BIOMEDICAL CENTER MUNICH
BIOMEDIZINISCHES CENTRUM MÜNCHEN

Sustainability in the wet lab

Please feel free to contact us:

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Why?

The BMC with its 450 employees consumes on average 6.3 Mio kWh per year whereas a 2-person household in Germany consumes on average 3,500 kWh per year (in 2021 in Germany[1]). In other words, each BMC employee consumes as much energy as ~4 households per year at work!

A lot of plastic waste is produced in the labs: serological pipets, pipet tips, tubes in various forms and sizes, gloves… A study of the University of Exeter has estimated that a scientist produces over 1,000 kg of plastic waste per year[2]. As a comparison, the plastic waste per person/year in Europe is 174 kg[3]. Worldwide, around 300 million tons of plastic are produced per year, of which 5.5 million tons are produced by laboratories[4].

Accumulation of small changes can impact on energy consumption, water consumption and waste production!

Our aims

1. Define and implement practical measures to improve sustainability at the BMC
2. Connect, share and collect information

Table of content:

1. BMC Green Lab

The BMC Green Lab Initiative is a grassroots initiative, founded by researchers, technical assistants and administrators from different divisions, institutes and departments who have joined forces to find ways to work more sustainably in the lab. Everybody is welcome to join! Just contact us: greenlab@bmc.med.lmu.de

Accumulation of small changes can impact on energy consumption, water consumption and garbage production!

So far, we have members from Molecular Biology, Physiological Chemistry, Clinical Neuroimmunology, Cell Biology and Physiological Genomics.

We meet every first Wednesday of the month via Zoom or in person to discuss, exchange experiences and develop new projects.

The BMC Green Lab Initiative is supported by the BMC Green Office Campus Martinsried, contact point for all questions on sustainability on campus: greenoffice@bmc.med.lmu.de

The Green Office also maintains the platform “Green Campus” on Confluence, a collection of facts on sustainability concerning Campus Martinsried. Check it out and add your knowledge.

Our past projects include the Information campaign Green Fact of the Month and participation in the My Green Lab certification program.

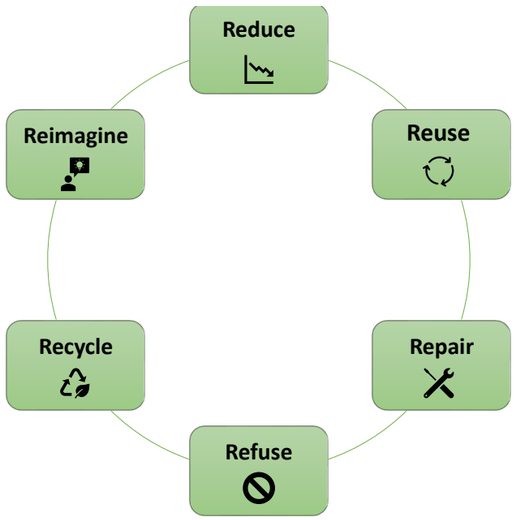
You can find more information in the BMC intranet.

2. Sustainable actions

There are six golden rules (6R) to improve sustainability:

- **Reduce**
- **Reuse**
- **Repair**
- **Refuse**
- **Recycle**
- **Reimagine**

We are glad for any input, contact us!



2.1 Reduce

2.1.1 Reduce energy consumption

starting with equipment with highest consumptions

A. Ultra-low temperature freezers

Ultra-low temperature freezers (ULT freezers) are energy-demanding devices that can consume up to 25-35 kWh per day each[5] which is equivalent to about three 2-person households in Germany (2021)[1]. While their function in the labs cannot be replaced, there are some actions we can take to reduce their energy consumption and prolong their lifetime:

