Green Laboratories:
Disseminating information and connecting IARU programs

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Placed with the Green Campus team at the University of Copenhagen
Acknowledgements

I wouldn’t have been able to complete this report without the help of many people.

First, I’d like to thank the Green Campus team at the University of Copenhagen, Tomas Refslund Poulsen, Preben Buhl, Thomas Østergaard Poulsen, Stine Thougaard, Christian Østergaard, and Nina Haugbelle. Thank you for the amazing experience and for showing me how sustainability works at the University of Copenhagen.

Additionally, I’d like to send a thank you to all of those who helped me in collecting information about each individual IARU program. It was the knowledge that you were able to share that allowed me to create this report. Any information that can’t be found from the ‘links to more information’ sections or in the works cited, I attribute to them.

Thanks to:

The Australian National University
Jennifer McMillin
Stephen Fahey
Tim Yiu

University of Cambridge
Leila McElvenney
Joanna Simpson
Paul Hasley

ETH Zurich
Dominik Brem

University of Oxford
Harriet Waters

National University of Singapore
Tham Yin Har
Amy Ho
Saravanan Gunaratnam

University of Tokyo
Taro Togo

University of California, Berkeley
Judy Chess
David Scrimger
Edward Sihua Yang

Yale University
Brenda Armstrong

**I was unable to make contact with a representative from Peking University. Thus I was unable to compile information on their program.**
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Introduction to Green Laboratories

What is a green laboratory?

In one sentence, a green laboratory is a research space that uses a combination of technical and behavioural actions that work to reduce the amount of resources the laboratory needs to function safely and effectively.

Green laboratories also go by the names of sustainable laboratories, energy-efficient laboratories, and s-labs. The actions that can be made are typically split into two groups, technical and behavioural.

Technical changes are the surest to implement to save resources but are typically the more expensive option. These kinds of actions include improved control and efficiency of ventilation systems, increased pipe insulation, exchanging old equipment for newer energy efficient models, switching old light bulbs for LED lights, lowering temperatures at night, improving lighting control and centralizing server facilities.

Behavioural changes are a more gradual way to save resources, and require that lab personnel alter their behaviour to help save resources. Examples of behavioural changes include shutting fumehoods, using less water, using timers on waterbaths, and turning off lights, computers, and equipment when not in use.

Why are green laboratories important?

Around the world, research universities consume vast amounts of resources. In fact, at the University of Copenhagen, 83% of total energy consumption is used at laboratory facilities. This accounts for a 4-6 times higher energy consumption per meter squared (Buhl). With the rising costs of energy and the constant pressure to expand laboratory areas, it follows that efforts need to be directed into making laboratories more energy-efficient, commonly referred to as more ‘green’.

Working towards green laboratories saves money for both the university and the scientists. While the initial steps of a green laboratory project can be costly, including buying energy efficient equipment and upgrading technical building aspects, these actions show great savings over time. This saved money can further be distributed to improving the university and then both directly and indirectly benefits lab personnel.

Green laboratories also contribute towards fulfilling a responsibility to the environment, a move in which universities must take the lead. In an increasingly climate aware society, improving laboratory efficiency not only serves as proper environmental stewardship, but also can be an attractive feature in recruiting new students and faculty.
Challenges going into research

Making laboratories more sustainable is not a new concept. In fact, some universities have had a focus on energy efficient laboratories for many years. However it has only been over the last few years that more institutions have started to embrace and begin their own green laboratory programs.

When I started my IARU project on green laboratories, I realized several problems quickly into my research. The greatest of these, and the most important, was finding useful information about green laboratory programs. The online resources vary greatly. Some universities reference best practice guides while others show point based certification system. Some have a page on their website with energy-saving tips yet on many, there is little pertaining to green laboratories at all. Furthermore, amidst this wide variety of sustainable information there is little indication of what demonstrates better or worse results, making it difficult to report meaningful action. I quickly came to the conclusion that the most accurate way to learn about the respective IARU green lab programs would be to get in contact with each university personally. I emailed those who were involved in their universities green laboratory programs and much of the information listed in the following summaries is a direct result of that communication.

