D2: Shut the Sash: A Green Labs Effort to Reduce Lab Energy Use at Caltech

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Any questions please email: greenlabsinfo@caltech.edu

For more information visit https://greenlabs.caltech.edu

A Green Labs Effort to Reduce Lab Energy Use at Caltech

***First: fair warning…. There are some gifs in this presentation

1. Green Labs origin story
2. Fume hood MASH project
   a. Bhakti Ahir Ahir
3. Lab plug load project
   a. Aarohi Patel
4. Translating energy savings into a full time position(s)
5. Thank you and questions

There were once two lab managers…

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- Mid-2022 gathered like-minded folks to discuss sustainability in labs
- Wrote our ideas up as a proposal and asked our division head for some money
- A month later (September 2022), we were granted $10k for a year
  - Condition that we show growth and improvement, especially in Green Labs Certifications
  - Mutually beneficial relationship

Caltech Green Labs

- Mission statement: Help labs adopt sustainable laboratory practices that do not compromise research objectives.

Caltech Green Labs

When we first began, we got really good advice from Kathy Ramirez-Aguilar:

START CAMPAIGNING FOR A FULL TIME POSITION ASAP

Caltech Green Labs

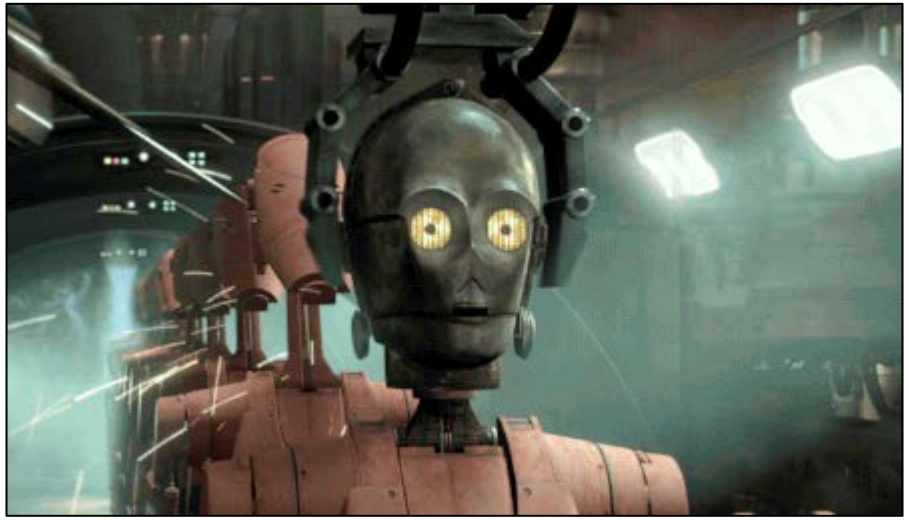
- Developed a website, an email listserv and an email for questions
- Incorporated into monthly newsletters, and the Sustainability Report
- Engagement with community
  - Green Labs Certification program
  - Meetings
  - Events →
- Resources galore
  - (Guides, Action Plan, Fact Sheets, Signage, Social media)

Pilot programs (and data!)

- Tabletop (Lomi) composters
  - 6,563 lbs food waste diverted in 2 years
- Sample storage temperature comparison
  - -70˚C/-80˚C storage shows no difference after 1 year
- Lab waste recycling programs
  - 2,775+ pounds of plastic waste diverted in 2 years
- Styrofoam recycling
  - 30+ dumpsters diverted in 6 months
- Pipette tip wash/reuse
- Test sustainable products in labs

All volunteer work!

- Presented multiple times to Caltech leadership
  - Didn’t bite…
- THEN…

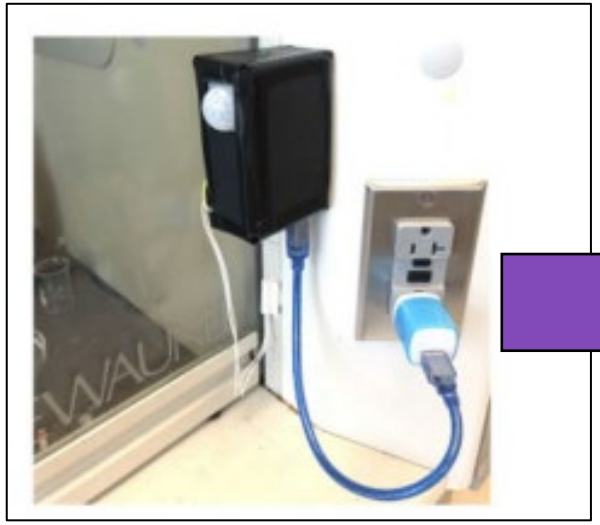


Summer student extraordinaire!

- Summer 2024 I was approached by 3rd year Genevieve Gandara

- She wanted to work on lab sustainability, and proposed building fume hood Motion and Sash Height (MASH) sensor
  - Wanted to see if we could realize same potential energy savings as other institutions

Genevieve's MASH sensor

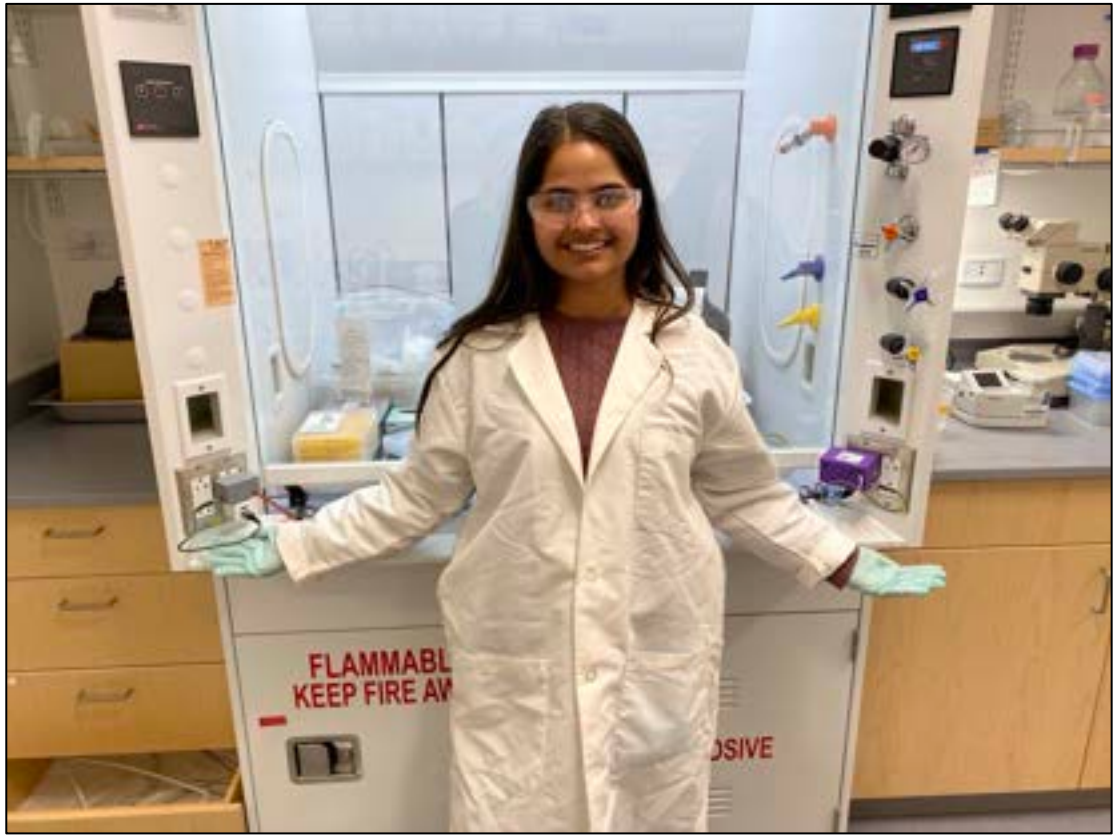


MIT MASH Sensor

Saved
$1,250
per fume
hood

MASH project – Bhakti Ahir Ahir

- Bhakti is a sophomore at Caltech studying Biochemistry. She developed a fume hood motion and sash height sensor designed to reduce energy consumption in laboratories. She is passionate about developing innovative solutions to real-world problems and contributing to society. After Caltech, she plans to attend medical school.



Enhancing Motion and Sash Height (MASH) Alarms to Increase Fume Hood Energy Efficiency

