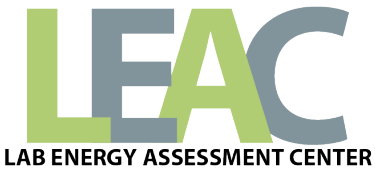
Lab Energy Assessment Report

Assessment Date: 4/6/17 and 4/21/17
Location: MIT Room N52-496, Cambridge, MA 02139
Lab Focus: Campus-wide safety and biological experiments
Report Date: 5/10/17

Assessment Team

Daniel J. Preston	Director
Alice Ursella	Assistant Director
Ariel S. Anders	Lead Technology Developer
Max Drake	MIT Undergrad '20
Georgia Phillips	MIT Undergrad '20
Dheekshita Kumar	MIT Undergrad '20



MIT Lab Energy Assessment Center
77 Massachusetts Avenue, Room 32-013
Cambridge, MA 02139
leac.mit.edu ‖ *mit − leac@mit.edu* ‖ 617 − 324 − 2087

Contents

Introduction

1.1 Lab Overview

The EHS lab is located on the 4th floor of building N52 of the MIT main campus in Cambridge. It is used mainly to analyze water and air samples collected on campus. The results are then compared with the regulated limits to make sure that the Institute is in compliance with the standards. From time to time MIT researchers borrow the lab space to use for experiments. The lab contains incubators, centrifuges,an ultra-low temperature (ULT) freezer, a tray sealer, a UV light box, a ultrasonicator, a mercury sampler, a toxic gas detector, etc. Depending on the workload the equipment is generally used from a couple of times a week to once a month. Some of the equipment is left plugged and running all day and night even if not in use, the main reason for this behavior is to have the instruments always ready to be used and avoiding the instrument warm up time.

The LEAC team collected energy consumption data for a total of 8 hours per day over two days of several pieces of lab equipment during a two-day assessment (April 6th and 21st).

1.2 Lab Equipment Monitored

Incubator

Power Draw: 886 W (Older Incubator), 279 W (Newer Incubator)

Allows one to grow and maintain microbiological cultures or cell cultures used in cell biology, microbiology and molecular biology for experimental work. The optimal temperature, humidity, carbon dioxide and oxygen concentration can be selected to control the bacteria or cell grow.

Centrifuge

Power Draw: 57 W at 2500 RPM

Works by using the sedimentation principle, while spinning around a fixed axis the centripetal acceleration disassociates the heavier particulates from the lighter ones

---

Ultra Low Temperature

Power Draw: 191 W

Freezers that maintain the temperature at -70 to -85C. They are used primary for long term storage for the biological sample like DNA, RNA, proteins, etc.

Tray Sealer

Power Draw: 583 W while warming (red light), 116 W while in steady state (green light)

Allows one to seal thermoplastic materials using heat. It is used to test for coliform presence in the swimming pool water.

UV Light Box

Power Draw: 9.7 W

When the sealed tray is put under UV light if coliforms are present the solution will florescence.

Ultrasonicator

Power Draw: 4 W on standby, 360 W while in use.

Lab spectacles that need to be cleaned at a microscopic level are submerged in a solvent bath. The ultrasonic frequencies traveling in the solvent have the ability to loosen the material adhering on the equipment surface.

Mercury Sampler

Power Draw: 5.4 W

It is used to measure mercury vapor concentration in the sink drain. The probe is inserted in the drain and a concentration value can be read on the instrument screen.

Toxic gasses detector: measures low-level toxic gasses. Air is drawn on a chemcassette making the tape to react and color up, the color intensity is then digitally transformed into a chemical concentration value that can be read on the screen.

Recommendations

2.1 Summary

Recommendation 1: Replace old incubator (Shel-Lab Incubator) with new model

Recommendation 2: Consolidate cold storage to one refrigerator

Recommendation 3: Turn off centrifuges when not in use

2.2 Replacing Old Incubator

2.2.1 Observation

There are three incubators currently used in the EHS space. We compared the two incubators with the same set point of 37 degrees. We noticed that one incubator, the Shel-Lab Incubator, is far less efficient than the newer incubator (with the same set point), the Heraeus BB-16-CU.

