S-Lab Environmental Good Practice Guide for Laboratories

- A Reference Document for the S-Lab Laboratory Environmental Assessment Framework

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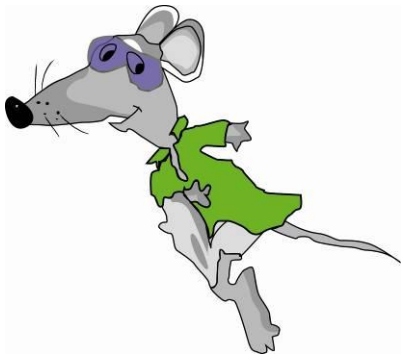
Developed by the
S-Lab (Safe, Successful and Sustainable Laboratories) initiative of
HEEPI (Higher Education for Environmental Performance Improvement)
See www.goodcampus.org

Inspired by the pioneering work of
the LabRATS (Laboratory Research and Technical Staff) programme
at the University of California, Santa Barbara
See http://sustainability.ucsb.edu/LARS

Lab-CURE:
Chemicals, Utilities, Resources and Environment in Laboratories



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Disclaimer

The information in this document is based on actual experience in UK and North American universities. It aims to provide examples and inspiration and every effort has been made to ensure accuracy but it is not intended to provide specific recommendations for individual laboratories and S-Lab accepts not liability for action or inaction based on this document. Every laboratory is different and readers should satisfy themselves that the information is relevant to their circumstances, verify its continuing accuracy, conduct relevant health and safety assessments and take appropriate professional advice before taking action.

The Guide is also a 'work in progress' and we welcome comment, and information about more best practice examples or guidance that we can include in subsequent editions.

Introduction

Laboratory operation has many significant environmental impacts ranging from energy and resource consumption to chemical and equipment use and disposal. Experience shows that many of these impacts could be reduced or avoided in cost-effective ways without compromising research, safety or teaching - indeed, they can often be enhanced.

S-Lab has produced three related documents to support analysis of environmental impacts in laboratories, and to identify and implement improvement opportunities:

- Individual laboratory assessment framework[1] - for individual laboratories/areas within a broader building or organisational unit.
- Organisation and building assessment framework[2] – addressing issues which are common to many individual laboratories/rooms within a building, school or department and which therefore needs to be done only once; and
- A good practice guide (i.e. this document).

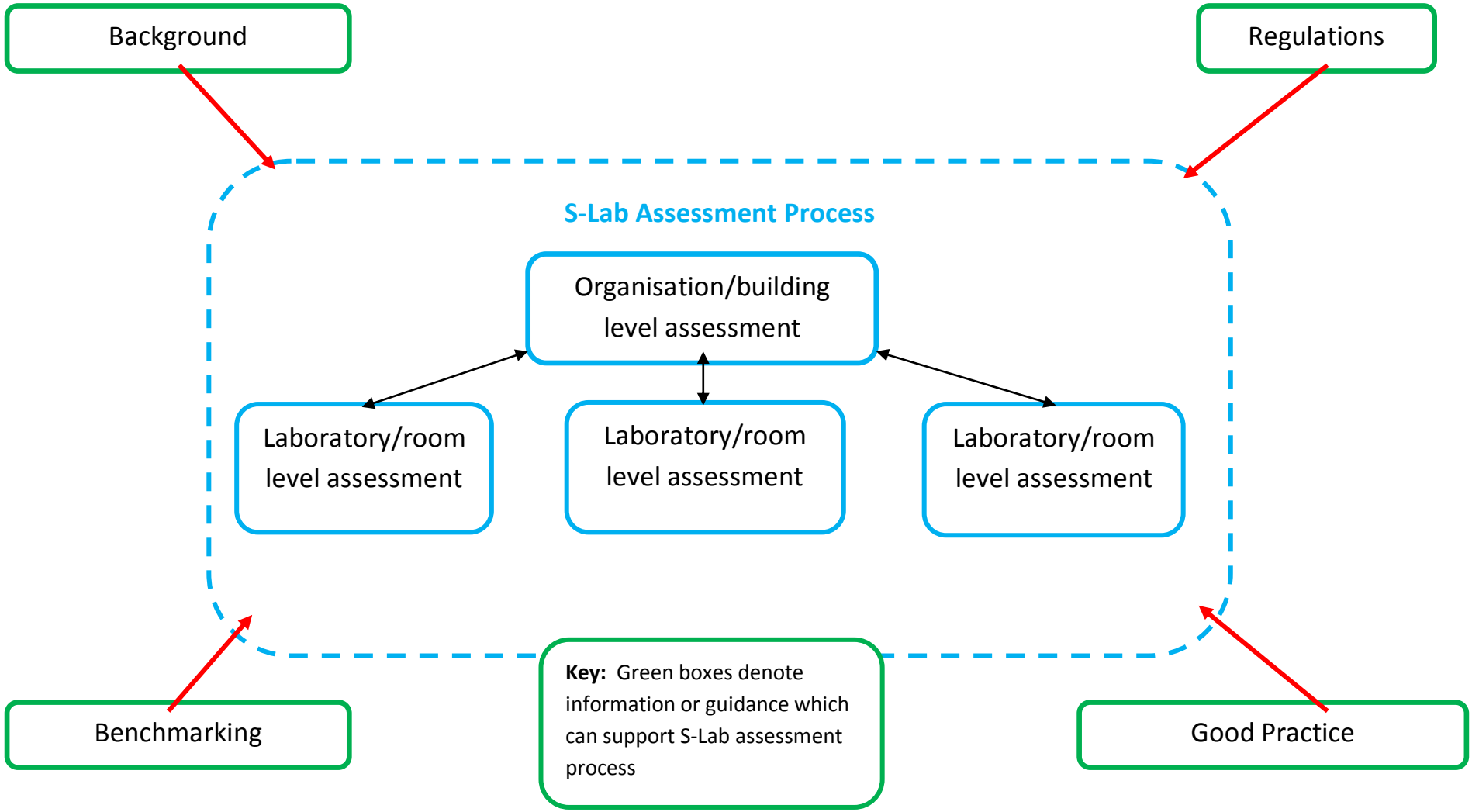
There are many S-Lab resources (summarised in Figure 1) which can help with assessment, by:

- Benchmarking – S-Lab have conducted several rounds of energy benchmarking of laboratory buildings[3], and a report also provides information on typical energy consumption of lab equipment.[4]
- Highlighting Good Practice – through a growing number of S-Lab case studies, briefing papers and technical reports which are summarised in this Good Practice Guide.
- Understanding Regulations – through the S-Lab guide to key energy and carbon regulations affecting laboratories.[5]

This Good Practice Guide summarises examples of good practice and general information for the 44 criteria in nine of the ten core sections - Chemicals and Materials (CM); Cold Storage (CS); Fume Cupboards (FC); Heating Ventilation and Air Conditioning (HVAC); Lighting (L); Management and Training (MT); Scientific Equipment (SE); Waste and Recycling (WR); and Water (W) - of the laboratory assessment framework.

