Although universities have been leading climate science for decades, most have not taken drastic climate action in their own operations. Sustainable transformation of the university sector requires accounting for all Scope 1–3 emissions and setting science-based reduction targets. It is high time for universities to practice what they preach and move back to the frontline of climate action.”

To answer this call to take a leading role in society’s transition to net zero, universities need to determine their sources of GHG emissions, i.e. place their climate sustainability strategies on a basis of data. This is necessary to make the reduction of emissions visible and accountable. Further, it enables a prioritisation: sources that are large and easy to eliminate (high yield/low cost/effort) can be given early priority; sources that are large and difficult to eliminate can be early targets for the development of mitigation strategies; sources that are small and difficult to eliminate need not become the focus of early actions which absorb efforts that would more efficiently be directed at other sources.

Thus, in this section we first review available data on GHG emissions at universities in Europe, before discussing current practices in the light of this data. As highlighted previously, we are not providing a complete summary of all available carbon reports, but instead provide an overview over many examples.

Overall emissions

In this section, we aim to develop a semi-quantitative understanding of the overall GHG emissions of European universities. It is not yet standard for universities to report these. For instance, only 5% of German higher education institutions reported estimates of their GHG emissions in 2016 (Azizi et al. 2018) and 17% in the UK in 2014 (Sassen et al. 2018). However, this is currently changing, with many universities having published their first reports on their GHG emissions within the last year or two. Similarly, the number of universities declaring a climate emergency is currently rising very fast: for instance in the UK, the University of Bristol was the first to declare a climate emergency in 2019, and 36 more UK universities followed over the next year (Latter and Capstick 2021).

Our report is not a complete account, as we did not perform a systematic study of all higher education institutions in Europe. Instead, we aim to provide a partial snapshot that provides examples for overall GHG emissions of a university as well as examples of current practices. We attempt to account for regional differences, where sufficient data are available, but also observe that in some regions, the climate impact of a university is not typically accounted for.

We use the GHG protocol categorisation of Scope 1, 2 and 3 (Greenhouse Gas Protocol Initiative 2004), because universities that report their GHG emissions typically use these categories. We briefly repeat the definitions of Scope 1, 2 and 3 here: Scope 1 includes direct emissions from owned and controlled sources. This can, for example, include emissions from vehicles a university owns and emissions from laboratories/experiments. Scope 2 includes so-called indirect emissions arising from purchased electricity and heating. Scope 3 includes all other so-called indirect emissions, e.g. supply-chain emissions (e.g. of office equipment, canteen food, as well as laboratory equipment and laboratory supplies), emissions generated through waste disposal, emissions from business travel and employee commuting as well as emissions from investments.

To obtain a first estimate of typical emission per full-time equivalent employee, we provide the estimated GHG emissions in Table 1. It is important to keep in mind that these are low estimates, because Scope 3 emissions are only in part accounted for. From Scope 3, typically only the carbon emissions from air travel and service travel are included in a university’s GHG emission estimates. Estimating supply-chain emissions, for instance, is difficult, and typically not attempted by universities.

Therefore, it should be kept in mind that although universities typically report GHG emissions up to the accuracy of 1 tonne, the systematic uncertainty of the estimate is significantly larger; providing an estimate of systematic uncertainties is, however, difficult. To provide an estimate of the size of the university, we also provide the number of staff and students. In fact, many universities with climate reports provide the GHG emissions per student or per full-time equivalent staff member. Reporting GHG emissions per staff member or student is a way of achieving some level of comparability across different universities, although it should be kept in mind that significant differences exist in what sources of emissions are included in reports. In cases where universities highlight that fluctuations in GHG emissions are connected to the pandemic, we report data from earlier than 2020; otherwise we report the most recent data available.

It is also important that there is currently no agreed-upon standard for the reporting of emissions, which makes the comparison between different institutions difficult and is a challenge to setting emission reduction goals. A project aimed at developing a common standard is currently being pursued by the Alliance for Sustainability Leadership in Education.[7]

7 See https://www.eauc.org.uk/advancing_sector_emissions_alignment_project for details.

Location	University, country and year	Total estimated emissions (Scope 3 in most cases only partially accounted for) in t CO_2-eq	Total number of staff (not full-time equivalent)/students
Aarhus	University of Aarhus, Denmark, 2019	27,752 (Scope 1, 2 and business travel and land use from Scope 3)	8005 (2020, FTE) / 26,521 (FTE)
Amsterdam	University of Amsterdam, the Netherlands, 2020	3767 (without Scope 3 emissions)	5216 / 38,940
Cambridge	Cambridge University, UK, 2019/20	69,128 (without supply chain in Scope 3, see discussion below)	11,528 / 24,450
Delft	TU Delft, the Netherlands, 2020	70,485 (Scope 1, 2 and 3)	6348 / 27,275
Dublin	Trinity College, Dublin, Ireland, 2020	18,144 (Scope 1 and 2 only)	3500 / 18,407
Edinburgh	University of Edinburgh, UK, 2018/19	78,903 (Scope 1, 2 and business travel, water and waste in Scope 3)	10,556 (FTE, 2021) / 43,380
Espoo	Aalto University, Finland, 2019	19,426 (Scope 1, 2 and business travel)	4125 (FTE) / 11,205 (FTE)
Ghent	University of Ghent, Belgium, 2019	47,572 (Scope 1, 2 and business travel and commuting)	15 000 / 49,000
Gloucestershire	University of Gloucestershire, UK, 2019/20	1955 (Scope 1 and 2)	1465 / 7979
Graz	University of Graz, Austria, 2020	5150 (Scope 1 and 2) (plus an estimated 5000 t associated with mobility)	2469 (FTE) / 17,718
Hamburg	Hamburg University, Germany, 2017	27,830 (Scope 1, 2 and only air travel in Scope 3)	5289 / 43,300
Hannover	Hannover University, Germany, 2016	59,000 (Scope 1 and 2)	4868 / 27,625
Leeds	University of Leeds, UK, 2019/20	55,384 (Scope 1, 2 and 3 without supply chain)	9200 / 38,000
Lisbon	University Institute of Lisbon, Portugal, 2019	787 (Scope 2 only)	1075 / 9907

Location	University, country and year	Total estimated emissions (Scope 3 in most cases only partially accounted for) in t CO_2-eq	Total number of staff (not full-time equivalent)/students
London	Imperial College, UK, 2018/19	60,670 (Scope 1 and 2)	7868 / 19,171
London	University College London, UK, 2018/19	478,000 (Scope 1, 2, and 3, including supply chain)	14,300 / 43,800
Louvain-la-Neuve	Catholic University Louvain, Belgium 2017	68,500 (Scope 1, 2 and business travel and commuting)	5840 / 30,957
Odense	University of Southern Denmark, Denmark, 2019	10,394 (Scope 1, 2 and business travel)	3800 / 27,000
Oslo	University of Oslo, Norway, 2018	67,952 (Scope 1, 2 and 3)	6685 (2020) / 26,450 (2020)
Oxford	Oxford University, UK, 2019/20	48,970 (Scope 1 and 2)	14,478 / 24,299
Potsdam	University of Potsdam, Germany, 2018	23,816 (Scope 1, 2 and business travel, commuting and IT supply chain from Scope 3)	3104 / 22,006 (2020/21)
Stockholm	Stockholm University, Sweden, 2019	36,500 (Scope 1, 2 and 3)	5716 (2020) / 29,300 (2020, FTE)
Trondheim	Norwegian University of Science and Technology, 2017	98,981 (Scope 1, 2 and 3)	7761 / 42,840 (2020)
Venice	Ca' Foscari University of Venice, Italy, 2019	12,043 (Scope 1, 2 and business travel and commuting from Scope 3)	1638 / 22,786
Zurich	ETH Zurich, Switzerland, 2019	28,878 (Scope 1, 2 and business travel and commuting)	12,280 / 22,193

Table 1: GHG emissions for 25 selected European universities. For sources see Appendix A. Where employee and student numbers are not for the same year as the carbon report, the year is indicated in brackets. We indicate which emissions are accounted for. In Scope 3, different subcategories are included; in particular supply-chain emissions are typically not accounted for (see the further discussion below).

Table 1 indicates that the reported emissions (typically excluding, for example, supply-chain emissions, which can be very significant) of universities in (Western and Northern) Europe typically lie between 20 kt and 75 kt CO_2-eq per year for universities with several tens of thousands of students. Per employee, the average amount in Table 1 is 7 t CO_2-eq per year, and per student it is nearly 2 t CO_2-eq per year.

For some universities, these numbers are significantly lower (see Figure 1). These are either universities that have already undertaken steps to reduce their GHG emissions (see the discussion below), or universities that report only a subset of all emissions. In particular, in Figure 1, universities that only report Scope 1 and 2 typically lie at the lower end of the distribution, whereas universities that report on many categories from Scope 3 (including an estimate of the full supply chain for the university with 32 t CO_2-eq per year per employee) typically lie at the higher end of the distribution. Thus, it should be kept in mind that the reported numbers in Table 1 are very likely low estimates for almost all universities, given an incomplete reporting of Scope 3 emissions, in particular missing

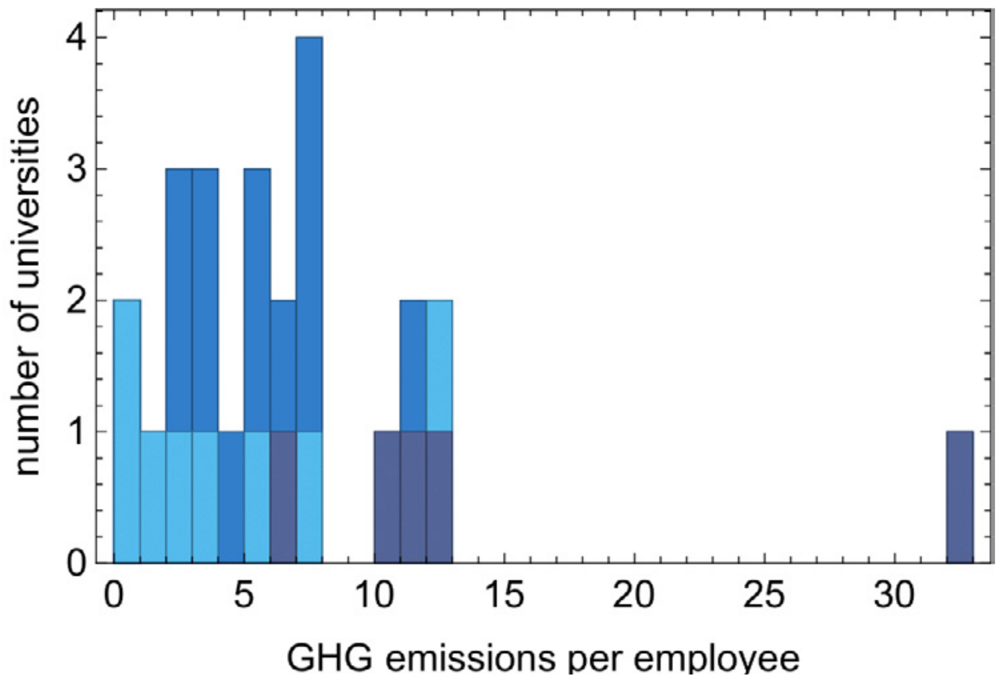

Figure 1: GHG emissions per employee for all universities in Table 1. Universities that report only Scope 1 and 2 are shown in light blue; universities that account for many categories in Scope 3 are in dark blue. All remaining universities (medium blue) account for Scope 1, 2 and travel emissions (which in some cases includes commuting).

supply-chain emissions. Other metrics, such as GHG emission per Euro expenditures, or GHG emissions per square metre of campus area, are also used (see, for example, Helmers et al. (2021)). A highly accurate calculation of emissions is not the goal, because the estimation of GHG emissions is only a means to an end, namely to support a university's pathway to carbon neutrality. Instead, investing person-power etc. in the refinement of the accounting system may even ultimately absorb a university's limited resources, which could be better spent in implementing reduction strategies. We therefore advocate a balance between uniform and robust accounting, without overly focusing on the choice of metric, and on reaching accuracies of the order of 1–10 tonnes.

Some universities do not estimate their GHG emissions, but instead keep track of electricity consumption, like the University of Barcelona (2020).

The relative importance of various sources of GHG emissions varies from university to university. Typically, electricity and heating contribute a substantial part, as does travel (commuting and business travel). We provide six examples detailing the distribution of various sources from several universities. We select six different countries to account at least in part for regional variability and we select universities that attempt to account for many of their sources of GHG emissions as well as universities that include only a subset of sources.

Differences in the inclusion of sources and grouping into different categories highlights a recurring theme: there is currently no agreed-upon standard for the reporting of GHG emissions of universities, also highlighted by the diverse range of sources included in Figure 2.

Although there is clearly some variability, electricity, heating, commuting and business travel consistently occur among the largest sources. In contrast, water and waste consistently (also for universities not included above) rank among the sources that are negligible compared to total emissions. Emissions from electricity are smaller for those universities that operate largely or exclusively based on green energy.

The importance of emissions typically not accounted for

A complete account of Scope 3 emissions is challenging and thus typically not done. In addition, carbon emissions along various supply chains can be many steps removed from a university and thus not just difficult to account for, but also difficult to influence. Nevertheless, examples exist where Scope 3 emissions have been accounted for more comprehensively:

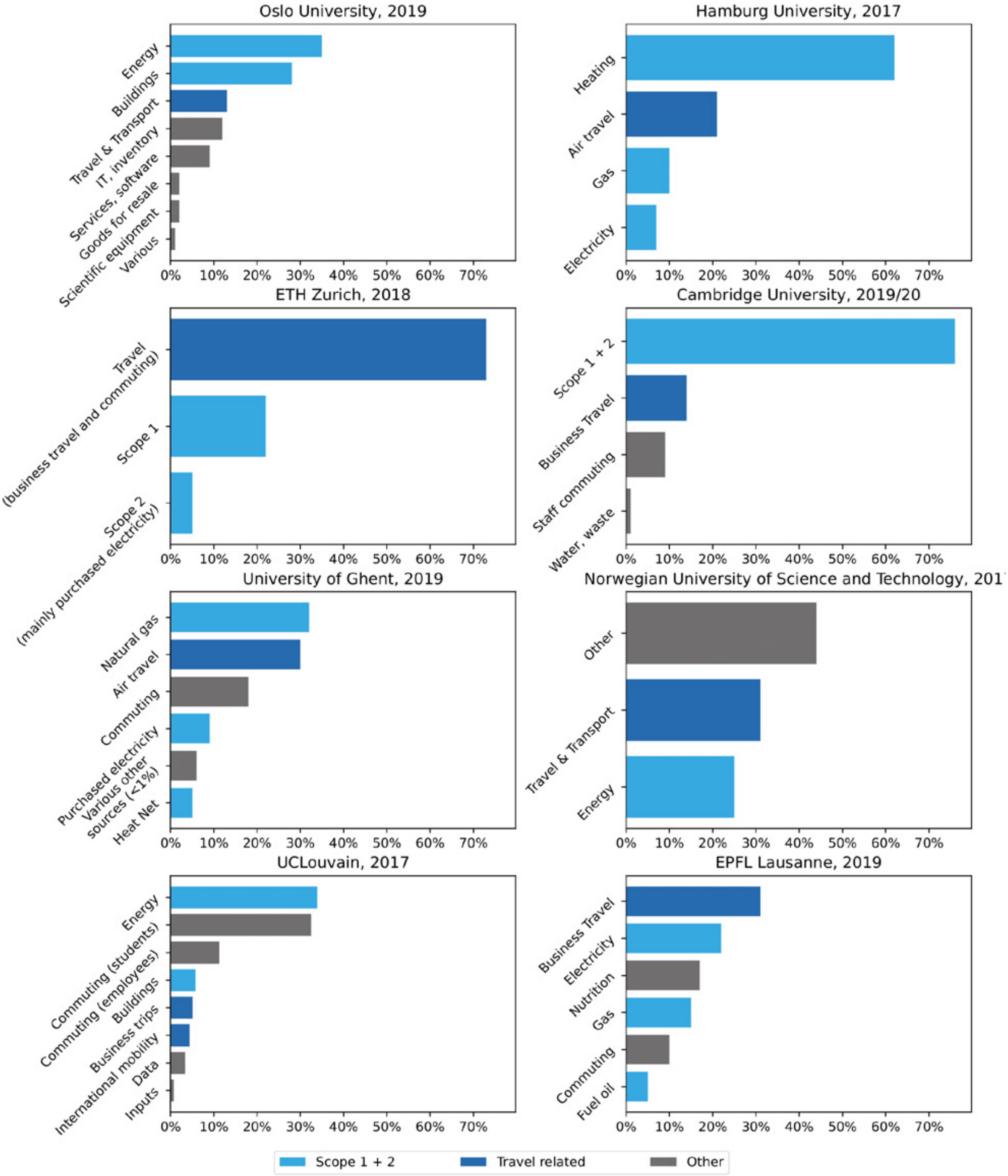

Figure 2: Relative fraction of different emission sources for various European universities.

Cambridge University has estimated about 400 kt CO_2-eq for all its Scope 3 emissions in 2019/20, compared to about 54 kt from Scope 1 and 2. This amounts to about 35 t CO_2-eq per employee per year and 16 t CO_2-eq per student per year – significantly higher than the average in Table 1, which includes many universities that do not account for Scope 3 emission comprehensively. In the Scope 3 emissions from Cambridge University, 385 kt arise from the supply chain (University of Cambridge 2021). Supply-chain emissions arise from, for example, office equipment, canteen food, laboratory equipment, chemicals, building materials, IT equipment and others. Supply-chain emissions are difficult to estimate; therefore this estimate comes with a significant error bar and the estimate is not included in the above figure. Many of these supply-chain emissions are not specific to universities, but affect many sectors of society. An example for university-specific supply-chain emissions, related to laboratory equipment, is discussed in Section 4b below. In Figure 2, the University of Oslo and the EPF Lausanne account for emissions from parts of the supply chain and/or emissions related to food (at university canteens), showing that these can be non-negligible sources of emissions.

The University of Copenhagen has estimated its full Scope 3 emissions for 2018 (Copenhagen University 2020), amounting to 90% of its total emissions, with, for example, maintenance and renovation, emissions linked to laboratories (although not necessarily the most important source) that are not included in the climate reports of most universities. For instance, consumables for laboratory use and chemicals in education and research together make up a fraction of GHG emissions similar to the total Scope 2 emissions.

Similarly, the Norwegian University of Science and Technology finds that Scope 3 emissions account for 75% of its total emissions, which amount to about 100 kt CO_2-eq (NTNU 2018), with transport and travel making up 31%, and 44% from other Scope 3 emissions. This again highlights the importance of including Scope 3 emissions in climate reports from universities.

As a final example, University College London (University College London 2019) has found that 85% of its emissions are Scope 3 emissions and the total emissions amount to 407,000 t CO_2-eq emissions in 2017/18. Of these, about half arise from the supply chain.

These examples very clearly highlight that climate reports based on Scope 1 and 2 only, or Scope 1 and 2 together with business travel, neglect an important source of emissions, namely supply-chain emissions. Therefore, the majority of entries in Table 1 should be viewed as very low estimates.

Additionally, there are universities with funds that they can invest independently, including, for example, endowment funds. The GHG emissions from these investments are not included in any climate report that the authors of this report are aware of; however, divestment initiatives and pledges have been made and are discussed below.

Focus on air travel

Air travel relative to overall emissions – is flying negligible?

Calls by academics to reduce air travel in academia are often contentious. This reflects trends in society more widely, as it is often argued that globally, air travel is not among the largest sources of emissions, as it only makes up approximately 11% of global GHG emissions from transport, while 72% of emissions from transport are from road-based transport (IPCC 2014b). Thus, in the context of universities, one may wonder whether reductions in air travel would be a symbolic rather than an efficient measure in reducing total emissions. This section will discuss the contribution of emissions related to air travel to a university's overall carbon footprint. In this context, it is also significant that research has shown that just 2–4% of the global population are causing aviation emissions (Gössling and Humpe 2020).

Monitoring systems used to report on emissions related to air travel differ between the universities. A recent survey (Kreil and Stauffacher 2021) suggests that the most common form of accounting for emissions related to air travel is to include flights paid for by the university itself, with some additional categories sometimes included. In practice, this means that flights by guests who pay from their own funding, as well as flights by staff when they are invited with costs covered, do not typically appear – thus the estimated GHG emissions related to air travel should be viewed as a low estimate. These differences in scope, as well as additional differences in how the carbon footprint of a flight is calculated (Kreil and Stauffacher 2021), make it difficult to compare the numbers below directly. For that reason, the numbers considered here give only a general impression of the overall importance of emissions related to air travel related to a university's carbon footprint.

Several universities (ETH Zurich,[8] Switzerland; University of Basel, Switzerland; Hanken School of Economics, Finland[9]) have identified air travel as their single largest source of GHG emissions. Similar patterns are realised in North America (e.g. Wynes and Donner 2018), while lower but still substantial shares are due to air travel at other universities, e.g. University of California in Santa Barbara (UC Santa Barbara 2017). This is not true for all universities; Ahonen et al. (2021) demonstrate the large variation in estimates even within one country (10–78%), which can be due to a university's funding, location or profile (e.g. teaching vs research-intensive), successful reductions of GHG emissions in other areas (e.g. electricity), and differences in accounting (e.g. which GHG sources are included in sustainability accounting). Even for universities where flying is not the single largest source of emissions, it still constitutes a substantial fraction (see Figure 1).

We conclude that air travel, whenever reported, constitutes a significant source of GHG emissions. Therefore, it is critical to understand (i) where a leading share of emissions from air travel comes from (e.g. long-haul vs short-haul; early career researchers or senior researchers, etc.; we are not aware of data that account for flights by administrative personnel separately) and (ii) how mitigation strategies can be developed and adopted.

Long-haul vs short-haul flights: what matters most – a few long or many short journeys?

The share of emissions caused by long-haul flights (as opposed to shorter journeys) is largely consistent across universities, at least in cases where it is reported. Long-haul flights are estimated to account for 86% of emissions related to air travel at ETH Zurich, Switzerland (Medhaug 2021a), 85% at Imperial College, UK (Grant et al. 2019), more than 80% at University of Basel, Switzerland (University of Basel 2021), nearly 80% at Hamburg University (Universität Hamburg 2019)[10] and 84% at the University of Potsdam (Universität Potsdam 2019). At the same time, the number of long-haul flights is typically significantly lower than that of short-haul flights (see Figure 3).

It is therefore clear that to significantly reduce emissions related to air travel, long-haul flights to distant destinations are a key lever. Such flights are much more difficult to replace by alternative modes of transportation. In the absence of reliable emission reductions in aviation technology of the scale that is needed, solutions to this problem will probably focus on developing software, hard capacities (e.g. stable internet connections), and human capabilities for rich and successful virtual communication. It is important to keep in mind that not all these long-haul flights can be replaced by virtual communication, with field trips being a clear example of an activity that cannot be done remotely. Thus, solutions have to account for specific requirements of disciplines, as well as individual researchers. Similarly, besides flights by researchers, administrative personnel might undertake flights, some of which might not be possible to substitute by virtual communication.

Flights in first and business class accounted for only 18.6% of emissions related to air travel at ETH Zurich in 2016–18 (Medhaug 2021a). Emissions are distributed very unequally across individuals (see Section 2b) and differ significantly between departments or similar sub-units of a university; for example, emissions related to air travel per full-time equivalent employee differed by a factor of 4.3 at ETH Zurich, Switzerland, in 2016–18 (Medhaug 2021a).

Online teaching, remote working and GHG emissions

The pandemic has demonstrated that working and studying from home using online communication can in many cases be a feasible, less expensive and carbon-effective choice (El Geneidy et al. 2021; Ørngreen et al. 2019). The GHG emissions associated with virtual events have been studied in the context of virtual conferences. For example, Burtscher et al. (2020) find 0.014 kg of CO_2 emissions per participant and Zoom hour, taking into account the energy consumption of the server, network and the participant laptops (see Section 8b for more examples). E-learning has made significant technical

8 ETH Zurich includes in its air travel reporting all flights paid for by the university, including flights by guests but excluding flights paid for by other institutions, as well as flights by students within the curriculum. Emissions are calculated with the VDR standard and the atmosfair airline index, using an emission weighting factor of 2.0 for emissions above 9,000 metres above sea level. We provide this information here as an example of the various factors that need to be taken into account when comparing emission estimates of different universities; moreover, not all of this information is always easily accessible.

9 See https://ethz.ch/en/the-eth-zurich/sustainability/context/air-travel.html (Zurich), https://www.unibas.ch/de/Universitaet/Administration-Services/Generalsekretariat/Nachhaltigkeit/Campus/Flugreisen.html (Basel) and Ahonen et al. (2021) for details.

10 These numbers are not directly comparable as the definition of a long-haul flight varies slightly between the different sources.

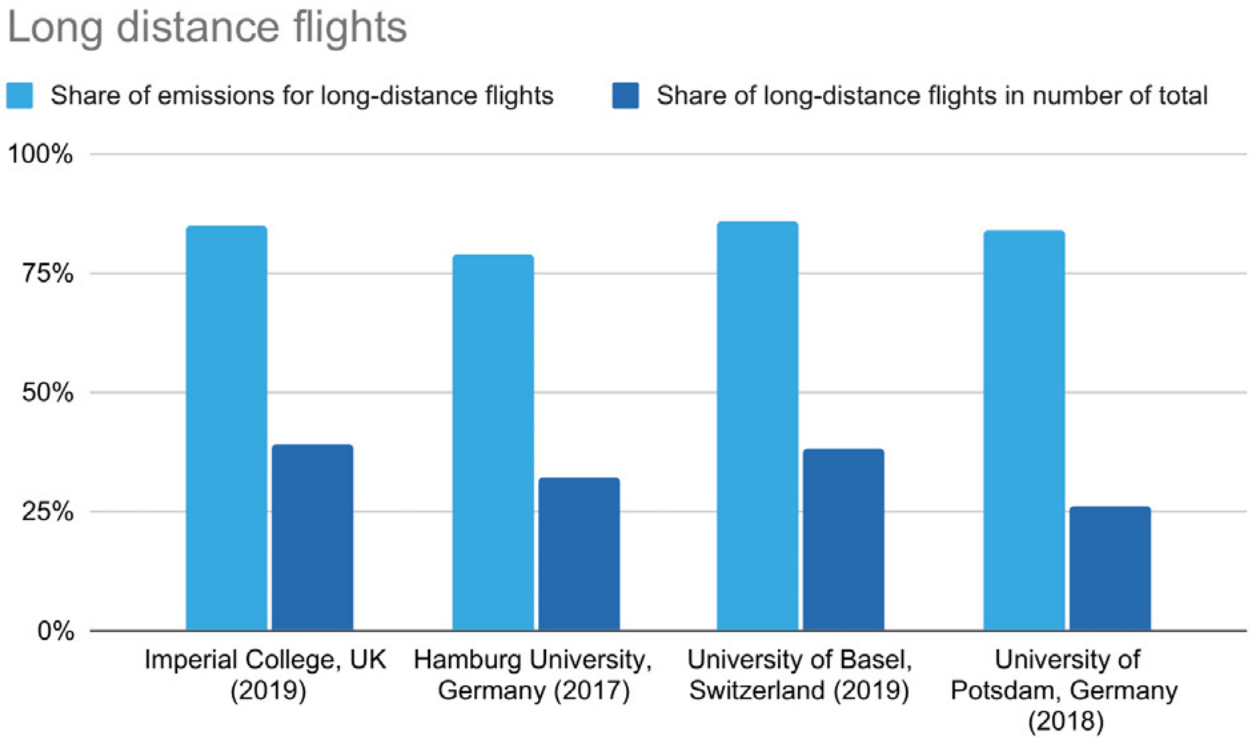

Figure 3: Relative share of emissions and the number of long-distance flights at various universities.

advancements (implementation of digital platforms and smart tools). Therefore, recognising the value of online education, it has been considered as an environmentally-friendly alternative for reducing on-campus emissions (Caird and Roy 2018; Perales Jarillo et al. 2019). When evaluating savings in GHG emissions from online teaching as well as remote working, increased electricity consumption and heating in homes have to be accounted for, in order to not create a false impression: working and studying remotely contributes to heating and electricity reduction at the university, together with no need to commute or have a dedicated office space (or being able to share office space between people who come in on different days), all aiding a university's carbon footprint reduction (El Geneidy et al. 2021). However, some of this comes at the expense of increased GHG emissions elsewhere: as emphasised in Filimonau et al. (2021), if properly accounting for increased electricity consumption and heating at home during home-office hours, the overall reduction in GHG emissions arises mainly from a drop in commuting (which can be significant for some universities, see, for example, UCLouvain 2019). Moreover, during cold times of the year, individual heating of homes might result in larger emissions than that from heating of university buildings; and, while decreasing a university's GHG emissions, might not result in an overall decrease of emissions. When assessing the climate impact of online teaching and remote working, it is thus critical to not only focus on the university's climate report, but adopt a more holistic view in order to avoid false conclusions.

