Saving Energy in Labs: The Chief Campus Consumer

Better Buildings Summit

May 10, 2016

9:45 – 11:00 AM EDT

Agenda

- This session will describe a comprehensive training program for laboratory operations and maintenance personnel, the results of a study on laboratory plug loads, and a North American Laboratory Freezer Challenge. Organized by the International Institute for Sustainable Laboratories (I^2SL) this session will provide information for enduring energy efficiency and environmental sustainability in laboratories.

Today's Presenters

The speakers for this session are:

- Tom Smith, President ECT Inc.
- Kathy Ramirez, Laboratory Sustainability Manager, University of Colorado Boulder
- Allison Paradise, Executive Director, My Green Lab

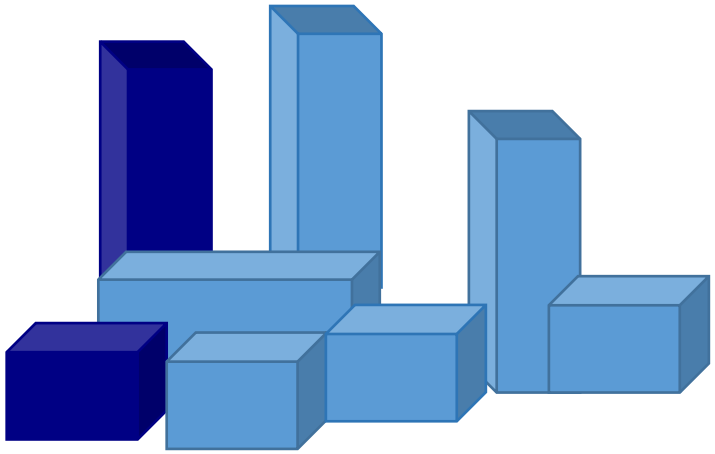
The moderator is:

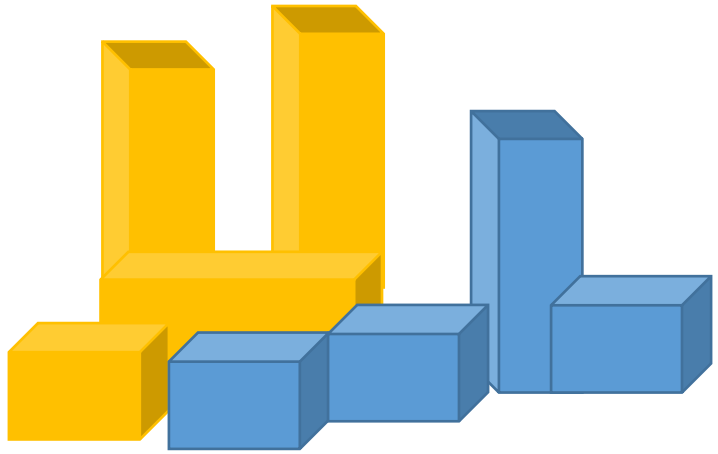
- Phil Wirdzek, President and Executive Director I^2SL

The Elephant in the Room: Tackling Efficiency in Labs

my green lab.

laboratories are the largest consumers of energy at research universities



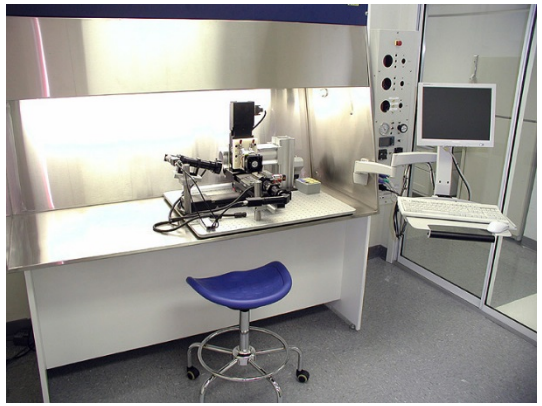


why are labs so energy-intensive?

labs contain many pieces of *energy-intensive equipment* that generally operate 24/7

