University of Nottingham
UK | CHINA | MALAYSIA

Sustainable Laboratory Good Practice Guide v1.2

go!
Your sustainable choices matter.

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Welcome to the Sustainable Laboratory Good Practice Guide

This guide has been created for members of the University of Nottingham (UoN) that are interested in developing safer, successful, and sustainable labs. The guide is composed of best practices covering methods on how to reduce energy consumption and waste in the laboratory environment. The guide represents just a portion of the vast body of knowledge on this topic and does not aim to be comprehensive, but a starting point for further discussion and action.

Please read thoroughly and keep for future reference.

Link to the UoN sustainability website www.nottingham.ac.uk/sustainability

Acknowledgement:

We would like to acknowledge the work of **Rabbab Oun**, who created the Sustainable Laboratory Good Practice Guide at the **University of Strathclyde Glasgow**. Their guide provided the foundation for our own work, and we are grateful for their permission to use it as a starting point.

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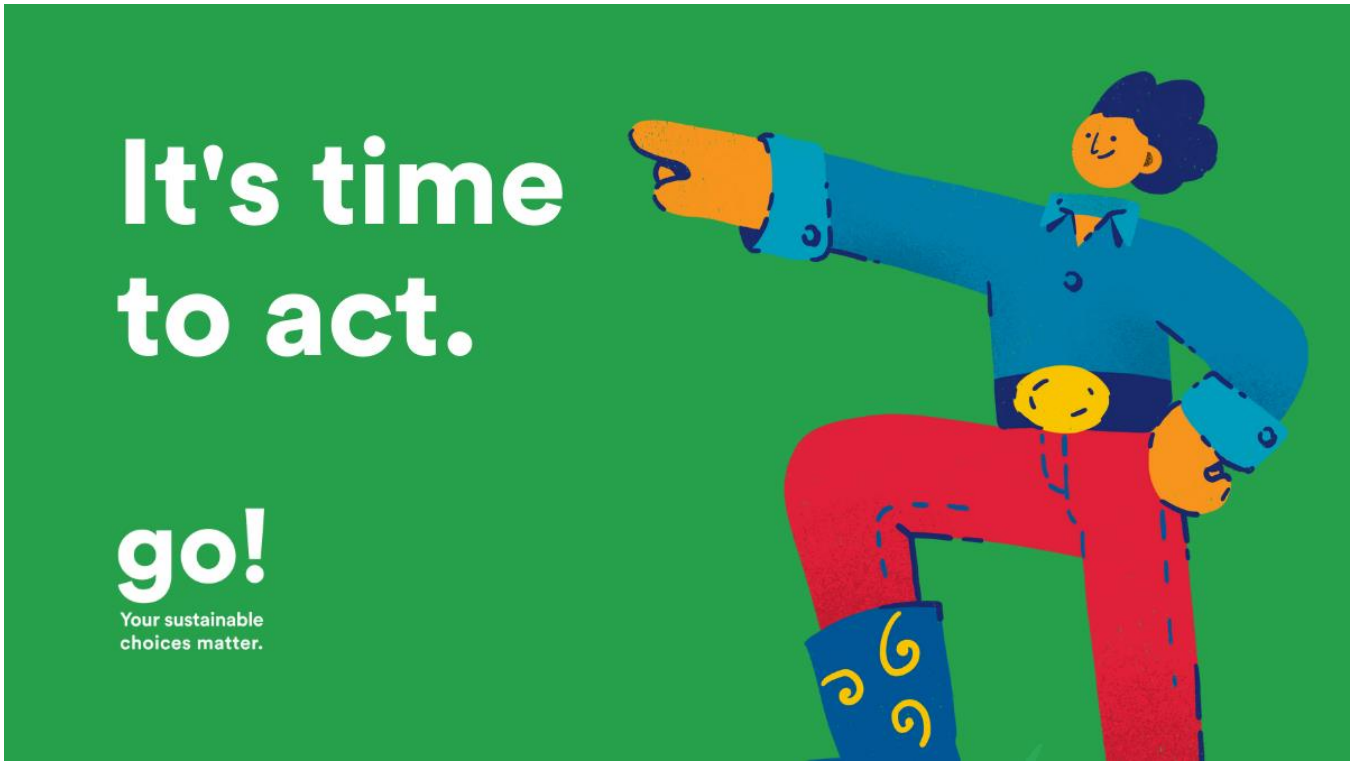
Introduction

The university is committed to maximising the positive impact it has on the local and global environment. It aims to reduce its environmental impact via a continued commitment to institutional-wide environmental sustainability excellence. The University recognises that it has a range of roles and interacts with several key stakeholders. It is an educator of future generations, the change agents of tomorrow; it is a significant local landowner, whose decisions can have a large impact on the local environment; it is a stakeholder in the community, committed to helping local people build a sustainable future; it is championing pioneering research, which could help address some of the biggest environmental challenges we currently face.

Lab spaces around the UoN are some of the biggest users of energy, water, and consumables and we're committed to our university being truly sustainable. We're already doing a lot, but now's the time to really step it up. We want to slash our carbon emissions by more than half by 2030, so we need everyone to join us in getting there.

Everyone can make a difference. Even the smallest actions add up to big impacts. Every sustainable change we make takes us closer to our goal.

Please see the Environmental Sustainability Policy 2023.



Vision and aims

The vision of this Sustainable Laboratory Good Practice Guide for the UoN is to create a more sustainable future for the university's laboratories. The guide will provide a framework for laboratories to reduce their environmental impact, improve their efficiency, and save money. The aims of the guide are to:

- Reduce the use of resources, such as energy, water, and chemicals.
- Improve the efficiency of laboratory operations.
- Save money on laboratory costs.
- Protect the environment.

The guide will be a valuable resource for laboratory staff, providing them with the information and tools they need to make their laboratories more sustainable. It will also help the university to meet its sustainability goals and reduce its environmental impact.

The following are some of the specific actions that laboratories can take to become more sustainable:

- Reduce energy consumption by using energy-efficient equipment and lighting.
- Conserve water by using water-saving fixtures and procedures.
- Reduce the use of chemicals by using safer and more efficient alternatives.
- Recycle waste materials.
- Purchase sustainable products and services.

By taking these actions, laboratories can make a significant contribution to the university's sustainability efforts.

Note : Health and safety must always be considered but often does not present a barrier to making the suggested changes, if you are in doubt please always ask your H/S representative for clarification.

Sustainability team

Name	Position
Andy Noland	Development & Sustainability Director
Gavin Scott	Head of Sustainability
Martin Oakes	Carbon Reduction Manager
Mariana Velasco Carrasco	Energy and Carbon Manager
Richard Mitchell	Energy Management Officer
Amy Scoins	Senior Environment Officer
Lee Hibbett	TSWG chair
Alison Clayton	Senior Environment Officer
Emma Taylor	Sustainable Travel Lead
James Bugg	BMS Officer
Douglas Leung	BMS Assistant

The team is based in the Professional service hub in Life Sciences and if you need to contact the team, please email sustainability@nottingham.ac.uk.

