BRIEFING PAPER

THE ENVIRONMENTAL IMPACT OF SCIENCE

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Author: Diana Potjomkina (Science Europe)

Acknowledgements: Anne Marie de Beaufort (NWO), Marta Dalla Vecchia (INFN), Martin Farley (UKRI), Inge Geurden (FWO), Christiane Joerk (DFG), Christiane Kaell (FNR), Ina Matt (FWF), Tarjei Nødtvedt Malme (RCN), Margarida Prado (FCT).

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Lead Editor: Lidia Borrell-Damián (Science Europe)

Editor: Rosemary Hindle (Science Europe)

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For further information please contact the Science Europe Office: office@scienceeurope.org

THE ENVIRONMENTAL IMPACT OF SCIENCE:

Why We Need More Sustainable Research

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Introduction

Science, like any other human activity, comes with its own environmental footprint. This evidence-informed briefing provides background information on that environmental impact and explains why it requires serious attention: not only from an environmental perspective, but also in light of other wider organisational and societal positive co-benefits that research organisations can realise by strengthening their efforts on environmental sustainability.

Environmental sustainability of research is a priority for Science Europe. Its work in this direction is spearheaded by the Working Group on Greening Research, which supports the focus of Science Europe members on the promotion of environmental sustainability as a fundamental value for research activity and organisations.

In 2024, Science Europe published the landmark Framework for the Environmental Sustainability of Research Organisations,[1] which sets the goal to promote environmental sustainability as a fundamental value in the organisation, management, and conduct of research and research-related activities on the systemic level in Europe, alongside research excellence and as a contributing factor to it. Environmental sustainability is also recognised in Science Europe's Vision and Framework for Research Cultures, which envisages the research sector as a role model for transparent, effective, fair, and sustainable policies and practices.[2]

This briefing has been developed to support the efforts of Science Europe's Member Organisations and its Office. It also aims to serve as an informative resource for other stakeholders, including research organisations, individual researchers, and policy makers interested in making science more sustainable, and in doing so, more credible and competitive, efficient, safe, and inclusive, in line with the objectives of the European Green Deal and the Sustainable Development Goals.

There are already research organisations that are making significant steps towards environmental sustainability and achieving excellent results. A recent Science Europe report identifies many examples of best practices by Science Europe members,[3] and several research organisations that are not members are also working on the topic. On the other hand, multiple studies have exposed systemic shortcomings in how environmental sustainability is addressed in the research sector.[4] This briefing addresses the evidence on the general unsustainability of the academic system and the diverse arguments in favour of environmental action. While it acknowledges the positive examples, these lie outside its scope.

The first section of this briefing restates the general context in which it was written. The second section addresses the environmental impact of research and research-related activities, based on a review of scientific and policy publications on the topic. It aims to offer a comprehensive perspective on diverse research disciplines (including, but going beyond, laboratories as the main focus of the literature on environmentally sustainable research so far); diverse types of environmental impact, not only focused on carbon emissions; and elements tied to managing research. The review also considers available data on the environmental impact of research in comparison to other societal and economic activities.

The last section brings attention to the additional, non-environmental benefits that may be derived from environmental action, including, among others, possible economic, safety, and reputational gains. This overview is based on a desk study and a series of best practice examples from Science Europe Member Organisations, and will be developed as a living review, reflecting ongoing learning and emerging practice.

1. Nicola Francesco Dotti and Diana Potjomkina, *Framework for the Environmental Sustainability of Research Organisations* (Science Europe, 2024), https://scieur.org/framework-sustainability
2. Sean Sapcariu et al., *A Vision & Framework for Research Cultures: Improving the Condition for Reseachers, Research Ideas, and the Research Endeavour*, ed. Lidia Borrell-Damián (Science Europe, 2025), https://zenodo.org/doi/10.5281/zenodo.15083979
3. Diana Potjomkina et al., *Survey Report: Appraising Greenhouse Gas Emissions of Research Organisations* (Science Europe, 2024), https://scieur.org/appraising-ghg-emissions
4. Notably ALLEA, *Towards Climate Sustainability of the Academic System in Europe and Beyond*, 2022, https://allea.org/portfolio-item/towards-climate-sustainability-of-the-academic-system-in-europe-and-beyond/; Thomas Freese, Nils Elzinga, Matthias Heinemann, Michael M. Lerch, and Ben L. Feringa, "The Relevance of Sustainable Laboratory Practices", *Rsc Sustainability* 2, no. 5 (2024): 1300–1336, https://doi.org/10.1039/d4su00056k; Directorate-General for Research and Innovation (European Commission), Nicola Francesco Dotti, Florence Benoit, et al., *Greening Research: Decarbonisation and Beyond* (Publications Office of the European Union, 2025), https://data.europa.eu/doi/10.2777/4318573 [literature review]; see also other studies quoted in this briefing.

1. General Context

According to the UN Climate Change website, we currently face a triple planetary crisis: climate change, pollution, and biodiversity loss.[5] Seven out of nine planetary boundaries have already been transgressed.[6] The environmental crisis threatens not only nature but also human health, society and the economy.[7,8]

On global and regional level, efforts are being made to address these challenges, with international agreements in progress or concluded on issues such as climate change, biodiversity,[9] water management,[10] and plastic pollution.[11] However, more ambitious, transformative action is needed. Focusing on climate change in particular, it is imperative to reach net zero in greenhouse gas emissions by 2050 to contain the increase in global temperatures below 1.5°C compared to the pre-industrial levels, as recommended by the Intergovernmental Panel on Climate Change and the European Climate Law.

Europe is "the fastest warming continent in the world" and according to the European Environment Agency, "is not prepared for rapidly growing climate risks".[12] If EU Member States limit themselves to currently adopted and planned measures, the EU will only reach a 64% reduction in net emissions by 2050.[13] To meet its climate goals, Europe needs "to start preparing for even deeper reductions after 2030."[14]

As societal actors and custodians of the concept of research as a public good, research actors including in the private,[15] public,[16] and not-for-profit sector, must play their role in sustaining science-based climate action.

5. UNFCCC, "What Is the Triple Planetary Crisis?", accessed October 14, 2025, https://unfccc.int/news/what-is-the-triple-planetary-crisis
6. Stockholm Resilience Centre, "Seven of Nine Planetary Boundaries Now Breached", text, September 24, 2025, https://www.stockholmresilience.org/news--events/general-news/2025-09-24-seven-of-nine-planetary-boundaries-now-breached.html
7. Jason Grealey et al., "The Carbon Footprint of Bioinformatics", *Molecular Biology and Evolution* 39, no. 3 (2022): msac034, https://doi.org/10.1093/molbev/msac034
8. Going Climate-Neutral by 2050: A Strategic Long Term Vision for a Prosperous, Modern, Competitive and Climate Neutral EU Economy (Publications Office of the European Union, 2019), https://data.europa.eu/doi/10.2834/02074
9. UNFCCC, "The Rio Conventions", accessed October 14, 2025, https://unfccc.int/process-and-meetings/the-rio-conventions
10. Sonja Koeppel, "Water Under Pressure: A Call to Action Ahead of UN Water Convention MOP 10", *SDG Knowledge Hub*, n.d., accessed October 14, 2025, https://sdg.iisd.org/commentary/guest-articles/water-under-pressure-a-call-to-action-ahead-of-un-water-convention-mop-10/
11. OECD, *Policy Scenarios for Eliminating Plastic Pollution by 2040* (OECD Publishing, 2024), https://www.oecd.org/en/publications/policy-scenarios-for-eliminating-plastic-pollution-by-2040_76400890-en/full-report.html
12. European Environment Agency, "Europe Is Not Prepared for Rapidly Growing Climate Risks", March 10, 2024, https://www.eea.europa.eu/en/newsroom/news/europe-is-not-prepared-for
13. European Environment Agency, "Total Net Greenhouse Gas Emission Trends and Projections in Europe", October 31, 2024, https://www.eea.europa.eu/en/analysis/indicators/total-greenhouse-gas-emission-trends
14. European Scientific Advisory Board on Climate Change, "EU Climate Advisory Board: Focus on Immediate Implementation and Continued Action to Achieve EU Climate Goals", January 17, 2024, https://climate-advisory-board.europa.eu/news/eu-climate-advisory-board-focus-on-immediate-implementation-and-continued-action-to-achieve-eu-climate-goals
15. Cf. Science Based Targets Initiative, "Ambitious Corporate Climate Action", accessed October 14, 2025, https://sciencebasedtargets.org/?adb_sid=4982e840-d7ea-4185-967b-b82a7c7971b2
16. Cf. Hauke Engel et al., *Target Net Zero: A Journey to Decarbonizing the Public Sector* (McKinsey, 2022), https://www.mckinsey.com/industries/public-sector/our-insights/target-net-zero-a-journey-to-decarbonizing-the-public-sector

2. Environmental Impact of Research and Research-related Activities

According to the European Federation of Academies of Sciences and Humanities (ALLEA), "the academic system is currently not climate-sustainable" and it is not undertaking sufficient steps to become so, as "a certain complacency in the academic system's reaction to the climate crises can be observed."[17]

Large-scale detailed data on the environmental impact of science in Europe are not currently available. One statistical approximation would be the Eurostat data on greenhouse gas emissions taken from the Statistical Classification of Economic Activities in the European Community (NACE) for "professional, scientific and technical activities", which amounted to approximately 0.7% of EU-27, Iceland and Norway's total emissions in 2023.[18] However, it is unclear what the exact proportion of scientific activities in these statistics is, and to what extent it reflects the full impact of scientific research.[19]

For comparison, Europe's education sector has been estimated to generate "an average of 9.1% of a country's carbon footprint per capita."[2] Among Science Europe Member Organisations, according to a 2024 survey, 65% of responding organisations have conducted some form of carbon footprint or emissions appraisal, but the scope differs widely: for example, while 52% of respondents have assessed emissions related to their offices/headquarters, only 13% have assessed the emissions related to suppliers. This means that, at present, only a cursory insight into the environmental impact of various types of research and research-related activities can be provided, without a possibility of meaningfully aggregating and directly comparing data.[20,21]

However, it is known that environmental impact of research and research-related activities differs according to discipline, infrastructure used, and other parameters.[22] For example, the work of a researcher in life sciences has been estimated to generate approximately 4–15 tons of CO_2 equivalent annually, while in chemistry this number is approximately 5.6–9.6 tons and in astronomy 18–37 tons[23] (other studies have quoted numbers between 4.7–50.6 tons in astronomy[24,25]). Human and social sciences tend to have lower carbon

17. ALLEA, *Towards Climate Sustainability of the Academic System in Europe and Beyond*, 2022, https://allea.org/portfolio-item/towards-climate-sustainability-of-the-academic-system-in-europe-and-beyond/
18. Eurostat, "Air Emissions Accounts by NACE Rev. 2 Activity", Eurostat, 2025, https://doi.org/10.2908/ENV_AC_AINAH_R2
19. "Eurostat data related to Air emissions accounts and footprints do not correspond conceptually with the GHG Protocol" – direct correspondence with the Eurostat User Support, 10 March 2025.

