Harvard Lab Sustainability Guide

This guide is intended for members of the Harvard research community interested in learning how they can take steps to reduce energy consumption and waste in the laboratory environment. The guide is composed of best practices from across Harvard's campus, and includes links to relevant external resources. It represents just a portion of the vast body of knowledge on this topic and does not aim to be comprehensive.

A compilation by the FAS Green Program, the HMS Sustainability Program, and Office for Sustainability

Last Updated: April 2013

Index

I. Chemical Use Information

Green Chemistry is a rapidly growing field in academics and industry, as the environmental and health impacts of using dangerous chemicals are gaining attention and raising concerns. Below are a number of "best practices" regarding efficient chemical use, as well as list of useful external resources.

Recommendations:

- **Cover chemical beakers when not in use.** EH&S recommends that lab users cover any beakers that are not currently in use and, by law, all hazardous chemical waste containers must be sealed except when actively adding chemicals. In a high airflow environment like a laboratory, volatile chemicals will off-gas very quickly, wasting your chemical and causing pollution. Fume hood exhaust is not filtered, but rather exhausted at a high velocity in order to dilute any pollutants sufficiently that they do not pose acute environmental hazards. So even if it is in a fume hood, please cover the beaker.
- **Utilize Green Chemistry.** Green Chemistry is defined by the EPA as "the design of chemical products and processes that reduce or eliminate the use or generation of hazardous substances," during the entire life-cycle of the chemical, including design, manufacturing, and use.[1] Ask yourself if you can apply the Green Chemistry principles to each significant step in your chemical research. Protect yourself, others, and the environment by being up to date on less toxic chemical alternatives and implementing sustainable chemical practices in your work.

Additional Resources:

- **MIT Green Chemical Alternatives Purchasing Wizard:** The Wizard is an MIT initiative to reduce the generation of hazardous wastes and potential workplace exposures in the labs. Containing over 200 journal references and case studies, it is an interactive tool designed to provide information on alternatives for some of the most commonly used hazardous solvents and substances in research laboratories.
- **SciFinder Scholar Green Chemistry Resources:** Available for members of the Harvard community with a Harvard ID and PIN, Chemical Abstracts/SciFinder Scholar has a number of useful tools:
    - You can create a "Keep Me Posted" profile for references about green chemistry (it sends a weekly digest of dozens of new results related to green chemistry).
    - You can search for solvent-free reactions, and filter by solvents, substances, reactions, processes, etc.
    - You can analyze by yield.
    - You can subscribe to green chemistry podcasts!

External Resources:

- EPA Green Chemistry Program Website
- EPA Pollution Prevention Resources
- American Chemical Society Green Chemistry Institute
- California Department of Toxic Substances Control, Green Chemistry Initiative
- University of California, Berkeley, Program in Green Chemistry and Chemicals Policy
- Center for Green Chemistry and Green Engineering at Yale University
- Green Chemistry Centre of Excellence at the University of York, UK
- Next Generation Environmental Technologies Published by RAND
- Green Chemistry at Tel Aviv University
- Green Chemistry Journal of the Royal Society of Chemistry
- Green Chemistry Letters and Reviews, Taylor & Francis

II. Equipment Energy Use Information

Lab equipment can be very energy intensive, particularly fume hoods and devices used to maintain hot or cold environments (ovens, ultra- low temperature freezers, etc.). Here are some tips to conserve energy where you can.

Liquid Nitrogen Storage Container Practices

Liquid nitrogen conservation is an important energy efficiency measure because production of LN2 is an energy intensive process.