[1] S-Lab Laboratory Assessment Framework. October 2011 (Version 1.4). Available at www.goodcampus.org
[2] S-Lab Organisation and Building Assessment Framework. August 2011 (Version 1.0). Available at www.goodcampus.org.
[3] Hopkinson L., James P., Lenegan N., McGrath T. and Tait M., 2011. Energy Consumption of University Laboratories: Detailed Results from S-Lab Audits. July 2011. Available at www.goodcampus.org.
[4] Hopkinson L., and James P., 2011. Saving Money Through Sustainable Procurement of Laboratory Equipment. March 2011. Available at: www.goodcampus.org.
[5] James P. and Hopkinson L., 2011. Carbon, Energy and Environmental Issues Affecting Laboratories in Higher Education - A Supplement to the HEEPI Report on General Regulations and Schemes on the Topic. July 2011. Available at www.goodcampus.org.

Figure 1: S-Lab Resources and the S-Lab Assessment Process



Issue 1: Chemicals and Materials (CM)

Overview

A large Chemistry school will have an inventory of tens of thousands of chemicals: the School of Chemistry at Edinburgh for example holds around 30,000 types, with an inventory value of £400,000 (see table for link). S-Lab guesstimates that the sector spends at least £60 million on chemicals and consumables a year. All of these will have an environmental impact throughout their life cycle – from manufacture, use in the laboratory through to their eventual disposal (which will often be as hazardous waste). This can be especially true of fine chemicals, which often require a number of synthesis stages (with considerable energy usage and wastage in each).

Minimising the use of chemicals and materials therefore has general environmental benefits, and can also create more tangible benefits such as:

- Reduced costs - for example at the University of Edinburgh, an electronic tracking system (see below) saved the School of Chemistry £100,000 of chemical purchasing costs and an additional £12,000 per annum management and disposal costs.
- Improved safety – especially if a general reduction in chemical inventories is accompanied by measures to find substitutes for the most hazardous ones.
- More effective compliance with regulations and requirements (e.g. of counter-terrorism agencies) through better information on what is being held and how it is being used.[6]

There are three main ways of achieving these benefits:

- Better chemical management - the Edinburgh example cited in sections CM1 and CM4 below describes how all chemicals containers in the School of Chemistry were barcoded and electronically tracked to provide details of their contents, and precise location within the School. The system allows users to view current in-house chemical inventory when ordering. This reduced duplication of orders and waste of unused chemicals significantly.

[6] For more information on regulations see James P. and Hopkinson L., Carbon, Energy and Environmental Issues Affecting Laboratories in Higher Education, S-Lab, 2011. Available at www.goodcampus.org under publications.

- Substitution of especially environmentally damaging and/or hazardous chemicals - there are many examples of different methods of achieving desired research results or teaching demonstrations, e.g. by using one solvent rather than another. The University of Bradford case demonstrates an attempt to do this systematically, using guidance from the Green Chemistry Network and other sources, whilst the University of Manchester case provides a particular example of ethidium bromide.
- Reduction of the amount of chemicals used in teaching or research - even in cases where environmentally damaging chemicals are essential, it may be possible to minimise their use (as well as that of other chemicals). Examples include the use of microscale chemistry – the reduction of chemical use to the minimum level at which experiments can be effectively performed, as has been done at the University of Strathclyde - reducing the amount of solvents for cleaning glassware, finding alternative ways of doing batch wet chemistry experiments, and by using simulations rather than physical experiments (e.g. as prelab exercises for students).

Summary of Resources

Criteria	Good Practice Examples	General Information
General		12 Principles of Green Chemistry An important starting point for any chemical lab. Developed by P. T. Anastas and J. C. Warner and reproduced with permission of Oxford University Press. Life cycle assessment studies of chemicals A list of publications by the Swiss Federal Institute of Technology.
CM1. All chemical containers are labelled with details of contents, approximate quantity, ownership, and (where relevant) hazard and emergency details, in a manner which can be understood by others if the 'owners' are not available.	Better Chemical Management at Edinburgh An S-Lab Case study describes the University of Edinburgh's School of Chemistry electronic 'cradle to grave' tracking of chemicals. This system has avoided around a quarter (£100,000 per annum) of the School's chemical purchasing costs (though avoidance of duplicate purchases). See also a presentation and some training demos of the system from an S-Lab event, Edinburgh, April 2010.	Chemicals (Hazard Information and Packaging for Supply) Regulations HSE Guidance on the CHIP 4 regulations.
CM2. The contents, approximate quantity held and location of all chemical containers are tracked.	Better Chemical Management at Edinburgh See above.	
CM3. The laboratory avoids accumulation of unwanted chemical stocks, e.g. by making surplus chemicals	LabRATS Surplus Chemical Programme The University of California Santa Barbara's LabRATS programme has a website run through the health and safety team, which allows researchers to post details of surplus	Action Plan for Chemical Management Labs21, the US programme to improve lab sustainability, recommend that labs develop an action plan to eliminate, minimize, substitute, recycle, and

available to other laboratories, by ordering in appropriate sizes, by clearing out when researchers leave	chemicals for use by other teams. The website has an expanded and updated inventory of all the chemicals in storage, complete with pictures and descriptions.	dispose of harmful chemicals safely, and provide strategies to achieve this.
CM4. Chemicals and materials are used efficiently within laboratory demonstrations, experiments and other activities so that waste is minimised.	Microscale Chemistry at University of Strathclyde Colin Gibson's presentation at an S-Lab event at York in June 2010 on the use of microscale chemistry experiments for Strathclyde's 3rd year chemistry students. Greening Chemistry at Bradford An S-Lab case on the review and modification of the University of Bradford's taught chemistry modules to incorporate green chemistry principles. This included the development of green chemistry metrics such as yield efficiency as a tool to compare experimental alternatives, and to increase student awareness.	Mini-scintillation Vials LabRATs recommend the use of mini-scintillation vials for biochemistry work which do the same job as regular vials. Clean Glassware with Minimal Solvent LabRATS recommend various ways to minimise solvent use when cleaning glassware. Alternatives to Wet Chemical Spectroscopy LabRATs recommend two alternative technologies to wet chemical spectroscopy to minimise the use of chemicals. The National Microscale Chemistry Centre A US based source of good practice.
CM5. All chemicals are stored in approved and secure locations.	Edinburgh's School of Chemistry tracking system (see CM2 above) allows storage locations to be controlled and encourages lab users to return chemicals to their proper (safe) location after use.	HSE Chemicals at Work HSE resources on the storage of chemicals at work.
CM6. There has been a systematic attempt to find alternatives to especially	Greening Chemistry at Bradford This S-Lab case study (see CM4) describes the modification of undergraduate practical scripts to include questions on	12 Principles of Green Chemistry (see CM3 above). The Green Chemistry Network run by the University of

environmentally damaging or hazardous chemicals.	the hazards of the chemicals used, and the scope for making them greener through alternative reagents and methods, such as catalysis. Replacing Ethidium Bromide at Manchester This S-Lab case study on sustainable lab practices at Manchester describes how a senior technician In Life Sciences identified 2 suitable replacements for the hazardous chemical Ethidium Bromide. LabRATS Mercury Thermometer Exchange Programme A mercury thermometer exchange programme initiated by students at the University of California, Santa Barbara, which replaces them with spirit thermometers for free.	York's Green Chemistry Centre aims to promote awareness and facilitate education, training and practice of Green Chemistry. The website and newsletter have a wealth of information including green chemistry practicals for undergraduates. MIT's Green Chemical Alternatives Purchasing Wizard A web-based tool which identifies less hazardous and more environmentally benign chemicals or processes that may be substituted. ChemSec's SIN! List The International Chemical Secretariat has produced a SIN (Substitute it Now!) list consisting of 378 (updated in May 2011) chemicals that have been identified as Substances of Very High Concern based on the criteria established by the new EU chemical regulation, REACH. Greener Education Materials (GEMS) for Chemists The University of Oregon Chemistry Department has been a leader in developing new "green" undergraduate chemistry curricula. GEMS is a database of green chemistry laboratory experiments and educational materials that will enable educators at all levels to easily identify and adopt specific experiments into their curriculum.