    Section M Professional, Scientific and Technical Activities includes Legal and accounting activities; Activities of head offices; management consultancy activities; Architectural and engineering activities; technical testing and analysis; Scientific research and development; Advertising and market research; Other professional, scientific and technical activities; Veterinary activities.
20. Jérôme Mariette et al., "An Open-Source Tool to Assess the Carbon Footprint of Research", *Environmental Research: Infrastructure and Sustainability* 2, no. 3 (2022): 035008, https://doi.org/10.1088/2634-4505/ac84a4
21. ALLEA, *Towards Climate Sustainability of the Academic System in Europe and Beyond*
22. Mariette et al., "An Open-Source Tool to Assess the Carbon Footprint of Research"
23. Thomas Freese et al., "The Relevance of Sustainable Laboratory Practices", *Rsc Sustainability* 2, no. 5 (2024): 1300–1336, https://doi.org/10.1039/d4su00056k
24. Naomi Oreskes, "Science Needs to Shrink Its Carbon Footprint", Scientific American, July 1, 2022, https://www.scientificamerican.com/article/science-needs-to-shrink-its-carbon-footprint/
25. Jürgen Knödlseder et al., "Estimate of the Carbon Footprint of Astronomical Research Infrastructures", *Nature Astronomy* 6, no. 4 (2022): 503–13, https://doi.org/10.1038/s41550-022-01612-3. Cited in: Directorate-General for Research and Innovation (European Commission) et al., *Greening Research: Decarbonisation and Beyond* (Publications Office of the European Union, 2025), https://data.europa.eu/doi/10.2777/4318573

intensity at least when it comes to procurement – one major source of environmental impact.[26] (Here and onwards, data on emissions refers to carbon dioxide equivalent or CO_2e; methodologies and years of studies may differ.)

To note, the reproducibility crisis in science also has implications for environmental sustainability. Farley et al. have written about the environmental importance of self-correction mechanisms in science. In their research, the carbon footprint of 1,183 studies that investigated an association originally reported in a scientific paper, even after this paper was proven to be irreproducible, had a footprint of approximately 30,068 tonnes of CO_2e.[27] These are just the emissions linked to scientific activity itself; in addition to that, the results of the research (for example, technologies that are being developed) can also have negative environmental effects.[28,29] The latter type of impact lies outside the scope of this briefing.

While scientific activities seem to account for a relatively small share of the total world's emissions, their impact when scaled by budget or per capita emissions can be compared to impact of other sectors of the economy, and can also be quite significant in absolute terms.

When looking at the numbers below, the following statistics can be considered for reference:

- Permissible annual global emissions (aligned with the 1.5°C target of Paris Agreement) per capita by 2030 have been estimated at 2.5 tonnes, by 2040 at 1.4 tonnes, and by 2050 as low as 0.7 tonnes, assuming no extensive reliance on negative emission technologies.[30]
- 1 ton of anthropogenic CO_2 emissions, generated anywhere on the planet, melts approximately 3m² of Arctic sea ice.[31,32]
- At least €270 per 1 tonne of CO_2: this is the latest estimate of the social cost of CO_2 emissions, which includes "effects on agriculture and human health, as well as the damage done by natural catastrophes and the degradation of ecosystems".[33,34]
- For a graphic illustration of the carbon footprint of research, please also see the annexes.

Most data available assessing the impact of research and research-related activities is measured through energy and/or carbon footprint (CO_2e), whereas environmental footprint also includes other aspects such as use of water, use of toxic chemicals, waste, and impact on biodiversity. The data on these other environmental impacts is even more limited.

26. Marianne De Paepe et al., "Purchases Dominate the Carbon Footprint of Research Laboratories", *PLOS Sustainability and Transformation* 3, no. 7 (2024): e0000116, https://doi.org/10.1371/journal.pstr.0000116
27. Martin Farley et al., "The Carbon Footprint of Science When It Fails to Self-Correct", preprint, Scientific Communication and Education, April 22, 2025, https://doi.org/10.1101/2025.04.18.649468
28. Anne-Laure Ligozat et al., "Ten Simple Rules to Make Your Research More Sustainable", *PLOS Computational Biology* 16, no. 9 (2020): e1008148, https://doi.org/10.1371/journal.pcbi.1008148
29. Cf. Gabrielle Samuel, "Responsibility for the Environmental Impact of Data-Intensive Research: An Exploration of UK Health Researchers", *Science and Engineering Ethics* 30, no. 4 (2024): 33, https://doi.org/10.1007/s11948-024-00495-z
30. Lewis Akenji et al., *1.5-Degree Lifestyles: Targets and Options for Reducing Lifestyle Carbon Footprints* (Institute for Global Environmental Strategies, Aalto University, D-mat ltd., 2019), https://www.iges.or.jp/en/pub/15-degrees-lifestyles-2019/en
31. UCL, "Arctic Sea Ice Loss Linked to Personal CO2 Emissions", UCL News, November 3, 2016, https://www.ucl.ac.uk/news/2016/nov/arctic-sea-ice-loss-linked-personal-co2-emissions
32. Dirk Notz and Julienne Stroeve, "Observed Arctic Sea-Ice Loss Directly Follows Anthropogenic CO2 Emission", *Science*, ahead of print, American Association for the Advancement of Science, November 11, 2016, world, https://doi.org/10.1126/science.aag2345
33. Frances C. Moore et al., "Synthesis of Evidence Yields High Social Cost of Carbon Due to Structural Model Variation and Uncertainties", *Proceedings of the National Academy of Sciences* 121, no. 52 (2024): e2410733121, https://doi.org/10.1073/pnas.2410733121
34. Universität Hamburg, "Actual Social Cost of CO_2 Emissions More Than Twice as High", December 18, 2024, https://www.cliccs.uni-hamburg.de/about-cliccs/news/2024-news/2024-12-18-klimakosten.html

It should be noted that this document relies on desk research, meaning that possible errors or omissions in data and methodologies have not been considered critically (e.g. assessment of carbon footprint may only cover scope 1 and 2 emissions, while typically a large percentage of emissions are in scope 3, or travel assessments may include only specific categories of travel[35,36]).

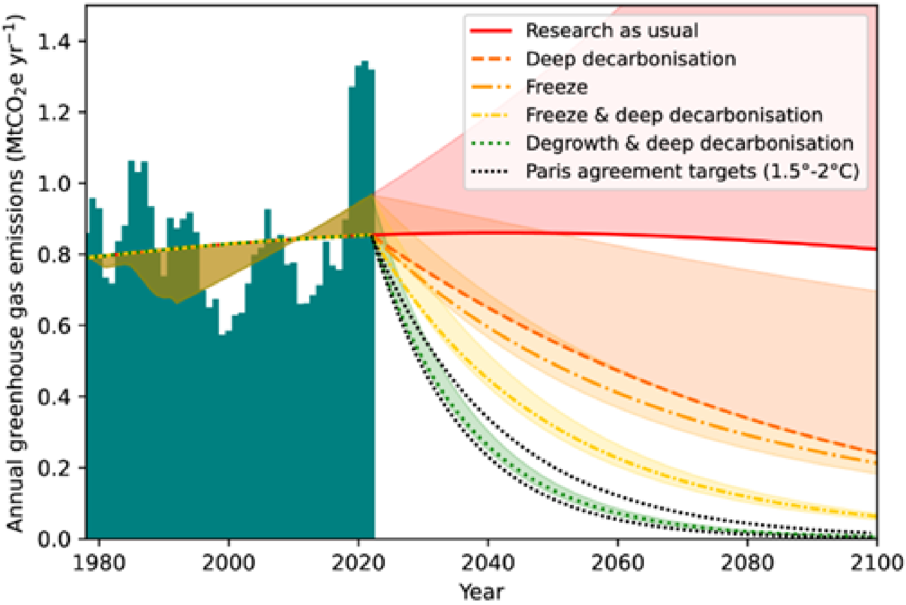
The sections below address the known evidence across several key categories of activities and assets related to the organisation, management and conduct of research, notably: physical research infrastructures, buildings, computing and artificial intelligence, STEM laboratories, travel and conferences, and other procurement.

