Community

Maintain the energy on your sustainability efforts!

- Share responsibility for sustainability across lab members and staff
- Revisit topics regularly to help train new people and explore new innovations
- Designate a point person in the lab to represent your lab group on a broader green team at your organization

Motivating the entire lab team to make sustainable changes in their day-to-day practices can take a little time and effort. A common strategy to motivate behavior change, which is what this Green Lab Certification is all about, is rooted in **understanding the barriers that your lab faces to making changes and attempting to remove those barriers through specific strategies.** One school of thought is called **Community-Based Social Marketing**, which is rooted in the science of social psychology. This can work both in a single lab and for broader green labs programs.

CONVENIENCE

Your lab will be more likely to succeed in starting sustainable practices if those new actions are convenient to do. For example, if you're hoping colleagues will put the autoclave in standby mode after a cycle is done, put instructions for doing that on the autoclave itself **-** or better yet, pre-program it.

SOCIAL NORMING

People pay attention to what their peers do, especially friends, family, coworkers, and neighbors. **Create norming behavior in your lab** and within your building by advertising what your lab group is trying to do to be more sustainable. And lead by example!

COMMITMENTS

The probability is greater that someone will try a sustainable action **if a peer asks them to make a commitment to do so**, and it is even better if the commitment is made in writing and is public. Could you ask your lab to sign a pledge you all create to focus on practicing three new sustainable behaviors in the lab over the next month?

PROMPTS

Use prompts in the lab to remind your colleagues what to do, such as turning equipment off overnight, turning off the lights in the lab, or reminding them to be conservative with ultrapure water use. Try using bold colors but avoid cluttering the lab with too many prompts at once.

Waste Reduction and Recycling

Labs produce many types of waste, and a lot of it, so this category is typically a high priority in greening your research. **Recycling and waste management will always depend on local regulations, organizational standards and more** – but there are simple steps that most labs can take to reduce impact.

The foremost tactic in the battle against waste is **REDUCTION**. A holistic approach of **smart purchasing, organization, planning, and communication** will ensure that your lab doesn't acquire or incorporate unnecessary waste in your research.

HAZARDOUS AND CHEMICAL WASTE

Chemical, biological and other hazardous wastes are much more prevalent in research industries, and unfortunately disposing of them is an energy intensive and often unsafe process.

- ✓ Properly segregate your waste
- ✓ Utilize Green Chemistry
- ✓ Avoid over-purchasing of reagents and chemicals

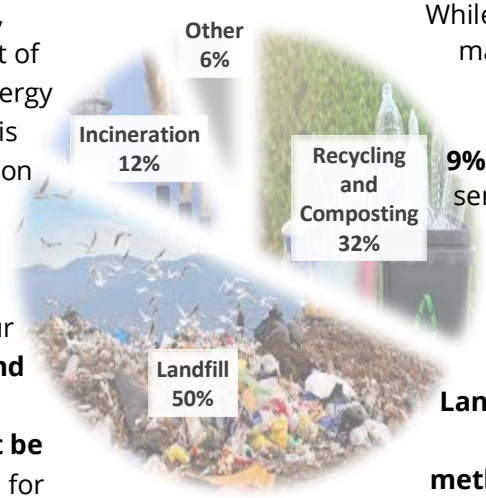
PLASTICS

In 2018, **plastics in labs became even harder to recycle** due to China's new import regulation which limited allowable contamination in materials sent there for recycling. Labs produce over 5 million tonnes of plastic annually! **How can we minimize plastic consumption?**

- ✓ **Swap** glass for plastic (vials, large pipetters, petri dishes, etc.)
- ✓ **Reuse plastic items –** check out this guide from University of Bristol
- ✓ **Choose vendors** with reusable containers & take back options
- ✓ Look for **compostable** plastic
- ✓ **Consolidate** orders – 30% of all plastic resins worldwide are used in packaging
- ✓ Perform a waste audit to identify targets for reduction

Where does our waste go?

Incineration, often as part of Waste-to-Energy technology, is more common in areas like Europe. Additionally, much of your **chemical and hazardous waste must be incinerated** for proper disposal.