Issue 2: Cold Storage (CS)

Overview

University laboratories, particularly bioscience labs, typically contain a large number of cold storage devices including fridges, freezers, and liquid nitrogen dewars. These can directly account for up to 5% of total laboratory energy consumption, and also create indirect consumption because their heat generation requires more cooling of ventilation air.[7] They also take up considerable amounts of space which could otherwise be used for research or teaching. There can be a considerable range of energy consumption between different cold storage devices.[8] At the University of Newcastle metering found that old -80^{o}C freezers may have three times or greater energy consumption than current, efficient, models (see case study cited in CS5). For very old models, there can be a five year payback or less by replacing them with the most energy efficient current models, especially if the opportunity is taken to introduce effective sample management as well.

Some of these impacts are unnecessary because unwanted or obsolete samples are being stored. Many biological samples are being stored at higher temperatures than necessary (e.g. ultracold freezers are often set to maximum settings such as -80C when -70 would be sufficient). Ambient temperature DNA storage technologies are also available. Many cold storage devices store fewer samples than they are capable of because of awkwardly shaped containers, poor racking etc. The energy consumption of cold storage devices rises if circuits or interiors are frosted, or if they are not working effectively. A holistic approach to cold storage requires ensuring that:

- Only wanted samples are actually stored (thereby reducing the overall amount of cold storage required);
- Storage requirements are minimised through efficient use of space;
- Materials are being stored at appropriate temperatures; and
- Devices used are energy efficient, both at purchase and in use.

These measures not only reduce energy and space requirements, but also create science benefits by minimising problems of degradation (e.g. partial defrosting as a result of leaky doors or frequent unpacking to locate samples).

[7] See footnote 3

[8] Hopkinson L, and James P. 2011. Saving Money Through Sustainable Procurement of Laboratory Equipment. March 2011. Available at www.goodcampus.org

Summary of Resources

Criteria	Good Practice Examples	General Information
General	Presentations from S-Lab event on Effective and Energy Efficient Cold Storage, Manchester, August 2011	S-Lab Briefing Paper 4 on Effective and Energy Efficient Cold Storage.
CS1. All stored materials are permanently labelled with details of contents, expiry and ownership in a manner which can be understood by others if the 'owners' are not available	Rationalising Sample Storage at the Blizard Institute An S-Lab case study describes how the Blizard Institute in London greatly reduced the number of frozen samples – by 50% in the case of those stored in liquid nitrogen – through better inventory management, and disposal of those which were unclaimed. They also have a customised tracking system which uses handheld barcode scanners and specially developed labels. Tracking Samples at CIGMR, Manchester An S-Lab Briefing Paper describes how the Centre for Integrated Genomic Medical Research uses an electronic Lab Information Management System to manage its biobank DNA samples.	Eliminate Old Samples in Your Freezer Advice from LabRATS.
CS2. All stored materials are associated with active uses, or are being kept because of specific archiving requirements.	Decanting Samples at Conway Institute, University College Dublin and the University of Manchester An S-Lab Briefing Paper describes how the Conway Institute uses a 'floating' freezer to decant samples when defrosting freezers – all samples had to be properly accounted for. The University of Manchester also follows this approach and further prevents PhD students from leaving old samples in freezers by signing a completion form before graduation.	

CS2 (contd.)	Sample Rationalisation at the Institute of Cancer Research The same S-Lab Briefing Paper describes the ICR's monitoring of samples which are categorised as fast moving, slow moving (can be stored off site) and disposable.	
CS3. Stored samples and materials are stored at the highest feasible temperature for effective preservation.	Room Temperature Storage of Samples at Stanford A pilot study at Stanford university investigated the possible transfer of biological samples from freezers to room temperature storage. It found an estimated 9-13 million samples (representing 20-25% of the total Stanford sample collection) could be moved from freezers to room temperature technology, saving an estimated £6-12 million. Freezer Challenge Competition at Cardiff An A-Lab Briefing Paper describes how the School of Medicine at the University of Cardiff asked researchers to increase freezer temperatures from -80 to -70 as part of a competition. Information on Sample Storage Temperatures from the University of Colorado (Follow link at the bottom of the page in the above link). A spreadsheet containing details of biological samples being stored by the University of Colorado at Boulder Labs at temperatures warmer than -70˚C.	Do Not Use Incubators as Fridges LabRATS advises against using incubators as fridges as they use 5-10 times more electricity.
CS4. All available space is utilised through use of	Better Utilisation of Space at the Blizard institute S-Lab case study describes how standardised containers at	

appropriate racking, storage containers etc.	the Blizard Institute enabled much more efficient use of space in cold storage facilities and, when combined with location tracking, made sample retrieval quicker and easier. Allocating Racks at University of Newcastle At the University of Newcastle's Institute for Ageing and Health they allocate racks rather than whole freezers to PIs.	
CS5. There is regular (at least annual) cleaning, defrosting and maintenance of devices. This includes cleaning heat exchange coils on fridges and freezers, and defrosting of any devices without auto-defrost.	Maintaining Fridges at the University of Oxford Oxford has a programme to keep fridges frost-free and clean. It has also installed compressor motor controllers, which reduce energy consumption, on a number of laboratory fridges which pay for themselves within 2-years. Refrigeration Motor Controls at the University of Glasgow University of Glasgow used Salix funding to scientific fridges and a/c saving £2,400 a year with a 2.3 year payback. Cleaning Freezers at the University of Newcastle The University of Newcastle's Institute of Ageing and Health cleans the freezer filters every month, and everyone who has a -80 freezer is part of a service contract.	Defrosting Tips Advice from LabRATS.
CS6. Energy costs of new cold storage devices are quantified and incorporated into a whole life costing approach to new purchases.	Freezer Replacement at the University of Newcastle An S-Lab case study on Newcastle's -80^{o}C freezers which cost up to £2,000 a year to run, with an average of £1,100. £180,000 was used to replace 36 -80^{o}C freezers over 10 years old, saving 136,836 kWh of energy and creating additional space and reliability benefits.	Saving Money Through Procurement An S-Lab report with recommendations for whole life costing when purchasing fridges and freezers, and data on measured energy consumption from the universities of Newcastle and York.