2.1. Physical Research Infrastructures

Research infrastructures have a significant environmental impact, with some of them operating "at an industrial scale."[37] Some of the most detailed accounts of this impact come from astronomy, focusing on astronomical observatories and space-based telescopes, alongside other activities such as travel and supercomputing. According to some researchers, "if the world is to meet the challenge of net-zero greenhouse gas emissions by 2050, astronomers will have to reduce the carbon footprint of their research facilities by up to a factor of 20."[38] Some examples:

- The European Southern Observatory (ESO)'s annual carbon footprint in 2019 was 28 000 tonnes; scaled by annual budget, carbon intensity of its operations is comparable to the internet and telecommunication industries, although it is approximately 10 times less than that of car manufacturing.[39] The ESO operates several telescopes in the Atacama Desert in Chile.
- Despite attempts to ensure its environmental sustainability – through which the expected power consumption has already been halved – the Square Kilometre Array Observatory (SKAO) is expected to require approximately 12 MW of power for its telescopes and computing facilities, comparable to the average annual consumption of 10 000 US homes.[40,41]
- In total, by 2022, astronomical facilities produced 1.3 million tonnes of emissions per year in 2022 (space missions amounting to 84% of the total and ground-based observatories to 16%).[42] The graph on the following represents different scenarios of astronomy research, demonstrating that only a "degrowth and deep decarbonisation" scenario comes close to achieving the goals set by the Paris agreement. One of the solutions proposed in the study is to build new facilities only once the existing datasets have been fully exploited, as some of the archival data – some of it 30 years old – has not been properly studied.[43,44]

35. Normative, *Carbon Accounting, Explained*, n.d., accessed October 14, 2025, https://normative.io/insight/carbon-accounting-explained/
36. ALLEA, *Towards Climate Sustainability of the Academic System in Europe and Beyond*
37. Tereza Pultarova, "The Mission to Reduce the Carbon Footprint of Astronomy", Space, February 2, 2022, https://www.space.com/reducing-carbon-footprint-of-astronomy
38. Oreskes, "Science Needs to Shrink Its Carbon Footprint"
39. Pultarova, "The Mission to Reduce the Carbon Footprint of Astronomy"
40. Mathieu Isidro, "Powering the World's Largest Radio Telescopes Sustainably", Issuu, accessed October 14, 2025, https://issuu.com/ska_telescope/docs/contact_-_issue_08/s/12801220
41. Pultarova, "The Mission to Reduce the Carbon Footprint of Astronomy"
42. Jürgen Knödlseder, "Environmental Impacts of Astronomical Research Infrastructures", *arXiv*, July 19, 2025, https://arxiv.org/html/2507.14510v2
43. Knödlseder, "Environmental Impacts of Astronomical Research Infrastructures"
44. Allison Gasparini, "'We Have To Slow Down', Study Reveals The Impact Of Astronomy On Climate Change", Forbes, accessed September 30, 2025, https://www.forbes.com/sites/allisongasparini/2022/03/23/we-have-to-slow-down-new-study-details-the-carbon-footprint-of-astronomy/



Evolution of annual greenhouse gas emissions from astronomical research infrastructures under different policy choices, including freezing or decreasing the number of facilities and increasing their decarbonisation (adapted from Knödlseder et al. 2024). Evolutions were based on current trends, with lines obtained from trends over the last 45 years and shaded bands for shorter periods down to 30 years. The histogram shows estimates of past greenhouse gas emissions for the period 1978–2022, where variations are due to construction activities of large space missions. The recent peak in emissions is due to a surge of missions to the Moon. The black-dotted lines show annual emissions reductions of 5–7%, which are the levels required to meet the Paris agreement targets.

Source: Knödlseder, Jürgen. "Environmental Impacts of Astronomical Research Infrastructures", *arXiv*, July 19, 2025. https://arxiv.org/html/2507.14510v2

- Coming from another field, the European Organization for Nuclear Research (CERN) in 2022 generated 361,264 tonnes of emissions in scopes 1, 2, and 3,[45] and accounted for approximately 2% of Swiss electricity consumption. This is equivalent to 5.5% of total direct and indirect emissions of the Geneva Canton for the same year.[46]

2.2. Buildings

According to the UN Environment Programme, "The buildings and construction sector is by far the largest emitter of greenhouse gases, accounting for a staggering 37% of global emissions."[47] In the EU, this number was 35% in 2021, with the European Environment Agency noting that it already had decreased by 31% since 2005, but that "a substantial acceleration in energy renovations is needed to reach EU 2030 targets."[48]

- In 2017, the University of Nottingham officially opened the GSK Carbon Neutral Laboratories for Sustainable Chemistry, a laboratory building that was awarded the highest level of green building certifications (BREEAM Outstanding and LEED Platinum). The building will offset the carbon emissions from construction within 25 years, and it reduces the use of water by 63% and the use of power by more than 60%.[49]
- The University of Cambridge Institute for Sustainability Leadership retrofitted its headquarters using best practices such as minimising the use of new materials through circular design and maximising nature-pos-

45. CERN, Vol. 3 (2023): CERN Environment Report—Rapport Sur l'environnement 2021–2022, 2023, https://e-publishing.cern.ch/index.php/CERN_Environment_Report/issue/view/156
46. Republique et Canton de Genève, Bilan Des Émissions de Gaz à Effet de Serre Du Canton de Genève En 2022 (2024), https://www.ge.ch/document/38792/telecharger
47. UNEP - UN Environment Programme, Building Materials And The Climate: Constructing A New Future (2023), https://www.unep.org/resources/report/building-materials-and-climate-constructing-new-future
48. European Environment Agency, "Greenhouse Gas Emissions from Energy Use in Buildings in Europe", October 31, 2024, https://www.eea.europa.eu/en/analysis/indicators/greenhouse-gas-emissions-from-energy
49. University of Nottingham, The Carbon Neutral Laboratory, https://www.nottingham.ac.uk/chemistry/research/centre-for-sustainable-chemistry/the-carbon-neutral-laboratory.aspx

itive design solutions. The cost was only 8% higher than conventional office refurbishment, and will be recovered within 5–8 years thanks to energy savings (approximately 85% of energy consumption, resulting in estimated savings of more than £1.5m over the first 15 years).[50]

- Retrofit of Salazar Hall at the California State University, Los Angeles, is estimated to have saved over 950 metric tonnes of CO_2 equivalent annually, bringing significant financial as well as environmental benefits.[51]

2.3. Computing and Artificial Intelligence

While the use of computer science and AI can benefit environmental research, for example, by assisting with evidence synthesis,[52] monitoring and forecasting, and developing innovative approaches to saving natural resources,[53] it also generates a significant amount of emissions and other environmental damage. According to some estimates, "a single data centre can use the same amount of electricity as 50,000 homes. The entire cloud has a greater carbon footprint than the entire airline industry."[54]

Moreover, we can expect rapid growth of energy and water consumption: according to the International Energy Agency, global electricity demand from data centres is expected to more than double by 2030, exceeding the entire consumption of electricity by Japan today, and the consumption of AI-optimised data centres will more than quadruple.[55] Similar growth trends can be expected in science. In the meantime, recent gains in energy efficiency for data centres have been described as "marginal."[56]

Specific cases vary widely; for example:

- Training the GPT-3 AI model (175 billion parameters) is estimated to have generated 552 tons of carbon dioxide equivalent, while training the similar-size BLOOM model – 30 tons.[57]
- Data transfer during the five-year prototype stage of the Giant Array for Neutrino Detection (GRAND) project is estimated to result in 470 tons of emissions. It would be "many orders of magnitude less carbon-emitting" to send hard drives by plane four times a year, compared to online data transfer.[58]
- In Australia, supercomputer use is the largest source of GHG emissions for astronomers: more than the sum of emissions from flights, observatories and offices. This, however, is also due to the carbon-intensive nature of the Australian energy mix, as supercomputing in Germany is multiple times less carbon intensive thanks to renewable energy.[59]

50. University of Cambridge Institute for Sustainability Leadership (CISL), Building Entopia: The Story behind the Ultra-Sustainable Retrofit of CISL's New Home in Cambridge (2022), https://www.cisl.cam.ac.uk/files/entopia_case_study_12_12_22.pdf
51. California State University, Los Angeles, Climate Action Plan: Pushing Boundaries in a Changing Climate (2019), https://www.calstatela.edu/sites/default/files/cal_state_la_2019_climate_action_plan_-_final_online_version.pdf
52. UKRI, *AI Investment to Transform Global Policy with Scientific Evidence*, September 22, 2025, https://www.ukri.org/news/ai-investment-to-transform-global-policy-with-scientific-evidence/
53. Molly Flanagan, "AI and Environmental Challenges", UPenn EII, accessed January 15, 2026, https://environment.upenn.edu/news-events/news/ai-and-environmental-challenges
54. Oreskes, "Science Needs to Shrink Its Carbon Footprint"
55. International Energy Agency, "AI Is Set to Drive Surging Electricity Demand from Data Centres While Offering the Potential to Transform How the Energy Sector Works - News", IEA, April 10, 2025, https://www.iea.org/news/ai-is-set-to-drive-surging-electricity-demand-from-data-centres-while-offering-the-potential-to-transform-how-the-energy-sector-works
56. Nicola Francesco Dotti, *Greening Research Webinars Series: Final Report* (Science Europe, n.d.), accessed October 14, 2025, https://scienceeurope.org/our-resources/greening-research-webinars-series-final-report/
57. Kate Saenko and The Conversation, "A Computer Scientist Breaks Down Generative AI's Hefty Carbon Footprint", Scientific American, accessed October 14, 2025, https://www.scientificamerican.com/article/a-computer-scientist-breaks-down-generative-ais-hefty-carbon-footprint/
58. Michael Allen, "The Huge Carbon Footprint of Large-Scale Computing", *Physics World*, March 2022, https://physicsworld.com/a/the-huge-carbon-footprint-of-large-scale-computing/
59. ALLEA, *Towards Climate Sustainability of the Academic System in Europe and Beyond*

- E-mails and websites also have environmental footprint.[60]