3c. Current practices: universities that reduce GHG emissions from various sources

Here, we review the current practices of a number of universities that are planning to or have already substantially reduced their carbon footprint. The universities we discuss here are by no means the only ones taking steps to reduce their carbon footprint. We select them because they provide examples of different measures, but also allow us to recognise common trends. Additionally, our selection is to some extent dictated by language and we mostly focus on reports in English, although we include examples from various countries across a number of European countries.

Further sources that review current practices include a climate action toolkit[11] by the Climate Commission

11 The toolkit can be found online at https://www.eauc.org.uk/climate_action_toolkit.

of the EAUC (The Alliance for Sustainability Leadership in Education), which contains a list of suggested steps with case studies for the various suggestions, all within the UK and Ireland.

Electricity consumption and heating

Those universities that have already achieved a significant reduction in emissions have typically done so by transitioning to renewable sources of electricity. The Free University Berlin has reduced heat and power consumption by 25% between 2001 and 2018, for instance by operating several photovoltaic plants. Installing photovoltaics is a measure opted for by other universities as well, and is in many cases quite feasible, given significant roof space. For instance, 96% of the electricity usage of the University of Gothenburg is from renewable sources, including photovoltaics installed on several buildings. Green electricity, in part (22%) produced on campus and in a significantly larger part (78%) produced off-campus, is also used at Ghent University, where the largest part of the on-campus green electricity comes from wind turbines. Transitioning from 'grey' to 'green' electricity in 2008 approximately halved its GHG emissions. Similarly, Scope 2 emissions at the University of Amsterdam arise only from heating, after the university transitioned to 100% wind power.

In some countries, a choice of energy suppliers exists and there, universities can reduce their Scope 2 emissions by choice of supplier. For instance, Hamburg University opted to obtain its electricity exclusively from renewable sources, leading to an estimated 26,000 t CO_2 emissions reduction per year. At the University of Potsdam, switching to a provider of green electricity has reduced the GHG emissions from electricity use to about one-quarter of its previous value. Similarly, the University of Sheffield is set to achieve a 17 000 t CO_2-eq emissions reduction per year by procuring its electricity fully from a supplier of renewable energy.

The Leuphana University in Lueneburg operates a biomethane heat and power plant, as a key ingredient in its overall very low net emissions. As two examples from Southern Europe, the Politecnico di Torino has installed solar panels and reduced energy consumption due to isolation of buildings (Politecnico di Torino 2020) and Ca' Fascari University of Venice operates a photovoltaic system (Ca' Foscari University of Venice 2021). These examples highlight that in many regions, emissions connected to electricity are largely or in part avoidable. Even in countries in which renewable energy is not supplied, on-campus generation of renewable energy can contribute to reducing emissions from electricity significantly. Emissions from gas consumption have been reduced significantly at the University of Padova, due to a replacement of old infrastructure (University of Padua 2020).

Air travel

It is important to recognise that there is no single, simple travel solution, and decisions regarding physical versus virtual mobility as well as the means of travel might have to be made on a case-by-case basis, or at least not with across-the-board regulations. Due to the social structure of the academic community, imposing strict rules in a top-down approach is very likely to result in strong resistance and be counterproductive, and could hamper research (with disciplines relying on field trips providing an obvious example). Instead, it is key to recognise that physical mobility, including by plane, will continue to be necessary in various circumstances. Instead, physical mobility can be substituted by virtual mobility in various other circumstances, and some universities encourage their employees to reflect about their decisions and factor in the climate impact of a given trip, for example by providing non-binding decision trees. This is also a question of empowering academics to make these decisions: a university-wide policy can encourage, empower and legitimise academics who decide to reduce their physical mobility. An example of this is given by KU Leuven (KU Leuven 2021): first, employees are provided with information to raise awareness; a list of 'white' and 'grey' cities provides destinations which are faster to reach by train than by plane (white) or which only take marginally longer by train (grey). In addition, employees are provided with information on how much the overall GHG emissions from travel would fall if everyone chose the train for all destinations in the 'white' and 'grey' lists. Second, mandatory CO_2 compensation for all air travel has been introduced, part of which funds videoconferencing equipment as well as research on sustainability.

As a recent example, we discuss Stockholm University, which recently implemented a new travel policy (Stockholm University 2021), clearly stating that employees and students must carefully evaluate the need for all work- or study-related travel. By default, trips must be replaced by digital meetings and it is not permitted to fly to a meeting or an activity that lasts less than one working day if digital participation is an option. When travel is justified, the means of transport that generates the lowest amount of carbon emissions must be prioritised, e.g. rail over air travel. Unless warranted by special circumstances, journeys shorter than 700 km must be made by other means than air travel. When flying is justified, flights that include stopovers should be avoided. Currently, the university has no official reduction target for flying but it is estimated that emissions from flying need to decrease by on average 5% per year until 2040. As soon as the university's carbon intelligence system has been implemented in 2022 and emission data from all sources in Scope 1–3 are available, the ambition is that the university will set specific central and local reduction targets for flying but also for other emission sources.

An up-to-date overview of current measures to reduce GHG emissions related to air travel is provided by the report *Greening in European Higher Education Institutions* by the European University Association (Stöber et al. 2021a). Among the 305 universities that participated in the survey and had greening efforts, low-carbon forms of transportation for staff and student mobility are encouraged at roughly half; incentivised at about a quarter, and standard and/or compulsory at 11–15%. The framework conditions that these universities typically set are therefore not rigid or strict and leave decisions on the means of travel largely to the individual researcher and student. In cases where strict measures exist, they typically relate to very short distances. For instance, at the University of Ghent, air travel is no longer allowed for destinations that can be reached within 6 hours by bus/train (Ghent University 2021). Similarly, the University of Amsterdam changed its travel policy, such that flights to destinations less than 6 hours away by train are no longer supported (University of Amsterdam 2021).

An open access online map (curated since 2018, latest update November 2021) lists over 90 academic institutions that are specifically engaging with the issue of their air travel-related GHG emissions in some way.[12] It includes 40 universities that have concrete plans to actively reduce these emissions (rather than, for example, relying exclusively on offsetting); more may exist that are not included in the map or have updated their strategies since their inclusion. Common actions among such institutions, as summarised in the map, are: defining a reduction target for air travel emissions, monitoring and reporting those emissions, improving infrastructure for virtual communication, and issuing recommendations or guidelines that encourage sustainable travel decisions (such as travelling via ground transportation within a certain radius, or substituting some travel with virtual communication).

A survey of 35 academic institutions in Western Europe and the USA, all aiming to GHG emissions related to air travel (Kreil and Stauffacher 2021), similarly shows that the most common policy measures implemented by these universities are:

» an official top-down commitment to reducing air travel emissions;

» promoting virtual communication through recommendations and providing software, training and technical support;

» recommendations to reflect on the necessity of each trip and use ground transport modes in certain situations (e.g. domestically);

» recommendations to fly economy class.

Here, we describe the air travel project of ETH Zurich[13] in more detail, because it has led to a reduction of air travel-related GHG emissions by 14.4% per capita (9.6% total) in the first year after it became binding (Medhaug 2021a), while also enjoying strong support among the university's members according to surveys (Kreil 2020). This was achieved by letting each of the university's 16 departments define a concrete target for how much they would aim to reduce their own air travel-related emissions within a 6-year period. Averaging the reduction targets decided on by the departments results in an overall goal of 15% reduction in air travel-related emissions per capita across the university within 6 years; these reductions must be achieved without offsets, and *in addition* to any efficiency gains on the part of the aviation industry during this time period (estimated at 10%). How these reductions would be realised was also left up to the departments and central organs to decide. In this way, each organisational unit developed its own mix of policy measures, adapted to its own specific needs and circumstances (Görlinger 2019). For example, several departments opted to introduce an internal tax on air travel emissions, expand capacities for virtual communication and recommend train travel for short-distance journeys. In addition, structural changes made centrally by the university made it easier for its members to fly less. These included

12 The map can be found online at https://www.google.com/maps/d/viewer?mid=1v49WXCeLrpWkeQFvl2xIak-8qrTvV7jGe&ll=46.95048960000001%2C7.43811900000002&z=8.

13 See www.ethz.ch/airtravel for further details.

lifting requirements to use the cheapest travel mode, permitting virtualisation of doctorate examinations, and introducing a sophisticated university-wide measurement and reporting system for air travel-related emissions.

There is scarce available data concerning acceptance of university-based initiatives aiming to reduce GHG emissions associated with academic air travel. However, the available data suggest that these initiatives are rather well received internally: a survey at the University of Basel, Switzerland (https://cdsbasel.github.io/lessformore), which is engaged in an air travel reduction programme (University of Basel 2021), showed that 77% of those members who responded to the survey think that the programme's approach of having the departments choose their own measures for reaching the overall 30% reduction target is 'good' or 'very good'. This highlights the importance of having an approach that integrates a top-down strategy with bottom-up decision-making on the implementation. The above-mentioned international survey (Kreil and Stauffacher 2021) of 35 universities engaged in similar efforts shows that the responsible people at most of these institutions report rather positive or very positive responses internally. A more detailed (although not representative, as the sample was drawn by self-selection) survey carried out at ETH Zurich (Kreil 2020) similarly shows high average support for ETH's project to reduce GHG emissions from air travel. It also suggests that support is particularly high among early career researchers and lower among professors, although 78% in both groups report that they are willing to reduce their own professional air travel emissions. A second survey carried out one year later measured significantly increased support for the project among professors, possibly due to the COVID pandemic or the increased runtime of the project (Wenger 2021a).

At ETH Zurich, the most supported policies among non-professorial scientific staff are: mandatory ground travel domestically (84% acceptance) or to destinations that can be reached within a certain time (74%); funding first-class train travel for long train trips (62%); investing in infrastructure for virtual communication (57%); minimising the number of in-person job interviews by conducting initial interview rounds virtually (54%); mandatory booking of economy class seats if travelling by air (52%); and an internal carbon tax (51%). No comparable data are available for professors, but data from the University of Basel show that professors generally display less support for all measures. There, too, policies in preference of train travel and supporting virtual conferences are the most popular.

As we have highlighted, there is no standardised approach to reporting GHG emissions from air travel at universities. Initiatives are now starting to engage with this challenge, such as, for example, the flyingless project (https://flyingless.de/en/), which is a collaboration between research institutes and universities in Germany, supported by funding from the Ministry for Science and Education. It aims to develop a monitoring tool for academic institutions to track their air travel emissions and quantify emissions reductions.

Buildings

The design, construction and operation of any new university buildings can help or hinder GHG reduction goals, making the adoption of frameworks for carbon-neutral buildings and their implementation a key part of institutional strategies. Universities also use external assessment methods and certifications in the construction of new buildings (e.g. Bournemouth University (2020)). The construction of new buildings with a negative carbon rating (e.g. through the use of solar panels, very good insulation properties, use of natural light and natural ventilation; see Nottingham Trent University (2015) for details) has also been achieved in at least one example.

At many universities, the need for auditoriums, laboratories and other space is growing. Instead of new constructions, which result in GHG emissions during construction as well as operation, in some cases existing buildings can be used more efficiently. For instance, the reservation procedure for auditoriums has been reorganised and centralised, allowing a more efficient use of existing buildings. Additionally, already existing buildings can be refurbished (see, for example, University of Cambridge (2021)).

At the time of writing of this report, the authors are not aware of an example where a university regularly shares its buildings with a neighbouring city or the city it is located in, e.g. for use during the evening hours when no lectures are taking place. This is one example where universities are currently following decarbonisation strategies that are independent of nearby municipalities, and where additional reductions might be possible.

Commuting

Measures to reduce emissions from commuting include bicycle repair services, bicycle parking, compensation for costs of bicycles on public transport, reduction of parking spaces, participation in regional and national 'bike-to-work' programmes, as well as university bikes for staff and students to hire, e.g. at EPFL, Nottingham Trent University. In addition to improving the attractiveness of cycling to university, working with public transport providers to ensure efficient connections to a campus with a timetable adapted to the needs of staff and students and offering discounted public transport tickets to staff and students can be successful. For example, at the University of Sheffield, such a strategy has resulted in a halving of all commuting trips undertaken by car. In another example, the Politecnico di Torino provides free yearly subscriptions to local public transport to those employees who waive the right to park their car on university parking spaces (Politecnico di Torino 2020).

Supply-chain emissions and procurement

A number of universities are currently in the process of assessing their supply chains and imposing sustainability criteria in the choice of supplier. For instance, Stockholm University is currently implementing a carbon intelligence system that will allow tracking emissions from all sources in Scope 1–3 using financial information from all the university's invoices. Using this system, it has been identified that the emissions from services and goods are as high as emissions from flying. Alongside managing emissions from buildings and air travel, the university leadership has therefore decided to also prioritise actions that aim to reduce emissions from purchasing services and goods. Although this certainly means intensifying the work on green procurements, at this stage these activities primarily aim to identify major flows of consumption products, chemicals and other lab equipment and consumables, for example, in order to improve transportation and logistics systems within the university. In this context, several initiatives have also been taken to enable sharing chemicals between research groups and departments as well as reusing lab equipment.

At many universities, sustainability criteria are factored into some parts of the supply chain. For instance, sustainability criteria matter for the procurement of office materials, furniture, lab coats and chemicals at Ghent University; there are plans to do so for some food items and IT materials in the coming years. For IT materials, recycling and reuse is also starting to play a part at some universities, e.g. the University of Gloucestershire has started to send laptops and servers for recycling or reuse. Similar initiatives that target the carbon emissions from the purchase of some categories of goods exist at a number of universities. Sheffield University is implementing a framework of sustainable purchasing principles together with new training schemes for professional services and lab staff. Such training is critically important to ensure that strategy decisions about sustainable procurement are aligned with day-to-day decisions.

Food choices and food waste at university canteens

Food at university canteens gives rise to Scope 3 emissions. For any given food item, they can depend on the choice of supplier, means of transport, etc. They also very strongly depend on the food categories chosen, with meat and other animal products typically associated with much larger emissions than plant-based food (see, for example, Foley et al. (2011); Kustar and Patino-Echeverri (2021); Poore and Nemecek (2018); Scarborough et al. (2014)). Thus, emissions from food can contribute to a university's GHG emissions. For instance, at EPFL, Switzerland, they account for about 15–18% of overall emissions (EPFL Lausanne, n.d.). Reduction strategies include a focus on making vegetarian/vegan meals one of the options, with EPFL planning that half of all offered meals will be vegetarian (EPFL Lausanne 2019) and Trinity College Dublin increasing the vegetarian and vegan meal options and turning one of their cafes into a vegetarian cafe in 2021 (Trinity College Dublin 2020). UCL has committed to making 50% of the food choices vegetarian/vegan (University College London, n.d.). Berlin Universities are transitioning to 96% vegetarian/vegan food choices (Studierendenwerk Berlin 2021). Further, universities are focusing on limiting or eliminating food waste (and thus associated emissions), for example at the University of Southern Denmark, as well as waste associated with food packaging (e.g. introducing reusable take-away packaging, see EPFL Lausanne 2019). The University of Gloucestershire sources nearly half of its fresh ingredients within a distance of 45 miles, reducing GHG emissions from transport.

Divestment from fossil fuels

Some universities own funds that they can invest as university leadership sees fit. These funds can range very significantly in size; therefore the contribution to Scope 3 emissions from the investments a university undertakes can also vary widely. Many universities have started divesting from fossil fuels in the last decade. UK universities have followed the example of the University of Glasgow (University of Glasgow 2014) and committed to fully divest from fossil fuel industries, including universities with large endowment funds, like Oxford University in 2020 (Kayanja 2020). These commitments are often subject to conditions, e.g. regarding the financial impact of that decision on the university. Stockholm University decided to divest from fossil fuels in 2016 as a result of a campaign where more than 1000 students handed in signatures. The University of Gloucestershire divested from all fossil fuel investments in 2018 with immediate effect. Similar commitments across other countries in Europe include, for example, the University of Münster as the first university in Germany in 2016 (Dohle 2018), followed by the University of Göttingen in 2018 (Georg-August-Universität Göttingen 2018). In Belgium, the University of Ghent has planned to no longer invest in a number of industries, including fossil fuels; KU Leuven has already divested from funds that exclusively or mainly focus on investing in fossil fuels (KU Leuven 2019).

Institutional strategies to reduce GHG emissions

Leadership and institutional strategy

Climate action requires a holistic strategy, where all management decisions account for impacts on the climate. Therefore, universities build climate sustainability (as well as sustainability more broadly) into their institutional strategies, often based on a broader framework, such as the UN Sustainable Development Goals. To undertake climate action is in part a value-driven decision and can mean that choices that are economically not the most favourable ones (at least in the short term) have to be made. This has been recognised and included into the institutional strategy at the University of Bournemouth, where the *Climate and Ecological Crisis Action Plan* (Bournemouth University 2020) explicitly highlights the need for university management to make decisions not based on financial criteria alone. Thus, some universities have vice-rectors, vice-presidents or persons at a similar level in university management who are in charge of sustainability, e.g. Trinity College Dublin has the new role of Vice President for Biodiversity and Climate Action (Trinity College Dublin 2021), Stockholm University has a Senior Adviser for Sustainability (Stockholm University 2022), the ETH Zurich has an Associated Vice President for Sustainability (ETH Zurich 2019). In order for a university to be able to act on a value-driven decision, these values must be, at least to some extent, shared by management, staff and students. Integration of top-down decisions and strategy development with bottom-up initiatives is therefore pursued at some universities. For instance, university leadership consults with staff and students, e.g. through surveys,[14] and can be encouraged in their decision to pursue a climate sustainability strategy by the emphasis that staff and students place on the topic. Similarly, such surveys or even votes can provide legitimacy to decisions undertaken by university leadership.

Accountability of university leadership is critical to ensure that GHG reduction targets can be met. Sustainability reports and strategies do not typically specify how accountability is to be achieved. At the time of writing of this report and to the best knowledge of the authors, this appears to be a potential gap in ensuring that sustainability strategies are implemented. Students may play a critical role in holding university management accountable.

At many universities that have a sustainability strategy, there is a dedicated Sustainability Office or Green Office. These Green Offices can also include students, e.g. at the University of Ghent.[15] At the University of Edinburgh, the Department for Social Responsibility and Sustainability engages with these topics more broadly, but their first priority is to transition the university to a zero carbon and circular economy university.[16]

Specifically, for air travel, the universities in the survey (Kreil and Stauffacher 2021) have on average one person (full-time equivalent) working on air travel emission reduction, who usually works in an administrative sustainability unit. They reported mostly positive responses from within the institution. Clear, ongoing communication with a variety of stakeholders within the university, and providing information about the carbon footprint of air travel, as well as alternatives and their potential financial benefits, were named as successful strategies for implementing air travel policies, along with support from leadership and other central administrative units, adequate funding and staffing. Many of the universities in the survey are engaged in active exchange with other institutions about this topic, and highlighted the importance of networks and dedicated to such exchange.

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14 See, for example, https://www.epfl.ch/about/sustainability/sustainability/our-climate-your-campus/ for an example at EPFL.

15 See https://www.ugent.be/en/ghentuniv/principles/sustainability/green-office-gent for a description of Green Office Ghent and https://www.greenofficemovement.org/green-office-case-studies/ for a list of Green Offices.

16 For a description of the department see https://www.ed.ac.uk/sustainability/about-us/contact/our-team and https://www.ed.ac.uk/sustainability/about-us.

Short-, medium- and long-term goals

By now, initiatives and measures to reduce GHG emissions from university operations are in many places part of a specific quantitative target: many universities have set emission reduction targets for 2030 and in some cases even 2025. These typically include Scope 1 and Scope 2 emissions, whereas goals regarding Scope 3 emissions are often less specific and left for a later stage.

In many cases, the announced goals are not specific with regards to emission sources. Robust accounting for and reduction in many Scope 3 emissions, e.g. supply-chain emissions, is difficult and pathways are not always clear. The variation in specificity with regards to emission sources, as well as details of planned pathways, highlight the need for a transparent, agreed-upon scheme for universities to report emissions and to set meaningful emission targets.

Table 2, which contains examples of big and small, well known and less known universities, shows significant differences between countries: whereas many universities in, for example, the UK and Scandinavia have set GHG emission reduction targets, fewer universities in other countries have done so, to the best knowledge of the authors. In reporting the targets, we follow the language used by universities. Our list is not meant to be comprehensive, but to highlight the diversity of goals (e.g. which scopes are included or how precisely the goal is phrased) and diversity of timelines (between 2020 and 2050). Where reduction goals are reported as, for example, 50% reduction by 2030, these refer to different, self-selected baselines. Many carbon neutrality pledges are collected at https://www.educationracetozero.org/, including examples in Europe beyond those examples shown in Table 2 and Figure 4 below.

In Sweden, a joint framework has been created which provides a basis for higher education institutions to develop their individual climate strategies. The Climate Framework requires all higher education institutions that sign up to it (37 Swedish higher education institutions so far: see KTH 2021) to implement measures to be in line with the Paris Agreement's 1.5°C target; since October 2021 this is mandatory for all universities that belong to the Association of Swedish Higher Education Institutions (SULF).

The Alliance of Science Organisations in Germany, which includes the conference of university rectors, has recently declared the goal of climate neutrality in their operations as well as research in 2035 (Allianz der Wissenschaftsorganisationen 2021); concrete pathways to achieve this, and also how large reductions in GHG emissions will be (and how much, if any is planned to be offset), have not been specified.

Emission pathways

Just as for countries, continents and the world as a whole, it is not just the final goal (e.g. net zero in a given year) that matters; the pathway to reaching that goal is also critical, because the cumulative emissions are what matters from a climate physics perspective – captured in the catchphrase that "every tonne counts". Thus, the University of Bournemouth has laid out several pathways towards its target. Similarly, the University of Edinburgh has modelled different pathways, in order to facilitate an informed decision-making process (The University of Edinburgh 2016) and the University of Hannover (Leibniz University Hannover 2017) has compared three different models ('current trend', 'climate protection' and 'climate neutrality') in terms of the necessary reduction in each source of GHG emissions.

Buying or producing offsets

Buying offsets is part of the institutional strategy to net zero at many universities. Universities emphasise that a meaningful reduction in emissions is necessary before deciding to purchase offsets, in order to maintain a credible net zero emissions strategy. Nevertheless, climate sustainability strategies typically assume that it is not possible for universities to be climate-neutral (or even climate-negative) without buying offsets.

The Leuphana University of Lueneburg implements a model where offsets are produced on campus (Leuphana University Lüneburg 2021): the university uses a heating network based on biomethane-powered heat and power units and additionally uses photovoltaics. When calculating its carbon footprint, the university includes a negative contribution associated with feeding electricity into the grid of the residential neighbourhood. The calculated overall emissions of the university are therefore negative, despite existing emissions from, for example, travel.

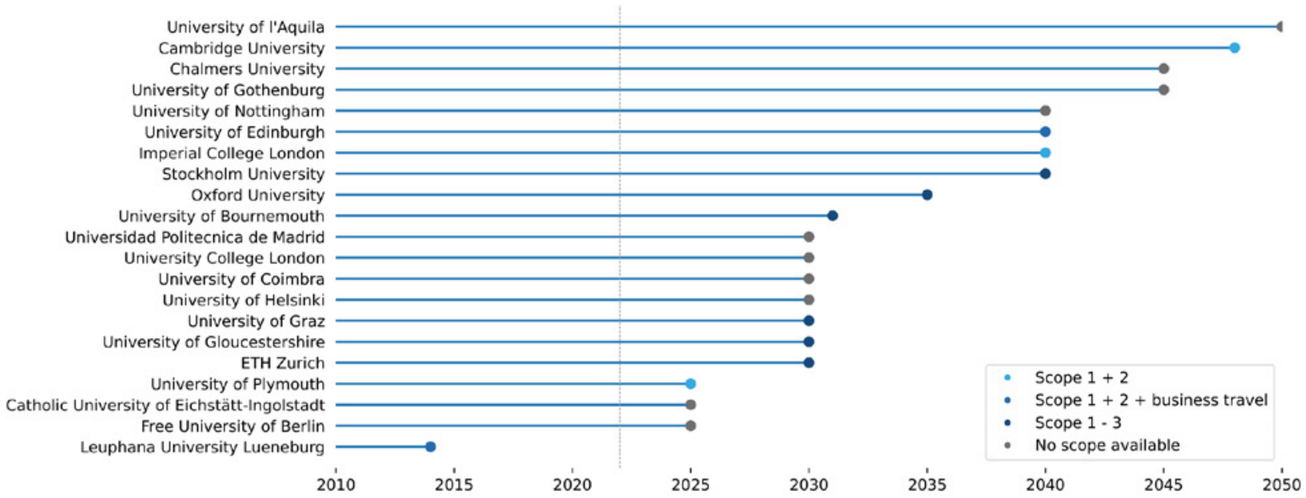

Figure 4: Examples of self-reported net zero targets for European universities, showing the diversity of scopes included and timelines. These targets might include offsetting.