CS6 (contd.)	Energy Efficient Fridges at Cambridge An S-Lab case study which describes an incentive scheme for energy saving at Cambridge which rewards/penalises departments through energy targets. The School of Biological Science which achieved energy savings resulting in a transfer of £43,000, put the funding into a ring fenced fund to finance further measures, such as purchase of very energy efficient (A** rated) fridges.	Energy Star for Lab-Grade Fridges and Freezers The US Environmental Protection Agency (EPA) is developing an Energy Star label for lab grade fridges and freezers which will enable researchers to find the most energy efficient products on the market.

Issue 3: Fume Cupboards (FC)

Overview

Fume cupboards are critical for health and safety, yet consume significant amounts of energy – mainly in the form of moving large quantities of (often heated or cooled) air around. A single device running continuously at full power can directly and indirectly use up to £2,000 electricity and gas a year. In many labs fume cupboards are operated 24/7 even when there are no experiments running. In some cases these could be switched off with attendant reductions in energy consumption.

Good practice is generally:

- To shut fume cupboard sashes when no one is working in them. This greatly reduces energy consumption for variable air volume (VAV) fume cupboards and is advisable on health and safety grounds for all designs. This can be achieved through education/awareness raising (stickers, posters, training), ideally coupled with incentives (not necessarily financial) to encourage long term behaviour change. An engineering solution is installation of automatic sash closure based on Zone Presence Sensors (ZPS) which detect if anyone is within a given range of the sash and close them when this is not the case.
- To switch off fume cupboards which aren't being used for long periods e.g. at night-time, weekends or during vacations. In many labs fume cupboards are operated 24/7 even when there are no experiments running. The fume cupboards should ideally have switches that operators can access to switch them off. Switching off unused fume cupboards can save significant amounts of energy.
- To ensure that fume cupboards are working properly and are well maintained. By law universities are required to carry out 14 monthly examinations to ensure fume cupboards are well maintained but it is not clear that this is done in every university department. Regular maintenance ensures safe operation and optimum energy consumption.
- To ensure there are no obstacles to internal air flow and that fume cupboards are not used as chemical storage cupboards. Fume cupboards are a very costly and energy inefficient way of storing chemicals which should be stored in ventilated cabinets. Blocking the air vents with equipment and chemicals means that fans have to work harder and increases energy consumption and can compromise safety.

Summary of Resources

Criteria	Good Practice Examples	General Information
General	Cutting Energy Use with VAV An S-Lab event held in Cambridge in May 2009 with presentations on Variable Air Volume fume cupboards and Demand Control Ventilation.	Energy Consumption of University Laboratories: Detailed Results from S-Lab Audits S-Lab audited the energy consumption of two chemistry and three life science laboratories and the final report has detailed information on the energy use of fume cupboards.
FC1. Fume cupboard sashes are generally down when no one is working in them, especially at night or over weekends.	Harvard University's Shut the Sash campaign Harvard Medical School has run "Shut the Sash" campaigns as a contest among labs which encouraged behaviour change for a month, which eventually became a habit. As a result of the campaign, the average sash opening in the five participating buildings dropped from 12 inches to 2 inches and saved the school over $100,000 (~£60,000) in energy costs per year. Automatic Sash Closure at Cambridge A presentation at an S-Lab event which describes the trial of Zone Presence Sensors (ZPS) on fume cupboards in 2 labs with VAV fume cupboards at the University of Cambridge. It was found that the lab fitted with ZPS, which was the busier lab, was using less power to supply more air than the lab without ZPS. It was estimated that there was a 40% electrical saving for the lab with ZPS.	

FC2. Fume cupboards are switched off when not in use for extended periods, where it is possible and when safe to do so (e.g. no effect on pressure requirements).	Raising Awareness at Nottingham An S-Lab case on the University of Nottingham Estates department which sends a monthly report on the cost of fume cupboard energy usage in the previous month (obtained from the Building Management System) to departments/schools together with the percentage savings compared to their running 24/7 at full power. Potential savings are estimated at around £150,000, or over 4 million kWh of energy per year. LabRATS Hoods Off Campaign A voluntary energy saving program run by LabRATS at University of California Santa Barbara, especially suited for older laboratory buildings where single fans exhaust each fume cupboard. Free pizza was offered to labs who offered to turn off their unused fume cupboards.	Fume Hood Energy Model Lawrence Berkeley Lab has a useful fume cupboard energy calculator which enables comparison of energy consumption of different fume hoods (US conditions only) which can show the effects of switching off.
FC3. There are effective mechanisms to encourage energy efficient use of fume cupboards.	Influencing User Behaviour at the University of Oxford An S-Lab case on Oxford's Chemistry Department, where devolved budgeting and safety concerns has meant that the Head of Department and senior departmental staff take fume cupboard sash closure very seriously. Actions include regular checks and using annual testing as a means of educating users in how to use fume cupboards effectively (see below). The Department is also considering introducing fines for sashes left open when cupboards are unattended.	

FC3 (contd.)	Financial Incentives at Cambridge An S-Lab case describes a shared cost/savings scheme for reducing electricity at the University of Cambridge introduced in 2008. All departments have a target based on previous year's electricity use with allowance for growth. This provides more money for Departments who better their targets, and motivation to do better for those who fail.	
FC4. There are no unnecessary obstacles to internal air flows within any of the fume cupboards in the lab, e.g. blocking of air vents with containers or equipment.	Removing Obstacles to Internal Air Flow at the University of Oxford An S-Lab case (see above) describes how during the annual inspection of fume cupboards at the University's Chemistry Department the engineer advises on the removal of obstacles to internal air flows. In one case this resulted in a lab user building shelves above the rear baffles to avoid blockages.	
FC5. The lab complies with COSSH regulation 1999 which requires 14 monthly examinations to ensure fume cupboards are "maintained in an efficient state, in efficient working order, in good repair and in a clean condition".	Annual Maintenance and Servicing at the University of Oxford An S-Lab case (see above) describes how the examination is used as a foundation for broader actions such as annual servicing of air balance controls and ensuring effective use.	A Simple Guide to Local Exhaust Ventilation (LEV) Published by HSE. The COSHH regulation specifies that:- (a) An employer who supplies a control measure to comply with the regulations shall ensure that it is maintained in an efficient state, in an efficient working order, in good repair and in a clean condition (b) LEV plant provided to comply with the regulations should be examined and tested at least once every 14 months, (in practice, once a year). (c) A suitable record of the examination and test should be kept for a minimum of 5 years from the date on which it was made.

FC6. Fume cupboards are not used as storage cupboards for prolonged periods (i.e. longer than the length of the set-up and conduct of an experiment).	Decluttering Fume Cupboards at the University of Manchester An S-Lab case study on sustainable lab practices at Manchester describes how the Geochemistry department has reduced the number of alarms on fume cupboards by ensuring that the air vents aren't blocked by chemicals or equipment and liaising with Estates to regularly check clogged filters.	