For any building issues please contact the estates helpdesk Estate helpdesk.

LEAF programme

LEAF stands for the Laboratory Efficiency Assessment Framework
And was developed at UCL by Martin Farley as a way of improving sustainability and efficiency of laboratories.

Why is it important?
Laboratory-based research is essential for advancing society, but it is also extremely energy and resource intensive. It's estimated that laboratories are responsible for around 2% of global plastic waste and use 3-10 times more energy per meter squared than a typical office.

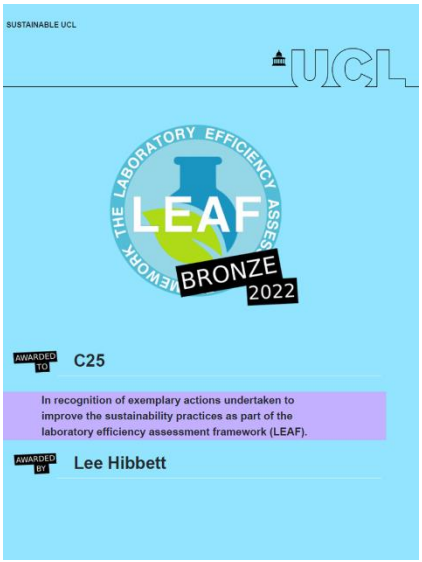
How does it work?

The LEAF programme comprises four elements:

- **The Framework**: An online tool that guides users through sustainability actions to save plastics, water, energy, and other resources in their laboratory.
- **Online calculators**: To help measure financial and carbon impact. You can estimate how sustainable your lab is now and track improvements.
- **Toolkit and Resources**: From guides to sustainable lab equipment and consumables to induction and exit procedures.
- **User Engagement & Training**: We offer each institution a tailored workshop to engage laboratory staff and students on sustainable science, and to introduce LEAF.

Users will fill in 16 questions and complete the online calculators. Submit and if all is okay, then that lab will be accredited a bronze award. Then some questions for silver and gold.

CATEGORY	Bronze	Silver	Gold
Waste	Provide recycling bins in the lab	Single-use plastic waste has been reduced (guidance provided)	Recycling rates have been increased, or overall waste produced has been decreased
People	Samples owned by departing staff are cleared or tracked	The lab has engaged other labs on LEAF and sustainability	One action to reduce travel has been implemented
Sample & Chemical Management	Labels are legible, and there's a common labeling system in place	Procedures are in place in case cold storage equipment breaks down	At least 80% of all samples and/or chemicals are clearly catalogued
Equipment	Equipment is turned off when not in use	There is a system in place for communal equipment booking	Excess equipment is repaired, sold, and/or donated
Ventilation	There is a clear reporting system for building issues	Fume cupboard sashes are kept closed when not in use	Solvent vapours are condensed and disposed and not released into the atmosphere

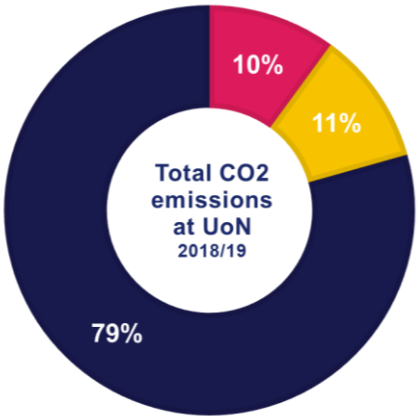


For More details, please contact Lee Hibbett lee.hibbett@nottingham.ac.uk or you can register at LEAF register to start your LEAF journey.

Energy

Our laboratories are some of the most energy intensive aspects of our operations at the university. Our aim is to minimize energy and water to reduce waste without compromising research opportunity, output, or quality.

One goal for the UoN is to reduce the CO^2 emissions from our lab spaces. So, how is energy broken down in the UoN (2018/19)



Scope 1 – gas 20,215t

Scope 2 – Electricity 21,224t

Scope 3 – supply chain/business 159,500

Biggest contributors vary year on year. In 2021/2022

- Medical/research equipment 34%
- Information Technology 15%
- Business travel 10%
- Construction 5%
- Food & catering 5%

As you can see Medical/research equipment is a large part of our scope 3 and a lot of this will be consumables for the lab work. There is also a very big difference in the energy usage between different types of buildings on campus as illustrated in Figure 1. And this is why it is important for everyone to do their part in the reduction of energy at the UoN.

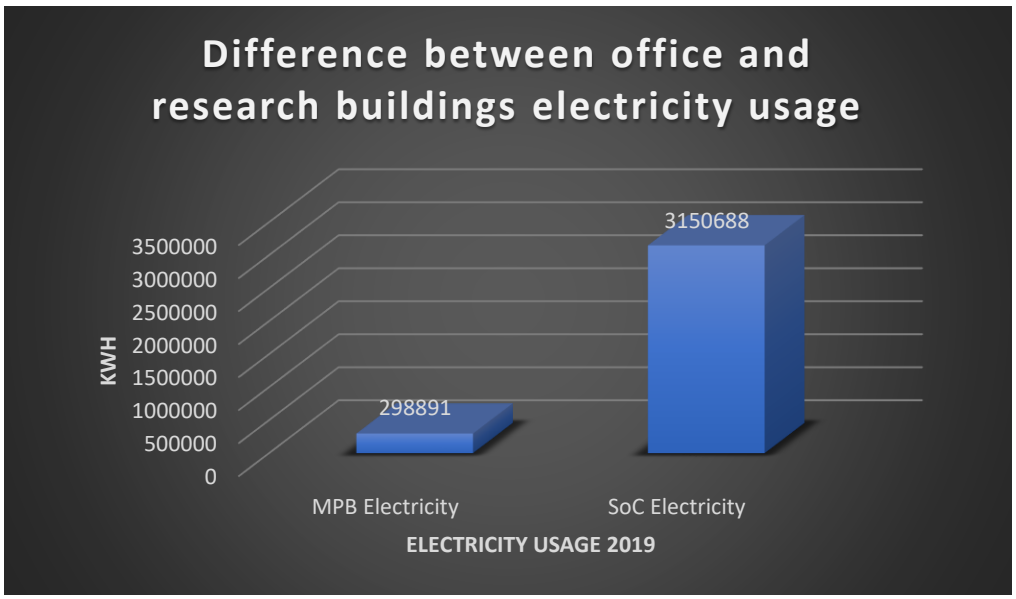


Figure 1. electricity usage for the Monica Partridge Building and the School of Chemistry

See the equipment section for ideas on how to save energy.
Tips for energy saving in offices office savings
Tips for energy saving in laboratories lab savings

Water

During the academic year 2018-2019 the University of Nottingham consumed approximately 658,500 m3 of water (~66 million litres) with most of this going straight to the sewer. This had a total cost of over £1,400,000. Over 60% of our water usage occurs in laboratory buildings.