Other environmental impacts include water use, which can be particularly serious in areas of water stress: according to one estimate from the United States, "a medium-sized data centre (15MW) uses as much water as three average-sized hospitals."[61] Training a GPT-3 model in Microsoft's US data centres has been estimated to consume 5.4 million litres of water, with additional consumption of approximately 0.5 litres per 10–50 medium-length responses.[62] Moreover, resources that are needed to manufacture computer equipment are sometimes obtained through unsustainable mining practices, and e-waste needs to be properly disposed of.[63,64] Finally, risks linked to the use of AI include potential AI biases against nature and animals.[65]

2.4. Laboratories (STEM)

While some definitions of laboratories include those working on human and social sciences, STEM laboratories tend to have significantly higher carbon intensity.[66] Laboratories, according to Dobbelaere et al., consume "more energy per square metre than any other sector except from data centres"[67]; for example, comparing to office buildings, their consumption per square metre is 5–10 times higher.[68] According to some estimates, "If clinical science were a country it would rank as the 40th largest emitting country in the world above Nigeria and Bangladesh, each of which has more than 100 million people."[69]

It should be noted that the environmental footprint of laboratories can (often) be significantly improved without compromising data quality or sterility.[70]

Some examples of laboratories' environmental impact are listed below (see Freese et al. for a recent comprehensive overview[71]):

- Laboratories are energy intensive.[72] A typical (7–10 people) life sciences laboratory likely uses more than 20 metric tons of CO_2 equivalent per year to power its equipment.[73] Yearly emissions from an average ultra-low temperature freezer are estimated to be comparable to those of one (US) home.[74] Moreover, processes such as use of refrigerants or incineration of acetone generate greenhouse gas emissions directly.[75]

60. Freese et al., "The Relevance of Sustainable Laboratory Practices"
61. David Mytton, "Data Centre Water Consumption", *Npj Clean Water* 4, no. 1 (2021): 11, https://doi.org/10.1038/s41545-021-00101-w
62. Pengfei Li et al., "Making AI Less 'Thirsty'", *Commun. ACM* 68, no. 7 (2025): 54–61, https://doi.org/10.1145/3724499
63. Freese et al., "The Relevance of Sustainable Laboratory Practices"
64. Samuel, "Responsibility for the Environmental Impact of Data-Intensive Research"
65. Taylor & Francis, *Is AI Bad for the Environment?*, n.d., accessed October 14, 2025, https://insights.taylorandfrancis.com/sustainability/ai-bad-environment/
66. Paepe et al., "Purchases Dominate the Carbon Footprint of Research Laboratories"
67. Jeroen Dobbelaere et al., "Achieving Sustainable Transformation in Science – Green Grassroots Groups Need Nurturing from the Top", *Journal of Cell Science* 135, no. 17 (2022): jcs259645, https://doi.org/10.1242/jcs.259645
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69. Freese et al., "The Relevance of Sustainable Laboratory Practices"
70. Patrick Penndorf, "A Review on Sustainable Practices in Scientific Research", *Global Journal of Science Frontier Research: H Environment & Earth Science* 24, no. 1 (2024): 1–16
71. Freese et al., "The Relevance of Sustainable Laboratory Practices"
72. Susan M. Meyn et al., "Addressing the Environmental Impact of Science Through a More Rigorous, Reproducible, and Sustainable Conduct of Research", *Journal of Biomolecular Techniques : JBT* 33, no. 4 (n.d.): 3fc1f5fe.d085ce95, https://doi.org/10.7171/3fc1f5fe.d085ce95
73. Grealey et al., "The Carbon Footprint of Bioinformatics"
74. Marta Rodríguez-Martínez, "Environmentally Sustainable Research Is the Only Way Forward", FEBS Network, September 7, 2020, https://network.febs.org/posts/environmentally-sustainable-research-is-the-only-way-forward
75. Freese et al., "The Relevance of Sustainable Laboratory Practices"

- Part of the waste laboratories produce is non-hazardous and comparable to general household waste. Much of it is plastic. A widely cited, although imprecise estimate from 2015 stated that laboratories worldwide were responsible for 1.8% of total global plastic waste.[76] According to a more recent and precise study, one lab researcher annually generates approximately 116kg of plastic waste per year[77]; and the labs at the University of Groningen alone produce 17 tons of plastic waste annually.[78] Measures to prevent, reuse or recycle waste are not always in place, meaning that it goes to landfill or gets incinerated.[79,80]

- Laboratories also produce hazardous, and often highly toxic, chemical waste, radiation, and biological waste, such as micro-organisms.[81] The amount of hazardous waste produced can be significant: for example, the University of Groningen labs produce 109 tons of hazardous chemical waste annually, or according to another calculation, a researcher in a chemistry laboratory produces on average 157.1kg of hazardous chemical waste per year.[82,83] Disposal of hazardous waste also comes at a financial cost.[84]

- Incorrect handling and disposal of hazardous products can endanger scientists themselves, as well as contaminate groundwater, air and soil.[85,86,87,88] Academic labs have been described to have a significantly worse safety track record than those in industry, with universities having 10–50 times greater number of accidents.[89] They also generate an unnecessarily high amount of waste due to relying on outdated laboratory practices.[90,91] On the other hand, reducing use of dangerous compounds is environmentally-friendly, safer, and has been found that it does not "impose a significant tax on research productivity."[92, 93]

- The use of animals in research poses a sustainability challenge, especially considering that "around 92% of drugs tested in animals

76. Rodríguez-Martínez, "Environmentally Sustainable Research Is the Only Way Forward"
77. Philipp M Weber et al., "What's in Our Bin?", *EMBO Reports* 26, no. 2 (2025): 297–302, https://doi.org/10.1038/s44319-024-00360-x
78. Freese et al., "The Relevance of Sustainable Laboratory Practices"
79. Cancer Research UK, "Treading Lightly – Reducing the Environmental Impact of Clinical Trials", *Cancer Research UK - Cancer News*, January 13, 2025, https://news.cancerresearchuk.org/2025/01/13/treading-lightly-reducing-the-environmental-impact-of-clinical-trials/
80. Hussein Emad et al., "Environmental Impact of Medical Waste Incineration - Literature Review", *International Journal of Scientific Research in Science, Engineering and Technology*, November 15, 2023, 103–25, https://doi.org/10.32628/IJSRSET2310526
81. Elizabeth de Souza Nascimento and Alfredo Tenuta Filho, "Chemical Waste Risk Reduction and Environmental Impact Generated by Laboratory Activities in Research and Teaching Institutions", *Brazilian Journal of Pharmaceutical Sciences* 46 (2010): 187–98, https://doi.org/10.1590/S1984-82502010000200004
82. Freese et al., "The Relevance of Sustainable Laboratory Practices"
83. Nascimento and Tenuta Filho, "Chemical Waste Risk Reduction and Environmental Impact Generated by Laboratory Activities in Research and Teaching Institutions"
84. Freese et al., "The Relevance of Sustainable Laboratory Practices"
85. Freese et al., "The Relevance of Sustainable Laboratory Practices"
86. Shannon Meirzon, "How Labs Can Avoid Polluting Waterways (and What to Do Instead)", Labconscious®, February 22, 2023, https://www.labconscious.com/green-lab-tips/how-labs-can-avoid-polluting-local-waterways
87. Mark Peplow and Emma Marris, "How Dangerous Is Chemistry?", *Nature* 441 (June 2006), https://www.nature.com/articles/441560a
88. Collins Otieno Odhiambo et al., "Managing Laboratory Waste from HIV-Related Molecular Testing: Lessons Learned from African Countries", *Journal of Hazardous Materials Letters* 2 (November 2021): 100030, https://doi.org/10.1016/j.hazl.2021.100030
89. Peplow and Marris, "How Dangerous Is Chemistry?"
90. Nascimento and Tenuta Filho, "Chemical Waste Risk Reduction and Environmental Impact Generated by Laboratory Activities in Research and Teaching Institutions"
91. Freese et al., "The Relevance of Sustainable Laboratory Practices"
92. Quote from Alberto Galasso et al., "Laboratory Safety and Research Productivity", *Research Policy* 52, no. 8 (2023): 104827, https://doi.org/10.1016/j.respol.2023.104827
93. Penndorf, "A Review on Sustainable Practices in Scientific Research"

as a preclinical step fail to pass the clinical stage"[94] and even harm human subjects.[95]

- Laboratories consume large amounts of water (amounting to 60% of the total water consumption of a university),[96] which can be problematic considering the increasing levels of water scarcity in the EU.[97]

2.5. Travel and Conferences

Travelling for research-related purposes generates significant amount of emissions, representing a "major" and often the main source of emissions in the academic system; all academic stakeholders across all research disciplines engage in travel.[98, 99] Flights, in particular, generate significantly more emissions per km travelled compared to alternative modes of transport; according to UK data, a domestic flight generates 246 grams of emissions per km travelled, compared to 35 grams from the national rail and 4 grams from Eurostar.[100] In contrast, virtual meetings "have a 1,000–3,000-fold lower carbon footprint" than in-person ones, in addition to being cheaper, more inclusive, and requiring no travel time.[101]

- Amongst all the various travel needs, conference attendance is a major source of emissions, according to different estimates accounting for 35% of a PhD student's carbon footprint or half of an academic's flight emissions.[102]
  - A roundtrip flight from Boston to San Francisco for an annual American Biophysical Society conference generates ~623kg of emissions, which is more than the average yearly per capita carbon footprint in 47 countries.[103]
  - A return flight Perth–London for the annual Immuno-Oncology summit generates ~3,153 kg of emissions, which is more than the average yearly per capita carbon footprint in 109 countries.[104]
  - The carbon footprint of the annual meeting of the Society for Neuroscience (around 30,000 attendees) is ~22,000 tons, compared to the annual carbon footprint of 1,000 medium-sized laboratories.[105]
  - The travel-related carbon footprint of the 2019 annual meeting of the American Geophysical Union is 80,000 tonnes.[106] For comparison, this is 6.54 times more than the annual scope 1, 2, and 3 emissions of the Madrid Metro in 2023.[107]

