RIGHT RESEARCH

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MODELLING SUSTAINABLE RESEARCH PRACTICES IN THE ANTHROPOCENE

https://www.openbookpublishers.com

ISBN Paperback: 9781783749614
ISBN Hardback: 9781783749621
ISBN Digital (PDF): 9781783749638
ISBN Digital ebook (epub): 9781783749645
ISBN Digital ebook (mobi): 9781783749652
ISBN Digital (XML): 9781783749669
DOI: 10.11647/OBP.0213

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Cover design by Emilie St-Hilaire.

13. Asking Why

Cultivating Eco-Consciousness in Research Labs

Allison Paradise

Scientists question everything about the natural world. They work tirelessly in pursuit of understanding how and why the world behaves as it does. And yet, as a community, scientists rarely question their own behaviour in the lab. Equipment is often left on 24/7, protocols using hazardous chemicals remain unchanged for decades and freezers are filled with samples that haven't been used since the turn of the century. These behaviours become habits, passed down through the generations. The following chapter by Allison Paradise demonstrates how My Green Lab, a non-profit founded 'by scientists, for scientists' has helped to build a culture of sustainability by helping researchers see their behaviour in a new light. By encouraging people who work in labs to ask 'why', My Green Lab has been instrumental in changing the culture of scientific research. This approach has led to significant reductions in energy, water and waste in labs across North America. The laboratory sustainability movement in research has also inspired innovation in manufacturing, with laboratory product suppliers starting to design their products with sustainability in mind. This approach to sustainability—encouraging people to critically examine their behaviour and make conscious choices—is a model that could be replicated in any industry. As the work of My Green Lab demonstrates, if we want to enact lasting changes, we need to start by looking inward

 https://doi.org/10.11647/OBP.0213.20

and questioning our habits and behaviours. When we do this it can have a profound effect on ourselves and on our planet.

Introduction

The foundation of the non-profit My Green Lab was laid many years ago, when I was in high school, on the first day of my internship at a pharmaceutical company. Somehow, I was allowed to run an experiment on my own, and over the course of the day I used a lot of plastic, which ended up being piled on my bench because I couldn't find a recycling bin. I went up to the PI, who was in charge of the lab, and asked her where I could recycle all the plastic. She looked at me like I was crazy. We don't recycle here, she told me, all of that goes into the trash. Then it was my turn to look at her as if she was crazy. I couldn't understand why we couldn't recycle clean plastic. When I asked her why she simply told me the company policy was to incinerate all waste.

The conversation I had that day stayed with me as I continued to work in labs over the next decade. Every lab I worked in had its own way of doing things, and I was taught to follow their rules. As scientists, we are taught to think critically about everything—to question how things work and to push our understanding of the systems we study. Rarely do we turn that lens inward and question our own behaviour in the lab. Instead we accept certain principles as established and follow protocols because they are known to work. And while this allows us to focus our energy on the most pressing questions, the impact of following the rules in the lab can be significant. Labs discard an estimated twelve billion pounds of plastic annually, enough to cover an area twenty-three times the size of Manhattan, ankle-deep. They also use five to ten times more energy than office buildings, and four to ten times more water.

There are, in fact, many examples in our lives of things we do because of how we were raised, or what we were taught, that we rarely question. In the decade I spent as a neuroscientist, I adopted countless habits, routines and behaviours from my mentors and peers. Everything—from how I kept my notebook, to which chemicals I used, to how I operated the equipment in the lab—quickly became habits that I never

questioned. What we often don't realize is that these habits lead us to limit our choices, and often ourselves. Asking 'why?'—interrogating our own behaviour—allows us to uncover habits, routines and behaviours of which we were previously unaware. And once we are aware of them, we have the opportunity to choose something different. Choice is only possible when we are aware of our behaviour; everything else is automatic.

Knowing that the outsized consumption of laboratories is not a requirement of research, it is clear that to reduce the environmental impact of laboratories, we needed to break our habits. The non-profit organization My Green Lab was founded with the mission of creating a culture of sustainability through science. Our approach to our mission is unique. We work directly with scientists to interrogate their behaviour—to ask why and to uncover the assumptions underlying that behaviour. Then we work with them to explore different approaches and options that would best sustain themselves and their work. In other words, we make sustainability personal. This approach has led to significant reductions in energy, water and waste in labs around the world and has inspired innovation in manufacturing, with laboratory product suppliers starting to design their products with sustainability in mind.

Holistic Programming

To affect meaningful behaviour change in the lab, My Green Lab developed a number of programs that bring awareness to the environmental impacts of the laboratory and what can be done to minimize them. Together, My Green Lab's programs address environmental sustainability holistically, from products to behaviour, and from an individual scientist to an entire organization.

The broadest program, and one that encompasses elements of the other programs, is the Green Lab Certification program. This program recognizes scientists for the actions they are currently taking to reduce the environmental impact of their lab and provides recommendations for improvement.

My Green Lab has also developed two programs to affect changes in product design and purchasing decisions. The first is the Center for Energy Efficient Laboratories (CEEL), which is a collaboration

between My Green Lab, kW Engineering and Frontier Energy. The CEEL works closely with utility companies and the Environmental Protection Agency (EPA) to identify energy-efficient laboratory products, which utility companies can then incentivize by establishing rebate programs.

ACT is the other program that has been developed to reduce the environmental impact of purchasing laboratory products. ACT, which stands for accountability, consistency and transparency, is the world's first eco-label for laboratory products. The ACT label provides critical information about the manufacturing, use and end-of-life impact of a product and its packaging. ACT labels are meant to be used like nutrition labels to compare products on the basis of their impact, allowing scientists and procurement specialists to make safer, more informed choices.

These programs are designed to help people interrogate their behaviour and create a culture of sustainability. This article will go into more detail on the development, implementation and impact of these three programs. Each section will include information on the market's receptivity to the programs and how they have been shaped—and are continually shaped—by new technology.