Water use in labs

Water consumption in laboratory buildings is significant relative to the typical water volumes associated with office buildings, (figure 2). Glass washers, sterilisers, autoclaves, and water condensers all contribute to significant water consumption (figure 3).

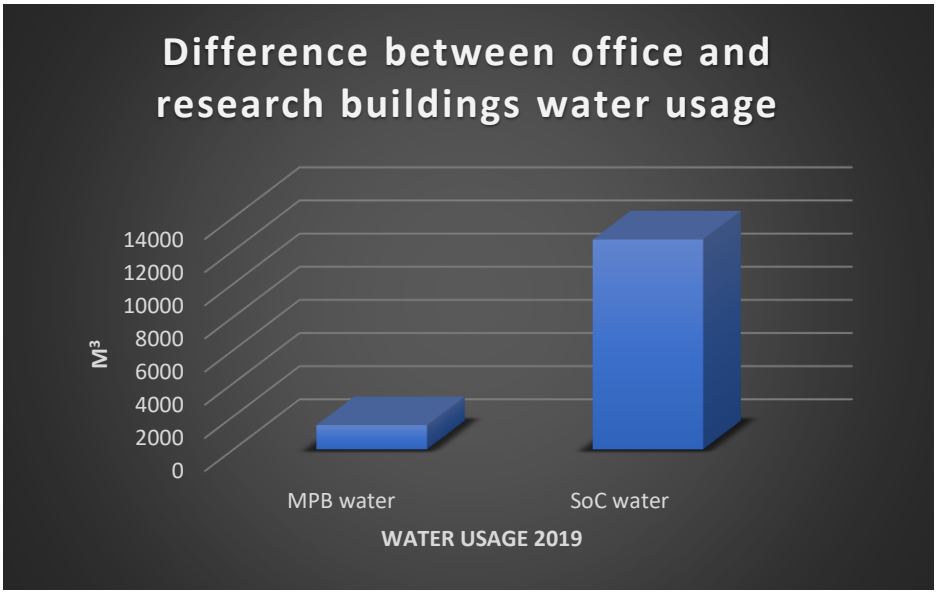


Figure 2. water usage in the Monica Partridge Building and the School of Chemistry

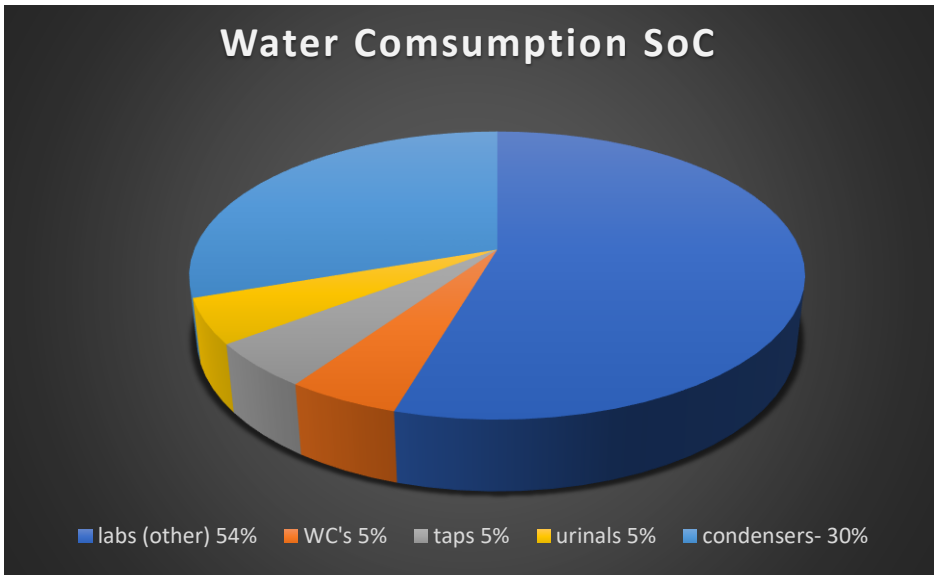


Figure 3. approx. water consumption for the School of Chemistry

Thus, it is important to find alternative water efficient replacements for this equipment.

Waterless condensers

Figure 4. Waterless condenser setup.

Waterless condensers are unique glass condensers that require no water for operation (Figure 4). They can be used with most solvents and used in the same manner as water-cooled condensers. They are economical and should be used whenever possible. The significant benefits of using waterless condensers include:

- Completely omit the need of water.
- Save money on water usage.
- No risk of flooding.
- Reduced risk of injury from tube fitting.

If you want to replace your water condensers with waterless condensers in your lab. Please let sustainability@nottingham.ac.uk know how many you need.

Chiller units

Figure 5. Lab chiller unit

Chiller units (Figure 5) are unique equipment that can substantially reduce water wastage. Compared to conventional tap water cooling offer higher rates of efficiency (tap water at 10-12°C – chiller unit -10°C), stable pressure, and flow rates. They reduce water consumption (~21 litres/h), making them an environmentally friendly refrigeration solution with low running cost. Chiller units in laboratories are often used with rotary evaporator systems. Up to four rotary evaporators can be attached to one chiller unit (depending on the model) figure 6. show the different setups on a rotorvap.

Figure 6. Chiller and tap cooling on rotorvaps

Using water for making a vacuum

For a long time, water has been used in labs to curate a vacuum via a water aspirator (figure 7.) But these use vast amounts of water, over 350 litres/h (tap open fully) and if the drain tube is not in the sink or there is a blockage, the resulting flood can be massive. By replacing these water aspirators with diaphragm pumps (Figure 8.) different sizes depending on the application, will reduction the water consumption for vacuum to nothing, stop floods, give a reliable vacuum and no water contamination of experiments via loss of vacuum due to water flow fluctuations.

Figure 7. Water aspirator

Figure 8. Diaphragm pump

If your lab wants to replace your water aspirators with diaphragm pumps, please let sustainability@nottingham.ac.uk know and there will be funding available.

Equipment using water

Some labs will have glass washers, sterilisers, and autoclaves, and while these are essential to the running of a lab, they still use a lot of water. Here are some ways of reducing water consumption.

- Only turn on and run when needed.
- Only run washer, steriliser, autoclave when it will be full.
- If your run will not fill the equipment to be ran, check in the lab if anyone else has items that can help fill it up.
- Have set run times and a location for items to be placed, to stop unnecessary runs.

Upgrade from a lab water bath to a bead bath

Thermal metallic beads (Figure 9) can replace water in any standard depth, **non-circulating,** and **non-shaking** lab water bath. Beads can also be used to replace water ice in ice buckets (you will need to keep the beads in a freezer before use). Water no longer needs to be replaced weekly and money can be saved by not having to buy additives to stop growth (e.g. avoiding potential legionella growth), the equipment experiences less wear and uses less energy. Lab Armor is available from several approved suppliers.