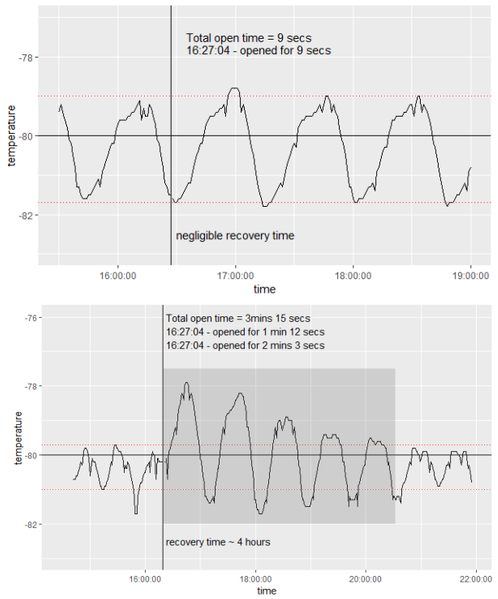


Figure 1: Temperature recovery of ULT freezers. *ULT freezer doors were left open for short (9 s; top) and prolonged (3 min and 15 s; bottom) times. Red lines indicate the maximum and minimum average temperatures of usual fluctuations. After opening for 9s, the freezer quickly returned to its normal temperature. After opening for 3 min 15 s, it took approx.. 4 h to stabilize.*
Measured: 2023 by grINIM, Freezer model: Thermo Fisher Scientific HFU400TV.

What you can do:

- Set the temperature of the freezers to -70°C instead of -80°C[5]. Look at My Green Lab for additional information on safe storage temperatures for different kind of samples and a lik to a public database on storage at -70°C.
- Ensure adequate spacing between the ultra-low-temperature freezers, and position them correctly in the room to allow optimal ventilation.
- Reduce the freezer's "open-time".
  → When we analyzed opening time in 2023, our freezers were kept opened for an average of up to 3 minutes (see Fig. 1). If a freezer is opened multiple times in a short time frame, the warming effect is cumulative[6].
  - Inventorize stored material and throw out old samples.
  - Keep freezers organized so it takes less time to look for samples while keeping the freezer doors open.
  - When searching for a box or samples in a box, take the rack or the box out and close the freezer door. Use dry ice when necessary.
- Reduce "dead-space". Put Styrofoam boxes in empty spaces when possible.
- Defrost freezers twice a year and remove ice buildup regularly.
- Vacuum clean the condenser filter and coils twice a year to ensure efficient cooling.
- Share emergency freezers.

B. Cell Culture Hoods

Energy consumption of one cell culture hood[7] is comparable to about two German 2-person households (2021) per day[1].

What you can do:

- Switch off the cell culture hood when not in use.
  → This also prolongs the device's lifetime.

C. Freezers (-20°C)

-20°C freezers are usually 5-6°C colder than what we set them[8].

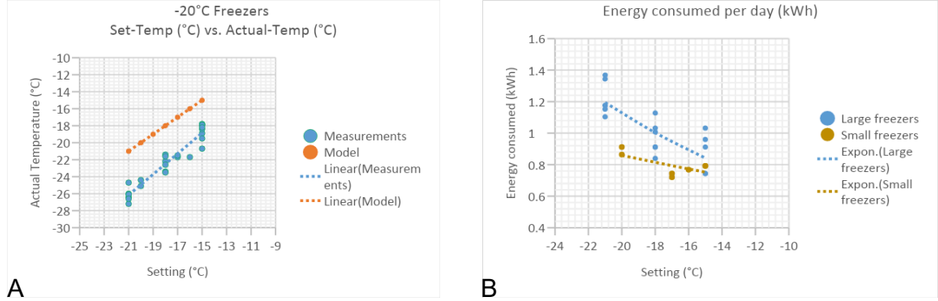


Figure 2 *A: The relation between the actual measured temperature and the set temperature at -20°C. The blue markers represent experimental measurements, while the orange markers indicate model predictions. B: Energy consumption per day for small and large freezers at different set temperatures. The blue markers show the energy consumption of a large freezer and the yellow markers indicate the energy consumption of a small freezer. Measured at the Institute of Neuroimmunology (INIM).*

What you can do:

- Measure the temperature of your freezers.
  → (Digital thermometers are available; Contact Barbara Hölscher: Barbara.Hoelscher@med.uni-muenchen.de)
- Set the temperature to measured -20°C.

D. Thermo-controlled shakers, benchtop devices and computers

We sometimes keep instruments switched ON or on "stand-by" (e.g. centrifuges, shakers, stirrers, cell counters, heaters, computer… etc.) when not in use, for convenience.

Some devices consume as much energy as if they were in use[9], since the function is maintained when idling. For instance, the heater needs energy to keep the device at a set temperature whether the samples are in there or not. An average heater takes approximately 5-10 minutes to reach 37°C and approximately 15-20 minutes to reach 95°C (see below).