Green Lab Certification

The recent emergence of a green movement focusing exclusively on laboratories has illuminated many opportunities for energy and water savings as well as waste reduction in labs. Championed by a coalition of scientists, facility managers, engineers, designers, sustainability directors and non-profits, the movement seeks to institutionalize sustainability in laboratories through the adoption of Green Lab programs. These programs have reached a wide variety of spaces, from university research and teaching labs, to biotech, manufacturing and hospital (clinical) labs.

My Green Lab is at the forefront of the Green Lab movement. My Green Lab developed the first-ever standard for laboratory sustainability best practices through the Green Lab Certification program.[1] Designed

1 https://www.mygreenlab.org/green-lab-certification.html

for individual labs, the certification program recognizes labs for existing safe, sustainable practices and encourages them to explore new ways to reduce their environmental impact.

Development

When My Green Lab was founded in 2013, there were fewer than ten campuses in the United States that had developed a set of recommendations for lab sustainability. The most comprehensive list was developed by Allen Doyle (formerly of the University of California, Davis) and Katie Maynard (University of California, Santa Barbara). Other universities, such as Duke, the University of Pennsylvania and Dartmouth, and companies, such as Genentech, had also developed their own sustainability standards for their labs.

To create a more universal standard for laboratory sustainability, My Green Lab gathered a group of scientists, sustainability professionals and safety officers from organizations with existing green lab programs to review existing best practices for laboratory sustainability. Led by My Green Lab, the group met bi-weekly for four months, questioning and discussing each recommendation, changing the wording as needed, and adding additional best practices whenever necessary. The result was a ~130 question assessment survey that covered eleven topics within the four main areas of energy, water, waste and chemistry. This assessment was intended to be used to evaluate existing practices in labs and to identify opportunities for more sustainable actions.

The new Green Lab Certification Assessment was beta-tested at the University of California, Los Angeles. Thirty labs participated in the pilot, providing feedback on the wording of the questions, the layout, and the overall impact of going through the process of completing the assessment. Their feedback was incorporated into the final Green Lab Certification Assessment, which became available on My Green Lab's website in June 2014. The Green Lab Certification Assessment has since undergone a series of updates and revisions to accommodate industry trends, new technology, and valuable feedback from scientists and industry experts. It is now ~180 questions and covers fourteen topics.

How the Program Works

In order for a lab to be certified, the lab or the organization first appoints someone to lead the program, also known as a Green Lab champion. The champion coordinates all sustainability related efforts in the lab by developing a roadmap for the lab. The champion assigns tasks to other lab members and hosts check-ins to track the lab's progress. Additionally, the champion is the point of contact to relay any roadblocks and/or successes to the organization during the implementation of the program. A meeting is then held with the lab to explain how the certification process works and the steps necessary to become a certified lab. At least half of the scientists in the lab must then complete the Green Lab Certification Assessment online, answering questions related to water, energy, waste, green chemistry, resource management and other key topics.

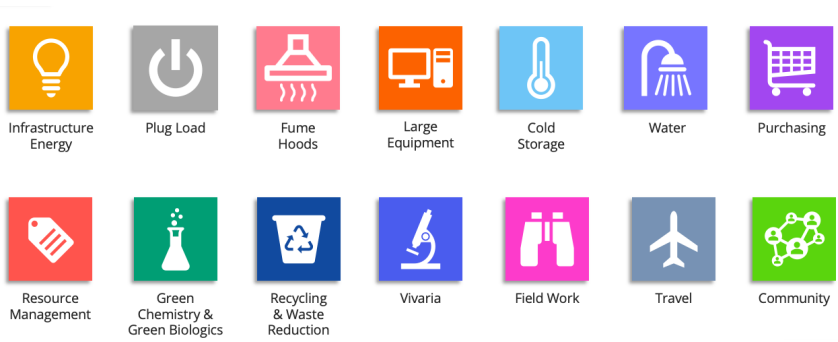

Fig. 1 Green Lab certification topics.

My Green Lab compiles the individual responses from the lab and scores the individual questions and topics to develop a baseline. The baseline identifies both green lab best practices already adopted by the lab, and opportunities for change. My Green Lab shares case studies and strategies for implementing best practices to give the lab a starting point in greening their lab.

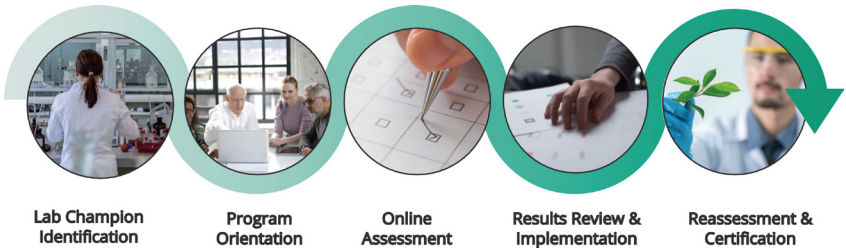

Fig. 2 Green Lab certification steps.

Once the assessments have been evaluated, a meeting is scheduled with the whole lab to present the results and discuss opportunities for improvement. The benefit of this approach is that everyone in the lab is able to see where they are already implementing best practices and where there is an opportunity for improvement based on the scores for each section. The results presentation can be very powerful for labs, particularly for labs that do not discuss these topics in lab meetings and have no guidelines for sustainable best practices. It is often inspiring for lab members to learn that their peers have switched to a greener solvent or have taken the time to turn off the lights every night or bring their paper recycling to the bin in the hallway. During these discussions we also encourage labs to ask themselves why they are doing things the way that they are doing them, and to consider choosing an alternative approach. In fact, many labs make decisions to change their standard operating procedures during this meeting.

