THE UNIVERSITY of EDINBURGH
Social Responsibility & Sustainability

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Sustainable laboratory equipment metering, procurement, and operations guide

Foreword

Laboratories are energy intensive operations which contain a variety of specialised equipment types. Such equipment, along with the ventilation required for such spaces, cause laboratories to use up to ten times more energy per m2 than typical research spaces. While many laboratories will possess standard equipment types such as freezers, incubators, or ovens, there is an incredible variety in each generic type which can render procurement of such equipment challenging. Through a better understanding of what resources are being utilised and whole-life costing, we see that sometimes cheaper upfront equipment leads to greater expense over the long term. This guide is intended to provide simple guidance for users on what to consider when purchasing generic laboratory equipment, and tips on how to make sure you get the best value and quality possible. It also includes basic tips on how to meter your equipment, an approximate target efficiency, and operational advice.

1. General advice

Core facilities / kit catalogue

Prior to purchasing new equipment, you should assess whether there is existing equipment available. University of Edinburgh has a variety of Core Facilities where you can use state-of-the-art equipment at a competitive price, and may include expert experimental support improving results. There are a variety of websites with this information, so a simple web-search may yield what you require.

University of Edinburgh is part of a UK-wide equipment database detailing significant research equipment. You can search for such equipment here: https://equipment.data.ac.uk and we would encourage you to upload any new purchases to the system.

Warp-it / local sharing

Warp-it is University of Edinburgh's portal for used equipment and items which owners no longer want to keep and are on offer for being claimed by University of Edinburgh staff. Check Warp-it for items prior to purchase, or upload items you no longer require. Or check with local lab managers.
www.warp-it.co.uk/company/universityofedinburgh

Sustainable Campus Fund

University of Edinburgh may be able to provide a grant to support the purchase of your lab equipment to incentivise more efficient kit. To learn more, visit:
www.ed.ac.uk/sustainability/staff/funding-and-support/sustainable-campus-fund

Packaging

Request minimal packaging from all suppliers. Some suppliers may have return schemes for packaging e.g. consumables from NEB and Promega, or glass "Winchester" bottles. Contact your local stores team to learn if this is feasible, or contact Procurement to report or to learn more.

Energy data and metering

University of Edinburgh Department for Social Responsibility and Sustainability may provide you with plug-in energy meters should you wish to meter any equipment. Ensure any metering is conducted safely and contact building services if in doubt.

Building energy data access may be available from Estates via Department for Social Responsibility and Sustainability. Get in touch to learn more.

Procurement

University of Edinburgh Procurement requires you utilise only approved suppliers. By using SciQuest for "e procurement" you will ensure you are compliant. See here for SciQuest information: www.edweb.ed.ac.uk/procurement/eprocurement/sciquest

See here for approved University of Edinburgh suppliers: www.ed.ac.uk/procurement/buy-at-ed

2. Cold Storage - ULT Freezers (ultra-low temperature, -70C or colder), -20C Freezers and 4C Refrigerators

Best performance:

- Request ULT freezers which have electricity use of 13.5 watts/litre/day or better.
- Seek ULT freezers that are larger than 500L which operate at 10 kWh/day or less.
- Request refrigerators and freezers which perform at 2.5 watts/litre/day or 1.5 kWh/day.
- Ensure digital temperature display and controls (i.e. not just a dial marked 1-6 for example)
- Eppendorf Cryocube range are currently examples of good practice for ULT freezers[1], and Leibherr range for -20C or warmer units.
- Ensure hydrocarbon refrigerants (not HFCs or CFCs)

Metering tips:

Such equipment may be assessed via a plug-in energy meter. As compressors will cycle, fridges and freezers should be assessed over period of a minimum of 12 hours, preferably 48h+. Ensure the unit is still running when applying and removing power meter (listen for compressors running)! When plugging a unit back in the wall after unplugging, it is recommended to wait at least one minute after unplugging. Consider the operational settings when metering, e.g. freezer contents, room temperature, and door openings.

[1] Currently, in the 500-600L capacity range of ULT freezers the Eppendorf F570h unit has the longest lifespan, best combined energy and temperature performance, likewise the F740h/hi leads the 690-790L range.