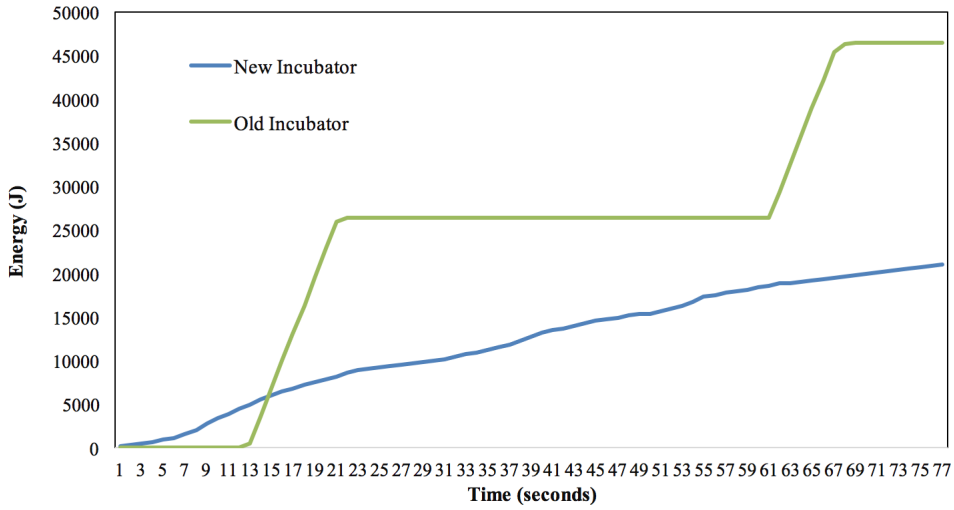


Figure 2.1: Total Energy Consumption of two incubators in the EHS lab space

2.2.2 Recommendation

Consider replacing the old incubator with a newer one. Based on the data obtained in the steady state, while running, the old incubator uses nearly 3 times as much power as the new incubator. This is due to the choppy nature in which old incubators maintain temperatures (Refer figure 2.1). Assuming that both the new and old incubators are running 24/7, if the EHS lab replaced the old incubator with a newer model, you would save 5305 kWh, which equates to $667 in savings per year.

Energy Savings (kWh/yr)	Energy Cost Savings ($/yr)	CO2 Savings (tons/yr)	Implementation Cost ($)	Simple Payback (yrs)
5305	666.92	3.391	1495	2.24

2.2.3 Calculations

Energy Savings

$$Energy\ Savings = H * W * k$$

H = Number of operating hours for incubators over one year (8,760 hrs/yr)
W = Average difference in power between new and old incubators
k = Conversion constant, 1kW/1,000W

$$ES = 8,760\ hrs/yr * (605.66\ W) * 1\ kW/1,000W = \mathbf{5305\ kWh/yr}$$

Cost Savings

$$Cost\ Savings = Energy\ Savings * Usage\ Rate$$

$$CS = 5305\ kWh/yr * \$0.1257/kWh = \mathbf{\$666.92/yr}$$

Reduction in CO_2

$$CO_2 = ES * CO_{2,APCo}$$

$$CO_2 = 5305\ kWh * 0.000741\ tons/kWh = \mathbf{3.93\ Tons\ CO_2/yr}$$

where $CO_{2,\ APCo}$ = tons of CO2 produced per kWh electricity generated, 0.000741 tons/kWh [2]

Implementation Cost

$Payback\ Period = Implementation\ Cost/Cost\ Savings$ = \$1495/\$666.9 = **3.93 yrs**

Implementation Cost = Total Initial Cost, estimated to be \$1495 [1]

Implementing this change would cost \$1495 to buy a new incubator, but the payback time is small, and the CO2 savings and cost savings are large, making this a worthwhile investment.

2.3 Consolidating Cold Storage

2.3.1 Observation

There are two refrigerators currently used in the EHS lab space, a Frigidaire model and Whirlpool model. There was also a model Penguin Jr. which was not in use. We observed that the Frigidaire consumed less power on average than the Whirlpool over the course of 6 hours.

