# The Environmental Impact of Research Communities

## Insights from conference sustainability chairs

**As sustainability chairs for key computing conferences, we explore the environmental impact of research conferences, reflect on the complexities of making physical and virtual conferences sustainable, and discuss the environmental consequences of computing research itself.**

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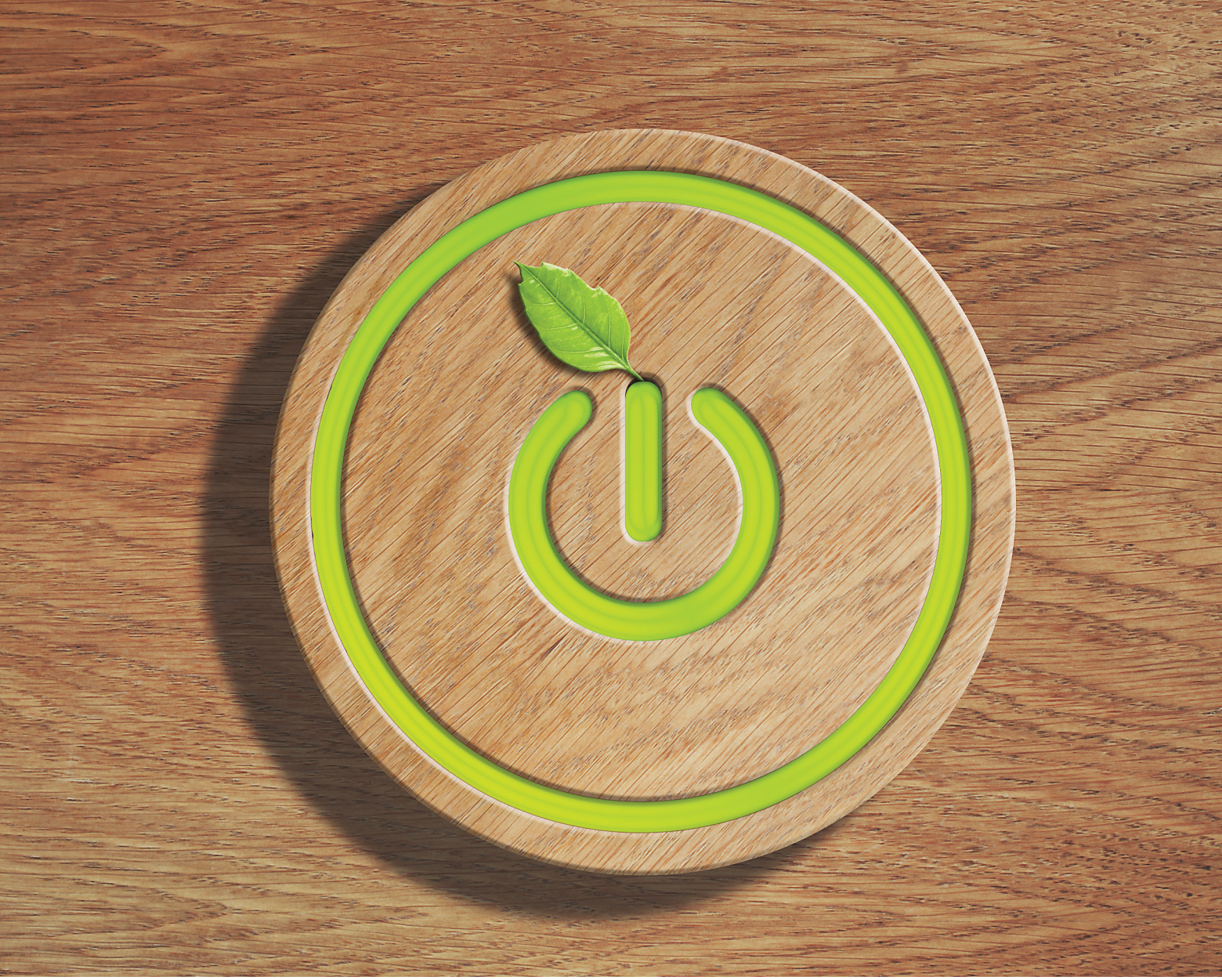
We are in a climate emergency. Scientific evidence demonstrates we must keep the global average temperature under 1.5 degrees Celsius above pre-industrial levels to significantly reduce the risks and impacts of climate change. To do this, we must create global change that provides for environmental protection while ensuring social inclusion and economic growth. Given the global effort required, we ask what can computing communities do to be more sustainable?