Procurement advice

- Durability and efficiency > purchase cost. Consider the balance between initial purchase cost and operational/ maintenance costs (i.e. life cycle cost) as part of procurement decisions. While a unit may cost more, it may have lower cost and carbon impacts through extended lifetime and reduced energy costs. It could also mean reduced maintenance, down time, and time spent managing repairs. Reach out to University of Edinburgh Department for Social Responsibility and Sustainability for information on top-up funding from the Sustainable Campus Fund to facilitate the purchase of efficient units.
- Target ULT freezers which utilise 13.5 watts/litre or better. Request refrigerators and freezers which perform at 2.5 watts/litre or better.
- Consider long-term storage requirements and balance with environmental consideration - Larger units typically will utilise space and energy more efficiently, though a small unit may be sufficient.
- Chest-units will keep temperature better, but require more floor-space.
- Always empty out unnecessary samples from existing units prior to purchasing a new unit.
- Spark-free is only necessary in laboratories containing combustible chemicals, and not applicable to ULT freezers.
- Consider internal fans, which will provide improved temperature stability and uniformity.
- Manufacturer's data varies in their collection methods, particularly the room / "ambient" temperature they use to achieve their energy figures. Request environmental testing conditions from manufacturers when evaluating energy performance.
- Manufacturers often provide data as a kWh/day figure. To make a like for like comparison which takes into account the different sizes of different models this must be converted to a kWh/litre figure.
- Racking can be a significant cost of a ULT freezer. Use racking from previous units (check if it compatible).
- Ensure there is local alarming, and consider the necessity of secondary temperature probes.
- Ensure units do not automatically defrost – auto defrost cycles will vary internal temperatures and can cause sample degradation.
- Require a digital display so that temperatures may be easily viewed and controlled.
- When considering refrigerants, it is recommended that hydrocarbons (HC) are preferred to other refrigerant types (such as hydrofluorocarbons – HFC's and Chlorofluorocarbons – CFC's) as they are more energy efficient, readily available (cheaper servicing) and more environmentally friendly. CFC's already no longer used due to their ozone depletion and HFC's are to follow suit with due to their contribution to global warming. From 2015 to 2030 regulations are set to reduce the availability of HFC refrigerants by 79%. Meaning their availability and cost will rise dramatically. Servicing and repair of HFC units will become costly and may prompt end users to replace rather than repair.
- It is strongly advised that any units submitted by vendors are also made available for testing so that energy, temperature performance at set point and capacity can be measured under controlled conditions. Manufacturers have recently begun to overestimate their available capacity and underestimate their energy consumption in their marketing literature. Energy consumption may be $\geqslant$40% higher than published whilst available capacity may be up to 20% lower.

Operational advice

- Warmer rooms will cause freezers to consume more energy. Target 15-18C room temperature for maximum efficiency.
- Opening the freezer door for periods greater than 30-45 seconds will cause a swift rise in temperature, particularly for samples closest to the door. Try to minimise the time the door is kept open.
- Doors seals: If compromised, they will lead to loss of temperature and wasted energy. Ensure they're not blocked by excess ice or frost, and can close securely.
- Ensure filters are not blocked with dust, and are regularly cleaned (typically only relevant to ULT freezers). Blocked filters will reduce the unit's ability to expel heat and cause units to waste energy whilst also adding extra load to compressors.
- Ensure that contents are tracked, in particular when there are personnel changes/departures in the lab. E.g. require departing staff/students to indicate what they require stored, for how long, and at what temperature.
- Ensure the warmest appropriate temperature is selected to preserve samples without excessive energy consumption (operating a ULT at -80°C uses c.30% more energy than operating at -70°C)

3. Walk-in Environmentally Controlled Rooms (Cold Rooms)

How to assess efficiency:

kWh/day to assess operational cost, kWh/m^3 to assess efficiency

Metering tips:

These rooms should **not** be assessed by anyone other than trained professionals – such rooms may require metering of 3-phase power, which would be dangerous for untrained workers. Such rooms should be assessed for a minimum of 24 hours.

Procurement advice

- Consider necessity of such rooms which are only efficient if used at or near capacity. Consider possible alternatives such as incubators or fit-for-purpose fridges. These offer improved resilience in case of compressor failure, reduced maintenance costs, and reduced energy consumption.

Operational advice

- Avoid use of cardboard or materials which will erode due to conditions.
- Ensure users understand how to react if the room is not at the correct temperature, or in the event of a complete failure. This may include movement of contents to backup facilities.
- Ensure there is a safe means of escape for any users.
- Maintain the door to ensure it shuts securely.
- Allow enough space for air to circulate, and don't block fans or compressors.
- Consider heat output of any equipment in the room, minimise such output where possible.

4. Incubators

Best performance:

14 watts/litre/day. Galaxy or Heracell ranges are currently examples of good practice.

How to assess efficiency:

kWh/day to assess total cost, kWh/litre to assess efficiency

Metering tips:

Incubators may be assessed with plug-in energy meters. Take care not to shift or move units if samples are present. Ensure the unit is still operational when applying and removing power meter.