Data from 2017 EPA estimations

While this number may seem high, consider that globally **only 9% of materials** sent to recovery centers are estimated to be actually recycled!

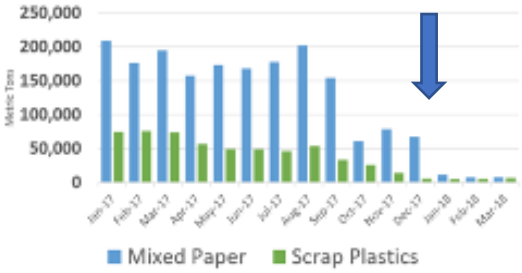
Landfills are still the disposal method of choice for most of the world.

When tackling waste, a few key stakeholders should always be involved:

- Environment, Health and Safety
- Facilities/Building Operations
- Waste Management

These are your local experts and will ensure that your waste management plans and goals are a success.

Materials accepted by China for recycling dropped dramatically after 2018



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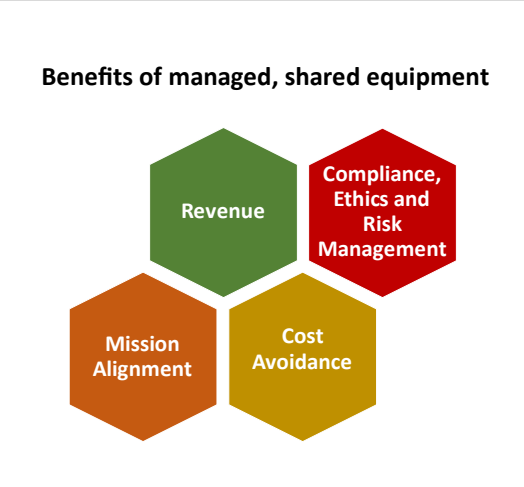
Resource Management

In this section, we asked you questions about **how you manage the reagents, chemicals, consumables and equipment** in the lab in order to minimize waste and keep materials out of the landfill or away from incineration.

WHY IS THIS IMPORTANT?

Once you bring materials into the lab it's imperative that they are used efficiently and discarded correctly. - **Millipore Sigma reports** that 5% of goods in labs each year are disposed of before they are used due to expiration! It is also important to make an effort to repurpose unused materials or equipment, rather than dispose of them.

- ✓ Sustainable resource management best practices also **overlap with general cost-efficiency**, which is extremely helpful when trying to maximize the funding dollars that you have available.
- ✓ A good **inventory management system** is necessary for most of the best practices mentioned in this section. **These systems can save the lab time and money,** while also preventing any unnecessary waste. Look into options such as Quartzy, Rheaply, LabNotebook, and more.



High Purity Solvents

These solvents typically require additional distillation and filtration steps to purify, greatly adding to the environmental footprint. Not only that, but they are generally more expensive!

Gas Lines

Proper gas line maintenance is necessary as all gases take considerable energy to isolate and bottle, and some gases, like helium, are in limited supply. Close lines when not in use and check tanks and hoses regularly for leaks.

Sharing Equipment

Check out this list from the University of Colorado Boulder on why **sharing equipment** benefits the lab. Reasons include space utilization, energy efficiency and safety.

Sharing Supplies

One example of successful supply sharing comes from the University of Michigan at Ann Arbor, which saw massive **savings of more than $250,000 a year** from implementing a campus-wide recycling and reuse program for chemicals, equipment and materials

Purchasing

Sustainable purchasing is the procurement of **products and supplies that have a reduced impact on the environment** when compared to similar options. These products can differ from each other in several areas, such as raw material usage, production, manufacturing, packaging, reuse, and disposal.

Key phrases used for sustainable products or supplies can include **"made from recycled content, environmentally preferable, bio-based, energy efficient, & eco-friendly"**. In the lab, these products range from energy-efficient freezers to lab supplies with reduced packaging materials.

Why focus on sustainability during the purchasing process?

