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Promoting Sustainability in Campus Laboratories

How can the University of Michigan Promote Sustainability and Foster Environmental Stewardship in Daily Lab Practices through Technological and Behavioral Change?

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Environ 391: Sustainability & Campus

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Executive Summary

The University of Michigan manages the largest annual research budget of any public university in the United States, totaling about $1.14 billion in 2010. A large portion of this budget goes towards laboratory operations, which can use up to five times more energy compared to a typical building. Therefore, as U-M moves towards a more sustainable campus, it is important for U-M labs to increase their sustainability efforts.

During the Winter 2011 semester, as a group project for Environment 391: Sustainability and the Campus, the Sustainable Labs Team investigated ways for laboratories to become more sustainable. Our goals were to create a lab sustainability recognition program, a user guide to sustainable behaviors, and to make recommendations to two specific labs on campus. The two labs we evaluated were the Lurie Nanofabrication Facility (LNF), a research lab, and the Undergraduate Science Building (USB), a teaching lab. The LNF is a 6,000 ft^2 facility, renovated in 2009, which uses solid-state electronics. The USB is a 14,000 ft^2 lab that was built in 2005. Both labs are fairly new and efficient compared to other labs on campus.

In order to investigate lab users' behaviors and attitudes towards sustainable initiatives in the lab, we created and administered a survey to LNF and USB lab users. We also interviewed lab managers and made observations from several lab tours in order to identify specific areas where the labs could improve their sustainability. Additionally, our team expanded the Green Laboratory Operations for Sustainability (GLOS) evaluation form, created by Planet Blue and the Office of Campus Sustainability, by adding new sustainability criteria, and by refining the ranking procedure by creating a point system. We then piloted the GLOS program in both the LNF and USB.

Our findings from the survey showed some discrepancies between the lab users' feelings towards sustainable lab practices and their actual behaviors regarding sustainability. For example, 62% and 53.6% of USB and LNF lab respondents, respectively, strongly agreed that it is very important to recycle or reuse all materials when possible. However, only 38% and 28.6% of USB and LNF lab respondents, respectively, always engage in such recycling behavior. Additionally, our survey results showed that most lab users are unaware of sustainable lab initiatives such as pollution prevention and the OSEH Chemical Reuse Program. From our interviews and tours, we identified several lab-specific recommendations for both the LNF and USB. Based on our GLOS pilots, the LNF scored an A+ and the USB scored an A-.

Based on our findings, we recommend several changes to both the LNF and USB. In the LNF, for example, motion-sensor lighting and solvent distillation units can be installed to reduce energy consumption and chemical waste. In the USB, we recommend encouraging lab users to shut fume hood sashes and sharing equipment among lab rooms. These recommendations suggest that both the LNF and USB are not completely sustainable, which is in contrast to their high GLOS scores. Therefore, we recommend improving the rating scale to better reflect the true sustainability levels of labs and running more GLOS pilots in various labs across campus. We further recommend implementing this program in all possible U-M labs, which can offer a means of comparison between labs on campus. To compliment the GLOS Recognition Program, and to bridge the gap between lab users' feelings about sustainable lab practices and their behaviors, we created A Guide to Sustainable Lab Behaviors, which should be distributed to lab users in all U-M labs during their orientation to the lab.

Goals

Our project is focused on creating a grading system and updating the current GLOS (the Green Laboratories Operations Sustainability) Recognition Program to examine the level of sustainability in U-M labs. The purpose of GLOS grading system is to help campus labs to gauge, compare, and improve their levels of sustainability. Additionally, our project aims to survey lab users in order to understand their work habits and attitudes regarding sustainability in labs. We also want to provide a guide for lab users to learn about and engage in everyday green lab behaviors. Our work in the Lurie Nanofabrication Facility and the Undergraduate Science Building will identify some specific technological and behavioral improvements that can be made.

Introduction/ Background

Established in 1817, the University of Michigan manages one of the largest annual collegiate research budgets of any public university in the United States, totaling about $1.14 billion in 2010[1]. While the increased budget for research has brought many renowned innovations, sustainability in U-M laboratories can still be improved. Large numbers of contaminants and exhaust devices, heat generating equipment, intensive ventilation requirements, 24-hour operational equipment, and limited green chemical substitutes all reduce the sustainability of U-M laboratories. More efforts are therefore needed to improve the current paradigms and sustainable lab policies to minimize energy and water use while reducing hazardous substances through green chemistry practices and effective solid waste minimization.

In helping to foster sustainability in U-M laboratories, a team from Environ 391: Sustainability and Campus collaborated with two sponsors - Jack Edelstein, the Energy Conservation Liaison for Planet Blue, and Dr. Sudhakar Reddy, the sustainability coordinator of the Office of Campus Sustainability (OCS) – to study the sustainability status of U-M labs and recommend what can be done on a daily basis to promote greener lab environments. Building on the work done by last year's Environ 391 group in the Lurie Nanofabrication Facility (LNF), we expanded our research to include a teaching lab, the Undergraduate Science Building (USB).

We created a set of survey questions to measure the students' sustainability behaviors and attitudes. Based on the survey results and the GLOS Recognition Program, we then recommend ways to improve sustainability in labs through four criteria: energy conservation, water conservation, waste minimization, and green chemistry practices. Acknowledging that the labs are built and equipped with high-tech equipment, our recommendations also focus on changing the behavior of the lab users. Through this project, we hope to help U-M lab users engage in environmental stewardship through sustainable lab practices.

Research Sites

Selection Criteria

For our project, we wanted to work with both a research and teaching lab on campus in order to evaluate both types of labs. For this reason, we chose to work with the LNF and USB based on the willingness of lab managers to participate in our project. However, these labs are both relatively new and efficient, which made it more difficult for us to understand the sustainability challenges of older labs on campus.

Lurie Nanofabrication Lab – Research Lab

Established in 2009, the LNF is 6,000 square foot lab operated by the U-M Solid State Electronics Laboratory, and includes a computer operating system that helps maximize the lab efficiency. The LNF consists of class 1000, 100 and 10 research lab rooms, which corresponds to particles per cubic meter[2]. The LNF operate 24 hours per day, seven days per week. The lab requires that all lab users wear lab coats, gloves, plastic shoe caps and hair nets before entering the lab in order to maintain optimal cleanliness.

Undergraduate Science Building – Teaching Lab

Stretching over 140,000 square feet; the USB accommodates teaching laboratories for the department of Molecular, Cellular and Developmental Biology. Constructed in 2005, the USB consists of more efficient technology than is found in some older labs such as the labs in the Chemistry Building[3]. Compared to the LNF, the USB is less energy and chemical intensive. However, it still produces considerable amounts of biological and solid waste that can be reduced through greener lab practices.

Methodology

For our methods, we used both primary and secondary research. For our primary research, we visited both the USB and the LNF to make on-site observations of lab equipment and user behavior. In addition, we interviewed lab managers and staff for details on how the labs function. To further our understanding of the behaviors of lab users, we designed a survey, which were delivered to both USB and LNF. The survey consists of three sections: attitudes vs. behaviors; awareness of sustainable initiatives; and current sustainability lab efforts as perceived by lab users. We targeted undergraduate students from biology 173 in the USB, and staff and students from LNF. Finally, we updated and expanded upon on the existing GLOS document provided by Planet Blue/OCS in order to form a recognition program. We developed a point system so that the labs can be graded for their engagement in sustainable initiatives. We piloted this recognition program in both labs.

For our secondary research, we carried out literature reviews on various sustainable lab practices in use by other universities. We focused specifically on green chemistry practices, energy conservation, water conservation, and waste management. Based on what

we learned, we were able to come up with a few recommendations. We also attended several talks on environmental practices and green chemistry as well as behavioral change. These talks provided us with some in depth knowledge on sustainability practices and green chemistry.

The information gathered from the literatures reviewed was then combined with the survey results to develop a guide to aid users to engage in sustainable lab behaviors.

Findings

Literature Review

To better understand current sustainable options for labs, our team conducted secondary research in four areas: energy conservation, green chemistry practices, water conservation, and waste management. We looked at the practices that our peer institutions are adopting to improve sustainability in these four areas.

Energy conservation

Fume hoods are one of the biggest resource hogs in lab setting. The resources required to maintain fume hoods are largely due to the regulations on a fixed minimal airflow through hoods. Conditioned air takes energy to heat and purify when being introduced into a clean lab setting, and cannot be reused elsewhere in the building. Also, electric motors running constantly use energy even when hoods are not being used. Installing a heat transfer system between the vented air from hoods and other ducts and incoming air would reduce energy required to heat fresh air[4]. A study done in the chemistry department at MIT was found to save an estimated $41,000 per year from sash closing behavior alone. Hoods equipped with variable speed electric motors could reduce the energy use while the sash is lowered and less suction is required[5].

Green Chemistry Practices

Students and teachers in the labs are often exposed to harmful odors and other associated hazards from chemicals. If misused, these hazardous chemicals can directly affect health. Therefore, we should substitute the hazardous chemicals with less hazardous ones whenever possible. The chemical substitution program such as the one in Yale and Harvard could help mitigate this[6]. Parts washers that employ petroleum distillate based on solvent or solvent distillation unit furthermore can help eliminate hazardous waste streams by recycling heavy liquids[8]. With short payback period (usually less than 1 year), the initial costs of installing solvent distillation unit and parts washers can be compensated easily. And when operated properly, they can save up to $5000 a year[7]. The execution of such programs and units will therefore earn its benefits both economically and environmentally.

Water Conservation

The largest source of water consumption in a lab is generally the water cooling systems. It has been shown that significant water reductions can be achieved if the water in cooling systems is recycled through the system many times instead of being discharged after a single pass through the system[9]. It was also found that improving water conservation

behavior in the lab can be achieved through increased awareness of sustainable water behavior and reminders for lab users in the form of labels, as well as providing lab users with feedback on the amount of water they have conserved by engaging in sustainable behavior[10].

Waste Management

Waste management is a complicated issue because it is subjected to heavy rules and regulations set by Environment Protection Agency and local authorities. At U-M, most of the lab wastes are managed and disposed by Hazardous Materials Management Program (HAMZAT) through Occupational Safety and Environmental Health (OSEH). OSEH has identified the waste generated by the laboratories as solid waste, chemical or liquid waste, radioactive waste and pathological waste. Different types of waste require different treatment methods or disposal processes[11].

LNF Findings

From our tour of the LNF lab with Nadine Wang, Lead Research Engineer and Sandrine Martin, the LNF User Services Supervisor, we learned that the LNF does not keep a record of the electricity and energy used in LNF. In addition, many of the same chemicals, materials, and lab tools are found in multiple places throughout the lab. Furthermore, from our interview with two LNF staff members, Leslie George and Robert Hower, we found that the LNF lab must be maintained at a high level of cleanliness, and this requires all ventilation, scrubbers and vacuums system to run 24/7, including holidays. The lights must always remain on due to some light-sensitive research. All chemical and hazardous waste in the lab is processed by OSEH. Therefore, the LNF is responsible for the amount of waste being generated but cannot control how the waste is processed. Also, none of the staff members we talked to were aware of the Green Chemistry Principles and the Chemical Re-use Program.

Here are some additional observations from the LNF lab:

- Most of the equipment is very efficient.
- It uses a huge amount of chemicals and energy.
- It is open 24/7 throughout the year.
- No motion sensors are installed in any of the equipment or the lighting throughout the lab.
- Several LCD monitors are operating on a 24/7 basis for advertisement and displaying purposes.
- No sashes are installed on any of the fume hoods.

From our GLOS grading scheme, LNF scored an A+ (97%). We found that they have implemented several sustainable lab initiatives, such as a battery recharge system, micro-scaling, and chemical substitution. Nevertheless, the LNF lost points for the followings:

- No motion-sensor lighting.
- Not re-using acetone for glassware cleaning.
- Not purchasing post-consumer products.

USB Findings

In the USB lab, the fume hoods were left running even though they were not being used. In addition, a full size refrigerator was placed beside a fume hood, making it inaccessible to lab users. The refrigerator was also empty except for one small item in the freezer section.

From our GLOS grading scheme, the USB lab scored an A- (84%). We found that the USB already participates in chemical sharing and the lab uses reverse osmosis to reclaim chemicals. The USB lost points for:

- Using a lot of aspirators.
- Not recycling light bulbs or glass.
- Not having sustainable alternatives for hazardous chemicals.

Survey Findings

We distributed our survey to a total of 78 people: 50 from the USB and 28 from the LNF. Part 1 of the survey focused on the lab users' thinking about some conventional lab practices. Part 2 of the survey measured how often users engage in these behaviors.

We found some discrepancies between the attitudes expressed in part 1 and the behaviors of lab users reported in part 2. For instance, in question 1(a), 62.0% of the USB survey respondents and 53.6% of the LNF survey respondents strongly agreed that it is very important to recycle or reuse all materials if possible. However, in question 2(a), only 38% of USB respondents and 28.6% of LNF respondents always engage in such recycling behavior. Additionally, in question 1(b), we found that over 80% of LNF lab respondents and 60% of USB lab respondents either agreed or strongly agreed that minimizing chemical use at the source is important. In question 2(b), however, only 4% of USB respondents and 17.9% of LNF respondents claimed that they always run small-scale experiments when possible.