Example:

Each bacteria shaker consumes 5.5 kWh per day to maintain 37°C[10]; however, it only takes about 20 minutes to warm up the shaker to 37°C after switching it on[9], so we could avoid this unnecessary consumption by switching them off by default.
=> Turn off the bacteria shaker when not in use.

W ("Watt") is the measure of the "rate of energy consumed" = 1 Joule per second.

Wh ("Watthour") is a unit energy consumption = 1W over 1 hour = 3600 Joules.

What you can do:

- Switch them off when not in use and/or share devices.
- Estimate the time until the device is functional again and share information with your lab mates to avoid delays in your protocols.
  → Put stickers on the devices
- Close the centrifuge lids between uses to keep the device at the set temperature and avoid additional cooling.
- Stop the stirrer when you remove the sample you have been mixing.
- Remember to turn off all devices and lights at the end of the day.
- Set devices, e.g. PCs, in "energy-saving" mode or "hibernate" during breaks.

2.1.2 Reduce water consumption

Working in a wet lab is associated with water consumption to prepare solutions, to run the autoclave and to clean glass- and plasticware.

→ Running the autoclave for sterilisation uses both energy and water. Approximately 270 liters of water/run for a standard lab autoclave[5].
→ A dripping tap can easily cost you 2L of water per day.

What you can do:

- Use the right water purity for each application .

→ **Tap water:** for cleaning benches, rinsing glass- and plasticware (Note: tap water in the labs has no drinking quality)
→ **Deionized water:** for most buffers and rinsing of critical instruments
→ **Milli-Q water:** for buffers used for sensitive applications (HPLC, ….)
→ **Autoclaved water** (deionized or MilliQ): is only needed for sensitive applications and should not be used for solutions which will be autoclaved anyhow.

- Run the autoclave only when it is full (collect items to autoclave).
- Use sterilized plastic-ware (tubes or tips for example) only when needed.
- Report dripping taps, eye showers, toilet flushes (FAMOS system/Apleona).
- Some buffers can be re-used several times, e.g. blotting buffer.

2.1.3 Reduce use of „fancy tips"

When do you need which kind of tip?

- Regular tips (no filter) in bags: can be used to fill tips manually which may or may not be sterilized by autoclaving.
- Regular tips (no filter) in boxes: are usually sterile and can be used for all applications.
- Regular tips (no filter) in towers: empty tray in box can just be exchanged by full tray from tower.
- Filter tips: are only needed to avoid contamination of pipets or samples for sensitive applications (radioactivity, RNase-free samples…).

What you can do:

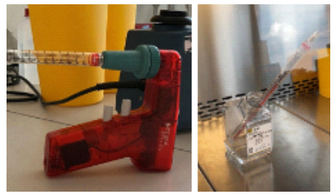
- Be aware what you really need and choose wisely.

2.2 Reuse

Labs produce incredible amounts of waste, of which a large percentage is non-hazardous.

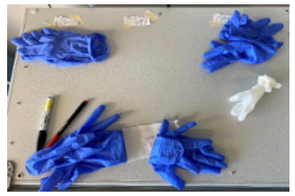
Sustainable plasticware (1.5-ml, 15-ml or 50-ml conical tubes) and gloves are available from several companies, however they may be more expensive.

The first step towards more sustainability is to reduce our consumption as much as we can in order to be able to afford more sustainable versions.



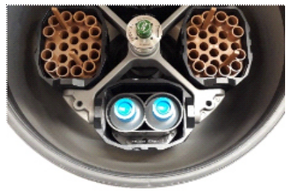
Serological pipets:

it is possible to reuse serological pipets by keeping them either on the pipet boy or in the bottle.



Gloves:

keep used gloves and reuse for other applications when possible. Refer to the Klinikum fact sheet in the appendix for guidance.



Centrifugation bottles:

use large centrifugation bottles instead of multiple falcons and consider to wash them and reuse them.

Other consumables you can reuse at least once: Aluminium foil, Saran foil, Whatmann papers ….

