

Green Lab Guide

Improve your lab's ecological footprint



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Faculty of Medicine - Version

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PRELIMINARY REMARKS

Laboratories are essential for both research and education, serving as hubs of innovation and discovery. In educational settings, laboratories provide students with hands-on experience, allowing them to apply theoretical knowledge to real-world scenarios. For researchers, laboratories are critical for conducting experiments, developing new technologies, and advancing scientific knowledge across disciplines. Additionally, they foster a collaborative environment where students, faculty, and researchers work together.

Laboratories require an abundance of resources. A laboratory consumes approximately ten times more energy and four times more water in comparison to office space¹. One study revealed that in 2014, laboratories worldwide produced approximately 5.5 million tons of plastic waste². A -80°C freezer uses the same amount of energy as a single-family home. These resource demands significantly affect the environment.

Sustainability and environmental issues are becoming more and more relevant when it comes to applying for research funding. In acknowledging the environmental impact of academic research, the German Research Foundation (DFG), for example, has put forth a Sustainability Guide and those applying for grants must submit a sustainability statement as part of the review process.

This guide includes practical guidance on how to work in a more environmentally friendly way in your laboratory and beyond. The Green Lab Guide provides information, recommendations and a checklist for the following key areas:

- Waste management
- Purchasing
- Energy use
- IT
- Green chemistry
- Research methodology and design
- Information dissemination

Following these recommendations should reduce energy and water consumption without sacrificing research quality or output. As not all labs use the same materials, users of this guide should adopt and adapt the recommendations according to specific circumstances.

The Green Lab Guide is updated on an ongoing basis. We are always on the lookout for further topics and best practice examples. If you would like to add something, please contact umweltschutz@tu-dresden.de.

WASTE MANAGEMENT

Effective waste management minimizes environmental impact, reduces pressure on landfills, promotes the safety of lab personnel, and ensures compliance with regulations. Proper sorting of contaminated and non-contaminated waste, avoidance of single-use plastics, and promoting reuse are key strategies that reduce waste and conserve energy and resources.

Common sources of waste in labs include single-use plastics, a high amount of packaging waste and paper use. Minimizing waste creation prevents waste generation rather than managing it post-production. To avoid waste, laboratories should prioritize using glass beakers and containers over plastic. Regular waste audits in laboratories help identify types and quantities of waste generated, highlighting areas for improvement. By categorizing and analyzing waste, laboratories can uncover trends and opportunities for waste reduction and better management practices.

Keeping inventories up to date prevents over-purchasing and reduces waste by ensuring only necessary materials are bought and used. Update lists regularly (Excel, LabUtils, GOECHEM), utilize digital tracking systems for real-time stock monitoring, and implement a "first-in, first-out" policy to prevent expiration and unnecessary disposal.

The University Hospital Dresden runs a furniture kiosk (<https://carusnet.med.tu-dresden.de/Service/Verwertung/moebelkiosk>) for furnishing office workstations. Furniture and office equipment which is no longer needed can be donated here, or you can collect furniture for your own use.

Waste disposal at the Faculty of Medicine is carried out in accordance with the University Hospital Dresden waste disposal guidelines. These stipulate that non-hazardous waste must be separated according to waste type. Safe disposal of hazardous waste such as chemicals, genetically modified organisms, and medical waste is crucial due to the increased expense incurred and risks these materials pose to health and environment. Autoclaving to inactivate microorganisms minimizes the risks associated with hazardous materials. Sterilization occurs through the use of steam, moisture, heat (at least 121°C) and pressure (105 kPa for a minimum of one hour). Compared to incineration, autoclaving reduces air pollution and is more efficient ³. The use of autoclaving is mandated for specific types of waste.

Chemicals must never be disposed of down drains. Proper disposal of chemicals requires using labeled containers (detailing what it contains or had contained). Due to the high costs of disposing of hazardous waste, non-hazardous waste should not be mixed with hazardous.