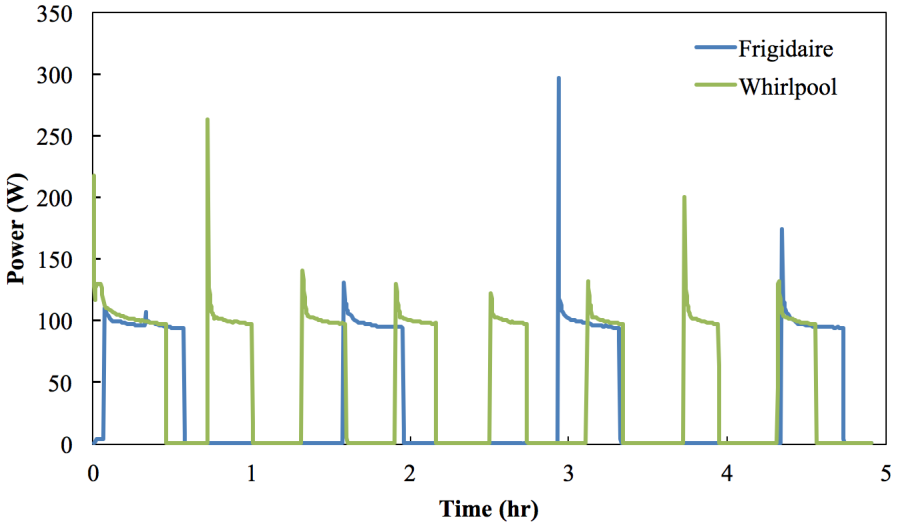


Figure 2.2: Energy Consumption of two refrigerators in the EHS lab space

2.3.2 Recommendation

If possible, consolidating cold storage to one fridge, preferably the Frigidaire model, would provide optimal energy savings. Based on data obtained over the course of 6 hours for the power consumption of the three different fridges in the EHS Lab 2.2, it is clear the Frigidaire model is more energy efficient than the Whirlpool. By integrating power consumption over the time, the total energy consumed by Frigidaire is just 60% that of Whirlpool. The difference in efficiency is also reflected by average power consumption in the table below, showing that using only the Frigidaire could save 45.7 W, while using only the Whirlpool fridge would save 34.8 W.

Energy Savings (kWh/yr)	Energy Cost Savings ($/yr)	CO2 Savings (tons/yr)	Implementation Cost ($)	Simple Payback (yrs)
400	50	0.296	15	.30

2.3.3 Calculations

Energy Savings

$$Energy\ Savings = H * W * k$$

H = Number of operating hours for fridges over one year (8,760 hrs/yr)
W = Average power consumed by Whirlpool fridge, 45.7
k = Conversion constant, 1kW/1,000W

$$ES = 8,760\ hrs/yr * (45.7\ W) * 1\ kW/1,000W = \mathbf{400\ kWh/yr}$$

Cost Savings

$$Cost\ Savings = Energy\ Savings * Usage\ Rate$$

$$CS = 400\ kWh/yr * \$0.1257/kWh = \mathbf{\$50/yr}$$

Reduction in CO_2

$$CO_2 = ES * CO_{2,APCo}$$

$$CO_2 = 400\ kWh * 0.000741\ tons/kWh = \mathbf{0.296\ Tons\ CO_2/yr}$$

where $CO_{2,\ APCo}$ = tons of CO2 produced per kWh electricity generated, 0.000741 tons/kWh [2]

Implementation Cost

$$Payback\ Period = Implementation\ Cost/Cost\ Savings = \$15/\$50 = \mathbf{0.30\ yrs}$$

Implementation Cost = Total Initial Cost, estimated to be $15

Implementing this change would cost perhaps an hour of labor to transfer items being stored, perhaps $15. However, the power saved would yield a very small payback period, making this a very feasible option for drastically improving energy efficiency with very minimal cost.

2.4 Turn off centrifuges when not in use

2.4.1 Observation

The centrifuge tested has a constant
Power Draw of about 2.815 W when plugged in. Assuming a centrifuge is normally operated about 5 times a day at 2500 RPM, for about 10 minutes per session, the standing power draw accounts for 58% of the total energy used in a day, and this number increases if the centrifuge is used less often.