Issue 4: Heating, Ventilation and Air Conditioning (HVAC)

Overview

The moving and conditioning of air through ventilation systems generally accounts for 40-60% of laboratory energy use.[9] These meet two different aims – providing air flow so that any hazardous or otherwise unwanted substances within the lab are diluted and dispersed, and also providing, through heating and cooling, the comfortable ambient conditions are also critical for user comfort and productivity and in some cases for the success of scientific experiments. Balancing these is always difficult, and even more so when laboratory layouts or uses change, so that they often don't work properly. Lab users may experience hot or cold spots, excess airflow or noise. Air flows are also often oversized for requirements as a result of building in a contingency element. Labs also tend to contain many split a/c systems which are often less efficient than central cooling systems.

Dealing with these issues is difficult for laboratory staff as control of the HVAC usually resides with Estates, and solutions to problems often require considerable capital investment (which is often cost-effective, but difficult to achieve when budgets are challenged). Hence, the laboratory-specific criteria focus on communication and collaboration with Estates as the key actions for laboratory users.

[9] See footnote 3

Summary of Resources

Criteria	Good Practice Examples	General Information
General	Although more relevant to HVAC specialists, the following S-Lab cases highlight good practice in laboratory ventilation: Well Designed ventilation at Queen's University Belfast The University's Centre for Cancer Research and Cell Biology, built in 2007, which has a Containment Level 3 lab, whose supply air is drawn from the main laboratory, with all extract through safety cabinet fans and filters. This avoids any possibility of positive pressure, and avoids the need for a separate ventilation supply and extract system, with consequent savings in capital and running costs.	Energy Consumption of University Laboratories: Detailed Results from S-Lab Audits A July 2011 S-Lab report with detailed breakdowns of energy consumption by category in 5 university labs. Laboratory Energy Audits: A Process Guide A sister guide to the detailed results of lab energy audits. This report identifies a 3-stage audit process, and methods of estimating consumption even when sub-metered data is not available. Sustainable Laboratories for Universities and Colleges - Reducing Energy and Environmental Impacts A 2007 S-Lab report which remains relevant. Sustainable Laboratories – Lessons from America and the Pharmaceutical Sector A 2007 S-Lab report which remains relevant.
HVAC1. The HVAC system is working to specification. If there is evidence that it is not, then laboratory users have made Estates aware of	Annual Servicing of Air Balance Controls at the University of Oxford This S-Lab case study describes actions to reduce energy consumption in the University's Chemistry Department, including an annual servicing of air balance controls	Remove Space Heaters Guidance from LabRATS on the costs of using individual space heaters and what to do if your lab building is not a comfortable temperature.

it. (Possible signs of not working to specification are frequent alarms on fume cupboard use; known problems with ventilation equipment; unpleasant working conditions for many users because of draughts and excessive cold or heat; fume cupboards not functioning properly and difficulty opening/closing doors because of pressure differentials).	(together with face velocity validation). Increased Set Point Temperature in Summer at the University of Oxford This presentation by Energy Manager Philip Pike describes how the University uses a set point of 24 degrees Celsius in summer rather than 18 degrees, and does not run cooling at night in its laboratories. Night and Weekend Setbacks at the University of Edinburgh This presentation at an S-Lab event describes an audit of the University's Cancer Research Centre and the energy benefits of night and weekend setback of the ventilation system.	
HVAC2. There are no examples of large spaces being ventilated or conditioned to a high specification in order to meet the needs of a small number of activities/devices, or occasional circumstances. If there are examples, then laboratory users have made Estates aware of it.	Continuous Commissioning at Imperial College S-Lab case describes how continuous commissioning at Imperial College enabled night setback of a lab which was not being intensively used at night. **Ventilation restricted to occupancy hours at Oxford** The University of Oxford's Richard Doll building changed lab ventilation to occupancy hours only, turning heating off at night and during summer, and cut gas consumption by 58% and saved over £36,000 a year. Rationing Air Conditioning at the University of Bristol The University has a review procedure for all new requests	Energy Efficiency Ratings of Cooling Equipment EUROVENT, the European Committee of Air Handling and Refrigeration Equipment Manufacturers, provide certification (and energy efficiency data) for a wide range of HVAC equipment, including comfort Air Conditioners, air handling units, fan coil units, heat exchangers for refrigeration etc.

HVAC2 (contd.)	for a/c in laboratories and other buildings. This includes the application of a specially developed decision tree to ascertain if special cooling needs are present, and a heat gain tool to analyse whether the heat load is sufficient to require cooling. If cooling is necessary, a new specification ensures that equipment is energy efficient and is properly installed.	
HVAC3. Equipment/plant noise does not cause significant annoyance or discomfort to users over prolonged periods. If the noise relates to plant, Estates have been made aware of it.		OSHA Factsheet on Laboratory Noise While the noise levels in most laboratories are below the threshold level that damages hearing, laboratory noise, e.g. from equipment operation, fans and compressors in fridges and freezers, can be sufficiently loud to be annoying and stressful. This US document provides guidance on how it can be controlled.

Issue 5: Lighting (L)

Overview

Lighting can consume a significant proportion of lab electricity – up to 15% - particularly when labs run 24/7 or in bioscience labs with a lot of plant growth rooms.

Actions for improvement include:

- Maximising the use of natural light - this has proven benefits for health and productivity compared to artificial light, and of course uses no additional energy. However, some labs have blinds drawn and artificial lighting on for much of the year. Whilst glare is a significant issue, there are other ways of dealing with this than completely blocking daylight.
- Switching off lights that are not needed – either manually or through presence detection systems. Lighting design specifications for labs are sometimes too high for subsequent uses. The US LabRATS programme has removed many luminaires where they are not necessary. Task lighting of a small area can also be more beneficial to users, and energy efficient, than general lighting of a much larger space.
- Replacing light fixtures with more energy efficient lighting - existing luminaires may be replaced with high efficiency ones such as slim T5 fluorescent lights or LEDs. LED lighting is not only more energy efficient, but in many cases may be better for the science because it can be more easily tuned to specific wavelengths.

Summary of Resources

Criteria	Good Practice Examples	General Information
General		
L1. There is maximum use of natural lighting.	Maximum Use of Natural Lighting at the University of Newcastle An S-Lab case on the University's BREEAM Excellent Baddiley-Clark Medical Sciences Building which maximises the use of natural light, An external glass wall provides a high level of natural lighting to write up areas and (via an internal glass wall) to the laboratories, which also have external windows. Natural Lighting at Queen's University Belfast An S-Lab case on the Centre for Cancer Research and Cell Biology, built in 2007, which was designed on a constrained site with a full height glass atrium, and the main labs around the perimeter for maximum daylight. Daylighting is increased by glazed screens on internal office walls, and windows to secondary labs.	
L2. All luminaires are high efficiency ones, e.g. compact fluorescent lamps for task lighting, LED or T5 fluorescent lights (rather than T8 or T12s) for overhead lighting.	High efficiency lighting at the University of Newcastle An S-Lab case (see above) describes the use of energy efficient downlights, which allows fewer fixtures to be used. The designers also avoided over-complex control systems and fixtures which are likely to require a lot of maintenance.	Lighting Federation Technical Statements Detailed information on lighting practice.