- Treat your liquid nitrogen (LN_2) cell storage containers like you would treat a freezer, minimizing the amount of time the door is open, thereby decreasing the amount of LN_2 that boils off.
- Use only what you need. Ask yourself if your cells need to be at the coldest possible temperature, or if you can use a tank that doesn't need as much liquid nitrogen input.
- Store the most frequently accessed samples near the top of the rack so that you can access them without compromising the temperature stability of other samples on the rack, and without letting a lot of LN2 boil off.
- Post a freezer map and inventory on the lid of the freezer and maintain a logical storage system to minimize time with door open trying to find samples.
- Share LN2 freezers with neighboring labs if possible.
- Make it a lab policy that researchers are responsible for clearing out their samples and/or labeling them and turning them over to other researchers when they leave. Reducing the number of old, unwanted, and/or poorly-labeled vials and plates in a freezer will increase the available space and the speed with which you can locate your own samples, while delaying the need for a new freezer as long as possible.
- Check lid seals on a regular basis to ensure that it shuts properly. Don't let ice buildup prevent proper lid closure.

Energy Efficient Oven Practices

- Ovens and other heating equipment can often be turned off during unoccupied hours.
- Evaluate the amount of time it takes for the oven to get up to temperature and place a "Turn me off sticker" with this information on the unit, so that users are informed about how long it will take to reach temperature and can plan accordingly
- Evaluate whether your usage of the equipment requires continuous heat, or if the heat can be reduced or turned off when the contents are not needed.
- Try to minimize the number of times the oven door is opened, and the length of time it is opened for.

General Best Practices for Equipment Energy Conservation

- **TIMERS:** Use timers on pieces of equipment that don't need to be left on overnight, or during specific periods of time throughout the day. This will reduce energy use, energy costs, environmental impacts, and often increase the life of the equipment. Timers are available free of charge from the FAS Green Program- email energy@fas.harvard.edu for more information.

- **SHUT THE SASH:** Fume hoods use a tremendous amount of energy (to put it in the context of home energy usage, think about turning on the heat or AC, opening all the windows, and blowing out all your conditioned air with large fans). Many Harvard hoods operate on a "variable air volume" (VAV) system, which means the volume of air exhausted will vary depending on the size of the face opening. Thus, the larger the fume hood opening, the larger amount of energy

needed to heat and cool the space. Keeping your hood closed when you are not actively using it is the single most important step you can take to save energy.

- **EDUCATE YOUR PEERS:**
  - Place "*It's OK To Switch Me Off*" stickers on equipment that doesn't need to stay on 24/7 to help remind lab mates to switch off equipment. These stickers include a space to indicate how long it takes for a particular piece of equipment to start up again, as well as a space for the Lab Manager to sign off in approval.
  - Put up signs near the door that encourages to last person to leave the lab each day to do the following :
    - Turn off the lights & any computers or other electronic equipment
    - Shut the windows & close any blinds
    - Close fume hood sashes

- **ELECTRONICS ENERGY SAVINGS:** Enable standby mode whenever possible on all computers, copiers & printers in the lab. For instructions download and read the OFS Green Office Program factsheets.

III. Energy Efficient Freezer Practices

The use of -80F freezers is a significant source of greenhouse gas emissions on campus. According to data compiled on the EPA/DOE Labs 21 Program Energy Efficient Equipment wiki, the direct cost of electricity use for an *individual -80F freezer* could be between $1000 and $1500 per year (at $0.15/kWh, not including the indirect cost associated with providing additional cooling to dissipate the heat generated by these units). In 2008, Stanford commissioned a study which found that its 2000 -80F freezers were costing the university $5.6 million per year to operate.
Take the following steps to save money on purchases, extend the life of your freezers, and decrease energy usage and emissions.

Responsible Purchasing

- Avoid purchasing a new freezer if possible. Can you clean out space in your existing unit to accommodate new samples, or share freezer space with a neighboring lab? This is a great way to save your lab money, and minimize your environmental impact.
- If you need to buy a new freezer, look for an efficient model:
    - Look for energy consumption information on the product's technical specifications, and talk to vendors about this topic. Many manufacturers are realizing that energy efficiency is an increasing area of concern for consumers, and are therefore making strides to ensure their products are as efficient as possible.
    - Larger freezers typically use more energy than smaller freezers relative to their size.
    - Upright freezers typically use more energy than chest freezers of the same age & size.
    - Some highly efficient ultra-low temperature freezers utilize cutting edge technology (like a Stirling engine) that increases their cost. If your lab is interested in purchasing a highly efficient freezer, but you're running into cost concerns, an Office for Sustainability student grant may be able to cover a portion of the cost differential in exchange for a case study. Contact sustainability@harvard.edu for more information.