What you can do:

- Share reagents and equipment, organize supplies, make inventories, use mail-lists to ask for reagents.
- Plan your experiments carefully and use reusable containers as much as possible, avoid disposable tools as much as possible (use reusable beakers, cylinders and filtration units….).
- When possible reuse tubes (50-ml or 15-ml conical tubes can often be reused several times to prepare solutions – they can also be rinsed or washed), tips (e.g. for loading gels), serological pipets, gloves.
- Offer devices and consumables you no longer need on the BMC Reuse Platform and/ or LMU Fundgrube.

2.3 Repair

Extending the life time of devices is one of the most sustainable actions.

What and where to get things fixed @ BMC:

- Workshop (gel chambers, blot chambers, ….)
- In-house electrician (from small to big electrical devices)

2.4 Refuse

We can increase sustainability in our purchasing. You can search for more sustainable options before purchasing reagents or devices using ACT.

What you can do:

- Be aware of how sustainable your reagent or providers are.
- Refuse catalogs and unnecessary packaging.
- Share your concerns with sales representatives concerning sustainability aspects like shipment packaging.
- Try to group orders from your department to reduce the number of shippings.

2.5 Recycle

Don’t simply choose the bin that is nearest to you and/or trash everything as residual waste.

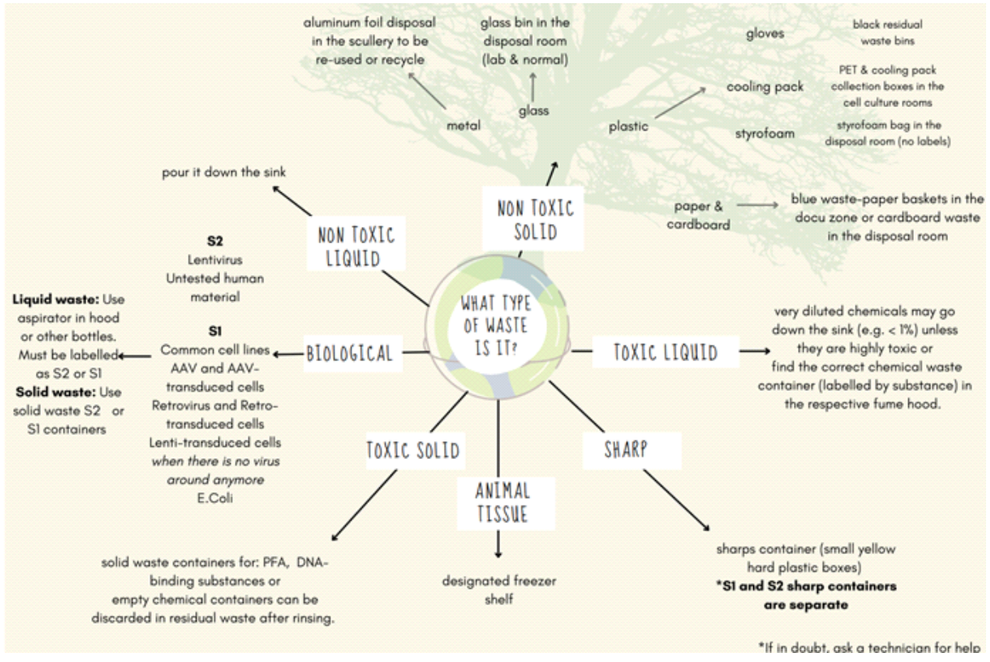
Two points to consider:

1. Is the waste harmful => disposal according to the waste type:

- Animal tissue is collected in the designated freezer drawers and forwarded to the animal crematory.
- GMO and infectious waste is collected separately, autoclaved, then considered residual waste.
- Toxic chemicals are collected in designated containers, then forwarded to the chemical disposal facility.
- Sharps are collected in yellow hard-plastic bins, which go into residual waste (or S1 / S2 if applicable) once full and safely closed.

2. Non-harmful, contaminated (S1 and S2) and non-contaminated waste can be recycled:

This graphic is made for and by the Institue of neuroimmunology. It may differ from the way things work in your department.



2.5.1 Waste sorting

A. Specific recycling programs

PET bottle recycling with PAN-Biotech

There are current efforts to recycle the plastic waste produced by research. However, recycled plastic granules are rarely used in the production of new laboratory plasticware due to their low purity. In general, plastic cannot be mechanically recycled more than a few times.