- ✓ Start sustainability choices "upstream" of the laboratory
- ✓ Prevent the need for more work down the line to achieve sustainability goals
- ✓ Influence market demand for greener products and supplies
- ✓ Improve lab member safety and health
- ✓ Reduce lab-generated waste

HOW TO USE THE ACT LABEL DATABASE

The ACT label provides **clear, third-party verified information** about the environmental impact of laboratory products.

All ACT labeled products can be found **here**. This database is **searchable and filterable** so that you can find the products you need quickly.

Label criteria is broken up into 12 categories, which combine to give the label its **Environmental Impact Factor (EIF).** Learn more **here**.


ACT. The Environmental Impact Factor Label — US

Product Name
Product Location
SKU 0000

Environmental Impact Scale
1 Decreasing Environmental Impact 10

Manufacturing	
Manufacturing Impact Reduction	3
Renewable Energy Use	Yes
Responsible Chemical Management	5
Shipping Impact	9
Product Content	1
Packaging Content	5
User Impact	
Energy Consumption (kWh/day)	2.5
Water Consumption (gallons/day)	13.1
Product Lifetime	4
End of Life	
Packaging	5
Product	1
Innovation	
Innovative Practices	-1
Environmental Impact Factor:	**50.1**
Label Valid Through:	January 2021

Market Influence

Preferentially purchasing greener products helps vendors understand their importance to consumers and encourages them to design more.

Advocacy at Your Institution

Even if another person or department at your institution manages purchasing, **you can push for better products and practices.** This curbs the flow of waste before it enters the lab and reduces transportation emissions.

Right Sizing

Purchasing products in a **volume that is appropriate** for the usage rate of the lab ensures that materials are not left on a shelf to expire or be discarded later

*Want to take a deeper dive? Check out **MGL's Accredited Professional course**!*

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Green Chemistry

After decades of global environmental disasters, human health crises and toxic spill events, scientists in the late 20th century conceived the concept of Green Chemistry – defined as **"the design of chemical products and processes that reduce and/or eliminate the use or generation of hazardous substances".**

The 12 Principles of Green Chemistry provide a framework for evaluating and minimizing the life cycle impacts of a product or process.

1. Pollution Prevention	**2. Atom Economy**
3. Less Hazardous Synthesis	**4. Design Safer Chemicals**
5. Safer Solvents	**6. Energy Efficiency**
7. Renewable Feedstocks	**8. Reduce Derivatives**
9. Catalysis	**10. Design for Degradation**
11. Real-Time analysis	**12. Accident Prevention**

Take it a step further!

- ✓ Beyond Benign – nonprofit group focusing on educational resources
- ✓ ACS: Industry Roundtables – convenes global companies to advance the implementation of green and sustainable chemistry and engineering
- ✓ Check out Green Chemistry/Engineering programs at these institutions worldwide
- ✓ Sign up to use Millipore Sigma's DOZN tool, which will help to effectively plan your synthesis and other experiments sustainably
- ✓ Share your green chemistry solutions with us – send us your ideas to programs@mygreenlab.org

Swap toxic items for less toxic

Exchanging mercury thermometers and discontinuing ethidium bromide use for gels are just a start to the ways your lab can cut back on harmful chemicals, reagents and precursors.

Substitute and Recycle Solvents

Our best practices guide breaks down available selection tools to help choose greener solvents. Many solvents (Acetone, Acetonitrile, and more) can be efficiently distilled back to + 99% purity using solvent recyclers and vendors.

Share Chemicals and Reagents

Many labs contain chemicals which are unused that could be valuable to others. Talk to your organization about hosting a chemical share/swap event, to ensure these valuable items are utilized by your peers.

Stay Informed and Engaged

Keep talking to your lab mates, managers, PIs, EHS personnel and more about your desire to incorporate Green Chemistry principles into your lab. Use our discussion guide as starting point!

Want to take a deeper dive?
*Check out **MGL's Accredited Professional course**!*

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Water

Water is often overlooked by scientists when it comes to resources use in our labs – even though labs use a whopping 4 times as much as a standard office building!

Never use single-pass cooling!

When cooling chemical reactions, use technology such as waterless cooling (Findenser or Asynt are good choices) to ensure that running water isn't used to cool your experiment. You can even use a fish pump in an ice bucket to create a recirculating water system in-house!