94. Freese et al., "The Relevance of Sustainable Laboratory Practices"
95. Freese et al., "The Relevance of Sustainable Laboratory Practices"
96. Freese et al., "The Relevance of Sustainable Laboratory Practices"
97. European Commission, "Water Scarcity and Droughts", accessed October 14, 2025, https://environment.ec.europa.eu/topics/water/water-scarcity-and-droughts_en
98. ALLEA, *Towards Climate Sustainability of the Academic System in Europe and Beyond*
99. Teun Bousema et al., "The Critical Role of Funders in Shrinking the Carbon Footprint of Research", *The Lancet Planetary Health* 6, no. 1 (2022): e4–6, https://doi.org/10.1016/S2542-5196(21)00276-X
100. Hannah Ritchie, "Which Form of Transport Has the Smallest Carbon Footprint?", *Our World in Data*, August 30, 2023, https://ourworldindata.org/travel-carbon-footprint
101. Bousema et al., "The Critical Role of Funders in Shrinking the Carbon Footprint of Research"
102. Freese et al., "The Relevance of Sustainable Laboratory Practices"
103. Sarvenaz Sarabipour et al., "Changing Scientific Meetings for the Better: Supplementary Information", *Nature Human Behaviour* 5, no. 3 (2021): 296–300, https://doi.org/10.1038/s41562-021-01067-y
104. Sarabipour et al., "Changing Scientific Meetings for the Better: Supplementary Information"
105. Grealey et al., "The Carbon Footprint of Bioinformatics"
106. Oreskes, "Science Needs to Shrink Its Carbon Footprint"
107. Metro de Madrid, *Informe de Sostenibilidad 2023* (2023), https://www.metromadrid.es/sites/default/files/documentos/InformedesostenibilidadESP_0.pdf

  - The rough estimate of carbon footprint from the travel of half of the world's academics (total: 8 million) to one international conference per year is Mt CO_2e, comparable to annual emissions of Niger, Nicaragua, or Latvia.[108]
  - In a study of 270 conferences over 2018–2019, only 5.6% (15/270) implemented a sustainability policy or a green strategy.[109]
- Research travel has been estimated to account for 25% of total GHG emissions in a study of French laboratories in 2019.[110]
- Travel linked to research management can also generate significant emissions. The carbon footprint of panel meetings of the European and Developing Countries Clinical Trials Partnership (EDCTP) and European Research Council-Starting Grant (ERC-StG) meetings in 2019 was 1,664 tons, "equivalent to the total weekly carbon footprint of 5,547 European households."[111]
- Air travel has been found to have no influence on academic productivity; for climate researchers, carbon footprint from air travel does affect their credibility in the eyes of the public.[112] Moreover, senior researchers tend to travel significantly more than early-career researchers who still need to develop their networks.[113]

2.6. Other Procurement

In general, 75–90% of research organisations' emissions have been estimated as indirect, linked to consumption of goods and services.[114] According to a study of 108 French laboratories, procurement accounts for 50% of median emissions.[115] Procurement includes, but is not limited to, the categories mentioned above. Embedding environmental sustainability in public procurement is an impactful strategy that is possible, notably under EU public procurement directives, and is already being implemented by many research organisations.[116]

In 2025, Science Europe submitted a response to a call for evidence by the European Commission on the evaluation of the EU Public Procurement Directives. The response highlighted the importance of green and circular public procurement for the research sector, pointing out that it can, among other actions, "contribute positively to environmental protection and human well-being, reduce the need for adaptation measures, and may offer greater cost efficiency over the entire product life cycle."[117]

108. Marie-Elodie Perga et al., "The Elephant in the Conference Room: Reducing the Carbon Footprint of Aquatic Science Meetings", *Limnology and Oceanography Letters* 9, no. 5 (2024): 499–505, https://doi.org/10.1002/lol2.10402
109. Sarabipour et al., "Changing Scientific Meetings for the Better: Supplementary Information"
110. Tamara Ben-Ari et al., "Flight Quotas Outperform Focused Mitigation Strategies in Reducing the Carbon Footprint of Academic Travel", *Environmental Research Letters* 19, no. 5 (2024): 054008, https://doi.org/10.1088/1748-9326/ad30a6
111. Bousema et al., "The Critical Role of Funders in Shrinking the Carbon Footprint of Research"
112. Seth Wynes et al., "Academic Air Travel Has a Limited Influence on Professional Success", *Journal of Cleaner Production* 226 (July 2019): 959–67, https://doi.org/10.1016/j.jclepro.2019.04.109
113. ALLEA, *Towards Climate Sustainability of the Academic System in Europe and Beyond*
114. Dobbelaere et al., "Achieving Sustainable Transformation in Science – Green Grassroots Groups Need Nurturing from the Top"
115. Paepe et al., "Purchases Dominate the Carbon Footprint of Research Laboratories"
116. Potjomkina et al., *Survey Report: Appraising Greenhouse Gas Emissions of Research Organisations*
117. Science Europe, "Response to the European Commission's Evaluation of Public Procurement Directives," March 17, 2025, https://www.scienceeurope.org/our-resources/science-europe-s-response-to-the-european-commission-s-evaluation-of-public-procurement-directives/
118. Penndorf, "A Review on Sustainable Practices in Scientific Research"
119. CESAER et al., "Call to Action to Research Organisations for the Net-Zero Transition", 2021, https://www.scienceeurope.org/our-resources/cop26-call-to-action/

3. Positive Co-benefits of Environmental Sustainability for Research Organisations

Alongside direct environmental benefits, environmental sustainability measures can also bring a number of positive co-benefits for research organisations. The list below largely overlaps with one previously identified by Penndorf,[118] further elaborating on the advantages of sustainability measures beyond purely environmental footprint. These advantages include:

3.1. Increased Credibility and Reputational Gains

Scientific evidence concerning the triple planetary crisis is unequivocal, and acting on this evidence is a core element of ensuring a responsible research culture and of maintaining the credibility of research organisations. It is widely acknowledged that they need to lead by example.[119,120,121,122] ALLEA specifically cautions against asking for exemptions on environmental sustainability, given the existing societal scepticism about science.[123]

Sustainability and University Rankings

EXAMPLE

A growing number of universities in Europe and beyond, are beginning to set GHG emissions targets, including climate neutrality. In parallel, new ranking systems emerge that are based on sustainability, although sustainability "is currently not included in the most influential global rankings".[124]

Universities increasingly see sustainability as a reputational gain,[125] while more than a half of students interested in UK universities were recently reported to be "actively researching their sustainability strategies and efforts as part of their decision making."[126]

120. Dotti and Potjomkina, *Framework for the Environmental Sustainability of Research Organisations*
121. Freese et al., "The Relevance of Sustainable Laboratory Practices"
122. Olivier Ragueneau and Audrey Sabbagh, "From Carbon to Meaning: Experimenting for Sustainable Science", *One Earth* 7, no. 5 (2024): 747–50, https://doi.org/10.1016/j.oneear.2024.04.015
123. ALLEA, *Towards Climate Sustainability of the Academic System in Europe and Beyond*
124. ALLEA, *Towards Climate Sustainability of the Academic System in Europe and Beyond*
125. ALLEA, *Towards Climate Sustainability of the Academic System in Europe and Beyond*
126. QS, "The Climate for Change: How University Sustainability Is Impacting Student Decision-Making", accessed November 3, 2025, https://www.qs.com/insights/the-climate-for-change-how-university-sustainability-is-impacting-student-decision-making

3.2. Competitiveness and Attracting Top Talent

Improving environmental performance is an important element of ensuring a responsible research culture, supporting research organisations' continued legitimacy in society and their capacity to attract and retain top talent.[127] This will also ensure research organisations' long-term competitiveness.

Young talent is attracted to sustainable workplaces

EXAMPLE

Young generations increasingly prefer to work for environmentally responsible workplaces: 76% of Europeans aged 20–29 mention sustainability as an important criterion in the choice of employer.[128] Similar trends can be observed on the global scale.[129] When it comes specifically to universities and research organisations, a survey of students at ETH Zurich showed that 86% of students who envisaged a future career in academia/research "would prefer, or strongly prefer, to work for a future employer that aims to reduce GHG emissions by reducing professional air travel".[130] At the University of Manchester, 97% of respondents were happy to work on reducing single-use plastic, and 84% of the respondents in the Royal Society of Chemistry survey wanted to reduce the environmental impact of their work, with 63% having already taken action in the previous two years.[131]

Environmental sustainability becomes a consideration in funding decisions

EXAMPLE

Several research funding organisations have already incorporated environmental sustainability in their funding decisions, or are doing so. Wellcome will require all funded laboratories to be environmentally accredited by end of 2025, and Cancer Research UK will require a green lab certification or equivalent from all applicants by 2026. Both organisations also ask that UK-based organisations are signatories of the UK Concordat for the Environmental Sustainability of Research and Innovation Practice.[132] UK Research and Innovation (UKRI) has set targets for 50% emissions reduction by 2030 and net-zero by 2050; its new Environmental Sustainability Strategy 2025–2030 aims to eventually include sustainability in its funding applications and assessments.[133] Such steps by research funders create incentives for their applicants.[134,135]

127. Penndorf, "A Review on Sustainable Practices in Scientific Research"
128. European Investment Bank, "76% of Young Europeans Say the Climate Impact of Prospective Employers Is an Important Factor When Job Hunting", March 21, 2023, https://www.eib.org/en/press/all/2023-112-76-of-young-europeans-say-the-climate-impact-of-prospective-employers-is-an-important-factor-when-job-hunting
129. Deloitte, "Deloitte Global Gen Z and Millennial Survey 2025", 2025, https://www.deloitte.com/global/en/issues/work/genz-millennial-survey.html
130. ALLEA, *Towards Climate Sustainability of the Academic System in Europe and Beyond*
131. Andy Tay, "Can Science Cure Its Addiction To Plastic?", *Nature*, September 25, 2024, https://www.nature.com/articles/d41586-024-03010-3
132. "Concordat for the Environmental Sustainability of Research and Innovation Practice", accessed January 15, 2026, https://wellcome.org/about-us/positions-and-statements/environmental-sustainability-concordat
133. UKRI, *UKRI Environmental Sustainability Strategy 2025 to 2030* (2025), https://www.ukri.org/publications/ukri-environmental-sustainability-strategy/ukri-environmental-sustainability-strategy-2025-to-2030/
134. Florijn Dekkers, "Greening Science: What's in It for You?", *Nature*, ahead of print, September 25, 2024, https://doi.org/10.1038/d41586-024-03011-2
135. Chris Woolston, "The Trials and Triumphs of Sustainable Science", *Nature* 633 (September 2024)

BEST PRACTICE

Staff demand for change driving environmental action at the Luxembourg National Research Fund[136]

While there are no legal requirements for the Luxembourg National Research Fund (FNR) to report or assess its environmental impact, its staff, supported by management, initiated the process of measuring its carbon footprint, based on their personal convictions and an awareness that other organisations in the research ecosystem in Luxembourg were beginning to do the same. Engaging FNR staff from the start of the process facilitated their involvement in the subsequent data collection and other ongoing actions which are being conducted internally.

