Ultra Low Freezer Management Guide

Introduction

Energy-intensive laboratories present particularly promising opportunities to help the University of Cambridge reduce its carbon emissions. Ultra Low freezers (ULFs), defined here as freezers that operate at temperatures of -80°C , typically make up over 66% of the energy used by all lab appliances[1].

An audit of select departments at the University in 2013 found that many ULFs were using far more energy and money than needed, simply due to poor management and maintenance.

These guidelines provide advice on how you and your department can manage your ULFs more effectively to save money, reduce carbon emissions, prolong freezer life and safeguard samples.

Day-to-Day Good Practice

1. Ensure that internal doors within freezers are closed properly before the main door is shut, and that both are closed as quickly as possible. This prevents warm air entering and reduces ice build-up. Stick a sign to that effect on the freezer door to encourage others to do the same.
2. Arrange for up-to-date inventories for each unit, detailing what goes where inside each freezer. Stick a copy of this on the freezer door in order to minimise searching times with the door open.
3. Keep samples in boxes and places boxes in racking, to allow for quick retrieval.
4. Clearly label your samples, including your contact details and an 'expiry date' for the sample. This will facilitate sample audits (see below), as well as keeping your samples safe.
5. Do not overfill freezers. Samples should not block grills, vents or obstruct the airflow to and from the coolers, as this will compromise temperature control.
6. Avoid leaving large empty spaces in freezers. The majority of the energy a freezer uses is spent cooling the air that enters upon opening the freezer door. If large areas of the freezer are empty, use spare polystyrene ice boxes to fill them.
7. Position freezers suitably:
    a) Store ULFs in a well-ventilated space away from sources of heat such as sunlight or warm rooms. Most hallways are not designed to effectively remove heat generated from ULFs; therefore, ambient temperatures can reach as high as 32˚C, especially during summer. Operating ULFs at these ambient temperatures increases energy consumption by as much as 24% and increases the risk of freezer failure, endangering samples.

[1] Yale University Study on Labs.

b) Ensure that there is space around the unit's vents to allow it to draw in and expel air. ULFs need at least 20 cm of clear space on the top, and a minimum of 15 cm of clear space at the rear and on both sides. Do not store items on top off or around ULFs.

8. When back-up ULFs are not being used, lower them to a set point temperature of -60˚C. This will both reduce energy and extend the life of the freezer, by lowering the duty cycle.
9. Make sure your freezer is reaching its temperature set point. If you can hear the compressor running constantly, or if the freezer is set for -80°C but only reaches -78°C, inform the lab manager and have the unit looked at immediately.
10. Where possible, fit energy monitors to every ULF to help identify malfunctioning freezers. Funding for monitors is available from the Environment and Energy Section through its Energy and Carbon Reduction Project (ECRP) (see: http://www.environment.admin.cam.ac.uk/what-are-we-doing/carbon/energy-and-carbon-reduction-project-ecrp).
11. Develop and maintain an inventory of the ULFs in your department. The key information to record is:
    - The number of ULFs;
    - The design/ model of each freezer;
    - The energy consumption (wattage) of each freezer;
    - The age of each freezer;
    - The location of each freezer, also noting whether anything is being stored on top of or around the freezer.

This information will enable you to:

- Characterise the age profile of the ULFs in your building – as a general rule, older freezers will tend to be less efficient[2];
- Target specific areas or labs for improvements, based on the number and age profile of the ULFs they contain;
- Develop a schedule for replacing the older and/or more power hungry freezers;
- Identify opportunities to improve where and how the freezers are located.

[2] The efficiency of ULFs decreases over time, due to loosening seals, refrigerant loss, degraded lubricants, fatigue in mechanical systems, or poor maintenance. Each year of a ULF's age translates in to approximately 3% increase in energy consumption.

Periodic Freezer Maintenance

1. Arrange for regular maintenance checks to be performed on all freezers, ideally on a monthly basis and at the least every 6 months. Allocate responsibility for performing these checks to a suitable staff member and have a set timetable. Poor maintenance can increase condensing temperature or reduce evaporating temperature by several degrees, resulting in an increase in energy use of up to 25%.
2. Annex A provides some guidelines on how to carry out routine ULF maintenance. *To avoid personal injury and damage to the freezer or samples, the actions described in Annex A should only be carried out by a nominated and suitably qualified staff member.*
3. Identify any 'zombie' freezers by regularly testing or metering freezers older than 10 years. Zombie freezers are those that, while still appearing to be fully functional, guzzle two-to-four times as much energy as a normal freezer to do so. Such freezers should be replaced.
4. Clear away any ice build-up with a soft cloth, dustpan and brush, or rubber mallet. Avoid sharp tools and be cautious to avoid damaging the rubber seals and gaskets. As frost builds up on the evaporator coils the heat transfer rate in the ULF cabinet is decreased due to the insulating effects of ice. This means the compressor has to work harder and longer to maintain cool temperatures, wasting more energy. Removing the ice regularly can also extend freezer life.
5. If the ice layer is too hard and thick to remove gently, perform a full defrost by following the 'How to Fully Defrost Your Freezer' advice in Annex B.

Sample Audits and Management

Unwanted and unnecessary samples could be taking up precious storage space in ULFs.

During the Summer of 2013, an intern student working with the Environment and Energy Section coordinated an audit of samples stored in the ULFs in a University department, which showed that a high percentage of samples (in some freezers, up to 100%!) were so poorly labelled so that they were unidentifiable to anyone other than the individual who stored them; and 9% of samples were older than 5 years or belonged to researchers who had left the department. A similar audit undertaken at the University of Colorado Boulder found that samples were often stored in ULFs without any consideration of whether they needed to be kept at ultra-low temperatures.