### SETTING OUR GOALS

We have been working on this question in our roles as conference sustainability chairs for two key ACM SIGCHI (Special Interest Group in Computer-Human Interaction) research communities: ACM Symposium on User Interface Software and Technology (UIST) and ACM Conference on Computer-Supported Cooperative Work and Social Computing (CSCW). As a global community of engineers, computer scientists, and information scientists who are members of the ACM, our community is committed to "ensur[ing] that the public good is the central concern during all our professional computing work" [1]. We can impact several of the global goals articulated by the United Nations (UN) at the UN Conference on Sustainable Development in 2012. For example, Goal 9 "Industry, Innovation and Infrastructure" aims to build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation. ACM members can significantly impact Goal 9's targets. To illustrate, developments in video-mediated communication can facilitate further innovation, reduce inequalities, help make communities more sustainable, provide education, and reduce our carbon footprint.

We believe by making ACM research communities more sustainable, our community is better positioned to nurture, develop, and sustain global populations without compromising the planet. As sustainability chairs, we promote sustainability within the CSCW and UIST communities and serve as stewards



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for sustainability in the organizational decisions within our research community. Although we focus on addressing the climate crisis, we have found our work quickly becomes entangled with concerns for developing an inclusive and vibrant computing community (more on this later). At the outset, we decided to focus our efforts on the following four goals:

1. Inform and help develop policy to promote more sustainable procurement, reduce travel, reduce waste, lower the environmental impacts of food choices, and lower direct and embodied energy demands
2. Collect data to track the environmental impact of the conference and enable annual comparison of conference choices
3. Support the general chairs in embedding sustainable decision making into the conference and its organization
4. Include research on sustainability in our call for papers.

## SUSTAINABILITY AND POLICYMAKING

One challenge to make a scientific conference more sustainable is integrating sustainability considerations within its overarching policies and procedures. These range from selecting venues to influencing what memorabilia is available to attendees. Many critical decisions occur at higher organizational levels than the conference's organizing committee, within the special interest groups (SIGCHI in our case), or even higher at the ACM level. For example, venue selection for a conference can happen years in advance long before the sustainability chairs are appointed. Integrating these considerations at higher levels requires buy-in from the broader community and convincing decision-makers who hold sway at these levels. We, as a community, need to demonstrate how much we care about these issues in order to raise awareness and show support for these changes. One policy that members can actively support is carbon offsetting. Conferences currently have the option to purchase carbon credits to offset carbon emissions generated by attendees if the SIG supports allocating budget balances to the effort.

## RETHINKING PHYSICAL CONFERENCES

As sustainability co-chairs, one of the first questions we asked was: How would we know whether our choices made the conference more sustainable than it otherwise would have been? Carbon accounting is one of the most

widely accepted methods for tracking and reporting a carbon footprint, and could be used to track the conference's impact on the environment. This approach was first used by ACM's Special Interest Group on Programming Languages (ACM SIGPLAN) and subsequently adopted by the UIST community in 2019. The SIGPLAN Climate Community has called for ACM conferences to begin publicly reporting their carbon footprint for conference travel, and to explicitly budget for carbon costs and the conference's environmental footprint. In line with these calls, we began tracking our conferences' travel carbon footprint.

Carbon accounting uses the Greenhouse Gas (GHG) protocol, setting out three scopes of emissions: direct GHG emissions, electricity indirect GHG emissions, and other indirect GHG emissions. However, carbon footprint measures can sometimes be incomparable depending on the emission scopes that are included and other discretionary decisions regarding whether an activity should be considered. For example, SIGPLAN's reporting emphasizes travel to and from the conference to focus on how the choice of conference location can substantially impact the overall emissions of the conference. Since air travel is a substantial contributor to GHG emissions, this emphasis focuses on optimizing the conference location to reduce air travel emissions. In contrast, early work investigating tracking and reporting emissions for the UN Climate Change Conference ignored travel to and from the conference as beyond the scope of their accounting.