By: Bhakti Ahir Ahir

PI: Julia Kornfield

Mentors: Dennis Ko, Tasha Cammidge, Maximilian Christman

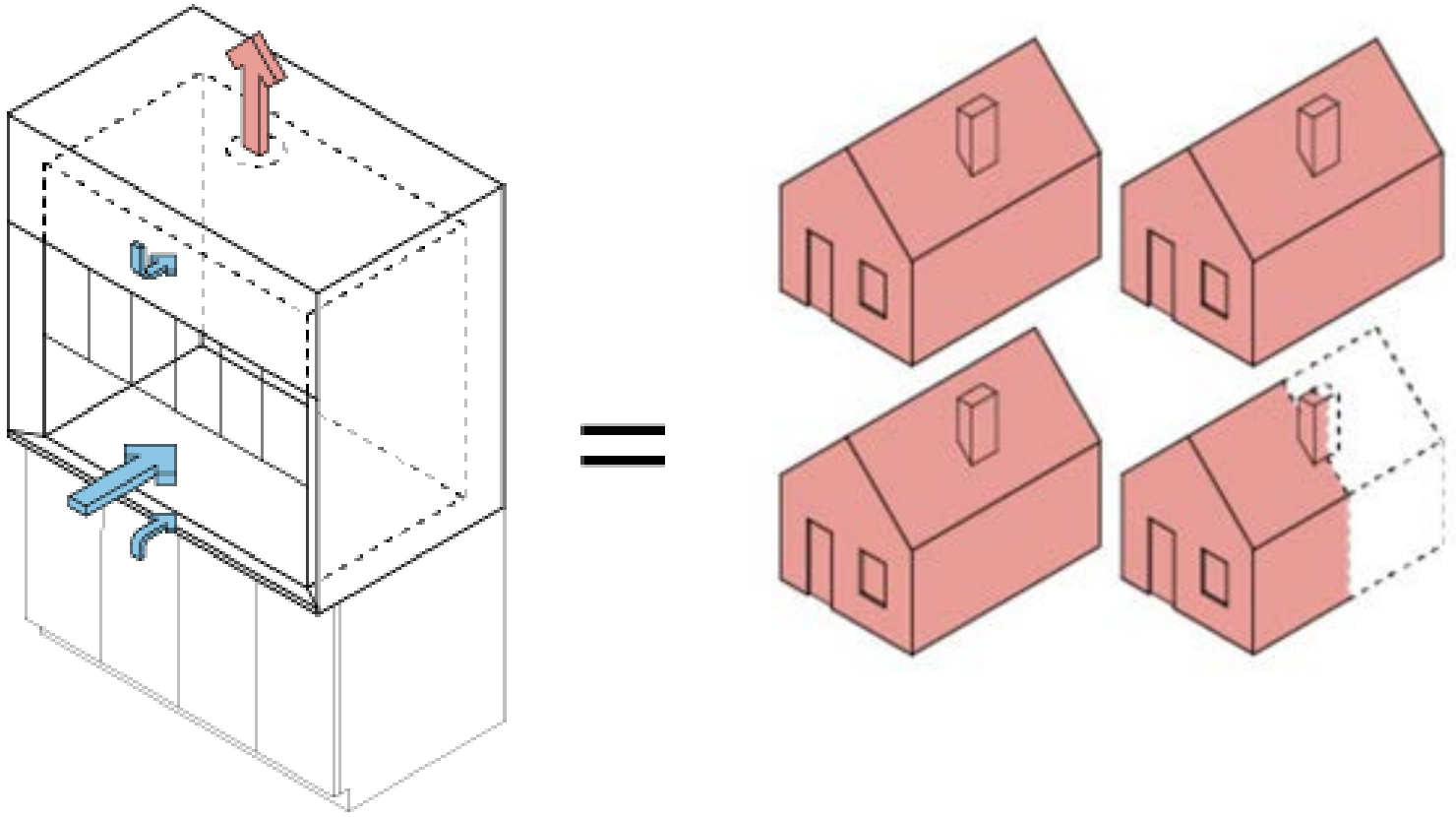
Caltech

Roadmap

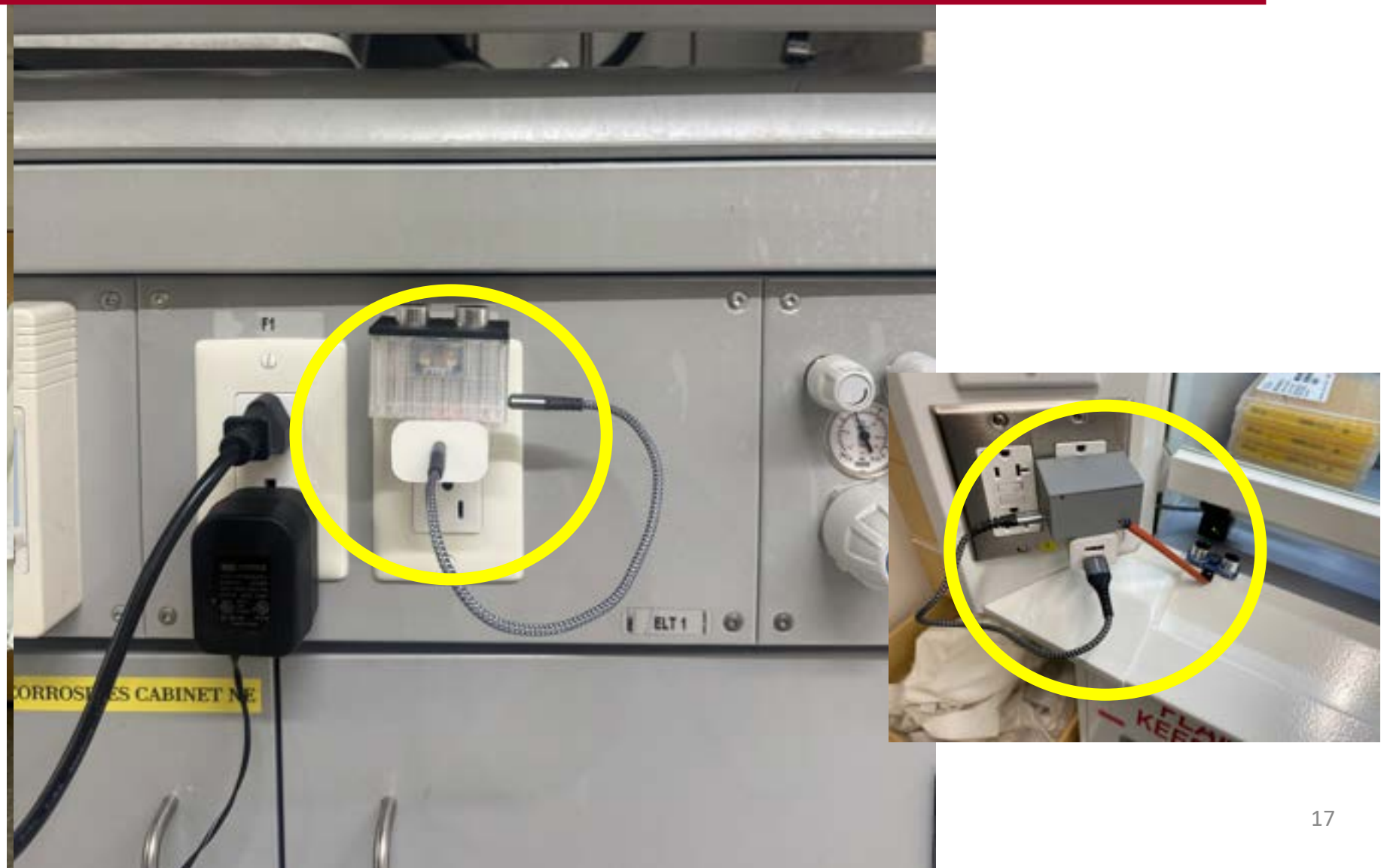
1. Introduction
2. Background
3. Methods
4. Cost Implications
5. Conclusions

Fume Hoods Account for 70% of a Laboratory's Energy Consumption

Consumes as Much Energy as 3.5 Houses

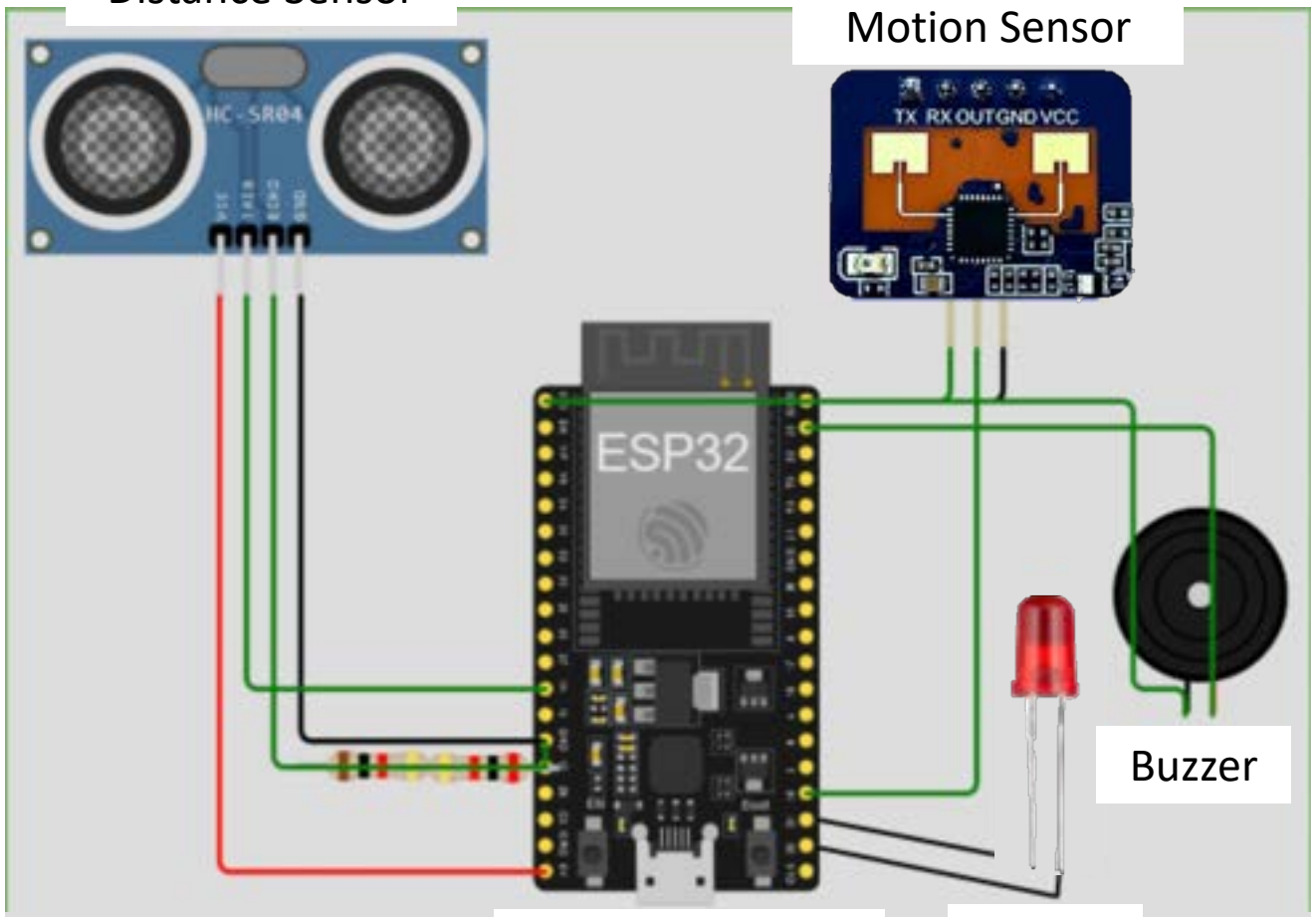


2025's Improved MASH Sensor

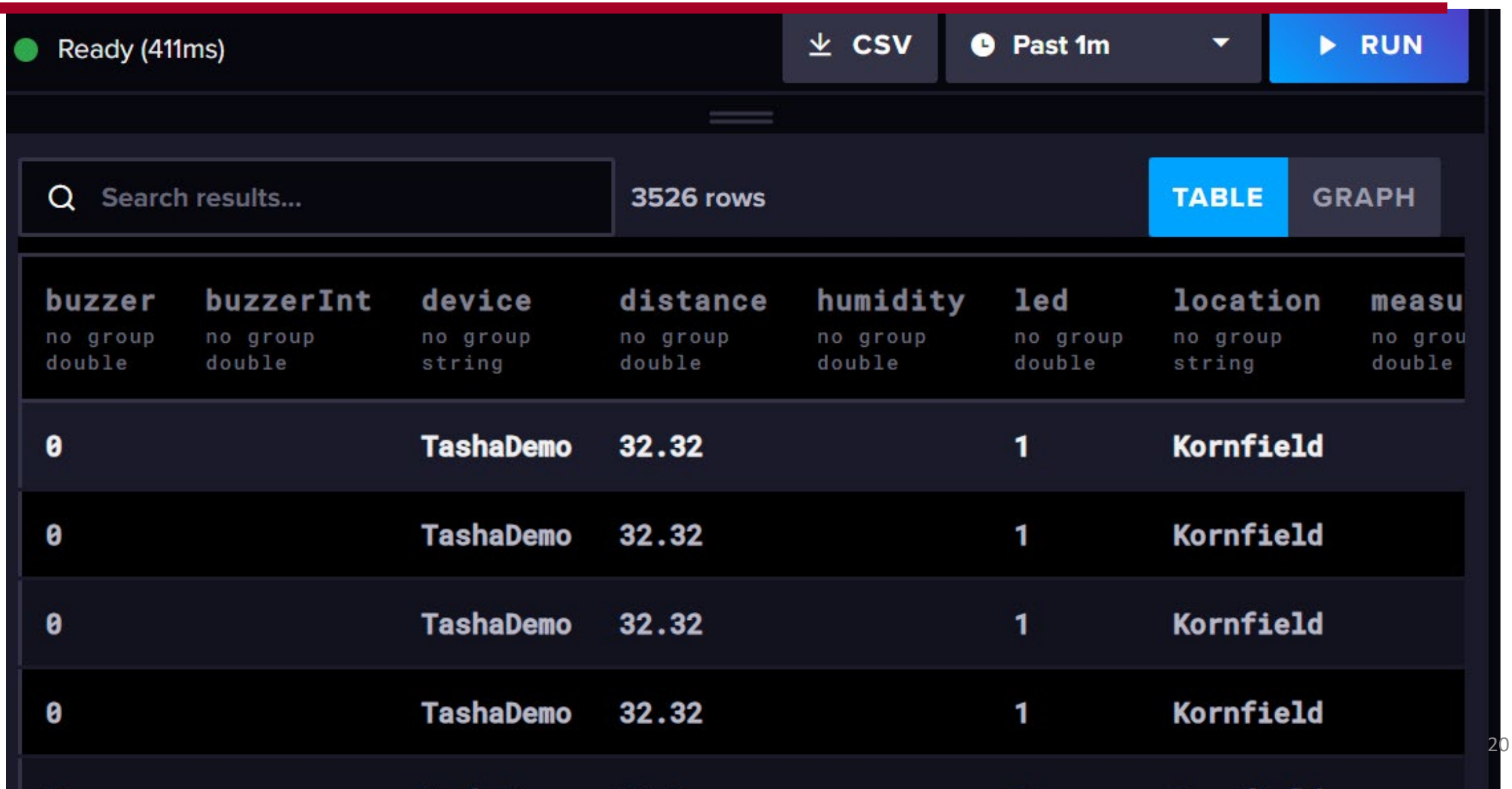


2025's Improved MASH Sensor

Sensor Components



Influx DB - Time Series Data Monitoring



buzzer no group double	buzzerInt no group double	device no group string	distance no group double	humidity no group double	led no group double	location no group string	measu no grou double
0		TashaDemo	32.32		1	Kornfield	
0		TashaDemo	32.32		1	Kornfield	
0		TashaDemo	32.32		1	Kornfield	
0		TashaDemo	32.32		1	Kornfield	