This is a successful example of change management, used to drive future actions for sustainability through building awareness, enthusiasm, knowledge and ability to engage and reinforcing all commitments. Other outcomes linked to active FNR staff engagement include receiving FNR's third consecutive Green Business Events certification in 2025, building on sustainable practices already in place and highlighting FNR's dedication to eco-friendly event organisation.

3.3. Cost Efficiency

Environmental sustainability measures aimed at saving energy and other resources have been demonstrated to bring significant savings thanks to decreasing resource consumption and extending lifetime of equipment;[137] they can also shield research organisations against price spikes such as those which occurred during the last energy crisis. According to some estimates, environmental sustainability measures "can save up to 40% of a researcher's funding over one year",[138] making it possible to reinvest the funds in scientific research.

Small adjustments can bring significant financial gains

EXAMPLE

At the University of Groningen, a two-week winter break and buildings closure in 2022–23 brought savings of €247,646. In 2023–24, these measures were complemented by some additional measures such as switching off 8 out of 12 fume hoods per laboratory in old buildings, generating additional savings of at least €248,000 in electricity and heating.[139]

At the same university, environmental sustainability measures for 46 LEAF-accredited laboratories helped save €398,763 annually.[140]

At the University of Virginia, addressing laboratory ventilation inefficiencies has the potential of generating approximately $5 million per year in energy savings.[141]

136. Republished from Potjomkina et al., *Survey Report: Appraising Greenhouse Gas Emissions of Research Organisations,* with revisions
137. Penndorf, "A Review on Sustainable Practices in Scientific Research"
138. Freese et al., "The Relevance of Sustainable Laboratory Practices"
139. Freese et al., "The Relevance of Sustainable Laboratory Practices"
140. Freese et al., "The Relevance of Sustainable Laboratory Practices"
141. Meyn et al., "Addressing the Environmental Impact of Science Through a More Rigorous, Reproducible, and Sustainable Conduct of Research"

Multimillion-dollar cost savings unlocked by use of shared facility models

EXAMPLE

Use of shared research resources "avoids proliferation of duplicative equipment, enabling resource and cost efficiencies for laboratory space, general and scientific infrastructure, materials and supplies, energy usage, and, in some cases, the avoidance of waste generation."[142]

In the Department of Biochemistry at CU Boulder, use of a shared cell culture facility by several research groups leads to savings estimated at $253,000/year (comprising $195,000 avoided in direct and $58,000 in overhead costs). Additionally, it brings 30% space savings as well as ventilation and electricity savings. If shared cell cultures were used in just 5% of the grants annually awarded by the US National Institutes of Health, or 2,500 laboratories, this would bring estimated savings of $30.5m/year in direct costs and $9m/year in indirect costs, plus reduced need to purchase equipment and savings in laboratory space.[143]

Sharing research resources has also been linked to various other co-benefits, including increased rigour, reproducibility, and transparency of research.[144]

BEST PRACTICE

Circular heating lowers expenses at the National Institute of Nuclear Physics[145]

INFN
Istituto Nazionale di Fisica Nucleare

The Italian National Institute of Nuclear Physics has implemented two heat recovery systems. The first one was installed at the National Laboratory of Frascati to recover heat from the cooling of the data centre: 1 GWh/year to heat 45% of the buildings. It has been in operation since 2014. The new ICSC Data Centre, currently under construction, will integrate the same solution to heat other buildings. Low temperature (42°C) heating seems to be the best compromise for a campus reuse of waste heat.

The second one is installed at the National Laboratory of Legnaro: a chiller serving the Alpi magnets, the third experimental room, and the helium compressors. It is equipped for the total heat recovery with a potential of 450 kW at a temperature of 50–45°C. During the operation of the Tandem-Alpi complex and the cryogenic systems, the heat is recovered and used to heat the following buildings: Third experimental room, Tandem, guest houses, canteen, and Auriga.

142. Meyn et al., "Addressing the Environmental Impact of Science Through a More Rigorous, Reproducible, and Sustainable Conduct of Research"

143. Meyn et al., "Addressing the Environmental Impact of Science Through a More Rigorous, Reproducible, and Sustainable Conduct of Research"

144. Meyn et al., "Addressing the Environmental Impact of Science Through a More Rigorous, Reproducible, and Sustainable Conduct of Research"

145. Republished from Potjomkina et al., *Survey Report: Appraising Greenhouse Gas Emissions of Research Organisations*

BEST PRACTICE

Sustainability measures increase operational cost-efficiency of the Research Foundation Flanders[146]

fwo

The sustainable management of the FWO building falls under the internal Climate Plan of the Flemish government, which foresees a reduction of 55% in CO_2 emissions and primary energy savings of 35% by 2030, when compared to 2015.

Based on an energy scan of the building performed in 2021, eighteen measures were taken into account (related to areas such as insulation, heating, and cooling) to achieve its objectives. These were implemented in the framework of the renovation of FWO's offices, which took place between March 2020 and July 2022. In particular, these measures have helped to save electrical and thermal energy, decrease natural gas consumption, as well as recycle and reuse water. As a result of the renovation, FWO now manages its building in a more efficient, environmentally friendly and cost-effective way.

Moreover, since 1 January 2020, FWO has introduced a pioneering sustainable travel policy that contributes to climate objectives: it recommends to avoid flying when the travel time is less than six hours; offers the possibility to offset a CO_2 contribution as an eligible cost for FWO-funded projects; and offsets the emissions from FWO's mobility and travel grants through annually awarding three operating grants for research on climate (Scientific Award Climate Research). In addition to creating awareness among the researchers, this landmark travel policy generates savings.

BEST PRACTICE

German Research Foundation extends use of research infrastructures[147]

DFG Deutsche Forschungsgemeinschaft
German Research Foundation

In 2023, to promote the operation of ecologically sustainable and resource-preserving research equipment infrastructures, the German Research Foundation launched a new call for ideas for researchers who operate major research instrumentation and equipment. This builds on DFG's commitment to anchor the concept of sustainability into research funding and aims to promote more sustainable equipment-related funding opportunities in close co-operation with the research community.

The call was open to all career levels and research institutions in Germany, for single-location as well as collaborative projects. It gathered 26 ideas, 15 of which were invited to submit a full proposal and 9 projects were funded, to the total amount of approximately €5.5 million (plus programme allowance). These ideas were also used to modernise DFG rules and framework conditions related to infrastructure, to allow for more long-term use, re-use and repair. Funding can be requested for investments aimed at repurposing, modernising, and upgrading existing large-scale equipment, which ideally will significantly postpone the need to acquire new equipment.

146. Republished from Potjomkina et al., *Survey Report: Appraising Greenhouse Gas Emissions of Research Organisations,* with revisions

147. Republished from Potjomkina et al., *Survey Report: Appraising Greenhouse Gas Emissions of Research Organisations*

3.4. Risk management

There are several ways in which improving environmental sustainability can support risk management or research activities. Circular economy measures can decrease the need for purchasing new materials and equipment, reducing supply chain risks. Sustainable buildings and infrastructures are more future-proof in the face of climate change, for example extreme temperatures, and rising energy costs. Environmental sustainability measures have been linked to increased safety benefits for researchers: for example, stronger quality management systems in case of sharing research resources have the potential to reduce laboratory errors and accidents,[148] and more frugal approaches to the use of resources can reduce the amount of generated toxic waste and risk to researchers' health.[149] Thus, for example, the application of Green Chemistry Principles is usually linked to improved safety.[150] In the long term, climate change poses significant risks to research infrastructures and research organisations, as their functioning and budgets may be threatened by the changing climate, notably extreme weather events and resource scarcity.

BEST PRACTICE

Environmental Sustainability of Infrastructures as Risk Prevention at UK Research and Innovation

UK Research and Innovation

In its refreshed Environmental Sustainability Strategy 2025 to 2030, UK Research and Innovation (UKRI) prioritises the long-term environmental sustainability of infrastructures it owns and operates. The Strategy stipulates that "funding of any new infrastructure investments will require minimising operational costs and exploitation of natural resources, as well as being capable of withstanding the increasing impacts of climate change for the duration of their operations."[151] This aims to adapt research infrastructures to the impact of climate change.