Use Faucet Aerators

These simple, cost-effective mesh inserts can reduce water flow at your lab sink by 60% while maintaining pressure – talk to facilities to ensure you have them.

Always use the correct quality water

Reverse Osmosis (RO), Deionized (DI), ultrapure – which do you need? Using the correct water not only has consequences on your research, but the energy and excess water used in production varies as well - **It takes 3L of tap water to make 1L of DI water.** Labconco's guide can help you think about the right water for your task.

Always consolidate

When running glassware washers, dishwashers, animal cage washers, or autoclaves, always ensure that you've **maximized the load** – don't run an autoclave for just one flask. Try using a schedule like the one here to make sure your team is aligned.

Mind the Tap

Be on the lookout for leaky faucets – one drip per second wastes more than 11,000L per year!

Autoclaves/Steam Sterilizers

These are a staple of most biological labs, as the combination of **heat, steam and pressure are used to sterilize materials** such as media, instrumentation, flasks, and more.

Full-sized, front-loading autoclaves can use **up to 60 gal of water per cycle**, mainly due to two features:

- Steam Jackets: Many models are designed with a "jacket" of steam around the main vessel, to aid in temperature uniformity. Filling this secondary area uses additional water and heat.
- Tempering water: Cold water must be added to the effluent hot steam/water to protect your building's plumbing. Often, this tempering water is left running constantly, and can consume up to 15,000 gallons a week.

  - ✓ Talk to your facilities/building personnel about **purchasing non-jacketed autoclaves** and installing devices to **control and limit tempering water**.
  - ✓ Limit the use of drying and cooling time on your cycles – they should only be necessary if you are running many loads per day, back-to-back.
  - ✓ If you have low throughput needs, purchase a **benchtop or top-loading** autoclave for your lab, as they use far less water and energy to operate.

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Plug Load

When academic research institutions have assessed the effect of laboratories on their campus' energy usage, they find that labs have a seriously outsized impact. The energy used by equipment you plug into your wall is the 'plug load' and can typically **account for 10-20% of the total energy your lab space uses.**

Stanford University published a [white paper] in 2015, revealing that **lab equipment comprises 50% of the total estimated plug load energy consumption** on Stanford's campus - this equates to 11% of total campus electricity consumption and 71% of total plug load energy use in lab buildings. Regardless of how you slice it, laboratory plug loads are drivers of energy consumption at research institutions.

Potential kWh/yr:

Drying Ovens **2,500**

Incubators **3,700**

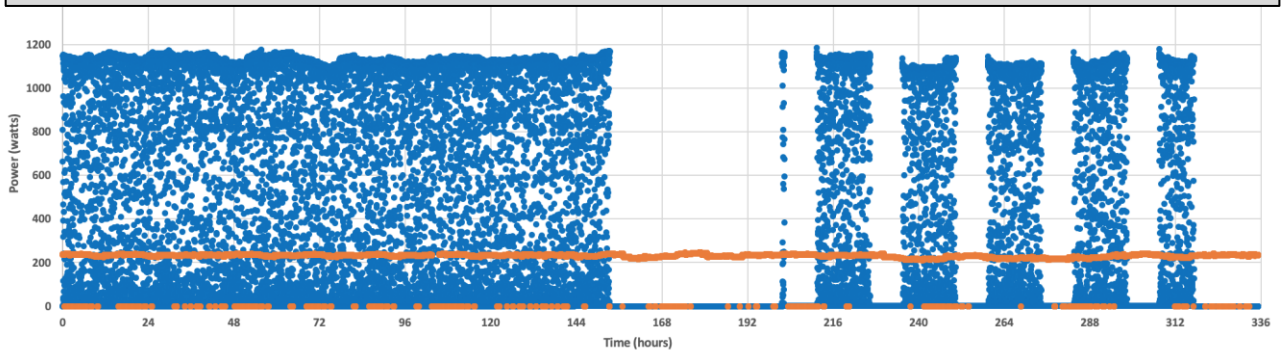
Thermal-cyclers **3,800**

Rotovaps **5,100**

Biosafety Cabinets **3,300**

Kitchen Fridges **1,500**

This is metering data from **MIT** (below), visualizing the potential savings from turning off equipment. Turning off the drying oven (blue) at night saved 1350 kWh/year. For comparison, a vacuum pump (orange) that was left on all the time, was metered as using 1825 kWh/year.



