Marie Skłodowska-Curie Actions Green Charter

Guidance Material

for research groups, organisations and consortia

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Introduction

The Marie Skłodowska-Curie Actions (MSCA) fund bottom-up research in all fields of science and across disciplines, based on scientific excellence and competitive funding. The programme supports the careers, skills development, and international mobility of researchers at all stages of their careers, with a strong focus on the development of excellent doctoral and post-doctoral research and training programmes. It is open to both academic and non-academic organisations and to researchers from all over the world.

The European Commission is committed to tackling climate, environmental and biodiversity challenges, in line with the EU Green Deal[1], the United Nation's 2030 Agenda[2] and the Sustainable Development Goals[3]. As an organisation, the European Commission is also determined to act as a front-runner in the transition towards a climate neutral society, by setting out an ambitious and realistic plan to achieve climate neutrality by 2030[4].

In light of the role of the MSCA programme supporting the future generations of researchers at the highest level, the MSCA Green Charter lays down a set of non-binding guiding principles that promotes the mainstreaming of environmental considerations in all aspects of research planning and implementation, throughout the life cycle of a project. The Charter seeks to help reduce environmental harm caused or induced by MSCA-funded projects, to raise awareness of environmental sustainability, and to serve as a catalyst in promoting sustainable practices in research.

All participants in MSCA-funded projects are encouraged to adhere to the principles of the Charter as much as they can without compromising the scientific excellence of their project, nor their freedom to choose what to investigate in a bottom-up manner.

This document contains guidance, concrete examples and other resources which can serve as a source of inspiration for research groups, organisations and consortia wishing to support the take up of sustainable research practices aligned with the principles of the MSCA Green Charter. A separate document offers guidance targeted at researchers and research managers. While all recommendations will not apply to all research settings or projects, these guidance documents can help our community better understand what can be done in practice to integrate environmental sustainability principles in research work.

This guidance has been elaborated thanks to the collective work of a group of stakeholders and experts coming from different parts of the research community, including representatives of researchers at different career stages, research managers, research performing and funding organisations, sustainability experts, as well as MSCA coordinators, fellows and alumni.

1 Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions. The European Green Deal (COM(2019) 640 final): https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX-:52019DC0640.

2 United Nations, 2030 Agenda for Sustainable Development: https://sdgs.un.org/2030agenda

3 United Nations. The 17 goals: https://sdgs.un.org/goals

4 Greening the European Commission: https://commission.europa.eu/about/service-standards-and-principles/modernising-european-commission/greening-european-commission_en

1. Travel, events and meetings

Mobility - through secondments, workshops, and conferences - remains central to research and career development, offering important opportunities for skill-building, knowledge exchange, and network expansion. At the same time, frequent travel and events come with an environmental impact and carbon footprint. As climate change intensifies, it becomes increasingly important to consider adopting sustainable approaches to travel and events and integrating environmentally conscious habits and skills into the research culture, while preserving the vibrant exchange of ideas that fuels scientific progress. Facilitating this shift involves individual researchers and project consortia exploring changes in mobility patterns and event planning, and organisations working towards embedding sustainability into their policies.

Several challenges complicate achieving a meaningful shift on this issue. These challenges can consist in lack of awareness, logistical and budgetary barriers, or individual and organisational approaches that prioritise cost and efficiency exclusively, without taking into account the environmental impact of travel or the availability of sustainable alternatives - such as rail travel, hybrid conferences, and longer research stays. At the same time, while digital collaboration offers solutions, it cannot fully replace the value of in-person engagement.

This section aims to offer research groups, organisations and consortia useful tools to make informed, climate-conscious choices impacting research related travel, events and meetings without compromising on research objectives.

Attending events: travel and mobility

Researchers attend events such as project meetings, workshops and conferences. As actors of mobility, their individual choices will impact the environmental footprint of attending one event. Yet, these choices are often limited within a framework defined by the organisation's rules. Adjusting mobility and travel policies at the organisational level can greatly facilitate green mobility for researchers.

Recommendations:

- **Encourage researchers to optimise travel**, prioritising longer stays over multiple short trips, or allowing researchers to travel from one meeting to another without having to go back to their home city.
- **Promote the use of low-carbon transport** such as trains over planes and adjust "minimum-cost" rules in place by default to also account for environmental impact. When low-carbon transport is more expensive than flying, the organisations can support the researchers in accessing funding to compensate for the extra expense – which could for instance be paid for by charging a contribution on booked flights.
- **Developing and provide "sustainable travel" guidelines** to enable informed decision-making on travel for new staff. Make booking sustainable travel easy for users. Ensure the travel agency uses aggregates CO2 emission data at the individual traveler's scale (such services are offered by CWT for example) to be able to analyse the travel impact from your teams.

Examples:

- Tyndall Center, from the University of Manchester, used the Tyndall Travel Tracker to log upcoming flights or train journeys. Researchers see how much carbon each trip produces and avoid short-haul flights in favour of online meetings. In one department, a carbon budgeting system was introduced alongside financial planning. Teams had targets for limiting air travel and reviewed their performance twice a year, which led to fewer flights and more planned group travel.
- ETH Zurich created a mobility platform where staff recorded flights, train trips, and local travel for business in one central system. Departments used the platform's reports to spot frequent-flyer habits and encourage rail or virtual attendance when possible. They also introduced a "flight budget" for certain departments, offering small rewards for those who stayed under their emissions limit. This mix of data tracking and incentives led to fewer short-haul flights and widespread use of virtual collaboration tools.
- The Travel better Package by EAUC-Scotland supports the reduction of air travel in the Higher Education and Research sectors. It includes a Q&A guide addressing concerns individuals may have about reducing air travel, as well as the Air Travel Justification Tool, which is an extension of a decision tree for individuals wishing to attend a meeting or a conference.

Additional resources:

- The Little Book of Green Nudges
- Green Guide for Universities

- Sustainable travel guidance from Research Ireland
- Sustainable travel policy of Research Foundation - Flanders
- Meeting and travel policy of Swedish Research Council for Sustainable Development (FORMAS)

Organising events

- Whether it is a small project meeting or a large conference, the choices made regarding the planning and organisation of an event have an impact. The following recommendations are addressed to the people operationally organising the event, whether they are a **researcher, research manager, consortium member, the organisation**[5], or a team composed of all of the above.

Planning phase

- **Implement and apply Sustainable Event Guidelines**. Create or use a sustainability checklist, to ensure you cover all aspects related to sustainability.
  - ✓ See for instance: 7 steps for Greener events and Guidelines for sustainable meetings and events (European Commission)
  - ✓ You may also apply for green event certification schemes available in your country (e.g. The National Research Fund of Luxembourg uses Green Business Events. Additional examples available in Science Europe's survey report)
- **Reduce unnecessary travel by promoting online or hybrid events**: wherever possible, offer an option to join online to reduce travel while ensuring inclusivity. Consider encouraging online participation with dedicated incentives (e.g. prize for best online presentation instead of or alongside prizes for in person presentations).
- **The selection of the location**: prioritise venues easily accessible by low-carbon transport. In the context of a MSCA consortium, consider the travel options of all your attendees to decide the best locality in which to host the event. Consider sustainability as a criterion for the choice of the venue: favour places that are well insulated and avoid unnecessary heating, or which provide water fountains, etc.
- **The choice of catering**: prefer sustainable caterers that use local ingredients and propose plant-based meals. Consider choosing a vegetarian menu for your event or, at least, finding alternatives to red meat. Request to the caterer that they avoid single-use plastic, if they provide cutlery, cups and plates.
- **Avoid food waste**: work with the caterer to optimise food quantities based on attendance. Wherever possible, provide compost bins for any food waste. Ensure that untouched food can be donated or redistributed (e.g. using apps such as Too Good to Go). Secure ways of having food remain untouched, i.e. cover food containers with transparent lids/covers whenever possible so that food remains accessible to event attendees yet at least partially protected and less exposed.
- **Minimise waste**: as much as possible, avoid single use glasses, cups, plates and cutlery. Prefer tap water or returnable glass bottles over plastic. Avoid unnecessary printed materials. Reuse conference materials from previous events (e.g. stands, banners, signage).
  If you plan to offer goodies to your attendees or gifts to the speakers or organising team, choose a provider that uses recycled and/or recyclable materials, or select local edible gifts. At the end of the event, collect lanyards used for the name badges, to reuse them. Wherever disposables cannot be avoided for logistics reasons, favour recyclable and compostable items.
- **Offer guidance to your attendees**: share information about low-carbon travel, recommend hotels with environmental labels and restaurant with sustainable values, that are easily accessible by public transport. Encourage the use of public transport, for instance by purchasing passes for your attendees if funding is available.
- **Communicate your intention** to minimise the environmental impact of the event with attendees at the planning/invitation stage.
- **Estimate the likely carbon footprint** of the event at planning stage using calculators (e.g. from myclimate).