Location	Institution	Reduction target	Scope
Aarhus	University of Aarhus, Denmark	35% by 2025 compared to 2018 and 57% by 2030 compared to 2018	Not specified
Amsterdam	University of Amsterdam, the Netherlands	85% per student by 2020, compared to 2010	Not specified
Barcelona	Universitat Pompeo Fabra Barcelona, Spain	25% in 2025, 55% in 2030, carbon neutrality in 2040	
Berlin	Free University of Berlin, Germany	Fully carbon-neutral in 2025	Not specified
Bournemouth	University of Bournemouth, UK	Carbon-neutral by 2030/31 (including offsetting)	1, 2 and 3
Cambridge	Cambridge University, UK	Zero carbon emissions in Scope 1 and 2 by 2048	1 and 2
Coimbra	University of Coimbra, Portugal	2030	Not specified
Copenhagen	University of Copenhagen, Denmark	50% by 2030 (relative to 2018)	1, 2 and 3
Edinburgh	University of Edinburgh, UK	Carbon-neutral by 2040	1, 2 and business travel from 3
Gloucestershire	University of Gloucestershire, UK	Net zero by 2030	1, 2 and 3
Gothenburg	Chalmers University, Sweden	GHG emissions halved by 2030, net zero by 2045	Not specified
Gothenburg	University of Gothenburg, Sweden	50% reduction in 2030 and climate neutrality in 2045	Not specified

Location	Institution	Reduction target	Scope
Graz	University of Graz, Austria	Net zero emissions by 2030 and climate neutrality according to ICM standard (at least 90% emission reduction) by 2040	1, 2 and 3
Helsinki	University of Helsinki, Finland	Climate neutrality by 2030	Not specified
Ingolstadt	Catholic University of Eichstätt-Ingolstadt, Germany	Climate-neutral by 2025	Not specified
L'Aquila	University of l'Aquila, Italy	Carbon-neutral by 2050	Not specified
Leuven	KU Leuven, Belgium	Climate-neutral by 2050	Not specified
London	Imperial College, UK	Carbon neutrality in Scope 1 and 2 by 2040; reduction of emissions from energy consumption in Scope 1 and 2 by 15% by 2025/26 compared to 2018/19	1 and 2
London	University College London, UK	Net zero buildings by 2024, net zero institution by 2030	Not specified for 2030 goal
Lund	University of Lund, Sweden	Reduction by 50% within 2023 with respect to reference year 2018	Not specified
Lüneburg	Leuphana University Lüneburg, Germany	Climate neutrality achieved in 2014 (according to an accounting system that includes negative emissions for green electricity fed into the electricity grid of a neighbouring residential area)	1, 2 and business travel
Madrid	Universidad Politecnica de Madrid, Spain	Zero net direct GHG emissions by 2030, climate neutrality by 2040	Not specified
Münster	University of Münster, Germany	Climate neutrality is recognised as a goal	Not specified
Notthingham	University of Nottingham, UK	Carbon neutrality with offsetting by 2040, carbon neutrality without offsetting by 2050, 63% reduction in emissions by 2030	Not specified
Odense	University of Southern Denmark, Denmark	57% by 2030 compared to 2018	Not specified
Oxford	University of Oxford, UK	Net zero carbon, and biodiversity net gain by 2035	1, 2 and 3
Plymouth	University of Plymouth, UK	Net zero from Scope 1 and 2 by 2025, net zero from Scope 3 by 2030–2050	1, 2 and 3

Location	Institution	Reduction target	Scope
Stockholm	Stockholm University, Sweden	Carbon dioxide neutral in 2040	1, 2 and 3
Warsaw	University of Warsaw, Poland	Climate neutrality as soon as possible	Various sources from Scope 1, 2 and 3
Zurich	ETH Zurich, Switzerland	Reduction of at least 50% by 2030 compared to 2006, to reach climate neutrality by 2030 through offsetting remaining emissions	1, 2 and 3

Table 2: Climate commitments of selected European universities. The sources for each of the pledges are listed in Appendix B.

Integration of top-down with bottom-up initiatives

Climate sustainability at a university requires changes in the framework conditions, overall decision-making processes, and the design, construction and operation of buildings. However, it also requires behavioural changes at the individual level. Therefore, an integration of top-down decisions with bottom-up initiatives is key. The University of Ghent and the ETH Zurich are both examples where university-wide climate strategies have been complemented by the development of strategies, plans and concrete reduction goals at the level of faculties and institutes.

Students can be important drivers of change through bottom-up initiatives. For instance, at the University of Nottingham, the Student Union first declared a climate emergency, before the university leadership followed.

To encourage bottom-up initiatives and integrate them with a top-down strategy, at some universities internal funding instruments have been put in place that provide funding for projects that help to reduce the university's GHG emissions, for instance at the University of Gothenburg (University of Gothenburg 2021).

Collaboration with the local region

The University of Sheffield motivates its climate plan by viewing itself as an integral part and important player within the local region: "Analysis by the Tyndall Centre for Climate Change shows that in order to meet its obligations under the Paris Agreement, the city of Sheffield needs to reach zero or near zero Scope 1 and 2 by 2038 at the latest. As one of the largest institutions in Sheffield and as a university carrying out leading research to tackle the climate emergency, we believe that we have a responsibility to help meet and exceed these targets." (The University of Sheffield 2020).

Other universities similarly view themselves as key drivers of change within their local areas. Integrated efforts exist, such as the feeding of green electricity produced on the Leuphana campus into the grid of a neighbouring residential area.

Collaboration between universities

Universities often do not act alone on climate sustainability, but are part of larger networks, an extensive list of which was given in Stöber et al. (2021b) for Europe. As emphasised in a report by UK universities on how they are tackling the climate crisis (Universities UK 2021), it is important for universities to follow a collaborative and not a competitive approach on this question. For instance, by collaborating, universities as a group can tackle Scope 3 emissions more efficiently. As a first step, agreed-upon and transparent ways of reporting emissions in all three scopes are important, because currently there is no standard of reporting.

Examples include the EAUC (Alliance for Sustainability Leadership in Education, https://www.eauc.org.uk/), founded in 1996, as well as many more recently founded networks, many of which are specific to a country, e.g. the German network HOCH-N (https://www.hochn.uni-hamburg.de/en.html), initially funded by the Ministry for Science and Education and now funded by member organisations), the Italian network RUS with a working group on climate change (https://reterus.it/), or the Alliance of Sustainable Universities in Austria (https://nachhaltigeuniversitaeten.at/). The main goal of these networks is the exchange of ideas, as well as good and best practices. To that end, the networks organise seminars, round tables and workshops; some report a boost in activity following the transition to virtual meetings with the beginning of the pandemic. The exchange of information can also be beneficial to motivate university management to take further action on climate sustainability, by highlighting actions and successes at other institutions. These networks differ in the amount of funding and consequently staff, with the number of employees ranging from zero (all staff members on a voluntary basis) to more than ten staff members.

Besides the examples that typically have a focus on a single country, international networks exist. For instance, the International Sustainable Campus Network, ISCN (https://international-sustainable-campus-network.org/) aims to provide an international forum to support higher education institutions in the exchange of information, ideas and best practices for achieving sustainable campus operations and integrating sustainability in research and teaching. Among other things it awards the ISCN Sustainable Campus Excellence Awards in the three categories: Whole Systems Approach, Partnerships for Progress and Cultural Change for Sustainability (ISCN 2022).

Additional networks are focused more narrowly on sustainable academic travel. For instance, the EU-funded project 'European University Network for Sustainable Mobility' (https://u-mob.eu/best-practices/) collects best-practice examples on sustainable campus mobility. The most recent of the three conferences that the network organised was an online conference.

4. Research institutes

Synopsis

- Research institutes are generally much smaller and more specialised than universities and have significant emissions related to specific research activities, including travel, laboratories and experiments, as well as computing. Many of these emissions are difficult to reduce significantly without immediately impacting the research.

- There is currently no systematic compilation of data available on GHG emissions from research institutes.

- From the examples that exist it is clear that specific large-scale infrastructures, such as, for example, particle accelerators, laboratories in the life sciences, supercomputer clusters and observatories can have high electricity consumption and thus a potentially negative impact on the climate. Some research activities, such as particle accelerators, also lead to GHG emissions directly from the experimental set-up.

4a. Introducing research institutes as relevant stakeholders

Research institutes primarily conduct research, and – unlike universities – typically do not educate undergraduate students. We focus on research institutes separately, because we concentrate on GHG emissions tied directly to research activities and laboratories. These emissions are also present for many universities, but are jointly discussed here, with the exception of air travel, which is also discussed in Chapter 3. Research-specific emissions include emissions from travel (e.g. for field trips), laboratories and experiments, as well as computing. Two factors make these emissions a particular challenge:

- First, some of these emissions are tied to highly specialised research activities. For example, particle detectors at CERN emit fluorinated gases (CERN 2021), generating just below 200 kt CO_2-eq emissions in 2017 and 2018. Mitigation strategies that are currently being researched include the optimisation of current technology, gas recuperation and the use of alternative gases. This example shows that emissions from highly specific sources can be large. However, their highly specific character means that their reduction constitutes a challenge that academia does not share with other sectors of society. Instead, research institutes and universities need to focus on these emissions themselves and develop mitigation strategies.

- Second, because of their direct connection to research activities, these emissions are particularly difficult to reduce significantly without immediately impacting the research. Therefore, the development of strategies that enable the research activities to continue, while those emissions are reduced, is important.

Research institutes can play a key role in academia's transition to climate sustainability: first, because they are typically much smaller than universities, and with a singular focus on research, they can be more agile in adapting their operations. Second, because they often focus on a single or several related disciplines, research institutes do not need to account for disciplinary differences in the same way that universities do.

In this chapter, we also address research-specific emissions (e.g. from laboratory use, large experimental and observational facilities and scientific computing), which are also relevant for universities, but are jointly discussed here.

We do not aim to develop a comprehensive picture, instead we provide a partial snapshot of the current situation by providing a few selected examples.

4b. Current practices and data on GHG emissions of research institutes

Data on the climate impact of research institutes are scarce. Therefore, a robust quantitative assessment across various disciplines is not currently possible and we limit ourselves to collecting evidence from individual research institutes, without assessing whether or not these are representative of typical research institutes. In particular, our focus will be

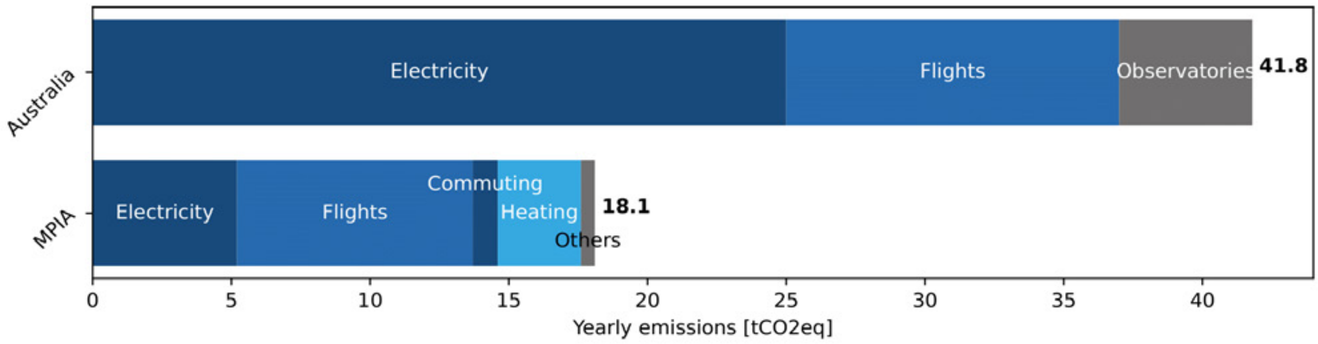

Figure 5: Yearly emissions per astronomer for the Max Planck Institute for Astronomy (MPIA) and for Australian astronomers. Data taken from Jahnke et al. (2020).

on emissions from institutes as a whole, before addressing research-specific emissions (e.g. from experiments, laboratories and scientific computing).

GHG emissions from research institutes and experimental facilities

We are not aware of a systematic compilation of data on GHG emissions from research institutes. Instead, several examples exist where the GHG emissions of individual institutes or similar facilities have been estimated, which we discuss as examples.

An attempt to estimate the full GHG emissions of a research institute, including those from flying as well as other sources, was made in 2020 by the Max Planck Institute for Astronomy (MPIA) (see Figure 5) (Jahnke et al. 2020). The total GHG emissions of the MPIA for 2018 were 18.1 t CO_2-eq emissions per researcher. This emission from professional activity alone is about 1.6 times the average total emission for a German citizen.

In astronomy, observatories are often located far away from the home institutes of researchers. Thus, next to electricity consumption on the site, GHG emissions from flights tend to make up a significant share of emissions (Aujoux et al. 2021; Flagey et al. 2021).

The climate impact of astronomical research infrastructures has been estimated to be 36.6 t CO_2-eq per year per astronomer, with an error of 14.0 t CO_2-eq per year per astronomer (Knödlseder et al. 2022). For large-scale infrastructure, such as observatories in astronomy, decisions on future observatories, undertaken now, are likely to lock in GHG emissions from these disciplines for the coming decades.

CERN requires roughly 2% of the electricity consumption of Switzerland (where CERN is headquartered) when the particle accelerators are running. As it is located on the Swiss–French border, it procures its electricity mainly from France, where electricity production is largely carbon-free. In 2018, this led to 31,700 t CO_2-eq emissions from energy consumption. Not included in the emissions are those resulting from 170 computer centres in 41 countries, which make up the Worldwide LHC Computing Grid. CERN is an example of high research-specific emissions: its total Scope 1 emissions were 192,100 t CO_2-eq emissions in 2018, 92% of which are related to the use of F-gases for particle detectors, as well as for particle detector cooling.

IMEC, a nano- and digital technology research institute based in Leuven, has monitored its GHG emissions in Scopes 1 and 2 since 2015. A total of nearly 45,000 t CO_2-eq emissions in 2015 was approximately halved to about 22,000 t in 2016 with a switch to electricity from renewable sources (IMEC 2021).

At the Energy Institute Hrvoje Požar (Croatia), the carbon footprint for 2017 amounted to 651 t CO_2-eq, or about 7 t per employee. Out of this, transport (roughly 60%) and energy use (roughly 22%) were the dominant sources (Jurić et al. 2019).

RISE (Research Institutes Sweden) aims to be climate-neutral in 2025, and reported GHG emissions of 3068 t in 2020 (RISE 2021) while employing 2840 staff members.

Laboratories in the life sciences can have very high electricity consumption and associated GHG emissions; see, for example, Ni et al. (2018) for a clinical lab, estimated to be 4–5 times the energy used at similarly sized commercial spaces (Woolliams et al. 2005). Similarly, at the University of Potsdam, electricity consumption for laboratory buildings is

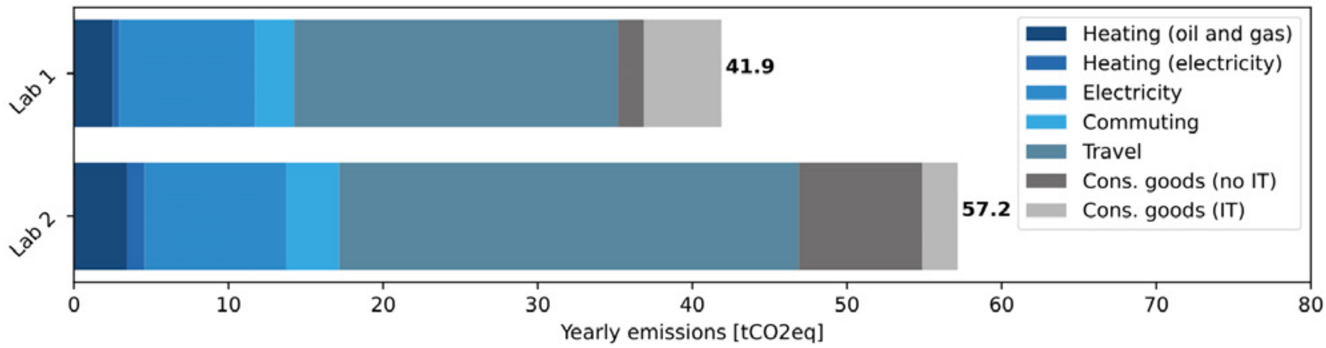

Figure 6: Carbon emissions for two labs at EPFL Lausanne. Data taken from EPFL and Zero Emission Group (2020).

approximately three times higher than for buildings primarily used for teaching and approximately five times higher than for buildings primarily used for administration (Universität Potsdam 2019).

At the EPFL, the GHG emissions were determined for two laboratories in the life sciences (see Figure 6; EPFL Lausanne, n.d. [Green Lab Project]). Yearly emissions were above 40 t CO_2-eq and nearly 60 t CO_2-eq, respectively, or roughly 4 t per year per researcher. Out of these, 50% of total emissions were due to flights, 20% due to electricity (out of which refrigerators are the dominant source) and 16–17% due to purchases (mainly of IT equipment for one of the two labs, and chemicals and plastic goods for the other).

Further, the Sustainable Trials Study Group (2007) studied the GHG emissions related to clinical trials, with trial-related travel a significant part of the total emissions. According to Adshead et al. (2021), there are 350,000 trials registered at ClinicalTrials.gov. Assuming the average GHG emissions per trial calculated by the Sustainable Clinical Trials Group, these add up to 27.5 million t CO_2-eq emissions.

GHG emissions from air travel compared to overall GHG emissions

A study of sustainability academics at the Lund University Centre for Sustainability Studies (LUCSUS) (Burian 2018) shows that on average, these researchers fly 72% more frequently than the average Swede, resulting in an estimated 2.61 t CO_2-eq emissions per year (from this professional activity only), more than twice as high as the emissions from flights taken by the average Swede.

Similarly, a survey at the Tyndall Centre for Climate Change Research in the UK, conducted in 2012 (including both social scientists/economists (56% of completed surveys) as well as natural scientists (27%) and engineers (13%)) found an average of 2.3 air trips per person per year, significantly higher than the UK employee average of 0.5 (Le Quéré et al. 2015).

The study at the MPIA (Jahnke et al. 2020) showed that of the 18.1 t overall CO_2-eq emissions per researcher per year, 8.5 t is due to flights. Ninety-one per cent of flying emissions are estimated to be due to intercontinental flights which cannot easily be replaced by alternative means of transport.

Studies of two labs at the EPFL (EPFL Lausanne, n.d. [Green Lab Project]) not only calculated the contribution of flights to the overall GHG emissions, but also reported them by career stage: senior researchers (e.g. professors) are responsible for 84–88% of emissions. PhD students, while making up 20% of people in the laboratories, only contribute 8% to the GHG emissions from flights.

In some disciplines, air travel is also connected to field trips; data on this appear to be scarce. A study focusing on climate change researchers (Whitmarsh et al. 2020) highlighted that field trips account for only a part of flights, with dissemination activities (e.g. conferences) constituting a substantial part of air travel in at least one study (Waring et al. 2014).

The same study (Whitmarsh et al. 2020) also highlighted that raising awareness alone has been found to be insufficient to trigger behavioural change, and so institutions need to consider additional measures if they are aiming to reduce the amount of GHG emissions from air travel. Triggered by the pandemic, possibilities for remote fieldwork have been discussed, e.g. in anthropology (Blum 2020).

GHG emissions related to computing

Computing generates GHG emissions through energy use, as well as through hardware production. Emissions from energy use are relatively easy to measure, whereas emissions from hardware production are more difficult to quantify. In the following, we therefore mostly focus on the former, while a better understanding of the emissions from hardware production is needed for a more complete assessment (see Gupta et al. (2020) for a study).

For non-scientific computing, the energy consumption by data centres and data transfer has remained approximately constant in the last 10 years (IEA 2021). In light of strongly increased workloads and data volumes, this corresponds to a large increase in computational efficiency. However, these efficiency increases have been more than compensated for by an increase in demand. Similarly, in several scientific disciplines, scientific computing is taking an increasingly important role. Thus, understanding the energy consumption and the related climate impact of scientific computing and comparing it to other sources of research-related GHG emissions is important.

As an example, Stevens et al. (2020) estimate that for astronomers in Australia, supercomputer use is the single largest source of GHG emissions, with an estimated 22 ± 7 t CO_2-eq emissions per year per full-time equivalent. This accounts for more than the estimated emissions from flights (7 t), observatories (at least 5 t) and offices (3 t) taken together. A comparison with an astronomy institute in Germany (Jahnke et al. 2020) highlights the impact of renewable energy, because there, (super)computing results in 4–5 t CO_2-eq emissions per researcher per year. In both cases, computing accounts for the largest fraction of electricity consumption per researcher (estimated to be 75–90% for the German example). Astronomy is a computationally intensive research discipline and thus the relative importance of emissions from computing is likely to be less in many other disciplines. Nevertheless, this example shows that computing can be a relevant source of emissions from research activities.

The existence of quantitative studies in the field of astronomy demonstrates an increased awareness of the need to align research and sustainability goals (see also https://astronomersforplanet.earth/), and could inspire similar efforts in other disciplines. An example from another discipline, namely neuroscience, can be found in Rae et al. (2021). In addition, the comparison already highlights a potential (mid-term) mitigation strategy, namely decoupling energy consumption and emissions by establishing supercomputing facilities in countries with a very large fraction of renewable energies, as advocated in Jahnke et al. (2020).

Further, cloud computing has been discussed as a more energy-efficient and hence less carbon-intensive alternative to in-house computing facilities. A report by NRDC (2012) highlights that this is typically the case (newer reports exist from outside academia, e.g. Lacy et al. (2020)), although depending on the server utilisation, the hardware efficiency and the efficiency of the surrounding infrastructure (e.g. cooling), emissions can vary. An in-house computing facility run in accordance with best practices can therefore be 'greener' than a cloud that does not follow best practices.

As in other parts of this report, when it comes to computing, both the larger framework (in this case including larger infrastructures, such as supercomputer facilities) and the choices of individual researchers matter (see, for example, Portegies Zwart (2020)). The choice of tools and algorithms also has a central impact on the efficiency of a computation (see, for example, the discussion in Portegies Zwart (2020) and Augier et al. (2021)). Individual researchers can estimate the GHG emissions of a given algorithm using an online tool (see Lannelongue et al. (2021)). A set of recommendations to make scientific computing more environmentally sustainable is provided in Lannelongue et al. (2021).

This in particular applies to the emerging field of artificial intelligence, which we briefly discuss as a particular example. Artificial intelligence is being applied in an increasing range of research fields. Much of it relies on computationally intensive deep learning models. Based on a study of the energy use of the training of neural networks, Strubell et al. (2019) recommend that researchers report training times of neural networks and prioritise efficient hardware and algorithms. Incentives for such reporting and prioritisation could be given by funding organisations; further, computing centres could prioritise efficient algorithms. According to a study in Henderson et al. (2020), reporting of carbon emissions is not yet done in papers that use machine learning (in contrast to other metrics, such as runtime, which are routinely reported). The lack of reporting could indicate a general lack of awareness of the climate impact of neural networks/artificial intelligence.

In summary, we find that in some computing-intensive fields, such as astronomy, awareness of the climate impact of the corresponding research activities exists, as shown by papers on the topic (Augier et al. 2021; Jahnke et al. 2020; Portegies Zwart 2020; Stevens et al. 2020).

To establish the practice of reporting across a broader range of research disciplines, suitable tools to estimate the carbon footprint of a computing activity are required. An example can be found in Lannelongue et al. (2021).

It should be stressed that gains in computational efficiency (emphasised in, for example, the European High Performance Computing Joint Undertaking, EuroHPC, https://eurohpc-ju.europa.eu/discover-eurohpc-ju) are prone to rebound effects: gains in efficiency are undone by increases in the number of computations. Reducing the GHG emissions related to scientific computing hence either requires decoupling electric energy consumption and emission intensity or reducing the growth of computations that are being run; efficiency gains on their own are probably insufficient (Association for Computing Machinery 2021).

Examples of current practices of engagement with climate sustainability

Overarching guidelines and recommendations

The Max Planck Society has over 80 research institutes, all but a few located in Germany, with nearly 24,000 employees. Since 2019, it has had the Max Planck Sustainability Network (https://www.nachhaltigkeitsnetzwerk.mpg.de/), with currently several hundred members from among its scientists, and technical and administrative personnel. The network is a grassroots initiative that engages with the broader topic of sustainability within the Max Planck Society. Its catalogue of recommendations (Beck et al. 2021), published in 2021, proposes to reduce the on-site energy use for electricity and heating (e.g. through improved insulation and installation of solar panels on roofs). Assessment and yearly monitoring are also proposed.

These are recommendations similar to those one may find for any other major enterprise, emphasising the point that the academic system is in many respects similar to other sectors of society. However, as stressed in the catalogue of recommendations, the academic system differs from society as a whole when it comes to mobility: whereas the main fraction of GHG emissions from mobility in Western societies like Germany comes from road travel, air travel is the main source of mobility-related GHG emissions in the academic system. Accordingly, it is proposed that virtual conferences should be promoted, in parallel with the establishment of a competence centre for the professional organisation of virtual meetings.

At the Alfred Wegener Institute (AWI) in Germany, the sustainability guidelines include the encouragement of low-emissions forms of transportation and carbon offsetting of air travel-related emissions (Alfred Wegener Institute 2019). In addition, the AWI recognises the opportunity to generate change along the supply chain by using its demand potential. The legal situation allows for procurement decisions to be based not just on financial, but also on social and environmental aspects.

Within individual disciplines, scientists are starting to engage with the climate footprint of their research, e.g. in neuroscience (Rae et al. 2021), astronomy (Stevens et al. 2020; Jahnke et al. 2020) and particle physics (Boisvert 2020; Bloom 2022).

Laboratories

Practices aiming at reducing GHG emissions from laboratories often fall into two main categories: (i) reducing the energy required to run the laboratory and/or run on renewable energy sources, (ii) reducing plastic consumption (and thus the GHG emissions associated with its production) and/or recycling laboratory plastics.

Electricity use of buildings containing laboratory spaces is typically higher than that of other university buildings. This can be reduced by the efficient use of equipment. For instance, at Ghent University, it is planned to use a centralised –80°C freezer instead of adding individual, decentralised freezers to the existing capacity (Ghent University 2021).

The Green Labs Guide from Trinity College Dublin (Gulman et al. 2021) proposes to run these ultra-low temperature freezers at –70°C instead of –80°C. An international challenge (https://www.freezerchallenge.org/the-challenge.html) proposes a list of good and cutting-edge practices, in which laboratories can engage to win an award, as a way to motivate a list of practices.

At the University of Nottingham, a new chemical laboratory building has been constructed with lower energy needs, where excess heat is used in adjacent buildings and runs on renewable energy, partially through solar panels.[17]

Reusing labware instead of using single-use plastics lowers the GHG emissions of a laboratory, and can even have the added benefit of reduced costs (Farley and Nicolet (2022)).

Currently, there is no standardised reporting scheme for laboratories. A step in this direction has been taken in Mariette et al. (2021), where parts of the GHG emissions of laboratories can be calculated and the impact of emission reduction actions can be estimated. The LEAF initiative also provides calculators to estimate the sustainability performance of laboratories[18] and provides toolkits and resources.[19]

Observatories and large-scale research infrastructure

The European Southern Observatory (ESO), which runs observatories in, for example, the Chilean Atacama Desert, has recently published its first climate report (ESO 2021) with a total of 28,000 t CO_2-eq; electricity, purchases and transportation of people and goods are the largest sources. Based on the report, ESO has committed to specific measures for which the estimated reduction in GHG emissions is provided (ESO 2021) and would add up to more than 4000 t CO_2-eq emissions.

The EIROforum, bringing together Europe's largest intergovernmental and USA's largest governmental scientific research organisations, recently declared its intention to improve the climate sustainability of the corresponding large science facilities (EIRO Forum 2021).