L2 (contd.)	LED for Emergency Lighting at the University of St Andrews A presentation at an S-Lab event shows how the new Medical Sciences Building at the University of St Andrews uses an LED source through fibre optic cable for emergency lighting.	
L3. The lab has examined replacement of mercury with LED low energy lighting for scientific tasks and is doing this whenever possible, e.g. in growth chambers, microscopy and plant growth rooms.	LEDs for Plant Growth at the University of Manchester The University used Salix funding to switch T8 and T12 lamps in growth chambers with low energy LED lamps, saving over £2,000 a year and improving research as the lamps wavelengths were more easily adjustable.	
L4. Room/corridor lighting is always turned off or down when not required, and when compatible with safety. If this is not the case, and requires Estates action, lab users have made them aware of the opportunities.	LabRATS BulbFree Campaign A campaign at the University of California Santa Barbara that encourages researchers to evaluate how much light they need and to intentionally remove bulbs in overlit areas. Automatic Lighting Controls at the University of Cambridge An S-Lab case describing an energy incentive scheme at the University of Cambridge which rewards/penalises departments based on energy targets. The School of Biological Science made savings through measures which included use of LED spot lights, installation of automatic lighting controls and encouraging staff to turn off lights.	

L4 (contd.)	Motion-controlled lighting at Manchester An S-Lab case study on sustainable lab practices at the University of Manchester describes how one research centre saw motion-controlled lighting in use in Geochemistry and is now piloting it.	
L5. Illumination is appropriate to tasks. If this is not the case, and requires Estates action, lab users have made them aware of the opportunities.	Using Task Lighting LabRATS guidance on the use of task lighting in place of overhead lighting.	**Lighting Benchmarks** LabRATS recommend levels of < 1 Watt/square foot (~11 W/m^2). The Carbon Trust have good practice lighting benchmarks for offices of 12W/m^2 (ECON19) S-Lab energy audits (see footnote 3) found lighting in a bioscience lab was 11 W/m^2 and in a chemistry lab was 4 W/m^2 though this included corridors, plant rooms etc.

Issue 6: Management and Training (MT)

Overview

Many actions to improve laboratory environmental performance require approval or active support by academics, and some may also have short-term costs (recompensed by medium-long term benefits). Senior management backing is obviously important in both cases. S-Lab cases and other materials can provide useful evidence to persuade senior managers of the benefits and feasibility of taking action. Often, things are not done because no-one takes responsibility for them. Assigning responsibilities – and ensuring that those given them can make a difference in practice – can be a powerful catalyst for improvement.

Summary of Resources

Criteria	Good Practice Examples	General Information
General		
MT1. There is senior management support (e.g. Head of Department) for the lab assessment and a willingness to implement any recommendations which result from it.	Aiming for the Greenest Chemistry Research at the University of Oxford An S-Lab case describes the support of the Department Chair, Professor Steve Davies, for improvement actions, and his goal that a planned new Chemistry building will be the "greenest chemistry research facility in the world." A Strategic Approach to Sustainability at the University of Manchester and University of California, Irvine An S-Lab Briefing Paper describes PVC level support for sustainable laboratory initiatives at the two institutions. Manchester has established a task force, one of whose first actions has been using the S-Lab assessment framework.	

MT2. The laboratory has, or is connected to, a responsibility structure for key aspects of environmental performance, e.g. sash closure.	Sash Closure Enforcement at the University of Oxford. S-Lab Case 7 describes how the Chemistry Department has energy efficiency induction for new lab users, focusing on the financial and safety benefits of sash closure, and sash closure reminders, through labelling, publicity and inspections by the Chair of the Department of Chemistry. Sustainable Labs Group at Institute of Cancer Research (ICR) The same Briefing Paper on Strategic Lab Initiatives notes the ICR) has established a multi-site, multi-function, sustainable labs group which are systematically evaluating and implementing improvement actions in their labs.	
MT3. The laboratory participates in broader networks (within the institution or beyond it) which provide opportunities to discuss and take action on environmental issues.	LabRATS at the University of California, Santa Barbara The Laboratory Research and Technical Staff (LabRATS) initiative – which originated at UCSB but is now state wide - is a groundbreaking, dedicated group which assists laboratories in becoming more sustainable. It has a number of programmes including Lab Assessments for Research Sustainability (which inspired the S-Lab lab assessment framework) and a wealth of resources on its website.	
MT4. All laboratory users are made aware of the energy and environmental impacts of their activities and the actions they can take to mitigate them.	Fume Cupboard Reporting at the University of Nottingham An S-Lab case which describes how the University's Estates Department sends monthly reports on fume cupboard energy use to lab users, with an estimate of the amount of savings compared to their running 365/24/7. This is complemented by stickers on fume cupboards, posters and other publicity materials highlighting the energy benefits of	

MT4 (contd.)	closing sashes in VAV fume cupboards, and the safety benefits in all kinds. Low Carbon Research at NREL A SusteIT case on the new National Renewable Energy Laboratory (NREL) in Colorado, US. which targets net zero carbon operation through its sustainable design features. The data centre's energy (total and key areas such as lighting and plug load) and water consumption is displayed in real time to users.	
MT5. There is a formal improvement process in, or connected to, the laboratory which has had demonstrable impacts on issues covered in this assessment, or other issues which are clearly related to environmental performance.	ISO14001 at the University of Bristol S-Lab Briefing Paper 6 on Waste Minimisation in Labs describes how annual hazardous waste audits are conducted jointly by lab and health and safety managers as part of the university's ISO140001 scheme. Any non-compliant labs must correct any issues within a given time. Continuous Commissioning at Imperial College Imperial has a continuous commissioning programme which identified that considerable areas of one lab building were not being used at night, creating an opportunity for setback. This allowed air change rate to be reduced from 13 to 6 air changes per house, saving nearly £50,000/year in energy costs.	

Issue 7: Scientific Equipment (including Personal computing and Printing) (SE)

Overview

University laboratories typically contain hundreds of items of equipment, much of it specialised and hugely expensive. Scientific equipment can be a significant proportion of laboratory electricity consumption – up to 30-40% or higher in some labs. Some of this equipment is left on 24/7 even when not used or needed, which wastes significant amounts of energy. In some cases equipment needs to be left on all the time because of the need for careful calibration. In other cases special procedures are needed to shut the equipment down safely. Often equipment is left running because lab users and technicians are not sure whether the equipment is about to be used, or can be switched off or needs some special procedure to switch off.

University laboratories are also increasingly IT-intensive, and responsible for a significant component of the sector's ICT-related environmental impacts. This impact will become even larger as a growing proportion of research and teaching is conducted 'in silico' rather than *in vivo* or *in vitro*. While there is an increasing focus on reducing the environmental impacts of university IT, lab related IT is often isolated from mainstream IT activities and IT departments within the sector. This is because much lab ICT equipment is purchased and operated independently of IT departments; some aspects of STEM-related ICT (e.g. HPC, high end workstations) are very specialised, are often specified and operated independently of mainstream IT functions, and have their own dedicated networks; and even non-specialised ICT decisions are often influenced by academic scientists and laboratory technicians as much as IT professionals.