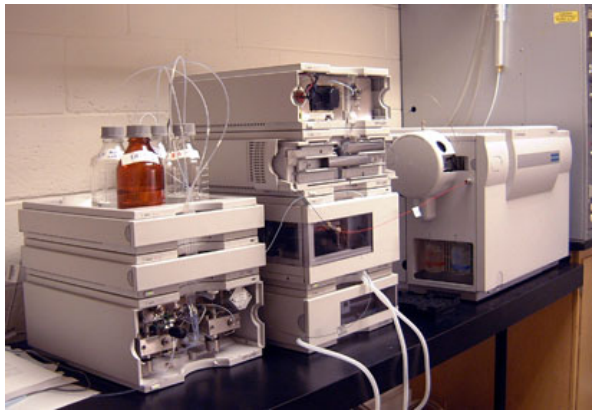

Cole-Parmer


BVC




WHIRLIMIXER


Benchmark
37.0
Digital Heat Block

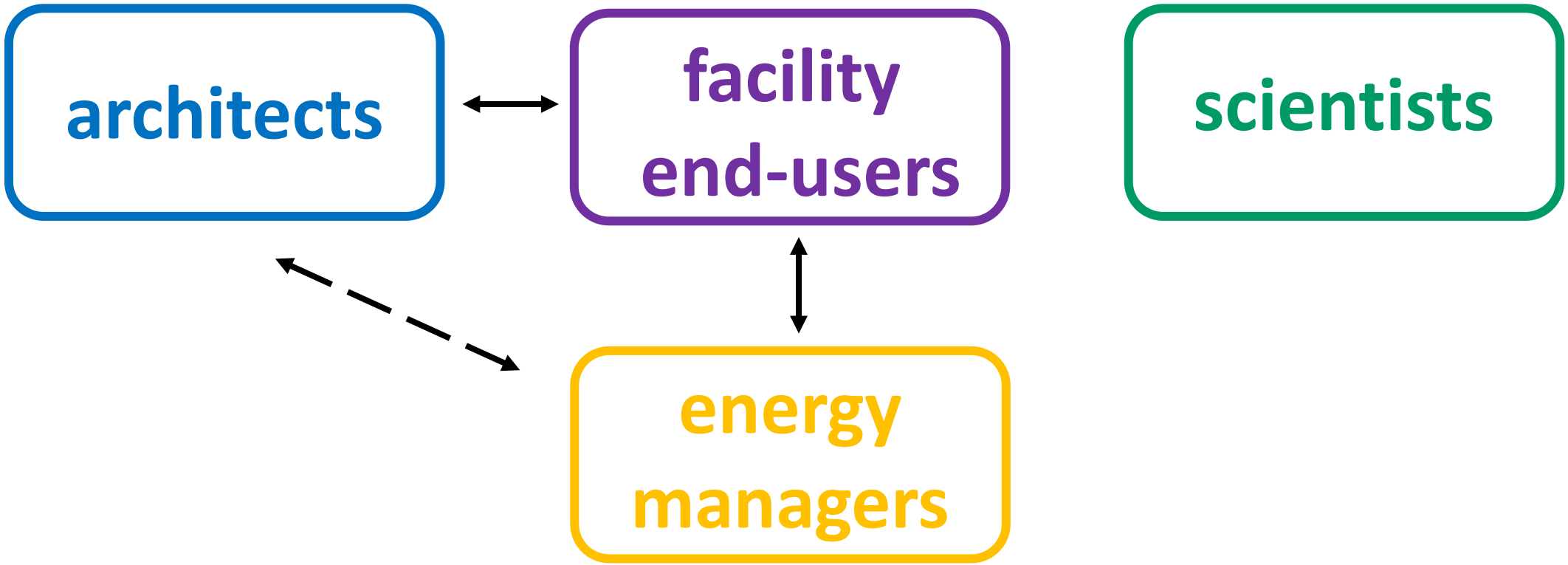


but…

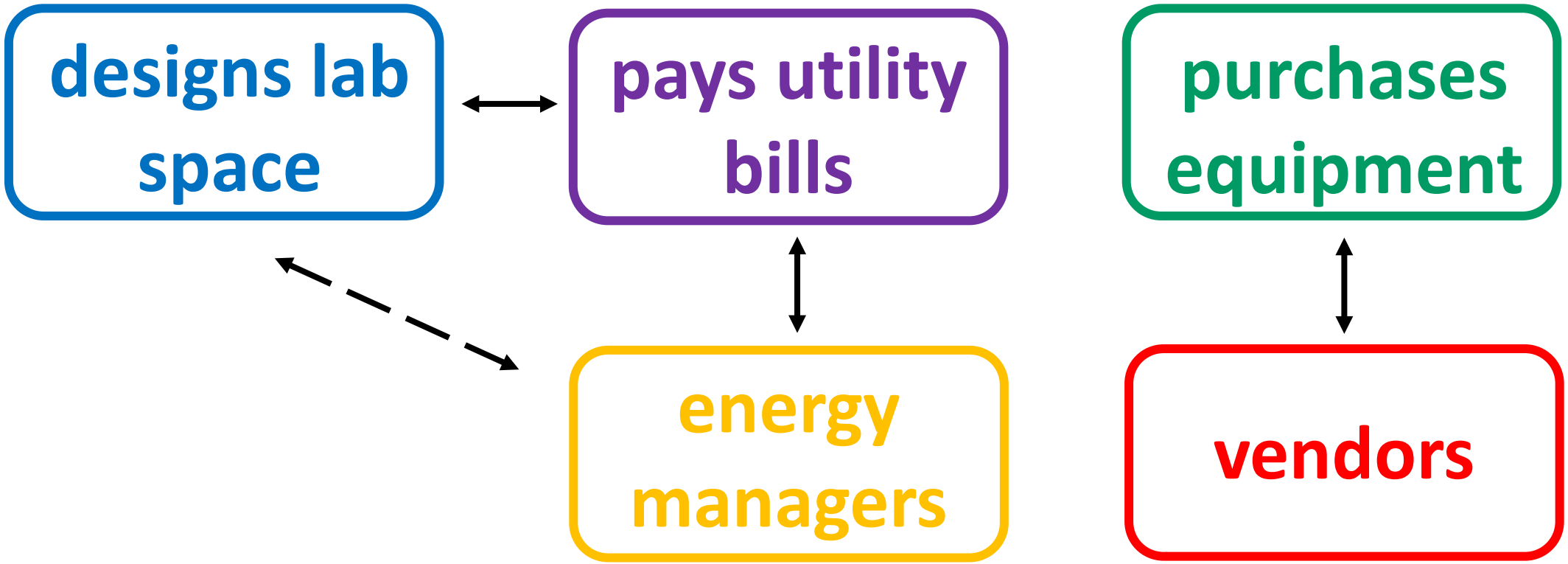
little is known or communicated by vendors
by end-users, or by utility companies
about energy consumption of laboratory equipment