After the results presentation, labs are given the opportunity to improve their score over a period of six to eight months. During this time labs may choose to change protocols, introduce signage or training, work their organization to understand current programs and capabilities. Whatever the lab decides to do, they become more aware of where environmental impacts exist in the lab and what they can do to minimize them.

When the lab is ready, they re-take the online assessment and My Green Lab again compiles the individual answers to create scores for the individual questions and topics. The topic scores are also accumulated into an overall assessment score that determines the certification level. By breaking the certification process into steps, the lab is encouraged to discuss impacts and make changes from the outset, which ensures

that the culture of the lab is changed through this process. Continuous improvement is built into the program as labs receive a new set of recommendations each time they take the assessment, and when those recommendations are implemented, the lab is eligible to be certified at a higher level.

Estimated savings from this outreach activity are calculated based on the implementation of the recommendations. For example, a lab that does not currently turn off a water bath overnight might be encouraged to turn it off. When this recommendation is implemented, the savings from turning off the water bath are attributed to the Green Lab program.

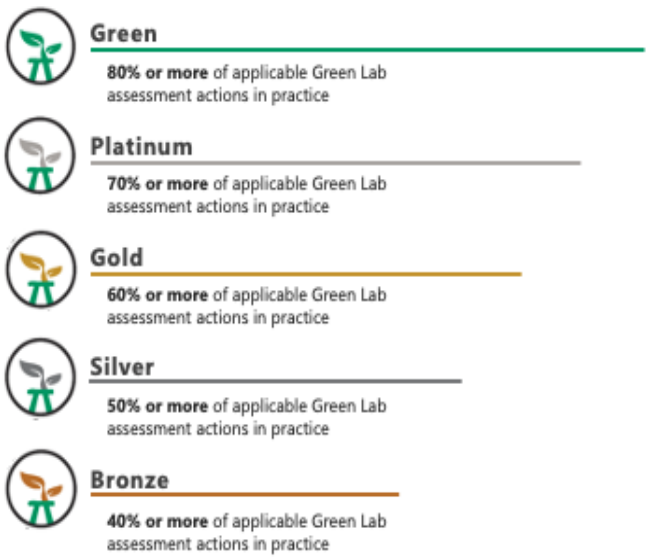

Fig. 3 Certification levels.

Program Reception

The response from scientists to the Green Lab Certification program has been overwhelmingly positive. Studies conducted by My Green Lab have shown that over 70% of scientists across the country see green lab initiatives such as energy reduction, water efficiency, and reduced hazardous chemicals as being 'very important' or 'important' to them; by contrast less than 5% of scientists said that these initiatives were 'not

important.' Recent articles published in prestigious scientific journals, including *Science* and *Nature*, also speak to the relevance of sustainability in the scientific community.[2]

Most labs that participate in the program have volunteered and have become Green Lab Certified by choice. Thus, labs are generally open and amenable to implementing the recommendations that are identified through their assessment. Typical recommendations that are embraced by labs include:

- Turn off equipment when not in use;
- Turn off lights at the end of the day;
- Defrost freezers regularly;
- Consolidate loads for autoclaves and dishwashers;
- Recycle plastic and gloves whenever possible.

Other recommendations are more difficult for labs to readily adopt. These include:

- Adjust set points on ultra-low temperature freezers to -70°C (from -80°C);
- Replace hazardous chemicals with more benign alternatives;
- Purchase right-size, energy-efficient, water-efficient and material-saving equipment;
- Turn off biosafety cabinets completely.

Comparing these lists, it becomes clear that the recommendations that are easiest to implement are the ones that mimic the actions people usually take at home, such as turning off lights and appliances, maintaining freezers, running full loads for dishwashers and recycling. The more difficult recommendations to implement are the ones that are

2 See, for instance, Zak, Joseph D., Wallace, Jenelle and Murthy, Venkatesh N., 'How neuroscience labs can limit their environmental impact', *Nature Reviews Neuroscience* 21 (2020), 347–348, https://doi.org/10.1038/s41583-020-0311-5; Madhusoodanan, Jyoti, 'What can you do to make your lab greener?', *Nature* 581 (2020), 228–229, https://doi.org/10.1038/d41586-020-01368-8; Rosen, Julia, 'Sustainability: A greener culture', *Nature* 546 (2017), 565–567, https://doi.org/10.1038/nj7659-565a; May, Mike, 'Adding efficiency to general lab equipment', *Sciencemag.org* (April 2016), https://www.sciencemag.org/features/2016/04/adding-efficiency-general-lab-equipment.

perceived as having an impact on research operations. For the points raised above, the concerns tend to be:

- Samples will not be preserved as well at -70°C;
- Benign chemical alternatives will not work as well in the experiment;
- Sustainable products will not perform as well as standard products;
- Biosafety cabinets must be kept on for sterility purposes.

Having conversations with scientists about concerns such as these is the most rewarding aspect of this program for all involved. These conversations get to the heart of examining the 'why' in people's behaviour. Why do scientists believe that samples are not preserved as well at -70°C? As of this writing there is no evidence that samples are unsafe or less stable at this temperature; it's simply a matter of 'that's how we do things' that has kept ultra-low temperature freezers set to -80°C. Even if a lab decides not to make a particular change, the discussion results in the lab making a choice about what is best for their research; they are no longer acting out of habit. Asking why does not always lead to a more environmentally sustainable outcome for each recommendation, but it does always lead to increased awareness and people making the choice that best sustains their work.

Receptivity to the recommended changes does not tend to follow age or position in the lab—graduate students are often as receptive as postdocs, and group leaders/principal investigators (PI) are as likely to champion the effort as their students. Staff who do not work in labs are also very receptive to the program. They see it as an opportunity to strengthen relationships between facilities management, safety officers, procurement and scientists. The Green Lab Certification program can also be used by management to identify organizational opportunities for sustainability. Organizations whose labs have been certified through this program often implement organization-wide changes based on the assessment results, such as eliminating single-pass cooling, installing low-flow aerators, providing rebates for energy-efficient equipment and supporting new recycling efforts.