Operational phase

- Communicate with attendees to help them understand how they can adhere to the sustainability principles implemented during the event (e.g. in the welcome speech, at the welcome desk if there is one...). Ensure **adequate signs are available to clearly indicate best practices**, such as clear signs on bins explaining what to throw in which; a map that indicates available water fountains, etc.
- Avoid **printed programmes**; instead, privilege an online document available with a QR code, or using a conference app for large events. Provide a digital map of the building and eliminate paper-based surveys or evaluations.

5 For more details on what can be done by researchers and research managers, see the MSCA Green Charter Guidance material for researchers and research managers.

- **Make sustainability part of the event**: invite attendees to engage in the conversation around sustainability, for instance using online live surveys during one of the sessions (e.g. Slido, Kahoot, Mentimeter, Vevox). You can ask them questions related to their own sustainable engagement while attending, what action they took to reduce the environmental impact of participating this event, what actions they can still undertake, or what they would expect from the organisers in terms of sustainability initiatives. Consider **non-material gifts** (e.g., donations, experiences) or **consumables** (e.g., drinks, food, cosmetics) to thank the organisers and speakers.

Post-event phase

- **Data collection** is key to evaluate the sustainability of your events. One simple way to do so is to send a short survey to the attendees or include sustainability questions in the satisfaction survey if one is already planned. Furthermore, collect data on waste by working with the subcontractors (caterer, venue providers) to identify weaknesses and optimise in the future.
- **Estimate the actual carbon footprint** of the event at post event stage using calculators (see for instance this CO2 calculator)
- **Make Sustainability part of the event's Close Out**: consider proposing to attendees to engage in the conversation around sustainability using collaborative tools. Ideas for questions could be: How did you consider sustainability during this event? Did you succeed in achieving environmentally friendly practices during your participation in the event?

Training on sustainable events and mobility

While some team members may have some pre-existing notion on sustainability from their personal interests, it is unrealistic to expect everybody to be able to implement sustainable practices related to mobility and event planning.

Sustainability can be incorporated as part of the early-stage researcher's training and career development plan. Organisations may make training, tools and materials on sustainable mobility available to researchers and research managers, who often have a key role to play on the organisation of events. Researchers may also actively seek training on sustainable practices, and suggest it to their group leader, project coordinator or organisation if it is not proposed by default.

Organising and attending events: practical examples

Fictitious Story: **Organising an Event**

Peter had always seen sustainability as intrinsic to his role as event organiser, aiming to ensure gatherings leave a positive impact on people while minimising harm to the planet. When he was tasked with organising an MSCA end-of-project conference, he saw this as an opportunity to implement eco-friendly practices.

Planning Phase: Peter started by creating a comprehensive sustainability checklist. He ensured that the event followed guidelines that promoted sustainable decision-making and reduced unnecessary travel. Understanding the carbon footprint of travel, Peter made the event hybrid, encouraging online participation by offering incentives for virtual attendees. When selecting a venue, he chose a location that was easily accessible by public transport and with sustainability certifications. He collaborated with a caterer that provided plant-based meals, minimised food waste and avoided single-use plastics. He recommended hotels with environmental labels to attendees.

Operational Phase: At the registration, attendees were reminded of the sustainability objectives of the organisers and invited to be proactive about reducing and sorting waste. Instead of printed programs, Peter introduced QR codes that provided instant access to schedules. Resources and name tags were designed to be reusable. Single-use plastics were discouraged, and water stations were set up to encourage attendees to refill reusable bottles. During the opening speech, Peter reminded guests about the event's sustainability goals and encouraged them to adopt similar practices in their professional lives.

Post-Event Phase: After the event, Peter collected and analysed data on emissions generated from both in-person and virtual participation. He sought feedback from attendees on how sustainability efforts could be improved for future events, to help shape better strategies for minimising environmental impact in future gatherings.

Additional examples and resources

- European Commission internal guidelines for sustainable meetings and events: https://green-forum.ec.europa.eu/news/guidelines-sustainable-meetings-and-events-2024-07-15_en
- Mobility guidance on Green Travel: e.g. https://www.tudelft.nl/studenten/mijn-studie-ik/onderwijs/study-abroad/before-your-stay-abroad/green-travel
- Sustainable events checklist together with a list of useful tools (such as a footprint calculator): e.g. https://www.universityofgalway.ie/sustainability/studentsresources/resources/sustainableeventchecklist/
- A comprehensive training, a toolbox and GHG monitoring tool: e.g. https://flyingless.de/en/
- Evaluate alternatives for your travel routes: e.g. https://ecopassenger.org/bin/query.exe/en?L=vs_uic
- Articles: numerous open access articles have explored the impact of reduced travel in academia, including: Kreil (2021), Does flying less harm academic work? Arguments and assumptions about reducing air travel in academia - ScienceDirect); Katz-Rosene (2023), Spiral-scaling climate action: lessons from and for the academic flying less movement; Eriksson et al (2020), On the Necessity of Flying and of not Flying | Proceedings of the 7th International Conference on ICT for Sustainability; Wenger et al (2025), Conference air travel's relevance and ways to reduce it - ScienceDirect.
- Reports: various reports provide an overview of developments in academia with respect to train travel (e.g. Flying high but flying less | De Jonge Akademie), practical tips on reducing travel and mobility by adjusting infrastructure, creating clear guidelines (e.g. Green Guide for Universities), or putting in place nudging techniques (e.g. The Little Book of Green Nudges | UNEP - UN Environment Programme).
- General sustainability training addressed to students: e.g. short videos from Ecole Polytechnique.
- Courses covering leadership, management, and research: e.g. EMBO practices and resources, including, funding for virtual meetings and encouraging hybrid events, covering additional costs and providing sustainability badges for reducing environmental impacts: How do you reduce the environmental impact of scientific meetings? – Blog – EMBO. See also "Organising an efficient hybrid meeting needs extra effort" blog post from EMBO.

Fictitious Story: **Attending and Travelling to an Event**

As Sara prepared to attend a conference bringing together staff from several partner organisations, she set her mind on making sustainable choices at every step.

Planning Phase: Before booking her trip, Sara carefully considered whether attending in person was necessary. Since networking opportunities and in-person exchanges of information were crucial for her work, she decided to go but ensured she minimised her carbon footprint. She opted to take the train instead of flying, as the travel time was under six hours. She selected a hotel with an environmental label and close to the venue.

Operational Phase: At the venue, Sara followed sustainable habits. She brought her reusable water bottle and coffee cup, avoiding single-use plastics. She chose plant-based meals and minimised food waste by taking only what she needed. She avoided printed materials, using digital schedules and QR codes. When she met a new acquaintance, she exchanged digital business cards rather than using printed cards. Throughout the event, Sara made a conscious effort to use public transports.

Post-Event Phase: After the conference, Sara calculated her travel emissions and compared them to previous trips. She provided feedback to the organisers, suggesting future green initiatives such as composting food waste.

2. Research practices and resource-intensive research settings

While scientific research is a driver of innovation and societal progress, research practices can rely on large amounts of energy, water, and single-use materials. The following practical recommendations can help organisations understand how, with their support, sustainability can be integrated into everyday research practices, with a focus on resource-intensive research settings. Sustainability in research still being an emerging field, links are included where available to relevant open-access resources, tools and training, some of which may undergo further development as the field matures. This section also introduces concepts and frameworks such as circular economy, life cycle assessments and green chemistry.

The recommended measures can not only help to reduce the environmental impact of certain practices; several of them can also reduce costs, enhance research quality, foster collaboration and improve efficiency.

Partnering up & getting started

To embed sustainability in research, collaboration between researchers, within research groups, consortia, and organisations is essential. A culture of sustainability can be fostered through training, accessible resources, support from green teams, and formal recognition.

- integrate sustainability training into onboarding processes and offer regular training opportunities for staff.
- support bottom-up initiatives by providing funding, recognition, and dedicated green team staff.
- include environmental sustainability in their strategies and sign up to sector-wide commitments.
- promote the use of high-quality lab certification schemes.

Examples and resources:

- **Network, training & resources**: Sustainable European Laboratories Network (SELs) https://sels-network.org/
- **Training**: e-learning courses by Green Labs Netherlands and UMC Utrecht. https://elearning.kcgh.nl/ (free registration).
- **Green team & lab awards**: Department for Social Responsibility and Sustainability at the University of Edinburgh https://sustainability.ed.ac.uk/about-us/contact ; https://sustainability.ed.ac.uk/take-action
- **Higher education training**: University of Galway (Ireland) provided a 5 ECTS (European Credit Transfer and Accumulation System) postgraduate module on Green Lab Principles & Practice BI5108-Green-Lab-Principles-and-Practice-module.pdf
- **Sector-wide commitment**: the Concordat for the Environmental Sustainability of Research and Innovation Practice: see e.g. https://wellcome.org/about-us/positions-and-statements/environmental-sustainability-concordat
- **Lab certification schemes**: see e.g. LEAF – Laboratory Efficiency Assessment Framework (not open access) https://www.ucl.ac.uk/sustainable/take-action/staff-action/leaf-laboratory-efficiency-assessment-framework, My Green Lab (not open access) https://www.mygreenlab.org/, SPARK-Hub (under development, open access) GreenerResearch.org.