Procurement advice

- Consider long-term storage requirements. Purchasing a larger unit in advance can save further purchases. Larger units typically will utilise space and energy more efficiently. This should be balanced with need – do not purchase larger units only for efficiency if the space will not be well utilised.
- Target units with copper shelving as copper possesses natural antimicrobial effects.
- Consider decontamination methods. H_2O_2 and chemical decontamination methods exist which require less time and energy than heat-cycle decontamination, but will require regular purchases of chemicals and reagents.
- Ensure heat range, humidity range, and attachments (CO_2) are appropriate.
- Compare temperature uniformity, ensure it's appropriate for your requirements.

Operational advice

- Avoid keeping the door open too long, as this will impact internal temperature and humidity.
- Maintain equipment including cleaning and decontamination (either H_2O_2 or heat)
- Consider emergency protocols and power sources – What happens during failure? Are some incubators to be prioritised?
- UV lights require maintenance and upkeep, and must be replaced frequently to maintain effectiveness.

5. Biological-Safety Cabinets (class II)

Best performance:

Recirculating units are far more energy efficient than ducted, though must be balanced with safety requirements. Aim for the lowest wattage possible whilst not sacrificing quality or endurance (typically lower than 120 watts).

Units:

kWh/day to assess operational cost (with lights on), kWh/m2 to assess efficiency where m2 indicates work surface area, and inflow/downflow for flow rates (m/s).

Metering tips:

To assess kWh, a plug-in energy meter may be applied. Be aware that some cabinets having two plugs. Ensure you monitor the plug responsible for powering internal fans. Fans and lighting will consume a steady amount of energy. This means that one can meter typical energy consumption quickly as a live wattage reading will provide sufficient data to determine kWh. For example if your cabinet consumes 250 watts instantaneously, your cabinet operational energy consumption will be 0.25 kWh each hour. Thus a cabinet in operation for 10 hours will consume 2.5kWh in total. Energy consumption associated with ducted units must be estimated using different methodology to take into account the loss of heated or cooled air from the building (contact Department for Social Responsibility and Sustainability for assistance).

Procurement advice

- Safety cabinets provide sample and user protection and are therefore different to fume cupboards, which provide user protection but limited sample protection.
- Consider whether ducting is necessary, or will HEPA filters suffice. Ducted units will consume significantly more energy. If uncertain, seek advice from your local Safety Officer.
- Request internal lighting to be LED.
- Energy consumption is typically listed as 'watts', though some manufacturers may apply kWh/day or /year. Watts may be converted to kWh/day by multiplying the wattage by 24/1000.
- Engage with local staff who have recently purchased such units. How has the servicing and customer support been? Are there engineers available during failures?
- Ensure the size of the unit is appropriate for the works to be conducted.

Operational advice

- Turn off cabinets when not in use. Whether through a booking system, timers, good practice, etc., cabinets should be closed and turned off when not in use. Leaving open and on will not guarantee a sterile environment. Instead close and turn off, and clean when commencing work.
- Inflow and down flows are set by professionals performing regular testing and maintenance. Inflow rates must be >0.4 m/s, while down flow rates must fall between 0.25 – 0.5 m/s. Avoid inflow rates in excess of 0.55 m/s.
- Critically consider the necessity/effectiveness of UV lights for sterilisation (consider maintenance and what materials you're working with). Minimise usage of UV lights.
- Consider your fumigation method (H_2O_2 should be favoured over Formaldehyde).
- Keep sash heights minimised during usage.

6. Ovens & Drying Cabinets

Best performance:

80 watts/litre or lower for drying cabinets. GenLab E3 range of drying cabinets are currently examples of good practice. Contact Department for Social Responsibility and Sustainability if considering purchasing any drying cabinet to access funding.

How to assess efficiency:

kWh/day to assess total cost, kWh/litre to assess efficiency.

Metering tips:

Such equipment simply requires plug-in energy meters. As such equipment will heat in variable cycles, to assess temperature two types of measurements should be considered: Energy required to achieve temperature from 'cold', and energy required to maintain temperature.

Procurement advice

- Ensure to differentiate ovens from drying cabinets. An oven will typically have significant insulation, and can operate at temperatures far higher than drying cabinets. Ovens will have better temperature uniformity, and are designed to contain samples. Drying cabinets are typically designed to dry glassware or consumables. Drying cabinets will consume far greater amounts of energy due to greater internal volumes and poor insulation.