Grafana – Graphs Data + Allows User-Interface

Potential Cost Implications of Sensor

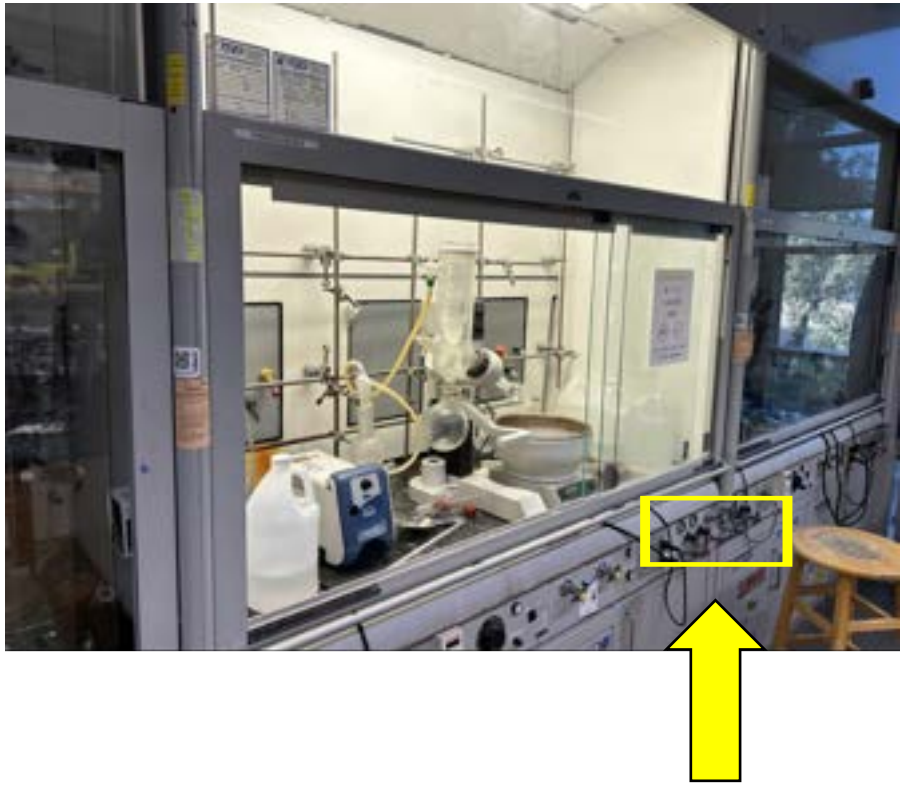
~$10,000 to run a single fume hood/year

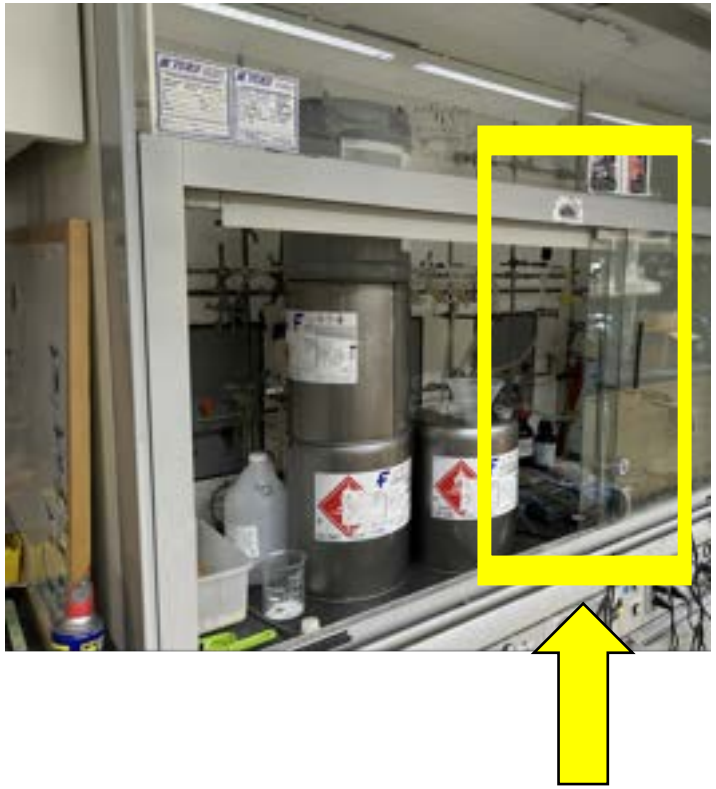
*extrapolated to 1 yr

<$15 to make sensor

Future work

- Improve user visualization
- Incorporate PCB to reduce wiring
- Battery Powered
- New mounting locations
- Ability to calibrate sensor on device





Thank you!

Plug load project – Aarohi Patel

- Aarohi is an undergraduate at Caltech studying Electrical Engineering and Robotics. She is a research fellow at Green Labs and launched the Energy Saving in Labs program at Caltech. In the future Aarohi would like to continue working in sustainability combining her experience with hardware to build technology using recycled parts.

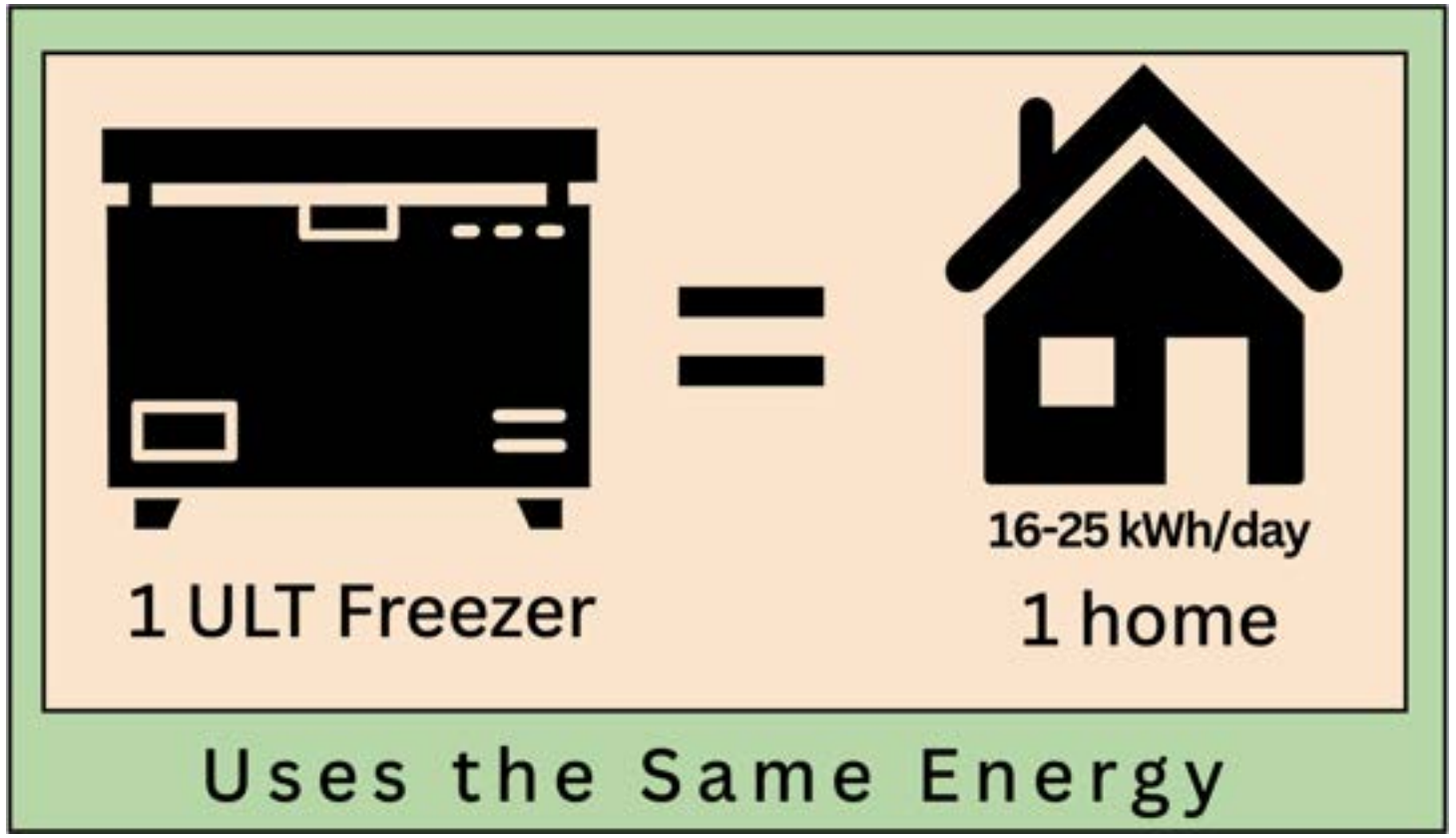
Measuring Energy Usage in Research Labs to Reduce Caltech's Energy Consumption

Aarohi Patel

Caltech | Kornfield Lab

PI: Julie Kornfield
Mentors: Tasha Cammidge and Dennis Ko
Maximillian Christman

What's the Problem?