Planning a research project

Sustainability principles can be applied throughout all phases of research projects, from literature review and hypothesis formulation to experimentation, analysis, collaboration and dissemination.

Consortia can play a role already at this stage by clearly assigning responsibility for sustainability planning. Organisations can provide guidance and provide support from dedicated staff to researchers in creating tailor-made sustainability plans for their research projects.

Examples and resources:

- **Organisational guidance**: European Molecular Biology Laboratory (EMBL)'s sustainable lab guide https://www.embl.org/about/info/sustainability/wp-content/uploads/2023/09/EMBL-Green-Lab-Guide_09.23.pdf
- **Organisational guide**: Barcelona Institute of Science and Technology (BIST) https://bist.eu/wp-content/uploads/2024/04/Handbook-Bist_final.pdf
- **Case study**: University of Groningen: https://pubs.rsc.org/en/content/articlelanding/2024/su/d4su00056k

Quantifying environmental footprint

Assessing the environmental footprint of research helps identify impact hotspots. While full greenhouse gas inventories or biodiversity impact assessments are complex, standard metrics (e.g., energy use, water, materials, waste) can be monitored more easily. Establishing a baseline of metrics at a project's start enables both researchers and their organisations to adopt measurable targets and evaluate progress. Standardised reporting templates or shared spreadsheets can help compare resource use and waste across projects, departments and organisations, enhancing transparency and best practice exchanges.

Recommendations to organisations and consortia:

- Assess the collective environmental impact of the consortium and monitor it through the project execution.
- Include the footprint of lab research in the organisation's sustainability reporting and introduce standardised reporting with Key Performance Indicators (KPIs) to track ecological impacts over time.
- Promote systemic thinking by providing at organisational level training on circular economies, life cycle assessment methodologies and, where available, providing access to Life-Cycle Assessment software [*for a definition of LCA, see below "Going further: definitions, principles, metrics and frameworks for sustainable research practices*].

Examples and resources:

- **Toolset to quantify and mitigate carbon footprint**: (initially limited to France, European version under development) https://labos1point5.org/
- **Carbon calculator**: (under development) https://www.epfl.ch/schools/sv/school-of-life-sciences/about-us/sv-sustainability-office/co2-calculator/
- **Waste assessment**: https://www.embopress.org/doi/full/10.1038/s44319-024-00360-x
- **Life cycle assessment of malaria trial**: https://journals.plos.org/sustainabilitytransformation/article?id=10.1371/journal.pstr.0000131
- **University-wide carbon footprint highlighting labs**: https://ethz.ch/en/the-eth-zurich/sustainability/facts-and-figures.html#treibhausgase
- **Biodiversity footprint**: https://www.nature.com/articles/d41586-022-01034-1

Reducing the environmental footprint of resource-intensive research activities

The following non-exhaustive list of measures aims to inspire immediate action to reduce the environmental impact of research activities, with a focus on resource-intensive research settings.

Recommendations:

- Power laboratories with renewable energy.
- Ensure organisational equipment and building maintenance, invest in energy recovery systems, update lab ventilation standards based on usage and risk assessment.
- Support washing of glassware, solvent recovery and chemical recycling.
- Centralise facilities and share infrastructure where possible. Promote shared use of major lab equipment and provide interdepartmental access to specialised infrastructure as appropriate. Examples include a central washing kitchen for glassware, centralised sample storage and sharing platforms for tools, data and instrumentation.
- Promote sustainable procurement of lab supplies and circular economy principles [*see also section on procurement below*].
- Optimise and, if possible, reduce the fume hood and controlled airflow.
- Where budget allows, finance and incentivise third-party lab certification systems.

Examples and resources:

- **Certification programmes**: the EU's Joint Research Centre launched a pilot Certification Program in partnership with MyGreenLab. Other certification programmes include for instance the Laboratory Efficiency Assessment Framework (LEAF), developed by University College London to improve the sustainability and efficiency of laboratories.
- **Metering, purchasing, operations guide**: e.g. https://www.ucl.ac.uk/sustainable/sites/sustainable/files/sustainable_lab_equipment_guide_-_metering_purchasing_operations.pdf.
- **Plastic recycling**: e.g. https://greenlabsaustria.at/recycling-lab-plastic/
- **Single use vs glass calculator**: e.g. https://apps.labos1point5.org/ecolabware
- **Cold storage**: e.g. https://www.kcl.ac.uk/assets/policyzone/estates/cold-storage-management-sop.pdf
- **Solvent eco-impact metric for chemists**: https://pubs.acs.org/doi/10.1021/acs.oprd.4c00546#:~:text=This%20metric%20leverages%20a%20comprehensive,and%20guide%20sustainable%20development%20initiatives.

Going further: relevant principles, concepts, metrics and frameworks for sustainable research practices

The following definitions, principles, metrics and frameworks can help researchers, consortia and organisations understand more deeply how to implement sustainable practices in research processes.

Environmental footprint

- **Carbon footprint (CO_2-equivalents):** summarises all greenhouse gas emissions from energy use (electricity, heating), production of materials, and any transport or refrigeration.
- **Biodiversity footprint**: estimates direct and indirect upstream and downstream impacts on biodiversity losses associated with activities.

Standard metrics

- **Energy consumption**: monitoring the electricity or fuel used by major equipment (such as freezers, centrifuges, and fume hoods). Recording energy use per experiment highlights high-consumption devices and potential savings (for example, by switching to more efficient models or optimising usage patterns).
- **Water usage**: measures direct water use (e.g. in baths or equipment cooling) and the embedded water in reagents (especially ultrapure water). By evaluating water usage and conservation (such as reusing rinsing water or closed-loop systems), teams can reduce demand for water resources.
- **Material use and waste generation**: tracks the mass of chemicals, plastics, and other materials used per experiment, as well as the weight or volume of waste produced (hazardous or general). Quantifying material flows helps identify unnecessary consumption and supports waste reduction efforts.
- **Baseline**: establishing a baseline of metrics at a project's start enables researchers to set measurable targets and evaluate progress. Standardised reporting templates or shared spreadsheets can help compare resource use and waste across projects, departments and organisations, enhancing transparency and best practice exchange

Environmental impact assessment

Assessing the environmental impact of research is key to systematically make research activities more sustainable. By analysing energy and material flows from input to output, Life Cycle Assessment (LCA) is a method to support data-driven decision-making in laboratory management. Integrating LCA early in research design enables the identification of environmental hotspots, encourages efficient experimental planning, and supports ecological accountability enabling researchers to identify and minimise overall environmental impact. At the same time, LCA can be resource intensive or rely on unavailable data. Involvement of lab management and/or of the organisation is an important enabler of success. Where there are limitations, it is recommended to apply LCA to the extent it is feasible. This section emphasises the role of LCA in laboratory-scale sustainability and provides suggested actions for applying LCA methodologies across research disciplines.

Key steps for applying LCA in a research context include:

- 1. **Define scope and boundaries**: clarify which life-cycle stages are included (for example: raw material extraction, manufacturing of reagents and equipment, use-phase energy, and waste treatment).
- 2. **Inventory analysis**: collect data on energy and material inputs and outputs for each stage (e.g. electricity consumption of instruments, quantities of chemicals and solvents, volume of water used, and waste generated).
- 3. **Impact calculation**: use recognised environmental impact categories (such as carbon footprint in CO_2-equivalents, freshwater ecotoxicity, or human toxicity) to quantify the environmental burdens of the experiment or process.
- 4. **Interpretation**: identify “hotspots” or steps with the highest impact and explore alternatives. For instance, if ultra-low freezers or autoclaves dominate the carbon footprint, consider more efficient equipment or modified protocols (such as reducing sterilisation frequency where adequate).
- 5. **Software Tools**: to perform these steps efficiently and in alignment with ISO 14040/14044 standards, specialised LCA software is recommended. Widely used tools in academic research include SimaPro (commercial), GaBi and OpenLCA.

Defining system boundaries

Clearly defining system boundaries is essential to ensure that LCA results are meaningful and comparable. In laboratory research, system boundaries should typically include the following stages:

- **Upstream processes**: production of chemicals, laboratory consumables (e.g. plasticware, reagents), and manufacturing of equipment.
- **Use phase**: energy and resource consumption during experiments (e.g. heating, cooling, instrument operation), along with any on-site chemical usage.
- **Downstream processes**: treatment and disposal of waste (e.g. recycling of chemical waste, degradation of products, or final disposal).

The system boundaries of an LCA should align with the specific goals and context of the research project. For example, a bench-scale experiment may warrant a boundary encompassing all stages from reagent synthesis to waste disposal - a cradle-to-grave approach that captures the full life cycle. Conversely, an instrument evaluation might adopt a cradle-to-gate perspective, assessing impacts from raw material extraction through manufacturing, use-phase energy, and decommissioning, without including downstream effects such as product use or disposal beyond the laboratory.

A well-defined and justified boundary ensures that the LCA results are both scientifically robust and practically meaningful, accurately reflecting the real impact of the research activities under evaluation.