STRATEGIES FOR REDUCING LABORATORY PLUG LOADS:

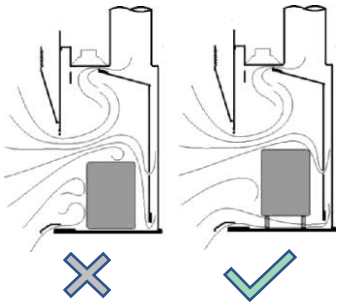
- ✓ **Share equipment** within your laboratory - and if possible, with other lab groups too
- ✓ Use prompts such as **stickers** [(use ours if you like!)] **or labels** to remind lab members to turn off certain equipment at night, over the weekend, or leave off until the equipment it is needed
- ✓ **Run a competition** in your lab to see if you and your colleagues can make it a habit to keep equipment off on a pre-determined schedule
- ✓ Try **outlet timers** to automatically power down some equipment overnight. Some versions which work as **energy monitors** can also tell you the amount of energy being used by the equipment and show you what you save when turning it off or changing the temperature. Check out our [Plug Load Guide] for more info!
- ✓ If you have equipment in your lab that you're not sure anybody ever uses, **have a group discussion** to clarify its use. If no one is currently using the instrument, opt to turn it off and unplug it

Fume Hoods

Fume hoods (or fume cabinets) exist to **keep researchers safe as they work with hazardous substances**. They are often also used for temporary storage of hazardous waste, to contain experiments with high heat loads or particulate emissions, and more.

While their benefits are undeniable, the energy costs associated with fume hoods continue to be a top target for lab sustainability professionals**. An inefficient fume hood which is improperly operated can consume as much energy as 3.5 houses per year!**

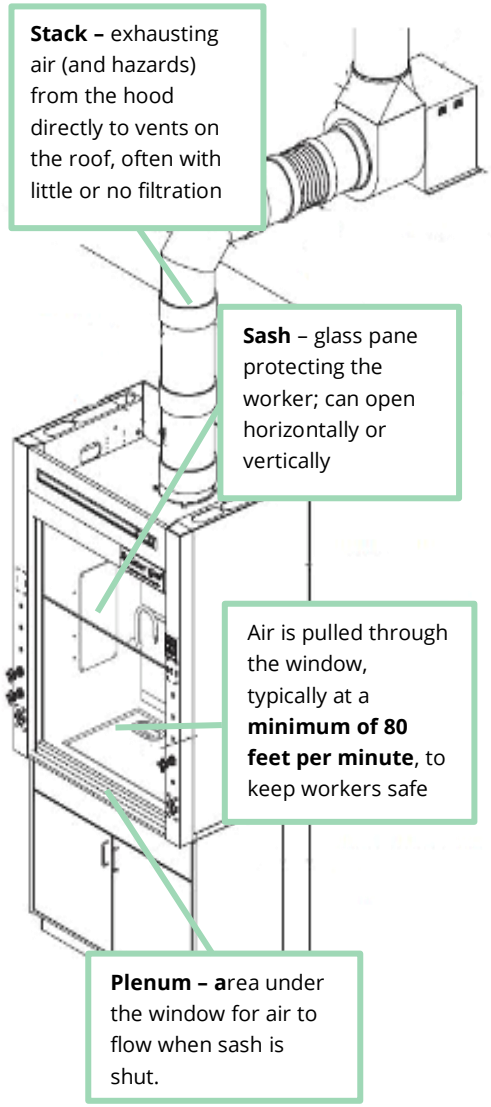
It's estimated that there are over 1 million fume hoods in more than 10,000 North American labs, **consuming in excess of $5 billion in energy each year.**



It's important to **follow best practices**.

Keeping equipment towards the front, and elevated if possible, ensures that **air flows safely** away from the user.

KNOW YOUR HOOD



Variable or Constant Air Volume?