market size unknown

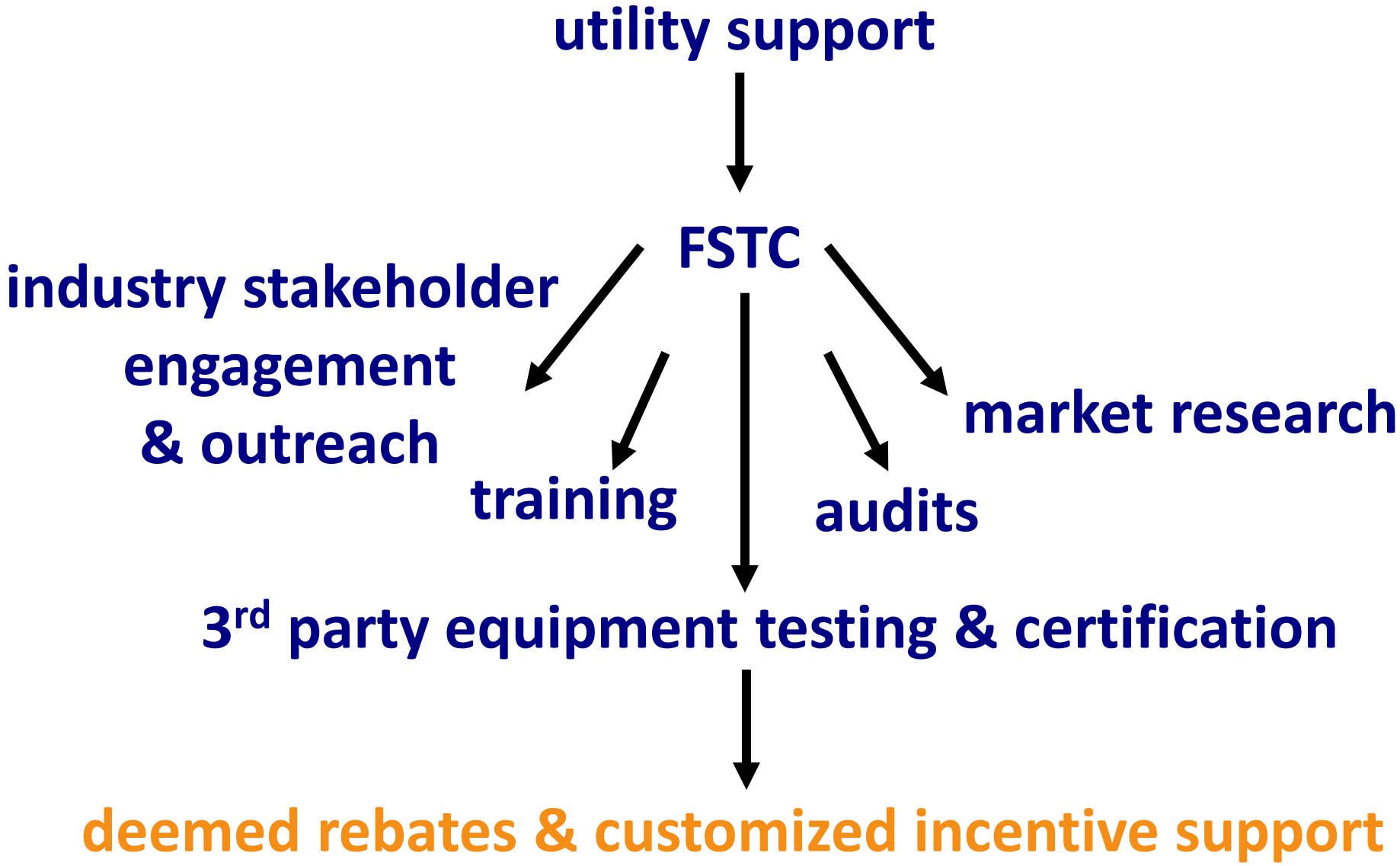
and


architects
facility end-users
scientists
energy managers

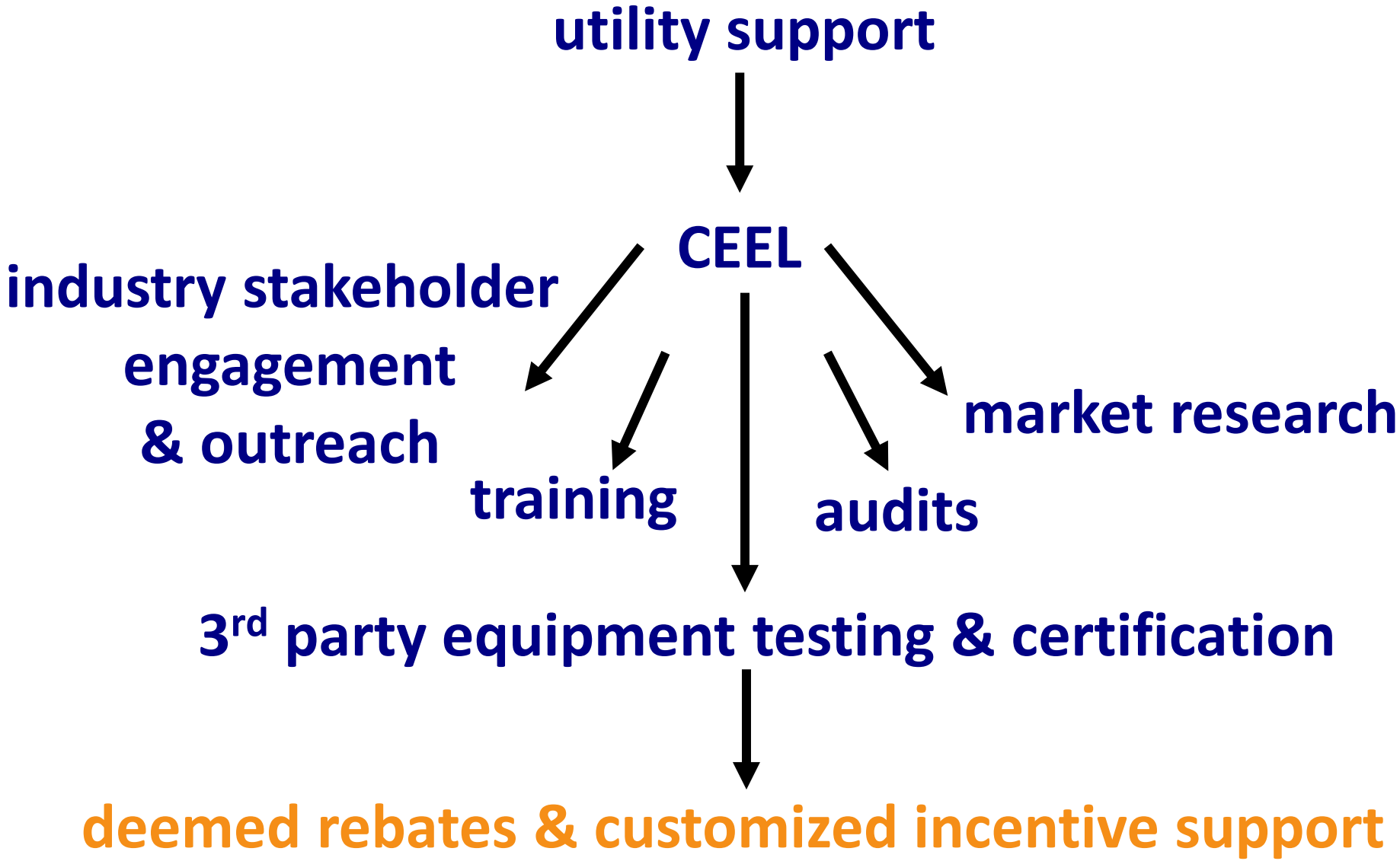
in other words



an existing model: Food Service Technology Center



the proposed model: Center for Energy Efficient Labs



Center for Energy Efficient Labs (CEEL)

my green lab.

industry stakeholder engagement, outreach, training

kW ENGINEERING

consulting: audits, measure development & implementation, training, deemed measure workpapers

Food Service Technology Center PG&E

3rd party equipment testing, outreach, training

phase I: market assessment

the CEEL market assessment sought to:

define and characterize laboratory spaces

estimate the quantity and usage of common laboratory plug loads

understand stakeholder attitudes about energy efficiency

identify potential opportunities for energy efficiency in labs

results: square footage of lab space

Market Segment	Estimated Lab Space in CA (sq ft)
Academia	37 million
LSR	68 million
Hospitals	8 million
Non-Profits	3 million
Total	**116 million**

estimated lab space in the US: 1.2 billion sq ft

results: equipment estimates

TABLE 75: ESTIMATED TOTAL NUMBERS OF LABORATORY EQUIPMENT IN CALIFORNIA

EQUIPMENT	AVERAGE NUMBER PER LAB REPORTED IN CA	ESTIMATED TOTAL NUMBER IN CA
-80°C Freezer	2.9	58,000
-20°C Freezer	3.7	74,000
Refrigerator	4.7	95,000
Fume Hood	3.0	60,000
Fluorescence Microscope	1.7	34,000
Heating Block	3.0	60,000
Water Bath	2.6	52,000
Centrifuge	3.8	76,000
PCR Machine	2.2	44,000
Magnetic Stirrer	3.0	60,000
Vacuum Pump	2.1	42,000
Shaker Table	1.2	24,000
Autoclave	0.8	16,000
Incubator	3.0	60,000
Tissue Culture Hood	1.7	34,000