There are a few reasons to focus on air travel alone. Standardized measures for trips from one city or continent to another are easily accessible and can be weighted by the number of conference attendees. Reducing these emissions significantly impacts the conference's total emissions. In contrast, focusing on organizational decisions quickly becomes complex. Individual conference attendees' behavior becomes difficult to measure and track. Purchasing decisions are embedded and distributed across a number of organizers who may not be aware of their suppliers' environmental impact. Further, standardized measures are not always easy to come by. For example, standardized emissions measures for European dietary food items are available for some countries. Yet, this data is only beginning to be developed for a North American diet and is almost non-existent for a substantial part of the world such as Asia, Africa, South America, and Australia [2]. However, a conference could potentially make a tremendous impact by favoring locally grown food and declining food items that have a long travel route (known as food miles) or have been air freighted.

When we focused on the UIST conference's air travel emissions, we learned that on average, an attendee contributed more than two tonnes of carbon. We developed a weighted average taking into account participant travel from major participating continents. We also learned how the location of a conference can introduce social trade-offs by making it easier for regional residents to attend (see Figure 1). For example, the conference was never held in Australia during the five years we examined the data, so average Australian travel emissions are correspondingly large:

- North America, 1.02 tonnes
- Asia, 3.14 tonnes
- Europe, 2.17 tonnes
- Australia, 6.66 tonnes
- Other, 4.25 tonnes

Further, we asked whether we could track and change the local decisions regarding how the conference itself was conducted. At UIST '19, we eliminated free memorabilia and paper programs to minimize single-use items. We worked with conference sponsors to eliminate donated, free memorabilia and requested they sponsor experiences instead, like a gathering at a local venue or provide edible handouts (like chocolate), if they really wanted to promote their company. They were happy to comply, especially if they knew none of the others would be giving away promotional items. We secured free, 30-minute complimentary use of bikes in the local bike-share program, and we publicized low-impact ways to commute such as sharing rides with other attendees, taking public transit, walking, and biking. We worked closely with our host venues to understand ways we could lower our impact on the facility such as encouraging attendees to reduce their laundry consumption by opting for reusable linens throughout their stay or to recycle their materials through the concierge.

**Figure 1. The geographic make-up of attendees at past conferences for UIST.**

The location impacts who can more easily participate. Any attempts to optimize the conference location to reduce carbon emissions from air travel confronts trade-offs with making the conference easier to attend for participants from some geographical areas over others.

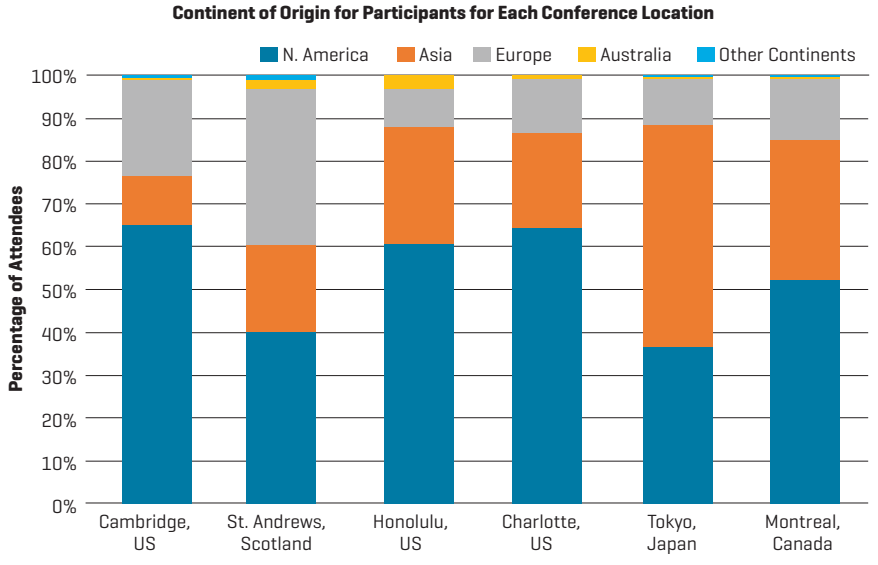

**Figure 2. An example badge from our initial experiments with making paper badges for the conference in order to eliminate single-use plastics.**