Part 3 of our survey examined the lab users' awareness of the sustainable lab initiatives on campus. Additionally, it measured the amount of lab users who thought that tips on reducing hazardous chemical waste would be helpful. 84% and 89.3% of USB and LNF lab respondents, respectively, said that tips would be helpful. The next three survey questions showed that most of the respondents were unaware of pollution prevention initiatives, the OSEH Chemical Reuse Program, and the Twelve Principles of Green Chemistry developed by the "father of green chemistry", Paul Anastas and John Warner.

Part 4 examined the current sustainability efforts in the lab as perceived by the lab users. 30% and 39.3% of the USB and LNF respondents, respectively, rated the current sustainability efforts in their respective labs as average. 22% of USB respondents and 25% of LNF respondents had no opinion for this question. This is likely to be the result of the lab users being unaware of how to rate the sustainability efforts of the lab. Some comments we received stated that lab users were unaware of what their labs are doing to promote sustainability.

Recommendations:

General to all U-M laboratories

I. Green Laboratory Operations for Sustainability (GLOS) Recognition Program

The original checklist was mainly focused on determining what chemicals were being used and on identifying alternative ways to reduce chemical wastes. In order to consider a larger variety of sustainability aspects, we added the following to the existing GLOS document:

1. Pollution Prevention checklist
2. Purchasing/Inventory Control checklist
3. Energy Conservation category
4. Utilities Conservation category
5. Point system

For most sections, there is a list of possible ways to increase sustainability in the lab, and we assigned point values to these actions based on the overall impact the action could have in increasing sustainability of the lab. One of the main difficulties in creating a recognition program like this is that every lab is unique and certain items in the checklist may not be applicable to every lab. To make this recognition program fair and applicable for all labs, we standardized the results of the points. Instead of labs being graded solely on the number of points earned, labs will first be determined the number of total points that applies to that particular lab. Then, a percentage will be determined by taking the points earned by that lab and dividing it out of the total number of points that applies to that particular lab. Therefore, although our point system has a total of 120 points (with an opportunity for 10 extra points), most labs will probably not qualify for all 120 points, and their percentage will be based on a total of less than 120 points. By making the point system standardized, there is an opportunity in the future for labs to be compared to one another and an award system could potentially be set up for labs with the best rankings, similar to how LEED buildings can be certified as Silver, Gold, or Platinum based on how many points the building earned. The GLOS Recognition Program could also be used for competitions between labs if enough labs end up participating in this ranking system. Our hope is that the U-M will eventually adopt lab standards based on this program for all labs across campus.

We suggest that each lab on campus be evaluated using the GLOS Recognition Program periodically. Some of the points are determined based on improvement (e.g., how much waste has been reduced since the previous year), and reassessing labs would provide labs with an incentive to continually try to improve their sustainability. We further recommend that the GLOS is surveyed and verified by administrators from Planet Blue or OCS to avoid any possible subject to biases.

The costs of staffing an administrator to implement this recognition program include:

1. Time
2. Administrator salary

II. A Guide to Sustainable Lab Behaviors

As a compliment to the GLOS Recognition Program, our team has put together a Best Lab Practices user guide. Our recognition program has a strong technical focus and is intended for lab managers or administrators to fill out. We would not expect most lab users to be able to effectively use this checklist to improve their sustainable behavior in the lab. However, we recognize that behavior change by lab users is a very important aspect in increasing the sustainability lab practices. Following the results of survey, implementing this guide would bridge the gap between lab users' attitudes and actions that accrue due to lack of education and information on how to green their labs.

We recommend providing lab users (both students and staff) with the guide during their orientation to the lab. It is easier to influence behavior when a person is first developing that behavior than after a certain set of behaviors have already been established. If sustainable behaviors are introduced and encouraged from the beginning, therefore, they are more likely to be seen as the norm by new users, increasing the likelihood that the lab users will actually practice these behaviors. Furthermore, the guide should be re-emphasized during the GLOS survey time.

The costs of distribution this user guide includes:

1. Printing fees
2. Distribution space

Lurie Nanofabrication Facility

Considering the findings, we recommend that the LNF do the following:

1. Reuse personal protective equipments such as shoe covers, hair caps, and body suits whenever possible. By better use of personal cubbies, reuse can be achieved;
2. Turn off the LCD display monitors during periods of low activity to avoid unnecessary energy consumption;
3. Install motion sensors for lighting when there is no light-sensitive research being conducted, and for equipment that can be turned off;
4. Install solvent distillation units to reuse chemicals. The recaptured solvents can be reused by teaching labs possibly through OSEH's Chemical Reuse Program.

The costs of implementing the above recommendations include space for additional cubbies, installation costs for motion sensors as well as solvent distillation unit, and the actual retail costs. The motion sensors' installation cost ranges from $40~70 depending on the type. However, benefits after installation quickly outweigh the costs within a short payback period. More specific to the solvent distillation unit, it requires trained personnel to perform recycling processes and operation of processing equipment. Given that the payback period is almost always less than one year, however, the solvent distillation unit would be cost effective for long-term research where the same types of solvents are being used in a large amount. Under proper operation, the unit can save up to $5000 a year.

Undergraduate Science Building

Considering the findings, we recommend that the USB do the following:

1. Faculty and staff inform students to shut the fume hood sash when not in use. This would save up $41,000 per year and up to 50,000lbs of CO2 being generated through fume hoods;
2. Have a common refrigerator that can be shared among different labs instead of having a full-sized refrigerator in each lab. Considering that the use of refrigerators are fairly limited, this would be a meaningful and simple step;
3. Have a better room layout. The refrigerator right next to the fume hood should be relocated to allow access to the fume hood;
4. Include prompts such as stickers and posters that would act as reminders for students to engage in sustainable behaviors.

The costs of implementing the above recommendations include the costs of designing and printing prompts.

2. Recommendations for future work on this project

The next step for future groups will be analyzing the effectiveness of our GLOS Recognition Program through piloting more labs. As the recognition program reaches more labs, further inventory categories should be added and point systems updated, so that each lab will be graded strictly and fairly based on each lab's capabilities. We recommend that behavioral components be added to examine lab users' engagement in general sustainability. This behavioral section should be stressed first and foremost.

Another important step is to determine the effectiveness of A Guide to Sustainable Lab Behaviors. Surveying lab users on their opinions and consequent behavioral changes about this guide will provide information to improve upon the guide and make it more applicable to their lab practices.

The Chemistry Building and Biomedical Science Research Building use 4 to 5 times more energy per square foot compared to the typical non-research buildings. Given this data, we recommend that future group target these two facilities in furthering this project.

Barriers/ Obstacles:

The main barrier we had during this project was to communicate with administrators. Our two main approaches of communication – E-mail and telephone – were largely unsuccessful. This delayed our access to the USB tour. Consequently, we did not have enough time to observe the chemical storing, handling, and disposing processes. This limited our depth of knowledge and ability to provide chemical-based recommendations. After our sponsor contacted the administrator, however, we were able to conduct our survey and interviews.

Getting access to the LNF could have been time-consuming. We had to go through a lengthy process of testing and getting approval from lab directors. However, these were done in a timely manner. We organized several tours to the lab, which aided our understanding of how the lab processes. We did not experience other administrative barriers in dealing with the LNF.

We noticed that the LNF and USB labs are very new and technologically savvy labs. The highly specific equipments and devices in the LNF labs narrowed the amount of technical recommendations that we could offer. In addition, the presence of hazardous chemical substances restricted our recommendations due to the strict regulations the labs had to meet. Furthermore, the fume hoods in the LNF do not have sashes, thus limiting our behavioral recommendations.

In addition, the small sample size of our survey also imposed a problem for us. We had hoped for a more representative sample size that would equally demonstrate the view point of faculty, staff, and students. With a small sample size, some of our data analyses might be susceptible to bias.

Conclusion/ Lessons learned:

Over the course of this project, our team gained valuable knowledge about various methods to increase sustainability in laboratories. We have found that there are more practical opportunities for increasing sustainability through behavior change than through increasing technological efficiencies in state-of-the-art laboratories. Survey results also revealed that lab users believe more information would be helpful in removing perceived barriers and increasing competence for engaging in green behaviors. Both lab administrators and lab users are vital in creating sustainable labs. By introducing lab administrators to sustainable initiatives, we can help them incorporate Chemical Reuse Program and green purchasing practices. Additionally, educating lab users through a simple guide will help them engage in sustainable behaviors in daily lab practices. Finally, a standardized recognition program such as GLOS will provide incentives for U-M labs to continually strive for higher levels of sustainability. An annual point system provides tangible steps towards achieving increasingly better sustainability rankings. Overall, there are many opportunities to create sustainable labs on campus. And by taking the opportunities, we believe that the U-M will be an exemplar to other universities in the level of sustainability.

Acknowledgement

We would like to thank the following people for their support and guidance throughout our project.

- Professor Mike Shriberg and Laura Matson were our instructors for the course and provided vital organization and planning of this project.

- Dr. Sudhakar Reddy (OCS) and Dr. Jack Edlestein (Planet Blue) were our sponsors throughout the project. They helped us gain access to facilities and personnel required for our research. Additionally, they provided necessary advice and instruction for reaching our goals.

- Dr. Pilar Hererra-Fierro (LNF) and Nadine Wang (LNF) were crucial in our understanding of laboratory procedures in the LNF. They met with us various times throughout the semester to discuss our work in the LNF as well as to offer insights into our recommendations for the lab.

- Sandrine Martin (LNF) was key to our quick access into the LNF.

- Carrie Stevens (USB) and Dennis Drobeck (USB) helped us assess the USB labs for our recognition program, therefore furthering our understanding of USB processes.

- Leslie George (LNF) and Robert Hower (LNF) gave us an extensive tour of the LNF which revealed many of the behind the scenes activities.

- Special thanks to the Biology department, the department of Electrical Engineering and Computer Science, OSEH, Planet Blue and OCS for their continued support throughout the duration of this project.

Appendix A

Facts from Interviews with LNF lab managers/staff

- LNF is very strictly controlled: Temperature, humidity, ventilation must be carefully monitored.
- Some of the same chemicals are segregated in order to maintain its purity.
- LNF does not keep a record of the overall electricity of energy used every year.
- Acetone, Propane and Silicon are the most common chemicals being used in the LNF.
- Personal Protective Equipments are kept in cubbies to avoid cross-contamination.
- None of the fume hoods can be shut down.
- The lights must be turned on at all times due to the light-sensitive materials.
- Vacuum Vs Non-vacuum
  - All the LNF labs must be kept at extreme cleanliness – which means that all of the vacuums must run continuously 24/7 and the labs must operate under a positive pressure. Scrubbers must be turned on to purify air.
  - HEPA filers cannot be turned off no matter what.
- The current number of students/faculties that use the LNF labs are 300 (Expected to be 500).
- Cooling systems for air is crucial to maintain the right air temperature and humidity in the labs. Air needs to run through several boilers during the winter and through cooler during the summer to keep the optimum temperature. Machines that keep track of this optimum temperature consume a lot of energy.
- Chemical use in the building
  - Approx. 20,000 gallons of liquid nitrogen per month
  - A few hundred gallons of Acetone and IPA per month
  - Solvent waste that they generate per week equals 100 liters.
- Waste Management
  - All the chemical wastes generated from the labs are sent to OSEH, where incineration takes place.
  - Solvent Distillation Units were considered initially for recycling purposes. However, the systems had to be specific to the solvents being used and contaminants being removed. This, combined with the high initial cost, hold back the installation.
  - One possible way to reduce chemical wastes is to start using sprayers for soaking wafers instead of full chemical baths.
  - Some chemicals have organic materials and metals in them, making it harder to recycle
  - Bottles and plastics are being recycled through OSEH. They use approximately 50~100 bottles a week.
- LNF generates de-ionized water 24/7 – 30,000 gallons per day.
- The water cooling systems reuse the water in them (not once-through systems), every inst rument has its own cooling system

Appendix B

Survey Design

Promoting Sustainability in the U of M Laboratories

1.	**Gender**	Female Male
2.	**Age**	_____
3.	**Current Status**	UM Undergrad / UM Grad / Staff / Faculty / Non-UM Researcher
4.	**Major or Department at UM (if applicable)**	_____
5.	**How often do you visit/work in the lab?**	_____hours/week
6.	**Purpose of going to the lab**	Research Class Work Other
7.	**If the purpose of going to the lab is for a lab course – what course is it? (U of M only)**	Course name:_____
8.	**Which UM lab are you currently using?**	LNF USB

1. **How do you feel about promoting the following sustainable behaviors in your lab practices?**
(1-Disagree Strongly……3-Neutral……..…5-Agree Strongly…….X-No Opinion)

a.	I think it is important to recycle/reuse all materials possible	1	2	3	4	5	X
b.	I believe minimizing chemical use at source is important	1	2	3	4	5	X
c.	I believe in turning off appliances when not in use to save energy	1	2	3	4	5	X
d.	Sharing lab resources with other lab users contributes to waste reduction	1	2	3	4	5	X
e.	I believe turning off lights where possible is important to reduce energy use	1	2	3	4	5	X
f.	I think it is important to have eco-friendly equipment in the lab	1	2	3	4	5	X
g.	I am concerned about global climate change	1	2	3	4	5	X