Some companies have established specific closed loop recycling programs.

PAN Biotech, a local biotech company, collaborates with a local recycler to recycle PET plastic bottles separately and achieve high PET purity which can be used again for production of PET bottles.

Several departments are participating to the program. The bottles are collected in specific PAN-Biotech bins (see picture). Ask your colleagues how the collection is organized in your division/institute.

How to recycle PET bottle

- Only recycle PET bottles with the according sign.
- Rinse PET bottles with tap water.
- Remove the lids and put them into the collection container separately.

Recycling of hard-shell cooling pads

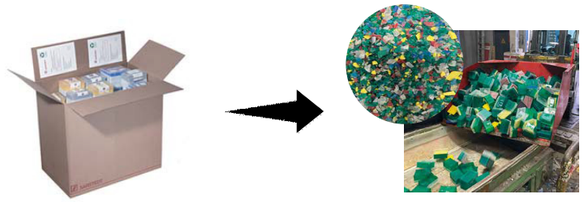
Hard-shell cooling pads can be handed in at the BMC drop-off point for chemical waste, from where they will be collected and taken back by PAN-Biotch.

Please note: There is unfortunately currently no general recycling program for soft-shell cooling pads. Only the company NEB takes back their soft-shell pads.

Recycling of tip-boxes

Some tip-box companies offer a recycling service. Once a sufficient quantity of empty tip-boxes has been gathered in the lab, the boxes are collected by the according companies and processed into single-type material. This material is then used to make new, high-quality plastic products, with some companies keeping the material within their own production cycle. This is called a closed recycling loop[11,12,13].

Examples, used at the BMC are **Sarstedt**, **Biozym** and **Starlab**.



https://www.sarstedt.com/en/US/life-science/liquid-handling/refill-recycle/refill-revolution

https://www.biozym.com/media/pdf/a5/46/8d/Recycling_Flyer.pdf

B. Organic waste

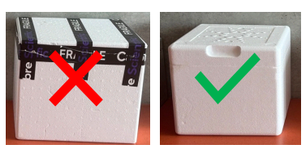
- Brown bins for organic waste are available on demand for all social kitchens.

organic

C. Plastic waste

- For PET, cooling pads and pipet tip box recycling see 2.5.1
- Yellow bins are for clean, recyclable plastic. Please note that only packaging waste can go in to the yellow bins in the labs.
- White styrofoam boxes: Remove all tapes and collect in the respective bag in the disposal room.
- Colored styrofoam boxes and styrofoam pieces: dispose of in the yellow waste bins in the disposal room.

plastic



D. Paper and cardboard

- Small pieces → blue paper waste bins in the docu zones, offices.
- Big pieces → big trolley in the disposal room (fold boxes before disposal).

Paper / cardboard

E. Aluminum

- Clean aluminum foil => collect in dedicated container for reuse.
- For recycling => aluminum bin in the disposal room.

aluminum

F. Glass

- There are two separate bins for “normal” and “laboratory” glass in the disposal room.
- Laboratory glass needs higher temperature for melting (ex: Schott glass), it should therefore be collected separately.

glass

G. Batteries

- Batteries are collected in a dedicated box at the BMC postoffice/guards.

H. Toner

- Toners are collected in a dedicated box at the BMC postoffice/guards.

I. Electronic waste

- If you have any broken electrical devices, ask the BMC electrician in the workshop if he can use them for spare parts.
- Anything that needs to be thrown away should be collected in the dedicated metal box in the yard. Ask the facilities managers from Blunck where to find it.

2.6 Reimagine

The "Reimagine" section offers suggestions on how to develop more sustainable working practices in the laboratories. Although sustainability often begins with everyday decisions, many people cling to familiar methods and routines that have become established over the years. However, working more sustainably requires more than just implementing individual measures. It also involves critically examining one's own working methods, both within one's own lab and in collaboration with other research groups, and staying open to change, as the range of available sustainable options continues to expand. Such changes are often not only more environmentally friendly, but also more time-efficient and cost-effective.

This section provides fewer concrete guidelines and is intended as inspiration for making gradual improvements to everyday laboratory life. The goal is to integrate sustainability into all aspects of daily work. In doing so, each team member can contribute his or her own experiences, ideas and motivation. The compiled approaches can then be adopted and implemented individually within one's own team.