There are also inherent conflicts with working on green laboratories themselves.

First, the type of laboratory will have a significant effect on how it can be most sustainably managed. Spaces that are designated for research must be approached differently than spaces designated for teaching laboratories. Similarly, the type of research, for example medical vs. chemical vs. physical, will also influence the sustainability approach. On top of this, most energy systems track the total energy used by the building, not the individual laboratories. This makes tracking specific energy usages difficult and makes it difficult to monitor individual areas in pilot projects.

Very importantly, all sustainable modifications in the laboratory must accommodate the researchers and their work. The primary goal of scientists is to pursue their research. Technical changes can be incorporated into laboratories with minimal effects on research but behavioural changes rely entirely on the researchers. There can be multiple people using one instrument and typically there are many people working in one laboratory space. In order for behavioural methods to work, all lab users must be aware and involved in sustainable practices. Thus it is extremely important that the sustainability teams work together with laboratory personnel to balance efforts to save energy with essential research needs.

There are hurdles standing in the way of green laboratories. However with inter-university connections and careful planning and communication, all involved institutions can learn and improve their respective programs.
Overview of IARU green laboratory programs

The Australian National University (ANU) sustainability.anu.edu.au

Overarching Goals

Working towards
• Achieving the campus wide target set for the end of 2015, a reduction in energy use and CO2 emissions by 20% below 2006 levels
• Achieving the campus wide target set for the end of 2020, a reduction in energy use and CO2 emissions by 35% below 2006 levels

Green Laboratory Activity

Present Action
• Requires all laboratories to use a chemical management system to complete a risk assessment and receive approval before ordering chemicals

Past and Continuing Action
• Chemical inventory system registers and tracks all chemicals within ANU
• Green laboratory campaigns including stickers, sensors, and other systems to encourage laboratory personnel to ‘lower the sash’ of fume hoods
• Encourages users to switch electronic equipment off when not in use

Findings

Most Effective
• Campaigns for behavioural change. E.g. ‘Lower the Sash’ programs have estimates of saving up to $300,000 a year for the University

Challenges
• Finding an way to make controlled laboratory environments, which have high energy requirements, more energy efficient

Links for More Information


For additional details, contact Jennifer McMillin at Jennifer.McMillin@anu.edu.au
ETH Zurich

Overarching Goals

Working towards

- Finding maximal building system integration to achieve best energy efficiency
- Implementing various technical features to make labs more energy efficient
- Sustainability label for lab buildings

Green Laboratory Activity

Present Action

- Designing a new lab building following building label guidelines. Includes attention to life cycle costing, safety restrictions, water/wastewater use, hazardous waste removal, user comfort, functionality and flexibility, ease of cleaning, and others
- Choosing a lab sustainability standard and applying it to next generation of lab buildings at ETHZ. Currently evaluating the DGNB laboratory standard from Germany

Past and Continuing Action

- New center for biomedical research opened in 2013 with key energy efficiency features including thermally activated building systems (TABS), connection to geothermal storage system, cascading of reusing waste heat/cooling energy and high temperature cooling for lab equipment

Findings

Most Effective

- Building new laboratory buildings with sustainable goals in mind. While upfront investment costs are large, the payoff due to life cycle costing has a significant positive effect in terms of reduced energy, water, solvent demand, less cleaning etc.