2. **How often do you engage in the following behaviors?** (1-Never…3-Sometimes…5-Always…X-N/A)

a.	I recycle lab materials when appropriate	1	2	3	4	5	X
b.	I run small scale experiments first	1	2	3	4	5	X
c.	I power down machines when I'm finished working	1	2	3	4	5	X
d.	I dispose of chemicals in proper areas	1	2	3	4	5	X
e.	I try to reuse PPE whenever possible	1	2	3	4	5	X
f.	I try to use environmentally safe equipment	1	2	3	4	5	X
g.	I turn off the lights if I am the last one leaving the lab	Yes					No

3. **Do you think it would be helpful if U of M provided tips on reducing hazardous chemical use?** Yes No

4. **Are you aware of the pollution prevention initiatives in University labs?** Yes No

5. **Are you familiar with upcoming OSEH Chemical Reuse Program?** Yes No

6. **Have you been introduced to any of the Green Chemistry principles for best lab practices?** Yes No

1. **How would you rate the sustainability efforts in your lab?** 1 2 3 4 5 X

(1-Poor…3-Average…5-Excellent ….X-No Opinion)

***For USB users only:**

How often do you use the fume hoods while in the lab? 1 2 3 4 5 X

(1-Never… .3-Sometimes… 5-Always)

Suggestion/ Questions box

If you have any comments, please contact Olivia Kramer at oliviak@umich.edu or Sulgiye Park at sulgiye@umich.edu

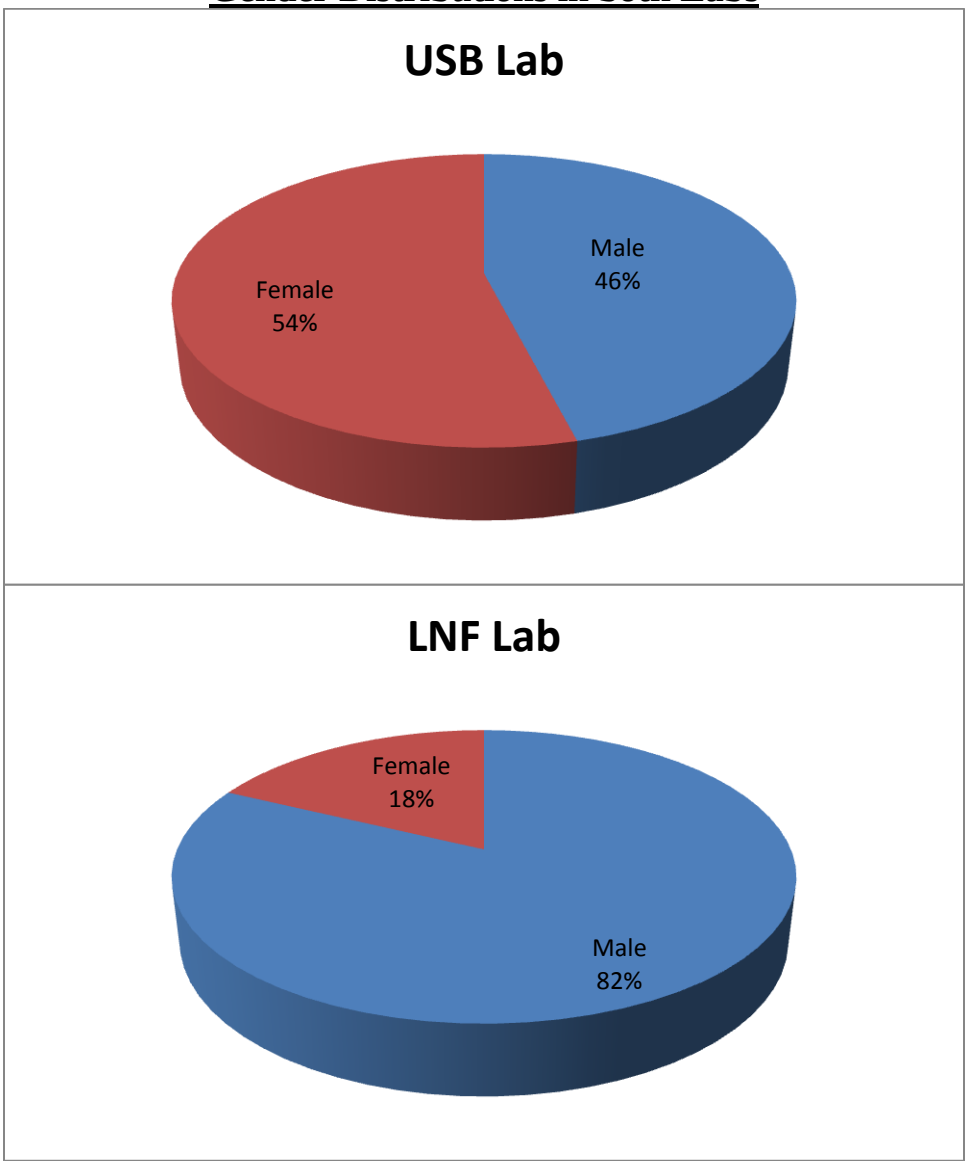
Thank you for your participation ☺

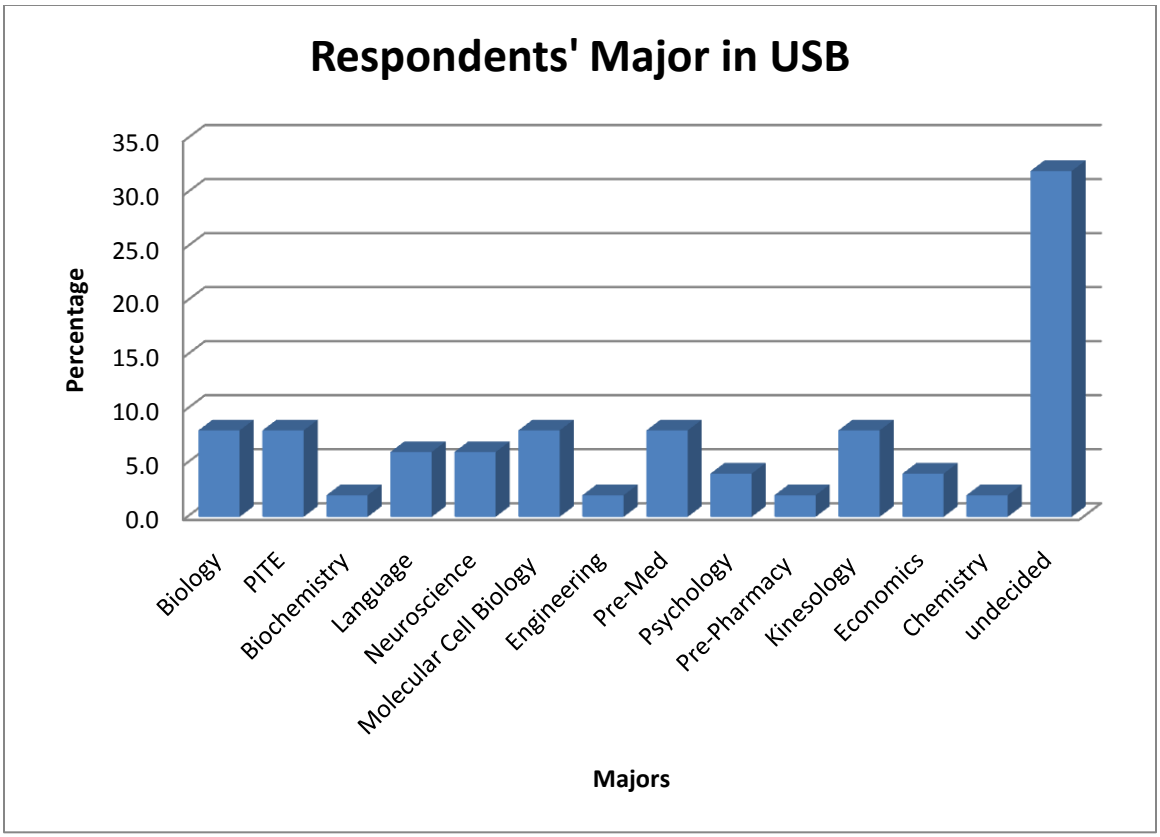
Appendix C

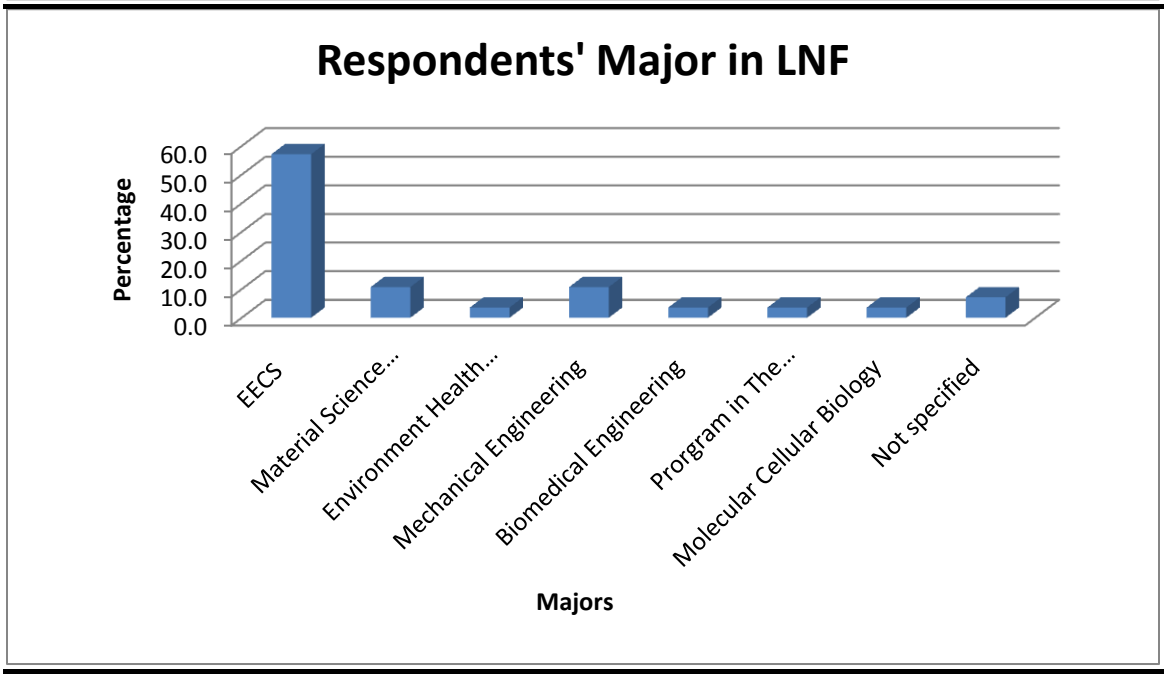
Survey results

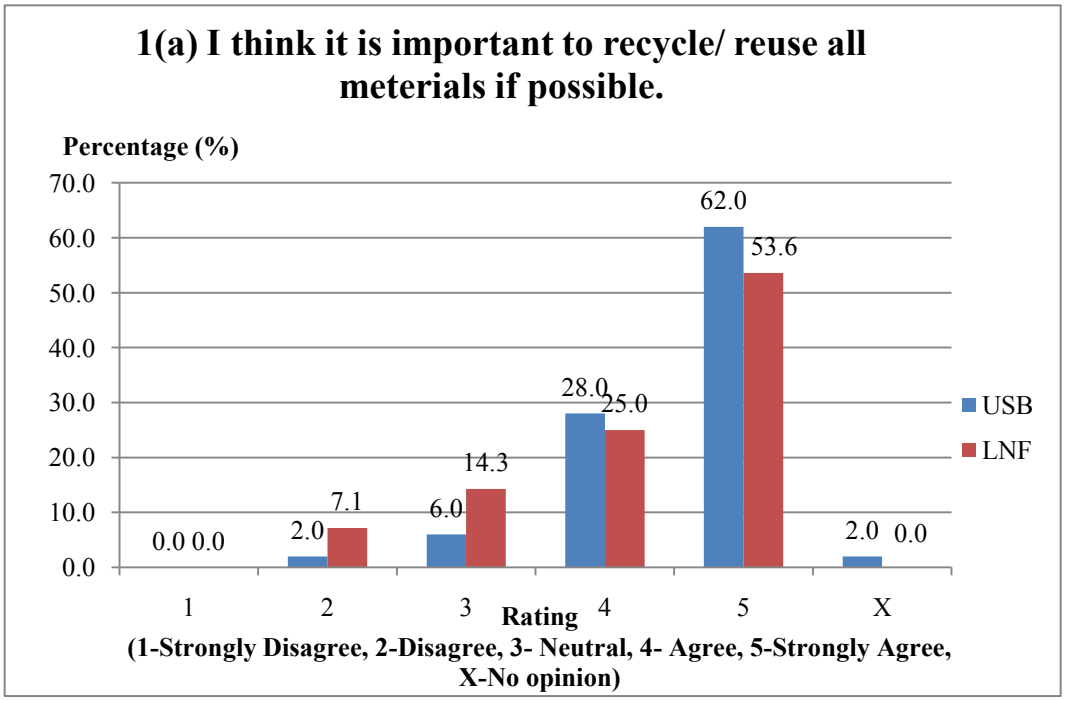
- **Total people surveyed: 78**
  - **USB: 50 Undergraduate**
    - Class: Biology 173 lab course
  - **LNF: 28 Grad, Staff, Non UM researcher**
    - Research, Work