In the planning of large experimental facilities, GHG emissions are starting to play a role. Large experimental facilities are particularly important in particle physics and in astronomy and climate sustainability is now being viewed as relevant in their development. For instance, the 2020 update of the European Strategy for Particle Physics (European Strategy Group 2020) explicitly states that: "The environmental impact of particle physics activities should continue to be carefully studied and minimised. A detailed plan for the minimisation of environmental impact and for the saving and re-use of energy should be part of the approval process for any major project. Alternatives to travel should be explored and encouraged." It is noteworthy that the two points that are highlighted explicitly contain the reuse of energy (which is highly relevant for large particle physics experiments) and travelling.

In astrophysics, there are initial examples where the GHG emissions of a planned facility are considered (Aujoux et al. 2021).

A discussion of the climate impacts of research stations in Antarctica can be found in Cordero et al. (2022).

17 See https://www.nottingham.ac.uk/chemistry/research/centre-for-sustainable-chemistry/the-carbon-neutral-laboratory.aspx for details.

18 https://www.ucl.ac.uk/sustainable/staff/labs/take-part-leaf.

19 https://www.ucl.ac.uk/sustainable/staff/labs/resources-and-materials.

5. Students

Synopsis

» Many students support actions taken to reduce GHG emissions, and grassroots initiatives in several countries have impacted the decisions of university managements.

» GHG emissions due to student mobility (commuting, international students, field trips, etc.) can contribute to a university's carbon footprint, but are often difficult to quantify.

5a. Introducing students as relevant stakeholders

Undergraduate students[20] are an important group of stakeholders in the climate sustainability of academia. They (i) are a cause of GHG emissions, (ii) can be active participants in a university's (climate) sustainability strategy development and implementation, and (iii) are tomorrow's academics and researchers, which makes them both a present as well as future key stakeholder.

Institutional sustainability reports and assessments acknowledge students as a relevant source of GHG emissions. In particular student mobility (alongside housing) can be a non-negligible part of the carbon footprints of universities, as will be explored below. This emission source is further split into commuting and long-distance travel such as undertaken by international students.

As active participants in a university's climate sustainability strategy development and implementation, students have the power to considerably influence university practices, both through grassroots initiatives as well as through formal participation in university governance.[21] Their legitimation to influence university policy is three-fold: first, they are the crucial element in one of the university's core roles, namely higher-level education; second, in some countries they pay tuition to the university, on which universities depend to different degrees; third, the governmental funding of many universities depends on the number of enrolled students. That climate sustainability can thus become a business case for universities is highlighted by a survey of 3700 prospective international students, of which 88% reported that the university taking action to reduce its environmental impact was essential or very important in making their decision (QS 2019).

In the area of sustainability, students are active on campus in the form of sustainability student groups, student representatives involved in policy-making, and Green Offices or similar models of cooperation with university administration (Filho et al. 2019). With regard to reducing GHG emissions associated with air travel in particular, a survey of 35 universities in Europe and the USA (Kreil and Stauffacher 2021) shows that students can effectively influence their universities to begin to address the emissions associated with air travel: the survey counts nine institutions where students played a role in initiating efforts to decrease air travel emissions.

Students are not just a present but also a future key stakeholder for climate sustainability in academia: because an academic degree is usually prerequisite to an academic career, almost all future academics are students first. As such, they should get a say in designing the future academic landscape. This matters in particular because it is expected that viewpoints, behaviours and values vary between generations. Thus, today's students might have different opinions on the climate sustainability of academia than yesterday's students (i.e. today's academics). For example, regarding travel patterns in academia, out of 159 undergraduate students at ETH Zurich (Wenger 2021b), 93% approved of their university's efforts to decrease GHG emissions from air travel (opposed to 77% of non-professorial

20 Graduate students are not covered as a separate group in this report. Graduate students can have widely different job profiles, sometimes more akin to students (e.g. unpaid, or taking many classes) and sometimes more akin to researchers (e.g. paid, near full-time teaching and research with very limited classes). As such, they are considered in this report to be subsumed under both Section 5a (students) and Section 5b (researchers).

21 See https://www.eauc.org.uk/student_climate_commissioners_publish_coy16_stu for a recent statement published by the UK's Student Commissioners of the Climate Commission for UK Higher and Further Education.

scientific staff and 68% of professors (Kreil 2020). A re-analysis of the data showed that although 34% of the 77 undergraduate students in that survey who envisioned a future career in academia/research did say that they expected flying to be relevant or very relevant for that future job, 86% said that they would prefer, or strongly prefer, to work for a future employer that aims to reduce GHG emissions by reducing professional air travel. This perspective should be kept in mind when deliberating on who future academic workplaces will attract, and who may be systematically de-selected out of academia if air travel, and more generally physical mobility requirements, remain a strong prerequisite to an academic career.

5b. Current practices and data on GHG emissions of students

Educating students is a key mission of universities, and as such a large part of the university infrastructure is directly related to students. This includes a large part of the university buildings, but also catering, in some cases student housing, etc. Most of these aspects are covered in Chapter 3. In a study at the University of Applied Science in Konstanz showed that students have a similar carbon footprint to the average German citizen (Sippel 2017), with less emissions from heating, but higher emissions from flying.

In this chapter, we focus on student mobility. We will not specifically discuss daily student commuting, which can be a substantial source of emissions, discussed together with reduction strategies in Chapter 3. Instead, we focus on medium- and long-distance travel, as associated with the enrolment of international students, for example. Note that the degree to which these aspects count toward the carbon footprint of a given university probably differs widely along with practices, funds and student base.

Calculating the GHG emissions associated with student air travel, and especially comparing these estimates with estimates of a university's overall emissions or between universities, is even more difficult than the already challenging task of calculating the emissions from the air travel of researchers (Biørn-Hansen et al. 2021). Students may undertake short-term journeys by plane for specific teaching events that may or may not be included in their curriculum; they may travel for longer periods in order to take a semester abroad; or they may complete an entire degree in a different country. Who pays for these different kinds of trips, and therefore who has access to data regarding them, varies, so that comprehensive datasets regarding student air travel require significant effort on the part of a university. A recent survey (Kreil and Stauffacher 2021) of 35 universities and other research institutions in Europe and the USA which actively try to reduce emissions related to air travel shows that even among these institutions, not all monitor student air travel. In fact, travel associated with the recruitment of international students is not known to be consistently monitored by any university at this time.

However, student mobility is responsible for a non-negligible portion of GHG emissions in universities. Arsenault et al. (2019) have estimated that each international/exchange student enrolled at the Université de Montréal emits on average 3.85 t of CO_2-eq annually by flying, which adds up to 21% of the university's carbon footprint.

For ETH Zurich, Switzerland, it has been estimated that even each bachelor/master student emits around 0.1–0.2 t of CO_2 annually by flying for study-related purposes, and that student air travel overall accounts for around 1600 t of CO_2-eq annually (Medhaug 2021a), which amounts to about 10% of the university's overall air travel emissions, and around 5.8% of the university's total emissions in 2018 (ETH Zurich 2019). Moreover, student travel-related emissions have doubled at ETH Zurich between 2006 and 2015 (Mobilitätsplattform ETH Zurich 2017). This number may be attributable to the well-funded situation of ETH Zurich, making it possible to design travel-based teaching events, and may not reflect the situation in most other universities. However, it does imply that student travel should be considered as a source of GHG emissions wherever it is built into curricula or recruitment strategies.

The increase observed at ETH Zurich is in line with global estimates of the growth of international student mobility (Shields 2019), which increased by an average of 5.26% per year from 1999 to 2014. The associated GHG emissions also increased at a rate of 1.65%, which is on the one hand slower than mobility growth itself due to increased intra-regional travel, but on the other hand still faster than the increase of GHG emissions overall during the same period. Globally, Shields (2019) estimates that emissions from student mobility ranged between 14.01 and 38.54 Mt CO_2-eq in 2014, which the author compares to the similarly large GHG emissions of Jamaica or Croatia. It is therefore clear that this emission source must be taken into account in designing the sustainability transition.

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Emissions from student mobility can be addressed in different ways. According to the survey by Kreil and Stauffacher (2021), among research institutions actively engaged in reducing emissions related to air travel, six of the 35 institutions issue recommendations to students to use ground travel for exchange programmes and similar, and another eight are planning to do so. Seven recommend limits to field trips and similar study-related events that require air travel, and eight are planning to do so. At ETH Zurich, this idea enjoys support from 44% of 63 undergraduate students who participated in a survey on the topic (Kreil 2020). Mandatory limits to teaching activities that require air travel have not yet been implemented, but are being planned by three institutions in the sample; in one institution, the idea has been attempted but discarded.

Of course, students can also act as agents in the academic system and drive change. For example, the student representatives of the Climate Commission for UK Higher and Further Education recently put forward a statement[22] that reports a high awareness and concern in the UK student population regarding the climate crisis and lists several demands for concrete action, ranging from mandatory carbon monitoring to policy changes which encourage and enable net zero targets for institutions. The statement also includes a recommendation to expand virtual teaching in order to improve inclusivity and reduce emissions from commuting. Another example is the Climate Students Movement (https://climatestudents.com/framework/) that began in Sweden, which is a growing organisation connecting different national student action groups to push higher education institutes to reduce GHG emissions. In Germany, Students4Future (https://studentsforfuture.info/), sparked by the global Fridays for Future movement, draws attention to the role of universities in the climate crisis.

22 The statement is available at https://www.eauc.org.uk/student_climate_commissioners_publish_coy16_stu.

6. Individual academics

Synopsis

- The academic system is to a large extent self-governed. As such, individual academics engaged in the transition towards climate sustainability can trigger systemic change through their community roles as well as through grassroots initiatives.
- A systematic study is lacking, but examples suggest that researchers often cause several tonnes of GHG emissions per year due to duty air travel, significantly above the respective national average per capita emissions due to air travel.
- Air travel activity often increases with seniority, with a sizeable fraction of air travel emissions caused by a small group of professors and senior researchers. Early career researchers who arguably have a special need for in-person interaction to create a professional network are currently not those travelling most.
- International exchange is an important factor in scientific progress. Virtual meetings and hub-based conferences can decouple internationalisation from physical mobility and substitute (a part of) physical mobility. More isolated geographic regions or regions with less developed digital infrastructure face additional challenges.

6a. Introducing individual academics as relevant stakeholders

As individual agents within the academic system, within their networks, and within the institutions where they are employed, researchers have several angles from which they can influence the climate sustainability of academia: they can change their own personal practices; interact with colleagues within and beyond their own groups and institutions in order to encourage more climate-sustainable practices; and they can – more impactfully together with others – ask for changes from their institutions, such as research institutes, universities, disciplinary societies, etc. (Naito et al. 2021). As such, individual researchers are an integral part of many of the changes that will be outlined in other chapters of this report, as they are both directly affected by any structural changes made, and their active collaboration – or at the very least their passive acceptance – is necessary for many such changes to be successfully implemented. Individual researchers are also crucial to the implementation of any top-down regulations, e.g. at universities and funding organisations: measures that appear well justified to the individual researchers and find their support are much easier to implement; in contrast, due to the high value that is placed on academic freedom, measures imposed top-down without sufficient support are likely to be circumvented, ignored or even counteracted.

Many of the same considerations apply to members of administrative staff, technical staff or scientific staff whose role is not primarily teaching. Therefore, we will also highlight aspects relevant for these members of the academic community, while primarily focusing on researchers.

In this chapter, we focus on the mobility of researchers, specifically air travel, because this is for many academics not only the main source of their carbon footprint (as will be explored below), but also an area in which they have relatively large autonomy: while individual researchers do not directly influence their institution's buildings or investments, the energy used or the catering offered, they do have an – albeit limited – independent ability to decide when they travel where, for what reason, and how; or whom they invite, thus causing another researcher to travel. This makes business travel a particularly important area of practice at the level of the individual researcher. We stress, however, that the actual autonomy which individuals actually have over their travel decisions varies significantly based on, among others, their career stage, and responsibility for change should be considered within that context. Similarly, air travel may be relevant for administrative staff, with similar considerations applying.

Researchers have always been leading international lives and careers and have therefore travelled (Parker and Weik 2014). However, the frequency and the carbon intensity of travel have drastically increased with the advent of modernity and, in particular, affordable aviation. Academic GHG emissions have grown at an accelerated pace, along with an expectation that the successful academic career entails a high level of international travel to conferences and workshops, invited lectures, evaluation panels, teaching sessions, research stints and for other purposes. Recent empirical work was, however, not able to establish a significant correlation between travel and academic performance, as will be discussed in more detail below.

Researchers are a diverse group, with vast differences in academic practice and associated travel behaviours. Categories of difference may include (sub)discipline and (sub)disciplinary norms, types of research (i.e. whether or not this depends on field trips or access to experimental sites or observatories), geographic scope of research, geographic location, contract type and funding, personal characteristics (such as gender and care obligations) and, not least, career stage. This last division will be explored with particular attention in Section 6b.

Internationalisation, and the need to demonstrate an international reputation and prestige, is built into academic recruitment and promotion exercises (e.g. Hopkins et al. 2016), and these can help to reinforce the need to travel – not only to conduct research, but also to build networks and potential future collaborations. This process is probably exacerbated by the casualisation of academia – increasing reliance on workers on fixed-term contracts – which can reinforce the need for conference attendance to find contracts, but also build strong networks that grant some resilience against uncertainty on the labour market (see Sennet, 2007, cited in: Storme et al. 2017). Early career researchers are arguably most exposed to this implicit and explicit pressure to travel. This should be kept in mind when forming committees or similar groups tasked with developing measures for a climate-sustainable academia, in particular in a transition phase when different institutions and funding agencies may be promoting different rules and guidelines. This external expectation to travel effectively removes much of the theoretical room for behaviour change which we ascribed to individual academics above. Once more, this is particularly true for early career researchers, who still need to prove themselves in their research field. Also, they will tend to emulate the practices they see their seniors engaging in: where senior scholars travel extensively, and invitations to provide keynotes or visit labs/research groups are associated with being a 'productive' or 'esteemed' academic, more junior colleagues also tend to aspire to increased mobility as well to mimic and emulate senior peers. Nevertheless, early career researchers also have the potential to offer behavioural innovation, to network laterally in low-carbon ways and to push for change from their institutions and within their research groups. In this context, it is crucial to note that early career researchers do not tend to be the group that travels most (Arsenault et al. 2019, Ciers et al. 2018, Medhaug 2021a; see also the discussion below), nor do they tend to use business or first class on their flights. In contrast, both – most frequent travel as well as choice of business or first class – is typically associated with senior researchers, who are less dependent on external pressures and have more freedom to make independent choices.

6b Current practices and data on GHG emissions of individual academics

The climate impact of air travel at an individual level

Taking one less transatlantic flight per year is one of the most effective ways in which an individual who flies can reduce their carbon footprint (Wynes and Nicholas 2017). It is therefore unsurprising that academic mobility makes up a large part of the carbon footprint of individual academics. In one case study, air travel made up 70% of a PhD project's total GHG emissions (Achten et al. 2013). Other self-reports from academics have shown greater annual emissions related to air travel than the average American emits for all annual activities taken together (Fox et al. 2009, Grémillet 2008). For example, marine biologists and oceanographers emit on average 6.2 t CO_2 per year by flying to conferences (Seuront et al. 2021). As another example, Jahnke et al. (2020) estimated 8.5 t CO_2-eq emissions from air travel per researcher per year at the MPIA in Germany. Also in Germany, those flights included in the respective university's climate reports amounted to more than 1 t CO_2-eq per year per employee for the University of Hamburg and University of Potsdam. Further, data from the Norwegian Institute for Air Research showed travel-related emissions of 3.9–5.5 t CO_2-eq per year (Stohl 2008). In two laboratories in the life sciences at EPFL (EPFL Lausanne, n.d. [Green Lab Project]), each researcher caused about 2 t CO_2-eq emissions from air travel per year. Also in Switzerland, about 1.5 t CO_2-eq emissions per full-time employee arose at ETH Zurich in 2019. For reference, we can compare this with the annual average per capita emissions due to air travel in the respective countries, https://ourworldindata.org/grapher/per-capita-CO_2-aviation-adjusted, which even in Europe (with the exception of Iceland) and North America were below 1 t CO_2-eq in 2018.

The relationship between air travel and academic performance

Although some academic travel has been degraded and ridiculed as 'academic tourism' (Høyer 2009, Høyer and Naess 2001), the general assumption has been that travelling generates benefits for the travelling researcher that are important for building or sustaining a career in academia, as mentioned above. We offer three responses to this assumption:

» First, the very requirement of mobility in order to achieve certain aspects of success in academia might be encouraging researchers to fly more than is really necessary. They may be choosing trips based on an opportunity to maximise metrics associated with their success, rather than actual research impact and increase in quality – in a classic example of 'hitting the target, but missing the point'. Indeed, it even bears consideration whether there may not be cases in which the quality of a researcher's work would increase with more time available at their institution – or, possibly, during an extended stay abroad. The connection between corporeal mobility and subject positions (i.e. 'successful academic') is strongly made in mobility scholarship, and given the correlation between increased mobility and seniority in academia, there is a critical need to better understand pathways to achieve and recognise esteem without high-carbon travel.

» Second, this close association between travel and academic success is empirically questionable. A growing amount of empirical investigation into the issue (for example, from Norway, Canada, Switzerland and other countries) has so far indicated that the connection is weaker than assumed and also that the causal relationships may not be straightforward: Wynes et al. (2019) found no significant correlation between emissions related to air travel and metrics of academic productivity such as the h-index, hIa (average number of h-index points gained per year), citations, or average number of authors per paper; they found, however, positive and independent associations between travel (emissions) and salary as well as travel and seniority, as well as a lower hIa for that group of researchers who billed no air travel at all during the 18-month study period. Data from EPFL (Switzerland) also find no significant correlations between air travel emissions and 18 different indicators of academic success, most crucially including Category Normalized Citation Impact and h-index (Ciers et al. 2019). Further, some travel (primarily of more senior researchers) may be of a more 'honorary' nature.

» Third, if travel really is an essential prerequisite to an academic career, then access to this important boon is distributed highly unequally across academics, as we will explore in the following section.

The unequal distribution of air travel in the academic system

At Imperial College (Grant et al. 2019), 15% of all total users of the university's travel agency account for 50% of the total emissions recorded. At EPFL (Lausanne, Switzerland; Ciers et al. 2018), 10% of researchers were responsible for 60% of the emissions from travel. At KTH (Sweden, unpublished manuscript), 10% of employees are responsible for 67% of all emissions (although it must be noted that administration is here included in employee count).

This uneven distribution is connected to the career stage: at the Université de Montréal, Canada (Arsenault et al. 2019), each professor is on average responsible for 5.6 times as much air travel-related emissions as a graduate student, and 2.4 times as much as a postdoc. At ETH Zurich, Switzerland, each professor is responsible for 7.7 times as much air travel-related emissions as a doctorate student, and 5.6 times as much as a senior researcher (Medhaug 2021a). In the study at EPFL (Lausanne, Switzerland; Ciers et al. 2018), each professor is even responsible for 10 times as much air travel-related emissions as a PhD student and five times as much as a postdoc (see Figure 7).

Whether this distribution is appropriate or not is a matter of debate. It can be argued that, if air travel is to be treated as a scarce resource in the future for ecological reasons (keeping in mind that travel funding is often already such a scarce resource), then this scarce resource is best invested in those individuals who have already proven their ability to generate excellent output – for example those who have advanced to the level of professor. A well-travelled individual may also be able to pass on some of the fruits gained through their travel to perhaps more junior group members, collaborators and protégé(e)s. On the other hand, many emphasise that early career researchers in particular need to travel in order to develop a network, attract attention and advance their careers. Also, career stage is not the only dimension on which academic travel is distributed unequally: gender, for example,

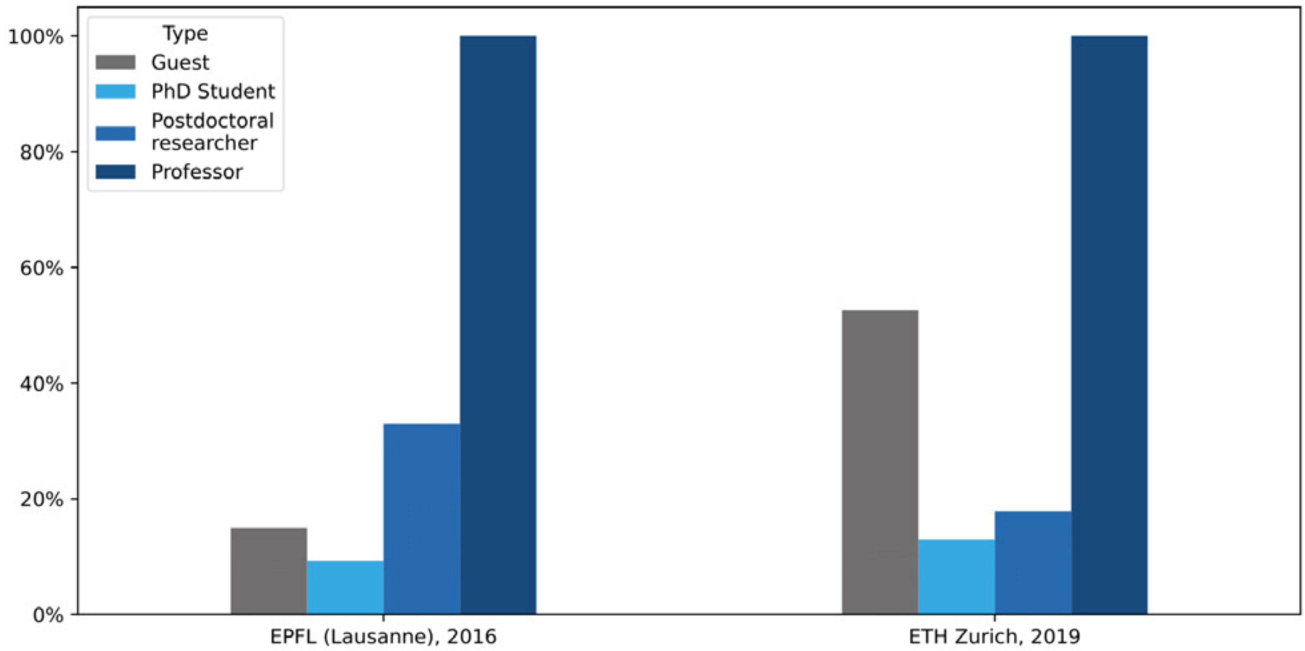

Figure 7: Relative per capita emissions for types of researchers, normalised to the emissions per professor for two research institutes (Ciers et al. 2017; Medhaug 2021a).

is another aspect that could create diverging mobility patterns (see, for example, Cohen et al. 2020).

Whichever position one takes regarding the fairness of current travel distribution patterns, attempts to reduce air travel-related emissions in the academic system should take note of the differences between groups of academics. That includes an understanding of the on average greater leverage an individual professor has to reduce emissions. However, one should also take note that because there are many more non-professors than professors working at a university, travel that professors undertake still makes up only about 28% of air travel-related emissions, e.g. at ETH Zurich, and therefore reducing just that source of emissions only addresses part of the problem (Medhaug 2021a), even though these emissions tend to be high when considered per individual.

It is equally important to note that the European academic system is not characteristic of the academic system worldwide. Researchers from Asia and Africa are much more likely to face visa-related restrictions on their mobility (McInroy et al. 2018). Academics in Australia (Glover et al. 2019) and New Zealand (Hopkins et al. 2016) have emphasised the particular mobility needs arising from their geographic isolation; this sense of isolation refers not merely to a Eurocentric or US-centric idea of 'remoteness' from perceived centres of academic activity, but also to long distances separating universities within some countries like Australia. While some European institutions and countries certainly are more geographically isolated than others (e.g. Finland; Ahonen et al. 2021), Europe as a whole is a densely populated continent with high academic activity and well-developed railway infrastructure and roads. It therefore has a better than average starting position for reducing emissions from academic air travel (primarily those caused by short-haul flights), and has perhaps the least to lose from (and therefore perhaps a privileged view on) alternative future systems of academic communication such as conference models based on regional hubs connected by virtual communication technology.

Although data are scarce, Whitmarsh et al. 2020 suggest that European researchers indeed fly less than colleagues based elsewhere; however, because at least 66% of that sample were European, with the largest other group being Australian researchers (10%), it is uncertain which contrasts are responsible for this finding. Chalvatzis and Ormosi (2021) find that, within economics, speakers from Latin American and Asia Pacific countries travel most on average, while speakers from European countries travel less on average. On the other hand, McInroy et al. (2018) find that researchers with a European nationality are the most likely to report travelling frequently for research.

The role of virtual communication from an individual researcher's perspective

Since the COVID-19 pandemic, expectations to travel less and replacing air travel with videoconferencing have been increasing. For instance, ICT solutions and tools, and the application of virtual or augmented reality, are enhancing communication quality, providing convenient opportunities for researchers to opt not to travel by air. Even before the pandemic, the physiological, psychological and social costs of hypermobility have been emphasised (Cohen and Gössling 2015), highlighting that alternatives to the academic system's hypermobile culture are worth exploring.

Virtual conferences or meetings may come with disadvantages that impact productivity and networking, for instance because of difficulties with schedules and time management due to time zones (Glover et al. 2017). Such negative effects may negatively impact the opportunities for researchers to present new research, share ideas and build networks at conferences.

A particular challenge is faced, e.g. by socio-economic research, often performed by Global North researchers and concerning the situation of the Global South, which is frequently focused on the operation of less developed societies and their improvement possibilities towards a more sustainable future. Such research is difficult to conduct without in-person social interaction (Baer 2019). Data collection, an integral part of research, can likewise depend on the mobility of researchers.

Furthermore, hearing about and presenting oneself as an interesting candidate for research/teaching positions is closely related to international research stays, visits to foreign universities or collaboration, principally depending on air travel.

Despite these challenges, existing evidence suggests positive attitudes among researchers towards video-conferencing (Nursey-Bray et al. 2019). It may also have financial benefits, because it mainly assumes an initial investment, contrary to the air travel costs repeated for each meeting.

Individual researchers as agents of change

Individual researchers can and have pushed for systematic changes through grass roots initiatives, such as the Max Planck Sustainability Network (https://www.nachhaltigkeitsnetzwerk.mpg.de/de) founded in 2019, the international Scientists for Future collective of scientists (https://scientists4future.org/), which was sparked by the Fridays for Future student protests, or the Astronomers for Planet Earth movement (https://astronomersforplanet.earth/). Pledges to no longer take short-haul business flights, e.g. for distances up to 1000 km (http://unter1000.scientists4future.org/), have received thousands of signatures. Less visibly, many researchers share the concerns about the climate crisis and have pushed for changes within the administrative procedures of the universities or research institutes, or have contributed to raising awareness and thus triggering behavioural changes among their colleagues and management. While systemic change is needed to face the challenges of the climate crisis, individual researchers can and should be part of these changes.

7. Funding organisations

Synopsis

» Funding organisations provide an important part of research funding and have leverage to set trends and values and influence the behaviours and choices of researchers.

» Funding organisations are currently not engaging very actively in climate sustainability. We are not aware of a funding organisation that monitors the GHG emissions of funded projects; some have started to monitor GHG emissions of interview and selection processes, which can be substantial.