3.5. Social Inclusion

Online meetings and remote observations are not only more environmentally sustainable through decreasing the need for travel, but also more inclusive towards persons with travel restrictions (for example, caring responsibilities or disabilities) and representatives from countries with emerging research and innovation systems.[152]

148. Meyn et al., "Addressing the Environmental Impact of Science Through a More Rigorous, Reproducible, and Sustainable Conduct of Research"

149. Penndorf, "A Review on Sustainable Practices in Scientific Research"

150. "12 Principles of Green Chemistry", American Chemical Society, accessed October 14, 2025, https://www.acs.org/green-chemistry-sustainability/principles/12-principles-of-green-chemistry.html

151. UKRI, *UKRI Environmental Sustainability Strategy 2025 to 2030*

152. ALLEA, *Towards Climate Sustainability of the Academic System in Europe and Beyond*

Virtual meetings enhance diversity, equality, and inclusion

EXAMPLE

According to a recent review of scientific literature, scientific convenings in an "entirely or primarily virtual format [...] can enhance meeting access, diversity, and climate [welcoming environment]."[153] In-person events may pose economic and travel-related barriers to attendance. In one of the cited studies, most of the analysed 270 scientific conferences "were organised in ways that led to exclusionary practices based on gender, career stages, and ethnic, racial, socio-economic, and geographical backgrounds," which could have been remedied through virtual participation.[154] In contrast, a switch to virtual events has been shown to lead to "a significant increase in attendees from under-represented groups".[155]

Researchers who have difficulty in attending in-person conference, are often also the researchers who are under-represented within a given discipline.[156] Studies have also shown that online conferences are available to participants from a much greater number of countries, in one example increasing from 28 in 2019 to 79 in 2020 (transition to a virtual conference due to Covid-19).[157] In another example, participation of women increased by 60 to 260% for virtual conferences.[158]

BEST PRACTICE

Sustainable travel policies and inclusion at Research Ireland[159]

Taighde Éireann
Research Ireland

Taighde Éireann – Research Ireland has put in place a Sustainable Travel Guidance for all grant recipients, their team members and grant applicants, aligned with the European Code of Conduct for the Recruitment of Researchers and the organisation's commitment to the Public Service Climate Action Mandate. The travel guidance encourages travel options to be deployed with the lowest carbon emissions.

Support is also available for various alternatives to travel, including video-conferencing, communication and file-sharing software (such as required functionality or subscription features) as green initiatives.

The organisation furthermore provides 'Personal Support', 'Childcare and companion travel', and 'Assistive Technology' as eligible costs in the Grant Budget Policy. This aligns with the National Sustainability Policy under the EU Sustainable and Smart Mobility Strategy.

153. Marie A. Bernard, "How Virtual Convenings Can Enhance Diversity, Equity, Inclusion, and Accessibility", February 24, 2022, https://web.archive.org/web/20250405143239/https://nexus.od.nih.gov/all/2022/02/24/how-virtual-convenings-can-enhance-diversity-equity-inclusion-and-accessibility/
154. Sarabipour et al., "Changing Scientific Meetings for the Better: Supplementary Information"
155. Bernard, "How Virtual Convenings Can Enhance Diversity, Equity, Inclusion, and Accessibility"
156. ALLEA, *Towards Climate Sustainability of the Academic System in Europe and Beyond*
157. ALLEA, *Towards Climate Sustainability of the Academic System in Europe and Beyond*
158. ALLEA, *Towards Climate Sustainability of the Academic System in Europe and Beyond*
159. Republished from Potjomkina et al., *Survey Report: Appraising Greenhouse Gas Emissions of Research Organisations*

BEST PRACTICE

Sustainable travel drives inclusiveness and cost savings at the Research Council of Norway[160]

Research Council of Norway

The Eco-Lighthouse certification scheme is Norway's most widely used tool for enterprises seeking to document their environmental efforts and demonstrate social responsibility, and is approved by the Norwegian public procurement authorities. Enterprises are certified subject to independent assessment and must undergo a re-certification process every three years, as well as submit annual environmental reports.

The Research Council of Norway has been certified as an Eco-Lighthouse organisation since April 2016, which includes having a sustainable travel and mobility policy.

For example, RCN reviewed over 2,660 applications for research grants in 2023 where 1,474 external experts where involved. These were all organised through digital panel meetings, reducing physical journeys to a minimum, which would mostly have been taken by air due to RCN's geographical location. Conducting the review process online does not only save travel costs and carbon emissions, but also makes it easier to secure reviewers' time and is more user-friendly for case officers, experts, and applicants.

As RCN also organises an annual 'walking and biking' campaign and competition for all employees. This includes financial support for bike repairs for those joining the campaign.

BEST PRACTICE

Sustainability-oriented mobility, telework practice and family-work balance at the Foundation for Science and Technology[161]

fct Fundação para a Ciência e a Tecnologia

The Foundation for Science and Technology in Portugal (FCT) has implemented a sustainability-oriented mobility and telework practice. As a research funding organisation, FCT conducts its evaluation processes remotely, offering hybrid options only in specific cases. Between 2023 and 2024, approximately 10,000 applications from major calls were assessed entirely online.

FCT has also introduced a Conciliation Policy facilitating remote work to promote a healthy balance between personal and family life. This shift has significantly reduced commuting and carbon emissions.

To further reduce carbon emissions, FCT has worked on renewing its car fleet to make it more eco-friendly. Of the current ten fleet cars, seven are electric, one is hybrid, and only two are fossil-fuel powered.

160. Republished from Potjomkina et al., *Survey Report: Appraising Greenhouse Gas Emissions of Research Organisations*

161. Republished from Potjomkina et al., *Survey Report: Appraising Greenhouse Gas Emissions of Research Organisations*, with revisions

3.6. Legal Compliance

Achieving net zero by 2050 is a legally binding goal for the European Union, enshrined in the European Climate Law and increasingly implemented through wide-ranging regulation. Recently, several landmark legal opinions have been issued affirming the legal responsibility of States to address climate change, including most recently the advisory opinion of the International Court of Justice.[162]

On several occasions, the argument has been made that science may face increasingly strict regulations in the future; it is therefore in the research sector's own interest to reduce its emissions in a 'self-determined' manner, rather than being subject to legislative approaches that may not be fully aligned with its needs.[163, 164, 165]

BEST PRACTICE

Government regulations driving sustainability at Research Ireland[166]

Taighde Éireann Research Ireland

Taighde Éireann – Research Ireland aligns with the Government of Ireland's Green Public Procurement Policy (GPP), where public bodies seek to source goods, services or works with a reduced environmental impact throughout their life cycle. The organisation prioritises virtual and hybrid events, local & sustainable suppliers, a digital-first communications strategy and a 'Reduce, Reuse, Recycle' policy. The grant awardees are also advised to comply with the GPP policy.

BEST PRACTICE

Government regulations driving sustainability at the Foundation for Science and Technology[167]

fct Fundação para a Ciência e a Tecnologia

The Foundation for Science and Technology in Portugal (FCT) was one of the first governmental public institutions to introduce a strategic initiative on energy efficiency, by publishing its Resource Efficiency Programme. This strategy document offers a coherent framework composed of internal environmental policies, guidelines, and commitments to comply with the Resource Efficiency Programme in Public Administration for the period up to 2030 (ECO.AP 2030).

This programme was designed to reach the Ministry of Education, Science and Innovation's priorities and goals concerning environmental sustainability and decarbonisation indicators. The document sets concrete measures to help FCT reduce energy consumption, water and material resources in its own operations; increase the use of renewable energy sources and improve the organisation's resource efficiency; support its energy and water renovation; reduce GHG emissions; and, to raise awareness and capacity training for FCT employees and users in these subjects.

162. International Court of Justice, "Obligations of States in Respect of Climate Change", 2025, https://www.icj-cij.org/case/187
163. ALLEA, *Towards Climate Sustainability of the Academic System in Europe and Beyond*
164. Pultarova, "The Mission to REduce the Carbon Footprint of Astronomy"
165. Penndorf, "A Review on Sustainable Practices in Scientific Research"
166. Republished from Potjomkina et al., *Survey Report: Appraising Greenhouse Gas Emissions of Research Organisations*
167. Republished from Potjomkina et al., *Survey Report: Appraising Greenhouse Gas Emissions of Research Organisations*

Conclusion

This briefing has reviewed the argumentation for increasing environmental sustainability in research: both from the environmental standpoint and considering the potential positive co-benefits for research organisations and broader societies. While climate action is already underway in (part of) the European research sector, ensuring the sustainable future of science requires even greater climate ambition.

As has been demonstrated in this briefing, science continues to have a non-negligible environmental impact that can can, in some cases, be compared to that of other industries. At the same time, this briefing also highlights the significant potential advantages of taking steps that go beyond the need to protect the environment, and link to the overall long-term sustainability of research organisations. Examples and best practices illustrate how environmental sustainability measures can deliver financial savings, strengthen risk management and preparedness for future regulatory requirements, promote social inclusion, and enhance institutional reputation and attractiveness as an employer.