results: energy consumption

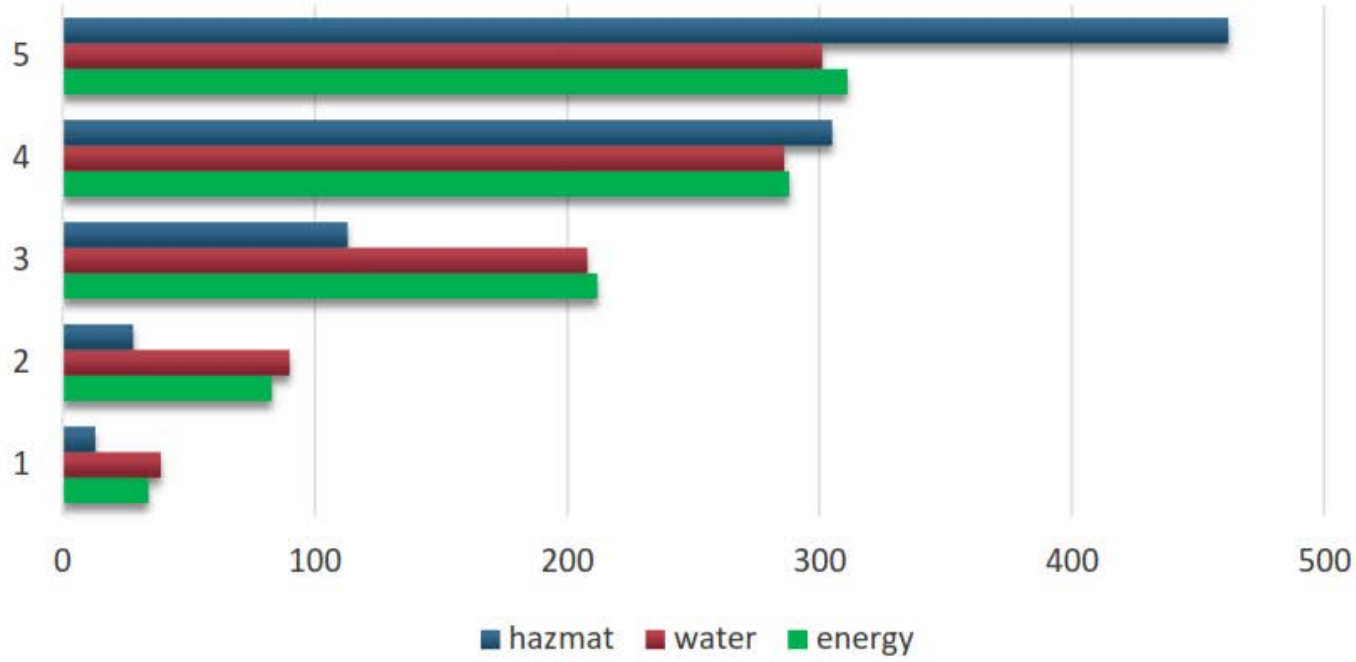
California Lab Equipment Estimates	Equipment Density (units/lab)	Approx. Number (thousand units)	Est. Energy Consumption (GWh/yr)
-80 Freezer	2.9	58	228 – 648
-20 Freezer	3.7	74	126 – 363
Refrigerator	3.7	95	19 – 254
Fume Hood*	3.0	60	661 – 1322
Fluo Micro	1.7	34	6 – 12
Centrifuge	3.8	76	12 – 227
Water 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

but do scientists care?