Challenges

- Not affecting research by implementing energy efficiency measures. Lab environment and research requires a certain amount of energy and lowering it could mean affecting the specifications of experiments
- Not compromising safety regulations while optimizing energy savings
- Checking the efficiency of unique research equipment is difficult

Links for More Information

Energy Trajectories: [http://www.ethz.ch/about/sustainability/energy/eth_entwicklungspfade_en.pdf](http://www.ethz.ch/about/sustainability/energy/eth_entwicklungspfade_en.pdf)

For additional details, contact Dominik Brem at dominik-brem@ethz.ch
National University of Singapore (NUS)

Overarching Goals

Working towards
- Preparing a Green Laboratories framework based off of the Labs21 scheme and the Singapore Building Construction Authority’s (BCA) Green Mark scheme for laboratories
- Identifying goals and best practices for sustainable laboratories and communicating them to applicable departments and schools

Green Laboratory Activity

Present Action
- Developing a ‘green standard’ for laboratories through consultations with local regulators and laboratory based organizations

Past and Continuing Action
- In 2012, a seminar on best sustainable laboratory practices was held with speakers from the Massachusetts Institute of Technology (MIT)
- The Office of Safety, Health, & Environment (OSHE) is sourcing and assisting labs in the purchase of energy efficient equipment
- Information on green laboratory practices is available to student and staff on intranet web-portals

Findings

Most Effective
- Peer pressure: educating lab users on green practices that have been adopted by other laboratories with similar activities
- Engagement: approaching lab managers with the business case for adopting sustainable green practices, that is, the energy and cost savings that result

Challenges
- Ability to benchmark the energy performance of labs due to the diverse nature of their activities
- Lack of commercially available options, in terms of equipment and materials, to reduce energy consumption
- High upfront investment needed for energy saving features for laboratories
- Maintaining safety and health requirements amid novel energy related technologies

Links for More Information

Office of Environmental Sustainability: www.nus.edu.sg/oes

For additional details, contact Amy Ho at amy.ho@nus.edu.sg
**University of California, Berkeley (UC Berkeley)**

**Overarching Goals**

**Working towards**
- Identifying laboratories with sustainable practices in their daily research routine then evaluating their methods
- Exemplifying pilot green laboratories to the campus community and providing additional information and best practice systematic approaches for various laboratory types

**Green Laboratory Activity**

**Present Action**
- Developing a green laboratory resource guide to assist labs in becoming more sustainable. It includes resources that lab personnel can refer to in order to meet the criteria on the green lab checklist
- Has real time building energy use available online for faculty and students to view

**Past and Continuing Action**
- Distributing a green laboratory checklist which is comprised of evaluative questions and requirements that labs are expected to meet. It acts as a method to standardize green laboratories and is updated regularly
- Energy saving competitions between laboratories and buildings

**Findings**

**Most Effective**
- Reach out to strategic big names first. This can include famous laboratories, department heads, and deans. Their involvement signals to other laboratories that going green is a worthwhile effort.
- Start with labs that already incorporate green efforts into their lab culture or whose research relates to sustainability. E.g. green chemistry or environmental science.

**Challenges**
- Maintaining interest and a dedication to the time commitment. Liaisons are typically graduate students with competing interests such as research, papers, and exams. Scheduling meeting times is difficult and occasional meetings are not effective for sustainable efforts.

**Links for More Information**

Green Laboratory Guide: [http://mypower.berkeley.edu/take-action/your-lab](http://mypower.berkeley.edu/take-action/your-lab)
Green Building and Construction: [http://www.facilities.berkeley.edu/GreenBuildings/gb_main.html](http://www.facilities.berkeley.edu/GreenBuildings/gb_main.html)
Real time Building Energy Use: [https://us.pulseenergy.com/UniCalBerkeley/dashboard/#/overview](https://us.pulseenergy.com/UniCalBerkeley/dashboard/#/overview)

For additional details, contact David Scrimger at dscrimger@berkeley.edu
University of Cambridge

Overarching Goals

Working towards

- A reduction in emissions related to activities associated with scientific and technical research, as measured in Tonnes CO2/£, by 34% from 2005 levels by 2020

Green Laboratory Activity

Present Action

- Began ‘Green Impact’ in November 2012 as the university’s environmental accreditation scheme. Departmental teams sign up and gain points and awards through green actions. There is a subset of actions specifically intended for lab users.
- Focus groups with key lab managers and principle assistants as a starting point for lab engagement and behaviour change. Simultaneously requested what support and resources lab users want for greening their laboratories.
- Pilot a fume cupboard campaign in the Department of Chemistry starting 2013-2014.
- Develop best practice for -80 freezers.