2.6.1 Ordering

What you can do:

- Coordinate and consolidate orders at the department level.
  → Use order sheets with clear labels such as "urgent" and "non-urgent" to enable administrative staff to group requests efficiently.
- Use shared budgets (e.g., at the department level) to purchase commonly used reagents such as chemicals, secondary antibodies, antibiotics, and restriction enzymes.
- Prioritize suppliers with environmentally responsible policies, particularly regarding packaging and recycling.

Examples:

- **NEB (There is a common freezer with enzymes at the BMC, coordinated by Barbara Hölscher, Molecular Biology):**

Deliveries (when not shipped on dry ice) arrive in cardboard boxes with plant-based insulation. Soft cooling packs can be returned using prepaid labels once accumulated.

- **Pipet tips:**

Suppliers such as Sarstedt, Biozym, and Starlab offer Refill systems (e.g., tower formats) which reduce plastic waste by requiring replacement of only the inner tray[11,12,13]. Nerbe Plus provides EcoRack systems, where the tray is packaged in cardboard, minimizing plastic waste[14].

2.6.2 Shared Inventory (Group / Department / Institute / BMC)

What you can do:

- Maintain shared inventory records using standardized templates (e.g. BMC-wide via the electronic lab-book eLABFTW):
  - Instruments
  - Antibodies
  - Common reagents (e.g., secondary antibodies, restriction enzymes)
- Ensure inventories are regularly updated and accessible to all relevant users to avoid duplicate purchases.

2.6.3 Experimental Design and Collaboration

What you can do:

- Encourage discussions within groups or departments on the reuse of consumables where appropriate:
  - Examples: Falcon tubes, antibody dilutions, etc.
- Optimize experimental design:
  - Evaluate when disposable consumables are necessary versus when reusable materials (e.g., glassware) can be used.
- Perform well-controlled pilot experiments to minimize unnecessary resource use.
- Foster collaborations with experts, particularly for technically demanding approaches, to reduce trial-and-error and associated waste.

2.6.4 Training, Awareness and Exchange

What you can do:

- Provide onboarding for new lab members on best practices.
- Share guidelines on sustainable laboratory practices.
- Encourage a culture of responsibility and continuous improvement.
- Define measurable goals (e.g., reduction in plastic use, fewer duplicate orders).
- Collect feedback from lab members.
- Promote the exchange of information with colleagues and with the BMC Green Team to further develop and refine sustainability best practices at BMC.

References:

1. https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Umwelt/UGR/private-haushalte/Tabellen/stromverbrauch-haushalte.html
2. https://news-archive.exeter.ac.uk/2015/december/title_488903_en.html
3. https://zerowasteeurope.eu/2022/07/blog-packaging-at-the-core/
4. https://www.nature.com/articles/528479c
5. https://mygreenlab.org/the-beaker-blog/8-ways-to-save-energy-in-the-lab/
6. https://cms-cdn.lmu.de/media/07-medizin/bmc/downloads/green-facts/temperature-observation-of-ult.pdf
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11. https://www.sarstedt.com/en/US/life-science/liquid-handling/refill-recycle/refill-revolution
12. https://www.biozym.com/media/pdf/a5/46/8d/Recycling_Flyer.pdf
13. https://media.starlabgroup.com/pdf/de/Nachhaltigkeit/Get-Green-with-Starlab-DE-Brochure-2026-04.pdf
14. https://www.nerbe-plus.de/de-de/liquid-handling-pipetten-dispenser/pipettenspitzen-mit-filter-oberfl%C3%A4chenoptimiert/ecoracks-np-green-tip-pipettenspitzen-mit-filter-oberfl%C3%A4chenoptimiert/

Additional resources:

- www.mygreenlab.org
- www.labconscious.com
- www.sels-network.org
- www.ucl.ac.uk/sustainable/make-your-lab-sustainable-leaf
- www.lean-science.org
- www.greenlabsaustria.at
- www.nachhaltigkeitsnetzwerk.mpg.de
- www.greenlabs-nl.eu
- https://sustainable.harvard.edu/our-plan/
- https://www.neuroimmunology-munich.de/sustainability/ca79e5efc66d1328
- Podcast: “The Caring Scientist: Mission Sustainable”