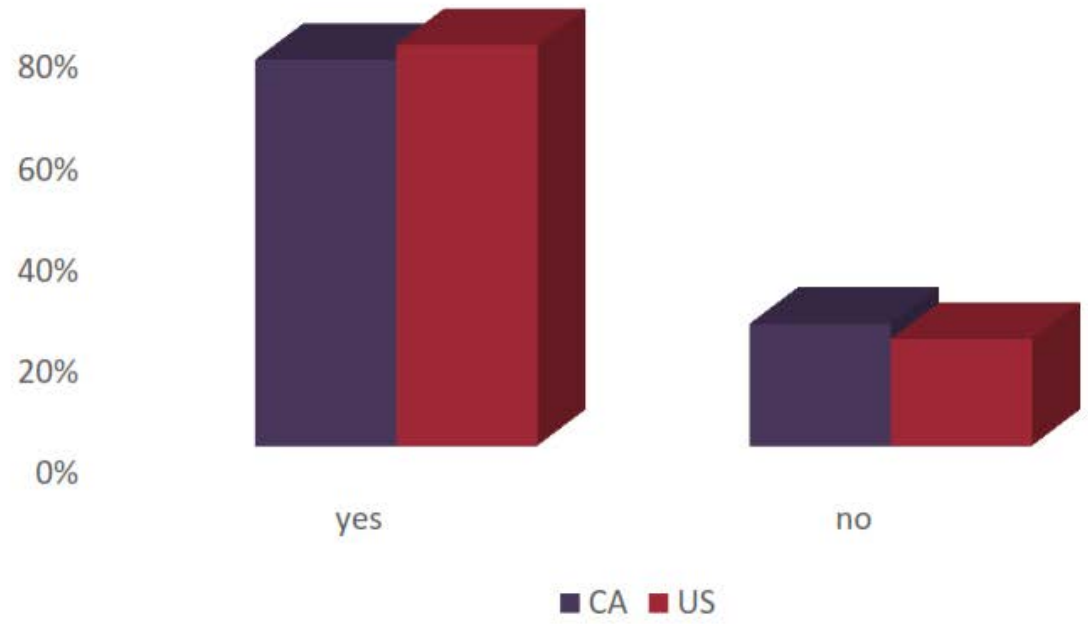
results: attitudes about sustainability

FIGURE 42: SURVEY RESPONSES REGARDING THE IMPORTANCE OF ENERGY AND WATER EFFICIENCY, AND REDUCTION OF HAZARDOUS MATERIALS IN THE UNITED STATES



results: attitudes about energy efficiency

FIGURE 45: INFLUENCE OF AN ENERGY STAR RATING ON PURCHASING DECISIONS



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special thanks

Pacific Gas & Electric

San Diego Gas & Electric

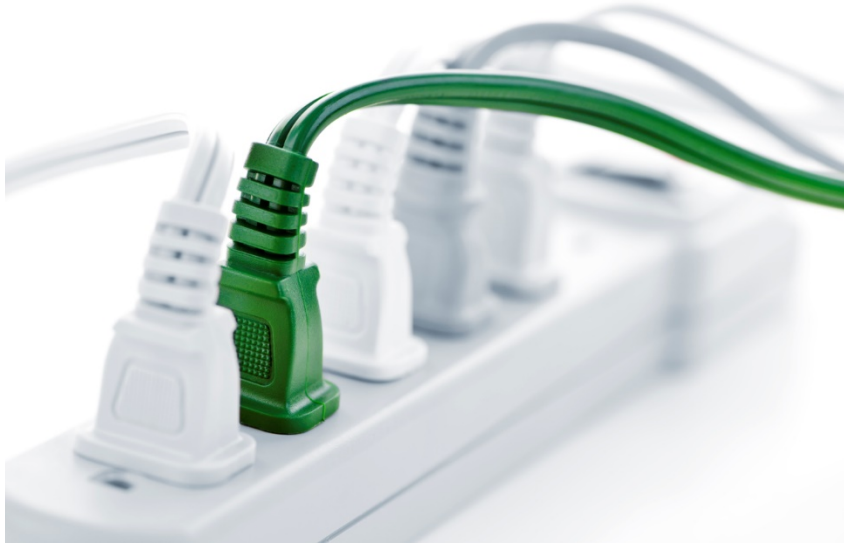
Southern California Edison

FNI

kW Engineering

Thank you!

Questions?



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Managing and Maintaining High Performance Laboratory Ventilation Systems

Training for Laboratory Facilities

Thomas C. Smith

ECT, Inc.

Exposure Control Technologies, Inc.
919-319-4290
tcsmith@labhoodpro.com

Introduction and Agenda

- **Thomas C. Smith**
  - President, Exposure Control Technologies, Inc.
  - BSME (NCSU), MSEE – Industrial Hygiene (UNC-CH)
  - Chair, AIHA/ANSI Z9 Ventilation Standards for Safety and Health
  - Chair, ASHRAE TC 9.10 – Laboratory Systems
  - Vice Chair, ASHRAE/ANSI 110 – Method of Testing Fume Hoods
  - Board of Directors – International Institute for Sustainable Labs
  - NCSU Engineering School Alumni Hall of Fame

- **Topics**
  - Building Health and Sustainability Profile
  - High Performance Lab Ventilation Systems
  - Training Lab Specialists
  - Discussion

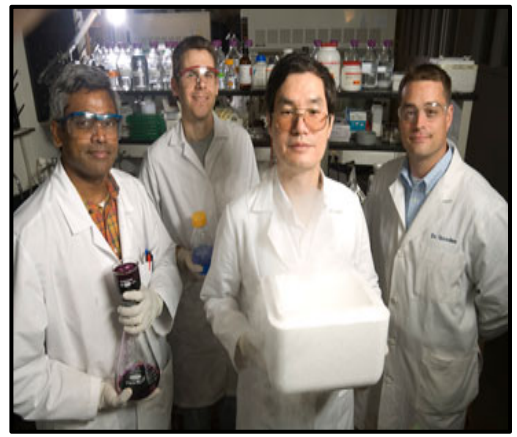
Laboratory Facilities

- Government
- Universities
- Chemical
- Biotechnology
- Pharmaceutical
- Microelectronic

- More than 10,000 facilities with one of more lab buildings
- Specially designed for use of hazardous materials
- Complex systems for controlled environmental conditions