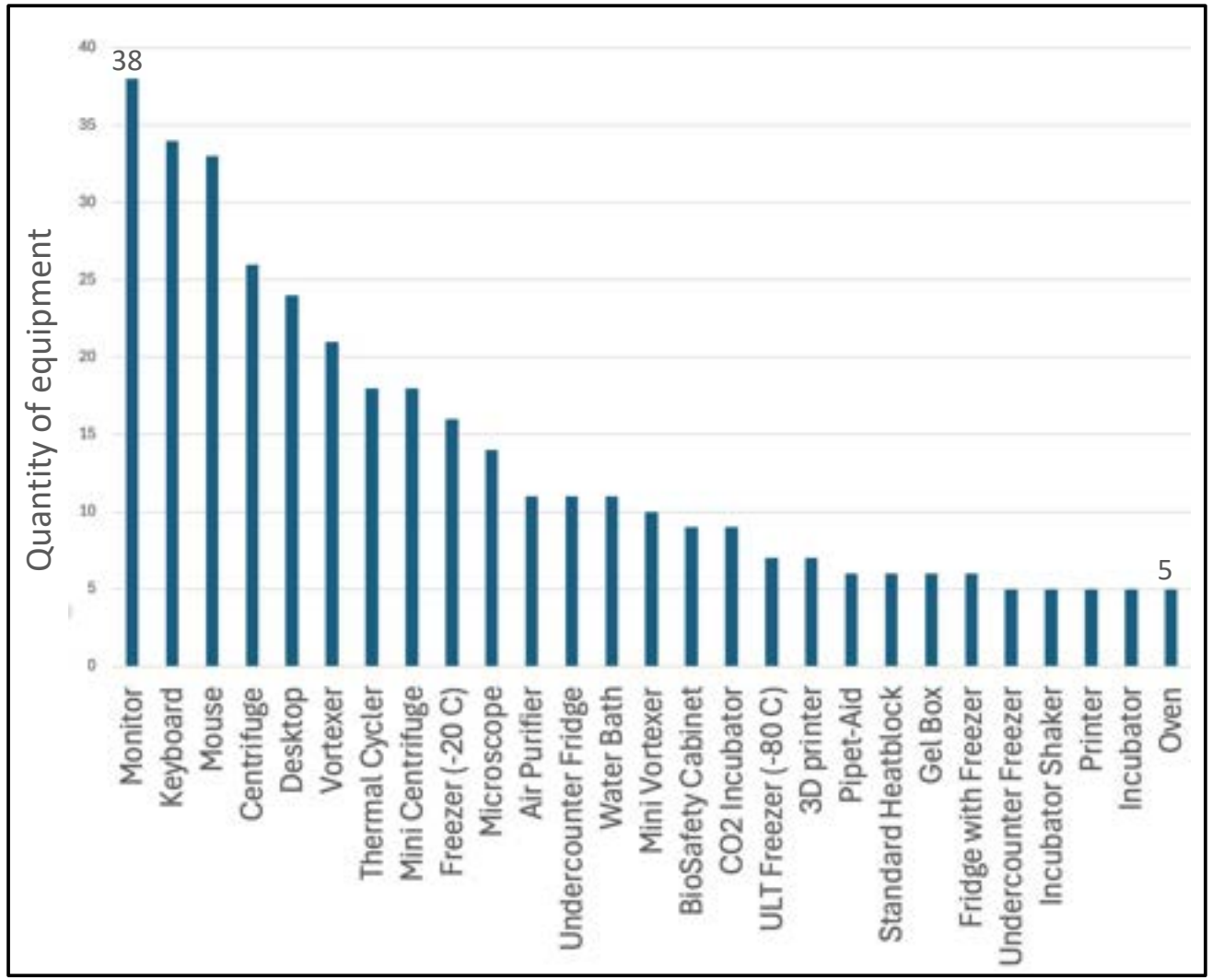


Caltech spent $24.8 million on energy costs in 2024

75% of costs come from research labs

What Items Should I Target?

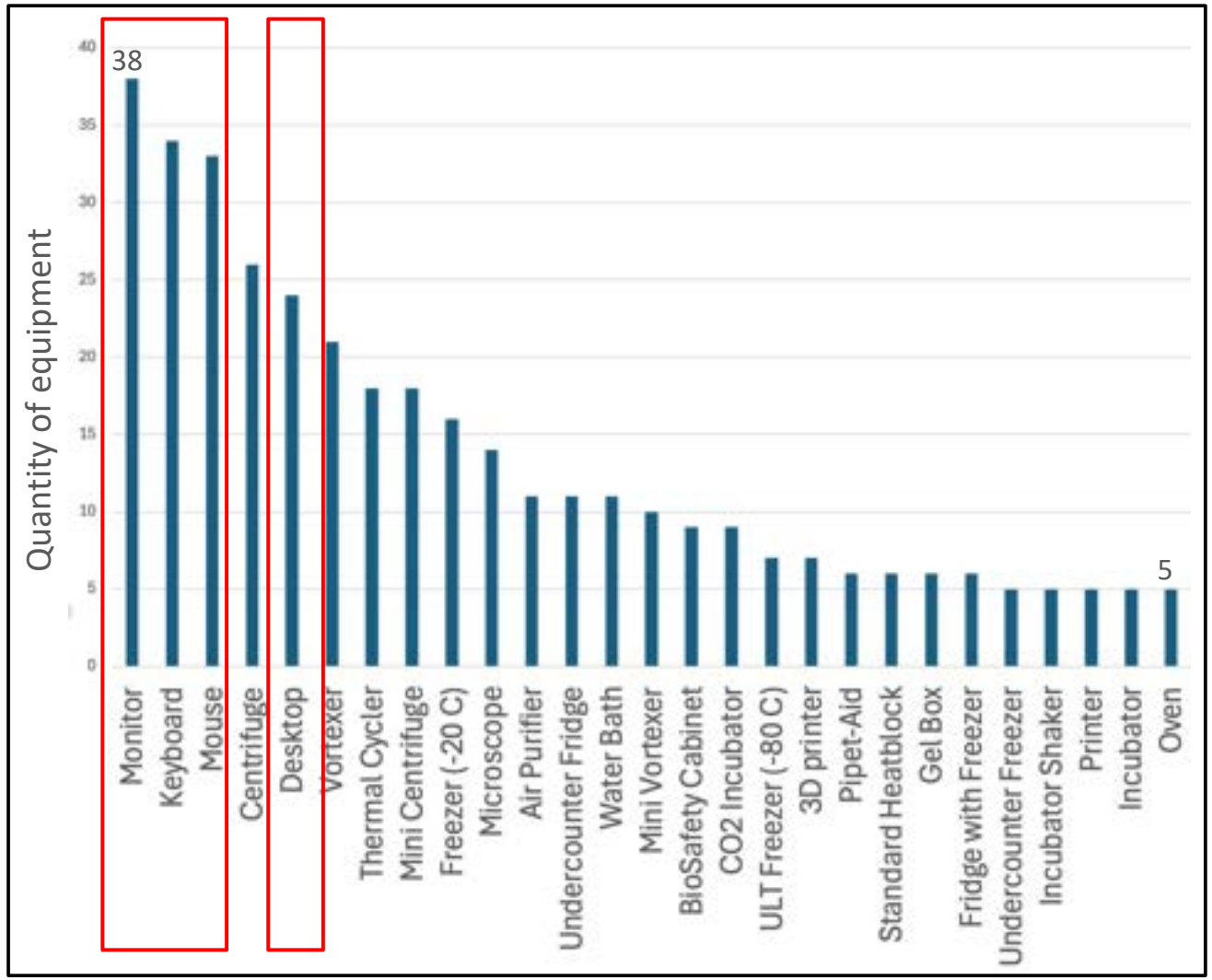
Organized Equipment by Quantity



What Items Should I Target?

Organized Equipment by Quantity

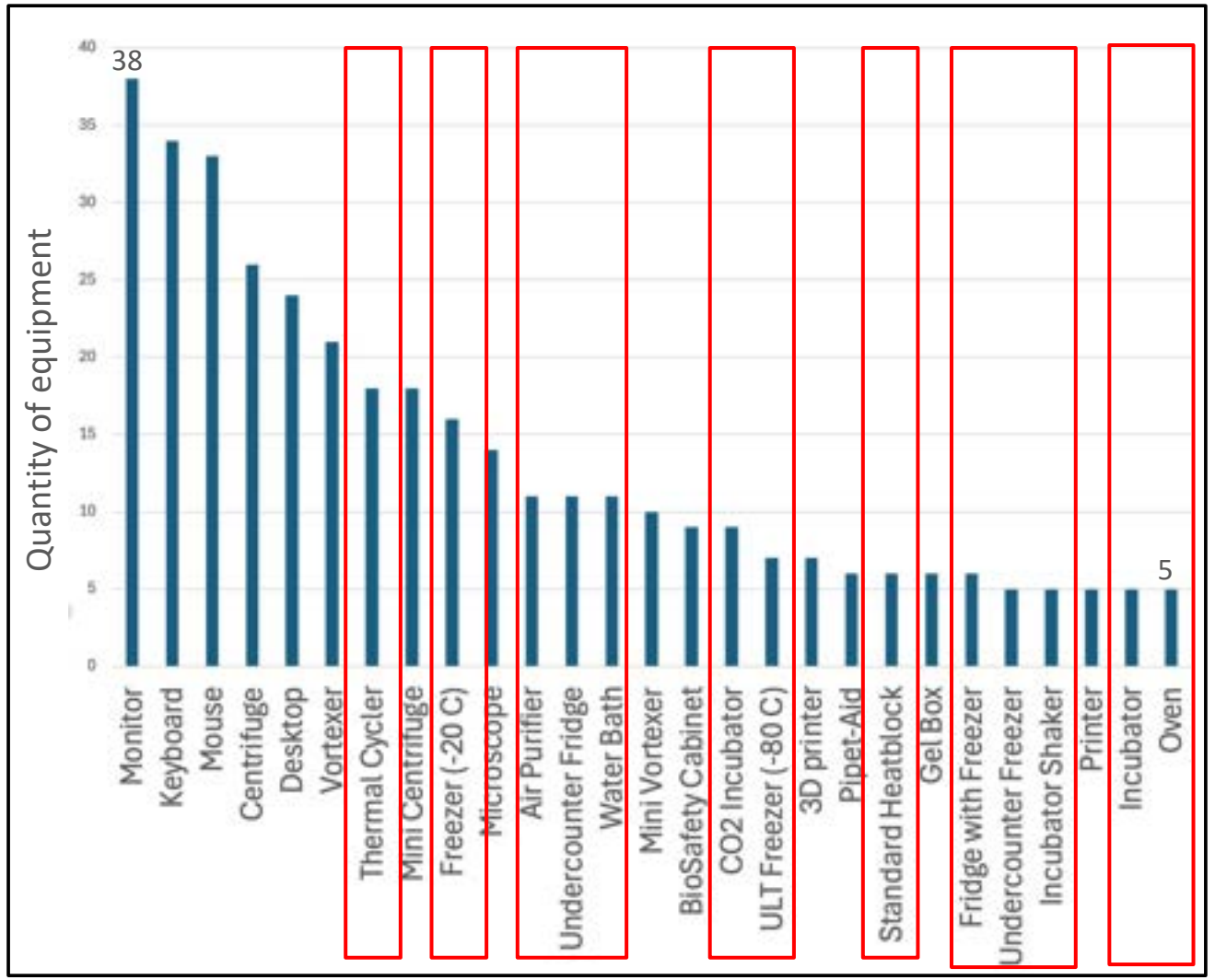
- There's a lot of office equipment in labs



What Items Should I Target?