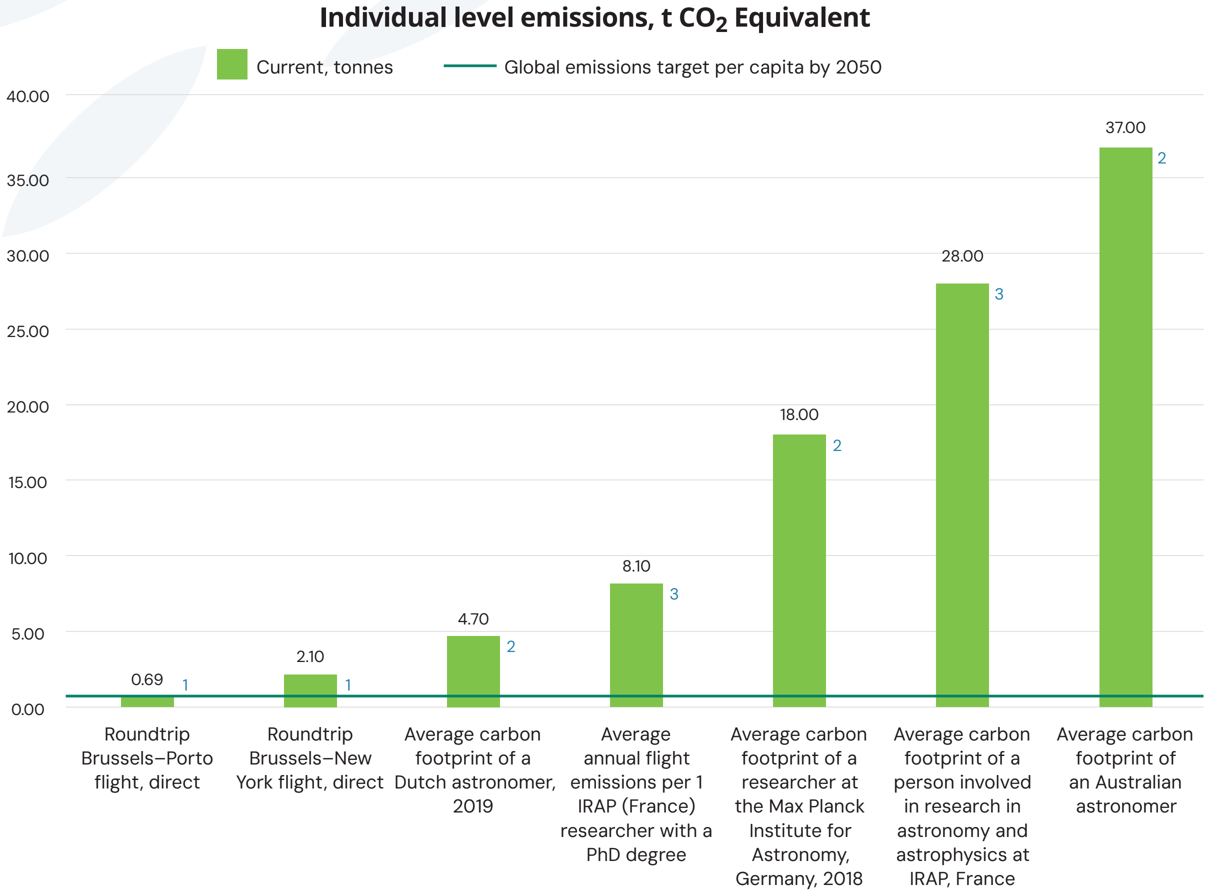
Science Europe is committed to implementing the Framework for the Environmental Sustainability of Research Organisations[168] and leading on environmental sustainability of research, in dialogue with research organisations and policy makers. The organisation currently works on strategies to support research organisations to decrease their environmental footprint, consider environmental sustainability in research assessment, advance novel science-for-policy approaches that can have environmental benefits (such as rapid and living evidence synthesis), and on creating a European network of organisations that work on environmental sustainability of research and research-related activities.

We hope that this briefing will help inspire further action across the research sector and contributes to collective efforts to strengthen environmental sustainability in research systems.

168. Dotti and Potjomkina, *Framework for the Environmental Sustainability of Research Organisations*

Annex: Comparison Charts

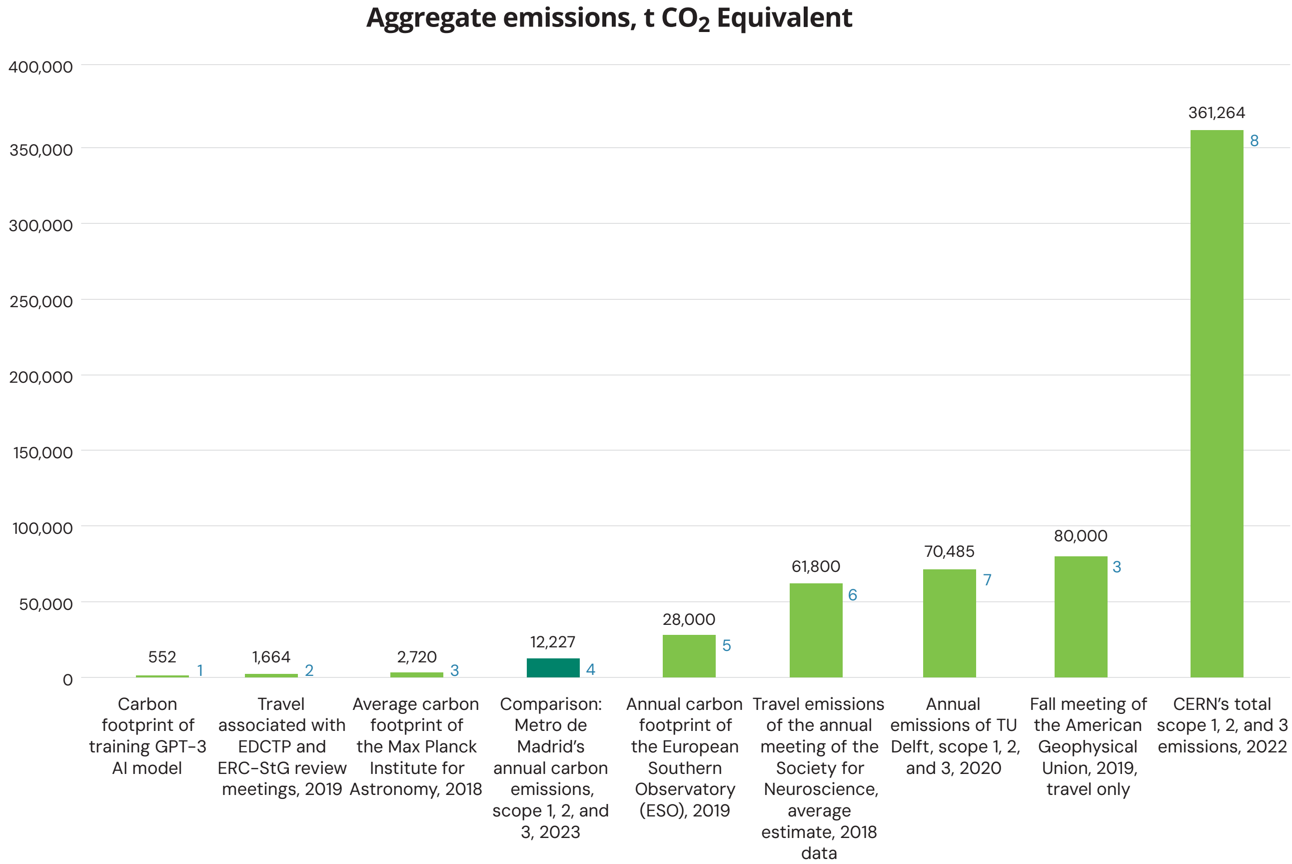
These comparison charts show, in a visually easy to understand way, several randomly identified examples of research-related carbon emissions. The examples are not necessarily directly comparable, notably due to differences in years and calculation methodologies.



Sources (see numbers in blue next to each bar):

1. Foundation myclimate, "CO_2 Emissions Calculator: Calculate Your Carbon Emissions," accessed January 15, 2026, https://co2.myclimate.org/en/calculate_emissions/ (Brussels-Porto and Brussels-New York)
2. Michael Allen, "The Huge Carbon Footprint of Large-Scale Computing," *Physics World,* March 2022, https://physicsworld.com/a/the-huge-carbon-footprint-of-large-scale-computing/
3. Pierrick Martin et al., "A Comprehensive Assessment of the Carbon Footprint of an Astronomical Institute," *Nature Astronomy* 6, no. 11 (2022): 1219–22, https://doi.org/10.1038/s41550-022-01771-3.

Baseline (global emissions target per capita by 2050 = 0.7 tonnes): Lewis Akenji et al., *1.5-Degree Lifestyles: Targets and Options for Reducing Lifestyle Carbon Footprints* (Institute for Global Environmental Strategies, Aalto University, D-mat ltd., 2019), https://www.iges.or.jp/en/pub/15-degrees-lifestyles-2019/en



Sources (see numbers in blue above each column):

1. Kate Saenko and The Conversation, "A Computer Scientist Breaks Down Generative AI's Hefty Carbon Footprint," *Scientific American*, accessed October 14, 2025, https://www.scientificamerican.com/article/a-computer-scientist-breaks-down-generative-ais-hefty-carbon-footprint/
2. Teun Bousema et al., "The Critical Role of Funders in Shrinking the Carbon Footprint of Research," *The Lancet Planetary Health* 6, no. 1 (2022): e4–6, https://doi.org/10.1016/S2542-5196(21)00276-X
3. Michael Allen, "The Huge Carbon Footprint of Large-Scale Computing," *Physics World,* March 2022, https://physicsworld.com/a/the-huge-carbon-footprint-of-large-scale-computing/
4. Metro de Madrid, *Informe de Sostenibilidad 2023* (2023), https://www.metromadrid.es/sites/default/files/documentos/Informedesostenibilidad2023ESP_0.pdf
5. Tereza Pultarova, "The Mission to Reduce the Carbon Footprint of Astronomy," *Space,* February 2, 2022, https://www.space.com/reducing-carbon-footprint-of-astronomy
6. Angie Voyles Askham and Shaena Montanari, "Neuroscientists Weigh Carbon Costs of Attending Annual Meeting," *The Transmitter: Neuroscience News and Perspectives,* November 6, 2023, https://www.thetransmitter.org/community/neuroscientists-weigh-carbon-costs-of-attending-annual-meeting/
7. ALLEA, *Towards Climate Sustainability of the Academic System in Europe and Beyond,* 2022, https://allea.org/portfolio-item/towards-climate-sustainability-of-the-academic-system-in-europe-and-beyond/
8. CERN, *Vol. 3 (2023): CERN Environment Report—Rapport Sur l'environnement 2021–2022*, 2023, https://e-publishing.cern.ch/index.php/CERN_Environment_Report/issue/view/156

Science Europe AISBL
RUE DE LA SCIENCE 14, 1040 BRUSSELS, BELGIUM

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