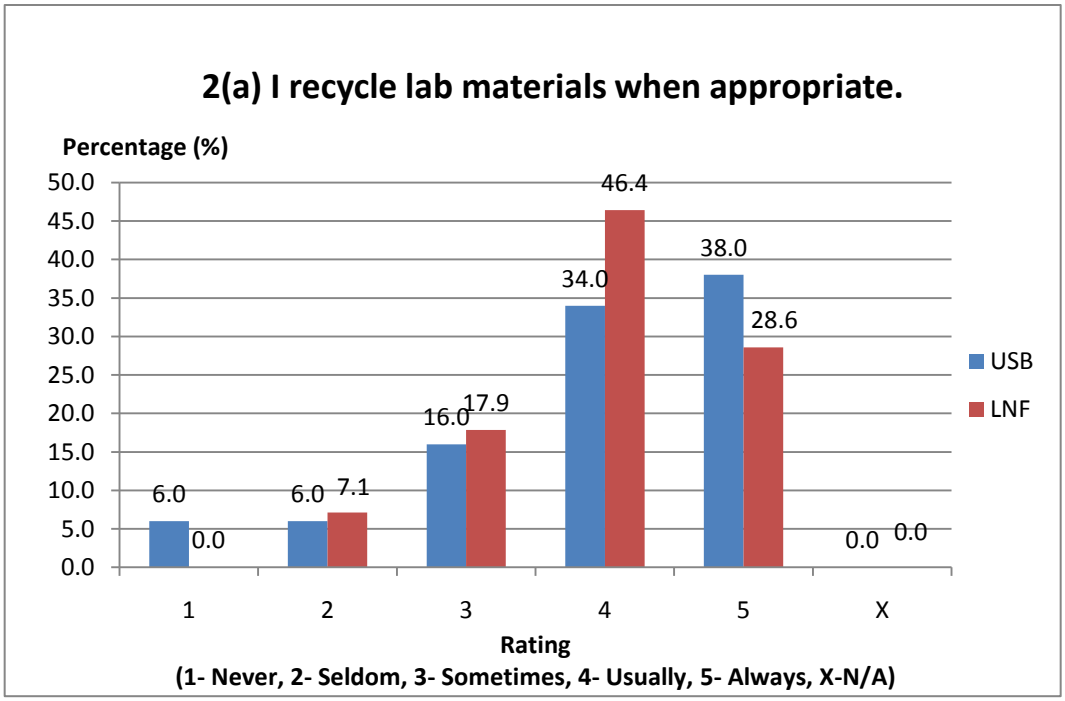
Gender Distributions in both Labs



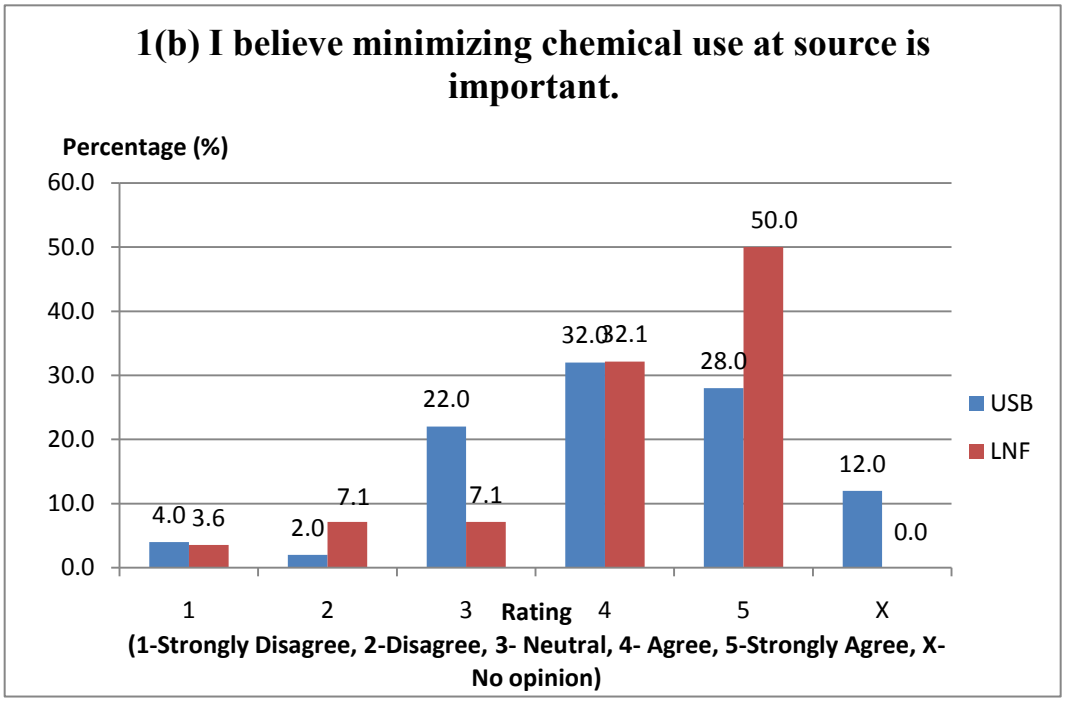

Respondents' Major in USB
Percentage
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Biology
PITE
Biochemistry
Language
Neuroscience
Molecular Cell Biology
Engineering
Pre-Med
Psychology
Pre-Pharmacy
Kinesology
Economics
Chemistry
undecided
Majors

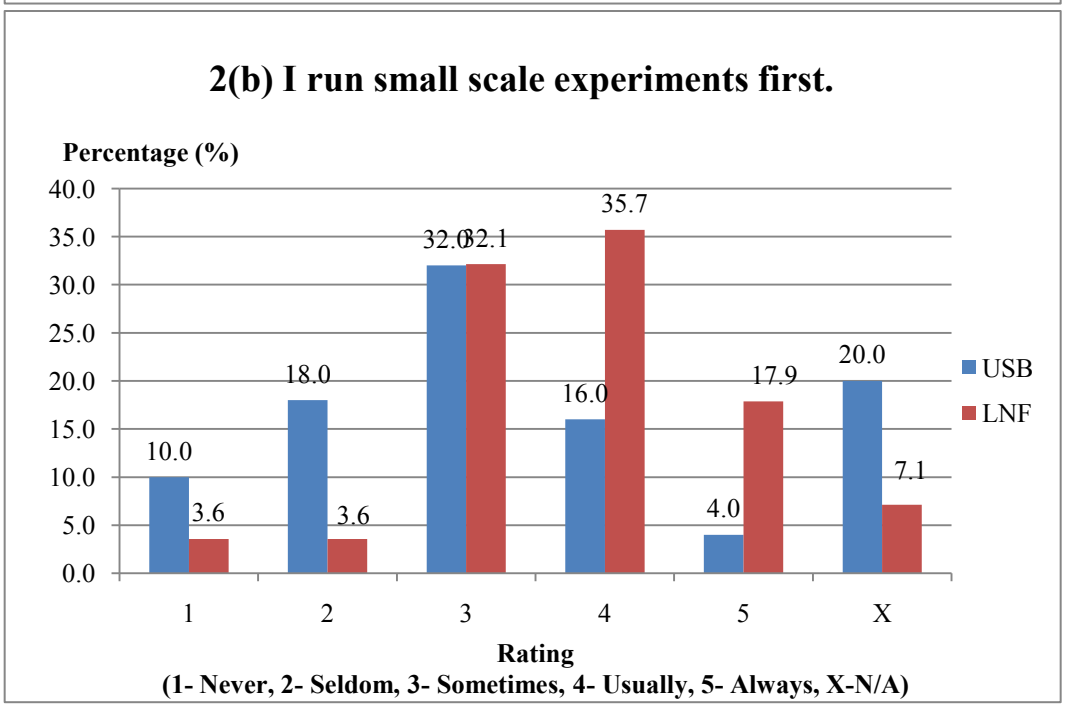

Respondents' Major in LNF
Percentage
60.0
50.0
40.0
30.0
20.0
10.0
0.0
EECS
Material Science...
Environment Health...
Mechanical Engineering
Biomedical Engineering
Prorgram in The...
Molecular Cellular Biology
Not specified
Majors



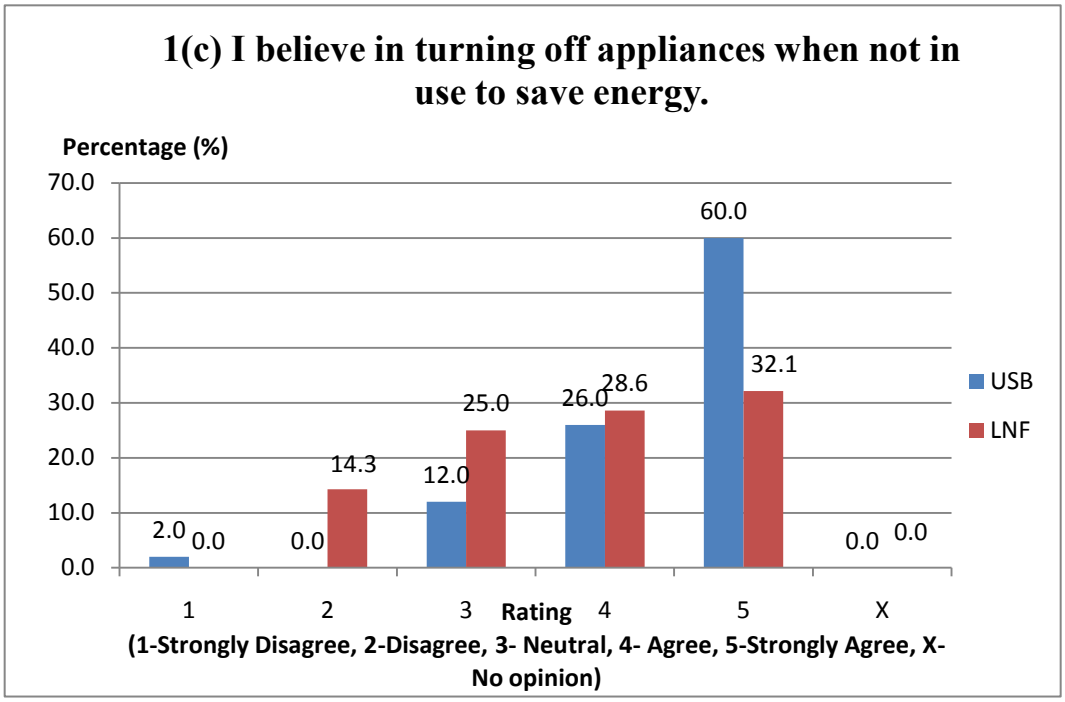


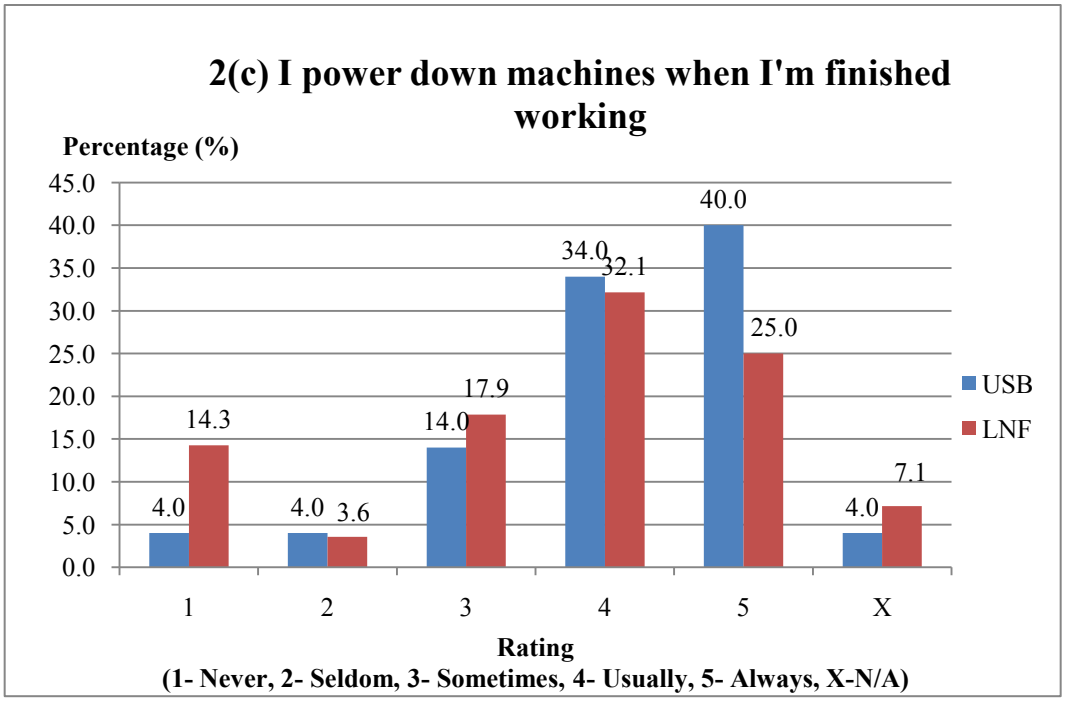
- For question 1A, over 50% of both LNF and USB lab users strongly agreed that recycling is important to them.
- The users were asked in question 2A if they did recycle whenever appropriate, and again the vast majority answered with either a 4 or a 5 (often or always).
- This indicates that recycling is an important aspect of lab behavior to lab users in both labs, and that there is a good opportunity to expand the recycling programs in both labs.
- Since most users already practice some sort of recycling, expanding the recycling program would most likely be an easy transition for the users to adapt to.