Green chemistry

Green chemistry is an area of chemistry focused on lowering the environmental and health impacts of chemical production. At the core are the twelve green chemistry principles, which aim to enhance safety, efficiency, and sustainability in chemistry. They are summarised below.

- **Waste prevention**: plan experiments to minimise by-products and overuse of chemicals. Follow the EU waste hierarchy: avoid creating waste whenever possible, then seek reuse or recycling before disposal. For instance, dispense and store only the exact quantity of reagent needed and design synthetic routes that generate fewer side products.
- **Safer chemicals and solvents**: whenever feasible, substitute hazardous reagents and solvents with lower-toxicity alternatives. Use water or bio-based solvents in place of volatile organic solvents and consult solvent selection guides or eco-impact metrics to make informed choices.
- **Energy-efficient processes**: conduct reactions under mild conditions (ambient temperature and pressure) when possible. Use catalysts or enzyme-mediated reactions to lower energy requirements. For example, microwave or photochemical techniques can shorten reaction times and reduce heating needs.
- **Renewable feedstock**: source materials from renewable or recycled resources rather than petroleum-based inputs. For example, use biomass-derived chemicals or recycled polymers as starting materials, aligning with the principle of using renewable inputs.
- **Maximise atom economy**: choose reaction pathways where most of the input atoms end up in the final product. High atom-economy processes generate less waste by design. Catalytic methods and multi-component reactions are strategies to improve atom efficiency.
- **Scale-down experiments**: perform micro-scale experiments where scientifically valid. Smaller reaction volumes and sample sizes reduce reagent consumption and hazardous waste and often improve safety by limiting the quantity of harmful substances handled.
- **Recycle and reuse**: follow waste management principles. Implement solvent recovery systems (e.g. distillation setups) to purify and reuse common solvents. Clean and reuse glassware or plasticware where possible. Establish take-back or recycling programs for plastics and chemicals through collaboration with organisational services.
- **Design for degradation**: when creating new materials or compounds, prefer designs that break down into non-toxic substances after use. This reduces long-term environmental impact and aligns with the principle of designing chemicals with minimal persistence.
- **Real-time monitoring**: use in-line or on-line analytical techniques (such as FTIR, NMR, or UV-Vis spectroscopy) to follow reactions in real time. This avoids over-processing or repeated trial runs, saving reagents and energy while ensuring optimal control.
- **Safer-by-design**: ensure that new procedures and products are inherently safer for human health and the environment. Minimise use of substances with known toxic or bio accumulative properties, prevent unsafe by-products, and design experiments to avoid extreme hazards.

On sustainable chemistry, see also: https://mediatheque.lindau-nobel.org/recordings/42562

3. Data, hardware and software

Sustainable practices for research data

During the research process, the different types of information generated and used as source for analysis, discussion or calculations that support research findings are known as research data[6]. The data comes from observations, experiments, simulations, surveys, interviews, recording, digitalisation, compilation of existing data and its analysis, among other sources. Moreover, in the digital era, the amount and speed of data generation has been increasing markedly. In this context, issues about data quality, storage, and sharing, among others, become central.

The data lifecycle is shown in Figure 1.

Figure 1. Data lifecycle[7]

6 Research Data Management – UCD Policy. https://www.ucd.ie/history/t4media/Research%20Data%20Management%20Policy.pdf

7 German Council for Scientific Information Infrastructures (RfII): The Data Quality Challenge. Recommendations for Sustainable Research in the Digital Turn, Göttingen 2020, 120 p

Additional environmental challenges associated to research data are related to the increasing need for data storage capabilities, which requires that more data centres are built. These facilities face challenges about greenhouses emissions, water consumption for cooling and electricity generation, vast energy consumptions, and land footprint. Actions on research data sustainability aim to limit some of these effects, whereas sustainability considerations should be embedded across the entire data lifecycle. This includes energy-efficient data collection and storage, minimisation of digital waste, and promoting reuse and sharing to avoid redundant processing and storage. Circular economy principles, such as designing data workflows for reuse and reducing resource consumption, can be useful guides data governance frameworks

The following principles and recommendations can help organisations (managers and IT personnel) improve the sustainability of their practices by acting on research data management.

- Provide researchers access to digital services and infrastructures to assure the availability of sustainable storage systems and establish a data Governance Protocol.
- Encourage effective research data management by creating an enabling framework for researchers to be able to effectively and ethically manage their research data, while ensuring this process is minimally disruptive to the project. Establish clear policies, offer guidance and supervision, provide training, and ensure support wherever necessary.
- Ensure research data compliance with organisational policies and funding/publisher requirements.
- Provide resources, services, expert advice, and technical support to help researchers meet their responsibilities.
- Filter dark data and remove unnecessary information[8]. Examples of dark data include data obtained through various computer network operations but not used to generate insights or support decision-making processes, as well as intermediary files derived from the primary data source during the analysis.
- Implement tape storage promptly if there is a requirement to archive redundant data for an extended duration[9].
- Review information technology data storage policies and migrate infrequently accessed data to modern tape storage solutions or consider their elimination entirely[10].

Additional information for Sustainable data practices for research data is given in the Practical Guide to Sustainable Research Data[11].

Sustainable hardware practices

This section outlines environmentally responsible approaches to the **procurement and disposal of computer hardware** in **research organisations** [*see also the section on procurement below*].

Digitalisation and the increased **adoption of ICT** (information and communication technologies) products and services can play a role in achieving decreased environmental impacts. However, several studies have also addressed possibilities of **negative impacts** of ICT and shown that the actual outcome will depend on the way the adoption is managed[12].

EU publications on the issue notably include the Green Public Procurement Criteria and Requirements[13] related to “Computers, monitors, tablets and smartphones”, as well as “Data centres, server rooms and cloud services”, which can provide relevant guidance on these topics. Additional guidance can be found in the EU publication on Waste from Electrical and Electronic Equipment (WEEE)[14].

8 Dlzar Al Kez, Aoife M. Foley, David Laverty, Dylan Furszyfer Del Rio, Benjamin Sovacool, Exploring the sustainability challenges facing digitalisation and internet data centers, Journal of Cleaner Production, Volume 371, 2022, 133633, ISSN 0959-6526, https://doi.org/10.1016/j.jclepro.2022.133633

9 FAIR data principles: https://www.go-fair.org/fair-principles/

10 Policy Statement on Ensuring Research Integrity in Ireland, Revised Edition 2024. National-Policy-Statement-on-Ensuring-Research-Integrity-in-Ireland-Dec-2024.pdf

11 Tommaso Boccali (National Institute for Nuclear Physics), Anne Elisabeth Sølsnes (Research Council of Norway), Mark Thorley (UK Research & Innovation), Stefan Winkler-Nees (German Research Foundation) and Marie Timmermann (Science Europe), Practical Guide to Sustainable Research Data - Maturity Matrices for Research Funding Organisations, Research Performing Organisations, and Research Data Infrastructures, June 2021, DOI: 10.5281/zenodo.4769703.

12 Hilty, Lorenz M., et al. "The relevance of information and communication technologies for environmental sustainability–a prospective simulation study." Environmental Modelling & Software 21.11 (2006): 1618-1629

13 https://green-forum.ec.europa.eu/green-public-procurement/gpp-criteria-and-requirements_en

14 https://environment.ec.europa.eu/topics/waste-and-recycling/waste-electrical-and-electronic-equipment-weee_en

Environmental impacts of ICT hardware

The environmental impacts of ICT hardware are related to:

- **resource use** for its production: manufacturing of an ever-increasing number of electronic products is resource intensive, accounting for significant extraction of natural resources, often of either rare or hazardous materials and plastics. Moreover, the water consumption for those natural resource's extraction and processing should be accounted for, as well as for the fabrication of the electronic products.
- **energy use** and associated greenhouse gas emissions arising from consumption during use, as well as greenhouse gas emissions from manufacturing, shipment, and disposal of products.
- **electronic waste**: obsolete products often end up in landfills.
- **hazardous chemicals**. Electronics carry heavy metals like mercury, lead, lithium, and other materials like batteries that pollute the air when incinerated or contaminate the ecosystem if thrown into the garbage. Mining of these metals also has major impacts on the environment.

Research indicates that a significant proportion of the environmental impact of laptops/desktops/monitors and other consumer electronic products is associated to the **manufacturing phase**, followed by transport, use and **end of life**[15],[16]. By adopting sustainable procurement choices that help reduce the impacts associated with manufacturing (through procurement choices) and end of life phase for electronic products, organisations can reduce their environmental footprint and promote a broader culture of sustainability.

The main **challenges** to overcome include budgetary constraints, organisational culture, lack of awareness/ expertise in the evaluation of sustainable hardware options, and difficulty in quantifying the impact of action/ inaction related to procurement and end of life.

The following recommendations are mainly aimed at **purchase officers, research group leaders** and **IT department managers** involved in drafting the organisational guidelines regarding procurement choices related to ICT hardware and their end-of-life disposal, as well as those having a **decision-making role** concerning procurement/disposal of hardware related to a specific research project.

Procurement

[*see also section on procurement below*] As a first option, it is recommended to assess if the needs of the researcher/project can be satisfied with hardware already available within the organisation which can be repurposed, or if shared resources exist that can be accessed.