Results

Six years later, My Green Lab's Green Lab Certification is recognized as the leading international standard for sustainable laboratories around the world. It is the most comprehensive, thoughtful, impactful program of its kind. The program has directly reached thousands of scientists in over four hundred laboratories, and it has indirectly touched tens of thousands of scientists whose operations have changed as a result of organizational changes that support reducing the environmental impact of labs, such as new recycling bins or rebates for energy-efficient equipment.

One of the unique benefits of the Green Lab Certification program is that the savings from the program can be quantified. Below are examples of realized and estimated savings in energy, water and waste.

Energy

Table 1 Estimated savings resulting from reduction of energy consumption of laboratory equipment by 10% at a large research university.

Equipment	**Estimated Units**	**Energy Consumption (MWh/year)**	**Potential Savings (MWh/year)**
-80°C Freezer	700	5,110	511
-20°C Freezer	890	2,950	295
Refrigerator	1,130	1,160	166
Fluorescence Microscope	450	120	12
Heating Block	700	160	16
Water Bath	630	200	20
Centrifuge	920	1,450	145
PCR Machine	530	430	43
Vacuum Pump	500	700	70
Shaker Table	290	650	65
Autoclave	200	3,300	330
Incubator	725	3,400	340
Tissue Culture Hood	410	2,040	204
Total		**22,170**	**2,217**

The table above illustrates the estimated savings that result from reducing energy consumption of laboratory equipment by 10% at a large research university. In most cases, this 10% reduction is achieved by turning off equipment when it is not in use or overnight. For pieces of equipment that must be left on 24/7, such as freezers and incubators, maintaining those units properly can lead to a 10% reduction in energy consumption.

Because each lab is unique, it is difficult to provide an estimated energy saving per lab. The typical energy savings associated with the recommendations in the Green Lab Certification program are below:

- Turning off equipment: >1 kWh/day (this assumes turning off two water baths overnight);
- Adjusting set points on ultra-low temperature freezers: 8 kWh/day/freezer;
- Closing fume hood sashes: 20 kWh/day/fume hood.

This results in a typical lab saving ~6,000 kWh/year, which is equivalent to removing one car from the road. There are an estimated 200,000 academic, biopharma, and clinical research labs in the United States. If every lab were to be Green Lab Certified, the energy savings would be equivalent to removing ~187,000 cars from the road or ~154,000 homes from the grid.

The Green Lab Certification program has directly saved an estimated two million kWh/year. The savings are reported 'per year' because the savings persist year-over-year. There have been additional realized savings in the form of implementing organizational changes, such as installing occupancy sensors on lights and reducing air change rates at night. Furthermore, this program has inspired Green Lab initiatives in dozens of other organizations, which have also realized energy savings as a result.

Water

Water savings in labs are often the result of three major changes:

- Aerator installation;
- Elimination of single-pass cooling;
- Installing water-saving devices on autoclaves.

Most lab faucets do not have low-flow aerators; standard faucets run at 4 gallons/minute (gpm). Low-flow aerators allow faucets to run at 1.5 gpm or less without reducing water pressure, resulting in a 70% reduction in water use. Large-scale aerator installation projects at universities have resulted in whole-building water savings from 100,000 to over 900,000 gallons/year.

Single-pass cooling can be found on many pieces of laboratory equipment and is a commonly-used technique in chemistry labs to cool distillation reactions. In these experiments, cold water is run from the faucet through a condenser and down the drain, i.e. the water is passed through the condenser only once before being discarded. Estimates have shown that a single lab, running the water at 2 gpm, consumes 1,900 gallons of water during a 16-hour reaction. Using this estimate, a typical lab will consume 5,000–9,000 gallons of water per week per reaction. Single-pass cooling can also lead to large-scale floods should the tubing become disconnected from the condenser overnight. Sharing this information with labs naturally leads to a conversation in which we ask why they have been using single-pass cooling and whether it truly is the best option for their work.

There are several good alternatives to single-pass cooling, including recirculating water baths, which may be homemade using a fish pump. There are also air-cooled condensers available that eliminate the need for water altogether. Whatever option the lab chooses, they will save thousands of gallons of water each week and eliminate the possibility of a flood.

Autoclaves (sterilizers) are also large consumers of water in North America. Older autoclaves have been shown to consume 700 gallons of water/day, mostly due to single-pass cooling. In the case of autoclaves, single-pass cooling is used to cool the effluent water from the sterilization cycle, which is too hot to go down the drain. The cold water runs 24/7 so that it can mix easily with the hot water when the hot water needs to be discharged. This process is clearly not an effective way of managing hot water effluent disposal. Organizations are encouraged to install water-saving devices on their autoclaves, which can result in reducing water consumption by as much as 70%. Labs are also encouraged to consider units with water-saving and energy-saving features when purchasing a new autoclave.

The Green Lab Certification program is estimated to save participating labs ~56,500 gallons of water per year. It is estimated that the program has directly reduced water consumption in labs by ~22 million gallons/year.

Waste

When labs first learn of the Green Lab Certification program, the first thing they ask about is how to reduce waste. Plastic, glass, gloves, EPS coolers and cardboard are all significant waste streams in labs, in addition to the hazardous and biohazardous waste that is regularly generated. Waste is highly visible to anyone working in a lab and reducing this can profoundly affect the lab's desire to engage with other aspects of an organization's sustainability program.

My Green Lab has not been able to quantify the amount of waste that has been reduced as a result of the Green Lab Certification program. Quantifying this would require extensive waste audits before and after the baseline assessment, which is difficult to do on a per-lab basis. In addition, there are different types of labs and the results of the waste audit will vary depending on the type of lab audited.