Photo courtesy of Alexandra Ion

During UIST '19, we talked with the chefs and liaisons for our venues to negotiate low-impact meals. We developed a more comprehensive understanding of the trade-offs involved through these conversations. For example, current research on the U.K. diet suggests fish-based, vegan, and vegetarian diets contribute lower emissions than high or medium meat-eating diets. Yet, our experience working with an American coastal hotel that made ample use of local supply chains in sourcing the kitchen's produce, cheeses, meats, and fish suggested that the national database's standardized GHG emissions may not have reflected our decision-making context. Specifically, the GHG emissions for many dietary items in the U.S. can be high because of the food miles involved. However, rather than travel inland through air freight, high GHG emitting items like fish, meats, and cheeses for our conference would come mere miles and through sustainability-conscious ecosystems such as fisheries managed and policed by the city and supportive of local economies. As one example, we confronted a choice to increase the dietary costs of the conference by purchasing oysters. Despite cost increases, this would benefit the local oystertecture program that was designed to revitalize the seaboard and adapt the local landscape to climate change risks of flooding by creating living breakwaters [3, 4]. These protect local marshes that have ecosystem impacts on the greater southeastern United States. Another certified sustainable kitchen tracked the trade-offs in water usage to wash glassware all at once for our hundreds of attendees versus composting single-use materials. They ultimately convinced us that by washing reusable glassware, we would be worse off environmentally speaking because of the venue's capacity limits. They reassured us they had disposal processes in place to re-allocate any food waste we generated to feed the polar bears and other residents at the local aquarium.

We also experimented with DIY fabrication at UIST '19. We specifically targeted the conference badge in our quest to remove single-use plastics. We designed a foldable badge that allowed for drink and vote tickets to be inserted into their pocket and ensured degradability by using Forest Stewardship Council certified 100% recycled paper (see Figure 2). The result was a lively experiment. Many attendees needed to return to the registration desk to ask for help repairing their badge because metal lanyard clasps were too hard on the paper badge. Yet at the same time, attendees were attuned to and aware of the environmental impacts we were trying to raise awareness about because of the ubiquitous and visible sign these badges provided. We plan to iterate on our badge design in the future to reduce wear and tear, and use seed paper so that badges can be planted and grow flowers at the end of their life.

## THE ROLE OF PHYSICAL CONFERENCES IN NURTURING A SCIENTIFIC COMMUNITY

Virtual conferences have garnered significant attention from the ACM community because of their potential to broaden global participation and reduce GHG emissions incurred from travel. ACM formed a presidential task force on what conferences can do to replace face-to-face meetings. These initiatives include holding the Program Committee (PC) meeting virtually. However, whether we remove conference travel depends in part on the implications for a conference's social benefits.

From a sustainability perspective, the question then arises: Do the benefits of a conference (for example, networking or career opportunities) outpace the environmental costs? In the previous section, we discussed how non-trivial it is to measure the environmental impact of a conference, unfortunately, we face the same problem when looking at the community impact. How can we measure the benefits of an ideation session, a spontaneous chat in a corridor that seeded an idea, or a serendipitous connection that leads to a job interview five years later? Further, are these benefits felt by all attendees, or only a lucky few?

Conferences are a central activity for scientific communities. They foster a sense of collective scholarly endeavor and provide a means to discuss state-of-the-art research. The computer science community relies heavily on the conference model. Many top-tier publication outlets and flagship venues depend on the conference model. Leaving aside that assessment metrics for research output use conference publication counts, conferences offer a number of advantages to our academic community. Beyond disseminating cutting-edge research, they foster ideas, facilitate debate, give rise to feedback, nurture learning, support networking with peers and senior colleagues alike, and provide a shared experience (essential for technology demos). They also expose attendees to infrastructure, cultures, and values outside of their home country. In turn, this exposure can push a scientific community to consider whether its advances benefit a global audience.