To decrease the environmental footprints of newly bought electronics, prefer environmentally friendly material inputs, energy efficient devices, equipment that can be upgraded, repaired and reused and keep your equipment as long as possible.

Look for the following features or ask suppliers what they can provide:

- eco-labels & certifications, such as:
  - ✓ **EPEAT**[17] (Electronic Product Environmental Assessment Tool), comprehensive of many sustainability criteria at the product and organisational level
  - ✓ **TCO**[18], addressing various environmental and social responsibility criteria throughout a product's life cycle. Their website is also full of current and helpful guidance and resources for sustainable IT.
  - ✓ **Energy Star**[19], indicates that a product uses less energy than at least 75% of available products in the market, in its given product category. Using ENERGY STAR–certified computers has been associated with annual energy savings of up to 25–40% as compared to uncertified models[20].
  - ✓ **RoHS**[21] (Restriction of Hazardous Substances)
- Devices with "smart" or "low power" modes that use less energy when not in use.
- Packaging made of recycled content (ex. recycled metal, postconsumer plastic, ocean- bound plastic) or rapidly renewable materials like bamboo.

15 Arushanyan, Yevgeniya, Elisabeth Ekener-Petersen, and Göran Finnveden. "Lessons learned–Review of LCAs for ICT products and services." Computers in industry 65.2 (2014): 211-234.

16 Ciroth, Andreas, and Juliane Franze. LCA of an ecolabeled notebook: consideration of social and environmental impacts along the entire life cycle. Lulu. com, 2011

17 http://www.epeat.net/

18 https://tcocertified.com/

19 https://www.energystar.gov/

20 European Commission. (2021). Green Public Procurement Criteria for Computers, Monitors, Tablets and Smartphones. https://green-forum.ec.europa.eu/green-public-procurement/gpp-criteria-and-requirements_en

21 https://www.rohsguide.com/

- Indications from suppliers, either through an eco-label or Safety Data Sheet (SDS), that products and components have been manufactured with non-toxic chemicals to ensure they are safe and easier to recycle.

Is the product **durable, upgradeable and/or repairable**? Choose devices with modular designs and available spare parts. Platforms such as iFixit provide repairability scores to help identify user-serviceable model. Ask suppliers if they provide repair services and ask for a long-term repair and maintenance warranty, not a "replace by new" warranty.

Check the supplier's website to see what efforts they have made, such as reducing emissions associated with product manufacturing and transportation, using renewable energy, or setting a science-based emissions reductions target (SBT).

Purchase **used/refurbished** if both possible and adequate to your needs and check out the possibilities offered by professional refurbishing and remanufacturing businesses.

Investigate **product as a service** (PaaS) if suitable. Under PaaS you pay for the use of products while the ownership of the equipment remains with the supplier. As a result, the supplier will aim to keep the equipment running as long as possible by avoiding non-reparable features and planned obsolescence.

End of life

Ensure devices are wiped securely before donation or disposal.

- **Donate usable devices**: functional but outdated devices can be transferred to teaching labs, NGOs, or local schools, promoting both reuse and community engagement.
- **Recycle through certified channels**: recycling electronic components is hard as well as energy and resource-intensive; therefore other avenues should be explored first. When recycling electronics, choose a reputable electronics recycling program to ensure that recycled products are ethically handled. Use university-endorsed e-waste programs or manufacturer take-back services. Many prominent brands offer repair and take-back options for various devices (e.g. Apple, Dell, HP, Samsung, and Lenovo).
- **Dispose of hazardous materials safely: batteries**, cables, and devices with heavy metals should be separated and managed according to organisational and environmental safety standards.

Some websites provide resources and recycling drop-off locations for electronics[22].

Addittional resources:

- https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-fifth-edition-volume-i-chapter-2-solid-waste-0
- https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/5-waste

Training

Consider offering training opportunities on:

- How to identify ecoefficiency equipment.
- Practices to optimise the use of the equipments.
- Applicable regulations
- How to optimise and extend the life of equipments.
- Management, Reuse, Recyling and disposal

Sustainable software practices for AI research

This section focuses on the adoption of environmentally responsible approaches throughout the lifecycle of artificial intelligence (AI) software development, deployment, and maintenance. As AI becomes increasingly integral to various sectors, its environmental footprint, particularly in terms of energy consumption and carbon emissions, has garnered significant attention.

The rapid advancement and deployment of AI models, especially large-scale ones, have led to substantial energy demands. Training state-of-the-art AI models can consume vast amounts of electricity, contributing to increased greenhouse gas emissions and straining existing power infrastructures[23].

Moreover, the operational phase of AI models, encompassing inference and real-time data processing, also contributes to ongoing energy usage. As AI applications become more pervasive, the cumulative energy required for their continuous operation creates sustainability challenges[24].

In response to these concerns, the concept of "Green AI" has emerged, advocating for the development of

22 https://www.return-it.ca/electronics/recycling/ - https://recyclemyelectronics.ca/

23 Luccioni, A. S., Viguier, S., & Ligozat, A. L. (2023). Estimating the carbon footprint of bloom, a 176b parameter language model. Journal of Machine Learning Research, 24(253), 1-15

24 Strubell, E., Ganesh, A., & McCallum, A. (2020, April). Energy and policy considerations for modern deep learning research. In Proceedings of the AAAI Conference on Artificial Intelligence (Vol. 34, No. 09, pp. 13693-13696)

AI systems that are not only effective but also energy-efficient and environmentally friendly[25]. This approach emphasises the importance of considering energy consumption and carbon footprint as primary metrics alongside traditional performance indicators.

Supporting sustainable software practices in AI research

Supporting sustainable software practices in AI research involves several strategies:

- **Energy-efficient algorithms**: promote the design and/or use of algorithms that require less computational power on sufficient performance levels, as appropriate for the task, rather than unnecessary overperformance. A shift toward sufficiency helps prevent rebound effects that can arise when efficiency gains lead to increased overall consumption.
- **Model optimisation**: promote techniques such as model pruning, quantisation, and knowledge distillation to reduce model size and complexity, thereby lowering energy requirements while ensuring performance remains adequate for the intended purpose.
- **Efficient infrastructure**: leverage hardware and cloud services optimised for energy efficiency, and use data centres powered by renewable energy sources.
- **Monitoring and reporting**: track energy consumption and carbon emissions associated with AI workloads to identify areas for improvement and promote transparency[26].
- **Use assessment**: equip researchers with the skills to evaluate or re-evaluate whether a large AI model, or AI solution, is indeed needed for a given task. In some cases, simpler computational methods or non-AI alternatives may provide sufficient outcomes with a fraction of the environmental footprint.

By integrating these practices, researchers and their organisations can mitigate the environmental impact of AI technologies, contributing to broader sustainability goals and ensuring that the advancement of AI aligns with ecological considerations.

Training opportunities

Equipping researchers and developers with the necessary knowledge and skills is key to successfully implementing sustainable AI practices. Training should cover both the environmental impacts of AI and practical steps to reduce them.

- **Understanding environmental impacts of AI systems**: offer seminars or webinars focused on the carbon footprint of AI, including lifecycle assessments of training and deployment stages23, 25.
- **Green software engineering principles**: deliver workshops on green software development, including efficient coding practices, algorithm selection, and profiling energy consumption[27],[28].
- **Using monitoring tools**: provide hands-on training for sustainability tracking tools such as CodeCarbon, CarbonTracker, and Green Algorithms to enable evidence-based decisions on AI energy use.
- **Sustainable data handling**: educate research teams on strategies for data minimisation, storage lifecycle planning, and avoiding unnecessary duplication to reduce emissions linked to data management[29].

Examples of training resources

- ✔ https://greensoftware.foundation/
- ✔ https://github.com/mlco2/codecarbon
- ✔ https://www.green-algorithms.org/
- ✔ https://github.com/samuelrince/awesome-green-ai

Community engagement

- Launch a sustainability challenge for AI teams to reduce model training emissions
- Feature lab success stories in organisational newsletters
- Collaborate with IT teams and data center operators to align infrastructure with green AI practices

25 Schwartz, R., Dodge, J., Smith, N. A., & Etzioni, O. (2020). Green AI. Communications of the ACM, 63(12), 54-63

26 Lacoste, A., Luccioni, A., Schmidt, V., & Dandres, T. (2019). Quantifying the carbon emissions of machine learning. arXiv preprint arXiv:1910.09700. https://doi.org/10.48550/arXiv.1910.09700

27 Agrawal, K., Goktas, P., Sahoo, B., Swain, S., & Bandyopadhyay, A. (2024, December). IoT-based service allocation in edge computing using game theory. In International Conference on Distributed Computing and Intelligent Technology (pp. 45-60). Cham: Springer Nature Switzerland.