Variable Air Volume (VAV) hoods are preferred in modern laboratories for most applications, as they can save over 40% of the energy of Constant Air Volume (CAV) hoods. They do this by **employing valves and building control systems which lower the flow rate through the stack when the sash is lowered,** ensuring that the face velocity remains high enough for safety purposes.

ALTERNATIVES TO CONSIDER

High Performance Hoods

Also known as "reduced flow" or "low-velocity" fume hoods, they **operate safely at reduced face velocities** due to their superior aerodynamic features.

Ductless Fume Hoods

Lower risk experiments can often be performed in hoods that do not connect to the building's ventilation, and instead **use HEPA filtration** to keep researchers safe, much like a biosafety cabinet. Talk to your lab and your EHS dept about making the switch!

Shutting the Sash: Sustainable and Safe!

Remember – keeping your fume hood sash low or closed isn't just saving energy, **it is primarily keeping you and your lab mates safe** from chemical exposures or even physical explosions.

Try a sticker to remind your lab, or go a step further and start a SHUT THE SASH competition like Harvard!

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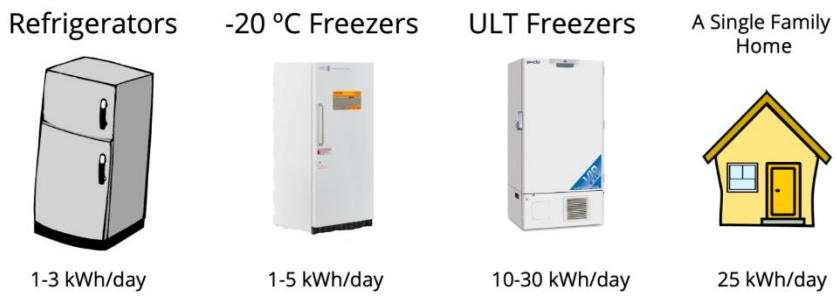
Cold Storage

After fume hoods, **cold storage units can be the most energy intensive group of equipment** in your lab space. Ultra-Low Temperature (ULT) freezers are especially energy consumptive and are often set as low as -96°C, and Ultra Ultra low freezers can reach temperatures of -200°C and below.



One ULT freezer can use more energy than an entire house!

Cold Storage Best Practices:

- Conduct routine preventative maintenance, as you would on a car to keep refrigerators and freezers running efficiently
- Because cold storage units **reject a lot of heat**, place them in areas with sufficient cooling and ventilation capabilities for greater efficiency
- Take steps to reduce the need to purchase additional cold storage units – consolidate your samples, clean out regularly, and share space!
- When you need to purchase a new unit, be sure it is energy efficient!

Any preventative maintenance recommended for your cold storage units is either detailed in the user manual or can be found on the manufacturer's website.

Some resources are gathered here regarding **preventative maintenance best practices.** Maintaining your cold storage units can result in 10% energy savings!

"Chill Up" your Freezer!

Thousands of ULT freezers around the world are now **set to -70 °C instead of the usual -80 °C.** We call this "chilling up" your freezer!

This setpoint change can result in a **30% energy savings** for your ULT freezer and puts less strain on your unit.

Be sure to get permission from your lab before changing your freezer set-point. Check out these resources we have gathered about storing scientific samples at -70 °C.

Join the Freezer Challenge!

The International Laboratory Freezer Challenge is a **competition designed to promote best practices** in cold storage management. Winning labs and organizations receive their **photo in *Nature*** and are recognized at the International Institute for Sustainable Laboratories conference each fall.

freezer challenge

my green lab.

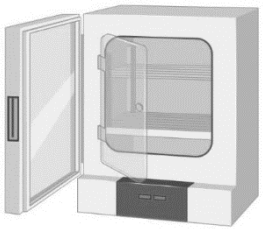
Large Equipment

In general, equipment that has a heating or cooling element or pulls a vacuum consumes a larger amount of energy than other types of laboratory equipment.

Depending on what you use in the lab, in this section we might have asked you about incubators, gloveboxes, tissue culture hoods/biosafety cabinets, vacuum pumps, or computers.