Nevertheless, the impact the certification program has had on waste reduction can be measured in other ways. It is estimated that an individual lab discards forty pounds of nitrile gloves per year. Many labs are unaware that there are opportunities to recycle gloves that are not considered hazardous waste and they do not think to question if there might be an alternative option to the standard procedure of throwing them in the trash. Labs become aware of glove recycling programs through the Green Lab Certification program, and as a result, most organizations that work with My Green Lab now recycle nitrile gloves. All Green Lab Certified labs have installed recycling bins and on average the amount of paper and cardboard that is being recycled as a result of the program has increased by 20%. Most certified labs also recycle and/or reuse EPS coolers whenever possible.

In addition to traditional waste streams, certified green labs also reduce their hazardous waste as they are directed towards tools that help them identify safer, more benign options. Labs that have participated in the program have reduced their use of ethidium bromide, a mutagenic

dye used to label DNA, by 26%. They are also increasingly choosing heptane over hexane (a chemical that becomes neurotoxic when metabolized) by 10%. Twenty percent of scientists in the Green Lab Certification program say that they are now choosing more benign chemicals over more hazardous chemicals as a result of the program.

Impact of New Technology on the Certification

Rapid advances in technology have impacted the Green Lab Certification program over the past six years. For example, when the assessment was first developed the group was not comfortable recommending that labs use solid-state illuminators over mercury or metal halide illuminators, which must be treated as hazardous waste due to their mercury content, for microscopy. That has since changed, as the benefits of solid-state illumination for scientific experiments as well as the environment are more widely recognized. Another significant change came when ENERGY STAR®-rated laboratory freezers became available in 2017. Prior to this, the assessment did not reference purchasing ENERGY STAR equipment, because none existed for laboratories; now the assessment asks scientists about choosing ENERGY STAR freezers when they purchase new units for the lab.

The Green Lab Certification program is regularly updated to reflect advances in technology, new information, and new best practices. Because of this, program participants are routinely challenged to question their behaviour and consider new ways of approaching their research.

Challenges

No program is without its challenges, and the Green Lab Certification program is no exception. The greatest challenge arises when labs have identified opportunities for improvement that an organization cannot support. This occurs frequently, as organizations are often new to supporting labs in sustainability. For example, a lab may receive a recommendation related to recycling. Yet the lab's ability to recycle depends on their organization's recycling ability, which is related to the contract the organization has with their waste hauler. If an organization

cannot find, or afford, a waste hauler to recycle material from the lab, this can lead to challenging conversations, especially when a lab feels strongly about implementing the recycling recommendation.

As another example, it may be recommended that a lab report faucet leaks. Faucet leaks can be a sensitive topic. Labs will often say that they have reported faucet leaks but that facilities management has not come to repair the leak in months. Conversations with facilities management often reveal how understaffed they are and how they do not have the capacity to respond to leaking faucets. As with the recycling example, this perceived lack of support can frustrate labs and an organization that is doing all it can to support their scientists with limited resources.

For some organizations, it can also be difficult to expand the Green Lab Certification program outside of labs that have a natural inclination to want to implement sustainable best practices. Program expansion may require incentives, which may take the form of equipment rebates, access to special funds, access to special recycling (such as glove recycling) and/or recognition. These require financial support and staff time to implement.

My Green Lab has been working with funding agencies to incorporate the Green Lab Certification Program into grant applications. This would eliminate the need for special incentives and make it much easier to expand the program to all labs.

Center for Energy Efficient Laboratories (CEEL)

Recognizing that behaviour change alone was not sufficient to truly create a culture of sustainability through science, My Green Lab co-founded the Center for Energy Efficient Laboratories (CEEL) to identify opportunities for energy reduction in laboratories. In order to develop targeted standards and programs to achieve increased energy efficiency, the CEEL developed a model that combines stakeholder involvement with objective evaluations of lab equipment energy consumption.

As shown in Figure 4, the CEEL works closely with utility companies, equipment vendors, and laboratory end-users to do market research, third-party testing of laboratory equipment, assist in the development of utility rebate and incentives, engage with stakeholders in the labs and support and consult with labs and procurement specialists in their sustainable procurement efforts.

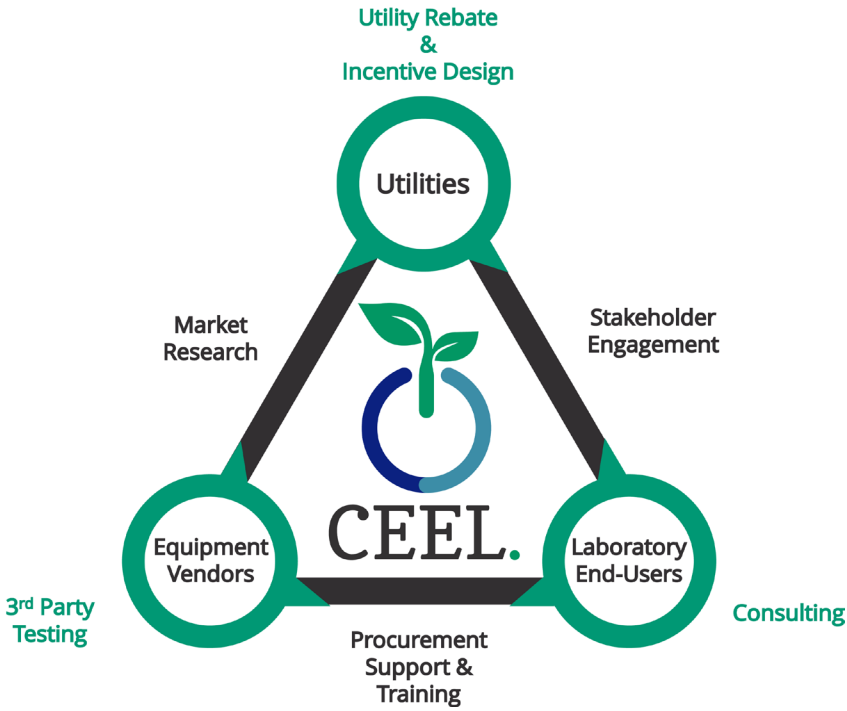

Fig. 4 The Center for Energy Efficient Laboratories (CEEL) brings together key stakeholders to drive energy efficiency in laboratories.