28 Hilty, L. M., Arnfalk, P., Erdmann, L., Goodman, J., Lehmann, M., & Wäger, P. A. (2006). The relevance of information and communication technologies for environmental sustainability–a prospective simulation study. Environmental Modelling & Software, 21(11), 1618-1629

29 Coroama, V. C., & Hilty, L. M. (2014). Assessing Internet energy intensity: A review of methods and results. Environmental Impact Assessment Review, 45, 63-68

Sustainable practices for computational (non-AI) research & general-purpose computational IT service use

The topic of Sustainable Practices for Computational (non-AI) Research & General-Purpose Computational IT service use is about quantifying the **environmental impact of computational research**, creating a culture of **sustainability awareness** in computational research, and promoting adoption of efficient approaches to reduce the impact of computational IT service use.

The construction of **digital twins**, i.e. computational models of physical systems to test their responses in silico, can be a powerful strategy to harness digitalisation for improved research sustainability, although the quantitative evaluation of the net impact of the actual implementation can be complex. The evaluation of the sustainability opportunities is application dependent. Measuring the net-impact of implementing digital twin solutions in reducing and avoiding greenhouse gas emissions across different sectors is covered by the guidance and science-based methodologies released by the European Green Digital Coalition and will therefore not be further expanded here [30].

Modelling, simulations and computer-assisted analysis have accelerated several branches of research, from computational chemistry for materials science and drug design, to large scale linguistic text analysis. Progress is enabled by access to ever-increasing computational power, also through local and regional/national **High-Performance Computing** (HPC) facilities. More broadly, accurate monitoring of the environmental impacts of **data analysis** is a key condition for sustainable research, as computational algorithms increasingly require more hardware and energy resources.

The following guidelines aim to minimise the environmental impact of computational research through:

- **Measurement** of the carbon footprint of computational jobs; and
- **Green computing** principles;

Computational research can also have positive emissions impact, for example by supporting the development of new energy storage technologies or by running the climate models that are used to provide evidence for setting emissions reductions policies and targets across the world. The emissions reductions from such activities are difficult to quantify. At the time of writing, these are typically not factored into the emissions estimates for computational research.

Recommendations

- Adopt accurate and transparent estimations of PUE of computational facilities, such as making reference or implementation of relevant ISO/IEC standard[31].
- Provide training on green computing practices to interested researchers and IT support staff.
- Clearly advertise available licensing options and access to commercial software, to avoid duplication.
- Promote open science principles in computational research via training opportunities and through access to sustainable computing infrastructure.

Training

Training on green computing, including HPC systems usage and comparison between different programming languages:

- ✔ https://www.archer2.ac.uk/training/courses/250513-green-computing/
- ✔ https://www.softwareimprovementgroup.com/publications/complete-guide-to-green-computing/

Additional resources

- The European Green Digital Coalition is an initiative of companies, supported by the European Commission and the European Parliament, which aims to harness the enabling emission-reducing potential of digital solutions to all other sectors.
- The Green Software Foundation promotes **carbon-aware coding** to reduce the operational carbon footprint of the software.
- The Green Algorithms project aims at promoting more environmentally sustainable computational science. It regroups calculators that researchers can use to estimate the carbon footprint of their projects, as well as find tips and training material on environmentally friendly practices.
- The Software Sustainability Institute developed **Green DiSC**, a new certification framework for organisations and researchers which provides a roadmap for research groups and organisations who want to tackle the environmental impacts of computing activities.
- The Green DiSC certification framework for organisations and researchers.

30 https://digital-strategy.ec.europa.eu/en/news/measuring-impact-digital-solutions-climate

31 I. S. O./I. E. C. 30134-2:2016(en), Information technology—Data centres—Key performance indicators—Part 2: Power usage effectiveness (PUE), https://www.iso.org/obp/ui/#iso:std:iso-iec:30134:-2:ed-1:v1:en

4. Green procurement, facilities and infrastructure

Procurement

In research organisations, procurement represents a key operational function, determining what is acquired, from which sources, and under which environmental considerations. As such, it is not a neutral process; each purchasing decision carries embedded environmental impacts in terms of resource use, emissions, and waste across the life cycle of goods and services.

Green procurement consists in a process whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life cycle when compared to goods, services and works with the same primary function which would otherwise be procured. It serves as a strategic lever for enabling organisational sustainability transitions in higher education and research. As potentially large public procurers, universities and research organisations are well positioned to drive environmental responsibility through the way they purchase goods, services, and infrastructure, across areas as diverse as research infrastructure, digital platforms, teaching materials, energy systems, and campus services.

Integrating sustainability and circular economy principles in these procurement processes not only contributes to the Sustainable Development Goals (SDGs), but also reduces environmental impact, stimulates innovation, and aligns with the broader societal transition toward a green economy.

This document outlines how environmental sustainability can be comprehensively embedded in organisational procurement. It should always be read in conformity with applicable norms and of the latest legislative developments. Useful concepts with regard to procurement can be found in environmental systems thinking and life cycle assessment (LCA) principles [*see also section 2 above*], aiming at ensuring that decisions are better aligned with the full spectrum of upstream and downstream environmental impacts. Moreover, life cycle costing (LCC) can be a complementary decision-support tool to promote both sustainability and long-term financial responsibility.

Foundations of sustainable procurement

Procurement in organisations performing research is complex and multifaceted. Needs arise from:

- Research organisation infrastructure, buildings – including for the campus in the case of universities, maintenance, utilities, offices, sports equipment,
- Research and innovation equipment, consumables, labs, databases,
- In the case of universities and certain organisations, learning and teaching (digitalisation, learning platforms, student services),
- Strategic operations (HR, mobility, ICT, catering, printing, etc.).

Choosing goods, services and works that generate lower environmental impacts across their lifecycle — instead of defaulting to the lowest upfront cost — enables organisations to align their operations with long-term climate and sustainability objectives. Such procurement can also enable financial savings, enhance resilience (e.g., to supply chain risks in cases of circular procurement), and can generate reputational benefits.

Principles

The following principles are designed to help organisations implement green procurement practices effectively:

- **Procurement as a systemic lever**: sustainable procurement operates at the intersection of operational needs and environmental responsibility. In research organisations - where laboratory equipment, infrastructure, IT, and consumables are continuously procured - guiding these decisions through environmental criteria offers an immediate pathway to reducing organisational environmental burdens.
- **From unit pricing to life cycle impact and value**: while financial cost remains a valid consideration, it important for organisations to evaluate the total value and environmental impact of their procurement choices. This means shifting the evaluation logic away from short-term unit pricing and toward:
  - ✓ **Life Cycle Assessment (LCA):** to determine

environmental trade-offs and impacts across all life stages. Align procurement strategy with LCA principles and reference international standards (e.g., ISO 14040, ISO 14044).
  - **Life Cycle Costing (LCC):** to assess the full cost of ownership, including energy use, maintenance, upgrades, and disposal.

  When used together, LCA and LCC allow organisations to make decisions that account for the full environmental impact of a product or service, from raw material extraction to end-of-life disposal. This is a core principle of green and circular procurement and supports the organisation's leadership in the green transition.
- **Internal alignment with organisational priorities**: procurement reflects the organisation's environmental vision and strategic goals. If an organisation declares commitments to sustainability, climate neutrality, or responsible consumption, these values should be embedded structurally in procurement practices and procedures.

Going further: key concepts for sustainable procurement

- **Life Cycle Assessment (LCA) as a scientific foundation**: such an approach requires to consider the full life-cycle environmental impacts of a procurement decision. These impacts include:
  - Raw material extraction and manufacturing emissions,
  - Use-phase energy and resource consumption,
  - Durability, maintenance needs, and repairability,
  - Disposal or recycling options at end-of-life.

  A key part of the process is to integrate third-party declarations (e.g., environmental product declarations) or credible documentation of life-cycle performance into the procurement process. However, difficulties may arise when suppliers do not have the resources to support individual LCA assessments of each product, while no widely recognised and transparent third-party declarations may be available. In the absence of these, purchasers can still engage overall suppliers on the carbon reduction plans.
- **Resource efficiency and demand justification**: evaluate procurement activities in light of organisational needs and requirements. Before purchasing:
  - Assess whether existing resources can meet the demand,
  - Explore sharing, pooling, or refurbishment options,
  - Purchase in bulk or reusable formats (e.g. refillable bottles instead of single-use containers),
  - Avoid duplicate acquisitions across departments.
- **Circular economy thinking**: in your procurement policies, consider following the R-ladder of circularity strategies, beginning with 'refuse and rethink'. In cases where procurement cannot be avoided, it is recommended to favour:
  - Long-lasting and upgradable designs,
  - Products with modular components and extended warranties, as well as commitments for providing parts for full life span of equipment,
  - Asking bidders to submit data on the product's energy and material use across its life cycle
  - Suppliers who offer reuse, leasing, product-as-a-service, or closed-loop solutions.
- **Functional and performance-based requirements**: design procurement specifications to describe performance needs and desired environmental outcomes rather than prescriptive product details, encouraging innovation and allowing suppliers to present more sustainable solutions.
- **Integrated procurement systems**: to ensure effectiveness, embed sustainability in:
  - Organisational procurement policies,
  - Tender documentation and contract language,
  - Evaluation criteria and scoring mechanisms,
  - Supplier selection and monitoring procedures.