Figure 9. Lab Armor beads

Stop any leaks

Report any leaks to the Estates helpdesk ASAP to ensure they are fixed quickly. A dripping tap wastes at least 5,500 liters of water a year – enough to fill a paddling pool every week for the whole summer.

Legionella Management

Legionella is a bacteria that can cause Legionnaires' disease, a serious lung infection. Legionella bacteria can grow in warm water, such as the water in a hot water system. Flushing taps regularly can help to reduce the risk of Legionnaires' disease by removing stagnant water, which is a breeding ground for Legionella bacteria, (note that the ideal range for growth being 20-45C).

Part of the UoN Legionella management, see H&S Department Legionella policy link requires that taps are flushed monthly for about 5 minutes to stop Legionella growing in the pipe/taps. In most labs there will be taps that are not regularly used so, will need to be flushed more regularly (typically weekly), adding to water waste. If this is the case and the taps are not required, it is advisable to have them removed. This will save time (not having to go around and flush all these taps) and save on water waste (>5 litres per tap).

To request taps and drains to be removed, please contact the Estate helpdesk.

Fumehoods

Laboratory fumehoods are one type of local exhaust ventilation – a system designed to capture and remove air-borne hazardous substances e.g., gases, vapours, aerosols, and dust generated during an experiment. The fumehood sashes serve as a physical barrier between the experiment and the user, offering a measure of protection against inhalation, exposure, chemical spills, and fires. It is essential that all fumehood users take the time to understand how to use their fumehood effectively, including proper set up, safe operation, and any required maintenance. Fumehoods should be inspected and tested by competent persons monthly.

Fumehoods make up most of the energy use in laboratories, both electrically and thermally. They should be operated responsibly to ensure energy waste is minimized. A fumehood running continuously with its sash fully open can cost £1,500 in electricity and gas annually. The energy use of a single fumehoods is equivalent to that of a household over a single year. In spaces with multiple fumehoods the operating cost can be very high. By operating fumehoods according to our good practice guide annual operating costs can be reduced dramatically to less than £300-500 p.a.

Extract type

Two types of fumehood supply and extract ventilation systems are used across the UoN: constant air volume (CAV) and variable air volume (VAV). In a constant air volume (CAV) system the extract fans operate at a fixed speed, extracting air at a constant volume. Variable air volume (VAV) systems are designed to modulate the extract fan speed relative to the sash position on the fume cupboard, maintaining a constant face velocity. When the sash is fully opened the volume of air extracted through the fumehood is the same as a constant air volume system, however when the sash is lowered the amount of air extracted through the fumehood is significantly reduced, normally by half.

Face velocity

The ‘face velocity’ is the velocity of the air moving across the front plane of the fumehood. Modern fumehoods, and the majority of fumehoods at the UoN, are designed to maintain a face velocity of 0.4m/s (CAV) and a sash closed (VAV) is 0.2m/s. Some of the older fumehoods are set at 0.5 m/s.

Fumehood sashes

Fumehoods sashes can be defined as an adjustable screen between the operator and the workspace. The purpose of the sash includes:

- Containment of fumes/vapours/gasses/powders that may potentially be toxic, thereby limiting their direct exposure to lab members.
- To impose a minimum impedance on the ergonomically efficient and effective use of the fume cupboard.
- To minimize energy demands while remaining consistent with the needs of containment and purge, this target being increasingly associated with the use of VAV. However, none of these operational objectives can be met if sashes are left routinely open when fumehoods are not in direct use.

Fumehood best practice

The following fumehood operating policies should be always put in practice. These policies are designed to improve user safety and reduce energy waste.

Shut the sash completely when the fume cupboard is not in use.	A fully open sash is ineffective against explosions, reduces the efficiency of fume extraction; and increases energy consumption. Keep the sash as low as safely possible.
Use the right sash height (≤ 0.5 m)	The sash is designed to protect users against explosions and contaminants. Keep the sash as low as safely possible. Never raise the sash above the manufacture's upper safety catch. Under NO circumstances should an experiment require an operator to position their head inside the fume cupboard.
A 150 mm wide free zone must be always maintained behind the sash.	Contaminants released near the sash are at increased risk of being drawn out of the fumehood. It is important to maintain undisturbed airflow in the fumehood, which may be caused by poorly placed equipment or operator movements. Overcrowding with equipment and reagents can cause turbulence which can block the air flow and result in a reduction in fume cupboard efficiency.
A 'free air flow zone' must be always maintained on the external approach to the fumehoods.	It is important to maintain undisturbed airflow *into* the fumehood to ensure effective airflow and safe containment. Hanging lab coats on gas taps or overcrowding the outside of the fumehood with equipment, causes turbulence and results in reduced fume cupboard efficiency.
Appropriate face velocity should be maintained.	Check your manufacturer guidelines; fumehoods are typically designed to maintain either 0.4 m/s or 0.5 m/s 'face velocity'. Large face velocities are NOT always better; excessively high air velocity (>0.7 m/s) can induce turbulence, decreasing containment. Ensure monthly checks of face velocity are being undertaken and report excessively high or low inflows to the lab technician.
Avoid using fumehoods to store chemicals and unnecessary equipment.	Use a dedicated ventilated storage area for chemicals, if required and where possible don't store underneath the fumehood, so it can be turned off when not in use.
Ensure gas and water connections are safe, well made, and managed.	All hoses MUST brought into the fumehood must be directed UNDER the aerofoil and secured safely. It is recommended they be brought neatly to the side of the fumehood. All hose arrangements must allow that the sash to be shut completely.
If possible, turn the fumehood off when not needed	Some fumehoods will aways need to be left on, but some that have equipment in and no underneath storage, can be turned off when not needed, saving 100% electricity.
Don't sort items on the aerofoil (the front part of the fumehood)	By storing item on the aerofoil, not only does this impede the air entering the fumehood but stops the sash closing correctly which becomes a safety issue in terms of potential exposure to the worker.
Avoid flushing any thing but water down the fumehood sink	By flushing chemicals, solvents, and reaction materials down the fumehood sinks you will be contaminating the sewage water and damaging the environment. Make sure all waste is treated correctly following your risk assessment and local rules.
When ever possible, make sure all large items are lifted of the base of the fumehood.	Lifting large items and equipment of the base of the fumehood help to improve the air flow in the fumehood, which is better for safety and the energy consumption. You can either make a platform of the item to sit on or use lab jacks.
Don't use water aspirators to generate vacuum	Remove all water aspirators from fumehoods and start using diaphragm pumps. This will save >350l/hour of water being wasted.

Stickers

The following sticker can be used on your fumehoods, to remind endusers to close the sash and help increase safety and reduce energy.

Please contact sustainability@nottingham.ac.uk for fumehood stickers.