» Some funding organisations have sustainability guidelines and green charters and similar for their grantees. Some funding organisations also encourage the use of low-carbon forms of transport. Additional funding organisations are in the process of considering how to implement climate sustainability.

7a. Introducing funding organisations as relevant stakeholders

Funding organisations are key players in determining the framework conditions for research. They determine whether the climate impact of a research project is a relevant factor in funding decisions and thereby influence very directly whether or not the climate impact of research is taken into consideration by researchers.

Given the urgency of the climate crisis, policy-makers might in the future decide to impose hard limits on the environmental impact of research institutions as a whole. Funding organisations thus now have the choice between being agents of change at the forefront of a transition to sustainable research or in the future responding to externally imposed regulations.

The impact that funding organisations could have in this area is exemplified by data from the European University Association's first report on ***Greening in European Higher Education Institutions*** (Stöber et al. 2021). There, 'enhanced national funding support' and 'enhanced European funding support' were among the top three measures to help universities overcome challenges in 'greening'.

Research funding organisations are in a strong position to support a transition to climate sustainability in academia. At the same time, such a transition comes with potential pitfalls. For instance, if the requirement for a low or vanishing carbon footprint is implemented in too simple a way, some research directions might be very seriously hampered. Keeping research quality and international competitiveness in mind is therefore crucial when research funders develop measures to incentivise climate sustainability and to reduce the climate footprint of funded projects.

In addition, some funding organisations currently incentivise some behaviours that increase the GHG emissions of funded projects. For instance, in some projects that include collaboration between partners at different locations, annual in-person project meetings are required. As another example, funding agencies often only support computing costs in local computing centres and not commercial cloud computing solutions, which can be more resource-efficient (NRDC 2012).

The sources of funding can be broadly categorised into governmental (EU-level and national programmes for research funding) and private (private funds, organisations and foundations that fund research in hopes of future profit, or because private foundations have been established in the past with the mandate to support research). These two differ somewhat when it comes to regulatory practices and the introduction of new sustainability requirements through legislation. Governmental funding schemes can be more easily moved toward the adoption of various sustainability requirements through legislation. In contrast, private funding for research is typically less regulated from a top-down perspective and can be subject to public opinion and social trends. This difference can be important to ensure a competitively funded research landscape.

EU-level funding

EU-level funding is typically project funding, e.g. through the ERC. Viewed from the perspective of international competitiveness, EU-level funding is in a good position to develop measures to reduce the climate footprint of funded projects. This is because competitiveness within Europe is automatically ensured, because all European researchers are subject to the same measures.

National governmental funding

National governmental funding is critical not just for research projects, but in particular also for the basic funding of universities and research institutes. Governments can and do apply conditions on their funding. In recent years there have been examples of such conditions where public research funding agencies have imposed demands on climate awareness in their operations, although these are early days and methods and practices need to be developed and streamlined.

National funding through private funds, foundations and organisations

Depending on the country within Europe, private funding can be more or less important. In some countries, a significant amount of project funding comes from private foundations, sometimes even basic university infrastructure (e.g. buildings) is funded by autonomous private or public foundations. Just as in the case of public agencies, certain foundations have introduced policies and measures to mitigate climate emissions following from their operations.

7b. Current practices and data on GHG emissions of funding organisations

There are multiple examples of funding organisations establishing funding lines to support research (and its translation) into climate-sustainable technologies, the understanding of the climate crisis and its physical basis as well as its socioeconomic consequences, its historical roots and socio-cultural contexts.

Despite this, funding organisations rarely engage with the climate sustainability of the research operations they fund and rarely include the research cost of GHG emissions into their funding decisions. It is critical that funding organisations not only fund research that helps to mitigate and adapt to the climate crisis, but also develop incentives that can help the academic system itself to mitigate and adapt to the climate crisis. There are challenges in such a development that require a balanced and deliberated way of proceeding, in order to prevent unintended consequences.

At the time of writing, we are not aware of any funding organisation that monitors the GHG emissions of the funded research. Therefore, the evidence base is currently lacking.

Below we discuss steps taken by funding organisations that recognise and address the need for climate sustainability in the day-to-day operations of the academic system. We discuss how these funding organisations are adapting their funding guidelines, opportunities and rules.

Funding organisations with policies aimed at reducing the climate impact of funded research

At the European level, the Marie Skłodowska–Curie Actions Green Charter (European Commission, Directorate-General for Education, Youth, Sport and Culture 2021) encourages grantees to (i) reduce, reuse and recycle, (ii) promote green purchasing for project-related materials, (iii) ensure the sustainability of project events, (iv) use low-emission forms of transport, (v) promote teleconferencing whenever possible, (vi) use sustainable and renewable forms of energy, (vii) develop awareness of environmental sustainability and (viii) share ideas and examples of best practice. Beyond individual researchers, it also addresses institutions and research consortia. Further, in the final reporting state of a project, grantees will be asked to elaborate on how they minimised the environmental impact of their research and implemented the principles of the Green Charter in their project. Given that this is a new policy, the impact of such measures, where it is left to the individual researcher to decide whether and how they implement the principles of the Green Charter, will need to be evaluated in the future.

At the European level of funding of student mobility, the Erasmus+ guidelines provide a top-up amount for less carbon-intensive means of travel and allow for up to four additional days of travel, where applicable (European Commission 2022b).

At the national level, we list a few examples to highlight currently implemented measures. Further, several funding organisations are now in internal deliberations regarding further measures to increase the climate sustainability of the funded research. Additionally, the GHG emissions from the direct operations of funding organisations can also be reduced; as an example, the UKRI has pledged to reach net zero in its own operations no later than 2040 (UKRI 2020).

Since 2020, the public German funding agency Deutsche Forschungsgemeinschaft (DFG) provides funding to offset GHG emissions resulting from business trips of its employees, reviewers and funding recipients (DFG 2020).

In 2020, the public German funding agency DAAD published a paper on 'sustainable mobility' (DAAD 2021). The paper addresses how internationalisation can be achieved without equating it to physical mobility (substituting 'internationalisation at home' through digital means) and how, if physical mobility is necessary, it can be decarbonised. These considerations apply both to student mobility and internationalisation in research. As a concrete example, the DAAD will therefore recognise digitalisation efforts as fundable expenditures. This is an example of a shift in thinking, where a funding organisation continues to fund internationalisation, but without an automatic coupling to physical mobility and instead with a shift of funds towards digital means of enabling internationalisation.

In a new policy published in early 2020, the global charitable foundation the Wellcome Trust calls on its grantees to minimise the number of journeys, choose means of travel with lower GHG emissions, and offset the emissions of their business trips (Wellcome 2021).

The German Alexander von Humboldt Foundation recently held a virtual meeting on 'new mobility' (Alexander von Humboldt Foundation 2021b), focusing on how to make future academic mobility climate-sustainable and what opportunities virtual mobility offers. Such activities show how funding organisations are currently focusing on the primary topic of this report and how physical and virtual mobility are being considered alongside each other. This initiative is part of a larger reorientation of the Humboldt Foundation, which recognises that: "By promoting new knowledge and practical applications, science organisations contribute to mastering this crisis [the climate crisis]. However, these organisations must likewise take action because many of their activities also contribute to greenhouse gas emissions." (Alexander von Humboldt Foundation 2021a). Its recently developed agenda for sustainability (Alexander von Humboldt Foundation 2021a) includes the goal to remain conscious of the worth of personal encounters, while establishing, testing and promoting hybrid meeting formats and, more generally, new forms of mobility.

The Swedish Riksbankens Jubileumsfond (RJ) started in 1964 and has had a general environmental policy since at least 2012, which is currently being renewed. In recent years RJ has added specific climate demands, for example on energy performance of buildings it owns, a more climate-friendly travel policy for its staff (train as the default for domestic travel), use of digital meetings and a sustainability-oriented service procurement policy. Sustainability demands (sustainability index, annual consultancy examination) also govern RJ's asset allocation policy for their €1.5 billion endowment. Carbon impact assessment of asset allocation is measured annually and reported to the board. As yet, however, RJ has no climate-related requirements on the actual spending of research funds of some €50 million per year and no climate profile on the topics and content of research. Other research funding foundations and public agencies in Sweden do have such a profile, notably MISTRA (a public foundation for strategic environmental research, in operation since 1994) and FORMAS, a government agency with a focus on funding sustainability research. MISTRA also pioneered work to develop green asset allocation starting in the early 2000s, accepting (if necessary) reduced returns on investment to improve sustainability.

There are no funding organisations that the authors of this report are aware of that require grantees to keep track of the GHG emissions related to their project, and/or to estimate these emissions prior to the application. Thus, while the financial budget of a project is estimated beforehand and kept track of meticulously, the same is not true for the carbon budget.

GHG emissions of funding decisions (interviews, committee meetings, etc.)

In their review and interview processes, funding organisations often demand that reviewers and interviewees are present in person, thus resulting in GHG emissions from the funding decisions themselves. During the course of the COVID pandemic, these practices have changed temporarily and some funding organisations are deliberating to keep some of these changes in place.

The ERC has estimated the carbon footprint of its decision-making process based on simulations for the 2020 round. The decision-making process includes two in-person meetings of the panel

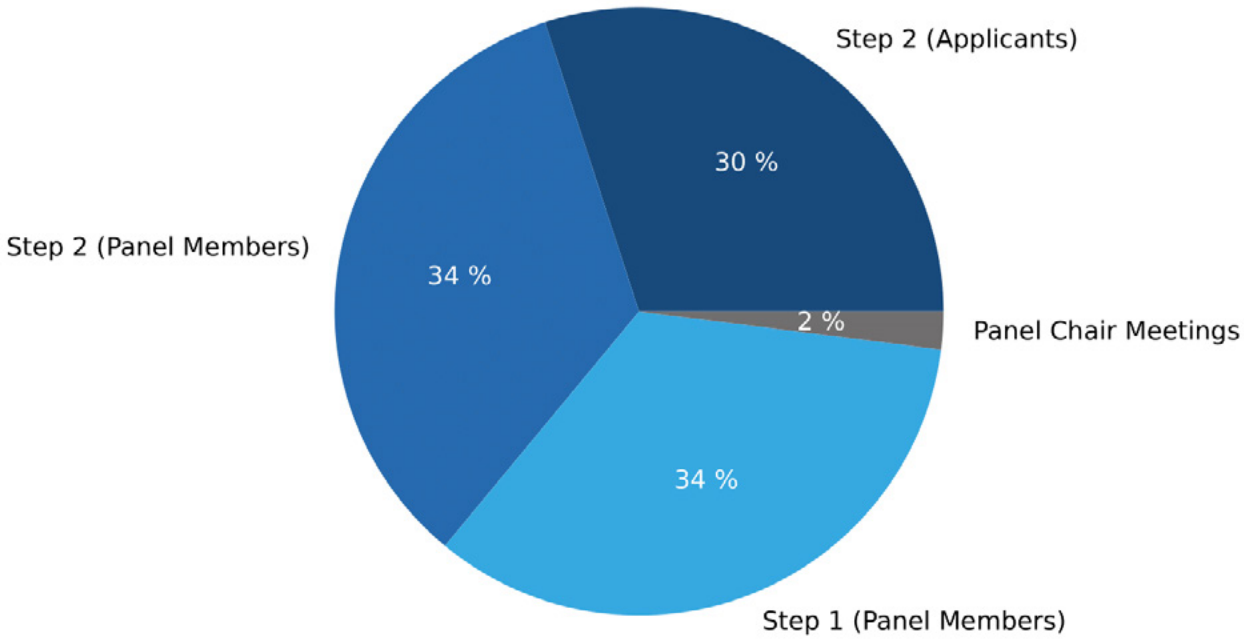

Figure 8: Fraction of travel-related CO_2 emissions generated in a simulation of the 2020 ERC Call. Emissions total to 3570 t CO_2-eq.

members, as well as in-person interviews. A total of 2486 interviews led to a combined CO_2-eq emission of 3570 tonnes, i.e. more than 1 tonne per interview (based on an analysis by the Data Analysis Group in unit B2 of the ERCEA) (see Figure 8). This total amount splits into roughly one-third for the interviewed candidates, and one-third for travel of panel members in each of stage 1 and stage 2.

Based on publicly available data for the ERC-StG, Bousema et al. (2022) have estimated the GHG emissions for 2019: assuming that the train was used for trips under 500 km, an estimated 1419 t of CO_2-eq results from an estimated 1013 interviews. This estimate fits with the simulation for 2020 (which accounted for more than twice as many interviews across all three stages of the ERC).

A second example for the GHG emissions associated with the decision-making process for research grants can be found in Bousema et al. (2022), which has estimated the GHG emissions for the European and Developing Countries Clinical Trials Partnership based on publicly available data for the home institutions of panel members and the assumption of economy class travel and one panel meeting. The resulting estimate of 245 t CO_2-eq emissions for 144 panel members is probably a conservative estimate.

Lack of funding initiatives as a challenge to the greening efforts of universities

According to the EUA survey (Stöber et al. 2021a) , general underfunding and lack of specific funding incentives are the two most important challenges to greening and sustainability initiatives at universities. This provides an obvious possibility for funding organisations to support the transition to climate sustainability in the academic system.

The importance of funding to support academia's transition to climate neutrality is also emphasised in a recent report by Universities UK (2021), where special funding opportunities such as the UK's Public Sector Decarbonisation Scheme (Department for Business, Energy & Industrial Strategy 2021) are highlighted as central to enable the investments needed to, for example, install low-carbon heating on campuses.

International competitiveness and climate footprint

One concern may be that when funding organisations in a given geographical region decide on measures to limit the climate impact of the academic system, the competitiveness of researchers within that geographical area could be reduced compared to other regions of the world. Here, it may be helpful to turn to other societal challenges as an example: for instance, taking paternity/maternity leave negatively impacts a researcher's career by reducing their research output, ability to network and collaborate, and opportunities to present results etc. over this time. Nevertheless, because there is a societal need to find a balance between research careers and the family lives of researchers, many funding organisations account for such leaves of absence when judging a researcher's research results and impact. Moreover, some funding organisations even offer specific grants that are only open to researchers who seek to return to research after paternity/maternity leave. This is an example where funding organisations actively support a societal need, even though at first glance this societal need could be viewed as detrimental to research output and the competitiveness of researchers.

Quantitative impact metrics and climate footprint

The climate footprint of research can sometimes be increased by a focus on quantitative metrics of impact. An example is the use of the number of international conference talks as a measure of impact. This incentivises travel to as many conferences as possible, irrespective of whether or not the trip is scientifically useful (e.g. in terms of networking, learning about other results, etc.). The extensive use of such quantitative metrics is viewed critically for reasons unrelated to climate sustainability,[23] because optimising a quantitative impact metric is not always the same thing as optimising actual research impact (and/or quality). Therefore, considering the climate footprint of certain practices could even have side benefits for a transition to more meaningful (potentially less quantitative) measures of research quality and impact.

To achieve this goal, referees of grant proposals play a critical role, because they need to align their criteria with those of the funding organisation.

What is perceived as a challenge by funding organisations?

Funding organisations have a significant leverage on the GHG emissions of the academic system, but do not typically use this leverage at present. Funding organisations typically base their funding decisions on research quality and are mindful of the freedom of research. Both aspects are viewed as a challenge to developing policies that aim to reduce the climate impact of the funded research, because these could base funding decisions on additional criteria (like climate sustainability) and could indirectly impact the freedom of research. Here, a balance needs to be struck that is best found in a close dialogue between funding organisations and researchers. Furthermore, including an account of the GHG emissions of a project into an application (whether on a voluntary or a mandatory basis) creates additional workload for the applicants that funding organisations have to be mindful about. To keep the workload light and ensure comparability of estimated GHG emissions across different applications, funding organisations could provide appropriate software to conduct easy and standardised assessments of the climate impact.

23 See, for example, https://ec.europa.eu/info/news/process-towards-agreement-reforming-research-assessment-2022-jan-18_en?wt_zmc=nl.int.zonaudev.zeit_online_chancen_w3.m_14.02.2022.nl_ref.zeitde.bildtext.link.20220214&utm_medium=nl&utm_campaign=nl_ref&utm_content=zeitde_bildtext_link_20220214&utm_source=zeit_online_chancen_w3.m_14.02.2022_zonaudev_int.

8. Conference organisers

Synopsis

- Conferences are key venues for exchanging knowledge, building networks and inspiring future research.
- Systematic studies across disciplines, as well as examples of individual conferences, indicate that typically about 1 t CO_2-eq emissions arise per participant.
- Often, a small fraction of participants causes the largest share of emissions due to long-haul flights.
- Virtual conference formats cause GHG emissions associated with electricity consumption, but these correspond to a tiny fraction of typical emissions of an in-person conference.
- Hub-based conferences, which link regional hubs (with in-person participation) together virtually, can significantly reduce GHG emissions due to long-haul flights.
- For in-person conference formats, GHG emissions can be reduced by an optimised choice of meeting location.
- Potential disadvantages of virtual/hybrid meetings can include challenges with networking and time zones. The latter can be addressed by using asynchronous formats.
- Throughout the COVID-19 pandemic, but in some disciplines already long before, alternative meeting formats have been experimented with. They indicate that simply copying the events of an in-person conference does not work well. Instead, successful virtual conferences use the novel opportunities that arise online.
- Virtual/hybrid meetings have a significant advantage over in-person meetings in being globally much more inclusive. The inclusion of previously excluded groups of researchers, e.g. from the Global South, and/or with family/care obligations, is an argument independent of climate sustainability in favour of online/hybrid conferences.

8a. Introducing conference organisers as relevant stakeholders

Conference organisers are important stakeholders in reducing GHG emissions in academia. First, conferences are significant sources of GHG emissions (Burtscher et al. 2020; Jäckle 2022; Milford et al. 2021; Nathans and Sterling 2016; Spinellis and Louridas 2013; Yakar and Kwee 2020). Second, conferences can act as platforms to determine cultural and behavioural norms within a research (sub)discipline. Third, conference formats have been impacted by the COVID pandemic to an extreme degree, leading to experiments with online formats: while the spring and summer of 2020 has seen many cancelled meetings, the academic community swiftly transitioned to online and/or hybrid meetings and has, to some degree, experimented with platforms, formats and tools. These 'experiments' have already yielded crucial insight into the use, (dis)advantages and (dis) functionalities of online and hybrid meetings.

Currently, conferences serve different goals with varying levels of success: conferences can be inspiring and network-intensive meetings that trigger important research progress, they can foster international exchange and collaboration, they can serve as information exchange bases on a dense programme of scientific talks, they can be viewed as a means of publishing results or, in some cases, may simply be a convenient way of spending time at a holiday destination. This heterogeneity in goals, formats and scientific value needs to be kept in mind when discussing the climate impact. The carbon footprint and the scientific value of a conference are two criteria to be weighed up in evaluating conferences. Career stage, gender, contract type and country of origin can all also affect the way one experiences conferences and the priorities for attending.

In-person conferences have a long history as venues for academic exchange and networking. A positive impact on research results and collaboration is often suggested and this is emphasised regularly at virtual meetings, when a wish to return to in-person meetings is expressed by some participants. There has, in pre-pandemic times, been paid less attention to:

1. Whether in-person meetings de facto exclude some groups of academics, including, for

example, academics from the Global South, academics subject to visa requirements, academics who cannot travel due to health reasons, or academics with family or care responsibilities who cannot travel.

2. Whether in-person meetings in their current format succeed in achieving their goal of productive academic exchange. Many speakers, for instance, may only attend for one day or even one session, the audience may only be partially attentive during talks – often burdened by other academic research and/or service tasks even when on conference leave. Further, inadequate time allocated for questions and discussions can hamper a fruitful and scientifically valuable exchange.

3. Whether in-person meetings are a significant part of the GHG emissions caused by research. In fact, for many academics, conference travel results in GHG emissions higher than the average emissions of citizens in their country (Arsenault et al. (2019)).

Point 1 speaks to the theme of inclusivity and point 3 speaks to the theme of climate neutrality. These can be addressed by holding virtual or hybrid conferences. Point 2 questions effective conference formats, where virtual or hybrid meetings face new challenges but can also open up new opportunities. For instance, online formats offer tools to enhance the effectiveness of conferences that are not (easily) available in in-person formats.

It is critical to keep in mind the diversity of needs of research disciplines, as well as individual researchers, when deliberating conference formats. No single conference format fits all needs and goals. Not only are the needs and goals of individual attendees different, so are the goals associated with particular conferences or conference series. Therefore, our discussion will consider different formats and, even when not clearly stated everywhere, it goes without saying that the benefits of in-person, virtual or hybrid meetings are diverse, and will be experienced differently, and therefore different choices may be appropriate for different events and researchers.

Who acts as a conference organiser depends on the discipline: while conferences in some disciplines are organised by professional companies, (groups of) individual researchers, often with logistical support from their university/research institute or a hosting institution, act as organisers in other disciplines. Further, learned disciplinary societies often act as conference organisers in their discipline. In the first case, conferences are often expensive, with a significant conference fee being charged. In the second case, the funding for conferences comes from universities and institutes, research grants as well as specific conference grants. Given this heterogeneity in conference organisers (and a presumed heterogeneity in their goals), the pathway to climate-sustainable conferences is likely to be discipline-specific. The following section is written with a broad range of possibilities in mind.

8b. Current practices and data on GHG emissions from conferences

GHG emissions of in-person conference formats

Overall GHG emissions

Sources of GHG emissions connected to in-person conferences include travel (e.g. transport to and within destinations), accommodation (e.g. heating and cooling) and hospitality (e.g. food services). Of these, studies typically focus on emissions from air travel, which is likely to be the largest source for an international conference, depending on the conference size and geographical diversity of participants (Jäckle 2022).

The term 'conference tourism' (Høyer 2009) has long been used to describe the international business of conference organisation, in particular centred on forms of conference that have been associated with holiday destinations. Høyer and Naess (2001) talk of the 'exotic places' where conferences might be held – often including beach and ski resorts. Such places, remote as they may be, lead to increased transport-related emissions and intercontinental travel, with few options beyond aviation. The location of conferences has a significant bearing on associated transport-related emissions (Klöwer et al., 2020).

GHG emissions due to flying

Burtscher et al. (2020) estimate 1855 t CO_2-eq emissions due to travel for an international astronomy conference of 1240 participants, i.e. an average of a little more than 1 t CO_2-eq. This is similar for the Annual Meeting of the Society for Neuroscience, with about 30,000 participants causing an estimated 22,000 t CO_2-eq emissions (Nathans and Sterling 2016), i.e. about 0.7 t CO_2-eq. Within medicine, Milford et al. (2021) calculates the median (not average) GHG emissions for a series of

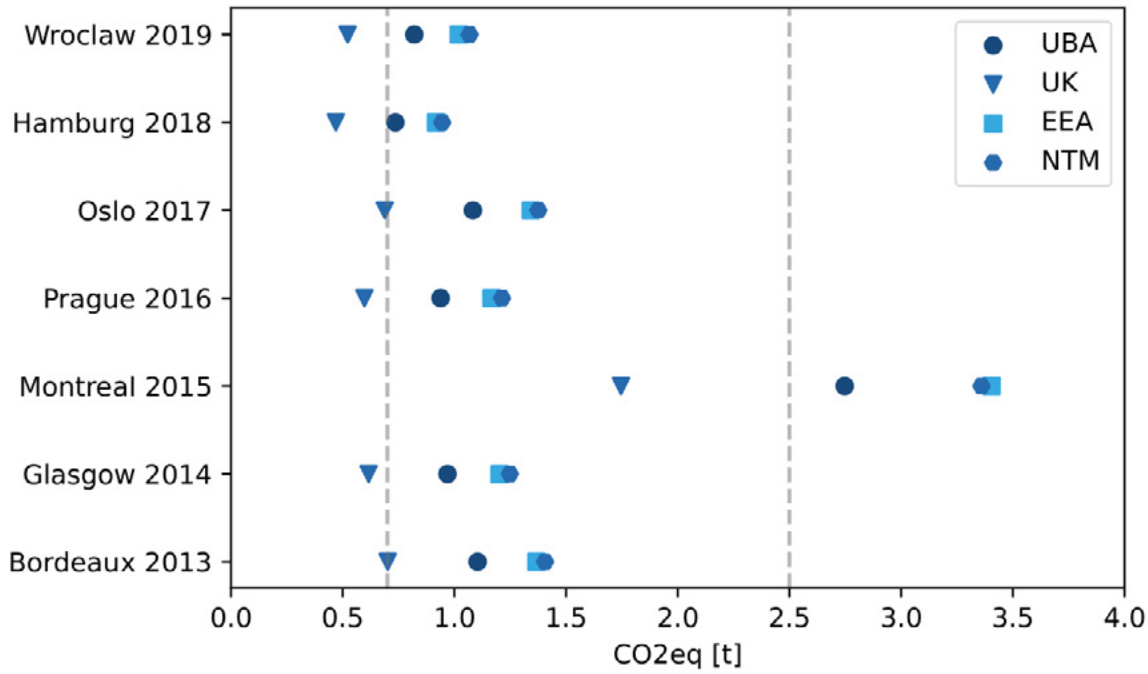

Figure 9: Average emissions per attendee at an international conference on political sciences. UBA, UK, EEA and NTM correspond to different emission estimation tools. The dashed vertical lines at 2.5 t and 0.7 t indicate per-person emissions compatible with the 1.5°C warming in 2030 and 2050. The figure is based on Figure 2.5 in Jäckle (2022); see this reference for details.

paediatric urology conferences, resulting in 0.6 t. Yakar and Kwee (2020) report 39,506 t CO_2-eq of air travel-related emissions for 23,506 attendees of a large radiology conference, i.e. about 1.7 t CO_2-eq emissions. These examples are in line with a more systematic study (Spinellis and Louridas 2013), which randomly retrieved conference proceedings papers from Scopus and used bibliographic information to estimate the GHG emissions for the corresponding conferences, resulting in an average of just under 1 t per participant. A similar average was found in Jäckle (2022); see Figure 9.

It is important to note the variation in emissions based on distance travelled – arguably the average is less interesting than the extremes. Intercontinental flights account for a significant proportion of GHG emissions for conference travel. For instance, in Burtscher et al. (2020) (based on a survey of about 22% of conference participants) only 10% of the trips were intercontinental flights, but produced 50% of the total emissions of survey participants. Similarly, for another large international conference, an analysis of home institutions of the participants comes to the conclusion that 75% of emissions were generated by intercontinental flights for one-way distances greater than 8000 km, made by 36% of the attendees. On the other hand, 22% of all attendees took flights of 1500 km or less. These 22% caused only 2% of the GHG emissions through air travel to the conference (Klöwer et al. 2020). A similar picture emerged from a study of a conference in agricultural economy, where 10% of participants caused 50% of emissions from travel (Desiere 2016). This underlines the importance of reducing intercontinental flights.

However, it should be borne in mind that short-distance flights also contribute to the carbon footprints of researchers and are often more easily substituted by low-carbon forms of travel. For example, a return flight from Munich to Berlin has a per-person CO_2 emission of approximately 0.3 t whereas a train for the same distance is less than 0.01 t (https://calculator.carbonfootprint.com).

Jäckle (2022) compares various possible actions by conference organisers to reduce GHG emissions, coming to the conclusion that measures such as not printing conference programmes on paper are ineffective in reducing emissions, and offering only vegan/vegetarian food choices has an effect, but one that is far lower than transitioning to online/hybrid modes.