- Consider specifying an internal fan – this will increase temperature uniformity and greatly reduce dry times, though will increase purchase costs. The additional cost of an internal fan will be repaid from energy bill savings if units are turned off after drying is complete.
- Require digital temperature and timer displays, and request built-in timers.
- Minimise drying cabinet size to the smallest appropriate for your usage.

Operational advice

- Run your drying cabinet on a timer, and avoid operating overnight.
- Typical drying cabinets will have a grate at the bottom from which heat emanates. Don't place items on this grate, as they can melt or even catch fire.
- Operate your units at minimal temperatures necessary.
- Ensure doors are kept well sealed and closed when in operation.
- Some drying cabinets will have small vents at the top. Keep closed unless the cabinet is becoming too humid.

7. Water Baths & Heating Blocks

Best performance:

Energy consumption is not typically advertised, though target wattage below 500, depending on block size. Favour water baths with beads over units which contain water (and thus require regular chemical sterilisation). Keep equipment off when not in use.

Units:

kWh/day to assess total cost, kWh/litre to assess efficiency

Metering tips:

Such units may be assessed for kWh with a plug-in energy meter. Such units should be assessed in operation for several hours, though not longer than 5 hours is necessary. As such equipment will heat in variable cycles, to assess temperature two types of measurements should be considered: Energy required to achieve temperature from 'cold', and energy required to maintain temperature.

Procurement advice

- Ensure water baths have a cover.
- Consider beads instead of water. They may have slightly higher upfront costs, but save long-term on decontamination reagents required to keep water sterile as well as reducing operational energy consumption[2].
- Ensure power cables are of sufficient length for your space, and there is space for a timer if applicable.
- Check the size – larger units may have slow warm-up times and waste energy.
- Typical water-baths are designed to heat between 5°C - 70°C. Consider your requirements.
- For heating blocks, consider temperature uniformity.

[2] Case study available from UCL upon request

Operational advice

- Keep water baths covered when in use.
- Don't leave units operating overnight unless required – contact Department for Social Responsibility and Sustainability for free digital timers or work with local users to ensure equipment is on only when necessary.

8. Water Purification Units

Procurement advice

- Consider your necessity of RO, DI, Ultrapure, or untreated water. Which is actually required for your experiments? Avoid usage of excessively processed water.
- Ensure that you consult with end-users about sizing units and ensure capacity is sufficient for work carried out in lab space
- Consider cost/maintenance savings associated with central fed, plumbed system rather than purchasing multiple point of use units. These work well in new build fit outs, less so in refurbishments of a small existing space.
- Consult with purchasers about the use of Electro-deionization units rather than standard cartridges. These can come with an increased initial cost however they require much less maintenance than standard deionisation cartridges.
- Ensure that pure water solutions purchased have built in standby/lab close mode that reduces energy and water consumption, while still circulating pure water.

Operational advice

- Ensure users understand which purities of water they require for their experiments, and avoid wastage.
- Ensure users understand dispensary controls to avoid spills or small floods.

9. Vacuum Pumps

Considerations:

Type of Pump - Vacuum pumps are used for a range of applications in laboratories. Different types of pumps are available and suited to different applications.

- Diaphragm pumps used for filtration should have a high pumping speed, and be turned on only when required. Diaphragm pumps for equipment requiring operation down to 0.5 mbar such as rotary evaporators should be fitted with a vacuum controller. Installing local area network diaphragm vacuum pumps fitted with a controller for these two operations should be considered in line with the requirements. It is often both more economical and efficient to purchase vacuum regulators next to equipment than individual vacuum pumps next every piece of equipment.
- Rotary vane oil pumps used for operations down to 1 x 10-3 mbar should only be turned on when required and in most cases should be turned off overnight at the very least. Unfortunately, it is not usually possible to fit these pumps with timers, as users will need to seal the system before switching off the unit. Controllers for these pumps are available and should be considered.

10. Waterless Condensers

Waterless condensers can replace water-cooled condensers in most applications. Replacing tap to drain water condensers saves approximately 120L of water per hour and requires no energy for operation.

Crucially, they reduce the risk of flooding in laboratories.

Considerations:

Consider which condensers are appropriate for your needs, as some models function better with solvents of particular boiling point ranges. Also consider physical manipulation of the units, as various designs will reach extremely high temperatures during use.

Boiling point considerations: It is recommended that to prevent breakthrough when using solvents with a boiling point below 60°C, that the heating bath/block temperature differential is kept below 10°C, e.g. for dichloromethane (bp 40°C) the heating bath/block temperature should not exceed 50°C. For diethyl ether (bp 35°C) this differential should be no more than 4°C.