Chemicals

The university has an inventory of tens of thousands of different chemicals. It is important that all labs always have an updated list of chemicals available. Some chemicals and materials are environmentally damaging and while a minimisation of their consumption and their correct disposal can have environmental and financial benefit, the substitution of hazardous chemicals for less hazardous ones (when possible) can be of equal importance.

Chemical segregation

Appropriate chemical segregation is important because it helps to prevent accidents and injuries. When chemicals are stored or handled in close proximity to each other, there is a risk that they could react with each other and cause an explosion, fire, or release of toxic fumes. By segregating chemicals according to their compatibility, we can reduce the risk of these accidents from happening.

Here are some examples of why chemical segregation is important:

- Flammable and combustible liquids should not be stored near oxidizers. When these two types of chemicals are mixed, they can create a fire or explosion.
- Acids and bases should not be stored together. When these two types of chemicals react, they can release toxic fumes.
- Toxic chemicals should be stored in a separate area where they cannot come into contact with people or animals. If these chemicals are released, they can cause serious health issues or even death.

By following the proper procedures for chemical segregation, we can help to keep ourselves and our environment safe.

Here are some additional tips for chemical segregation:

- Always read the safety data sheet (SDS) for each chemical before you handle it. The SDS will tell you the chemical's hazards and how to store, handle, and dispose of safely.
- Store chemicals in their original containers. This will help to prevent contamination and accidents.
- Label all chemical containers clearly with the chemical's name, hazard class, and date of purchase.
- Dispose of chemicals, solvents and solutions properly. Many substances require specialised waste disposal so ensure you follow the local rules for waste disposal in your area. **Never pour down the drain or onto the ground**.

By following these tips, you can help to keep yourself and your environment safe from the hazards of chemicals.

Storage

Safety storage of chemicals is essential to prevent accidents and injuries.

Here are some additional tips for sustainable chemical storage:

- Use less hazardous chemicals. There are many chemicals that are less hazardous than others. When possible, choose to use less hazardous chemicals.
- Reduce the amount of chemicals you use. The less chemicals you use, the less you have to store and dispose of.
- Recycle and reuse chemicals (taking account of age and condition). Many chemicals can be recycled or reused. This can help to reduce the amount of chemicals that need to be disposed of and thereby the costs associated with specialised waste disposal.
- If possible, don't store chemicals under a fumehood. Remember, fumehoods cost a lot of energy to run, so what are the alternatives?

Chemical storage cabinets

By using chemical storage cabinets (figure 10), not only are you not needing to run a fumehood 24/7, you will also be using <10% the amount of energy. The cabinets come in different sizes and have different types of filters depending on what is being stored big cabinet SLS small cabinet SLS . The only cost to the school/department is the yearly cost of changing the filter. So, if the reason you can't turn off a fumehood is due to chemical storage, please talk to the sustainability team to see what can be done.

Figure 10. Chemical storage cabinet

ChemInventory

The UoN is rolling out the use of ChemInventory, a web-based inventory for logging all your lab chemicals in your school/department. This is being rolled out by the H&S Department so please speak to your school/department's Health and Safety Coordinator if you're not already using ChemInventory.

Sustainability benefits of using ChemInventory:

- Improved safety: ChemInventory can help to identify and track hazardous chemicals. This information can be used to develop safety procedures and training programs.
- Reduced waste: ChemInventory can help to identify and track unused chemicals. This information can be used to reduce waste by **donating, recycling, or reusing chemicals**.
- Protected environment: ChemInventory can help to identify and track chemicals that are harmful to the environment. This information can be used to prevent pollution, protect natural resources and bring a focus to reducing the quantity of such chemicals.
- Sharing chemicals: ChemInventory can be used to stop unnecessary buying of chemicals. If you are only needing a small amount of a substance, the inventory can be searched and if available, the relevant lab contact can be asked if some can be taken. Consider transport issues if borrowing chemicals from outside your own building.

Green chemistry

Green chemistry is a philosophy of chemical research and design that emphasizes the prevention of pollution at the molecular level. It is a scientific approach that reduces or eliminates the use or generation of hazardous substances in the design, manufacture, use, and ultimate disposal of chemical products.

Green chemistry is a relatively new field, but it has already had a significant impact on the chemical industry. Many companies are now using green chemistry principles to develop new products and processes that are more sustainable and environmentally friendly.

There are 12 principles of green chemistry, which are as follows:

1. **Prevention:** It is better to prevent waste than to treat or clean it up.
2. **Atom economy:** It is better to use less material and fewer steps in the synthesis of a product.
3. **Less hazardous chemical syntheses:** Wherever possible, synthetic steps should be designed to use and generate substances that are as little hazardous to human health and the environment as possible.
4. **Designing safer chemicals:** Chemical products should be designed to be inherently safer, so that they are less toxic, less persistent, and less bio accumulative.
5. **Safer solvents and reaction conditions:** It is better to use safer solvents and reaction conditions to avoid potential hazards.
6. **Increased energy efficiency:** Energy requirements should be minimized throughout the life cycle of a product, from design, to manufacture, to use, and to ultimate disposal.
7. **Use of renewable feedstocks:** Wherever possible, raw materials should be renewable rather than depleting.
8. **Reduce derivatives:** Unnecessary derivatization should be avoided whenever possible.
9. **Catalysis:** Catalytic reactions are preferred over stoichiometric processes because they use less material and generate less waste.
10. **Design for separation and purification:** Separation and purification steps should be designed to minimize waste and improve efficiency.
11. **Real-time analysis for pollution prevention:** Analytical methods should be developed to monitor and control pollution prevention in real time to prevent hazardous substances from being formed.
12. **Design for inherently safer chemistry:** Processes should be designed to minimize the potential for chemical accidents, including explosions, fires, and releases of toxic substances.

Green chemistry is a powerful tool that can help to protect human health and the environment. By following the principles of green chemistry, we can create a more sustainable future.

For more information and links Green Chemistry

For more information from the UoN on Chemical Sustainability and links to green chemicals
UoN chemical guidance

Waste and recycling

The UoN is proactive in its commitment to reducing and recycling resources. The strategy for managing laboratory waste aims to maximise health and safety and to minimise its environmental impact. As well as chemical waste, labs create large amounts of solid waste, including equipment at the end of its useful life, packaging and consumables. Reducing this not only has environmental benefit but can also reduce disposal costs and, in some cases, avoids extra purchases because things can be recycled or reused.

Types of waste

The UoN uses a company called ENVA of its waste management of normal and recycling. As you can see (figure 11) only around 11% of the 2326 tonnes of waste from the UoN goes to landfill. The UoN also sent 270 tonnes of clinical waste for incineration, and this is from our labs!