Best Practices for Ongoing Operations

- Adopt energy efficient freezer maintenance practices:
    - Make it a lab policy that researchers are responsible for clearing out their samples and/or labeling them and giving them to other researchers when they leave.
    - Defrost freezers at least once per year, or when ice buildup reaches more than 2 cm in thickness.
    - Check door seals on a regular basis to ensure that doors seal properly. Don't let ice buildup prevent proper door closure. If the doors are not closing properly, contact the FAS Energy Team immediately at energy@fas.harvard.edu.
    - Find out the policy for freezer maintenance in your department: In some departments preventative maintenance is the responsibility of the research group, whereas other groups have a contract by which 3rd party companies come in to inspect the freezers for signs of wear and tear, and address any problems that might impact the freezer's efficiency and reliability. FAS labs are eligible to enroll in a free preventative maintenance program for -80 freezers; for more information email energy@fas.harvard.edu.
- Conduct an annual cleanout of old unwanted samples from researchers no longer affiliated with the research group. Any questions on proper disposal of samples should be directed to your lab's safety officer and/or the EHS point person for your building. See "How to Facilitate a Freezer Cleanout" (page 7) for tips on how to plan an effective freezer cleanout.
- Post a freezer map and inventory on the door of the freezer to keep samples organized and minimize the amount of time needed to find a sample:
    - Minimizing the amount of time the freezer door is open reduces temperature fluctuations within the unit, saves time, and saves energy.

    - Plan ahead to make sure you know everything you need and where it is located before you open the freezer door.
    - Database programs like those provided by Freezerworks, Cryotrack, and Labrepco can help your lab stay organized – a database is only as useful as you make it though, so make sure everyone keeps it up to date.
    - See "Sample Inventorying Guidelines" below for more information on alternative methods for tracking your samples, and tips on creating an effective inventory.
- Consider using existing technologies- such Biomatrica - that allow you to store dehydrated DNA and RNA at room temperature for extended periods of time without degradation instead of cold storage.
- Share freezers with neighboring labs if possible.

Sample Inventorying Guidelines

Sample inventorying is one of the best ways to optimize the use of your freezer. By having an accurate account of what is located in the freezer and where, sample access is quicker, saving time and energy. Needless samples can also be identified and disposed of, saving space in the freezer and reducing the need for additional units. Lastly, freezer management techniques (such as changing temperature setpoints) can be implemented appropriately according to the types of samples stored in the freezer, providing a safe environment for the samples.

Inventorying methods range from a simple freezer map taped to the door with handwritten information, to database programs designed specifically for sample tracking. Regardless of your method, the following parameters for each sample should be recorded:

On the Sample	In the Database
Date	Unique Code/Identifier
Unique Code/Identifier	Date
Researcher Initials	Researcher Name
	Category (antibody, cryosections, viral stock, etc.)
	Volume: # of sections, etc.
	Strain
	Description of Work Performed

If your lab is interested in keeping an electronic inventory of your samples, but would like a scaled-down version of a database program, there are some free web-based tools that may make a good starting point for your lab. Two options are outlined below.

1. **Dropbox & Excel:** Dropbox is a useful application because it can handle many different types of files. The application is downloaded from the web and a folder is created that you can store files to. A shortcut to the folder is located on your taskbar for easy access. The files are visible to everyone the Dropbox is shared with, and files are automatically "synced" each time they are updated. An Excel file stored in a Dropbox folder would be a great way to track samples. Find out more here.

1. **Google Doc's** are another useful tool. Although limited to a spreadsheet (no pictures), Google doc's are easy to use and share with other users. The Google Doc can also be downloaded onto your computer in a number of formats, including Excel. The Google Doc can also be accessed from any computer, making it extremely convenient. Find out more here.