Good practice generally involves:

- Switching off equipment which is not needed - Observation can show which equipment are running unnecessarily. Plugs/off switches should be easily accessible and energy saving devices, e.g. automatic timers on drying ovens, 'slave' sockets, which switch off all connected peripherals when main equipment can be used. Stickers/posters can be used to raise awareness and it is also good to have someone assigned responsibility for making sure equipment is turned off.
- Regular maintenance and servicing of equipment – this can help it to run more efficiently in terms of energy consumption.
- Sharing equipment to avoid duplication – S-Lab has found many examples of equipment duplication between different research groups within the same building, or in other parts of the university. Sharing equipment can save costs, space and reduce waste from ultimate disposal of the equipment and is now being strongly encouraged by funding bodies such as Research Councils.

- Run equipment at high loadings - many items of equipment, e.g. drying ovens, some autoclaves, often have a base power consumption which means that their total consumption does not increase in line with loading. Hence, it can be more energy efficient to batch small job/loads, rather than running many times at low loadings, or to use smaller units more frequently.
- Purchasing energy efficient equipment - the results of S-Lab energy audits have shown that lab equipment and IT can be a significant proportion of total lab energy use – around 25% in bioscience labs and 15% in chemistry labs. There is a wide variation in consumption between different types of equipment, as a result of both differing power draw (e.g. a range of 7-70 kWh/day for different models of -80 freezer), and their pattern of use (e.g. freezers and fridges are generally in continuous operation, whereas a centrifuge may be used only a few times a week or month for short periods). 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 taken into account at procurement stage, it may be more cost effective to purchase more resource efficient but higher first cost equipment at the outset.

Summary of Resources

Criteria	Good Practice Examples	General Information
General		
SE1. Equipment that can be is generally turned off or powered down when not in use, together with related devices (e.g. AC/DC converters).	Turning Off Equipment at the University of Cambridge An S-Lab case describing a financial incentive scheme for energy saving at Cambridge, which rewards departments that save energy and penalises those who fail to meet targets. The School of Biological Science achieved savings by, amongst other things, continuing vigilance by Departmental staff who encouraged colleagues to turn off lights and (more importantly) equipment such as autoclaves off every night.	Powerdown Stickers for Equipment Downloadable/editable stickers which can be placed on equipment indicating whether equipment can be switched off, whether care is needed before it is switched off, or it should not be turned off. Powering Down Personal Computers A briefing paper on the benefits of powering down PCs and monitors and examples of universities who have done this successfully. Turning Off Equipment LabRATS guidance on the benefits of turning off ovens, chilled centrifuges and GCs when not in use.
SE2. Energy, water and waste issues and costs (including any secondary costs such as increased room cooling) are explicitly considered when purchasing lab equipment.	Energy Costs and Purchasing at the University of York An S-Lab case which describes how the University of York Department of Biology track and benchmarks equipment energy and has developed energy efficient procurement guidance (accompanied by performance data). It also covers the additional costs of energy efficient freezers (compared to cheaper standard equivalent models).	Sustainable Procurement of Laboratory Equipment An S-Lab report with detailed information on equipment energy use and recommendations for whole life costing on key equipment. See also presentations from the S-Lab event, London 18/3/11 on this topic.

SE2 (contd.)		Interest-free Funding for Energy Efficient Labs An S-Lab Briefing Paper describes interest-free recoverable grants which are available from the Recycling Green Fund (RGF1 and RGF2) to fund energy efficient lab equipment and plant. **Green IT Labelling Schemes** SusteIT Briefing Papers on Energy Star for ICT and Green ICT Product Labelling Schemes explain the different ICT eco-labels which can be specified to ensure the most energy efficient and environmentally less damaging products are purchased. Labs21 Energy-Efficient Laboratory Equipment Wiki A US Labs21 facility to share information about laboratory equipment efficiency among users, and encourage manufacturers to provide more data on the energy use characteristics of their products.
SE3. The laboratory supports and participates in mechanisms which allow lab equipment to be shared between users in different teams/labs where appropriate.	'Freecycling' Equipment and Consumables at the University of York An S-Lab case describes how the University's Biology Department has a 'freecycle' table for small equipment where surplus equipment or consumables can be placed and taken by other lab users for free. Having a departmental energy manager also helps to identify under-utilised equipment (and opportunities to save money through consolidation).	Setting Up Free Shelves LabRATS guidance on how to set up a free shelf where researchers can donate surplus equipment.

SE3 (contd.)	LabRATS Flea Market for Lab Equipment LabRATS runs a twice annual 'flea market' to swap surplus equipment and operates a Surplus Inventory Program to recycle surplus equipment via a dedicated website. University of Manchester's Equipment Library S-Lab case 14 notes that Manchester has established a lending library for redundant equipment which can be lent out to other researchers. The equipment is tested and, if necessary, repaired – and taken back if required by donors. Equipment Cataloguing Web Site at the University of Loughborough The University has developed an open source online system, Kit-Catalogue, to help effectively catalogue, record and locate their kit (equipment). The system can also be opened up to the public, allowing companies and other third parties to hire out equipment that might otherwise be lying idle.	
SE4. There is regular (at least annual) checking and servicing of large equipment.	Servicing Freezers at the University of Newcastle All -80 freezers at the University of Newcastle's Institute of Ageing and Health is part of a service contract.	
SE5. Energy-intensive equipment is 'rightsized' for tasks and used with as high loadings as possible.	Right-sizing ovens at University of Manchester This S-Lab case on sustainable lab practices at Manchester notes how Geochemistry bought a smaller drying oven to avoid putting larger part loads into a larger oven. Central autoclaving at Manchester also allowed phasing out of 10 local autoclaves and to operate on very high loadings.	Rightsizing Equipment LabRATS advice on how to rightsize equipment.

Issue 8: Waste and Recycling (WR)

Overview

In addition to the chemical waste covered in Issue 1, there is also waste from a variety of other sources including:

- Broken, obsolete or surplus equipment - some of this can sit idle for years at a time in university labs;
- Packaging waste;
- Disposables/consumables in scientific experiments; and
- Biological waste.

Waste is much more expensive than it usually appears to be because its costs usually fall into different budgets. Hence, no-one sees the overall figure. This often includes:

- The costs of purchasing items which end up as waste;
- The costs of managing and storing items which end up as waste (including any space charges for floor area taken up);
- The costs of managing, treating and storing waste itself (again including floor space);
- The costs of disposing of waste, which can be expensive when it is hazardous.

Good practices to minimise waste include:

- Centralised storage and/or tracking system for chemicals and materials (see Edinburgh example over)
- Convenient recycling facilities (particularly for consumables and packaging waste);
- Careful separation of clinical/hazardous waste so that other wastes are not commingled with it;
- Procurement contracts that specify collection of containers/packaging;
- Listings, reuse tables or similar mechanisms to enable unwanted equipment, materials etc to be donated or exchanged;
- Ordering or making up in quantities appropriate to needs to avoid surpluses which are never used.
- Awareness materials around the laboratory, and on line; and induction courses for new staff and students.