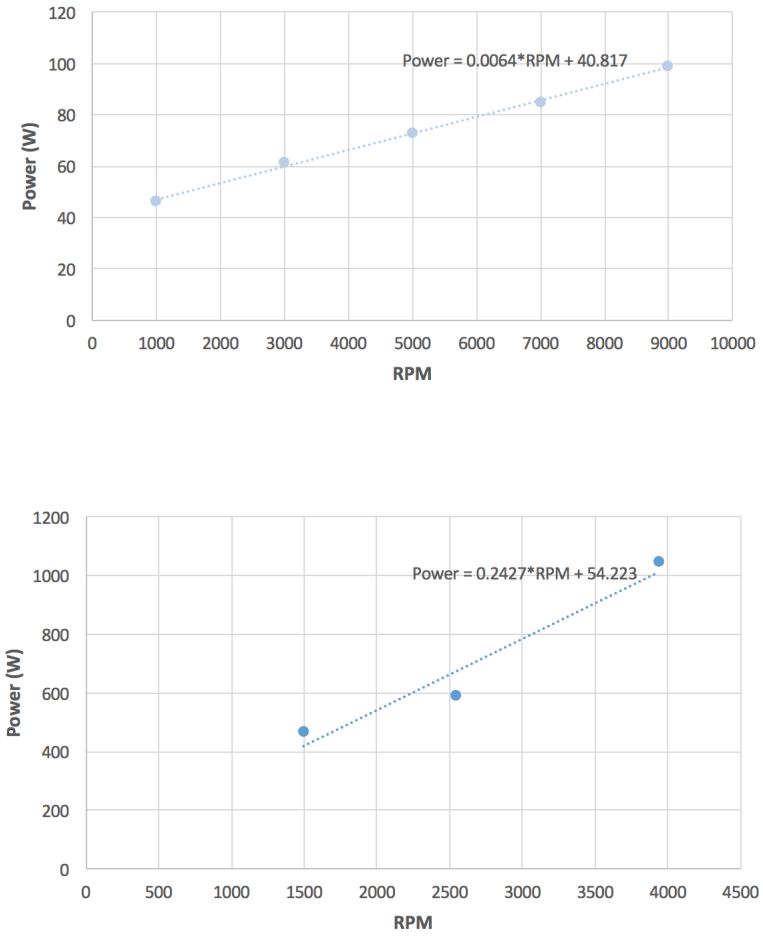


Figure 2.3: *Power Drawn* By Centrifuge per RPM

At 2500 RPM, a 10 minute centrifuge session uses .0095 kWh of energy Used 5 times a day, this amounts to .0475 kWh / day. On standby, the centrifuge draws 2.815 W On standby for 23 hrs 10 mins, it uses .065 kWh/day.

2.4.2 Recommendation

By turning off a centrifuge while not in use, we would eliminate 58% of its total energy consumption2.4.1. This requires very little time and brainpower to make into a habit, and so could be very easily implemented through signs or e-mail reminders.

Energy Savings (kWh/yr)	Energy Cost Savings ($/yr)	CO2 Savings (tons/yr)	Implementation Cost ($)	Simple Payback (yrs)
23.72	3	0.018	0.10	0.03

2.4.3 Calculations

Energy Savings

$$Energy\ Savings = D * W * k$$

D = Number of operating days for fridges over one year (365 days/yr)
W = Average power consumed by Centrifuge
k = Conversion constant, 1kW/1,000W

$$ES = 365\ days/yr * (0.065\ W) * 1\ kW/1,000W = \mathbf{23.72\ kWh/yr}$$

Cost Savings

$$Cost\ Savings = Energy\ Savings * Usage\ Rate$$

$$CS = 23.72\ kWh/yr * \$0.1257/kWh = \mathbf{\$3/yr}$$

Reduction in CO_2

$$CO_2 = ES * CO_{2,APCo}$$

$$CO_2 = 23.72\ kWh * 0.000741\ tons/kWh = \mathbf{0.018\ Tons\ CO_2/yr}$$

where $CO_{2,\ APCo}$ = tons of CO2 produced per kWh electricity generated, 0.000741 tons/kWh [2]

Implementation Cost

$$Payback\ Period = Implementation\ Cost/Cost\ Savings = \$0.10/\$3 = 0.03\ yrs = \mathbf{12\ days}$$

Printing a page costs $0.10 and a negligible time commitment.

Best Practices

1.Freezer was chilled up to -70 C

The average power consumed at -75 degrees Celsius was around 206 W, while the average power consumed when the freezer was set to -70 degrees Celsius was just 177 W. This means that the freezer consumes around 17% more power at just five degrees lower. Therefore, it would be most energy efficient to chill up and keep the freezers at slightly higher temperatures whenever possible.

2. Penguin Jr. refrigerator is not used

Continuing not to use the Penguin Jr. fridge is a best practice because it was by far the most energy inefficient of the three fridges, consuming nearly four times as much power as the Frigidaire model. Keeping this model out of use as much as possible, therefore, is the optimal option.

3. Small lab equipment was generally turned off when not in use

equipment was generally turned off when not in use. We had to turn on most of the equipment that we logged data for.

References

[1] LabX, https:\www.labx.com/item/90-day-wty-heraeus-bb16-function-line\-co2-incubator/LV36681088

[2] Alabama Power Company,