Incubators

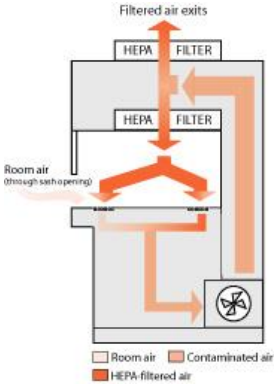
- Incubators consume between 1 and 10 kWh/day.
- Even on the low end, turning incubators off would be equivalent to reducing emissions associated with driving over 1000km; on the high end it's equivalent to half a home's worth of electricity use for the year.



Computers

- Putting computers to sleep can save up to $75 a year per computer!
- Limiting paper use and using paper with recycled content are two ways the lab can decrease their impact on forest resources
- Chlorine-free paper is an alternative that prevents harmful chemicals from negatively impacting aquatic environments.

Biosafety Cabinets / TC Hoods



- A tissue culture hood or biosafety cabinet can consume nearly 1400 kWh a year - the equivalent of driving over 3800 km in your car.
- **Avoid using UV lights to sterilize surfaces** in biosafety cabinets and tissue culture hoods, as the UV lights lose their intensity over time and become ineffective at sterilizing. Furthermore, UV light exposure is hazardous to scientists' health. Read more **here**.
- For more information, see our **BSC guide**!

Gloveboxes

- Employing best practices such as leak prevention, pump maintenance, shutting off the lights and coordinated antechamber use all will help the lab save energy and reduce waste related to glovebox use.

Vacuum Pumps

- A poorly maintained vacuum pump and/or improper use of a cold trap will eventually lead to pump failure and require a rebuild.
- If your pump usually runs 24/7, you could save the greenhouse gas emission equivalent of driving over 1,800 miles (or 2,900 kilometers) per year just by turning your pump off overnight.

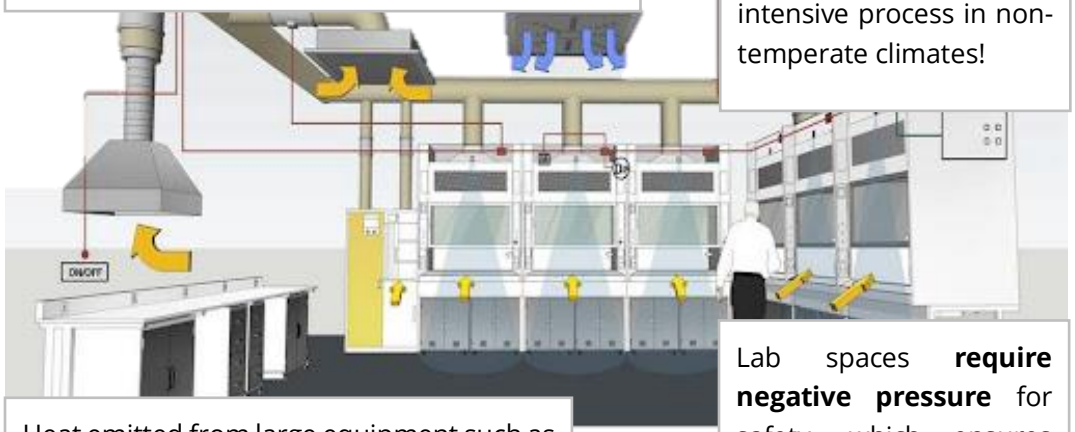
Infrastructure Energy

HVAC (Heating, Ventilation and Air Conditioning)

The air that moves through your laboratory, while invisible to the eye, is typically responsible for over 50% of the energy used by any lab building – that could be up to **10 million kWh/year,** or **as much as 850 homes**! Research spaces are heavily regulated by groups such as ANSI and ASHRAE in order to maintain safe environments, and therefore must conform to standards in ventilation and air conditioning. **Here are just some of the ways that labs use extra energy to move and condition air in ways that office spaces usually do not:**

The minimum rate for lab ventilation is generally **6 air changes per hour (ACH**) but can go as high as 20 or more. Talk to your organization to ensure your rates are correctly calibrated for your lab space – many will allow for **lower flows overnight/unoccupied, or in situations with fewer hazards present.**

In most labs, the air coming in must be **100% outside air,** meaning it must be heated/cooled, humidified and filtered before entering your space – a very energy intensive process in non-temperate climates!