Undertaking a similar audit for yourselves would allow you review your day-to-day sample management practices. For example, creating a sample database, showing where each sample is stored, the sample owner and expiry date, will help to identify samples that are no longer required, especially if responsibility is assigned for carrying out regular 'sample reviews'. Sharing this database amongst staff and students can also help to reduce the amount of time that freezers doors are left open whilst individuals try to find particular samples.

Strategic Measures

On a more strategic level, there several steps your department can take to reduce its freezer energy use:

- Develop a freezer management programme: This would be a comprehensive strategy that would pull together and address all the challenges associated with ULFs: equipment maintenance, sample maintenance, purchasing/retiring, and data gaps. As part of this programme, your department could develop some guidelines on when it is 'best' to replace an old or inefficient ULF with a more efficient model; and adopt stringent procurement standards for new freezers[3]. The Environment and Energy Section could assist in developing this programme and could also possibly assist with funding for the replacement of inefficient ULFs.
- Require business cases for new ULFs: Your department could require anyone wishing to purchase a new/additional freezer to provide a strong business case outlining why this is necessary.
- Charge for the use of old ULFs: Your department could consider charging those who continue to use inefficient models or, alternatively, offer a subsidy for the use of more efficient models, for example based on £/m^2. An old inefficient ULF can cost over £1,000 per annum in electricity, compared to £300 for a New Brunswick U570.
- Consider -70°C: Only cool samples to the temperature that is absolutely needed. In the majority of cases, samples can be safely stored at -70°C rather than -80°C. A study done by the University of Harvard demonstrates that antibodies, antigens and nucleic acids can be stably stored for at least 20 years at a temperature of -70˚C. Some departments at Cambridge are now setting their ULFs to -70˚C.
- Involve Staff: UC Davis run a ULF competition all year around, which focuses on separate areas of freezer management over the course of the year. See http://sustainability.ucdavis.edu/action/conserve_energy/store_smart.html. Competitions like this are a great way of making the issue fun for staff and can be particularly engaging if prizes and incentives are awarded.

[3] The Department of Biochemistry has committed to only using energy-efficient freezers within the next 3 years. The optimum for energy efficiency is the Panasonic VIP eco range.

Annex A: How to Carry Out Routine ULF Maintenance

Note: To avoid personal injury and damage to the freezer and samples, these actions should only be carried out by a nominated and suitably qualified staff member.

- Check the gaskets and rubber seals around the freezer door for leaks, clean them, and keep them free from ice. If the seals are broken, schedule a repair. Broken seals allow cold air (and energy) to escape and warmth to enter.
- Check the condenser coils. Condensers can become blocked with dust or debris, preventing efficient cooling. This can result in an increase of up to 10kWh per day. Therefore, if the condenser coils are dirty, arrange for them to be cleaned:
- Check with the lab manager as to whether the freezer is enrolled in a maintenance contract programme and, if so, contact the contractors to arrange for the coils to be cleaned.
- If the freezer is not enrolled in a maintenance contract programme, follow the 'How to Clean Condenser Coils' section below.
- Clean the freezer filter by vacuuming. Alternatively, rinse it in clean water and then allow it to dry before replacing it. Dust on the filter blocks the normal air flow through the condenser, which reduces the ability of the ULF to dissipate heat. Any air flow that passes through the clogged filter will carry dirt to deposit on the condenser.
- Check and clean the rear of the freezer. Keep the radiator at the back clean and free from dust.

How to Clean Condenser Coils

- ***Disconnect the power to avoid shock or injury.***
- Locate the coils. Condenser coils are thin, tube-like pieces that are connected with fins. For upright -80°C freezers, condenser coils are normally located at the bottom front of the freezer, or mounted on the rear of the freezer. You may need to remove a covering panel or grill. Otherwise you will find the coils behind the freezer's access panel. You will need to remove the access panel, usually by unscrewing each corner.
- Go over the condenser coils with a vacuuming hose.
- Brush away stubborn dirt using a coil brush or a narrow paint brush.
- If there are remaining build-ups on the coils, wipe them away with a rag dampened with warm, soapy water. When done, remove the moisture from the coils with a dry rag.
- Replace any grills or panels, and plug the freezer back in.

Annex B: How to Fully Defrost Your Freezer

- Before you set about defrosting any freezer, *notify all lab users well in advance*. Be sure to state the date that the freezer will be defrosted, how long the freezer will be out of use for, and ask all users of the freezer to relocate their samples during this time.
- You should also make it clear that any samples that have not been removed by the specified date will be temporarily relocated; say who will be moving the samples; and where the samples will be relocated to (say exactly where the alternative freezer is located). Also say who will move samples back to the defrosted freezer, and when they will do this.
- Before unplugging the freezer, manually remove as much ice as possible. Doing this will help reduce pools of water forming.
- If the freezer is on an alarm system, inform the control office that the freezer has been turned off so they know that no action is required.
- Unplug the freezer, leave the door open and wait for the ice to melt. This may take several hours. You can accelerate the process by placing a pot of hot water inside the freezer and then closing the door.
- Think health and safety! If the floor becomes wet, set up warning screens, to alert other lab users.
- Once thawed out, remove any pools of water and wipe the internal surfaces and doors dry. Check that all doors, door clips, hinges and seals are in good condition to help reduce the build-up of ice. Report any faults to the lab manager or to maintenance.
- Switch the freezer back on and allow 24 hours for the freezer to chill down and stabilise to the desired temperature before putting it back to use.