GHG emissions of virtual conference formats

It is important to recognise the GHG emissions associated with virtual conference formats. These emissions arise largely from data centres and ICT requirements. Tao et al. (2021) provide an analysis of different models of in-person, hybrid and virtual conference formats, and suggest a 94% reduction in GHG emissions arising from the shift to fully virtual events. Examples where GHG emissions associated with a virtual conference have been estimated include Faber (2021), where a one-day conference led to a total of just over 1.3 t CO_2-eq emissions, about 65% of which were associated with network data transfer emissions, 20% to meetings of organisers in preparation of the conference, and smaller fractions to other sources. An in-person and a virtual instalment of an annual conference were compared in Burtscher et al. (2020), with roughly a factor of 3000 in GHG emissions between the two. Similar estimates exist in other disciplines; e.g. in political sciences, a reduction of emissions by a factor of 97 to 200 was estimated for a European political sciences conference (Jäckle 2021). Similarly, from the field of medicine, Duane et al. (2021) estimate that a 98% reduction in GHG emissions can be achieved by switching from an in-person conference to a virtual format.

Reduction of GHG emissions through choice of conference location

As already noted, for in-person conferences, the choice of conference locations can have a significant impact on the total emissions. As an example, Stroud and Feeley (2015) investigated four conferences of the International Biogeography Society, which were very international (e.g. 409 attendees from over 40 countries at a meeting in 2013 in Miami, USA). Averaged over four meetings, emissions were 2.5–3 t CO_2-eq emissions per attendee. About 30% higher emissions would have been connected to a randomly chosen meeting location, and 20% lower emissions would have been achievable with an optimal conference location (i.e. a location that minimised average distance). This example shows that the choice of conference location matters (for other examples see Ponette-González and Byrnes 2011; Wenner et al. 2019; see also Fig. 9). For some conferences, locations are chosen that are attractive travel destinations, in order to have an added attraction in attending the conference. This practice disregards the very significant change in climate impact that can be tied to the choice of conference location.

GHG emissions of hub-based conference formats

A hub-based format has been suggested to allow for some in-person activities, but overcoming the need for long-distance travel. In a hub-based format participants meet in person at regional hubs, where regional might even cover a whole continent. These hubs are then linked virtually.

Such conference formats are not yet very common, thus systematic data on emissions are not available. Based on the data provided above on the GHG contributions of long-distance versus short-distance flights, it is to be expected that such a format results in significantly lower GHG emissions than an in-person format at a single location. Klöwer et al. (2020) discuss advantages and disadvantages of such a model. Among the disadvantages, it has to be kept in mind that hubs are simpler to organise on continents with a high density of researchers. Thus, the inclusion of researchers from, for example, countries in the Global South, might not be possible without some long-distance flights. Additionally, a mix of synchronous and asynchronous formats may be necessary for a successful hub-based conference linking locations in very different time zones.

GHG emissions of hybrid conferences

A hybrid format allows participants to connect remotely, while simultaneously accommodating a fraction of the participants at the conference venue. This allows participants from more remote locations or participants with other travel restrictions to at least partially participate in the conference activities. The technical challenge of this format is to make the key conference ingredients such as presentations, discussion sessions and networking events equally accessible to both the local and the remote audience. This conference format was not very common before the pandemic; however, a lot of experience has been gathered recently through hybrid teaching formats at many universities and various conferences in 2021. Systematic data on the GHG savings of this format are not yet available, but the combination of having some benefits of an in-person format together with reducing the need for (long-distance) travel and retaining at least some degree of inclusivity makes this format an interesting compromise. Jäckle (2022) estimates that, if those participants with a long-distance (>4000 km) flight attend a conference online, reductions of GHG emissions of about 50% can be achieved. This is in line with the estimate that a smaller fraction of participants can cause the largest share of GHG emissions. In such deliberations, it is important to keep in mind that researchers in the Global South, where local networks of researchers may be less dense, or in remote locations, are not systematically disadvantaged.

Virtual platforms and 'green' conference organisers

The past two years have seen rapid development regarding virtual meeting platforms such as Gather (https://www.gather.town/), Remo (https://remo.co/) and Wonder (https://www.wonder.me/). Each participant is assigned or chooses an avatar and can move around the virtual meeting space, interacting via video call with other avatars in their proximity. To some extent, this can mimic informal discussions during coffee breaks of in-person conferences or poster sessions (Brice et al. 2020). In practice, various challenges arise. Due to the multitude of different softwares, browsers and operating systems, technical difficulties are not infrequent. This applies in particular to computationally expensive virtual environments, which exclude participants without high-end devices. Moreover, employing this as a coffee break substitute does not achieve the goal of screen breaks, physical exercise and other biological needs; therefore, such virtual breaks work best in combination with an actual break, with time away from the screen. With improved software and tailored usage (instead of simply mimicking the structure of in-person conferences) this technology could, however, have a lot of potential in the near future.

Going beyond simple virtual meeting spaces, virtual environments can also mimic entire office spaces or conference hubs, tailored to the needs of the specific event and with integrated Zoom rooms, digital whiteboards and document repositories.

Challenges of virtual/hybrid conference formats

A historical perspective can be useful when discussing the challenges of virtual/hybrid conference formats. The large number of conferences and resulting extensive travelling of researchers is a relatively new phenomenon. Prior to that, research functioned with fewer but longer meetings. Quality, not quantity, of meetings is clearly the decisive factor when it comes to the scientific value of conferences.

Informal exchange and networking

Informal exchanges and networking require time and opportunity. At a conference, this means time that is agenda-free and put into the schedule without talks or scheduled scientific discussions. At in-person conferences, established formats exist which include coffee breaks and conference dinners. At virtual conferences, these formats have often been copied, with mixed results. Challenges at virtual conferences are: time away from the screen is needed to take a physical coffee break, thus a combination of coffee break/dinner and networking is more difficult; platforms for informal discussions are relatively new (implying functionalities that are still being developed and unfamiliarity of participants with the tools); 'Zoom fatigue' (Fauville et al. 2021) means that breaks from screen time are desired in between talks.

Overall, this means that many researchers find that typical current formats of virtual/hybrid conferences lack the networking opportunities and quality of in-person conferences. Some researchers, on the other hand, find aspects of virtual/hybrid networking beneficial. For instance, random Zoom breakout rooms 'democratise' who gets an opportunity to talk to whom.

In summary, networking opportunities of online conferences, as they have been organised during the COVID-19 pandemic, are typically not of the same quality as for in-person meetings. It should be kept in mind that this holds for online networking, which attempts to provide an online duplicate of a physical setting – the 'online coffee break'. In contrast, online tools could be more suitable to develop novel settings. In addition, the quality of online networking depends on the quality of available platforms and functionalities (which are rapidly evolving) and on the experience of participants with these platforms.

Early career researchers and networking

Conferences play an important role for early career researchers to build a professional network. This should be kept in mind when proposing changes in our conference culture, and it is critical to consult early career researchers themselves on this issue. Given that value systems, digital literacy and the impact of the climate crisis on their individual lives can differ significantly between early- and late-career researchers, one can expect that many early career researchers weigh environmental impact and in-person networking opportunities differently against each other than senior researchers would on their behalf.

Preferences for interaction formats depend on personality

When it comes to informal exchanges and networking, it is important to consider that not all individuals who participate in a conference have similar personalities. Some might thrive in an in-person meeting format with lots of opportunities for in-person interactions. Others might prefer an online format and feel more comfortable to interact virtually, or not turn on their camera and prefer to post questions in the chat. There is no amount of affinity for personal interactions that is preferable to any other – a research community is made up of a variety of personalities. Therefore, what are arguments against virtual formats for some, might actually be arguments for virtual formats for others.

Anecdotal evidence, e.g. from some researchers with visible disabilities, or researchers who belong to visible minorities, suggests that a virtual format, in which the personal appearance is not automatically visible or is less important, can make these participants much more comfortable and encourage them to engage in discussions.

Digital divide

When no sufficiently fast internet connection is available, or regular power cuts are expected, virtual conference formats are not inclusive for researchers subject to these limitations. In some cases, such limitations may be restricted to times of the day (peak electricity and internet usage) and can be mitigated by a carefully chosen conference schedule or the chance to access recorded talks at a different time (although the latter does not address networking difficulties). There is a digital divide, often between the Global North and Global South, but also, for example, between urban and rural areas of a country.

Similarly, access to high-quality technical equipment can favour researchers from the Global North, which is problematic. For example, a poor audio quality can give the audience a lower perception of the speaker's abilities and qualifications. This can be mitigated by avoiding, for example, very computationally expensive virtual environments, allowing participants to post questions in the chat and using other means of (asynchronous) communication formats, e.g. slack channels or similar.

Alternative conference formats, relying on asynchronous components (e.g. pre-recorded talks, written discussion sessions and similar) can mitigate the impacts of the digital divide.

Time zones

Accommodating speakers from very different time zones is a challenge in virtual formats, and can put pressure on academics to accept conference participation well out of their usual working hours. On the other hand, by the nature of the problem, these speakers would require very long-distance flights to reach the conference venue, at the cost of time, jet lag and GHG emissions. Conference organisers can mitigate this problem by careful scheduling and working with recorded talks and chat-based discussion platforms, allowing for asynchronous conference participation. For an example of an asynchronous conference format that has already been running for several years before the pandemic, see Hiltner (n.d.). Asynchronous networking formats in particular are needed.

A recent study of several virtual conferences showed that for fully synchronous conferences, based on live talks, attendance dropped for regions of the world where the times of the talks fell outside normal working hours. In contrast, a conference with an asynchronous format, where recorded talks were available for some time, and live question sessions with speakers were scheduled, showed increased participation from all regions of the world (Skiles et al. 2021).

Co-benefits of virtual conference and meeting formats

Leochico et al. (2021) list benefits of online conference formats aside from their reduced climate impact. These include inclusivity, broader access to content that can more easily be shared with colleagues, no organisation of conference venue, participant accommodation, conference meals etc., the possibility for an international scientific organising team, higher availability of speakers, free attendance for students, no time, energy and economic cost of travel.

Similarly, Trappes et al. (2020) present three main arguments for online conferences in philosophy: first, their reduced environmental impact; second, their inclusivity (in particular for under-represented groups of researchers); and third, their lower cost.

In addition, virtual formats offer several advantages to junior researchers and/or students: first, for a session chair, it is much easier to keep track of the order in which hands are raised to ask questions. Thus, there is more fairness in who gets to ask questions than there might be in in-person formats, where more senior, well-known researchers might be given the first chance to ask questions. Second, various online tools make it easy to submit questions anonymously, lowering the hurdle to ask questions for everybody, but in particular for students and junior researchers.

Below, we expand on two of the most important co-benefits of virtual conference formats.

Inclusivity of virtual compared to in-person conference formats

A critical co-benefit of hybrid/virtual meetings is their significant increase in inclusivity. Here, inclusivity refers to various groups of researchers for whom an in-person conference is very difficult or impossible to attend. Often, this coincides with groups of researchers who are under-represented within a given discipline. This includes researchers from certain geographic regions, in particular the Global South; researchers with childcare or other care responsibilities and researchers with health or other personal reasons against travelling.

Under-representation of certain geographic regions can have many different reasons. Participation in research is contingent upon funding – of one's own position, of necessary equipment, of access to publications and journals, of one's participation in conferences. Even within Europe, regional inequalities persist. Inequalities become more severe when researchers in Europe are compared to researchers from countries in the so-called Global South. Moreover, visa restrictions are a very serious obstacle preventing researchers from certain geographic regions from attending conferences abroad.

Therefore, conference participation, which is a matter of course for most researchers based in Western and Northern Europe, is not always attainable for researchers from Eastern Europe and is often impossible for researchers from the Global South. This results in a critical lack of opportunities to (i) present one's research and hear constructive criticism from others, (ii) hear of novel ideas in the research field before they are presented in papers, (iii) hear of and present oneself for job opportunities. As a result, achieving the same quality and impact of research results becomes a much bigger challenge for researchers from the Global South. It is thus imperative to address this lack of fairness as well as the associated loss of brainpower, new ideas and diverse perspectives, all of which impede the progress of research.

Data on participation in online conferences during the COVID pandemic show that online meetings are accessible to participants from a much larger number of countries: for instance, participants at the April meeting of the American Physical Society came from 28 different countries to the in-person meeting in 2019, but from 79 countries to the virtual conference in 2020 (Almanza 2020). As a second example, the number of countries represented at Botancy 2020 jumped from 35 to 45, including, for example, Rwanda (Almanza 2020). Similarly, the data compiled in Sarabipour (2020) shows increases in the number of countries from which participants attended online meetings in 2020, in particular Figure 1 in Sarabipour (2020) shows that among 17 meetings, not a single one has participants from more countries in its in-person format than in its virtual format (cf. Figure 10).

Regarding researchers with childcare responsibilities, Sarabipour et al. (2021) compile data from 270 national and international conferences, finding that only 19% offered any form of on-site childcare. Even when childcare is available, it may be limited in duration as well as age groups covered. Enabling online participation in conferences can thus play a key role in empowering researchers with childcare responsibilities to be an active part of their scientific community. In many cases, this in particular concerns female researchers, who are an under-represented group in many disciplines. In fact, a study comparing in-person to virtual conferences shows an increase of female attendees of 60–260% compared to baseline values from in-person conferences (Skiles et al. 2021). The same effect was visible in submitted abstracts: for a 2020 meeting, 26% of submitted abstracts were from women, when the meeting was planned as an in-person conference. This value was consistent with a baseline from previous years. After it was announced that the meeting format was changed to virtual, 37% of submitted abstracts came from women. Not all female researchers have care responsibilities, and male researchers can have care responsibilities as well, and so care responsibilities may not be the only reason behind this change, but it is likely that it is one of the causes.

Lower required budget as an opportunity for early career researchers

In some disciplines, many conferences and workshops are organised by researchers themselves. They often apply for a conference grant with a funding organisation or their home institution. Obtaining such grants is simpler for more senior researchers with previous workshop/conference organising experience. Alternatively, workshop/conference funding can be included in larger research grants, which are often not open to applications from early career researchers.

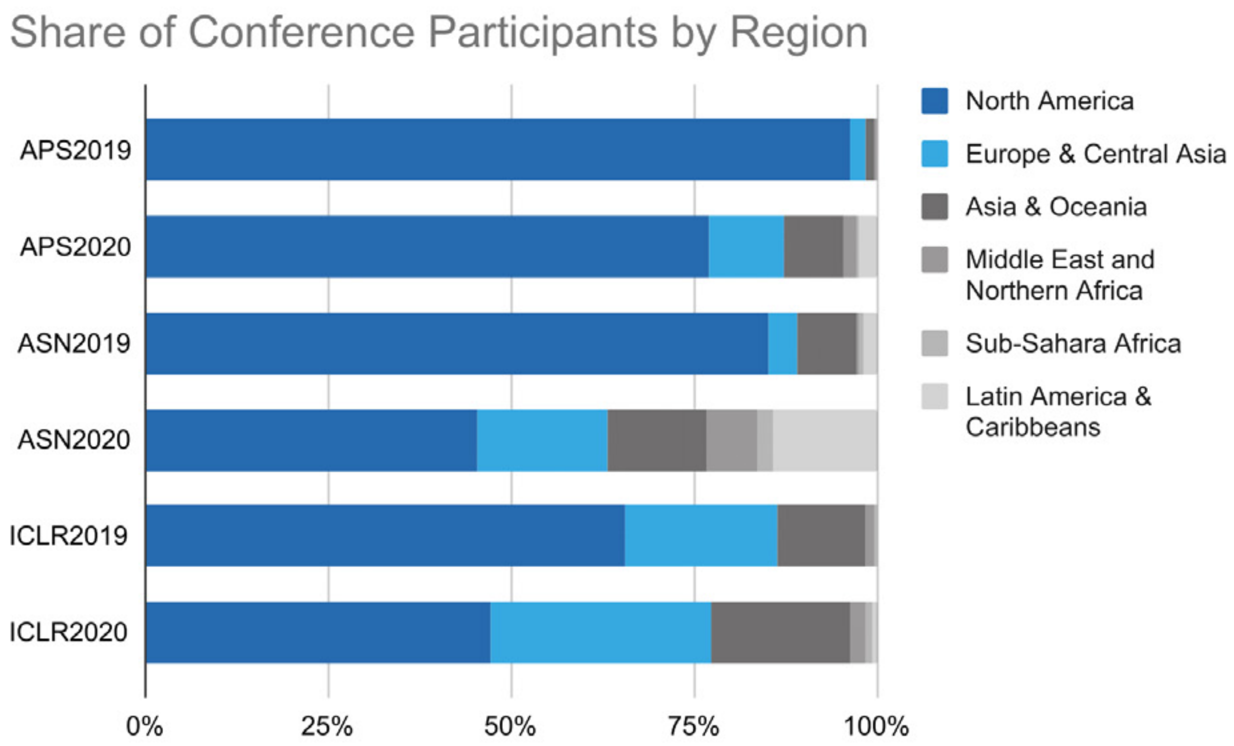

Figure 10: Share of conference participants for three large conferences by region. Data from Sarabipour (2020).

In contrast, organising a virtual workshop requires very little to no funding. Thus, junior researchers, even junior postdocs who have a good idea for a conference or workshop topic, can organise virtual meetings. This has benefits for the research field, but also for the careers of junior researchers. After all, being an organiser of a conference/workshop is a catalyst for network-building and for increasing visibility for one's scientific profile. Indeed, anecdotal evidence suggests that at least in some disciplines, early career researchers have very successfully made use of this opportunity during the pandemic, and have thereby very quickly established a large international network and made a name for themselves in their respective research communities.

Alternative formats for conferences and other meetings

Alternative virtual conference formats, which rethink scientifically successful conference formats, have been explored and tested well before the COVID-19 pandemic brought a wave of online conferences. For an example in philosophy see https://consciousnessonline.wordpress.com/information-for-contributors/, while https://hiltner.english.ucsb.edu/index.php/ncnc-guide/ gives examples in the humanities. These formats ask speakers to upload their talks (e.g. slides or papers, a video if the speaker wishes to do so) beforehand. The conference is open over a period of a couple of weeks, during which discussions take place via the comment section below each talk. This asynchronous format solves the challenge of time zones. Simultaneously, the quality of comments is typically high, because participants have the time to think about and formulate their questions and comments.

These conferences deviate from the traditional conference format. They present a thought-provoking take on the broader question "What are the goals of a conference and how can they be reached in the best possible way?" (and similarly for workshops and schools). They place a focus on an inclusive exchange of academics from all parts of the world.

9. Academies, learned societies and professional bodies

Synopsis

- Academies and learned societies are important platforms to exchange knowledge within as well as across disciplines.
- Data on the GHG emissions from the day-to-day-operations of these organisations are largely non-existent. Data on conferences organised by these bodies is in part available (see Chapter 8).
- A limited number of academies and learned societies encourage their members to behave in a climate-sustainable way or engage with the topic of climate sustainability in the academic system.

9a. Introducing academies, learned societies and professional bodies as relevant stakeholders

Academies,[24] learned societies and professional bodies promote a particular field of research, and facilitate communication within that field as well as across disciplines and with the wider public. These organisations can provide evidence-based policy advice for the climate crisis, as they do for instance in Europe (see for example the Science Advice for Policy by European Academies (SAPEA) report on the energy transition, SAPEA 2021), as well as nationally.

By collecting expertise and translating it for policy advice and general science communication, academies can play an important role in mitigating the climate crisis.

While some prominent researchers have called for change (e.g. Vardi 2019) to more sustainable formats of conferences organised by learned societies, the called for changes have not materialised yet. In particular, the shift from physical meetings to virtual ones due to the COVID pandemic is seen by many as temporary and a swift return to the previous state is hoped for. This appears to reflect a larger trend across various disciplines. For example, a representative of the European Economic Association wrote to us: "Whilst we would like to make all future meetings hybrid, our surveys are clearly indicating a preference of members to return to an in-person format."

In summary, the role of academies, learned societies and professional bodies can therefore be two-fold: first, by making their own operations climate-sustainable, they can act as role models within the academic system. Second, by bringing together researchers, often in decision-making capacities, within or across disciplines, they can act as highly effective platforms from which a transition to climate sustainability in the academic system can be driven by setting norms within a field and providing a platform for discussion and exchange of best-practice examples.

9b. Current practices and data on GHG emissions of academies, learned societies and professional bodies

Academies, learned societies and professional bodies cause GHG emissions due to building infrastructure, supply purchases etc very much like organisations outside the academic system. Data on these emissions is scarce/non-existent, but it can be assumed to be similar to organisations outside the academic system with a similar office-size. As an example, the American Physical Society has undertaken a GHG inventory of Scope 1, 2 and 3 emissions in 2015 (APS 2018). Scope 3 emissions include GHG emissions from travel, for instance to the early APS conferences (estimated 12.000 t CO_2-eq) and from the APS investment portfolio (estimated 62.000 t CO_2-eq) totalling an estimated 75.000 t CO_2-eq emissions, which is a factor of 100 larger than Scope 1 and 2 emissions.

24 The term academy has different meanings in different academic systems. In particular, in Central and Eastern Europe, many academies are clusters of research institutes (e.g., the Czech Academy of Sciences or the Polish Academy of Sciences). This type of academies is covered in Section "4. Research institutes" and we focus here on academies with mostly honorary memberships. Note that ALLEA is an umbrella organization of academies of both types.

In cases where they act as conference organisers, either for interdisciplinary or for disciplinary conferences, similar considerations apply as described in Chapter 8.

Academies, at least to some extent and depending on the geographical region, also fulfil the role of research institutes. For the relevant considerations, see Chapter 3 above.

Academies, learned societies and professional bodies bring together researchers from a subject area across different institutions or researchers from across different disciplines and institutions.

In the first case, they can be effective platforms to discuss and demand change, e.g. of conference formats or research practices, within a subject area. As an example, the recently formed sustainability committee of the Canadian Astronomical Society states "every field of human activity, astronomy included, must take urgent steps to mitigate the [climate] crisis and avoid the worst potential outcomes, while adapting to those consequences that are now inevitable." (CASCA 2021) and concludes that "in light of the crisis, greenhouse gas (GHG) emissions from our various professional activities must be understood as significant research costs, to be ethically justified, budgeted, and rationed."

In the second case, e.g. in the case of interdisciplinary academies, they can be effective platforms to exchange knowledge and best-practice examples across disciplines.

One of the main activities of learned societies is in organising academic meetings. To give a specific example, annual meetings of the American Association for Cancer Research regularly (pre-COVID-19) have more than 20,000 participants. To give another example, the above-mentioned assessment of internal emissions of the American Physical Society estimates the GHG emissions related to a single meeting (in March 2015 in San Antonio, Texas, with almost 10,000 participants) to contribute 7,000 t CO_2-eq, almost ten times the operational carbon footprint of the offices of the American Physical Society.

We have collected information about circa 30 leading learned societies across all fields of sciences. At the moment of writing, the environmental sustainability activities and goals of these societies can be grouped as follows (with many societies engaging in no such activities):

» Appeals to individual members, for example by emphasising environmental responsibilities in a code of ethics. For instance, the APS encourages its members to calculate the carbon footprint of their travel and donate to an environmental organisation (Johnson 2018). This is suggested as an alternative to the purchase of carbon offsets, which have been criticised.

» Climate advocacy. Examples include reports by Science Advice for Policy by European Academies (SAPEA 2021) or a call by the American Physical Society to the US government to accelerate the transition to carbon-neutral energy sources (APS 2017), as well as activities by the Leopoldina German National Academy of Sciences (German National Academy of Sciences Leopoldina and German Council for Sustainable Development 2021).

» Promoting sustainable research directions. For example, the American Chemical Society runs the "ACS Green Chemistry Institute" (https://www.acs.org/content/acs/en/greenchemistry/about.html) with awards and grants in 'green chemistry'.

» Generating awareness for climate sustainability of the academic system. Among academies, several young academies in Europe have engaged with the topic of climate sustainability in the academic system; the Dutch Young Academy through a discussion of air travel for research; the German Young Academy through publishing a set of recommendations on how to reduce the climate impact of research through an air travel reduction (Die Junge Akademie 2020).

» Pledges of climate neutrality. The Royal Society of Chemistry has pledged to become climate-neutral in 2040 (Royal Society of Chemistry 2021), with a 50% reduction of emissions by 2030.

10. Ranking agencies

Synopsis

» University rankings can be influential in determining which performance indicators universities focus on.

» Climate sustainability (or sustainability more broadly) is currently not included in the most influential global rankings. Instead, separate sustainability rankings exist.

» University rankings are competitive, thus potentially discouraging collaboration and exchange of best-practice examples. In other domains, such as gender equality, benchmarking and accreditation systems exist which are not competitive.

10a. Introducing ranking agencies as relevant stakeholders

Universities (also programmes, schools, etc. but here we focus on universities for simplicity) are in competition with each other in national and global rankings, which are conducted by external entities. These university rankings do not necessarily have a lot of direct influence, but they are consulted for example by students choosing universities to enrol in, researchers choosing where to apply for positions, and they grant prestige to the highly ranked universities and their researchers and graduates. As such, influencing what goes into the rankings is a possible lever for influencing what is valued and esteemed in the academic system, and analysing the current ranking factors allows insight into what the academic system currently prioritises.

The ratio of positive to negative consequences of global university rankings is controversial; however, while they do exist and are taken into account by many students and academics, it is at least worth considering what is rewarded in these rankings: should a university's (climate) sustainability performance not be a major criterion for its excellence, trustworthiness, and its ability to lead the way in the challenges facing us in the 21st century?

Various ranking systems are available, with each functioning differently and quantifying different aspects of universities' performance. The three most influential global rankings of universities are arguably:

» Times Higher Education (THE)

» Academic Ranking of World Universities

» Quacquarelli Symonds (QS)

These three ranking systems value reputation and achievements, citations, income, output, international diversity, and a high employee to student ratio, in different combinations and variations. (Climate) sustainability does not generally play a role in these rankings as a positive factor, although THE introduced in 2019 a new Impact Ranking system that is built upon the framework of the UN Sustainable Development Goals. It can be argued, nonetheless, that they favour unsustainably intense academic mobility patterns indirectly by including the ratio of students and staff from abroad.

Several dedicated ranking systems have been created that focus specifically on sustainability, such as the UI GreenMetric ranking and the Sustainability Tracking, Assessment & Rating System (STARS), an undertaking of the Association for the Advancement of Sustainability in Higher Education. In this report, we will highlight some of these alternative ranking systems which focus on the sustainability of academic institutions. Boosting the visibility and usage of such alternative ranking systems could go some way to shifting the basis on which esteem and prestige are distributed in the academic system. Indeed, universities increasingly recognise that climate sustainability action can lead to an improvement in reputation (see, for example, University of Nottingham (2020), p. 12) and highlight their placements in sustainability rankings. Additionally, there are indications that students value environmental sustainability actions of universities highly (QS 2019), supporting the case for sustainability ranking.

However, sustainability-oriented rankings are unlikely to replace the mainstream ranking systems altogether, and it is therefore important to consider also how mainstream ranking systems such as the three largest listed above could integrate sustainability metrics into their algorithms, or else reconsider the inclusion of some of their existing metrics on the basis of their entanglement with unsustainable practices.