Organized Equipment by Quantity

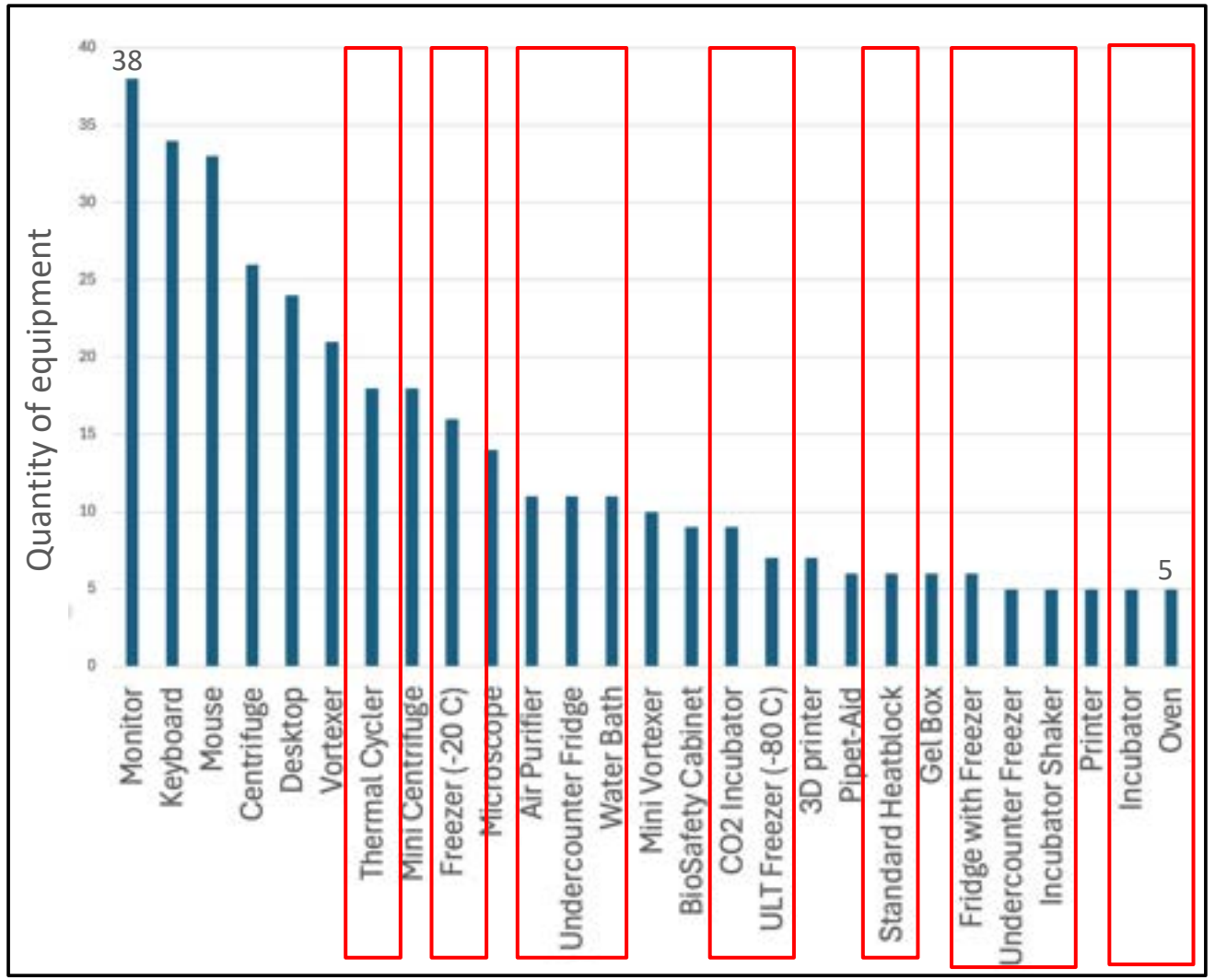
- There's a lot of office equipment in labs
- A lot of heating and cooling equipment



What I Decided to Measure?

Conducted the Energy Monitoring Experiment in a **singular lab** with **access to all this equipment**

Installed Govee Smart Plugs with Energy Monitoring into 20 pieces of equipment

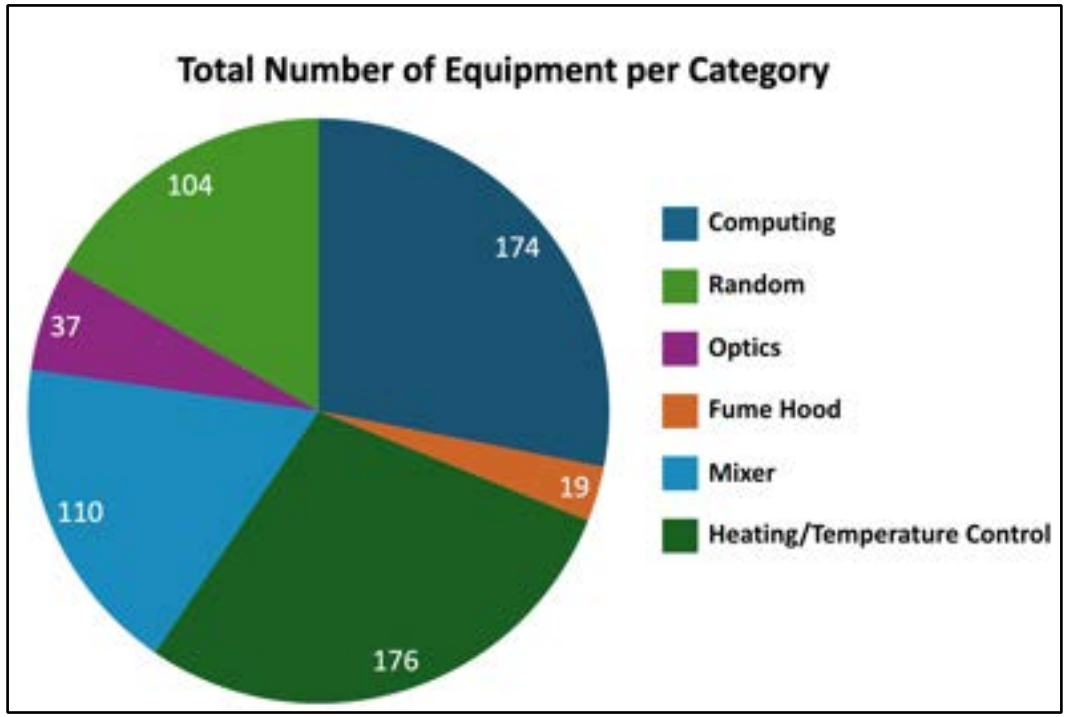


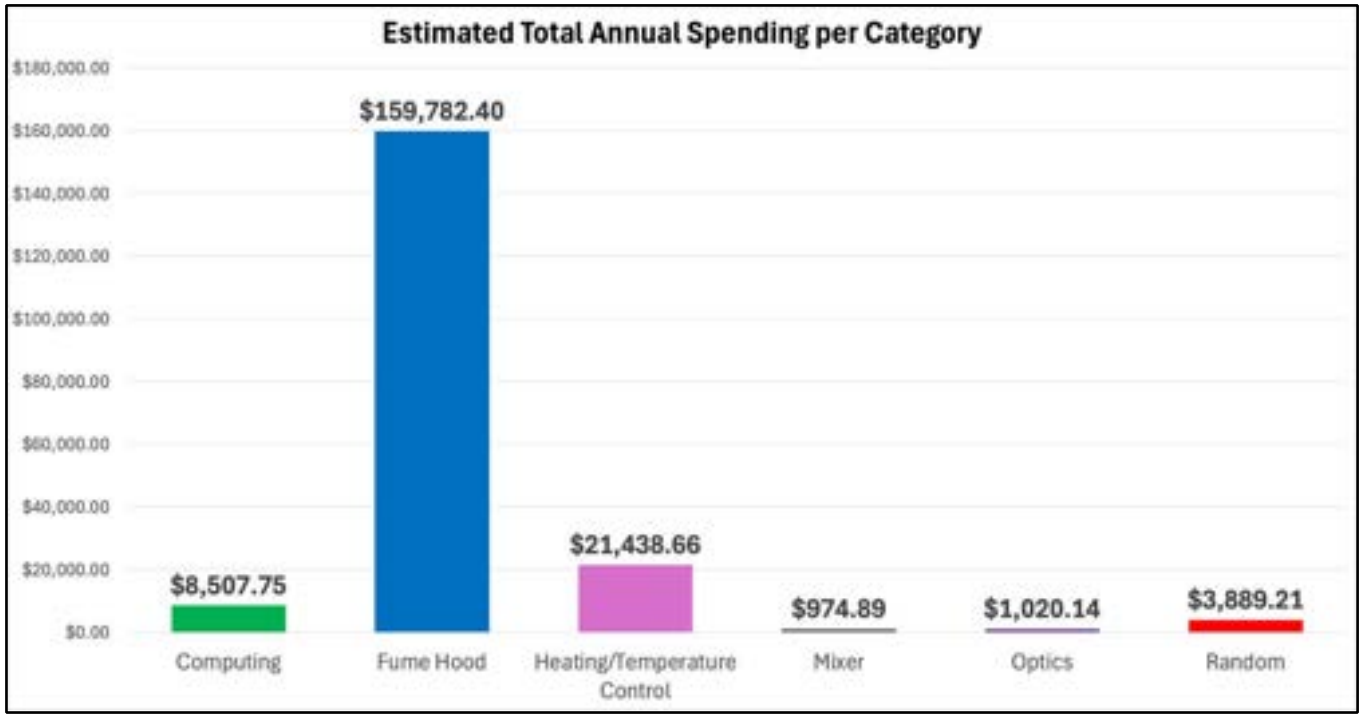
What is the Database?

- A **collection of the equipment (619)** inventoried during the walkthroughs with categorization and energy consumption information.

- Created and built as a source for lab managers and researchers to use as **reference for their own lab energy calculations**

Which Category Had the Most Energy Costs?