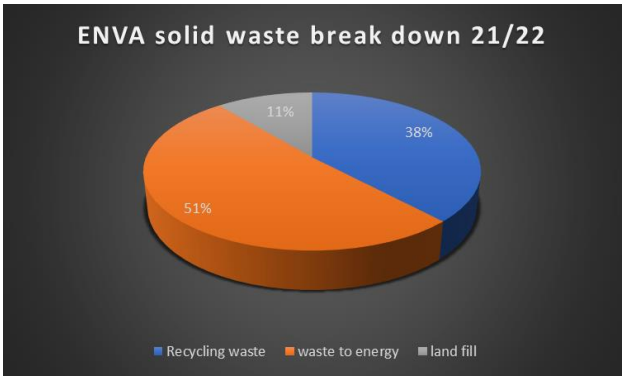


Figure 11. Waste break down UoN

For a link to the UoN lab waste guidance please link here lab waste guidance this guidance page will cover standard recycling, lab recycling, lab glass recycling, lab plastic recycling, polystyrene recycling and waste A-Z

Bespoke recycling bins

The UoN has designed and purchased branded Correx recycling bins (figure 12) for the labs, as a way of increasing recycling from our labs. The idea that if they are all the same no matter the lab, all end users will know what will go in them, thus increasing recycling.
These bins can be used for any clean and chemical/bio free lab recycling, currently we have labels for glass and plastic. Please feel free to make your own labels if needed.
To inquire about getting these bins in your lab or if you require more click sustainability@nottingham.ac.uk

Figure 12. Branded recycling bins

Lab waste reduction tips

- Prevent waste from being generated in the first place. This can be done by designing experiments that use less material, by using more efficient equipment, and by recycling and reusing materials whenever possible.
- Reduce the volume of waste that is generated. This can be done by consolidating waste, by using smaller containers, and by using less hazardous materials.
- Recycle and reuse waste items whenever possible. This can help to reduce the amount of waste that goes to landfills and incinerators.
- Dispose of waste properly. Hazardous waste must be disposed of in accordance with UoN regulations, check your local rules and speak to your school/departmental Hazardous Waste Coordinator for more details.

Additional tips for lab waste reduction:

- Conduct a waste audit. This will help you to identify the types and quantities of waste that are being generated in your lab.
- Develop a waste reduction plan. This plan should include specific goals and objectives for reducing waste.
- Educate your lab staff about waste reduction in their lab inductions. This will help them to understand the importance of waste reduction and how to reduce waste in their work.
- Implement the waste reduction plan. This will require making changes to lab procedures and practices.
- Monitor and evaluate the waste reduction plan. This will help you to track your progress and make necessary adjustments.

By following these tips, you can help to reduce lab waste and protect the environment.

Equipment

Scientific equipment can contribute to a significantly high proportion of laboratory energy and water consumption. Some equipment is kept turned on even when not used or needed, which wastes significant amounts of energy. In other situations, some equipment is left turned on because of the need for careful calibration or ventilation. Often equipment is left turned on because lab users and technicians are not sure whether the equipment is about to be used or can be switched off or requires special procedure to switch off. Energy, water, and waste costs can make a significant contribution to the whole life costs of equipment – in some cases more than the initial purchase costs. If these costs are considered at procurement stage, it may be more cost effective to purchase more resource efficient but higher first cost equipment at the outset.

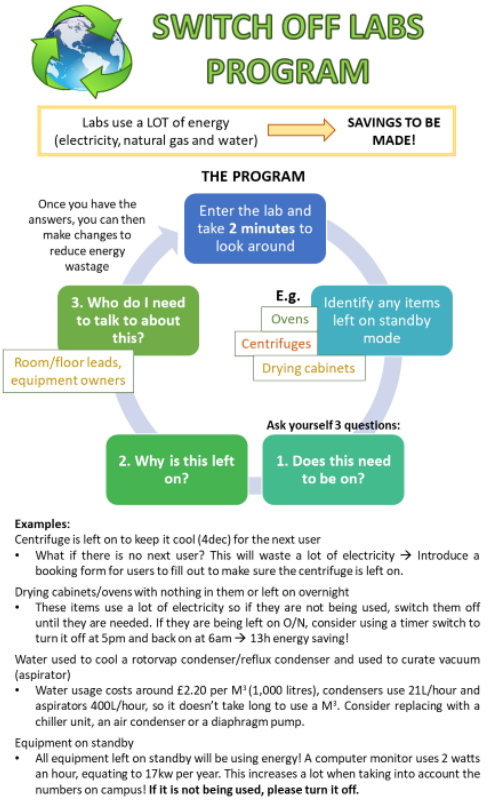
Turn off

Labs often have equipment left on all the time. The question we all need to ask is why? Some equipment needs to be on for experiments, or it is detrimental to it to turn it off. But equipment is often left on for no good reason. Amid a climate and energy crisis, this is not acceptable.
If equipment can be turned off at certain times, UoN can supply timer switches (figure 13). These switches allow equipment to be turned off at a desired time that will not interfere with the day-to-day operation and save over 30% on energy costs.
To obtain a timer, email sustainability@nottingham.ac.uk

Figure 12. Timer switch

Why is equipment left on standby?

Equipment left on standby mode still use energy. An 800w microwave uses 2w per hour when on standby. If it is left on 24/7, it will use 17Kw per year. This applies to most electrical equipment including computer monitors, centrifuges, PCR machines, etc.
Next time you are in the lab, do a **'two-minute switch off'**. Check what is on (even standby mode)
and turn off what you can at the plug. Start getting the lab into the habit of doing this every day.



Do you need it?

Up to 83% of an item's total carbon footprint is generated during its manufacturing. Before purchasing a new piece of kit, assess if it is really needed. Can existing equipment be shared with another team or department? Can it be hired?
If equipment is no longer needed but still works, have a conversation with the owner, arrange for appropriate cleaning/decontamination and then see if it can be passed on to other labs. It is better to have the equipment used than stored in the cupboard!

Stickers

The sustainability team has designed these stickers to help you know if equipment can be turned off and what needs to be left on. Please contact the team to receive some sustainability@nottingham.ac.uk.

Repairs and our workshops

Laboratory equipment is essential for conducting scientific research. However, laboratory equipment can be expensive and can break down over time. When laboratory equipment breaks down, it can be a major setback for research projects and impact on teaching. This is where the UoN workshops come in. UoN workshops can provide a cost-effective way to fix lab equipment.

There are many different types of UoN workshops that can be used to fix lab equipment. Some workshops are specifically designed for repairing specific types of equipment, such as pipettes or microscopes (more lab based). Other UoN workshops are more general and can repair a variety of different types of equipment.

UoN Workshops can be a great way to save money on lab equipment repairs. The cost of repairing equipment in a workshop is typically much lower than the cost of sending it to a professional repair service. In addition, workshops can often repair equipment more quickly than professional repair services. This can save the laboratory time and money in the long run.

In addition to being cost-effective and efficient, UoN workshops can also be a **sustainable** way to fix lab equipment. When equipment is repaired, it is kept out of landfills and incinerators. This helps to reduce the amount of waste that is produced, and it also helps to conserve natural resources.