10b. Current practices of ranking agencies

Some examples for ranking systems evaluating the sustainability of universities are:[25]

» The STARS system requires that institutions produce reports according to STARS standards, based on which they are then given a rank in one of five categories from 'reporter' to 'platinum'

» UI GreenMetric

» THE Impact Rankings by SDGs – for example, Climate Action (SDG 13)

» Princeton Review Green Colleges (only US)

» People & Planet University League (only UK)

These sustainability ranking systems mostly do not take into account travel as a separate category (although 'transportation' is a category, for example, in UI GreenMetric and STARS and Princeton, but only includes things like commuting), but they do take into account GHG emissions and efforts to reduce them (UI GreenMetric, STARS, Princeton) or even carbon neutrality (THE Impact Rankings). The only ranking system of which we are aware that specifically includes business travel is the People & Planet University League, which is only available for UK universities, and which includes Scope 3 emissions including, among others, business travel emissions, under its 'carbon management' criteria.[26]

An important consideration in the design and implementation of university rankings is whether they operate on a competitive basis or a threshold basis. Typically, university rankings – as the name suggests – pit universities against each other in an attempt to identify the 'best' university according to some metric. Such systems may have unintended consequences and may inhibit collaboration between universities. An alternative approach is to develop a benchmarking and certification system that would set minimum thresholds for climate sustainability. Any university meeting this threshold would be awarded the appropriate certification, which could be developed along a sliding scale (e.g. bronze, silver, gold). Examples of such an approach can be found in other domains, such as Athena SWAN, a framework developed in the UK in 2005 which is used across the globe to support and transform gender equality within higher education and research.[27] Universities and also individual departments/units can apply for accreditation under the scheme.

25 See https://stars.aashe.org/ (STARS), https://greenmetric.ui.ac.id/ (GreenMetric) and https://www.timeshighereducation.com/impact-rankings-2020-sdg-climate-action-sdg-13-methodology (THE Impact Ranking) for more information.

26 See https://peopleandplanet.org/resources-training/people-planet-university-league/methodology/5-managing-carbon for details.

27 See https://www.advance-he.ac.uk/equality-charters/athena-swan-charter for more information on the Athena SWAN charter.

11. Policy-makers

Synopsis

- Policy-makers determine the framework conditions in which the academic system operates.
- In some countries, national law strongly influences the climate sustainability measures of public bodies and thereby public universities.
- Academic freedom implies that policy-makers typically do not take a lot of direct influence on how the academic system operates, although the degree of self-governance varies.
- The high degree of autonomy within the academic system enables researchers to develop international codes of conduct, e.g. within disciplines, without the need for policy-makers to get involved. Successful examples exist outside the question of climate sustainability.

11a. Introducing policy-makers as relevant stakeholders

Policy-makers and governments are a final important group of stakeholders. Governance of higher education sets the framework conditions and parameters within which universities themselves as well as the wider ecosystem of actors in higher education set out above operate. Policy-makers can shape the context for (climate-) sustainable academia in a variety of ways.

First, policy-makers can set the frameworks within which universities operate through overarching laws and policies. For example, a national law on the climate crisis or environmental protection may allocate certain duties to or place constraints on universities or a broader category of public bodies. Similarly, to the extent that universities are public bodies, they may be governed by national (or EU-wide) framework laws for higher education, which could specify certain frameworks within which universities must operate.

Second, in the case of universities that are public bodies, universities may also be governed by national statutes and policy frameworks in respect of certain activities. For example, public universities may be governed by national laws and regulations concerning public procurement, energy performance, water conservation, transport, or other aspects of their operations and activities. To the extent that this is the case, policy-makers may have direct levers of control over some of the day-to-day activities of universities.

Third, by setting the strategic direction for national and European funding priorities, policy-makers can exert influence on research prioritisation in universities. This overlaps with Chapter 7 on funders. We distinguish here between funding agencies as stakeholders in their own right (covered in Chapter 7 above) and policy-makers who set the overall direction for (public) funders, and shape the landscape within which funders operate, whom we consider in this chapter.

Two important caveats need to be entered regarding the role of policy-makers in academia as it pertains to academia. The first caveat concerns the principle of academic freedom. At a time when academic freedom is under increasing strain in a variety of contexts, it is important to ensure that any attempts to leverage policy frameworks to promote the climate sustainability of the academic system do not constitute an undue interference with the principle of academic independence. It may sometimes be challenging to strike an appropriate balance in this regard. On the one hand, academics have a legitimate expectation that they can conduct their activities without interference from governments or other powerful actors. On the other hand, however, the defence of academic freedom should not be allowed to become a fig leaf for protecting unsustainable status quo practices against change.

The second caveat concerning the role of policy-makers as stakeholders concerns the wide diversity across different national and regional contexts. Different relationships between the state and the higher education sector will have a strong role in determining the extent and ways in which policy-makers constitute stakeholders in a climate-sustainable academic system. Section 11b below provides some illustrative examples from a number of different national contexts, but it is unlikely that what works in one jurisdiction will be directly transferable to another jurisdiction, or that a one-size-fits-all best practice approach can be identified.

11b. Current practices of policy-makers

Building on the three-fold distinction above, the first way in which policy-makers can act as stakeholders is by shaping the policy landscape for higher education and research through overarching laws and frameworks. An increasing number of countries in Europe and beyond have enacted overarching framework legislation to address the climate crisis (Duwe and Evans, 2020; Nash, Torney and Matti, 2021). Such framework laws typically set long-term strategic direction by enshrining short, medium, and/or long-term decarbonisation targets in legislation. They also put in place mechanisms for policy planning, as well as for monitoring and reporting on progress and accountability mechanisms. National framework climate laws differ in their levels of policy and sectoral specificity, but many set out only broad directions rather than specifying that particular public bodies must undertake specific actions. Nonetheless, framework climate laws can set strategic goals and institutionalise societal commitment to transformational decarbonisation, which then feeds into actions of academic institutions either directly or indirectly.

In Denmark, for example, universities are covered by general commitment by the government to reduce GHG emissions. The Danish government enacted a revised framework climate law in 2020 that set an economy-wide decarbonisation goal of 70% reduction by 2030 compared to 1990. This general goal has been taken up by universities in Denmark. For example, the University of Southern Denmark has committed to a decarbonisation target of 57% reduction below 2018 levels by 2030, which corresponds to a 70% reduction below 1990 levels – the same as the target set out in the national climate law (SDU 2021) and the University of Copenhagen has already reduced its emissions (Scope 1 and 2 plus transport) by 65% in 2019 relative to 2006 and is now set to achieve a 50% reduction of all emissions by 2030 compared to 2018 (Copenhagen University 2020).

In Ireland, an amendment to the 2015 climate law enacted in 2021 (Climate Action and Low Carbon Development (Amendment) Act 2021) legislated for a 51% reduction in GHG emissions by 2030 relative to 2018 levels. The climate law itself does not set out decarbonisation targets or actions for universities, but it requires all public bodies to perform their functions in a manner consistent with the decarbonisation targets set out in the law. As public bodies, all Irish universities are subject to this requirement. Moreover, the 2021 Climate Action Plan (Government of Ireland 2021), published by the Irish government in November 2021 as required under the climate law, includes a commitment that all public bodies will publish 'Climate Action Roadmaps'. It is too early to tell at this stage what practical effect these requirements will have.

At the level of the EU, the EU Emissions Trading System (EU ETS) aims to reduce GHG emissions in electricity generation, heavy industry and intra-EU air travel. In total, approximately 13,000 facilities throughout the EU (which correspond to about 45% of total GHG emissions in the EU) are subject to the EU ETS. The instrument could thereby be crucial for the EU to achieve its climate goals and its international commitments within the Paris Agreement. Of particular relevance to the climate impact of the academic system, GHG emissions from air travel have been included in the EU ETS since 2012. It requires all (European and non-European) airlines operating in Europe to monitor, report and verify their GHG emissions, and to surrender allowances against those emissions. They receive tradable allowances covering a certain level of GHG emissions from their flights per year. To date, the EU ETS has applied only to flights within the European Economic Area.

In July 2021, the European Commission proposed a legislative package aimed at bringing the EU's Climate Framework in line with the EU's commitment to achieve climate neutrality by 2050, and to reduce emissions by 55% by 2030. Under this proposal, the sectors covered by the EU ETS must reduce their emissions by 43% compared to 2005 levels, which corresponds to an annual reduction of 2.2%. Of relevance for the academic system to reach climate sustainability, the Commission's proposal intends to increase this share with the introduction of additional sectors such as shipping, as well as a new ETS for transport and buildings from 2026.

The EU ETS for air travel will be subject to a new review in the light of international developments. The next review should consider how to implement the global measure in EU law through a revision of the EU ETS legislation. If the academic system aims to reduce GHG emissions from its business travels, this – at least currently – means acting more forcefully than the EU ETS does, especially since flights outside Europe are not covered by the system.

A second way in which policy-makers can act as stakeholders in the context of public universities is by setting rules and regulations that apply to public bodies and, by extension, to public universities. Such regulations could cover a wide variety of aspects of universities' activities, such as energy, water, and resource consumption, building operation, or travel, for example. Depending on the context, these regulations could also potentially apply to private universities under some circumstances, but policy-makers are likely to have stronger and more direct policy leverage over public universities.

In Sweden, for example, general environmental protection obligations are placed on universities, while in Switzerland and Germany, government regulations apply to university travel and sustainability.

In some German states, guidelines on official travel of civil servants (this category includes professors) dictate that travel expenses are only reimbursed if they are associated with activities that cannot be conducted online (NRW 2022). Moreover, sustainability has been incorporated into university development plans, e.g. (Saarland University 2020; University of Regensburg 2020; Ruhr-University Bochum 2020). Additionally, in at least one of the German states, Baden-Württemberg, a new law from 2020 requires that all air travel by university employees must be offset (Heidelberg University 2021).

In Scotland, since 2014 universities are required under Public Bodies Climate Change Duties Reporting to report on their Scope 1, 2, and 3 GHG emissions, though in practice reporting is not as complete as it might be, particularly with respect to Scope 3 emissions. In England and Wales, by contrast, reporting of Scope 1 and 2 emissions is voluntary and reporting of Scope 3 emissions is discretionary (Peres 2020).

The third way in which policy-makers can act as stakeholders is by setting the overall strategic direction for research funding. For example, four of the five missions within the EU Horizon Europe funding programme relate to environmental sustainability (Adaptation to Climate Change; Climate-neutral and smart cities; Soil Deal for Europe; and Restore our Oceans and Waters). In such cases, individual decisions about scheme design and funding allocation may be delegated to funding agencies or other authorities, but policy-makers play an important role in setting the overall direction, and can choose to either prioritise or de-prioritise funding for climate and sustainability focused research.

Finally, the freedom and responsibility of academic self-governance has led to the successful implementation of international agreements among universities on a variety of topics, for example commitments to publish open access. Such initiatives are also taking up speed as a response to the climate crisis, for example at the time of writing more than 1000 universities have pledged to reach net zero emissions by 2050 (https://www.educationracetozero.org/home).

12. Recommendations and further considerations

In this chapter, we introduce the set of principles on which our recommendations are founded. We then provide three recommendations which are of overall importance for the academic system, namely the development of an evidence base, the development of virtual communication skills and tools and a 'mix-and-match' approach to meeting formats.

In Chapter 13, we provide further recommendations that address individual stakeholders as well as groups of stakeholders.

12a. Principles underlying our recommendations

1. The academic system need not be harmed by transitioning into climate sustainability

We believe that academia's transition into climate sustainability is well compatible with three cornerstones of the academic system, namely research quality, international collaboration and freedom of research. To ensure that these three cornerstones are safeguarded, the academic system's transition into climate sustainability must be carefully deliberated, so that unintended consequences can largely be avoided or strategies quickly adjusted.

2. The academic system has an opportunity to be a role model for other sectors in society

By acting quickly and decisively, the academic system can show how a whole sector can transition into climate sustainability by avoiding 'greenwashing' and taking meaningful action instead.

3. Internationalisation and physical mobility are distinct concepts

Internationalisation, including, for example, international collaborations, international student exchanges and international research careers, has long been deeply entwined with physical mobility. However, these two are not only distinct concepts, but internationalisation can also be achieved with virtual mobility or a mix of physical and virtual mobility. After a rush to increased international physical mobility has placed increased demands on researchers and generated a high cost for the climate, now is an opportunity to take a step back and carefully evaluate which aspects of internationalisation are desirable, and how they can be best achieved, with climate sustainability being much more than just an afterthought.

4. Social justice and equity dimensions matter

A worry often voiced in connection with academia's climate sustainability is whether a reduction in air travel by researchers will not unduly hurt early career researchers by hindering them in the development of their networks. In fact, keeping equity across career stages is important. Yet, we find it important to point out that currently, the means to travel are already highly unequally distributed for example (i) across career stages and (ii) across different regions of the world, most importantly between Global North and Global South. Thus, the starting point of academia's transition to climate sustainability is an inequitable one and the status quo is not a state that is desirable to retain, but rather a state upon which academia can significantly improve.

5. Implementing climate sustainability can bring important co-benefits

In the academic system's transition to climate sustainability, co-benefits can arise. For instance, a shift from 100% in-person meetings to a mix of online, in-person and hybrid meetings opens the door to researchers from the Global South (provided that the digital divide is addressed), who are often de facto excluded from in-person meetings. Beyond this example, additional co-benefits can arise, e.g. in the compatibility of family and/or care obligations with active and regular conference participation, and thus transitioning to climate sustainability provides academia with a positive opportunity.

6. Climate sustainability should be a strategic priority for all stakeholders

To achieve climate sustainability, it must become a strategic priority for all stakeholders in academia. In this way, climate sustainability will be embedded in all decision-making processes, and become a key guiding principle for all operations in academia. Frictions and conflicts, as they would arise, if only some stakeholders adapt climate sustainability as a strategic priority, can be avoided. In turn, this will trigger systemic change that will allow academia to adapt and continue serving society.

7. The first steps towards climate sustainability

In the following, we put forward recommendations that we consider to be implementable right now and that in combination can reduce the climate impact of the academic system significantly. However, the medium-term goal of net zero emissions as early as possible but at the latest by 2050 requires a bolder vision, with numerous stakeholders working together to implement changes. We invite all stakeholders to participate in developing this bolder vision, in parallel to implementing the recommendations presented here.

12b. The importance of an evidence base

An evidence base is crucial to determine how a given organisation or sector can become climate-sustainable. Without a solid evidence base, i.e. reliable data, it is unclear, by how much GHG emissions need to be reduced and which sources they primarily come from. Thus, without a solid evidence base, it is virtually impossible to develop a feasible pathway towards climate sustainability.

Therefore, we consider the following points crucial:

1. The evidence base must include more organisations and be more comprehensive for many of those organisations which already report their emissions, thus also ensuring comparability across different organisations.

a. For many universities and some research institutes, a start has been made, but an agreed-upon and comprehensive reporting scheme is lacking. The inclusion of research-specific emissions (e.g. from purchasing and operating laboratory equipment, scientific computing and the corresponding purchases) is important and not yet generally included. Similarly, a comprehensive inclusion of all Scope 3 emissions is a step that needs to be taken.

b. For other organisations in the academic system (including among others funding organisations, academies and learned societies), an evidence base needs to be developed.

c. For conferences, a relatively good general understanding of emissions exists, and it should become standard to calculate and report emissions for any given conference.

2. Gathering an evidence base is a means to an end, not the goal.

a. The collection and publication of data on emissions is important, but a given organisation does not become more climate-sustainable just by publishing a climate report. A climate report is the very first step.

b. Therefore, climate reports should be produced with efficiency, so that the (limited) resources organisations have to become climate-sustainable are then focused on reducing emissions.

c. To be efficient in producing a climate report, universities can look to other universities' climate reports to learn what sources of emissions are typically large and what sources of emissions are typically negligible; similarly for other categories of stakeholders. The inclusion of negligible sources of emissions may not be necessary in early climate reports, and only becomes important in later years, when a university has already progressed far towards climate sustainability.

3. The evidence base should not just include data on emissions, but also systematic data collection about effectiveness of measures to reduce emissions, about how such measures were developed and about reactions to them.

a. A critical assessment of measures to identify true best-practice examples, but also identify problematic measures and measures with unintended negative consequences is crucial in order to allow many organisations to move forward at significantly higher speed towards climate sustainability.

4. Keeping bureaucracy and the burden on researchers low is important.

a. For some stakeholders, collaboration with researchers is important to determine the stakeholders' climate impact. An example is the climate impact of research that is funded by a given funding organisation. To generate an evidence base, researchers can be asked to provide climate reports, but with efficiency and low work load in mind. Automated data collection and tailored software tools can also be helpful here.

5. Using the evidence base to set goals and hold organisations accountable is key.

a. Climate reports make it possible to set meaningful, quantitative reduction goals; thus climate reports should be used to also set quantitative goals. Reports typically show what the 'low-hanging fruit' are where reductions are achievable easily, and they also facilitate medium-term plans for those emissions which are more challenging to eliminate.

b. Holding organisations accountable, both when they report on non-decreasing total emissions and when their reports show that goals have not been met, is crucial. The advantage of public reporting is that it can ensure accountability. This requires (groups of) people to hold the organisation accountable. At a university, this could for instance be the students. They are not in the same state of dependence as the employees, who might hesitate to hold university management accountable.

12c. Developing virtual communication skills and tools

As we have shown repeatedly throughout this report, GHG emissions from air travel account for a relevant part of the overall emissions of the academic system. Further, a significant share of emissions results from long-haul flights that cannot easily be substituted by alternative means of transport. Thus, reducing these emissions will depend on adopting forms of virtual communication. At the same time, virtual communication enables a significantly higher degree of inclusivity, making its wider adoption attractive for more than one reason.

Successful virtual communication requires taking concerns, problems and challenges seriously

Unsatisfactory virtual meetings and conferences have led to frustration for some researchers and to the belief that certain things simply cannot be done virtually (Kreil 2020). Limitations are often reported to networking, meeting new people, and building trust virtually. To improve, these concerns must be taken seriously, but must not become a self-fulfilling prophecy; both technological solutions as well as social habits can adapt.

Dedicated research is important to understand how to improve virtual communication platforms

(Inter- und transdisciplinary) research is required to better understand the challenges and tiring aspects of virtual communication and how to improve upon them. A better understanding can directly be implemented in improved platforms; this could for example be done by start-ups coming directly out of research groups.

Improving virtual communications is an opportunity for the academic system to serve societal needs at large

How to have meaningful, effective virtual encounters across a variety of social constellations and purposes is a highly pressing practical question facing not only the academic system, but many aspects of our globalised societies in need of rapid decarbonisation. Through dedicated research, development of new platforms, and experimentation with meeting formats, the academic system can be at the forefront of delivering workable solutions to society at large.

To ensure successful virtual meetings, meeting formats need to be re-evaluated

Meeting formats that work reasonably well as in-person meetings need not necessarily function as virtual meetings. Instead of trying a 'virtual copy' of an in-person meeting, one can experiment with new formats and make use of the added options that exist online, e.g. for asynchronous communication.

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Dedicated support can provide users with technical and conceptual support for easy-to-set-up, smooth-to-run and successful virtual and hybrid meetings

Virtual and hybrid meetings are a new, specific and rapidly developing format. Apart from dealing with purely technical issues it is important to recognise that training and exchange of ideas between organisers is needed to find the best concepts of these meetings.

Distinguishing between the situation in and after the pandemic is important in judging the problems and potential of virtual communication

Many researchers who are sceptical about the broader and sustained use of virtual communication had extended experience with virtual communication only during the pandemic and thus judge virtual communication based on their pandemic experience. It is important to note that this situation has added sources of stress (general lack/reduction of physical social contacts, requirement of online teaching) that are absent in a post-pandemic situation. 'Zoom fatigue' is much less likely to occur when most of one's interactions are physical and only meetings with people far away are (mostly) virtual.

12d Meeting formats: mix-and-match

A 'mix-and-match' approach to meeting formats is most promising to bring together climate sustainability with successful meetings

Meetings serve a variety of purposes. Conferences, workshops, schools, board meetings, committee meetings, interviews with applicants, collaboration meetings and seminars differ in their scope and goals. Even within these diverse categories, different meetings can aim to achieve different things. Therefore, different formats – online, hybrid, hub-based or in-person meetings – can work better or worse for a given meeting. Below, we compare five meeting formats along four different categories. We encourage a flexible and deliberated approach where no across-the-board decisions are made regarding meeting formats, but where meeting organisers reflect what the key goals of their meeting are and which format is overall best suited. In such an approach, advantages and disadvantages of different formats can be balanced, diverging opinions of meeting participants can be accommodated (e.g. by switching formats from one to the next instalment of a given series) and climate sustainability becomes an achievable goal.

We focus on the following five formats:

1. 'Traditional' in-person meetings,
2. In-person meetings, for which the choice of meeting location minimises the climate impact due to air travel,
3. Hub-based meetings, for which one larger meeting is split into two or more hubs (e.g. on different continents), at which participants meet in person, while the hubs are connected virtually,
4. Hybrid meetings, which participants attend either in person or virtually,
5. Online meetings, which all participants attend virtually.

Meeting format	**Online**	**Hybrid**	**Hub-based**	**In-person with optimised meeting location**	**In-person**
Climate sustainability	Highest	High, depending on who participates virtually 1)	High, depending on location of hubs 1)	Low 2)	Lowest 3)
Networking opportunities	Anecdotally reported as lower, but depends on implementation	Depends on implementation	Good within a hub; between hubs depends on implementation	Best	Best
Suitability for brainstorming/ creativity	Anecdotally reported as lower for groups of people not familiar with each other	Depends on implementation	Expected high	High	High
Global inclusivity	Highest	Can be high, if no "two classes" of participants arise	Depends on hub placement	Low	Low

1. For hybrid and hub-based meetings, all long-distance flights can be avoided for an appropriate choice of hub location/ virtual participation. Long-distance flights make up a far greater share of emissions than short-distance flights, see Chapter 8.
2. Optimising a meeting location so that GHG emissions from air travel are lowest can lead to a reduction of approximately 20%, according to Stroud and Feeley (2015), see Chapter 8.
3. The GHG emissions just from air travel at an in-person conference are estimated to be a factor 100–3000 higher than the total emissions for an online meeting, see Chapter 8.

13. Recommendations and further considerations for individual stakeholders

13a. The first steps towards climate sustainability

In our recommendations, we focus on the next or in many cases first steps the academic system can take towards climate sustainability. We put forward recommendations that we consider to be implementable right now and that in combination can reduce the climate impact of the academic system significantly.

These steps are likely not going to be sufficient to make the academic system climate-sustainable. The medium-term goal of climate sustainability (in the sense of net zero emissions) as early as possible before 2050 requires a bolder vision. This vision of a decarbonised academic system with its changed modes of operation must be developed in parallel to taking immediate steps towards decarbonisation. Many of these changes require numerous stakeholders to work together, and some changes might appear unrealistic or highly challenging to some from today's perspective. Therefore, we will not present such a vision here, because we believe that in order for it to be successful, it requires a broad and in-depth dialogue that includes all stakeholders in the academic system.

We invite stakeholders in the academic system to view our recommendations as a first step to be taken right now and encourage all stakeholders to think beyond these recommendations about the next steps, but also about the final goal of this process. We further invite stakeholders to embed climate sustainability in their (institutional or even individual) strategies and make climate sustainability a key metric in any decision-making process. Within this changed framework and new way of thinking, stakeholders can recognise how the evolution towards climate sustainability offers opportunities for new and creative ideas that improve the academic system as a whole.

13b. Universities

Report GHG emissions, but remember that reporting is only a means to an end

Reporting GHG emissions is crucial in order to develop a climate sustainability strategy that is based on a solid evidence base. Reporting is only a preliminary step to take towards climate sustainability. Thus, it is crucial to always consider the GHG report as a means to an end and to take steps that lead to measurable reduction in GHG emissions.

Report GHG emissions according to a sector-wide standard including Scope 3 emissions

Scope 3 emissions can make up a very substantial part of total emissions, therefore their reporting is important for a comprehensive climate report. To ensure that climate reports provide a meaningful and comparable basis for transparent reduction targets, a sector-wide reporting standard should be developed and used for all institutions in the academic system.

Start as soon as possible, because changes of norms and behaviours take time

Some of the changes towards climate sustainability at universities require individual behaviour and norms for such behaviour to change, e.g. when it comes to commuting or air travel. Such changes require time to occur, thus starting to trigger those changes as soon as possible is important. A strategy in which universities first tackle behaviour-independent aspects (e.g. electricity supply) and only later move on to address changes in norms and behaviours, is likely to incur very significant delays.

Develop a travel policy in a transparent, open and well-communicated fashion

To develop a travel policy that will be acceptable to the staff, engaging them early and addressing their concerns is critical. To that end, workshops with administrative and research staff can be held to understand their concerns and develop a travel policy that accounts for these. The travel policy roll-out should be accompanied by extensive and well-prepared informational resources, such that all questions can be answered promptly. Even if informational resources address all possible questions and concerns, continuing to hold a dialogue with researchers and administrative staff is important to address all concerns.

Incentivise the use of low-carbon forms of travel

Universities can lift requirements to choose the economically cheapest form of travel, such that the ecological cost also becomes a relevant criterion to choose the means of travel for employees.

Further, many universities can – depending on their geographical location and ease of access to a train network – not only incentivise low-carbon forms of travel, but even follow the example some universities have already set and develop rules that prohibit air travel below a certain distance and require offsetting emissions or introduce an internal carbon tax for any work trip.

Provide technical equipment and expert personnel for virtual meetings

High-quality and easy-to-use equipment to give virtual talks, hold virtual discussions, workshops, and conferences is critical to enable researchers to reduce their travel without compromising (international) collaboration. It is also key to have expert personnel who can support academics in organising and setting up virtual meetings, provide workshops to school academics in the use of virtual tools, and who can quickly trouble-shoot any issues that arise during virtual meetings. It is important to recognise that a lot of the necessary support in setting up virtual meetings may be conceptual rather than purely technical.

Capitalise on attitude changes towards online meetings

The pandemic has brought a change of attitude towards online meetings, with the recognition that many different types of meetings that used to be in-person can successfully be transferred online. This includes meetings within the scientific community (e.g. for collaborations, job committees etc), but also for many research areas, meetings with external stakeholders, such as companies. Here, universities can act as driving forces in making this change permanent.

Adapt rules for doctoral and other thesis defences and other committee meetings with external participants to allow virtual participation

Enabling international experts to participate in defences or committees does not require travel, in particular not long-haul air travel. Giving committees and individuals the freedom to choose whether in-person participation is important enough to justify travel generates awareness about these choices and enables the benefits of internationalisation without an associated cost for the climate. Further, the economic costs decrease as well.

Hire experts to support organisational change and decarbonisation

Change management can be more successful if expertise in this area exists, which university management can obtain either via advanced training or by hiring experts in this area. Similarly, decarbonisation requires a certain amount of expertise, which can be provided by allocating funding to hire expert staff.

Join a sustainability network to learn from others and share own experiences and best-practice examples

Sharing knowledge on sustainable campus operations among universities is important. Universities that are only starting to develop a climate sustainability strategy can learn from other, more experienced institutions and can thereby be more efficient in developing actions with impact. Universities which have already gained experience – both with successful best-practice examples as well as with failed initiatives – can support others by sharing both positive and negative experiences. Cross-talk between various networks can also be important, thus a university can consider joining several networks.