Heat emitted from large equipment such as ULTs, ovens and more results in more air intake to maintain temperature in the lab space.

Lab spaces **require negative pressure** for safety, which ensures that the air will not flow into hallways in the event of a spill.

LIGHTING

Keeping our labs brightly lit can account from 8 to 25% of the energy used in your lab, depending on the bulb type:

- **Fluorescent -** Commonly seen in labs, these are usually the tubular lights in your ceiling, and produce 60-100 lumens per watt consumed. Compact Fluorescent (CFL) bulbs use fluorescent technology but are designed to fit in a standard bulb socket.
- **LED –** Light Emitting Diodes have been steadily growing in for decades, understandably since they use 75% less energy and last 25 times longer than their incandescent predecessors.
- **Incandescent and Halogen** bulbs are rarely seen in labs nowadays, due to the increasing popularity of more efficient bulb types.

One of the best ways to conserve energy in lighting is to **turn off overhead lights** when they aren't needed. As seen here, sunlight is by far our most efficient light source, and many activities in lab can be completed with **task lighting** or simply **ambient natural light.**

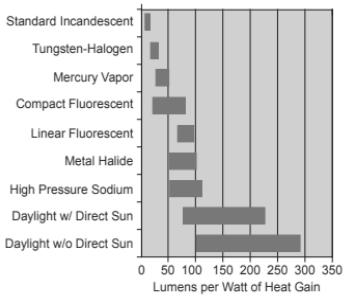


Figure 8. Luminous efficacy of various light sources.

Installing occupancy sensors in your lab can **control the lights, air change rates, and temperature when you're gone**– check out this SmartLabs case study at Emory University!

Travel

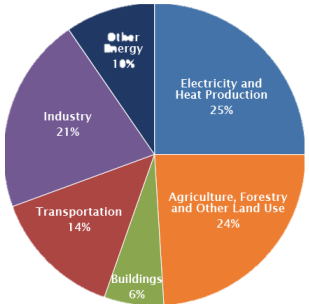
Travel, and more specifically road travel, is **one of the main sources of carbon dioxide (CO_2) emissions**. With CO_2 being one of the largest contributors to global warming, reducing travel-based CO_2 emissions is crucial in the fight against climate change.

Moving away from car travel toward alternative transportation options like walking, biking, and public transit is the best option to achieve the necessary reductions in emissions. Though travel may not affect how you work in the lab, it is an inextricable element of how you get to work as well as meet with and engage with the broader scientific community.

GLOBAL IMPACT OF TRAVEL

Road transport (cars, buses, taxis, etc.) accounts for 17% of global CO_2 emissions.

Flying accounts for 2.5% of global CO_2 emissions, and 12% of the United States' transportation-based CO_2 emissions



Global Greenhouse Gas Emissions by Economic Sector

UNDERSTANDING YOUR TRAVEL

A travel-focused carbon footprint calculator like this one can be used to first understand the impact of your own commute to work. You can then look for options that help lower the impact of your weekly commute.

Biking and Walking

Biking and walking **eliminate carbon emissions** and other pollution from your commute while also providing numerous health benefits. See these biking and walking to work guides for some helpful tips to get you started.

Public Transit

Public transportation is any bus, train, or other form of transportation that runs on a fixed route and is publicly available. Riding light rail produces 62% less carbon emissions per passenger mile while **buses produce 33% less carbon emissions**.

Teleconferencing/Videoconferencing

These technologies provide face-to-face meetings from our homes or workplaces. This **cuts down on flights** that otherwise would be contributing to CO_2 emissions. And while aviation's share of global carbon emissions aren't shockingly high, flying is still the most damaging form of travel for the climate.

Carpooling

Carpooling may not be as impactful as public transit, but it's a good option if access to other options is restricted. Carpooling reduces the number of vehicles on the road and the total number of miles traveled, which decreases emissions and improves air quality.