Past and Continuing Action

- Gurdon Institute (a biomedical building with high energy usage) ran an energy saving competition. Lab energy metering information was available to all with log in credentials.
- Green lab campaigns with fume hood stickers, posters, energy saving information, etc.

Findings

Most Effective

- Competitions with prize incentives. E.g. Behavioural Change Program→Energy saving competition between laboratories in the Gurdon Institute. After the 6 month challenge, total energy use had been reduced by 19% and the lab with the most reduction was given £1000.

Challenges

- Sustaining momentum for green laboratories amid new staff, new technologies, and consistent demand for resources
- Fighting myths that any reduction in energy or resources will be detrimental to science
- Time commitments of staff
- Individual perceptions of what words and phrases mean. E.g. carbon, climate change, and green.

Links for More Information

Gurdon Institute Energy Saving Campaign: [http://www.gurdon.cam.ac.uk/green.html](http://www.gurdon.cam.ac.uk/green.html)

For additional details, contact Leila McElvenney at Leila.McElvenney@admin.cam.ac.uk
University of Copenhagen (UCPH)

climate.ku.dk/green_campus

Overarching Goals

Working towards
• Achieving the sustainability targets set for the end of 2013, reduction of energy and CO2 emissions 20% below 2006 levels (on track)
• Creating Green Action 2.0, a new sustainability strategy to be started in 2014

Green Laboratory Activity

Present Action
• Meeting and recruiting various types of laboratories to determine best practices. Currently nine laboratories have expressed interest in participating
• Green IT program, Joulex, connected to UCPH’s system that can indirectly power down approved machines such as computers, printers, fax machines, etc.

Past and Continuing Action
• Focus has been on various technical energy efficiency projects including pipe insulation, LED lighting, lowering temperatures at night, improved control and efficiency of ventilation systems, upgrading to energy-efficient fume hoods, improving lighting control and centralizing server facilities.
• ‘Destination 2012’ action plan including three energy efficiency campaigns with ‘shut the sash’ stickers, informational green laboratory handouts, distribution of energy saving power strips etc.

Findings

Most Effective
• Campaigns for behavioural change. E.g. Closing the fume hood campaigns showed a saving of at least 4-5% of total energy consumption.

Challenges
• Identifying best practice for various types of laboratories and learning what equipment can be switched off
• Getting lab personnel permanently involved and excited about sustainable behaviour
• Finding ways to have researchers take initiative in green actions and feel responsibility for making their building area sustainable

Links for More Information

Green Campus Results: http://climate.ku.dk/green_campus/green_results_and_indicators/

For additional details, contact Preben Buhl at Preben.Buhl@adm.ku.dk
Working towards

- Reducing carbon emissions 11% below the 2005 baseline by 2015 and then 33% by 2020.
- Meeting carbon dioxide reduction targets set by the UK government
  - HEEPI benchmarks for bioscience/medical labs are 121 kWh/m² for gas and 250 kWh/m² for electricity
  - CIBSE benchmarks for ‘generic’ science labs under good practice are 110 kWh/m² for gas and 155 kWh/m² for electricity

Green Laboratory Activity

Present Action

- Expanding the sustainability team by recruiting a sustainable building officer
- Implementing recommendations from the Midnight Oil Report including adding energy reporting in departmental meetings, encourage and supporting ‘green champions’ among researchers, and encourage relationships between building architechs, building managers, and energy specialists

Past and Continuing Action

- Burning the Midnight Oil project, an intensive study on four 24-hour research buildings conducted between 2010-2012. Includes a wealth of information on night-time lab use and behavioural, technical, and design recommendations on methods to save on carbon emissions.
- 10:10 Campaign to reduce 2009 CO₂ emissions by 3-10% between April 2010 and March 2011