The most important aspect to any freezer inventory is to ensure that it is kept up to date. Have a conversation with your lab to determine the best approach for your group. Talk to your lab manager about making it a regular practice for everyone to record changes to their samples in the freezer. By

working as a team to keep the freezer inventory accurate, you can be sure that your samples will be safe and accounted for well into the future.

How to Facilitate a Freezer Cleanout

1. Inform your group of the upcoming cleanout in advance so they can plan their participation.
2. Develop a schedule and have each group member sign up for a time slot to clean out their shelf, boxes, or racks. The clean out should happen one shelf at a time to avoid excess warming.
3. All samples that will be kept should be properly labeled and entered into a sample database. For tips on how to create a sample database, see the "Sample Inventorying Guidelines" section.
4. The lab manager should be on hand to answer any questions.
5. Excess ice should be removed using a rubber mallet or a soft cloth.
6. At the end of the clean out, fill empty space in the freezer with water jugs to help the freezer maintain temperature.

IV. Workspace Comfort & Efficiency

Lighting, heating, cooling, and ventilation comprise a large but largely invisible fraction of your lab's energy demand. While the building systems are the responsibility of the facilities management team in your department, communication and cooperation with facilities management can help drastically cut these energy costs and greenhouse gas emissions.

How much do these systems actually use?

- Lighting – typically 1/3 of the energy cost of the building
- Heating, ventilation, and air conditioning (HVAC) – heating, cooling, & dehumidifying lab air uses a ton of energy. In just 15 labs in the Chemistry department, they have saved $200,000 each year based on increased attention to fume hood sash position.

Lighting Recommendations

- Express your willingness to remove redundant bulbs in overlit hallways, common spaces, and other spaces – you can always put the bulbs back if it is not bright enough
    - Many labs are designed with three parallel fluorescent tubes in a single fixture, which is a lot of light, based on the assumption that all lab environments and lab tasks require brighter lighting than office type tasks. Your building manager may be able to remove these without you noticing the difference.
- Request motion sensors for areas where lights frequently are left on, but make sure that the technology is appropriate so that it doesn't turn off when the room is occupied. Ask your facilities manager for dual technology, ceiling mounted sensors. HVAC can also be tied into motion sensors if your building is sufficiently modern.
- Put up reminder prompts for the last person in lab to turn off the lights on the way out. Use a group meeting to make sure everyone knows where the switches are. Reminder prompts available on request from OFS.
- If you are the only person in the lab, consider using task lighting at your desk to save energy.

Reducing Peak Energy Demand in the Summer

During periods of peak demand in the summer, the electrical grid is stretched to capacity, requiring the most expensive and dirtiest power generators to come online. Reducing energy during times of peak demand- called "Demand Response"- cuts pollution, avoids the need to build new power plants, and saves money. Each of Harvard's Schools has a Demand Response Plan for addressing peak load on the hottest days of the summer. Here are some tips for how your lab can help:

- Close variable volume fume hood sashes whenever possible to reduce ventilation rates. Encourage labmates to do the same.
- Defer autoclave cycles and dishwasher runs, if possible, until the end of the day so that they run overnight after the peak air conditioning load has passed.
- Avoid opening freezers for prolonged periods of time in case a brownout might impact their ability to maintain temperature, particularly if these freezers are not on backup power.
- Close blinds in order to reduce solar heat load, particularly if there is direct sunlight coming in.
- Have the lab manager email the entire lab about the issue, requesting that group members adapt their practices when possible, and find equipment that can be temporarily turned off.

Saving Energy in a Lab with Reheats

Before entering a lab space, outdoor air is conditioned to meet certain temperature and humidity requirements. First, it is cooled- causing water vapor to condense, and reducing humidity. The air is then commonly re-heated so that it enters the laboratory at a temperature that is comfortable for the occupants. The steps required to condition air are very energy intensive, and may be more stringent than

is necessary depending on a lab's research requirements. Here are some ways you can help save energy in your building:

- Discuss with your PI, lab manager, and lab mates what temperature and humidity requirements are necessary for your group. If you research can permit a slight variation in temperature (say 68° F-75°F, or whatever you decide), that will save even more energy!
- Talk to your Building Operations team about how the temperature and humidity requirements you decided on with your group compare to the settings for your space. They may be able to make adjustments to the controls to allow for a wider range in temperature and/or humidity where possible.
- Are there any areas of your lab that are particularly cold or uncomfortable? See if your facilities group can redirect the supply air with a different shape of air diffuser, so that it is not directly dumping cold air onto people who are already too cold. This will reduce the need to reheat the air while providing a more comfortable work environment.
- See if the supply air volume can be reduced, reducing the need to reheat the air.