Summary of Resources

Criteria	Good Practice Examples	General Information
General		S-Lab Briefing Paper 6 on Waste Minimisation and Recycling in Labs (includes examples summarised left)
WR1. There are convenient recycling facilities for materials, packaging, and equipment within or nearby the lab and these are used in practice.	University of Bristol Cuts Lab Waste An S-Lab Briefing Paper describes the successful initiatives of the University of Bristol to promote separation and recycling of lab waste. This includes recycling of Expanded Polystyrene used for medical box packaging.	Reuse Disposable Plastic and Glass Items Guidance from labRATS on how to take advantage of hand washing, solvent rinsing, or autoclaving to clean and reuse plastic and glassware. Includes links to a Green Washing page.
WR2. There is no mixing of contaminated with uncontaminated materials/water etc. so that the latter has to be treated as hazardous or special waste.	Laboratory Waste Segregation at the University of Edinburgh This presentation at an S-Lab event includes measures that the University of Edinburgh finds useful for lab sustainability such as in-house training on segregation of lab waste. The university has a special laboratory waste website with flow charts illustrating segregation procedures. Reducing Clinical Waste at the University of Newcastle An S-Lab Briefing Paper describes how the University of Newcastle's audit found only 3% clinical waste required incineration. They have since developed a Clinical Waste Minimisation Strategy to divert waste from incineration.	Health Care Technical Memorandum 07-01: Safe Management of Health Care Waste Department of Health best practice guidance on colour coded waste segregation.[10] Waste audits are also essential for duty of care and compliance.

[10] http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_063274

WR3. Measures are in place to minimise 'hoarding' of unused equipment with no clear future application.	See SE3	See SE3
WR4. Procurement contracts require collection of empty bottles, packaging etc.	Reusable Solvent Bottles at the University of Manchester An S-Lab Briefing Paper notes that the University of Manchester's Life Sciences faculty uses a supplier who provides solvents in reusable bottles.	Reusing Bottles and Packaging Fisher Scientific collects bottles and associated packaging from customers for reuse and has won an award for its lab chemical bottle collection, wash and recycling facility.

Issue 9: Water (W)

Overview

Although it is not known how much water is used in HE labs, some data collected from HEEPI benchmarking based on 2001-02 data suggests that that typically labs consume around 1-3 cubic metres of water per metre square of floor area. Based on a typical laboratory of 5,000 m^2 this translates into an annual water consumption of between 5,000-15,000 m^3 at a cost of £11,500-£34,500 This is obviously much lower than lab energy costs, but nevertheless it is likely some savings can be made at very little additional cost.

Good practices are:

- Creating awareness of water consumption and associated costs/environmental impacts amongst users;
- Monitoring consumption to detect leaks and to identify improvement opportunities;
- 'Rightsizing' water-using equipment for tasks and using with as high loadings as possible;
- Using closed loop rather than continuous flow cooling;
- Using purified water appropriately and sparingly, and producing it by reverse osmosis (RO) wherever possible;
- Only buying water efficient devices (with a 'top up' fund to assist if these have a higher first cost).

Summary of Resources

Criteria	Good Practice Examples	General Information
General		Reducing Water Use in Research Laboratories A presentation by Amorette Getty of LabRATS with lots of examples of how to save water in labs. Reducing Water Consumption in Laboratories S-Lab Briefing Paper 5 (includes examples summarised left).
W1. In laboratories with considerable water use, there is awareness of related cost and environmental issues amongst laboratory users and policies on appropriate practices.	Sample Rinsing Technique Saves Water LabRATS demonstrate that poor sample-rinsing practices can lead to significant water waste, as well as dirty samples. Three 30-second rinse/dump cycles was more effective than 10 mins of a continuously overflowing beaker. Efficient Water Rinsing at the University of Manchester An S-Lab Briefing Paper describes water saving practices at Manchester's Geochemistry Dept which include soaking glassware in a water bath after an acid bath to reduce multiple water rinsing.	Labs21 Water Efficiency Guide for Labs A useful guide, which though aimed at US labs also contains a number of measures applicable to UK conditions. These include rainwater harvesting, low water toilet fixtures and piping condensate from the AHUs and chilled water coils back into nearby cooling towers for use as make up water. **LabRATS Guidance** Advice on Using Timers for Water Valves and Washing Labware Efficiently (with links to a Green Washing page).
W2. Water for cooling is recirculated rather than running continuously to waste.	Closed Loop Water Cooling at the University of Bradford An S-Lab Briefing Paper describes how closed loop water cooling systems is used for a cell sorter at the University of Bradford, saving 11-45 litres per minute.	**LabRATS Guidance** Advice on Reducing Single Pass Cooling and Eliminating Vacuum Aspirators.

W2 (contd.)	Recirculating Chillers at the University of Aberdeen An S-Lab Briefing Paper describes how the University's Marine Biodiscovery Centre replaced 12 water jet vacuum pumps with recirculating chillers, with a payback of less than 3 years. Reducing Water Consumption at the University of Oxford An S-Lab Briefing Paper describes how the University's Physics building has reduced its water consumption by over 60% as a result of a series of water conservation measures including water flow restrictors on water cooled apparatus and process chillers to replace mains to drains cooling systems. State of the Art Washing at a US Biomedical Facility The Whitehead Biomedical Research Building at Emory University, Atlanta, Georgia has a vivarium with a state-of-the-art, automated cage-washing system. This recycles water through four stages of cleaning using a counter-current rinsing process. An automated process using robotics disposes of the dirty bedding, feeds the cages through a washer, fills the clean cages with clean bedding, and replaces cages in the racks.	
W3. Water-using equipment is 'rightsized' for tasks and used with as high loadings as possible.		Water Efficiency Practices for Health Care Facilities A US fact sheet provides some useful tips on saving water from sterilisers and autoclaves in laboratories including installing automatic shut-off valves, recycling

W3 (contd.)		steam condensate and running with full loads only. **LabRATS Guidance** Advice on Rightsizing Autoclaves and minimising water and energy use from Ice Makers, Autoclaves and Stills.
W4. Purified water is used only when appropriate, and produced by reverse osmosis (RO) wherever possible.	Replacement of Water Still at the University of St Andrews A presentation at an S-Lab event describes how the University's new Medical Sciences Building has replaced a water still with RO and has also installed a water recirculation system for cooling water.	**LabRATS Guidance** Advice on Using Appropriate Water Quality and Eliminating Water Stills.

Issue 10: Innovation and Dissemination (IND)

Overview

The variety of laboratories and practices means that there may be some innovative actions for environmental improvement that have not been covered by other laboratory criteria. Similarly, there may be examples of individuals, research groups or universities who have disseminated information about successful actions to the broader laboratory community. Hence, the S-Lab framework has an additional 4 credits for actions such as these. We will provide some or all of the examples that have been provided by laboratories undertaking the assessment in a future edition of this document.