Findings

Most Effective

- Influencing the design of new laboratories and research buildings
- Engaging senior management and department heads
- Set the default setting as ‘off’ for most building services during irregular working times

Challenges

- Differing academic perceptions of energy management. Some believe that large, energy intensive buildings attract academics while others believe that practising scientists will be more attracted to minimizing the environmental impacts of their research
- Buildings and laboratory spaces shared by multiple departments, difficult to establish formal means to address energy issues

Links for More Information

Midnight Oil Report Summary: http://www.eauc.org.uk/midnight_oil_case_study_aug_2012
10:10 Energy Campaign: http://www.admin.ox.ac.uk/estates/environment/energy/1010campaign/energyreports/
Lab Swap: http://www.admin.ox.ac.uk/estates/environment/labswap/

For additional details, contact Harriet Waters at harriet.waters@admin.ox.ac.uk
**University of Tokyo**

**Overarching Goals**

**Working towards**
- Achieving the Todai Campus Sustainability Project goal (TSCP-2030) by reducing CO2 emissions 50% below the 2006 baseline levels in 2030

**Green Laboratory Activity**

**Present Action**
- Installing visual power meters to help curb the increase of emissions due to the expansion of educational and research activities
- Developing a model to help disseminate energy-saving equipment through large-volume purchases
- Introduce energy creation methods that were previously financially unfeasible including photovoltaic power generation

**Past and Continuing Action**
- Replace deteriorating equipment with energy-saving models
- Provide financial support to faculty, staff, and students who are involved with the Energy Research Network and encourage their active participation in the project.
- Maintenance of university forests to offset CO2 emissions
- Implement technical changes including the renewal of large-scale heat source systems, installing light sensors, full conversion to high-efficiency fluorescent lights, and upgrading refrigerators and room air conditioners.

**Findings**

**Most Effective**
- Ensuring energy efficiency and making use of renewable energy

**Challenges**
- Working with the university to promote and practice wise energy use.

**Links for More Information**

Sustainability goals and actions: [http://www.tscp.u-tokyo.ac.jp/en/about.html](http://www.tscp.u-tokyo.ac.jp/en/about.html)

For additional details, contact Taro Togo at togo.taro@mail.u-tokyo.ac.jp
Overarching Goals

Working towards
- 50% of all laboratories signed up under the Green Laboratory Certification scheme (currently has 95 of a total 500 primary investigators involved)
- Reducing energy consumption in laboratory spaces by 8% (goal managed by Yale Facilities Office)

Green Laboratory Activity

Present Action
- Green laboratory certification based on a point system
- One-on-one sustainability talks given to laboratories
- Looking into developing a program to assess aging equipment and provide an exchange for more energy efficient models

Past and Continuing Action
- Close the sash stickers for fume hoods
- Comprehensive health and safety survey performed for each lab with a green laboratory and energy efficiency section
- Night-time energy audits through several science buildings which focus on evaluating overall energy use

Findings

Most Effective
- Competitions with food incentives. E.g. Chemical Amnesty Day → Yale’s chemical waste vendor and trained lab pack chemists receive, segregate, and package chemical waste without labs having to tag or fill out paperwork for one day. The lab with the most chemical waste cleared out wins a pizza party. 3,063 pounds of chemical waste was collected.

Challenges
- Keeping interest and spreading knowledge about the Green Lab certification program
- Determining how to manage shared lab spaces where lab equipment is used by many people
- Overcoming communication barriers between primary investigators and graduate students.
- Dispelling belief that keeping a green laboratory will take time away from research

Links for More Information

Green Laboratory Certification: http://sustainability.yale.edu/green-lab-certification
Sustainability Strategic Plan: http://sustainability.yale.edu/sustainability-strategic-plan-0

For additional details, contact Brenda Armstrong at brenda.armstrong@yale.edu
Recommendations to the University of Copenhagen

1. *Make energy usage information accessible to staff and students*

Reasoning:

During my time at the University of Copenhagen, I sat in on several of meetings with individual laboratories. These labs are at the forefront of starting green laboratories at UCPH and were looking into incorporating more sustainable practices into their daily work. One of the recurrent queries was about being able to see energy feedback about their green practices. Particularly with behavioural changes, it is vital that this information is made available. Changing behaviour is a process that takes time and requires constant reminders. Providing data on laboratory energy use reinforces drive to continue green lab efforts and also fosters innovation in being more sustainable.