The Hospital Ecology team, especially the Waste Management Officer of the University Hospital Dresden, is happy to advise you on waste disposal at any time.

PURCHASING

Sustainable procurement guides the selection of products and services aligned with environmental goals. When choosing between products, priority is placed on firms that manufacture using sustainable practices, local firms to reduce carbon emissions resulting from delivery, and products that result in minimal waste or in recyclable materials. For example, pipette tips can be ordered in bulk and then placed in boxes.

Strategic purchasing

Carefully planned purchasing results in money saved and reduces waste and energy expenditures. Consider gathering several requests to one firm into one order, thereby reducing the monetary and environmental costs of delivery. Items sent with dry ice that are bought and shipped together net considerable savings. Maintain inventories to avoid accidental redundancies. If you notice expired products, consider buying these in lesser quantities in the future. Products with shorter lifespans might cost less initially, but they need to be replaced rapidly. This increases the total costs and generates additional waste.

Certifications

Energy efficiency ratings and labels make it possible to assess whether a device is environmentally friendly. The EU energy labels for devices give a letter rating of A to G with an A label being the most energy efficient. Although repairing old equipment reduces waste, purchasing new might substantially reduce energy costs. Germany awards the Blue Angel (Blauer Engel) seal for products and services deemed particularly environmentally friendly. The EU Ecolabel is the European Union's equivalent environmental label.

ENERGY USE

In laboratories, ventilation, exhaust systems, and electrical devices consume 3-5 times more energy than in offices. Therefore it is important to reduce energy use and to implement measures increasing energy efficiency. By identifying inefficiencies such as outdated equipment or unnecessary off-hour usage, labs can conserve resources, minimize their environmental footprint, and lower operational expenses.

Lighting

Lighting accounts for 15% of total lab electricity use.³ This is approximately twice as much as in office space. Use daylight as the primary light source and supplement using electric lighting. Design workplace lighting so that it illuminates specific tasks effectively. This accomplishes greater energy efficiency than general overhead lighting. When an area is unoccupied, make sure to switch off the lights.

Fume hoods and biosafety cabinets

Fume hoods and biosafety cabinets require substantial energy to function. A single fume hood uses nearly as much energy as 3,5 homes.⁴ Fume hoods utilize powerful fans to pull conditioned air in from in front of the hood for release outside. Keep the sash of the hood closed unless performing experiments within the cabinets. Shutting the sash reduces the amount of air volume drawn from the room and protects lab members from chemical exposure and hazardous materials in the hood. That said; do not conserve energy at the expense of safety.

Cold Storage

Ultra-low temperature (ULT) freezers normally operate at either -40°C or -80°C, accounting for the largest expenditure of energy in a lab⁵. These freezers, especially the older models, consume around 25-30 kWh energy a day. An adjustment from -80°C to -70°C cuts electricity by 30%³. This adjustment usually does not affect the quality or the viability of biological samples.

To reduce the need for more freezers, periodically assess the materials stored and eliminate any unneeded reagents or samples. However, be aware that a full freezer operates with greater efficiency than one that is almost empty. Maintaining organization in freezers reduces the amount of time that freezer doors remain open.

Ice formation limits freezer space and efficiency. Moreover, a build-up of dust on the exterior coils causes the freezer to work harder to maintain a stable temperature. Regular coil cleaning and freezer defrosting improves energy efficiency while also extending the life of the device.

Other electric equipment

Use of equipment such as ovens, heating blocks, and centrifuges, requires reaching a specific temperature which often can be achieved in 20 to 40 minutes. Maintaining this temperature, however, consumes a significant amount of energy. Do not turn on until ready to use.

By turning devices off when not in use, you can save up to 10 kWh / day ⁵. Alternatively, consider using an energy-saving, stand-by mode when the equipment is not in use.