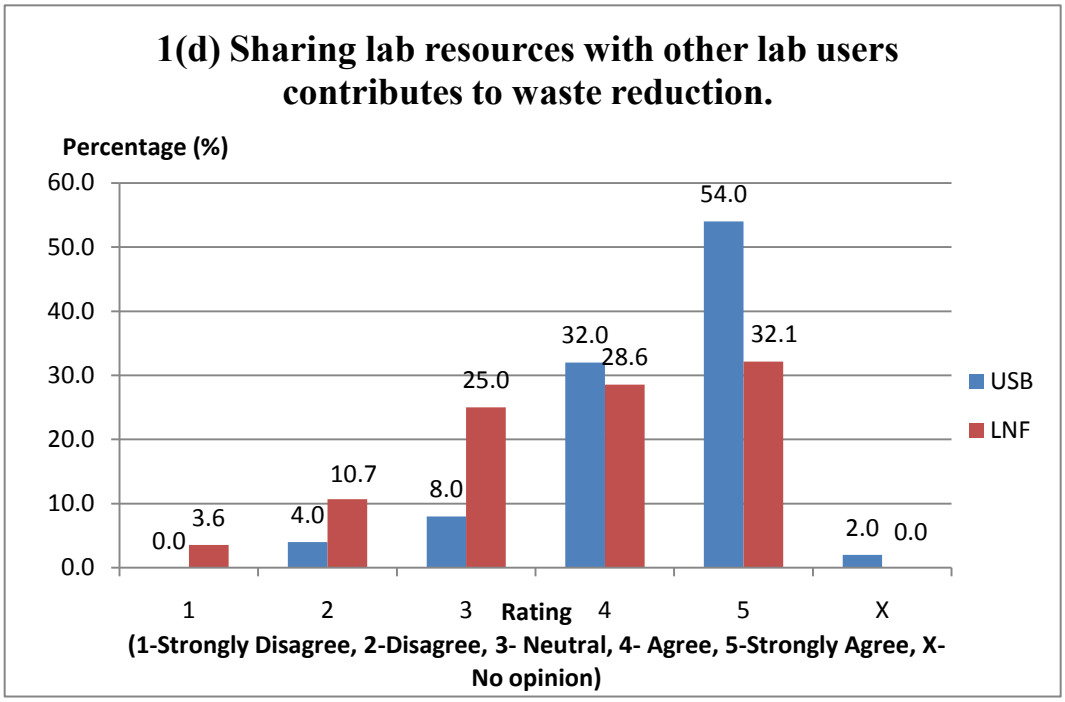


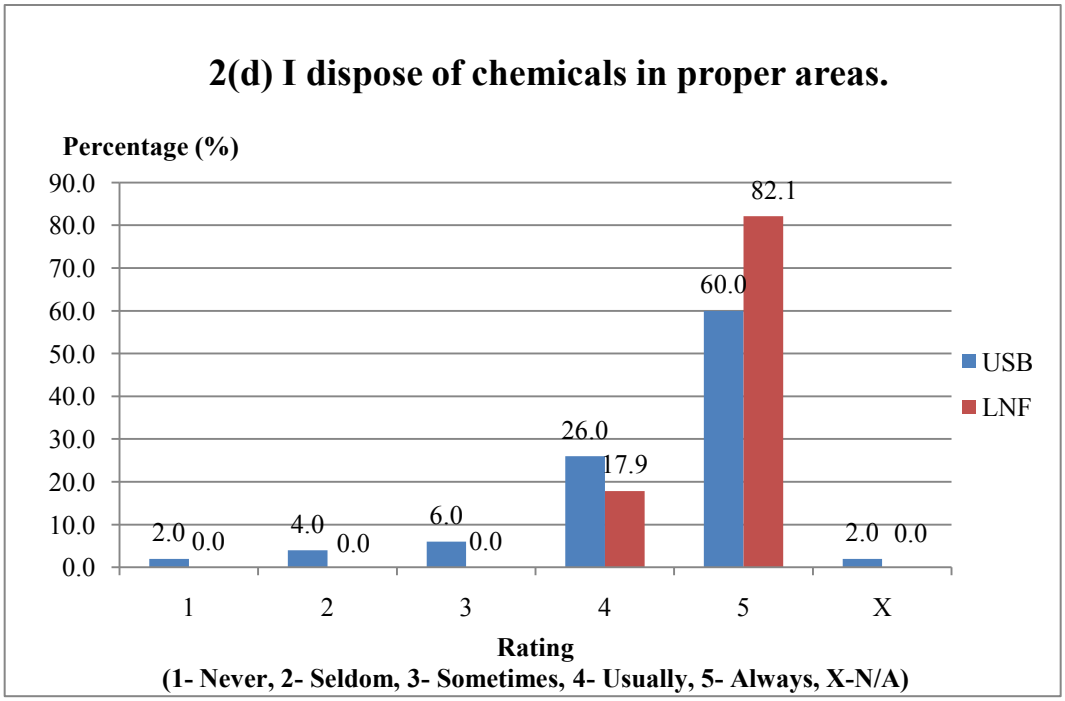
- In question 1(b), over 80% and 60% of LNF and USB lab users, respectively, either agreed or strongly agreed that minimizing chemical use at source is important.
- In question 2 (b), 53.6% of LNF users said that they did so often or always, but only 20% of USB users replied with often or always. Since the USB is a teaching lab, this might simply be a matter of the GSI teaching the lab using microscaling as much as possible. There is still an opportunity in the LNF to increase efforts of chemical reduction, and this might involve reinforcing this behavior more often, perhaps by using posters or stickers to remind users to micro-scale.



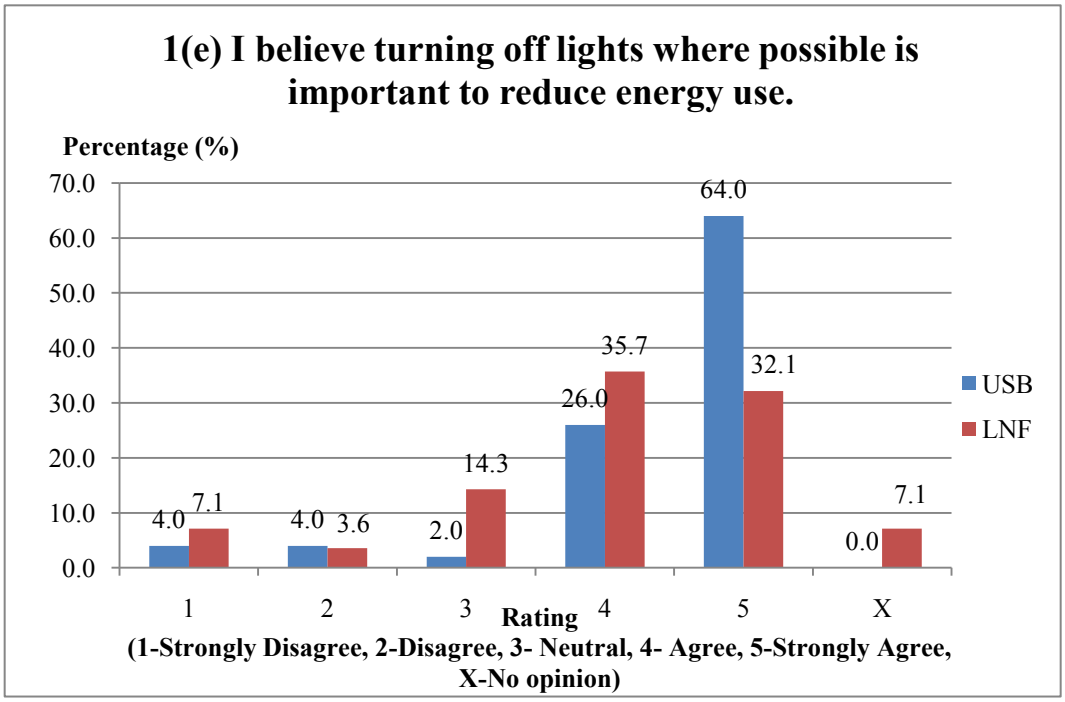


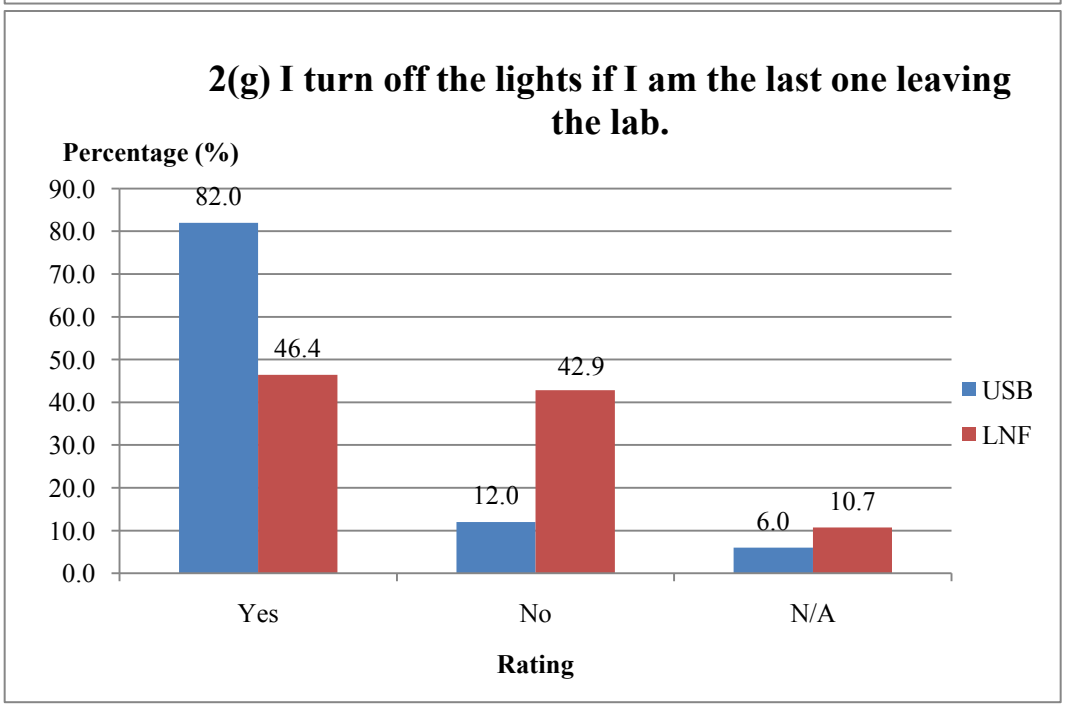
- In question 1(c), 80% and 60.7% of USB and LNF lab users, respectively, agreed or strongly agreed that turning off appliances when not in use is important.
- In question 2(c), only 40% and 25% of USB and LNF lab users, respectively, said that they always power down machines when finished working.
- In the LNF, we got the feedback of several users stating that in many cases in the LNF, equipment can take very long periods of time to power on (up to 24-48 hours, in some cases), and therefore powering down certain equipment is not actually more energy efficient and sometimes not possible. .





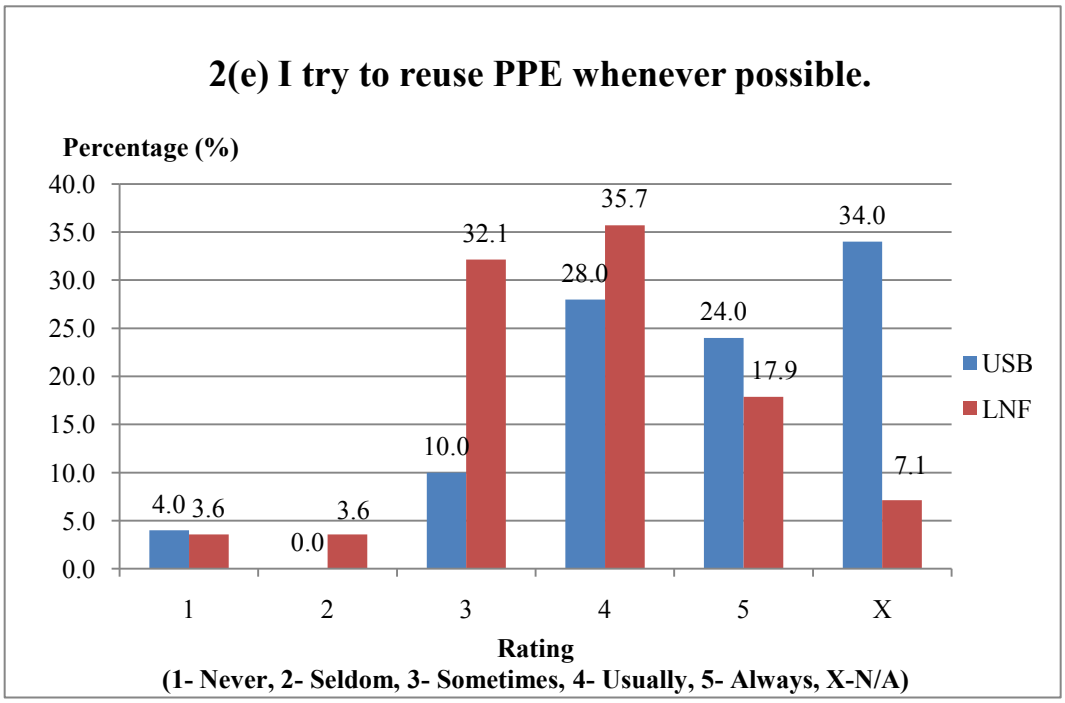
- In question 1(d), 86% and 60.7% of USB and LNF lab users, respectively, agreed or strongly agreed that sharing lab resources with other lab users contributes to waste reduction.
- In question 2(d), 60% and 82.1% of USB and LNF lab users, respectively, answered that they always dispose of chemicals in proper areas. This indicates more than half of lab users are already trying to dispose of chemicals in the best way possible. Therefore, the important next step would be to inform users on how to reduce chemical wastes at source.