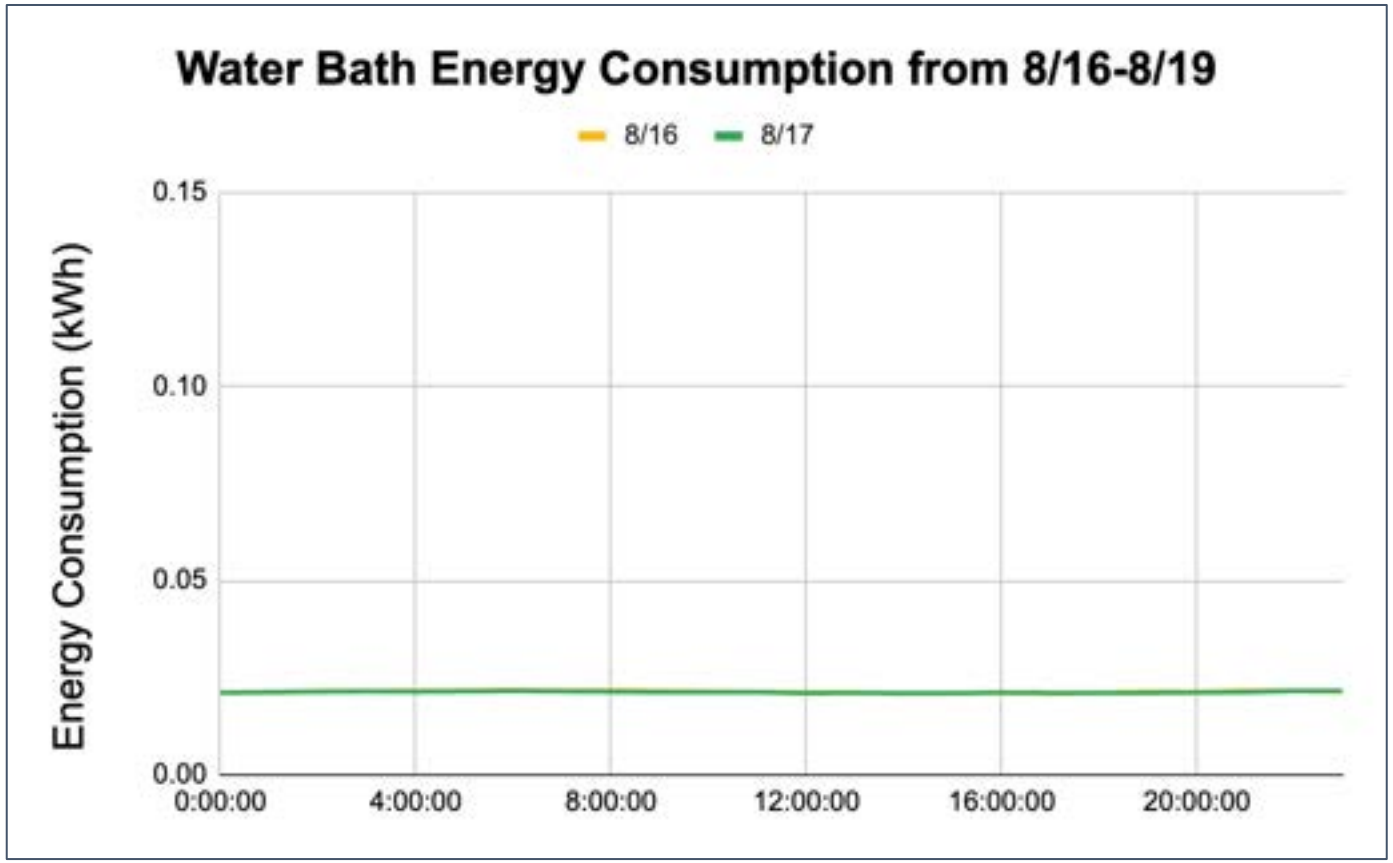


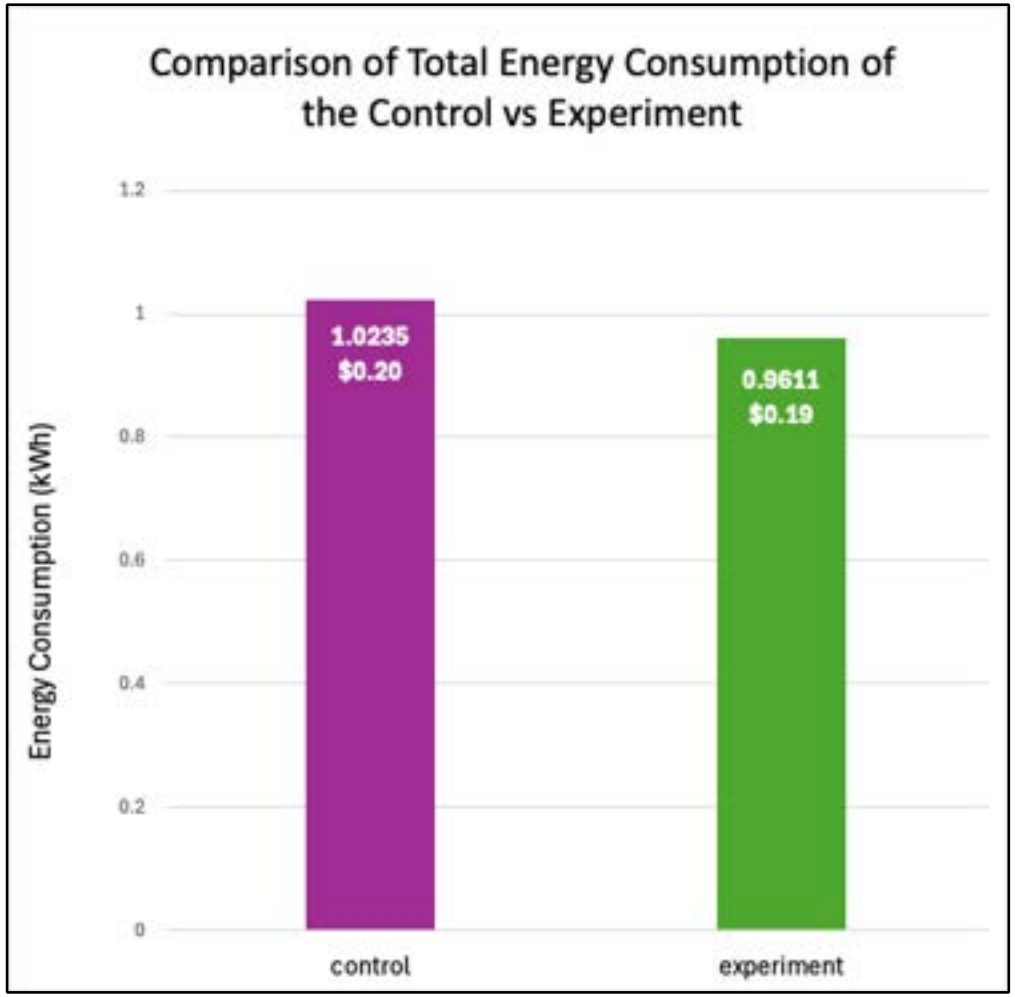
Highest Energy Consumption: Fume Hood and Heating/Temperature Control

Category to target → Heating Temperature Control (water bath)

What was my Energy Saving Experiment?

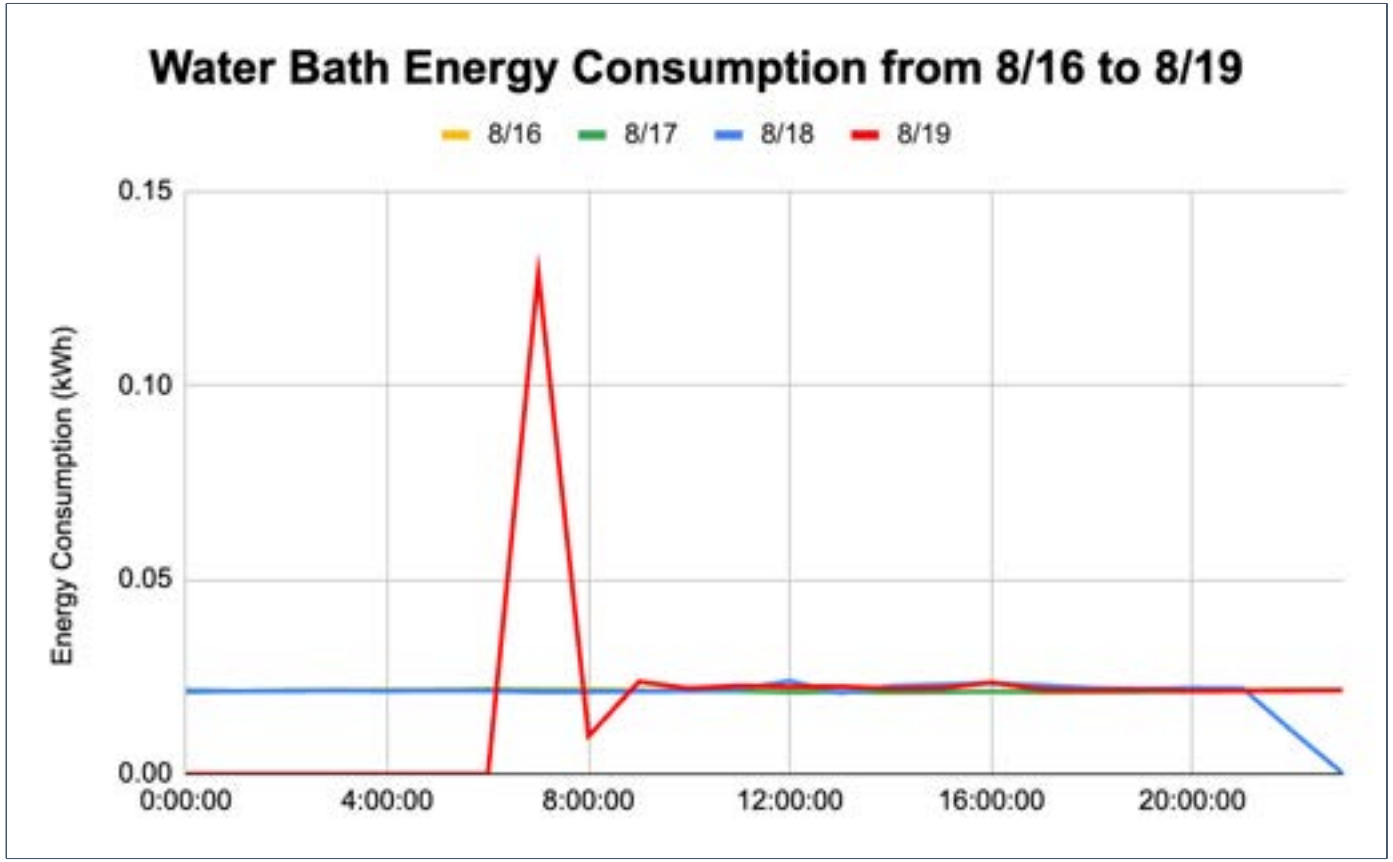
Water Bath Experiment:

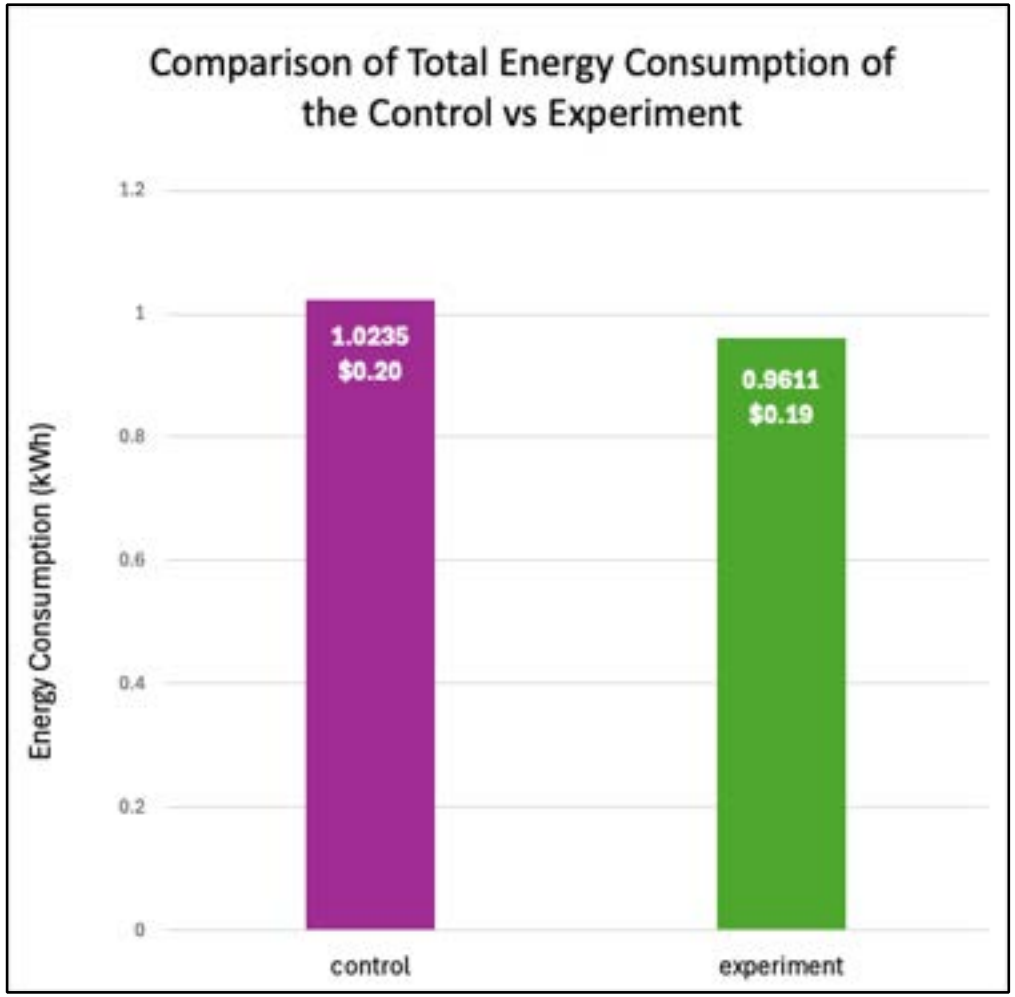




What was my Energy Saving Experiment?