Show legitimacy of planned changes by holding surveys/voting campaigns

To show that a planned change is supported or even demanded by a majority of staff and students, surveys or voting campaigns can be held. For these, the communication needs to be well-prepared, so that all questions, in particular tough and legitimate ones, can be answered. The outcome of such a voting campaign can provide legitimacy for the change towards the university community and generate buy-in among senior management.

Develop a climate sustainability strategy and then make it a core part of the general strategy

Developing a (climate) sustainability strategy is a first very important step. In order to fully incorporate sustainability in all strategic decisions, the second step is to make the sustainability strategy a core part of the general strategy. In both steps, it is important to be aware of conflicts between different aspects of the strategy, e.g. misalignment of building strategies (bias towards a new building vs renovating an old one) with climate sustainability. If climate sustainability is a core part of the strategy, such strategy conflicts can be decided in favour of climate sustainability.

Transition to renewable energy providers or install sources of renewable energy (solar, wind) on campus

A change of energy provider is possible in some regions, and in others, installation of solar panels or wind turbines on campus may be feasible. Depending on the country/region, this can be achieved together with national governments or other entities, if these are the owners of a university's buildings.

Make supply chains, including of food at cafeterias and of research equipment, more climate-sustainable

Supply chains can account for large GHG emissions, including, e.g. food at cafeterias as well as research equipment. Many universities can follow where individual universities are already leading: changing supply chains to more climate-sustainable choices. Further, food choices in cafeterias can be adapted to reduce the climate impact of food.

Divest from fossil fuels

Universities can – if they have not already done so – divest from fossil fuels. This is best done as soon as possible and in a transparent way.

Recognise opportunities to seed change in the broader community

In many cities, university students and staff make up a significant part of the population. Thus, behavioural change and change in norms to increase climate sustainability, started at a university, can act as a seed for similar changes in the local community. Such effects can be strengthened if universities engage with the local community to communicate the changes they are implementing and explain their reasons for it.

Collaborate with the local environment (e.g. municipalities) to reduce the overall GHG emissions by co-use of buildings

University auditoriums are often largely empty in the late afternoon and the evening, while still producing GHG emissions from electricity and heating. At the same time, municipalities need buildings to offer, e.g. adult learning programmes (language courses and such), and clubs and associations require spaces to meet etc. Co-using the same buildings, by opening up university auditoriums and class-rooms for municipalities, clubs and associations to use in the evenings saves GHG emissions linked to building new buildings and maintaining, heating and lighting existing ones.

Generate awareness

As an important player in our society, universities can take a leading role in generating awareness for the climate crisis, both among their employees and students as well as when reaching out to the general public. Besides showing open management support for grassroots initiatives, a top-down approach could involve regular colloquia on the topic, as well as open communication around GHG reports and proposed measures.

Define a framework for the offsetting of GHG emissions

We stress that the offsetting of GHG emissions can only be the very last measure, after having exhausted all possibilities to reduce emissions. An accounting system for costs of offsetting can be implemented

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in different ways, from a collective offsetting at the institutional level to a billing procedure touching the individual researchers' travel budget. While the former is likely administratively more efficient, the latter may have a bigger impact in terms of awareness and directly influencing individual travel habits. When there is no legal framework in place to allow for universities to offset GHG emissions, universities are well placed to advocate for such a framework with their governance body.

13c. Research institutes

Make climate sustainability a key part of the institutional strategy

Research institutes can incorporate climate sustainability in all their decision-making processes, including travel policy, laboratory equipment and procedures (where applicable), computing resources and their use (where applicable), purchase of goods and research equipment, maintenance of building infrastructure, and organisation of seminar series, workshops and conferences.

Generate awareness and communicate openly to develop an accepted and impactful climate sustainability strategy

An impactful climate sustainability strategy touches several aspects of researchers' day-to-day work. Therefore, awareness for the climate impact of research is an important prerequisite for researchers to accept the strategy. Further, a strategy can be most impactful when concerns by all staff members are addressed, the reasoning behind strategy choices is clearly communicated, and an open and ongoing discussion of the strategy is conducted.

Explore opportunities to virtualise work

Similar to some companies, not all research requires a researcher to be present in a lab. Research that can be conducted from home can be considered for virtual working, even, where feasible and not detrimental to the quality of the research, over longer periods of time. This can have added benefits for early career researchers, enabling them to work from a different location or even country (where legally feasible) and reducing the pressure for physical mobility and the resulting challenges to reconcile an academic career with family and care obligations.

Reduce emissions from computing by efficiency gains, optimising locations of new computing centres and using 'green' clouds

Efficiency gains in scientific computing are often 'eaten up' by correspondingly larger computations. Increased individual awareness can allow researchers to instead use increases in, for example, code efficiency, to reduce GHG emissions of computations. A tool to calculate GHG emissions associated with running a given algorithm is available at https://www.green-algorithms.org/. Avoiding idle times on computing clusters reduces GHG emissions. Therefore, cloud computing can reduce GHG emissions if it is ensured that the cloud servers are run in an energy-efficient manner. It is expected that new computing centres will be built. Placing them in countries with a large share of renewable energy and/or providing them with their own supply of renewable energy can reduce GHG emissions.

Raise awareness and lower the climate impact of projects by requiring climate sustainability assessments of projects

Asking researchers to provide a (climate) sustainability assessment of each planned project can raise awareness and lead to researchers finding low-carbon implementations. It is critical to implement such a measure carefully, in order not to overburden researchers and/or trigger a negative backlash. Thus, the amount of work that is needed to assess climate sustainability should be in proportion to the size of the project. Further, individual researchers typically do not have relevant expertise to assess the climate impact of their project; thus having a team of experts at an institution or working with external expertise can be useful. In addition, having one team of experts (either in- or external) who assess the climate impact of all planned projects ensures comparability of these assessments across different projects.

13d. Students

Hold university management accountable

Students can play an important role in holding their universities accountable. If an institution does not already have effective sustainability policies in place, students can make inquiries regarding this lack of policy, and express their concerns. If, however, the institution does have policies and targets in place, students can pay attention to whether the institution lives up to its promises, and otherwise again address their leadership with an expression of concern. It is probably most effective if such communication with university leadership is channelled through an official and representative student organisation, and if students take the time to inform themselves of the universities' present and past efforts toward climate sustainability before advancing new demands.

Demand divestment

There are successful examples of student campaigns asking for divestment from fossil fuels. Similar campaigns can be successful at other universities.

Ask for low-emissions food choices at the university cafeteria

Several universities already offer a significant fraction of meals as vegan or vegetarian options. Students can ask their university cafeteria to follow these examples.

13e. Individual academics

Generate awareness by discussing climate sustainability of the academic system

Academics can make the climate sustainability of the academic system a topic of debate in their immediate circle of influence, and create an environment in which others – especially people in less senior positions, such as undergraduate or graduate students – can raise the topic and express their concerns as well. This is independent of the individual researcher's own 'track record' of climate sustainability. At the same time, academics can be mindful about the assumptions and expectations they communicate to colleagues – especially junior colleagues – about what is normal, necessary, or desirable, and be open to critical questions and new ways of doing things.

Work with your colleagues

Informal alliances and initiatives of like-minded academics have great transformational potential. In fact, many positive changes described in the sections above were achieved through organised informal initiatives of academics.

Consider all your opportunities for leverage

Many individuals are involved in self-governing activities at their universities, research institutes, and research societies. The role of senior academics and their potential to make climate sustainability a strategic priority is obvious. However, junior researchers as well as non-academic staff can contribute substantially to establishing new norms either through their official roles or simply by raising their voice as members of the academic community. In addition, involvement in various committees or as a referee of scientific proposals is one of the possible roles in which individuals have opportunities to contribute to change.

Consider the climate impact of research and research equipment

Purchase and use of laboratory equipment, computing, IT equipment etc. can be done with climate sustainability in mind.

Consider reducing the number of long-haul flights for conference and meetings

Reducing the number of long-haul flights has a very significant impact on the individual carbon footprint. It can be achieved by (i) attending fewer conferences, (ii) attending some conferences virtually instead of in person or (iii) combining several trips into one, e.g. by spending time between two conferences as a visitor at a university on the same continent. Further, carbon efficient airlines and, where possible, direct flights, can significantly reduce emissions for a given trip. Geographic location matters in these deliberations: for Europe-based researchers, a large network of scientific contacts is typically within reach by train. For researchers in the Global South, the situation may be quite different.

Consider hybrid modes for local seminars and colloquia

Seminar series and colloquia can be run in a hybrid mode: some speakers can attend in person (e.g. if they can attend by train or if they visit for an extended stay, e.g. for a collaboration), while others can give talks remotely. As to added benefits, such hybrid seminars are economically cheaper and make it feasible to invite high-profile researchers who are less likely to come in person.

Avoid short trips and consider substituting by virtual communication

Avoiding short trips, especially related to giving a lecture, presentation or seminar which takes a few days of stay (e.g. 1–2 nights) will decrease total emissions. Besides, same day return flights and non-economy flight tickets prove to be a considerable segment that, once controlled, could result in additional reduction in emissions (Wynes and Donner 2018). At the very least, researchers can choose direct flights with carbon efficient airlines, and they may consider buying carbon offsets.

Be creative and deliberate about virtual networking

Developing a strong academic culture of low-carbon internationalisation requires not only technology and funding, but also the willingness of individuals to keep trying, inventing, and practising new formats and modes of meeting, connecting, and working with colleagues. Virtual networking in particular requires and deserves the same determination and strategic deliberation as successful face-to-face networking: much like making sure to meet the right people at an in-person conference rather than simply waiting to run into them, researchers should deliberately seek out and initiate promising opportunities to meet and exchange with interesting colleagues.

13f. Funding organisations

Ask that applicants discuss the climate impact of their project in their application

The inclusion of a climate impact section in the application process could be implemented either on a voluntary or mandatory basis for the applicant. For the latter, it is crucial to keep the workload for the applicant as low as possible, e.g. by focusing only on the most relevant sources of emissions. As a first step, a climate impact assessment raises awareness.

Funding agencies should develop procedures and software tools which allow applicants to assess the most relevant expected emissions in an efficient way, and provide the necessary support to aid the applicants and grantees when determining the relevant emissions. When funding organisations provide the tool to perform the GHG assessment, this also ensures comparability of the estimates across proposals.

Develop green charters and encourage grantees to follow them

By providing a set of principles and listing possible steps for grantees to take to lower the climate impact of their research, funding organisations can generate awareness. By asking grantees during the reporting stage of a project to elaborate on how they implemented the principles, accountability (at a voluntary level) is generated and awareness is raised further.

Fund technical equipment and software licences for remote collaboration

By funding technical equipment and software licences for remote collaboration, funding organisations can enable virtual exchange of sufficient quality to collaborate remotely. This can include not just equipment at a researcher's home institution, but also at the institution at which the collaborators are based. This is particularly important for collaborations with researchers in the Global South, where means to buy the equipment might not be available. To date, funding organisations often fund travel by the applicants themselves as well as their collaborators. In a similar way, they can fund technical equipment for both.

Virtualise committee work

Members of assessment committees used to meet in person before the COVID-19 pandemic, but committee meetings have shifted to virtual formats during the pandemic. Largely keeping such a format (with exceptions for well-justified cases) results in reduced emissions and has the co-benefit of less time investment and less travel stress for committee members, many of whom are already very short on time. This in particular affects members of underrepresented groups in a given discipline, who are often asked to serve on disproportionately many committees.

Virtualise funding interviews fully and avoid hybrid formats

If all applicants who are interviewed for a grant are interviewed virtually, no single applicant is disadvantaged compared to other applicants. This is unlike in hybrid formats where applicants get a choice of whether or not to come in person and where the perceived or real disadvantage of a virtual interview is a strong incentive for travel. Virtual interviews lack certain aspects of a 'personal impression' – however, this impression is arguably not relevant and possibly more receptive to unconscious biases, for an informed decision on funding. This is different for job interviews, where interpersonal skills of applicants can matter and can be more easily judged in person. Therefore, we consider virtual interviews to be more suitable for grant interviews.

Fund research on climate sustainability of the academic system and challenges of virtual communication

Achieving climate sustainability of the academic system requires further research, (i) to find climate-sustainable alternatives to GHG-intensive research procedures, (ii) to understand how universities and other organisations are successful in their change management and can make large steps towards climate sustainability, and (iii) to improve virtual communication. Funding organisations can consider new funding lines to support research on these three topics. At the same time, they can consider how to best disseminate the findings of this research among the relevant stakeholders.

Allow researchers to choose the least carbon-intensive instead of the economically cheapest way to travel

Funding organisations can empower individuals to make climate-sustainable choices by allowing a choice in the means of travel instead of requiring the economically cheapest choice. Where travel budgets are low, funding organisations can also provide top-up amounts for the choice of more climate-sustainable means of travel.

Remove incentive to travel a lot by asking researchers to list only one in-person invited conference talk per year in their CVs

Currently, an incentive to travel a lot exists, in particular for early career researchers, because the number of invited conference talks is used as a metric for research impact. This motivates researchers to accept invitations to conferences, even if they consider the conference to be of low scientific interest. Limiting the maximum number of invited in-person conference talks per year (or 5-year period) that can be included in a CV, removes this incentive.

Set an incentive to conduct events virtually by counting virtual events on the same footing as in-person events.

Giving remote instead of in-person talks and organising virtual instead of in-person workshops sometimes may be perceived to count less, e.g. when CVs are reviewed as part of a funding decision. This incentivises in-person events, even when there is no added value in the in-person format for any specific, given event. By explicitly asking their reviewers to judge virtual events on the same basis as in-person events and communicating this practice to applicants, funding organisations can remove an incentive for travel and contribute to a change in norms.

13g. Conference organisers

Maintain a (partial) virtualisation of conferences

GHG emissions from conferences can be reduced significantly by implementing fully virtual conference formats, hybrid conferences (online and offline participation), hub-based conferences or alternating between in-person and virtual conference instalments. While reducing in particular long-distance air travel, an inclusive and international research environment must be achieved. To achieve it, it is crucial that online and offline participants can participate equally, i.e. give presentations, ask questions and clearly hear the questions asked by the in-person audience. Depending on the technical equipment (individual microphones, ceiling microphones, hand-held microphones) this may require an adaptation of the conference etiquette.

Understand the diverse needs of conference participants to find the technological solutions which enable efficient communication and networking in virtual formats

Depending on their career stage, familiarity with the specific scientific community, access to high-end technology and large internet bandwidth, relative time zone, digital literacy, personality, etc., different participants will have different needs and goals when attending a conference. Beyond information exchange, networking is often an important factor, in particular for early career researchers. Conference organisers can provide opportunities for virtual informal exchange (e.g. through discussion sessions, break-out rooms, virtual environments), and should take into account the diversity of their participants.

Lower travel-related GHG emissions by choice of conference location

Significant reduction in GHG emissions can be reached even for fully in-person conferences if the location is chosen to minimise overall travel distance and avoid the need for connecting flights. While there are often valid reasons for choosing a conference location that is not the geo-centre of the expected participants (such as promoting geographic diversity and inclusivity) these should be reconsidered in light of the climate crisis. In particular, conference venues which are chosen mainly for their holiday destination character and retreats which require air travel are difficult to justify.

Consider that conferences play a crucial role in setting norms in a given field

Conferences can shape the norms and culture of a field by including a presentation, discussion time or even an entire session dedicated to climate sustainability, similar to numerous existing efforts regarding diversity and inclusion. They can moreover openly confront the topic on their conference webpage, listing the efforts undertaken at this specific conference.

Monitor and report GHG emissions as a first step towards quantitative reduction goals

Recording and reporting the GHG emissions associated with conference attendance can form the basis for strategies of further emission reduction. This moreover enhances the awareness of the role of conference travel in the climate crisis and may in the future become an integral part of conference funding applications. An open-source online tool which facilitates this process is described, for example, in Barret (2020).

13h. Academies and learned societies

Become platforms to exchange knowledge and coordinate climate sustainability efforts across individual institutions and across disciplines

Academies bring together leading researchers across institutions and disciplines. They can thus trigger or even to some extent coordinate change towards climate sustainability in the academic system. Further, they can serve as platforms for the exchange of best-practice examples, e.g. by scheduling talks and discussion sessions on the topic as part of their general assemblies and board meetings.

Set norms on climate sustainability within disciplines

Learned societies can, for example through the format of their own meetings and conferences, set new norms within the disciplines. In that sense, high-profile meetings such as prize award ceremonies can be particularly relevant. Further, they can provide opportunities to learn about best-practice examples, e.g. by scheduling sessions on climate-sustainable research practices as part of their annual/biannual conferences.

Embed climate sustainability in strategic goals

As academies and learned societies adapt to the changing demands of society and the academic system, they can include climate sustainability as a central strategic goal, making it an integral component of their decision-making processes and strategic development.

Make day-to-day operations climate-sustainable

In their day-to-day operations, the offices of academies and learned societies face similar opportunities to universities to make their buildings, procurement, and travel climate-sustainable. Accounting for the associated GHG emissions can be an important prerequisite to making efficient steps towards climate sustainability.

13i. Ranking agencies

Include climate sustainability alongside other criteria in university rankings

Climate sustainability can be viewed as one of several criteria to measure the quality of a university. Therefore, instead of ‘standard’ rankings without (climate) sustainability criteria, and ‘green’ rankings focusing on (climate) sustainability criteria, all university rankings could include climate sustainability criteria.

To devise informative metrics, develop a common standard and include the rate of change in GHG emissions

To design an informative metric, a common standard for reporting of GHG emissions is necessary. Then, not only the amount of GHG emissions per researcher or student can be informative, but also the rate of change in GHG emissions. Together with the total emissions, the rate of change is a critical measure to determine whether climate sustainability plays a core role in a university's strategy.

Consider abandoning a competitive ranking model for a collaborative threshold model

Rankings are by nature competitive, because they order universities. This competition can discourage the sharing of best-practice examples among each other and can hinder collaboration to achieve climate sustainability. Further, a ranking only highlights how universities perform compared to each other, but does not compare their climate sustainability performance to an absolute standard.

As an alternative to a competitive ranking model, we recommend a threshold model which encourages collaborative behaviour. In the threshold model, all universities that achieve a certain meaningful climate sustainability standard are listed alongside each other in this category. The standard can, for example, be based on the amount of GHG emission per researcher or student (based on a comprehensive accounting scheme), together with the rate of change of GHG emissions.

13j. Policy-makers

Translate high-level national/sectoral targets into concrete targets for universities

A growing number of countries in Europe and beyond have taken steps to enshrine GHG targets in national and/or subnational law. In many instances, however, the degree and manner in which these economy-wide targets apply to specific universities and other public bodies is lacking in clarity. Governments can set clear targets for absolute GHG reduction for universities, and clear mechanisms for accountability should be established for such targets.

Adapt procurement rules for public universities to enable climate-sustainable choices

In many instances, universities are public bodies that are subject to public procurement rules set by national or regional governments. These rules shape the purchasing decisions of actors across the academic system, and are therefore an important lever to change consumption processes. Green public procurement policies should be developed or strengthened in order to create the right incentives for purchasers across the public university sector to make more sustainable choices, e.g. in the procurement of electricity.

Set society-wide targets for energy and resource consumption and apply them to universities

In many cases, relevant performance standards for building energy consumption, water conservation, etc. are set at national or sectoral level. Policy-makers have a key role to play in setting such targets in a manner that is in line with the need for rapid decarbonisation and can also make sure that such performance standards apply to universities.

13k. Recommendations that require the cooperation of several stakeholders

There are concrete steps towards climate sustainability in the academic system that a single (category of) stakeholder cannot, or not as successfully, take individually. These require different stakeholders to cooperate.

Provide and use funding to decarbonise existing buildings

A significant share of GHG emissions from a university campus comes from electricity and heating, i.e. from the energy required to operate buildings. These emissions can be reduced by transitioning to renewable energy sources and by modernising and renovating buildings (e.g. increasing insulation). This requires funding, provided for example by regional or federal governments as well as funding organisations, and it requires universities to use their available funding in this manner. Typically, these stakeholders will need to collaborate because existing university budgets may not provide leeway to fund renovations, but increases in budget must also be used appropriately.

Set incentives to modernise and renovate existing buildings instead of adding new buildings

Many universities find it simpler to obtain funding to add new buildings instead of modernising existing ones. This 'new-building bias' can lead to increased GHG emissions (from construction and operations of old and new buildings). If governmental and other funders work together with universities, the 'new-building bias' can be converted into a more climate-sustainable 'modernise-first bias'.

Plan future large-scale research infrastructure compatible with future climate sustainability goals

Some disciplines, such as astronomy or particle physics, require large-scale infrastructure built for several decades, which can be very GHG-intensive. Decisions on such large-scale infrastructure, when made now, will likely lock in GHG emissions from these disciplines for the coming decades.

Thus, stakeholders from these disciplines as well as funders (including, where applicable, policy-makers) need to urgently discuss now, how to ensure that large-scale research infrastructure that is under development now, can be made climate-sustainable to ensure that climate sustainability goals for 2030, 2040 and even 2050 can be met.

Conduct research and implement new solutions to reduce research-related GHG emissions

Some research-related GHG emissions cannot currently be avoided without stopping the research activities in question. For these, individual researchers, universities, research institutes, and funding organisations can work together to research less GHG-intensive alternatives.

Allocate funding for the decarbonisation of the academic system

Decarbonisation can be expensive. Therefore, governmental and other funding organisations can support it by allocating additional funds for decarbonisation. However, academic institutions also need to make climate sustainability a strategic priority. Making climate sustainability a strategic priority also means that available resources need to be allocated appropriately, i.e. steps towards climate sustainability need to be made also without an increase of overall funding.

Allow carbon offsetting, but consider it as a last resort

Carbon offsetting should only be the third, least preferred option among the three actions 'avoid, reduce, offset' GHG emissions. Where GHG emissions cannot be avoided and/or reduced, it can be considered and can in fact be helpful in generating awareness, e.g. when GHG emissions that cannot be avoided must be offset (as individual organisations are currently proceeding with regard to travel emissions). In some countries or funding schemes, offsetting is currently not allowed. Thus, the organisations generating GHG emissions need to collaborate with funding organisations and/or policy-makers in order to allow for offsetting if avoiding and reducing of emissions is not possible.

Organise a structured dialogue and process to achieve systemic change towards climate sustainability

Systemic change towards climate sustainability requires all stakeholders in the academic system to develop a common vision and a pathway towards it. This development requires an extended dialogue and a structured process that can be triggered and organised by a consortium of organisations. These might include, e.g. the European Environmental Agency, the European University Association, various learned societies, national academic umbrella organisation and others. Representatives from all stakeholder must then be included in the process itself. Within this process, some questions are specific to disciplines, making learned societies suitable to organise the discipline-internal process. Other questions cut across disciplines, making overarching umbrella organisations within the academic system suitable to organise the trans-disciplinary process. Complementing this top-down organisation and implementation of a process should be bottom-up initiatives.

Closing remarks and outlook towards a vision for climate sustainability

Many individual actors within the academic system are already making steps towards climate sustainability. The recommendations put forward here are the very next step towards a climate-sustainable academic system. They are implementable right now and can lead to reduction in GHG emissions as early as this year. However, this first step is very likely not enough. The transformation of the academic system will have to go beyond the changes sketched out above. It needs to go beyond actions at the level of individual actors, and change the framework conditions, the norms, and the system of incentives within which the academic system currently operates.

This change might well include measures that could seem unrealistic or even radical when considered now. However, the academic system has undergone many such changes, often triggered by societal changes, and has often come out more successfully, before. Therefore, the academic system has the potential to go through a transformative change towards climate sustainability, and even emerge more successfully from this transformation.

In contrast to many other sectors in society, the academic system is more self-determined, with academics themselves being key decision makers in setting the framework conditions for the academic system. Thus, the academic system is very well-positioned to transform to climate sustainability in a self-determined and carefully deliberated manner.

In order for this transformation to succeed, a common vision of a decarbonised academic system is necessary. To develop and implement such a vision successfully, all stakeholders in the academic system must be included in a broad dialogue, in which legitimate concerns can be addressed and various points of view and inputs can be considered.

The process to develop such a vision can be started in parallel to taking the next steps, suggested by the above recommendations. We invite all stakeholders in the academic system to make suggested changes now and develop the next few steps and their vision for the final goal, in parallel to that.

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Appendix A: university emissions

Aalto University

https://www.aalto.fi/en/sustainability/sustainability-reports

https://www.aalto.fi/sites/g/files/flghsv161/files/2020-03/board_report_and_financial_statements_2019_aalto_university_0.pdf

Aarhus University

https://medarbejdere.au.dk/en/sustainability/greenhouse-gas-emissions-report/greenhouse-gas-emissions-report-2019

https://international.au.dk/index.php?id=93713

University of Amsterdam

https://www.uva.nl/binaries/content/assets/uva/nl/over-de-uva/over-de-uva/duurzaamheid/milieubarometerrapport-2020-uva.pdf

https://public.tableau.com/views/UvAFactbook/FactbookUvA

Cambridge University

https://www.environment.admin.cam.ac.uk/sites/www.environment.admin.cam.ac.uk/files/environmental_sustainability_report_2019-20.pdf

https://www.cam.ac.uk/about-the-university/cambridge-at-a-glance

UCLouvain

https://uclouvain.be/en/discover/university-transition/bilan-carbone-evaluer-pour-mieux-agir.html

https://uclouvain.be/en/discover/faits-et-chiffres.html

TU Delft

https://www.tudelft.nl/sustainability

https://www.tudelft.nl/en/about-tu-delft/facts-and-figures

Copenhagen University

https://baeredygtighed2030.ku.dk/pdf/Gr_nt_Regnskab_2019__10-06-2020_.pdf

https://about.ku.dk/facts-figures/

https://about.ku.dk/facts-figures/students/

https://sustainability2030.ku.dk/pdfer/B_redygtighedsm_l_2030_UK.pdf_copy

University of Edinburgh

https://sustainability.ed.ac.uk/report/2018-19/#climate-link

https://www.ed.ac.uk/human-resources/about/facts-figures

http://www.docs.sasg.ed.ac.uk/gasp/factsheet/Student_Factsheet_31072019.pdf

ETH Zurich

https://ethz.ch/content/dam/ethz/main/eth-zurich/nachhaltigkeit/Berichte/Nachhaltigkeitsbericht/ETHzurich_Sustainability_Report_2019_2020_web.pdf

University of Ghent

https://www.ugent.be/en/ghentuniv/principles/sustainability/sustainabilityreport2020.pdf

https://www.ugent.be/en/ghentuniv/principles/presentations.htm

University of Gloucestershire

https://sustainability.glos.ac.uk/wp-content/uploads/2021/04/UOG_ASR_2020_FINAL-22.04.21.pdf

University of Graz

https://static.uni-graz.at/fileadmin/projekte/umweltmanagement/Umwelterklaerung/Umwelterklaerung_2020.pdf

Hamburg University

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Hannover University

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Oxford University

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Free University of Berlin

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University of Bournemouth

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Cambridge University

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University of Coimbra

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University of Lund

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Universidad Politecnica de Madrid

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