Suggestions:

The University of Copenhagen already has the program Joulex that monitors real-time energy use throughout the university. I suggest that UCPH makes use of this valuable program and distributes the information so that the university community has access to energy consumption. This could be implemented in various ways. The University of Berkeley has energy building use available on a public website and shows daily electricity usage of every building. (Energy) Other options include linking energy information to a website only available via a site requiring University log in credentials or publishing quarterly energy reports.
2. Organize annual competitions between laboratories

Reasoning:
Competitions between laboratories provide a wonderful opportunity to promote green laboratory practices. Not only do they effectively accomplish the competition’s goal (reducing energy use, fume hood height, water use, chemical waste, etc.) but they also increase knowledge about sustainable practices and inspire lab members to be ‘green’ in a fun and interactive way. Friendly competition induces participation from various laboratories and having a competition can act as a kick off for green behavioural changes.

Suggestions:
The competition can focus on any aspect of a green laboratory. Yale University runs an annual competition that targets chemical waste called “Chemical Cleanout Day”. The University of Cambridge ran a competition focused on behavioural change in a biomedical engineering building with high-energy usage. For more details on either specific competition, please refer to the individual pages on each university or the websites http://ehs.yale.edu/news/ehs-safety-bulletin and http://www.gurdon.cam.ac.uk/green.html respectively.

3. Collaborate with IARU institutions with similar green laboratory program development

Reasoning:
At a first glance, it’s difficult to determine what and how other universities are implementing green laboratory programs. After pulling together information from IARU institutions, I’ve found that there are recurring challenges in developing each program. Communicating and disseminating experiences will save both time and energy.

Suggestions:
The University of Copenhagen is in the process of identifying and studying various types of laboratories to pilot green laboratories on campus. Both the University of Cambridge and the University of Berkeley are also embarking on this same step. By establishing a connection with the green laboratory organizers and then sharing tips and experiences, all universities involved could stand to benefit.
4. Strongly encourage the smart design of new lab buildings

Reasoning:

The University of Copenhagen is undergoing various construction projects, most notably of several new science buildings. Pressure must be placed on the energy efficiency of the new laboratory spaces that will be built. There are many technical changes that can be made to a laboratory to make it more energy efficient. To have these systems in place at the start of these new lab spaces would dramatically lower the overall energy use of the new buildings over their lifetime. There is the potential for these future lab spaces to be premiere examples of world-class green laboratories, and they represent an opportunity that shouldn’t be missed.

Suggestions:

As the Danish government owns the buildings at the University of Copenhagen it may be difficult to influence the building plans. However this shouldn’t prevent a meeting between key building officials and a green laboratory representative. Having the opportunity to influence the smart design of new laboratories can have major long-term effects. Suggestions including purchasing energy star appliances, efficient HVAC systems and comprehensive metering systems have the capability of making these new research buildings truly impressive. The University of Oxford published a report called ‘Burning the Midnight Oil’. Within it is a vast amount of recommendations for both technical and design recommendations for saving energy. I would strongly recommend its review and subsequent application to the new laboratory buildings.
Works Cited

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Ho, Amy, Yin Har, and Saravanan Gunaratnam. "Green Laboratories Question." Message to the author. 10 July 2013. E-mail.


Waters, Harriet. "Inquiring about Green Laboratories." Message to the author. 3 July 2013. E-mail.

Yang, Edward S. "Green Lab Questions." Message to the author. 4 July 2013. E-mail.

**I wish to stress again the importance of the communication I had with representatives from the IARU institutions. I gained much of my knowledge from their emails. Please see page 2 for a listing of those who aided me by order of university.**