Reducing a conference's carbon footprint by lowering air travel emissions implies we will need a drastically different approach to conferences. This may include virtual conference elements. As it happens, the COVID-19 global pandemic forced academic conferences online. We took this opportunity to investigate the effect on environmental and social sustainability when transitioning to a purely virtual conference by conducting a survey of attendees yielding a 19% (UIST 2020) and 14% (CSCW 2020) response rate. From this, we think there will ultimately be trade-offs between a physical and a virtual conference,

with varying environmental, social, and economic impacts. To our knowledge, there is no research comparing conference formats to help us understand trade-offs between the environmental impact to the social impact on a scientific community. To inform the community's decision-making on the sustainability of future conferences, we are investigating the environmental and social impacts of switching from in-person to virtual for the UIST/CSCW '20 and '21 conferences.

From an environmental perspective, the advantage of holding a conference online is apparent. We remove the need to fly hundreds or thousands of people around the globe, and this reduction in flight emissions is substantial. Yet the social impact of a distributed conference, rather than co-located, is not quite clear. The advantages of virtual conferences extend beyond the carbon emissions saved to greater inclusivity.

▸ **Financial.** Virtual conferences are cheaper to organize and run. This makes them more accessible to those who cannot afford the expenses associated with in-person travel, accommodation, and registration fees. Of those who answered the question, 21% of UIST '20 and 26% of CSCW '20 survey respondents cited lower financial costs as enabling their attendance.

▸ **Easier attendance.** Virtual conferences enable participation by those who may not have the ability, desire, or time (for example, due to caregiving responsibilities or for those who find travel difficult) to attend conferences in-person. The virtual format enables different interactions and involvement that may be more conducive to attendance than in-person gatherings. Thirty percent of UIST '20 and 17% of CSCW '20 survey respondents would not have attended had the conference been held physically. Of those who answered the question, 22% of UIST '20 and 16% of CSCW '20 respondents cited lower time commitment/burdens; and 25% of UIST '20 and 25% of CSCW '20 respondents cited lower travel burden.

▸ **Accessibility.** The nature of online presentations means they can be more accessible for those with disabilities or those who find it troublesome to get a visa to the host country. In an online format, captioning becomes the norm and is helpful for those who find the audio-only format difficult. Of those who answered the question, 5% of UIST '20 and 2% of CSCW '20 survey respondents cited no visa requirement as enabling their participation. Seven percent of CSCW '20 survey respondents cited better accessibility as enabling their attendance (0% for UIST '20).

Inclusivity is important for these conferences. Almost half of the attendees are there for the first time. At UIST '20, 49% were first-time attendees. At CSCW '20, 40% were first-time attendees and another 12% were there the second time around.

Despite the advantages of online conferences, there are also drawbacks. The majority (80%) of survey respondents from the UIST '20 survey favored an in-person UIST '21 conference, and 53% found a virtual conference worse than past in-person conferences they attended. Twelve percent of CSCW '20 respondents were not likely or extremely unlikely to recommend attending a virtual version the next year, and 11% were not likely to attend.

The primary reason behind the attendees' preference for physically co-located conferences seems to be that virtual conferences have a negative impact on allowing people to network and nurture professional and scientific collaboration. Virtual conferences seem to remove the spontaneity and personal nature of meeting people. Over half of our survey respondents reported negative views about their ability to network and meet new people at the virtual conference (51% at UIST '20 and 55% at CSCW '20). These trends were worse when we asked about specifics like developing a new collegial relationship (negative responses were recorded for 61% of UIST '20 attendees and 45% at CSCW '20), finding a future collaborator (67% at UIST '20 and 55% at CSCW '20 responded negative), leads to job opportunities (70% at UIST '20 and 55% at CSCW '20 responded negative), and finding a future mentor/mentee (65% at UIST '20 and 53% at CSCW '20 responded negative).