UoN workshops can also help to reduce the demand for new equipment. When equipment is repaired, it can last for many years longer than it would if it were replaced. This helps to reduce the need to manufacture new equipment, which can have a significant environmental impact.

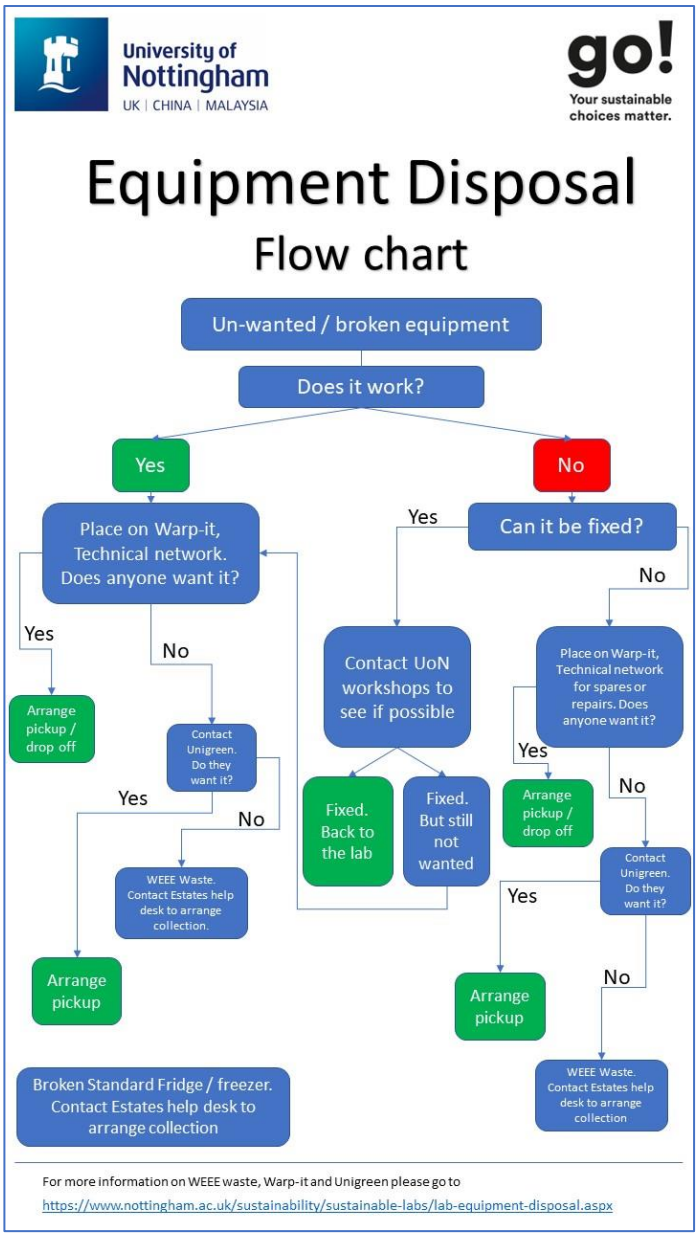


Figure 13. equipment disposal

If you have broken equipment, before throwing it away see if it can be fixed (figure 14). Flow chart on what to do). If it is no longer needed, check to see if others can use it and failing that, speak to Unigreen Scheme, to see if they want it.

Unigreen Scheme

Unigreen scheme is a free service that helps universities laboratories recoup valuable space, generate revenue, and hit their environmental targets by collecting, storing, and selling their unused or surplus high-value laboratory equipment.
Unigreen Scheme works by collecting unused or surplus laboratory equipment from its clients. The equipment is then stored in Unigreen Scheme's warehouse until it is sold to a new owner. Unigreen Scheme charges a commission on the sale of each item, which is shared with the client.
In addition to providing a free service, Unigreen Scheme also offers several other benefits:

- A carbon impact report: Unigreen Scheme provides its clients with a carbon impact report that shows the environmental benefits of using the service.
- A dedicated account manager: Each client is assigned a dedicated account manager who can help with the collection, storage, and sale of equipment.
- A secure storage facility: Unigreen Scheme's warehouse is a secure facility that is fully insured against theft and damage.

To use the scheme for recycling unwanted lab equipment, first take pictures of the equipment and compile a list stating its condition (excellent, good, ok, and spares or repairs) then send this onto Ben Glazier ben.glazier@unigreenscheme.co.uk who will let you know if they want it. Unigreen will then arrange pick up, recycle your equipment, and offer a share of any profit.

Be aware of decontamination requirements for H&S before sending to Unigreen.

Equipment disposal

If all the above avenues have failed to take the equipment and it needs disposing off, it will become WEEE waste.

WEEE waste

You can return old electrical and electronic equipment free of charge by using suppliers' or manufacturers' take-back schemes. If you are unable to trace their take-back scheme, contact your building manager or Estate Office Helpdesk to arrange collection of the equipment. Please specify the approximate quantity and location.

It is illegal for the university to send waste electrical and electronic equipment (WEEE) direct to landfill; it should be collected separately to enable reuse and recovery of materials.

Fridges and freezers

Please contact your building manager or Estate Office Helpdesk to arrange collection of redundant fridges or freezers, specifying the approximate quantity and location.

Disposal cost is currently £45 for small fridges/freezers and £75 for large fridges/freezers.

Computer equipment

A small proportion of redundant computer equipment is given to charity, but most is collected for recycling by the University's IT supplier.

Read more about the process for requesting a PC disposal collection [UoN access only].

Be aware of decontamination requirements for H&S before sending IT equipment, that was based in a lab environment, for repair, recycling, re-use.

Cold Storage

Cold storage devices such as fridges and freezers are one of the highest laboratory energy consumers. They directly account for up to 15% of total laboratory energy consumption. Also significant is the indirect energy consumption associated with heat generation, which requires an increase in mechanical cooling and ventilation in the building. It is important these cooling and ventilation impacts are considered when placing cold storage devices. The energy consumption of cold storage devices rises when circuits or interiors are frosted, or not working effectively. Regular defrosting and maintenance is important.

Best practices for cold storage

Cold storage labelling

It is important that only wanted samples are stored (thereby reducing the overall amount of cold storage required) and that these samples are correctly labelled, correctly boxed and a full inventory of the contents of the fridge / freezer are up to date and available. These are good labels to use Fisher cryo labels make sure that the label has a name, date, contents and the PI name.

Defrosting

- We recommend defrosting the entire freezer at least once a year.
- Defrosting is a multistep, manual process. First, remove all samples from the freezer and
- Transfer them to another freezer. The transferring of samples should be done in small batches, because if the door is kept open for too long, you will warm up the freezer prematurely. After all the samples have been removed, turn the freezer off, unplug it, open the door, and let the ice melt. Make sure to place towels on the floor to soak up the water, or routinely wipe up the melted ice. Or if possible, move outdoor and leave overnight.
- Take the opportunity during your annual defrost cycle to evaluate what samples you're storing. It is okay to appropriately dispose of samples that are not labelled, have expired, or belonged to researchers who left years ago. This will open room for other, more important samples and make them easier to find.
- Post a freezer map and inventory on the door of the freezer to keep samples organized and minimize the amount of time needed to find a sample.
- Minimizing the amount of time, the freezer door is open reduces temperature fluctuations within the unit, saves time, and saves energy.
- If possible, pull out the fridge / freezer and vacuum any dust of the compressor and cooling fins at the back of the unit. This reduces the potential for fire and help heat regulation of the cooling system.