Water Bath Experiment:



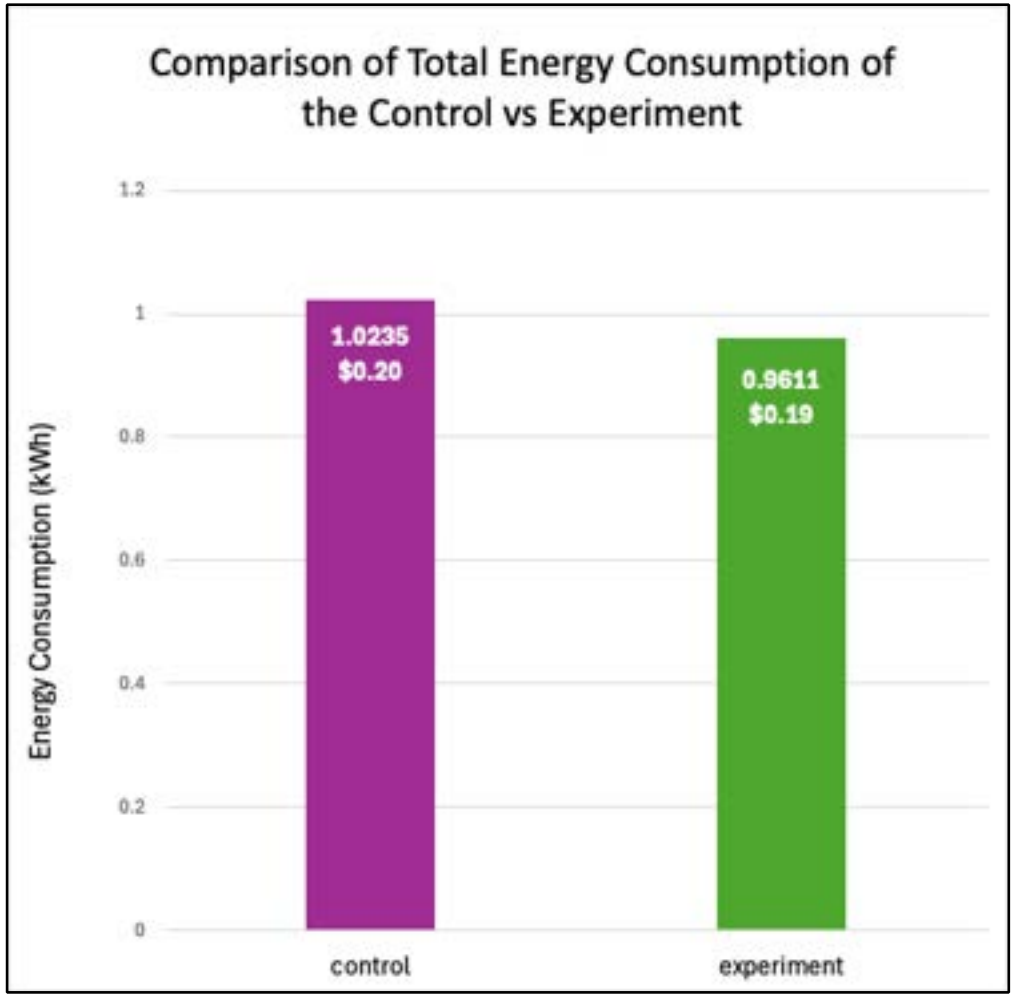


What was my Energy Saving Experiment?

Water Bath Experiment:

The experiment saved **0.0624 kWh** using shutoff protocol and resulted in **$0.01** of savings (over 2 days)!

For a whole year → $1.825 (365 x $0.01/2)



Outcomes of My Energy Saving Experiments?

- ➔ Created recommendations for better lab practices for Caltech labs
- ➔ Caltech labs on average can save $2.88/sq ft if they incorporate our recommendations

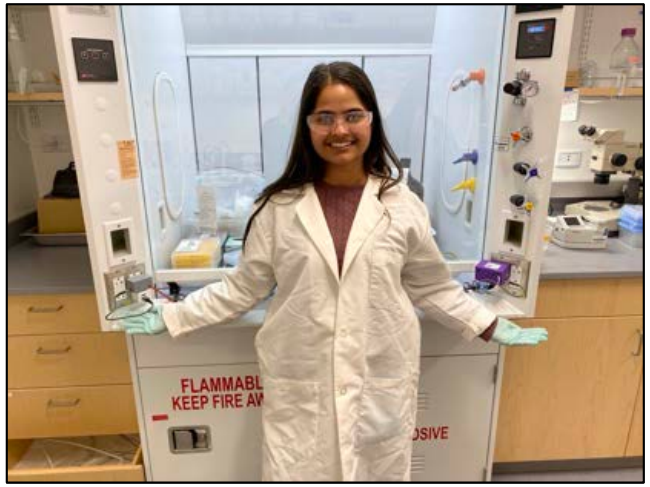
My Plans for the Future!

- ➔ Build my own energy monitoring system prototype
- ➔ Create stickers for high consuming devices and send out energy data collected and potential saving strategies to all labs participating
- ➔ Make the database accessible to all lab managers at Caltech

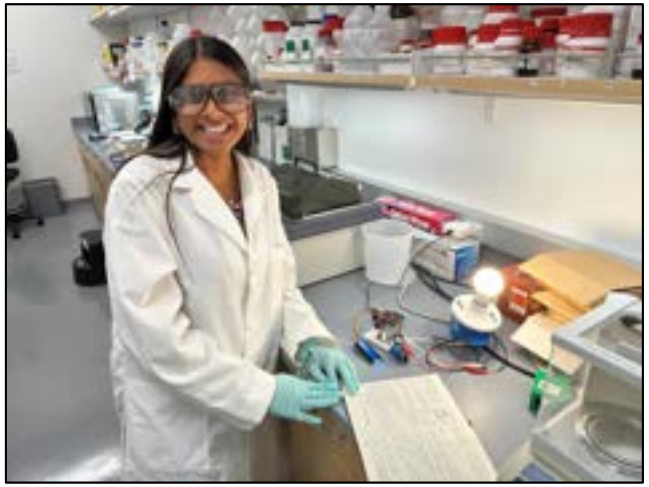
Thank you!

Potential savings extrapolated…

Genevieve Gandara (2024)



Bhakti Ahir Ahir (2025)



Aarohi Patel (2025)

Total

$39 K

700+ fume hoods ($100k+ potential)

$2.88/ SQ FT

1.9M research sq ft ($100k+ potential)

Turn these cost savings into a full time position(s)

- Presented once again to Caltech leadership
- HUGE amount of support from Manager of Sustainability Programs (Max Christman)

- FINALLY convinced leadership to create… multiple positions!

Turn these cost savings into a full time position(s)

- Our work on energy savings and recycling/compost programs has (in part) validated the creation of:
    - Recycling and Materials Coordinator (Chris Kalaw)
    - Recycling Team Lead x2
    - Green Labs Coordinator (…)

New Green Labs Coordinator!

Turn these cost savings into a full time position(s) + projects!

- Our data also contributed to Graduate Student projects being realized
  - Compost bins installed outside the student housing on campus
  - Good thing too…!

- Permanent recycling programs for Styrofoam and pipette tip boxes

What turned the tide?

- DATA
- Volunteers collected data from multiple projects
  - Fume hood study and energy reduction in labs
  - Sample storage temperature comparison study
    - Saved 30% energy when switching from -80 to -70
  - Autoclaves
  - Sustainable purchasing and reuse
  - Recycling and composting initiatives

What turned the tide?

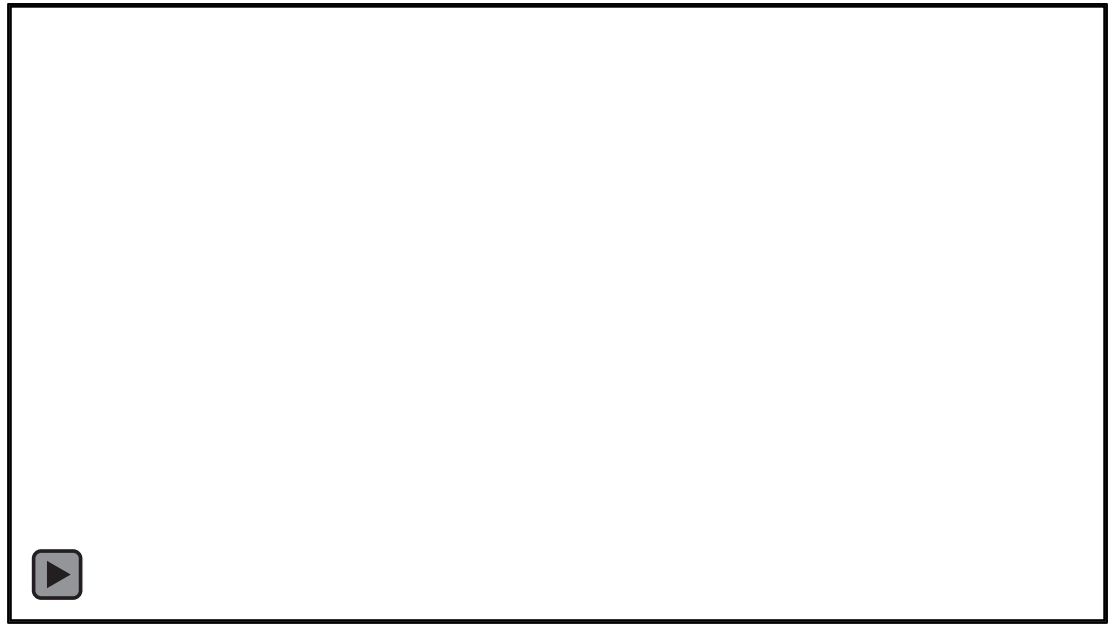
- MATH
  - Calculated how much money we could save Caltech if we enacted simple changes across the campus
  - Those savings could pay for multiple roles
    - For example: savings from fume hood project alone potentially saves at LEAST $100K annually!
    - Just ONE example

What turned the tide?

- (SOCIAL) PRESSURE

What turned the tide?