Development

The Center for Energy Efficient Laboratories (CEEL) is a collaboration between My Green Lab, kW Engineering and Frontier Energy. The CEEL was formed in 2014 with the goal of identifying energy-efficient laboratory equipment that may be eligible for utility incentive programs. Prior to the formation of the CEEL, laboratory equipment manufacturers were not working with utility companies, and utility companies did not have incentive programs for their laboratory customers. The CEEL team recognized that there was an enormous opportunity to reduce energy consumption in laboratories and that providing incentives and rebates to customers would quickly drive the market toward energy efficiency.

How the CEEL Program Works

The CEEL is currently supported by the California investor-owned utility companies (IOUs). The CEEL team works with manufacturers, sustainability professionals, scientists, and the utility companies to identify new projects. Projects are chosen on the basis of their potential to move the market toward energy efficiency.

Once a product has been chosen, Frontier Energy tests products from multiple manufacturers to determine the range of energy consumption for a particular product category. The data are given to the EPA and ENERGY STAR to assist with the development of standards for ENERGY STAR-rated laboratory equipment. They are also shared with the California utility companies, who determine whether there is enough information to develop an incentive program for the product category.

Program Reception

The CEEL work has been widely regarded as one of the most positive collaborations the California utility companies have been involved with in the past decade. The California Energy Commission (CEC) has recognized the CEEL and the supporting utility companies for their work. Outside of California, utility companies across the United States have used the findings in the CEEL reports to start similar incentive programs in their territories. Scientists have also praised the work of the CEEL as it has led to rebates on laboratory equipment (see Results).

Results

With the support of the California investor-owned utility companies, the CEEL has already taken a significant step toward addressing energy efficiency in laboratories by assessing and quantifying energy consumption due to plug loads. A 2015 study completed by the CEEL[3]

3 Allison Paradise, Jeff Beresini, Paul Delaney, and Kate Zeng, *Market Assessment of Energy Efficiency Opportunities in Labs* (March 12, 2015), https://www.etcc-ca.com/sites/default/files/reports/ceel_market_assessment_et14pge7591.pdf.

identified a minimum of 116 million square feet of laboratory space in California in just the academic, life science research, and hospital market sectors alone, and found that the market is growing at an average rate of approximately 5% per year. Extrapolated to the rest of the United States, laboratory space in the life sciences sector occupied ~1,200 million square feet in 2015. The study also discovered that plug loads from just thirteen pieces of commonly used laboratory equipment account for an average annual usage of 0.8–3.2 TWh/year in the state. Extrapolated to the rest of the United States, laboratory plug loads account for 80–320 TWh/year.

The CEEL study identified several pieces of equipment that present opportunities for energy savings in laboratories.

Table 2 Estimated energy consumption of common laboratory equipment in California.

California Lab Equipment Estimates	**Equipment Density (units/lab)**	**Approx. No. (thousand units)**	**Est. Energy Consumption (GWh/yr)**
-80 Freezer	2.9	58	228–648
-20 Freezer	3.7	74	126–363
Refrigerator	3.7	95	19–254
Fume Hood*	3.0	60	661–1322
Fluo Micro	1.7	34	6–12
Centrifuge	3.8	76	12–227
Water Bath	2.6	52	115–201
Heat Block	3.0	60	15
PCR Machine	2.2	44	35
Incubator	3.0	60	41–524
Shaker	1.2	24	53
Autoclave	0.8	16	26–527
Vac Pump	2.1	42	1–115
TC Hood	1.7	34	106–235
* HVAC electricity consumption due to fume hoods			

The chart above shows the estimated energy consumption of thirteen commonly used pieces of equipment in California's laboratories (reproduced from the 2015 study). Of these, only laboratory refrigeration has been studied to any depth, and within this category ultra-low temperature (ULT, -80°C) freezers have garnered the most attention. Therefore, following the 2015 study, the CEEL published a comprehensive report on ULT freezers.[4] This report was used as the basis for establishing ENERGY STAR standards for ULT freezers.

The ULT freezer report written by the CEEL changed the landscape of the life sciences industry. Prior to this work, only one manufacturer made freezers that were marketed as energy efficient. Now five major ULT freezer manufacturers make energy-efficient models that use low global warming potential refrigerants, and other manufacturers are following suit. A standard ULT freezer consumes 20 kWh/day, or as much energy as a single-family home. The energy-efficient models consume 50–70% less.

The California utility companies offer a $300 or $600 incentive for purchasing an ENERGY STAR-rated ULT freezer (the difference in rebate is based on the size of the freezer). Other utility companies, such as Eversource in Massachusetts, also offer ULT freezer rebates, and organizations themselves have begun to provide financial incentives to scientists willing to purchase energy-efficient freezers over standard models.

Prior to the CEEL's work on ULT freezers, energy-efficient laboratory equipment was not a topic of conversation. Now it is part of every major life science manufacturer's marketing materials. It is part of their design phase for equipment. And scientists are more aware than ever of the impact their purchases have on the energy consumption of their laboratory.

As scientists started to question why they were purchasing standard units instead of energy-efficient models, their purchasing decisions began to change. This change in purchasing meant that they were now more aware of how to save energy in their labs, which led to additional changes in behaviour, such as being more mindful of properly

4 Allison Paradise et al., *Ultra-Low Temperature Freezers: Opening the Door to Energy Savings in Laboratories* (August 31, 2016), https://www.etcc-ca.com/reports/ultra-low-temperature-freezers-opening-door-energy-savings-laboratories.

maintaining their new freezers and discarding old samples so as to avoid purchasing new units. This is a cycle that is typically inspired by My Green Lab's programs.