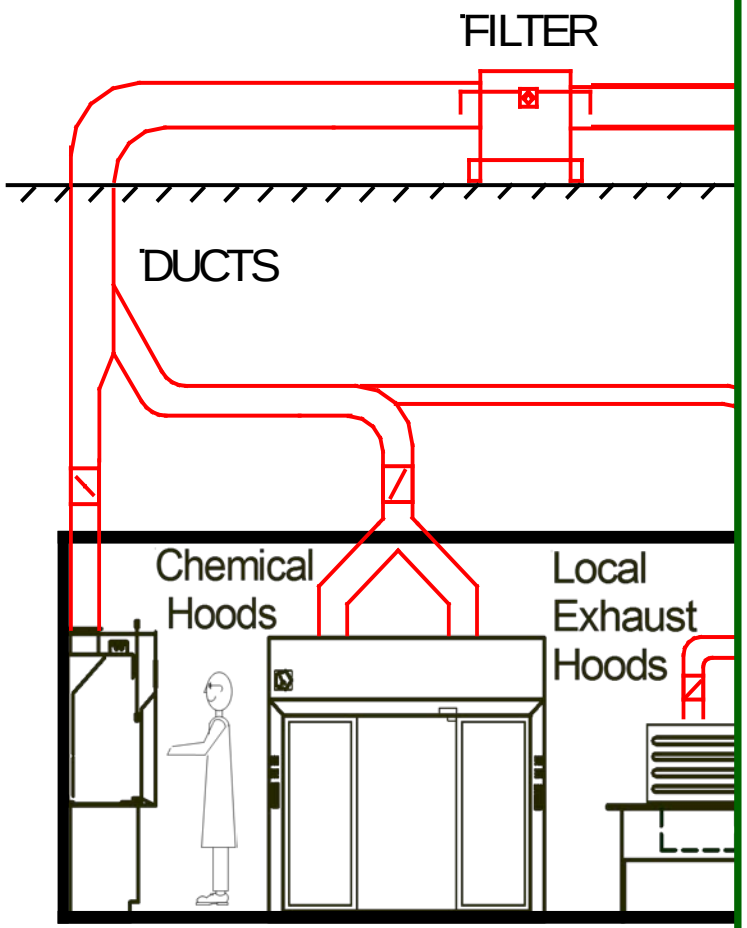
Objectives of A Lab Facility

- Attract & retain top talent
- Promote high quality research
- Provide safe & productive environments
- Minimize energy use & operating costs
- Maximize sustainability
- Comply with codes & standards
- Manage & mitigate risk

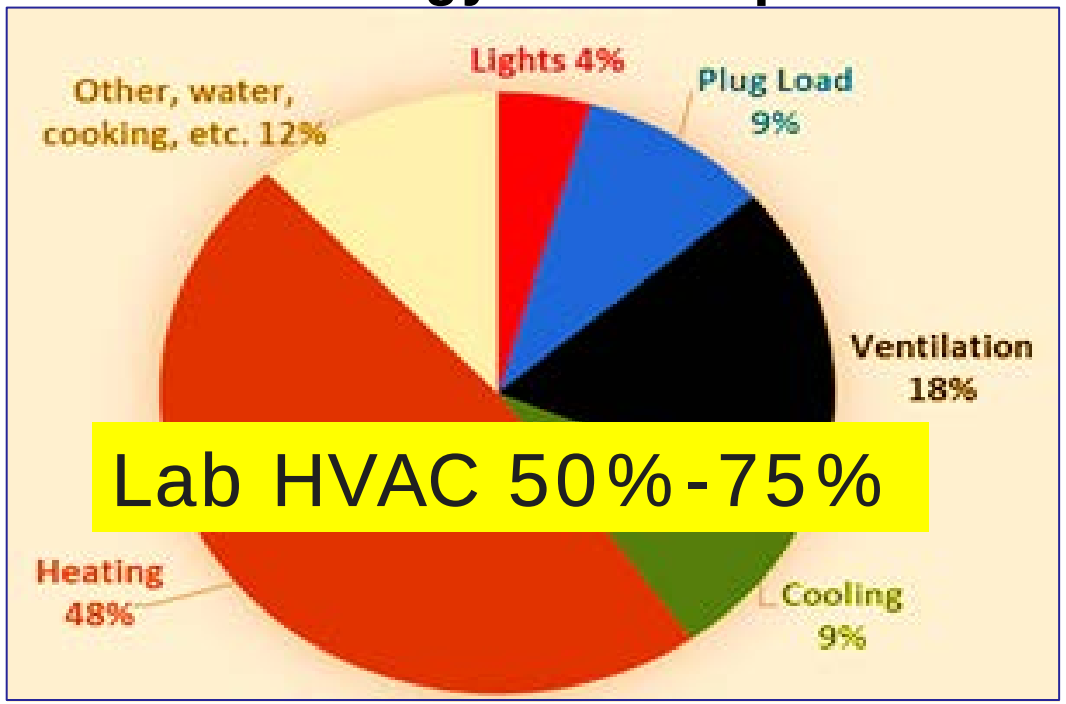


A laboratory building and the mechanical systems serve building occupants and support scientific development