Autoclave efficiency

The most common, reliable, and cost-effective way to sterilize is through steam or pressure. However, autoclaving is highly energy and water use intensive.⁶ Carefully evaluate the need to autoclave a particular item. Run a cycle only when full.

IT

Computer simulations and mathematical models can replace some experiments, thereby, reducing material waste. However, IT use contributes to CO₂ emissions.^{7,8} In 2020, it was estimated that the IT sector accounted for approximately 2-6% of global CO₂ emissions, and that in 2030, this figure would increase to 20%⁹. Other adverse environmental effects result from the manufacturing and disposing of computer hardware.⁹

Hardware choice

In choosing hardware, including processor, memory capacity, and task runtime, consider the needs of the work to be performed on it. The processor and memory available can be modified on most high-performance computing (HPC) platforms.

Energy requirements are largely dependent on memory availability rather than memory utilization⁹. Parallelization or switching from central processing units (CPUs) to graphics processing units (GPUs) can enhance processor efficiency to minimize runtime, thereby, decreasing energy use.

PC and printer settings

Computers and printers can usually be put into sleep mode, and the devices also have energy-saving settings. The sleep setting kicks in when a device sits idle for a determined period. Energy consumption in standby mode is lower than when it continues to run unused. The small surge of power needed when the computer awakes from sleep mode is more than compensated for by the net gain in not sitting idle.

Even turned off, some gadgets continue to draw a small amount of power. The best way to avoid this is to connect them to a smart power strip, turn off the strip and thus cut off all access to power.

Software choice

Assuring that you are utilizing the most energy efficient and optimized software for the task is a simple way to reduce the environmental impact of your research. Optimized programs are lower in size, use less memory, and require less execution time¹¹. However, improved software efficiency does not always lead to a reduction in computing time and can result in the need for hardware replacement. For more information, please see the "Guide to environmentally friendly public procurement of software" from the German Federal Environment Agency

https://www.umweltbundesamt.de/sites/default/files/medien/11850/publikationen/leitfaden_beschaffung_software_barrierefrei_0.pdf).

Data storage

Preserving data correctly minimizes energy use and prevents experiment duplication. Moreover, the DFG and TUD require research to be stored for a minimum of ten years. Whether you want to digitally save, back up, or archive your data, the TU Dresden Center for Information Services and High-Performance Computing (ZIH) offers network drives or storage services as well as central data storage to all TU Dresden members. Limitations in capacity and redundant systems are provided based on the

user's security and availability needs. Learn more here: https://tu-dresden.de/zh/dienste/service-katalog/arbeitsumgebung/datenspeicher?set_language=en.

GREEN CHEMISTRY

Green Chemistry is an innovative method to create chemical products and processes that minimize or eliminate the creation and use of harmful compounds. Green chemistry can lead to a reduction in waste and improved experimental efficiency. It focuses on developing chemical products and processes that have a low environmental impact through the use of renewable resources and increased energy efficiency. The aim is to develop solutions that are both economically and ecologically sustainable throughout their entire life cycle. For example, solvents from sustainable resources, such as plant-based solvents like bioethanol, ethyl lactate, or Cyrene™, can replace petrochemical compounds. For more information please visit e.g.: https://www.sigmaaldrich.com/DE/en/campaigns/sustainable-chemistry?srsId=AfmBOors4rgk4RThEsSgk1wDM8tZiFGcxYIRG6M9TR7B51Smr_kj5Zq

Minimizing hazardous waste

Reducing hazardous waste in laboratories is also critical for safety and environmental protection. Substitute less hazardous materials where possible, use minimal quantities, and store chemicals properly. Implementing miniaturized techniques can drastically reduce waste generation, cutting disposal costs, improving lab safety and decreasing the need for extensive disposal procedures and autoclaving, thereby lowering associated energy consumption and costs.