Impact of New Technology on the CEEL

The CEEL program is designed to be receptive and adaptive to new technologies; the team is always looking for new energy-efficient technologies to test and incentivize. The list of products that the CEEL will be evaluating over the next five years is extensive and includes many emerging technologies in the laboratory product space.

Challenges

The greatest challenge with the CEEL program is finding manufacturers who are willing to let the team test their equipment. Although the results are anonymized, manufacturers of non-energy-efficient equipment are nevertheless reluctant to provide equipment to test because they do not want to lose business on the basis of their energy performance. The CEEL attempts to overcome these challenges by establishing a coalition of manufacturers who are willing to work together toward the common goal of identifying energy-efficient equipment. Having manufacturers work together on CEEL projects has been a great way to move the industry forward.

ACT Label

The ACT label is the world's first eco-label for all laboratory products, i.e. consumables, chemicals and equipment. By emphasizing accountability, consistency and transparency (ACT) around manufacturing, energy and water use, packaging and end-of-life, ACT makes it easy to choose safe, sustainable products. ACT-labelled products are independently audited by SMS Collaborative, LLC (SM) (SMSC) and verified by My Green Lab.

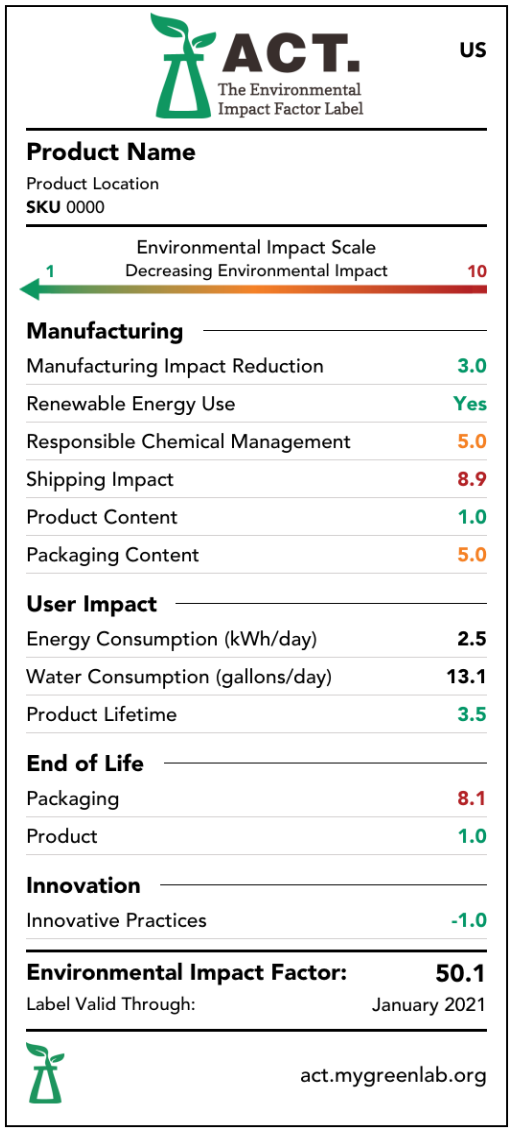

Fig. 5 ACT, the world's first eco-label for laboratory products.

Development

The ACT label was developed by My Green Lab in response to a growing need for transparency around the environmental impact of laboratory

products. In 2016, very few manufacturers considered sustainability when designing their products or packaging. And those that did made unverified environmental claims that were often ambiguous. After observing the success of the CEEL program, it became clear that the life sciences, industrial sciences, and healthcare industries needed environmental standards. However, there weren't enough data to develop those standards at the outset. For example, not enough was known about how conical tubes were manufactured to say brands X and Y make a sustainable product.

Therefore, the ACT label was conceived as an eco-nutrition label, intended to provide valuable information on the environmental impact of a product without making claims about whether it is sustainable. The criteria for the ACT label, also known as the Environmental Impact Factor (EIF) criteria, were developed with industry input. Scientists, sustainability directors, procurement specialists, and manufacturers provided valuable feedback on the EIF criteria, resulting in a comprehensive product labelling program for life science products. My Green Lab also worked closely with SMSC, an industry leader in developing third-party product certifications, to develop the EIF criteria.

Reading the ACT label is simple: the lower the score, the lower the impact on the environment; the greater the score, the greater the impact on the environment. Most categories are rated on a scale of 1–10; energy and water are reported as kWh/day and gallons/day (or liters/day), respectively. Like a nutrition label, which can be used on its own or to compare the nutritional values between products, the ACT label can stand on its own, providing a snapshot of the overall environmental impact of a product and its packaging, or it can be used to compare products on the basis of their environmental impact.

The ACT label program began as a pilot in May 2017 with twelve products. Feedback from this pilot study led to improvements in the label, which was formerly launched in October 2017. By January 1, 2018, over one hundred products had obtained an ACT label.

In late 2018, participants in the ACT label program made it clear that there was value in expanding the program beyond North America to the UK, Europe, China, and India. This feedback led My Green Lab to develop a UK and EU specific label in 2019.

How the Program Works

All products participating in the ACT program undergo an extensive desktop audit led by SMSC. The audit covers the key product attributes on the label, namely:

Manufacturing Impact Reduction: An evaluation of the manufacturing facilities to determine whether steps have been taken to reduce energy, water or waste in the manufacturing process.

Renewable Energy Use: An assessment of whether the product was manufactured using renewable energy.

Responsible Chemical Management: An assessment of the product's chemistry and the company's chemical management systems.

Shipping: An assessment of the impact of shipping the product from the manufacturing location to the distribution site.

Product Content & Packaging Content: An evaluation of sustainable content in either of the product or its packaging.

Energy and Water Consumption: A determination of the amount of energy and water consumed by the product when it is in use in a laboratory.