Suggest to labmates who are cold in the summer to store a sweater at their desk just in case.

Space Temperature Controls

An uncomfortable work environment is often an inefficient one. Read here to find out how you can make your workspace more efficient and more comfortable with some simple steps.

<u>If you're too hot:</u>

- Many factors contribute to space comfort, including the position of air diffusers, your proximity to drafty windows, personal temperature preferences, etc. If you are consistently uncomfortably warm, talk to your facilities team and labmates whether the heating setpoint can be reduced for the whole zone or if it will make certain areas too cold.
- Fan coil units, radiators, baseboard heating, and central ventilation all require adequate circulation of air in order to meet temperature setpoints. Remove any books, lab supplies, or other obstructions from these pieces of HVAC equipment.
- Close east-facing blinds in the morning, and west-facing blinds in the afternoon
- Electrical equipment produces waste heat. The more you can conserve by setting power-saving standby modes, turning off un-needed lights, and unplugging equipment, the less heat load will be in the room.

<u>What NOT to do if you are too hot:</u>

- Don't open the windows – even if the breeze feels better, it will be adding humidity to the space and if you have hoods, it may compromise their effectiveness.
- Don't trick thermostats by putting a heat source under them. This may lead to ineffective temperature control in the rest of the lab/zone.

<u>If you're too cold:</u>

- Store a comfortable sweater or light long-sleeved layer in lab to wear in case you don't come in with appropriate indoor layers on any given day.
- Fan coil units, radiators, baseboard heating, and central ventilation all require adequate circulation of air in order to meet temperature setpoints. Remove any books, lab supplies, or other obstructions from these pieces of HVAC equipment.
- Are you sitting right underneath an air diffuser? If so, see if you can move your workstation or ask facilities to find a different diffuser that will channel air away from your workstation. Make sure that any changes in the diffuser geometry will leave you equally satisfied in the summer.

<u>What NOT to do if you are too cold:</u>

- Don't block diffusers on your own – you will be changing the air currents in the room, which could have an adverse effect on fume hood performance, and may cause the thermostat to tell the HVAC system to work overtime to meet its temperature setpoint.
- Don't buy your own space heater. It may be against building policies, and you may be able to find a better solution if you speak with building management.
- Don't trick thermostats (icepacks, etc…). This may lead to ineffective heating or cooling in the rest of the lab/zone.

A note on space heaters:

If you, or labmates, are tempted to use a space heater to supplement the building's heating system, keep the following points in mind:

- Space heaters are banned in many Harvard buildings due to their tendency to get very hot and start fires. Check your local policies.
- Space heaters use electricity to produce heat, one of the least efficient and most expensive ways to produce heat (U.S. DOE, www.energysavers.gov).
- There is a wide range in efficiency of various types of space heaters. Radiant panels can heat you (and other objects in their line of sight) without heating the air around you, yielding greater efficiency. Check with your building manager to see what the options are. The need for a space heater is probably being caused by a fixable problem, such as drafty windows or improperly balanced air delivery.

V. Waste Reduction

The purchase and disposal of ongoing consumables in a laboratory often create large amounts of waste. Learn and share best practices for reducing the amount and type of waste generated in a laboratory setting.