Catalysis vs. stoichiometric reactions

Prioritize catalytic processes, in which catalysts are used to increase reaction efficiency and reduce waste, over stoichiometric reactions, in which the reactants are used in exact proportions and by-products are produced that must be disposed of. Catalytic processes employing natural enzymes are used in biochemical processes to provide great specificity and efficiency while generating less waste than standard chemical reactions.

RESEARCH METHODOLOGY AND DESIGN

The methods used to collect and analyze data, as well as the choice of experimental design, both should be planned accordingly to ensure responsible and resource efficient research.

Open-access data and protocol platforms

Published, trustworthy data may be used to serve as a foundation rather than being reproduced or replicated. Learning a technique not established in the lab or optimizing a new kit can result in first runs that waste materials and time and do not lead to data generation. Websites such as Protocols.io or GitHub offer researchers a place to share fine-tuned, peer-reviewed methods and, thus, prevent some waste

Miniaturization

When performing chemical reactions or biological assays, scaling smaller for pilot studies can reduce the quantity of materials used. For instance, low-volume PCR protocols reduce the volume of DNA samples and reagents required.¹² Algorithms can guide minimum sample size needed for statistical significance. The DFG asks that researchers consider fitting the scale of the experiment or field trial to the scope required to answer the question or substituting a simulation wholly or in part.¹³

INFORMATION DISSEMINATION

To this end, each laboratory should designate a person responsible for staying informed about developments in the field of sustainability, particularly from TUD and UKD, and for passing this information on to their team for implementation. This person could also take on the role of a so-called "Carus Green Ambassador" to maintain close communication with the environmental, waste, and energy management departments of the UKD. Further information can be found here: https://carusnet.med.tu-dresden.de/Service/carus-green/news/copy_of_carus-green-unsere-umwelt-initiative-sucht-sie

TUD is dedicated to addressing global environmental challenges through sustainable practices. The university aims to take a pioneering role in terms of efficient use of resources, environmental protection, and responsible action.

Strategy: TUD has outlined a comprehensive Sustainability Strategy focusing on six key areas: governance, campus and operations, research, teaching, digitalization, dialogue and transfer. The strategy aims to achieve climate neutrality by 2035, minimize resource consumption, and foster sustainable development.

Research and Teaching: The University is committed to conducting research that addresses environmental and climate issues and supports sustainable societal change. TUD integrates sustainability into its curriculum to equip students with the knowledge and skills for responsible action.

Campus and operations: TUD is working towards a green campus by implementing energy-saving measures, reducing waste, and promoting sustainable transportation. The university is also focused on constructing and renovating buildings according to sustainability standards.

Challenges and Opportunities: Laboratories are significant resource consumers, and TUD is addressing this through initiatives like the Green Lab Guide. The university recognizes the importance of digitalization but aims to ensure it is ecologically sustainable and fair.

Collaboration and Engagement: TUD emphasizes collaboration with students, staff, and the community to achieve sustainability goals. The university is actively involved in public discourse on sustainable development and seeks to influence policymakers.

There are many things you can do to improve sustainability in your everyday work with minimal effort. Here, you will find tips on saving energy, how to travel in a sustainable way, how to borrow a cargo bike, how to purchase in an eco-friendly way, and how to plan events and meetings sustainably.

https://tu-dresden.de/tu-dresden/nachhaltigkeit/mitmachen/nachhaltigkeit-im-hochschulalltag/?set_language=en

GREEN LAB CHECKLIST FOR FACULTY OF MEDICINE

Waste Management

- Think about strategies to reduce lab materials.
- Use reusable materials and minimize single-use plastic.
- Check whether items can be repaired by the UKD's Medical Technology Department, for example, before disposing of them because they appear to be defective. (Contact: Holger.Bauermeister@uniklinikum-dresden.de)
- Separate your waste in the lab (laboratory waste –“B-Abfall”, paper/cardboard, Green Dot [Grüner Punkt]).
- Dispose of other waste in accordance with the waste disposal guide (keyword: hazardous waste, S 1 and S 2 - Waste).
- Check whether you can reduce the amount of chemical/hazardous waste by reducing the chemicals used.
- Collect pipette tip boxes and pure polypropylene plastics (PP) separately. They can be disposed of at Medical Theoretical Center (MTZ). Contact Hospital Ecology at 458-4085.