ULT Freezers

Ultra Low Temperature (ULT) Freezers typically operate between -70 and -80°C, consuming between 7-27KWh per day. This is roughly three times the average daily consumption of a UK household (9KWh/day). Assess the items being stored and if possible, run the freezer at -70 to save >25% on energy compared to -80.

ULT freezers can consume significantly more energy than needed due to poor management and maintenance.

The following guidelines provide advice on how to manage your ULT freezers more effectively to reduce energy consumption and prolong freezer life whilst safeguarding samples.

• **Close the doors!**
○ Ensure that the internal doors are shut properly before the main door is closed promptly. This prevents warm air entering and reduces ice build-up.
• **Keep an inventory**.
○ Minimise how long the door is kept open by keeping an up-to-date inventory stuck on the outside or near each unit. It should detail clearly both the sample and the location. If possible, keep samples in boxes on racking, to allow for quick retrieval.
• **Label your samples.**
○ Label all samples clearly, including contact details and if possible, an 'expiry date'. Remove old samples where possible, particularly when members of staff leave.
• **Manage your space.**
○ Freezer space should be maximized whilst ensuring that samples do not block grills, vents or obstruct the airflow to and from coolers, as this will compromise temperature control. Avoid large empty spaces - the energy a freezer uses is spent cooling the air that enters upon opening the freezer door. If it is a standby freezer, place polystyrene boxes in the empty spaces until needed.
• **Position your freezer.**
○ Store in a well-ventilated area away from sources of heat and out of direct sunlight with low ambient temperatures. High ambient temperatures increase energy consumption and may also increase the risk of freezer failure. Ensure that there is space around the unit's vents (keep 15cm of space around behind and on top). Do not store items on top of or around ULT freezers.
• **Make sure your freezer is reaching its temperature set point.**
○ If you can hear the compressor running constantly, or if the freezer does not reach its set point (as seen from another thermometer), inform the lab technician to have the unit looked at immediately.
• **Periodic maintenance / cleaning**
○ Arrange for regular maintenance checks by an appropriately trained member of staff to regularly defrost de-ice and clean filters. **This should happen at least annually.** The seals should also be checked.

Responsible freezer purchasing

Avoid purchasing a new freezer if possible. Can you clean out space in your existing unit to accommodate new samples, or share freezer space with a neighbouring lab? This is a great way to save your lab money and minimize your environmental impact. If a new freezer is necessary, look for an efficient model: Look for energy consumption information on the product's technical specifications. Many manufacturers are realizing that energy efficiency is an increasing area of concern for consumers and are therefore making strides to ensure their products are as efficient as possible. Larger freezers typically use more energy than smaller freezers relative to their size.

Further reading on ULT freezers

https://www.ed.ac.uk/files/atoms/files/efficient_ult_freezer_storage.pdf
https://www.freezerchallenge.org/uploads/2/1/9/4/21945752/poster_a2_freezer_maintenance_en02.pdf

Networks

There are a couple of great sustainability networks at UoN.

Technical Sustainability Working Group

(TSWG) is a group of lab technicians from across the university's Nottingham and Derby campuses, working to embed sustainability within labs.
Technicians are at the forefront of university labs and therefore well-placed to lead green initiatives and share best sustainable practices and ideas. This is shared not just with each other via the working group but also with the university sustainability team and external partners to make the work we all do greener and more sustainable.

For more information about the Working Group, please contact Lee Hibbett at Lee.hibbett@nottinghm.ac.uk

Staff Environmental Champions

Environmental Champions are a group of enthusiastic staff who help improve the environmental performance of the university by raising awareness of environmental issues within their School or Professional Service.

Find your departmental champion or more information:
UoN ES champions.

Lab exit form

On the next page is a lab exit form that should be used when lab endusers are about to leave the lab. It askes some basic questions to make sure that the lab space is cleared, sorted and gets a senior lab member to check and sign of that it has been done. This stops waste building up in the lab, chemicals are not left in cupboards, cold storage is sorted and get the lab ready of the next new member.

Lab exit form

Building / Laboratory / Area

All staff & students **MUST** ensure that this form is fully completed (in conjunction with their PI/ supervisor / technician / senior lab member) when finishing their work in their labs.

Name	
Staff/Student ID	
PI/Supervisor/s	
Project Code	Used for waste disposal costs if waste is found after you have left

#	Action to be completed	YES / NO* / NA	Name / signed	Date
1	Have all lab books, electronic data and computer equipment been returned to your supervisor/s *supervisor to sign*	YES / NO / NA		
2	Have you cleared and cleaned your work area/bench/shelves in the lab *technician / senior lab member to check and sign off*	YES / NO / NA		
3	Have you cleared and cleaned your fumehood/ MSC *technician / senior lab member to check and sign off*	YES / NO / NA		
4	Have you cleared and cleaned out your lab fridges, freezers, and cupboards *technician / senior lab member to check and sign off*	YES / NO / NA		
5	Has all waste been removed from the lab, fumehoods, fridges and freezers *technician / senior lab member to check and sign off*	YES / NO / NA		
6	Have all your own chemicals and reagents been labelled and placed and entered into lab inventory *technician / senior lab member to check and sign off*	YES / NO / NA		
7	Have all your samples/final compounds been labelled, sorted, logged and placed into cold storage *technician / senior lab member to check and sign off*	YES / NO / NA		
8	Have all your transformed cell lines been labelled, logged and placed into cold storage *technician / senior lab member to check and sign off*	YES / NO / NA		

*Where you have stated No to any question above, please provide for each one, an explanation of why and state what has been put in place to mitigate any health and safety risks

Signature of student…….
Signature of supervisor …….
Date …….

Please hand this form into the nominated person, so it can be checked and the form filed.

Version

Version	Purpose / change	Author	Date
1.0	First draft	LPH	26/05/2023
1.1	Added an acknowledgement	LPH	25/07/2023
1.2	Document edit	LPH	08/04/2024

Resources

Laboratory resources can be downloaded from the UoN Sustainable Labs website. These include posters, lab exit forms, incentive fund applications, fume cupboard stickers, switch off stickers as well as case studies.

Sustainable Labs website:

https://www.nottingham.ac.uk/sustainability/sustainable-labs/sustainablelabs.aspx

If you want to make additions or edits to this guide, you can get in touch directly with our Sustainable Labs Co-ordinator and this guides author, Lee Hibbett.

Lee.hibbett@nottingham.ac.uk