Domain-Specific Recommendations

Scientific equipment and research infrastructure

- To the extent possible, apply LCA-informed analysis and cost-performance reviews when acquiring high-impact technical assets.
- Integrate lifecycle thinking by prioritising durability, reparability, and end-of-life recyclability of products. Engage suppliers that offer take-back schemes, leasing models, or product-as-a-service options.
- Where feasible, use LCC to compare options across energy, consumable inputs, service life, and end-of-life costs.
- Encourage interdepartmental coordination and equipment sharing systems to reduce unnecessary duplication by creating organisational systems for redistribution, reuse, or refurbishment of research equipment.
- Prioritise needs-based purchasing to avoid overconsumption. Assess whether existing resources

can be reused, shared, or refurbished before acquiring new goods or services.

Building materials and infrastructure

- Require environmental performance information for construction materials, including embodied carbon, recyclability, and documented environmental impact.
- Adopt procurement specifications that reward both environmental quality (LCA) and long-term economic performance (LCC) of construction systems.
- Include circular design and deconstruction clauses in infrastructure contracts
- Facility services and utilities [*see also dedicated sections below*]
- Include environmental performance targets in cleaning, waste management, lighting, heating, and other contracts.
- Consider bundled service contracts with shared targets for emissions reductions or energy savings.
- Evaluate bids using both LCA-aligned environmental outcomes and lifecycle financial costs.

Consumables and operational goods

- Establish minimum environmental quality thresholds (e.g., eco-certification, low toxicity, recycled content) for high-volume consumables.
- Use LCA or simplified product footprint data where available to prioritise procurement of low-impact or circular alternatives.
- For repeat procurement, evaluate supplier performance and cost over time using an LCC framework.
- Consolidate procurement across organisational units to generate synergies in transport and disposal logistics, reduce costs, and avoid duplication of efforts.

Organisational mobility and transport

- Set emissions reduction goals within vehicle procurement strategies and transport-related service contracts.
- Evaluate vehicle options using well-to-wheel emissions profiles (aligned with LCA) and total operating costs (LCC).
- Consider shared mobility or fleet electrification approaches supported by infrastructure upgrades.

Strategic Framework

Enhance procurement planning and needs assessment

- Only buy when needed. Introduce mandatory needs assessments and encourage reuse, sharing, or repair before initiating new procurement.
- Include lifecycle cost assessments and Total Cost of Ownership (TCO) models in procurement planning to evaluate environmental and financial impacts over time.
- Anticipate sustainability-related needs early in the procurement process by engaging sustainability staff, researchers, and end-users during the planning phase.

Engage in collaborative procurement

- Work with other local research performing organisations in joint procurement.
- Leverage consortia to negotiate greener frameworks or sustainability clauses.
- Where purchasing alone and without joint exercises, ensure that the organisation uses the same language regarding sustainability as others, to provide collective pressure on suppliers.

Prioritise procurement with green criteria

- Integrate environmental objectives into organisational procurement strategies. Procurement should not be an isolated administrative process, but a strategic tool aligned with the organisation's sustainability goals.
- Adopt organisation-wide green procurement policies that are supported by leadership and embedded in procurement manuals, templates, and checklists.
- Consider mandating the use of environmental criteria in tender specifications, award criteria, and contract performance clauses across all departments and procurement categories.

Empower procurement teams and build capacity

- Professionalise procurement staff and provide targeted training on sustainable procurement, EU green criteria, and circular economy practices.
- Foster internal collaboration between procurement officers, sustainability coordinators, researchers, and facilities teams.
- Support innovation procurement, allowing staff to experiment with sustainability-oriented approaches and supplier dialogues (e.g. market consultation or pre-commercial procurement).

Streamline legal and procedural flexibility for

green criteria

- Use the full breadth of possibilities offered by applicable legislation on procurement, notably regarding:
  - Environmental award criteria (e.g. energy efficiency, emissions, recyclability)
  - Life-cycle costing
  - Supplier qualifications related to sustainability
  - Innovation partnerships for new green solutions
- Avoid over-standardisation and over-emphasis on lowest price.
- Clarify internal rules and guidelines for applying environmental and social clauses in a legally robust and consistent manner.

Strengthen governance and accountability

- Create oversight structures (e.g., a green procurement taskforce or sustainability committee) to monitor and steer procurement practices.
- Develop clear sustainability performance indicators (KPIs) and monitor progress in sustainable procurement across departments and projects.
- Ensure transparency by publishing green procurement goals, indicators, and outcomes, and including them in organisational sustainability reporting.

Foster a culture of sustainable procurement

- Communicate the purpose and value of green procurement across the organisation's community.
- Celebrate success stories of sustainable purchasing and supplier partnerships.
- Encourage behavioral change among researchers, academics, and administrative staff through awareness campaigns, internal guidelines, and incentives for responsible consumption.

Organisational Implementation and Governance

Governance and coordination

- Establish cross-functional teams to oversee implementation, including procurement, sustainability, facilities, finance, and academic stakeholders.
- Integrate sustainability responsibilities into the existing procurement chain of command.

Capacity building and support

- Provide dedicated training to procurement officers and project managers on integrating LCA and LCC principles.
- Develop internal guidelines that translate scientific environmental principles into procurement criteria.

Supplier engagement

- Organise supplier dialogues, open market consultations, and innovation challenges to inform the market of sustainability goals and to receive feedback on feasibility.

Monitoring and reporting

Define and track indicators such as:

- Percentage of tenders requiring environmental documentation,
- Estimated environmental impact reduction per procurement category,
- Cost savings and avoided impacts from reuse and extended product life.

Results should be transparently reported and integrated into organisational sustainability progress monitoring.

Additional resources

- European University Association: "The green transition at universities: public procurement as a powerful tool": https://www.eua.eu/our-work/expert-voices/the-green-transition-at-universities-public-procurement-as-a-powerful-tool.html
- Science Europe: "Survey Report: Appraising Greenhouse Gas Emissions of Research Organisations": https://www.scienceeurope.org/our-resources/survey-report-greenhouse-gas-emissions/

Facilities

Facilities can be defined as utilities and services such as heating, water, electricity, wastewater, cooling, cleaning and maintenance (see e.g. here and here).

This section addresses facilities as they relate to research processes and provides recommendations as to how organisations can support the efforts of research teams to reduce their environmental impact with respect to the use of utilities and services in the course of a research project.

Research practices involving facilities are considered for three key phases: Planning, Operation, Decommissioning/ Close-out.

Planning phase

- Consider environmentally sustainable renovations (e.g. insulating buildings, installing heat pumps) and ensure the energy installations (e.g. electricity) are up to standard, especially for old buildings.
- Adhere to an Environmental Management System (EMS), ideally independently certified.

Operational phase

- Implement an Environmental Management System (EMS).
- Adopt and promote environmentally friendly practices to reduce energy consumption e.g. switch off heating in the weekends, green cleaning.
- Reduce temperature of freezers and fridges where possible.
- Optimise space and building use.
- Consider the use of smart technology (sensors) for auto controls of lights, heating and cooling.
- Ensure computer servers and in adequate buildings and or re-use the heat of computer server rooms to warm up hot water.
- Evaluation of carbon footprint can also be used to identify the main areas for improving existing practices.
- Consider how facilities can enable, or be harmonised with, teleworking, for example running heating on specific days when everyone is at the office.
- Decarbonise energy and heat using alternative renewable sources.
- Consider generating own solar or wind energy or joining a local cooperative who is doing so.
- Consider energy and heat storage to eliminate wastage.
- Use technologies such as digital-twin modelling to support decision making and provide the most efficient decarbonisation outcomes.
- Secure sky water from roofs, in order to reduce dependence from city water (e.g. for sanitary purposes, irrigation of greenhouses)

Decommissioning/Close out

- Consider adapting or repurposing existing facilities or installations to service new projects. This will reduce waste and redundancy.
- Coordinate with research teams in advance of the project end date to plan the closeout phase. If long term storage or samples, materials under specific conditions or data is required post project, ensure that the duration is clearly defined and that volumes are minimised. [*see also section on data management*]
- Consider efficiencies trough shared facilities and spaces.

Infrastructure

In this section, infrastructure is looked at on the organisational level and refers to the planning, construction, and management of physical infrastructure, including buildings, fixed installations and generally permanent structures at research organisations). This section does not address technical infrastructure used in specific research areas.

Infrastructure plays a major role in organisations' greenhouse gas emissions and broader environmental impact. Globally, the building and construction sector accounts for 37% of global emissions – more than any other sector[32]. In the EU, this number was 35% in 2021[33]; the EU is pursuing greening of its buildings sector, notably through the Energy Performance of Buildings Directive[34] and the Energy Efficiency Directive[35], with the aim to "achieve a highly energy efficient and decarbonised building stock by 2050[36]."

Moreover, green procurement is an essential aspect of the sustainable transformation of research and higher education [*see section on procurement above*].

The recommendations below mainly apply to organisations, which are directly in charge of infrastructure. However, research groups and individual researchers can play a role in encouraging and supporting their organisations to implement more environmentally friendly measures.