Purchasing

- Share or borrow equipment with other research groups.
- Optimize orders to avoid overordering items. This way you can minimize storage needs (space and energy use). Bundle orders to minimize shipping.
- Check whether various chemicals can be replaced by “Green Chemicals”.
- Use a system for tracking and managing chemical inventories to minimize excess stock.
- Implement an inventory system (e.g., using Excel) to track laboratory materials.
- Perform regular inventory checks to sort out expired or no longer needed samples.
- Choose high-quality, long-lasting products (warranty period, repairability).
- Check for Blue Angel, Energy Star, EU Ecolabel or similar certifications before purchasing new equipment.
- Give preference to suppliers who minimize transport packaging or offer a return system.
- Utilize smaller-sized lab materials, e.g. petri dishes, if the experiment allows it.
- Purchase pipette tips in bulk and insert them yourself, if staffing levels allow.

Equipment and infrastructure

- Use the Dresden Technology Portal to search for specific equipment, complex systems or services for your research.

- Use University Hospital Dresden and the Faculty of Medicine medical technology exchange (<https://carusnet.med.tu-dresden.de/Service/Verwertung/medizintechnikiosk>).
- Turn off equipment when not in use.
- Print double-sided, and in black and white to save paper and printer ink, thereby conserving resources.
- Use shared printer locations and the "Zentraldruck" feature to print on the central printer.
- Place a collection container for paper near the printer(s) to collect misprints and use them later for sticky notes.
- Use recycled paper and reuse paper that has been printed on one side.
- Buy magazine subscriptions online and don't print out articles to reduce paper waste.

Large equipment

- Always close fume hood sashes and biosafety cabinets after completing your task. Remind your colleagues regularly.
- Use equipment as instructed by the operating manual in order to avoid damage, thus avoiding repairs or the purchase for new equipment.
- Nominate equipment supervisors who will conduct initial training and regular refresher courses.
- Have the scheduled maintenance work carried out regularly on all devices.
- Only sterilize items in the autoclave when absolutely necessary.
- Do not run the autoclave when it is only half full.

Cold Storage

- Share a freezer with a neighboring lab.
- Raise freezer temperature from -80°C to 70°C and from -20°C to -18°C.
- Use a sample management system to reduce the time spent looking for sample and conduct regular inventory checks, remove samples that are no longer needed.
- Regularly defrost and clean refrigerators and freezers.

Lighting

- Turn off lights and use daylight or task lights.
- Remember to turn off lights when leaving rooms.

IT

- Use devices for as long as possible and ask your admin to repair them if possible.
- Activate sleep mode or automatic shutdown on all computers and printers, or ask your IT department to do so.
- Use Ecosia or another eco-friendly search engines such as Gexsi, Ekoru, Lilo, or OceanHero for internet searches.

- Regularly tidy up data on your mail server or cloud service, or contact your IT department for assistance.
- Use links to cloud storage instead of attachments in emails.
- Archive data in cold storage (in collaboration with the IT department).

Information dissemination

- Encourage lab members to propose new ideas for sustainability measures.
- Appoint a sustainability officer to update the lab on TUD's sustainability initiatives during meetings.
- Provide regular training on green lab practices.