Product Lifetime: A determination of the product's usable lifetime and durability.

Product Disposal: An evaluation of the end-of-life options for the product. Each product component is assessed separately for products with multiple components (e.g., polypropylene cap and PET tube).

Packaging Disposal: An evaluation of the end-of-life options for product packaging. Each part of the packaging is assessed separately for packaging that contains multiple components (e.g., EPS cooler, cardboard box).

Innovative Practices: The innovation credit encourages manufacturers to achieve exceptional results in reducing their impact through innovative solutions that do not fall within the scope of any other Environmental Impact Factor. The resulting impacts can affect any

stage of the product or packaging life cycle - raw material acquisition, transportation/distribution, manufacturing, use phase, or end-of-life.

My Green Lab verifies the work of SMSC, and no labels are released until all parties—SMSC, My Green Lab and the product manufacturer—are in agreement. After the audit, manufacturers are shown opportunities to improve their scores. The process is similar to that of the Green Lab Certification—manufacturers are asked why they are using certain materials or manufacturing processes, and are encouraged to look for safer, more sustainable alternatives.

Due to the sensitive and proprietary nature of the material requested for the audit, all ACT assessments are performed under a mutual non-disclosure agreement.

The time required to undergo an ACT assessment varies based on the amount of information already available about the product. Most audits take two to six months, pending data availability. The ACT label is valid for two years, after which time products must be reassessed.

Once a product has obtained an ACT label, that label is made available online on the ACT website and also on the manufacturer's website. Products may also carry an ACT logo if the manufacturer so chooses.

The ACT label program perfectly fits in with the behaviour → products → behaviour cycle. The Green Lab Certification program encourages scientists to think more deeply about the products they purchase. It asks them to step back and ask why they are purchasing a particular product from a certain manufacturer. This reflection often leads scientists to seek more sustainable alternatives, often by requesting to see the ACT label or by requesting that a product obtain the ACT label. Being more mindful of their purchases leads to scientists more mindful of their overall environmental impact in the lab. In fact, there are often more opportunities for energy/water conservation and waste diversion as a result of making more deliberate purchasing choices.

Program Reception

The ACT label program has been well-received. Over forty top research universities and biotech companies around the world have already

taken steps to integrate the ACT label into their procurement systems. The International Institute for Sustainable Laboratories recognized several of these organizations as leaders in sustainable procurement in 2018 and 2019. In addition, manufacturers are increasingly recognizing the impact of disclosing the environmental impact of their product and are increasing their participation in the program. The ACT label also won a leadership award from the Sustainable Purchasing Leadership Council in 2018 in recognition of the label's potential to transform the life sciences industry.

Results

To date, there are over 500 ACT labelled products, with over 2,000 expected to be added in 2021. Although the full impact of the program has yet to be felt (owing to the fact that it is less than three years old), it has already had a substantial impact on the life sciences, industrial sciences and healthcare industries.

Every manufacturer that has undergone the process of obtaining an ACT label has made a change to their manufacturing, product, or packaging design. Manufacturers and suppliers are now taking steps to reduce the environmental impact of their products, and they are communicating these changes in an independently-verified way to their customers. Several manufacturers have begun take-back programs for their products as a result of the ACT label program; some have redesigned their products to be more energy-efficient; and others have found new vendors to supply sustainable packaging for their products. The ACT label program is transforming the life sciences industry.

The ACT label is also recognized as meeting the Living Building Challenge criteria, which means that any laboratory project that is aiming to be Living Building Challenge certified will need to purchase ACT-labelled products for their project. For the first time, laboratory buildings are being designed with regard to laboratory equipment, ensuring that the building will consume fewer resources and be a healthier space for scientists to work.

Impact of New Technology

As with the CEEL, new, sustainable technology is perfectly suited to the ACT program. My Green Lab actively looks for new laboratory products that have been designed with sustainability in mind to join the ACT program. By embracing new technology, the ACT program continues to make it clear to manufacturers, scientists, and procurement specialists that the laboratory products industry is moving toward sustainability.

Challenges

There is a fee associated with participating in the ACT program. This fee is less than any other product certification on the market; however, for an industry that is not accustomed to product certifications, it can be a challenge to include the ACT label in the budget. To assist companies in participating, My Green Lab has developed 'product family' pricing rather than 'per product' pricing.

Although there are quite a few ACT-labelled products, the list is by no means complete. This can be challenging when asking procurement specialists to include specifications for the ACT label in request for proposals (RFPs), as there simply aren't enough ACT-labelled products to do so yet. Moreover, because having an ACT label does not mean that the product is sustainable, procurement specialists can be reluctant to include the label in sustainable procurement guidelines.

The most effective way to overcome these challenges has been to find other ways to make it clear to suppliers that transparency is important. For example, some organizations have incorporated the ACT label into their e-procurement websites so that those products with an ACT label appear at the top of searches. The University of Virginia's most recent RFP requested that their suppliers actively pursue the ACT label.

Final Thoughts

With over 100 green labs programs at organizations worldwide and the transformative impact the ACT label has had on lab product manufacturing, My Green Lab is truly creating a culture of sustainability through science. Through our programs, we distil down all the potential opportunities for sustainability into broad ideas and concepts that are

designed to provoke scientists to ask 'why' for the habits that have the greatest impact in the lab. Once scientists start on this path, they carry it further with their own creativity and insight into their laboratory operations to build a culture of sustainability that is suited to their unique lab space.

My Green Lab's approach to sustainability—encouraging people to critically examine their behaviour and make conscious choices—is a model that could be replicated in any industry, and beyond the lab into our personal lives. All of us inherit habits and behaviours, and once we settle into life, we rarely take the time to question why we act the way that we do. If we want to change this world, we need to start by looking inward. As the work of My Green Lab has shown, when we do this, it can have a profound effect on ourselves and on our planet.

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