The following recommendations consider the distinct phases of Planning, Operation, and Decommissioning of infrastructure.

32 https://www.unep.org/resources/report/building-materials-and-climate-constructing-new-future

33 https://www.eea.europa.eu/en/analysis/indicators/greenhouse-gas-emissions-from-energy

34 Directive (EU) 2024/1275 of the European Parliament and of the Council of 24 April 2024 on the energy performance of buildings (recast).

35 Directive (EU) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on energy efficiency and amending Regulation (EU) 2023/955 (recast).

36 https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings/energy-performance-buildings-directive_en

Planning phase

- Consider running and promoting sustainability schemes such as LEED, BREEAM, DGNB.
- Engage in securing certifications at the time of planning or renovating infrastructure.
- Promote sustainable building certification to set clear example of expectation for sustainability operation phase.
- Encourage green commuting (e.g. by installing bike parking and showers) and hybrid working to reduce energy demand
- Facilitate the involvement of end-users (i.e. research community) by providing guidance on how the infrastructure will be used and by whom and for what duration
- The developer team within the organisation should be made aware of applicable legislation (see notably the Energy Performance of Buildings Directive and its transposition under national law) and make sure planners (architects, engineers, etc.) and afterwords contractors understand their obligations.
- Integrate sustainability principles within smaller refurbishing projects as well as larger ones (see e.g. https://www.cisl.cam.ac.uk/about/entopia-building).

Operational phase

- Implement an Environmental Management System (EMS) [*see also section on Facilities*]
- Ensure consistent maintenance and upgrades as necessary
- Organise for data capture and evaluation of carbon footprint as well as water consumption, to set benchmarks and improve future decisions.
- Raise awareness of how sustainability was considered in the design and planning of infrastructure and how these decisions can enable sustainable usage

Decommissioning

- Consider sustainable reconstruction and material reuse or re-/upcycling.
- Add end-of-life thinking into all capital project plans.

Green procurement, facilities & infrastructure in practice: additional examples and resources

- **Environmental management system**: the EU's Eco-Management and Audit Scheme (EMAS) offers not only the management system itself but also additional resources and case studies https://green-forum.ec.europa.eu/emas_en
- **Wageningen University (WUR), Netherlands** https://www.wur.nl/en.htm has implemented several strategies to make its research more sustainable. WUR integrates sustainability across various disciplines to ensure that research projects consider environmental, social, and economic impacts. The campus is designed to be highly sustainable, with energy-efficient buildings, renewable energy sources like solar panels, and green spaces that promote biodiversity, in order to achieve 80% climate neutrality. WUR focuses on reducing energy consumption and optimising resource use in its research facilities. This includes using energy-efficient equipment and implementing waste reduction strategies. The university promotes circularity in its operations, aiming to minimise waste and maximise the reuse of materials. This includes comprehensive recycling programs and sustainable procurement practices.
- **UK Research and Innovation** as an organisation has developed a net-zero target for 2040, which was published via its Environmental Strategy in 2020. It is currently working to renew this strategy in 2025. To support this, UKRI has been reporting on its own direct (scope 1) and indirect (scope 2) emissions from UK operations, plus UK business travel (scope 3) for over five years. The reporting of its emissions is managed through an environmental data platform, which allows it to map its performance against the UK's Greening Government Commitments (GGC). It reports on its progress annually through its Annual Report. https://www.scienceeurope.org/our-resources/survey-report-greenhouse-gas-emissions/
- The collection of data for the carbon footprint calculation of the **Luxembourg National Research Fund** was based on a data structure provided by external technical experts. However, data collection itself was carried out by FNR staff and co-ordinated by the sustainability project team. This combination of using external technical advice when required for specific analyses, while performing the data collection and follow-up internally, enabled a high quality of assessment, active staff engagement and considerable control over the process for the FNR. https://www.scienceeurope.org/our-resources/survey-report-greenhouse-gas-emissions/

- At the **Foundation for Science and Technology in Portugal, FCCN** has conducted an internal pre-assessment questionnaire, gathered suggestions for new practices to be implemented, and developed an environmental policy based on 14 principles of commitment. https://www.scienceeurope.org/our-resources/survey-report-greenhouse-gas-emissions/
- The **Swedish Research Council for Sustainable Development** recently conducted an environmental assessment to identify its direct and indirect, positive and negative environmental impacts. Using the findings from this assessment, it developed its environmental policy, goals, and action plan for the period 2024–2027. https://www.scienceeurope.org/our-resources/survey-report-greenhouse-gas-emissions/
- The **Research Council of Norway** has been certified as an Eco-Lighthouse since April 2016. On sustainability, the following focus areas have been selected: procurement, energy use, travel/transport, waste management, and working environment.
  - During the eight years RCN has been certified and focused on the en¬vironment, it has improved at waste sorting, energy consumption has decreased, and 82% of its suppliers are now environmentally certified.
  - A focus for RCN is transport, especially air travel. It has a strict travel policy [*see section on travel above*], and it has invested in better equipment for digital meetings and video conferences. https://www.scienceeurope.org/our-resources/survey-report-greenhouse-gas-emissions/
- The sustainable management of the **FWO** building falls under the internal Climate Plan of the Flemish government, which foresees a reduction of 55% in CO2 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. https://www.scienceeurope.org/our-resources/survey-report-greenhouse-gas-emissions/
- **Entopia** – the headquarters of the Cambridge University of Sustainability Leadership – have been retrofitted in a sustainable way, achieving "radical" energy savings and other environmental benefits "at a cost that is competitive to a conventional office refurbishment". https://www.cisl.cam.ac.uk/about/entopia-building
- At the **University of Galway, Ireland** the Research Community and the University Operations Teams as well as the University Leadership and others work closely together on joint initiatives to integrate sustainability into education, into education, research, leadership, operations, and community engagement. The Community and University Sustainability Partnership (CUSP) at the University is a multi-disciplinary, voluntary team of students, staff, and community partners working together to optimise sustainable practices across the campus. The research led teaching model is seen as a key enabler in realising the University's commitment to embed sustainability across all educational programs (see Teaching & Learning - University of Galway). The main University of Galway campus acts as a living laboratory for sustainable research. Newer campus buildings incorporate numerous new and existing green-building initiatives. Data is gathered on these initiatives from embedded sensors allowing the monitoring of structural and energy performance. This data is used in undergraduate teaching and research.
- 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 Center, 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 heat recovery system 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. https://www.scienceeurope.org/our-resources/survey-report-greenhouse-gas-emissions/
- **On waste disposal**: see e.g. https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-fifth-edition-volume-i-chapter-2-solid-waste-0; https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/5-waste

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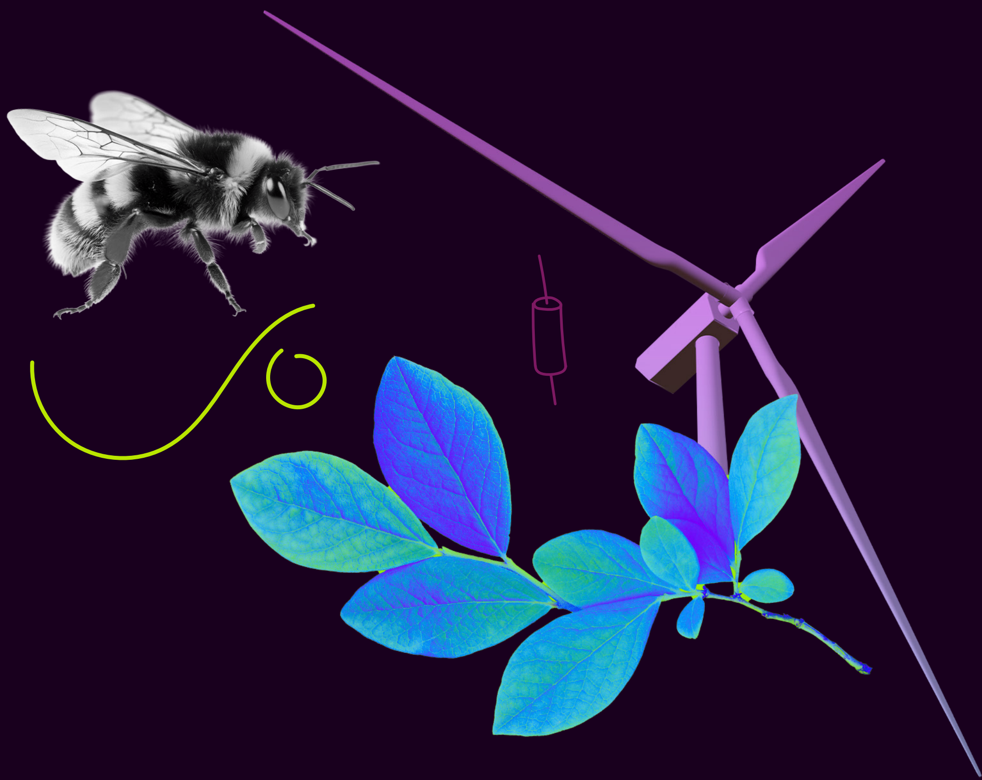

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