DISPOSAL PLAN FOR LABORATORY WASTE AND RECYCLABLE MATERIALS

Disposal plan for laboratory waste and recyclable materials																
Carl Gustav Carus University Hospital and Carl Gustav Carus Faculty of Medicine																
Area of activity: Laboratory																
Laboratory waste			Hazardous substances					Infectious waste		Recyclable materials						
Solid laboratory waste	Liquid laboratory waste	Waste Sharp and	Old chemicals	Halogen-free solvents	Halogenated solvents	Staining solution	Cytostatics	Microbiology	Green Dot	Paper / cardboard	w-iron glass / stained glass	Pipette tip boxes PP Plastics				
																
Permitted			Permitted					Permitted	Permitted	Permitted	Permitted	Permitted				
Solid materials with (chemical) adhesions: - Rags and cloths, wipes, gloves, tools - Silica gel, activated carbon, filter material - Pipette tips - Used or expired respiratory protection filters - Disposable laboratory items - Autoclaved solid laboratory waste			Liquid waste and sharps that do not fit in the small sharps containers, broken glass Needles, knives, lancets, cannulas, scalpels, broken glass					All old chemicals, acids, alkaline solutions, organic / inorganic laboratory chemicals liquid / solid e.g.: Ethanol, methanol, xylene, acetonitrile, toluene, phenol, halogen-free mixtures with low water content	Halogenated organic solvents, e.g., chloroform, dichloromethane	Staining solutions (Giemsa, fuchsin, or other staining solutions)	CMR substances—carcinogenic, mutagenic, toxic to reproduction	All potentially infectious waste, according to waste disposal guidelines; Cell culture waste	- Plastic packaging, clean films and bags - Composite packaging, TetraPaks - Small pieces of polystyrene	- Paper - Envelopes - Brochures, magazines, newspapers - Paper towels without contamination	- Low-iron glass / stained glass - Rinsed, cleaned chemical glass bottles with hazard labels removed and without pictograms - Glass beverage bottles	- Clean pipette tip boxes made of PP from various manufacturers - Other clean products made of PP plastic
Prohibited			Prohibited					Prohibited	Prohibited	Prohibited	Prohibited	Prohibited				
Old chemicals, liquid laboratory waste, sharp and pointed objects			Syringes, gloves, other laboratory waste					Asbestos solvents, halogenated solvents, PCB / PCT, Hg, cyanide	Asbestos solvents, PCB / PCT, Hg, cyanide	PCB/PCT, Hg, cyanide	Other old chemicals	Other old chemicals	Chemically contaminated packaging, residual waste, gloves, cannulas	Coated or contaminated paper, residual waste	Broken glass, incandescent bulbs, halogen bulbs, ceramics, porcelain, chemically contaminated glass bottles	All other types of plastic
Collection			Collection					Collection	Collection	Collection	Collection	Collection				
Gray container, blue bag	Red II-waste container 30l	Yellow container, red lid, various sizes as SAP order	Clearly labelled, marked with hazard symbols, original containers if possible	In reusable canisters (5l; 10l; 20l) with red label Requested via LOG book	In reusable canisters (5l; 10l; 20l) with white label Requested via LOG book	In reusable canisters (5l; 10l; 20l) with green label Requested via LOG book	In yellow 1l or 30l containers, requested via LOG book	In black containers with yellow lab, 30l or 60l, requested via LOG book	Yellow container with yellow bag	Wastepaper basket without bag or blue container with transparent bag	White or green container with bag to protect the container	Separately in boxes or transparent bags				
Disposal			Disposal					Disposal	Disposal	Disposal	Disposal	Disposal				
Transport from disposal rooms After registration in the LOG book, transport from disposal rooms; container labeling with laboratory code required			Transport from disposal rooms; please place gel disposal trolley					Once a month, registration with hospital ecology (see chemicals round calendar)	After registration LOG book	After registration LOG book	After registration LOG book; label containers with laboratory abbreviation where required	After registration LOG book; label containers with laboratory abbreviation where required	Transport from disposal rooms	Registration in the LOG book or independent filling of IBCs provided in H92 and H21		
Batteries: 																
Green or gray collection container with bag. Disposal: Internal transport, Tel.: 3283. Please only hand over the filled bag for disposal; the container remains on site.																

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