- (SOCIAL) PRESSURE
  - Students on the Graduate Student Council
    - Have a lot of sway on campus
  - Lab Managers, Professors, Technicians, and more
  - Presented at events such as Division retreats, safety meetings for Divisions
  - Certification Program was VERY popular
  - High-visibility events (Styrofoam Bowling)

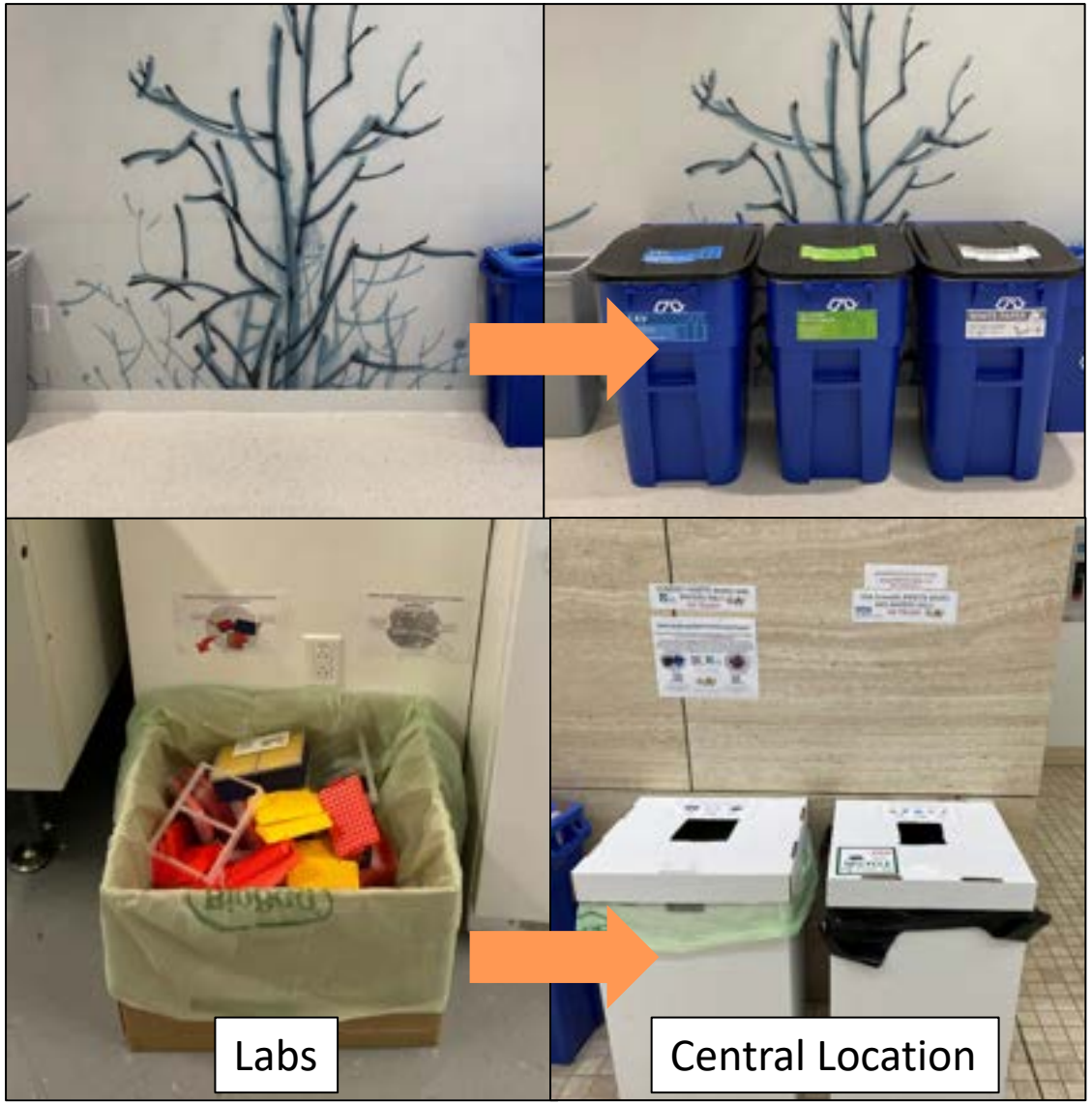


Labs WANT to be sustainable!

- For example, labs:
  - Willing to sort their recycling
  - Willing to travel to recycle
  - Need infrastructure and support to be in place

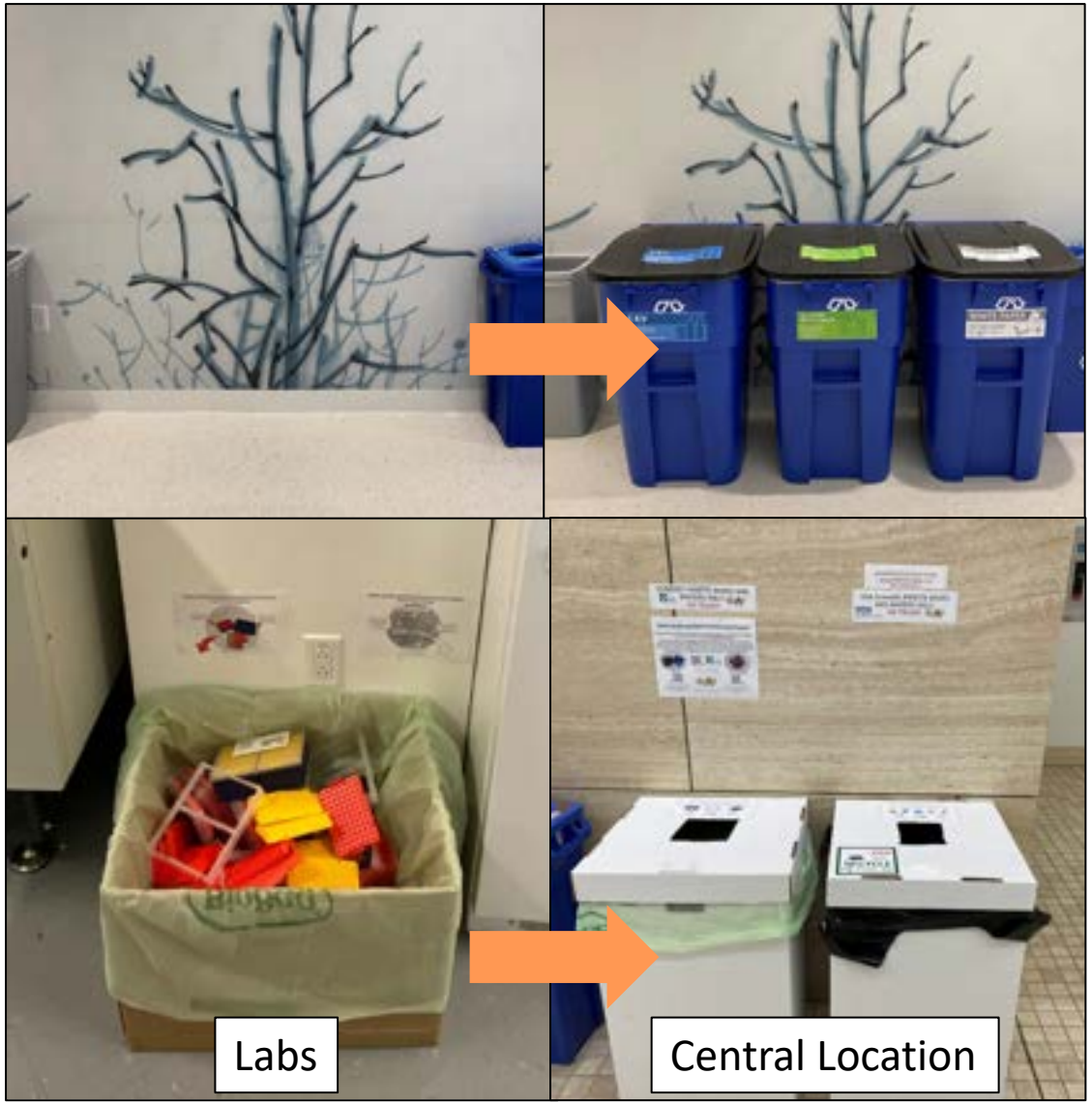
- SOMEONE needs to organize and run these programs, and volunteers are not to effectively

- Used these lessons and the passion of our volunteers to put pressure on leadership



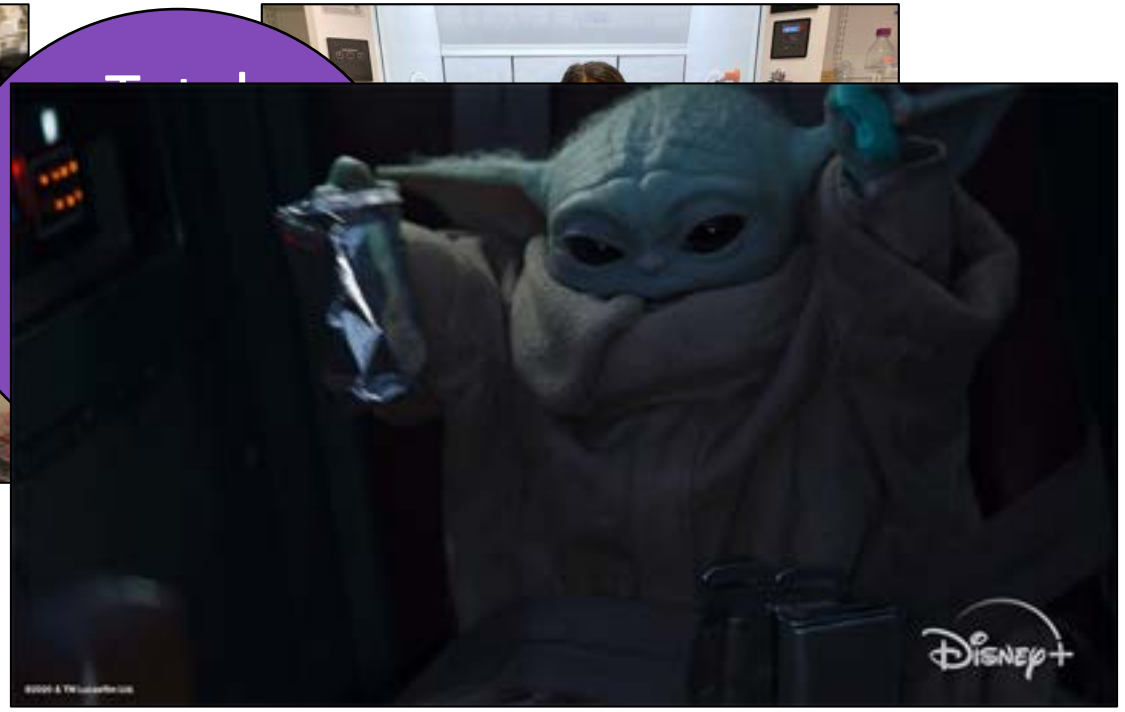
Advice for other programs

- Choose simple projects (like MASH) that have a large impact
- Collect lots of DATA
- Do the MATH for the entire campus
- Put PRESSURE on administration
- SHOW (off) YOUR WORK
- Share our data!



Potential savings extrapolated…

Genevieve Gandara (2024)



Aarohi Patel (2025)

$2.88/ SQ FT ($100k+ potential)

DATA, MATH, (SOCIAL) PRESSURE = FULL TIME POSITION!

Caltech green labs

Thank you:

- Caltech Green Labs!
- Caltech BBE and Facilities/Sustainability for funding
- John Stauffer Charitable Trust and Caltech Chemical Engineering Department for funding
- Summer Undergraduate Research Fellowship (SURF)
- David Feldser and Alexander Malinowski from the electric shop
- Christopher Kalaw
- **Genevieve Gandara and other Caltech volunteers**
- **Maximilian Christman**
- **Dennis Ko**
- **Julie Kornfield and lab members**
- **Kathryn A. Ramirez-Aguilar** (CU Boulder) and the UAG!

We're on Instagram!

CALTECHGREENLABS

Questions?

Green Labs LinkTree

Any questions please email: greenlabsinfo@caltech.edu

For more information visit https://greenlabs.caltech.edu