General Guidelines

- Check with your building's EHS point person to find out about the recycling guidelines for materials in your lab.
- Make sure your lab space has enough recycling bins, and that they are properly labeled. If you need more bins contact your facilities team, and if you would like more labels (or custom labels!) contact energy@fas.harvard.edu.
- Try to use reusable materials (like glass pipettes instead of plastic pipettes) whenever possible.
- Check with product manufacturers to see if they have take back programs for packaging or other materials. Some suppliers- like New England Biolabs- provide pre-paid shipping labels so that Styrofoam coolers can be returned to them for recycling free of charge.
- Keep lab supplies and appliances out of the waste stream as much as possible. Post any unwanted (but still functioning) items on Harvard's Lab Reuse List so that other labs at Harvard may make use of them. For items that are broken or have reached the end of their usable life, contact your facilities team to arrange for proper recycling.

Techniques for Avoiding Cold Shipments

Biological samples such as plasmids and restriction enzymes are commonly shipped on dry ice in Styrofoam containers. By following these techniques, you can cut down on the number of deliveries of standard plasmids and enzymes, resulting in reduced energy cost from production of dry ice and Styrofoam, less fuel burned during the transportation of samples (through reduced shipping bulk and weight), less physical waste, and reduced costs.

- Purchase cold samples from the VWR Biolabs stockroom, where cold samples can be shipped in greater bulk.
- Find companies that are willing to send DNA samples with dry room temperature storage techniques, such as DNAGard by Biomatrica, rather than on dry ice. If you are transporting your own samples from the field or sending samples to other labs, also consider dry room temperature storage options as insurance against mailing delays that would lead to warming of samples.
- Set up a sharing database for common plasmids, restriction enzymes, and primer stocks.

VI. Design Charettes

Labs are among the most energy intensive buildings on campus, and the energy use depends strongly on whether sustainable features are incorporated into the design early in the process.

Key Recommendations:

- Ensure that the appropriate lab representatives (PI or lab manager) attend design charettes when invited. If the lab is not invited, contact the project team or your Facilities Department to request access to the charettes and design updates.
- Promote integration of efficiency measures into your lab's design and construction. Sample ideas include:
    - Setting aside space for shared autoclaves, glassware washing facilities, and general supply storage
    - Using life cycle costing as a tool for evaluating all decisions with significant financial or energy impacts.
    - Trying cutting edge products such as LED lighting, dual technology motion sensors, and more, and request an opportunity to see a mock-up or a comparable installation to see how you like it
    - Control banding for chemicals based on their toxicity

Ensure that the design team understands your research operations and needs, in terms of chemical use, humidity control, ventilation, etc.

When and how should we get involved?

As soon as you know that your lab will be moving or that significant work will be done, you should contact your PI or lab manager to discuss design opportunities.

VII. Equipment Purchases

Lab equipment accounts for a significant amount of electricity use (sometimes called "plug load") in laboratories on campus. Many lab equipment vendors are starting to install power save modes, efficient motors, and other strategies for reducing energy use of plug load lab equipment.

Key Recommendations:

- Try to substitute reusable products (like glass pipettes instead of plastic pipettes) whenever possible.
- If you need disposable products, look for brands with reduced or recycled content packaging.
- Utilize end-of-life take back programs.
- Centralize chemical purchasing and keep an inventory up-to-date.
- When purchasing a new appliance, ask your vendors about the available energy efficient options. If no options are available, start a dialogue with them to encourage them to supply more sustainable products at a reasonable cost.
- Check out Harvard's Lab Reuse List to see if you can obtain your desired item free of charge from another lab at Harvard- saving money and minimizing your carbon footprint!

External Resources:

- Labs for the 21st Century's Energy Efficient Laboratory Equipment Wiki

VIII. Stay in the loop!

Join the Harvard lab sustainability best practices sharing network, "greener benches", to receive periodic email updates with information about energy and waste reduction in labs, including new resources, upcoming events, and surplus materials available.

- Cambridge Campus (FAS)
- Longwood Campus (HMS & HSPH)

Do you have questions, new ideas, or feedback? Please get in touch! The appropriate email addresses for each campus are as follows:

- FAS: energy@fas.harvard.edu
- HMS: sustainability@hms.harvard.edu
- HSPH: greenideas@hsph.harvard.edu