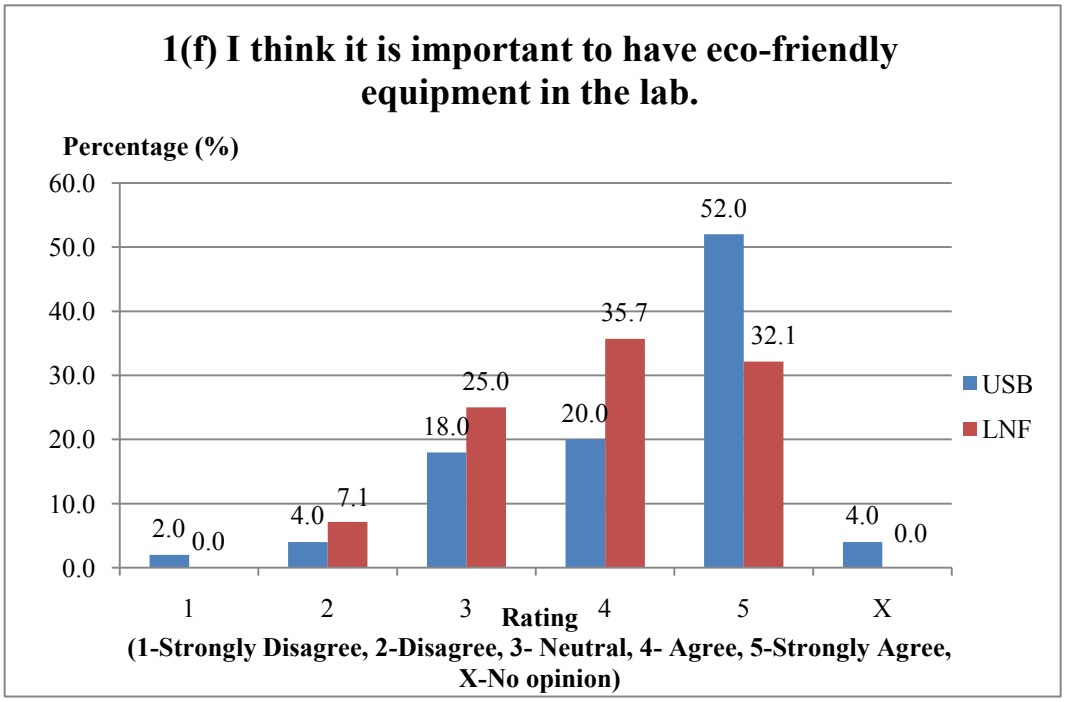
- In question 1(e), 90% and 67.8% of USB and LNF lab users, respectively, agreed or strongly agreed that turning off lights is important to reduce energy use.
- In question 2(g), 82% of USB lab users responded that they turn off the lights when they are the last one leaving the lab. However, only 46.4% of LNF lab users said that they engage in such action. Once again, we got some strong feedback from some LNF users that turning off the lights may not be the best way to increase sustainability in this particular lab. One reason is that the LNF is a 24-hour operational lab, and there always are users present in the lab. Turning off lights could therefore be a safety issue. Also, since the LNF has so much electrical

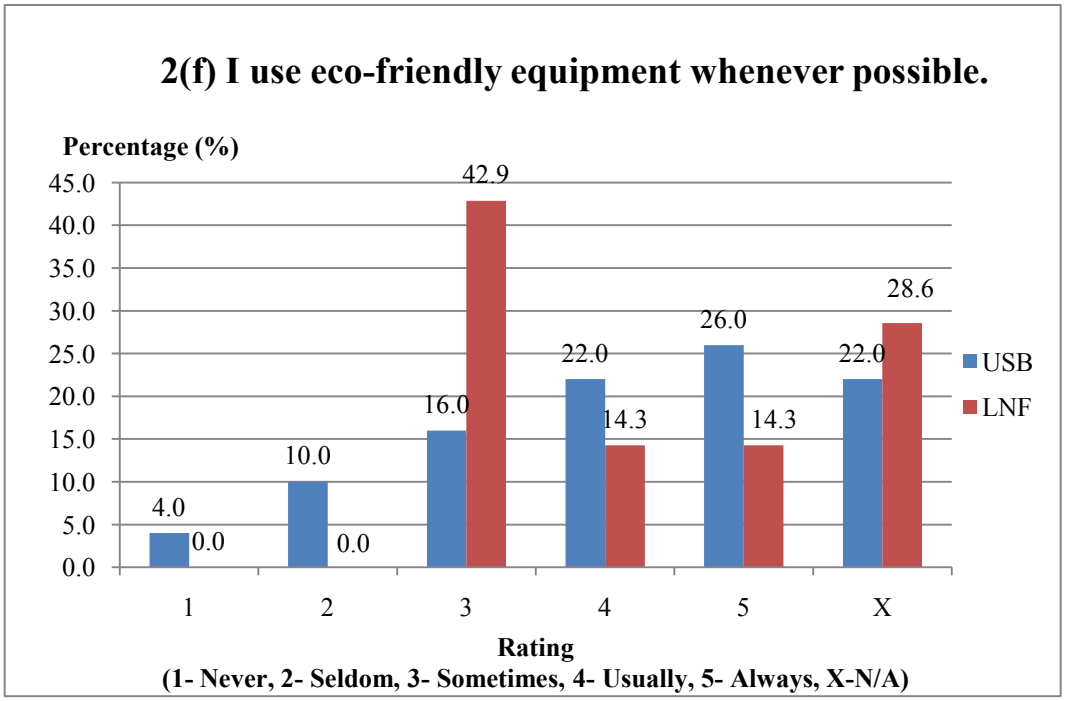
equipment, lights account for a very small portion of its total energy usage and therefore turning off lights would not have much of an impact on energy usage in the lab.



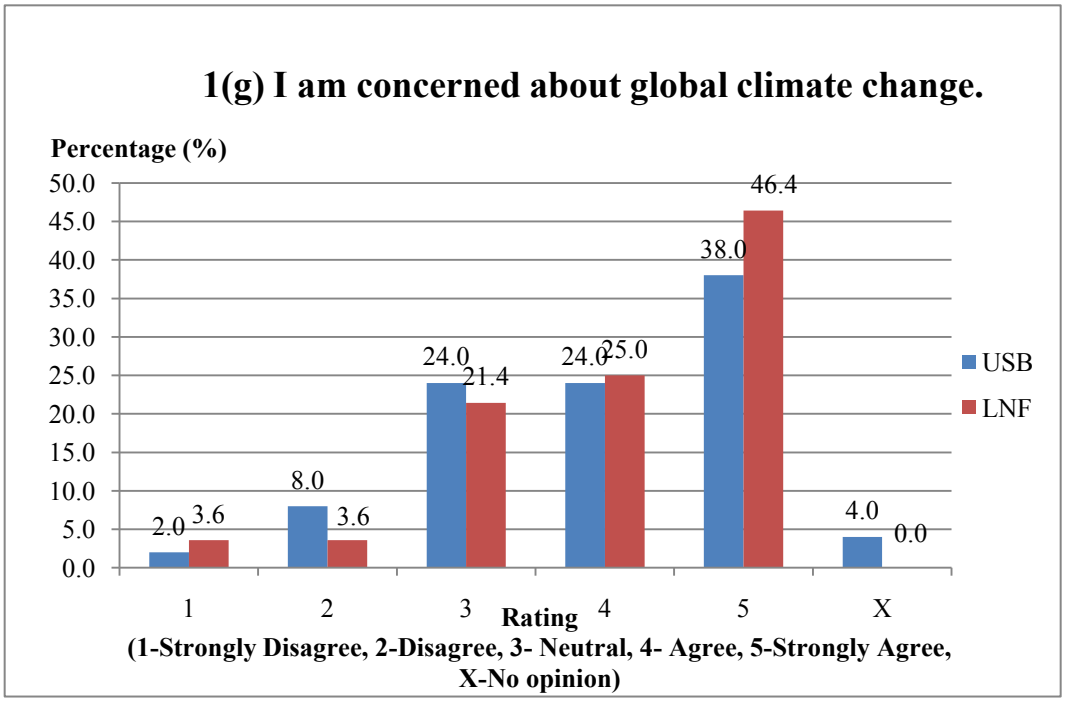
Question 2(e) asked users if they try to reuse PPE (Personal Protective Equipment) whenever possible.

- 52% of USB users said they do so either often or always, and 53.6% of LNF users answered either often or always.
- Both labs show a good opportunity to improve lab behavior in this area. PPE accounts for a large amount of solid waste being generated in labs.
- Especially in the LNF, where full body suits, boot covers, and hair nets are required, reusing PPE is very important in reducing solid waste.
- This equipment can be reused safely and easily, and it is mostly a matter of emphasizing the importance of this behavior to lab users.





- In question 1(f), 72% and 67.8% of USB and LNF lab users, respectively, agreed or strongly agreed that it is important to use eco-friendly equipment in the lab.
- In question 2(f), 48% of USB and 28.6% of LNF users answered that they often or always use eco-friendly equipment whenever possible.
- It is unclear if this low level of sustainable behavior is due to a lack of knowledge in the part of the lab users as to what equipment is actually eco-friendly, or if perhaps this type of equipment is simply not available in these labs.
- More information is needed to adequately address this type of behavior change in the lab.



Question 1(g) asked if lab users felt concern about global climate change.

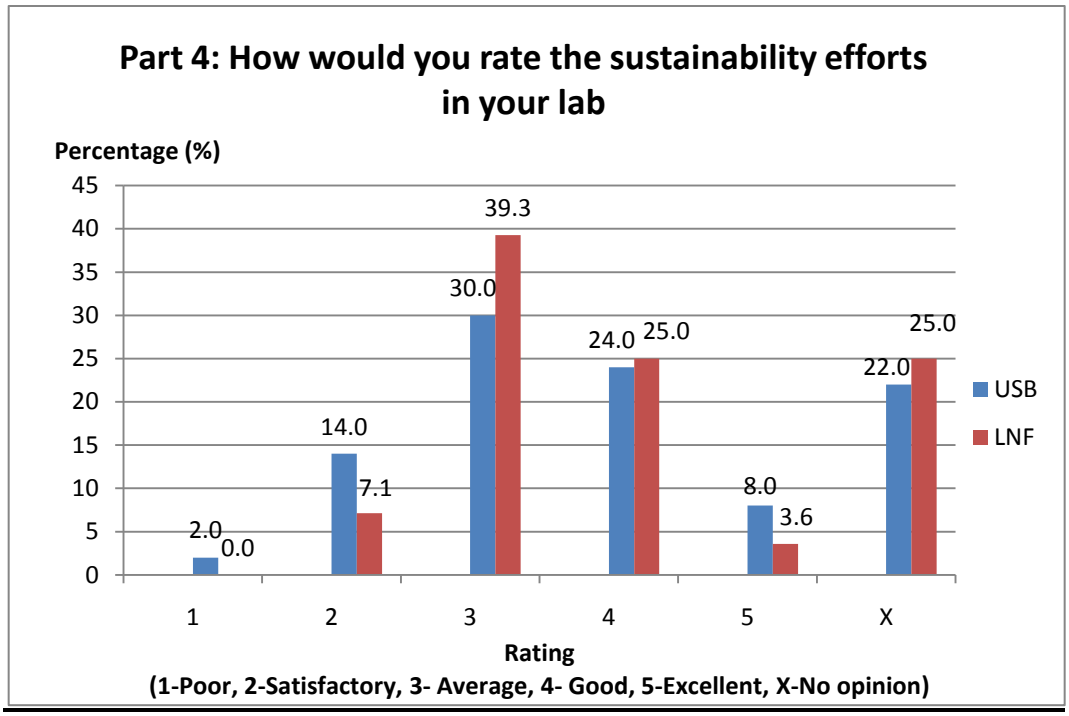
- 62% of USB users and 71.4% of LNF users either agreed or strongly agreed with this statement.
- This shows that climate change is generally an issue that lab users care about, and therefore promoting sustainable behavior change in the lab would likely be something lab users are interested in.