**Do the benefits of a conference (for example, networking or career opportunities) outpace the environmental costs?**

It should be noted our survey could be confounded by the COVID-19 pandemic. We have no reason to think responses in any way reflect on the conference organizers. Rather, we think the responses show the potential risks involved with shifting conferences to a virtual format. When we ran our survey, many people had been stuck in front of their screens for the majority of the day for months on end, with limited social contact outside their immediate household sphere. We are currently planning to collect comparable data from in-person conferences to understand how well in-person conferences are able to support networking to enable professional and scientific collaborations.

Despite all of these drawbacks, 91% of UIST '20 survey respondents wanted to see future in-person conferences enable remote attendance. Seventy-five percent of UIST '20 respondents and 83% of CSCW '20 respondents were likely to attend next year's conference even if it would be virtual. It would be interesting to see whether a hybrid conference could combine the benefits of the environmental savings from virtual conferences with the networking benefits of in-person conferences.

## THINKING LONG TERM

In addition to the conference itself, we are pushing for a cultural shift to get computer and information scientists to reflect on the implications of their research and development for sustainability. Digital technology can have two roles: 1) the environmental impact of its production, use, and disposal; and 2) its impact on other sectors—whether it increases or decreases the global economy's emissions.

In regard to the first, scholars critiqued the estimates of the climate impact of the digital technology sector. When the full lifecycles and supply chains of digital technology are considered, the sector forms between 2.1–3.9% of global GHG emissions [5]. Further, future climate impacts of new digital technologies are less clear due to a number of debates and assumptions in this research domain (similar to the scoping GHG conference emissions measurements) [5]. At issue is a debate about technology's impact on the global economy—whether it helps, or adds to, the climate crisis. Some estimates project that it enables up to 20% emissions savings by 2030 through introducing efficiencies in other sectors (for example, food and transport). However, these estimates do not consider "rebound effects," whereby digital technology's introduction or efficiencies actually lead to a growth in emissions rather than a reduction [5].

Video conferencing provides a case in point. As noted above, using digital technology for video conferencing may be much more environmentally friendly than physical meetings or conferences. Yet when rebound effects are considered, video conferencing allows connections to be established across the world which otherwise might not have been possible. Thus, video conferencing could lead to new physical meetings and their associated emissions (for example, travel) in the future. This is an example of a rebound effect, and these are just the types of complexities that researchers in the domain are dealing with.

To get involved, there are many great research and technology groups that are driving initiatives in sustainable digital technology. Within our own community, these include the green IT and sustainable HCI research domains that focus on: 1) reducing the energy demands of our innovations, 2) use data gathering or ubiquitous technology to help understand the development of climate change, or 3) adapt unsustainable human behaviors. Emerging research in HCI, for example, has begun to experiment with changing how we design and create new technologies to consider their lifecycle environmental impacts in the design and development stage. There are also conferences centralizing environmental and social sustainability such as ICT4S (ICT for Sustainability), Computing within Limits, and even conference tracks (for example, the "Critical and Sustainable Computing" track introduced at CHI '20). Similarly, adjacent fields have formed their own communities of like-minded researchers like Climate Change AI. In complementary fashion, standards and targets are being set by technology industry leaders to meet global net-zero emissions targets, or even become carbon negative [5]. Given the scale of the climate crisis, we recognize further efforts are required across academia, industry and policy. Yet, this is an exciting challenge for computer and information scientists to help address.

**We, as a community, need to demonstrate how much we care about these issues in order to raise awareness and show support for these changes.**

## CONCLUSION

As we write this article, a summit of 40 world leaders is being held to renew conversations on how to globally collaborate on addressing climate change. We see our scientific community as essential for this agenda of global collaboration to succeed. Making our own conferences more sustainable offers an incredible opportunity to drive new forms of technological innovation as well as broaden who participates in the computing community. It is therefore important that current and future generations of digital technologists work with other disciplines and stakeholders to help make these initiatives a reality. We see it as our duty as sustainability chairs to help raise awareness of the estimates, debates, and complexities associated with sustainable digital technology, and to highlight opportunities for our community to get involved.


## ACKNOWLEDGEMENTS

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**Biographies**

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