Part 3

Question	Yes		No	
	USB	LNF	USB	LNF
Do you think it would be helpful if UM provided tips on reducing hazardous chemical use?	84.0%	89.3%	16.0%	10.7%
Are you aware of the P2 initiatives in labs?	18.0%	39.3%	82.0%	60.7%
Are you familiar with upcoming OSEH Chemical Reuse Program?	16.0%	25.0%	84.0%	75.0%
Have you been introduced to any of the Green Chemistry Principles for best lab practices?	14.0%	17.9%	86.0%	82.1%

- From part 3, we found out that 84% and 89.3% of USB and LNF lab users, respectively, thought it would be helpful if U-M provided tips on reducing chemical use.
- The next portions of part 3 showed that the majority of lab users were not familiar with pollution prevention (P2) initiatives, OSEH Chemical Reuse Program, and Green Chemistry Principles.
- Those who were more aware of the U-M sustainable initiatives were the LNF lab users.
- The USB lab users, on the other hand, were mostly freshmen or sophomores, who are less familiar with the current U-M sustainability initiatives, which account for the lower percentage compared to that of the LNF.

Part 4



- When asked to grade the current sustainability efforts in the lab settings, at least 30% of lab users from both the LNF and USB gave the rating of average, which is most likely due to the lack of informed individuals on sustainable initiatives that the labs are engaged in.
- Surprising number of lab users also stated that they had no opinion, which is possibly due to the non-standardized definition of sustainability and system of grading.

Survey Respondents' Comments (From suggestion/question box)

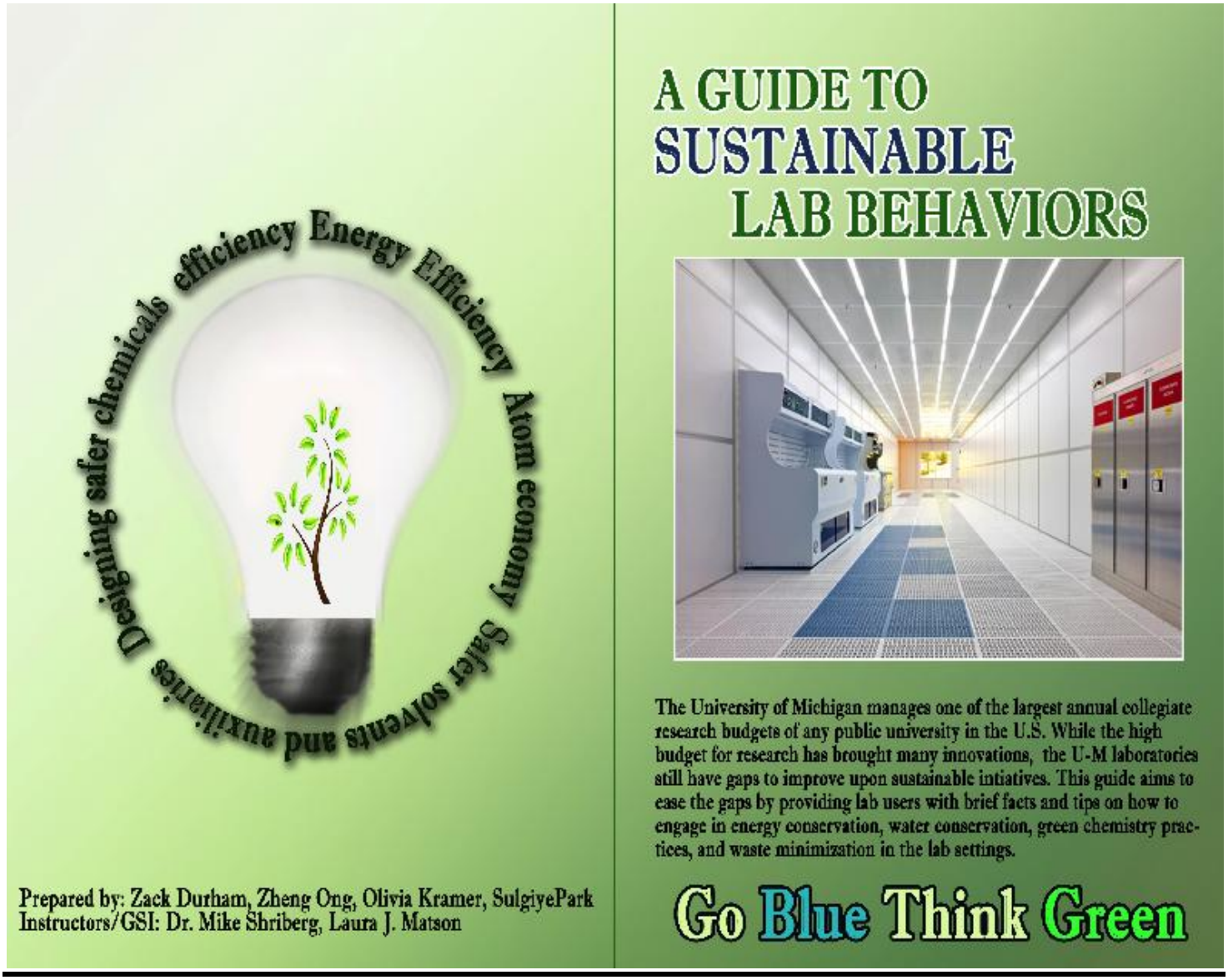
LNF respondents:

- "It sometimes takes more energy to restart appliances."
- "LNF should start cycling through various coveralls and booties."
- "Answered neutral to several questions due to feelings of being uninformed."
- "The electricity usage mostly includes the tools, not the lights, so lights are left on 24/7 for display purposes (turning them off would only save <5% of the bill). That's probably why LNF doesn't consider lights in sustainability programs."
- "I, absolutely, philosophically believe in improving sustainability and conservation. However, cleanliness and safety factors in many cases need to be primary considerations
- "Provide information to students about green initiatives."
- "Maybe at the beginning of the semester, there should be an overview of how to safely dispose of stuff and info about the benefits of cutting of the lights etc.
- "I have no idea on what are the sustainability efforts. Perhaps sharing more education on this would be helpful. Any green efforts, as long as they are safe, are great initiatives."

Appendix D

A Guide to Sustainable Lab Behaviors

***Note: The following pages are not in the order as it would appear in the form of the pamphlet.**



Green Chemistry Principles

Green Chemistry Principles refer to philosophy that encourages the design of processes that minimize the use and generation of hazardous substances.

* Anastas, P. T.; Warner, J. C.; Green Chemistry: Theory and Practice, Oxford University Press: New York, 1998, p.30.
By permission of Oxford University Press.

1. Prevention

It is better to prevent waste than to treat or clean up waste after it has been created.

2. Atom Economy

Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.

3. Less Hazardous Chemical Syntheses

Wherever practicable, synthetic methods should be designed to use and generate substances that possess little or no toxicity to human health and the environment.

4. Designing Safer Chemicals

Chemical products should be designed to effect their desired function while minimizing their toxicity.

5. Safer Solvents and Auxiliaries

The use of auxiliary substances (e.g., solvents, separation agents, etc.) should be made unnecessary wherever possible and innocuous when used.

4. Waste Minimization

Did you know...?

Waste management is a complicated issue because it is subjected to heavy rules and regulations set by the Environmental Protection Agency. At U-M, most of the lab wastes are managed and disposed by Hazardous Materials Management Program (HAMZAII) through Ocupational Safety and Environmental Health (OSEH). Concerning the complicated issue of waste management, the best way to engange in sustainability is to reduce wastes at source.

1. Check for recycling containers before trash
2. Set the printers to double-sided printing
3. Clean and re-use lab equipment/tools whenever possible
4. Purchase recycled products whenever possible
5. Recycle any possible used solvent(s)

3. Green Chemistry Practices

Did you know...?

Students and teachers in the labs are often exposed to harmful odors and other associated hazards from chemicals. If misused, these hazardous chemcials can directly affect health and environment. This is why we need green chemistry practices. Also known as sustainable chemistry, green chemistry seeks to reduce and prevent pollution at its source.

1. Try use minimal amount of chemical to reduce waste generation
2. Use computer stimulations to deduce the ideal reaction conditions
3. Share experimental resources
4. Be aware of OSEH's Chemical Reuse Program
5. Use less hazardous chemicals when options are available

6. Design for Energy Efficiency

Energy requirements of chemical processes should be recognized for their environmental and economic impacts and should be minimized. If possible, synthetic methods should be conducted at ambient temperature and pressure.

7. Use of Renewable Feedstocks

A raw material or feedstock should be renewable rather than depleting whenever technically and economically practicable.

8. Reduce Derivatives

Unnecessary derivatization (use of blocking groups, protection/ deprotection, temporaary modification of physical/chemical processes) should be minimized or avoided if possible, because such steps require additional reagents and can generate waste.

9. Catalysis

Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.

10. Design for Degradation

Chemical products should be designed so that at the end of their function they break down into innocuous degradation products and do not persist in the environment.

11. Real-time analysis for Pollution Prevention

Analytical methodologies need to be further developed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances.

12. Inherently Safer Chemistry for Accident Prevention

Substances and the form of a substance used in a chemical process should be chosen to minimize the potential for chemical accidents, including releases, explosions, and fires.

1. Energy Conservation

Did you know...?

Laboratories have unusually high plug loads compared to other commercial and institutional buildings. In fact, research labs consume 5-10 times more energy than a typical office building. Among others, fume hoods are one of the biggest resource hogs.

1. Close fume hood sash or set to lower setting when not in use
2. Turn off lights if you are the last one to leave the lab
3. Unplug or power down unused instruments whenever possible
4. Use the 'sleep mode' setings on computers and monitors
5. Consolidate materials in freezers and refrigerators to use less energy

2. Water Conservation

Did you know...?

The largest source of water consumption in a lab is the water cooling systems. Significant water reductions can be achieved if the water in cooling systems is recycled instead of being discarded after a single pass. A simple behavioral change can also contribute to help reduce water usage.

1. Turn off the tap when not in use
2. Turn off pipette washer/rinser as soon as pipettes are cleaned
3. Look for leaks and report them to get repaired

Appendix E

planet blue the sustainable difference	UNIVERSITY OF MICHIGAN OFFICE OF CAMPUS SUSTAINABILITY GUIDELINE	
Number 1	Green Laboratory Operations for Sustainability (GLOS) Recognition Program	
Date: April 14, 2011	Revision: 2	Page: 1 of 10

This guideline is issued by the Executive Director of the Office of Campus Sustainability (OCS) and will be periodically reviewed and updated. The mission of OCS is to promote sustainable campus operations in order to improve environmental quality, while seeking efficiencies that improve both the quality of the educational experience on campus and recognize efforts to positively impact the financial operations of the University. If there are any questions, please address them to the Executive Director of OCS.

SUMMARY: The Green Laboratory Operations for Sustainability (GLOS) Recognition Program is designed to promote sustainable operations in University of Michigan laboratories through the use of alternative chemicals, more efficient equipment, or procedures. While University laboratories are central to meeting the University's mission of world-class, leading edge research, they are also the largest generator of regulated wastes and consume significant amounts of energy and resources. This program is designed to reduce the amount of hazardous waste being generated, which will result in a cost savings and other lab operational efficiencies. Costs for stock chemicals should also be reduced, and the recognition received through this program may be beneficial during the application process for federal grants.

This recognition program introduces environmental best practices to the laboratory research and teaching community. Implementation of the program will result in the following improvements:

- Reduction or elimination of the use and generation of hazardous substances
- Reduction of waste products
- Increase in recycling
- Improved safety for laboratory faculty, staff, and students
- Reduced consumption of energy and water

The Sustainable Laboratory Practices Working Group -- comprised of members from the Office of Campus Sustainability (OCS) and the Hazardous Materials Management program of Occupational Safety and Environmental Health (OSEH), and of Planet Blue -- will partner with laboratory faculty and staff to evaluate current operations, seek ways to reduce hazardous substances, and identify areas for increased efficiencies. Under this program, the following lab practices will be evaluated:

- Source reduction
- Product substitution
- Purchasing

- Equipment
- Lights
- Ventilation
- Micro-scale analytical
- Reuse and recycling
- Neutralization
- Disposal

PROCEDURES: 1. Laboratory Assessment Team

During the assessment phase, the types of research, equipment used, protocol, waste streams generated, and any current pollution prevention initiatives in practice will be evaluated. Because each laboratory is unique, evaluations will be made on a case-by-case basis. The following team will be involved with the Assessment:

- Principle Investigator
- Lab Manager
- Sustainability Coordinator (if appointed by Lab Manager)
- Lab staff (as needed)
- OCS and OSEH staff

The OCS representative(s) will meet with the Principle Investigator and Lab Manager to discuss the program, answer any questions, and obtain approval to proceed with the Assessment. It is suggested that a Sustainability Coordinator be assigned to act as the main contact person during the Assessment phase, and to encourage participation from other laboratory staff. This role may be filled by the Lab Manager or another key staff member who is knowledgeable about the practices, equipment, and chemicals used in the laboratory.

The Sustainability Coordinator is also responsible for collecting signatures from at least 75% of laboratory personnel to indicate commitment to the program. This helps to ensure the success of the program goals by educating staff, and providing a more cooperative atmosphere dedicated to actions for sustainability.

2. Data Collection and Analysis

The OCS/OSEH team will visit the laboratory accompanied by the Lab Manager or Sustainability Coordinator to evaluate operations. The number of visits required will depend on the size and complexity of operations, but will typically be between 1-3 visits lasting 1-2 hours in length each.

The OCS/OSEH team will compile and analyze the data collected and make recommendations for more sustainable practices. The Sustainability Coordinator will work with the team in coordinating and implementing feasible recommendations.

3. Green Chemistry Recognition

Once the recommendations have been implemented by the laboratory, the facility will be formally recognized as a UM Sustainable Laboratory. The laboratory will be presented with a Certificate of Recognition and will be featured on the OCS web site. Laboratories may wish to use this recognition as one of their achievements when applying for grants.

ATTACHMENTS Green Laboratory Operations for Sustainability Assessment Form

GUIDELINE ISSUE DATES: Original November 20, 2010

UNIVERSITY OF MICHIGAN
OFFICE OF CAMPUS SUSTAINABILITY

planet blue
the sustainable difference

GREEN LABORATORY OPERATIONS FOR SUSTAINABILITY

Dept/Lab:	
Date:	Performed by:
Met with:	

Description of research, operations, equipment, techniques, etc.: _____
_____
_____
_____
_____
_____
_____
_____
_____

Waste Streams Generated (type, amount, frequency, costs):
_____
_____
_____

Are any of these waste streams present? (Top 15 Most Expensive)

☐ Explosives	☐ Mercury-Containing Solutions	☐ Halogenated Solvents
☐ Compressed gas cylinders	☐ DEA Controlled Substances	☐ Non-Halogenated Solvents
☐ Reactives	☐ Mercury Devices	☐ Act 451/121 Regulated Liquids
☐ Oxidizers	☐ Flammable Solvents	☐ Aqueous Acids/Bases
☐ Dioxin/Furans	☐ Heavy Metal Solutions	☐ Paint/Paint-related Materials

Has researcher identified any chemicals or processes that they would like alternatives for? If yes, explain:
_____
Points will be awarded depending on the amount of green chemistry alternatives they propose and implement (maximum up to 5 points)
_____

Pollution Prevention (P2) Initiatives at UM

Any previous or existing P2 initiatives in the lab?
_____
1 point will be awarded per initiative provided in the lab (up to 6 points)

Checklist	Status
Check for leaks	
Make sure lab users are correctly using equipment	
Make sure lab users are doing small-scale experiments	
Keeping track of waste stream sorting	
Make sure there are recycling bins in the lab	
Others	

Is P2 training provided? ☐ yes ☐ no _____

2 points will be awarded if P2 training is provided in the lab

Are any of the existing UM P2 initiatives underway in lab?

Chemical Redistribution:	Aware of program?	☐ yes ☐ no
	Participates in program?	☐ yes ☐ no

5 points will be awarded if the lab is actively participating in a redistribution program

Mercury Elimination – Have all mercury-containing devices been properly disposed? ☐ yes ☐ no

Properly dispose – meaning it is being recycled?

2 points will be awarded if the lab is engaged in the proper disposal of all mercury

Recycling of Universal Waste:	Bulbs?	☐ yes ☐ no
	Electronics?	☐ yes ☐ no
	Batteries?	☐ yes ☐ no
	Paper/Cardboard	☐ yes ☐ no
	Glass	☐ yes ☐ no

1 point will be awarded for each of the above 'yes' category

Are any of the following methods be implemented?

☐ Ethidium Bromide Waste Reduction
☐ Regeneration of De-staining Solution for Electrophoretic Gels
☐ Sample Preparation for Metals Analysis by Microwave Digestion
☐ Non-Radioactive System for Measuring Cell Proliferation
☐ Elimination of Mixed Waste from Northern Blot Washings
☐ Substitution of Non-Flammable Carbon Dioxide for Flammable Ether in Immobilization of Drosophila
☐ Elimination of Methanol in Western Blotting
☐ Automated DNA Sequencing
☐ Solid Phase Extraction (SPE) of PCBs & Pesticides from Water Matrix

One point will be awarded for each of the methods actually being implemented (up to 9 points)

PURCHASING/INVENTORY CONTROL

Department person responsible for chemical storage/stock rooms: _____

How are chemicals purchased within the department? _____

_____

Describe current method of maintaining inventory: _____

_____

Does the current program adequately prevent the generation of waste due to over-purchasing? ☐ yes ☐ no

2 points will be awarded for each of the methods in place to prevent over-purchasing (up to 10 points)

Checklist	Status
Take inventory before every order placed	
Chemicals are used in first-in, first-out order	
Chemicals are shared within a lab	
Chemicals are purchased in the smallest quantity possible	
Others	

Does vendor supply requested quantities? ☐ yes ☐ no

1 point will be awarded if the lab double-checks that vendor is supplying appropriate quantities

Does the current inventory system adequately prevent waste generation? ☐ yes ☐ no

3 points will be awarded if the lab has innovative inventory system that adequately prevents waste generation.

Comments/Suggestions: _____

SOURCE REDUCTION

Are gas cylinders, including lecture bottles, purchased from vendors who will accept the empty back?	☐ yes	☐ no
Are chemical derivatives avoided using blocking or protecting groups or any temporary modifications?	☐ yes	☐ no
If using high performance liquid chromatography (HPLC) are capillary or micro-pore columns used?	☐ yes	☐ no
Are containers of VOCs and other substances capped when not in use?	☐ yes	☐ no

1 point will be awarded for each of the 'yes' category

Comments/Suggestions: _____

_____

_____

MICRO-SCALING

Are experiments conducted using smaller ratios of chemicals? ☐ yes ☐ no
5 points will be awarded if the lab users are taught to use microscaling
Instrument methods use smaller chemical quantities than wet chemistry.
(chromatography, spectrophotometry, atomic absorption, NMR, X-ray diffraction) ☐ yes ☐ no
3 points will be awarded if the lab employs instrument methods

Comments/Suggestions: _____
_____
_____

CHEMICAL SUBSTITUTION

Are non-toxic or less-toxic chemicals available and used frequently? ☐ yes ☐ no
Are less-toxic water-based cleaners/degreasers available and used frequently? ☐ yes ☐ no
Are specialty detergents substituted for chromic/sulfuric acid for cleaning glassware? (Alconox, biodegradable surfactants, ultrasonic baths) ☐ yes ☐ no1
2 points will be awarded for each of the above 'yes' categories
What types of solvents are used, and are there substitutions? (refer to Solvent Alternatives Guide) ☐ yes ☐ no
2 points will be awarded if there are greener substitutions being used
_____
_____
Are many different solvents used for cleaning - if yes, can it be standardized? ☐ yes ☐ no
1 point will be awarded if the lab is using standardized solvents
Are alternatives to solvent extraction used? (Solid Phase Microextraction or Supercritical Fluid Extraction) ☐ yes ☐ no
1 point will be awarded if the lab is using alternatives to solvent extraction
Are stoichiometric reagents substituted with catalysts? (Catalysts are used in small amounts and can carry out a single reaction many times; stoichiometric reagents are used in excess and work only once.) ☐ yes ☐ no
1 point will be awarded if the lab has made efforts to substitute stoichiometric reagenets with catalysts
Are alternate chemical reaction conditions used? (Sonication, microwave digestion, etc.) ☐ yes ☐ no
1 point will be awarded if the lab is using alternative chemical reaction conditions?

Comments/Suggestions: _____
_____
_____

RECYCLING / REUSE / DISTILLATION

Can a distillation process be added so solvents can be extracted, cleaned and re-used? ☐ yes ☐ no
1point will be awarded if the lab has solvent distillation units, which are being used.
(1 point/unit) – maximum up to 5 points
Is acetone reused for cleaning glassware? ☐ yes ☐ no
3 points will be awarded if the lab is reusing acetone to clean glassware
Is laboratory glass and equipment cleaned and reused versus disposable materials when possible? ☐ yes ☐ no
1point will be awarded if the lab is cleaning and reusing glassware and equipment
Are supplies that contain post-consumer products purchased? ☐ yes ☐ no
1point will be awarded if the lab is engaged in purchasing post-consumer products. Another point will be awarded the lab is purchasing over 50% of their supplies from post-consumer products
Are you using Ultra HPLC (UHPLC) in your applications? ☐ yes ☐ no

1point will be awarded if the lab is using Ultra HPLC in the applications

Are you aware of SmartTrak to use in HPLC to recycle the eluent? ☐ yes ☐ no

1point will be awarded if the lab utilizes SmartTrack to use in HPLC to recycle the eluent

Have you considered alternate solvents to acetonitirle in you HPLC applications? ☐ yes ☐ no

1point will be awarded if the lab has alternate solvents to acetonitirle in its HPLC applications?

Comments/Suggestions: _____

_____

_____

TREATMENT (NOTE: Must work with OSEH on treatment protocol due to stringent regulatory requirements)

Are waste chemicals treated to reduce hazards/disposal costs? ☐ yes ☐ no

☐ Neutralization – Treating a corrosive material to a neutral state. RCRA regulated waste cannot be neutralized without a permit. Note, chromic acid and hydrofluoric acid cannot be sent to sanitary even after neutralization.

☐ Separation – separating two materials from each other by different techniques (i.e. straining, separating two insoluble materials that are different in density, etc.)

☐ Oxidation – Treating phenols with hydrogen peroxide and an iron catalyst

☐ Precipitation – Using sodium sulfide in a neutral state, aqueous solutions containing toxic metal ions can be precipitated as insoluble sulfides

☐ Mitigation – Mitigation of bromine in bromine/methanol solution to inorganic bromide salts to increase safety in handling

2 points will be awarded for each of the above methods being used

Comments/Suggestions: _____

_____

_____

ENERGY CONSERVATION

Did Planet Blue host an open house in your building ☐ yes ☐ no

Do you shut the sash of a chemical hood when not in use ☐ yes ☐ no

3 points will be awarded if the lab actively engages in shutting the sash when not in use

Do you disconnect the power to an instrument when not in use ☐ yes ☐ no

2 points will be awarded if instruments are unplugged whenever possible

Do you turn off computers when you go home ☐ yes ☐ no

1point will be awarded if all computers are turned off at the end of the day

Do you print on both sides ☐ yes ☐ no

1point will be awarded if all computers' default settings are set to double-side printing

*Comments/Suggestions:*_____

_____

_____

UTILITIES CONSERVATION

Eliminate water aspirators ☐ yes ☐ no

Eliminate single pass water systems ☐ yes ☐ no

Run washers/autoclaves only when full ☐ yes ☐ no

Check for leaks and drips periodically and get them fixed ☐ yes ☐ no

Install low-flow faucets ☐ yes ☐ no

Do you have motion sensors for lighting your lab ☐ yes ☐ no

2 points will be awarded for each of the above 'yes' categories

*Comments/Suggestions:*_____

_____
_____

DISPOSAL

Are waste streams segregated? ☐ yes ☐ no

☐ Separate hazardous from non-hazardous
☐ Separate organic waste from inorganic waste
☐ Separate chlorinated from non-chlorinated waste
☐ Separate radioactive from low level radioactive or non-radioactive
☐ Separate HPLC eluent into hazardous/non-hazardous waste

1 point will be awarded for each of the above method used

Comments/Suggestions: _____
_____
_____

MISCELLANEOUS

Can PBT's be eliminated or reduced? (aldrin/dieldrin, benzo(a)pyrene, chlordane, DDT, hexachlorobenzene, alkyl-lead, mercury and compounds, mirex, octachlorostyrene, PCBs, dioxins and furans, and toxaphene) ☐ yes ☐ no

1 point will be awarded for minimizing PBT's in the lab

Comments/Suggestions: _____
_____
_____

If the lab has shown reduction from previous year, extra points will be awarded depending on how much improvement was made

Percentage Improved	Points awarded
1-9	1
10-19	2
20 -39	3
40-69	4
70-100	5

Extra point will be awarded if the lab is engaging in innovative green practices (up to 5 points depending on what type of innovative green practices the lab proposes)
For Example

1. Using life-cycle analysis to promote water or waste conservation in the lab
2. Hosting sustainable lab events
3. Have posters/stickers in the lab to promote sustainable behaviors

Total point: 120
With extra points combined: 130
*** Not all the labs are applicable for the points i.e., some labs may not be using certain chemicals**

Score is based on percentage of points earned out of total points the lab is qualified for

A+	95 or above
A	85~94
A-	80~84
B+	75~79
B	65~74
B-	60~64
C+	55~59
C	45~54
C-	40~44
D+	35~39
D	25~34
D-	24 or below

Additional Comments/Suggestions

_____

_____

_____

_____

Office Use Only:

Score:_____

Subsequent visits necessary: ☐ yes ☐ no
Recommendations:_____
_____

Case: Approved/Pending

Closed on:

Literature Cited

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[11] "OSEH: Waste Minimization Programs." *U-M Occupational Safety & Environmental Health (OSEH)*. Web. 20 March 2011. <http://www.oseh.umich.edu/hazmats/waste-min.shtml>.

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