Exposure Control Devices (ECDs) & Ventilation Systems



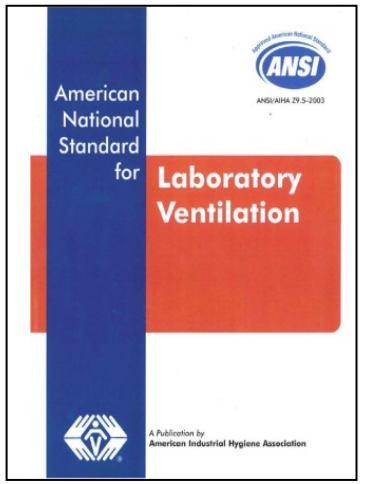
Lab Energy Consumption

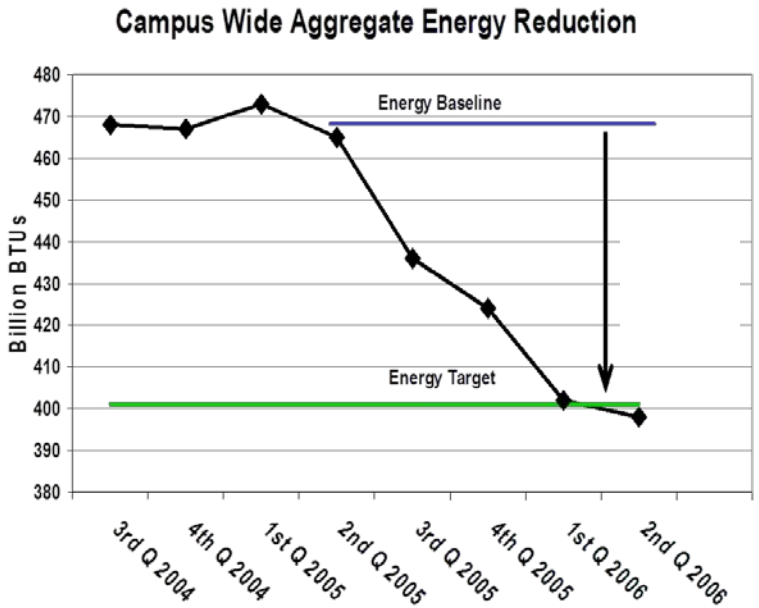


- Lab Buildings are Complex and Costly
- LVS approximately 15%-40% of Construction Costs
- HVAC ≈ $3 to $9 per cfm-yr
- Annual Energy wasted by inefficient HVAC ≤ 50%
- 15% to 30% of traditional fume hoods often fail to meet ANSI Performance Standards
- 5 yr. degradation in system performance ≈ 30% to 50%

High Performance "Smart Lab"

- **Safe**
  - Protect people working in, on or around the building
  - Compliance with standards and reduced risk of liability
- **Effective**
  - Environments conducive to high quality research & results
- **Efficient**
  - Minimum energy consumption
  - Minimum operating costs
- **Sustainable**
  - Minimum carbon footprint
  - Maintainable systems
  - Maximum lifecycle of building systems





Building Health and Sustainability Profile

> 10,000 Lab Buildings in USA	Profile			
	Class A	Class B	Class C	Class D
Energy Reduction Potential	Good	Good	Fair to Good	N/A to Good
State of the Systems	Good	Fair - Good	Poor - Fair	Poor
Upgrade Project Complexity	Low	Medium	High	Very High
Upgrade Project Duration	Short	Medium	Long	Very Long
Project Payback	< 3 yrs	3-5 yrs	5-10 yrs	>10 yrs
Est. % of Lab Buildings	10%	35%	50%	5%

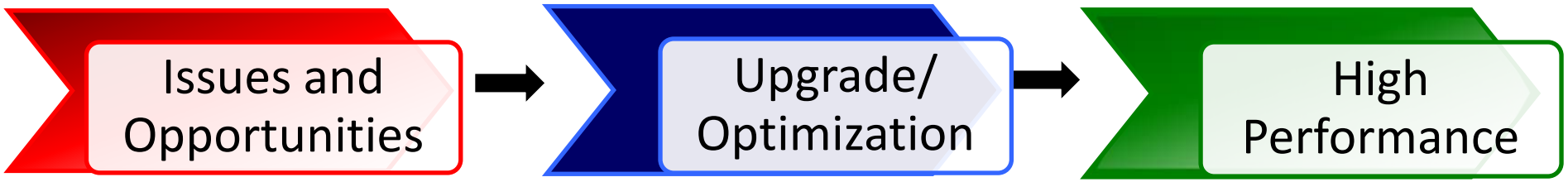
- Annual Energy Consumption ~ $13 Billion (1.07 Quad BTUs)
- Annual HVAC Energy Consumption ~ $6.5 Billion
- Potential Annual Reduction = $3.3 Billion / year (0.27 Quad BTU)

Building Health and Sustainability Profile

- Do you understand your risk profile and required specifications for ventilation (i.e. Flow, ACH, Pressure)?
- Is your organization at risk if your lab ventilation systems are dysfunctional, inefficient or ineffective?
- Are your lab ventilation systems adversely impacting research and experimental results?

- How would your organization benefit if you improved efficiency of your lab ventilation systems and reduced energy consumption while enhancing safety and productivity?
- Are you confident you have adequate resources and properly trained personnel to manage and maintain high performance lab ventilation systems?

Achieving High Performance Laboratories



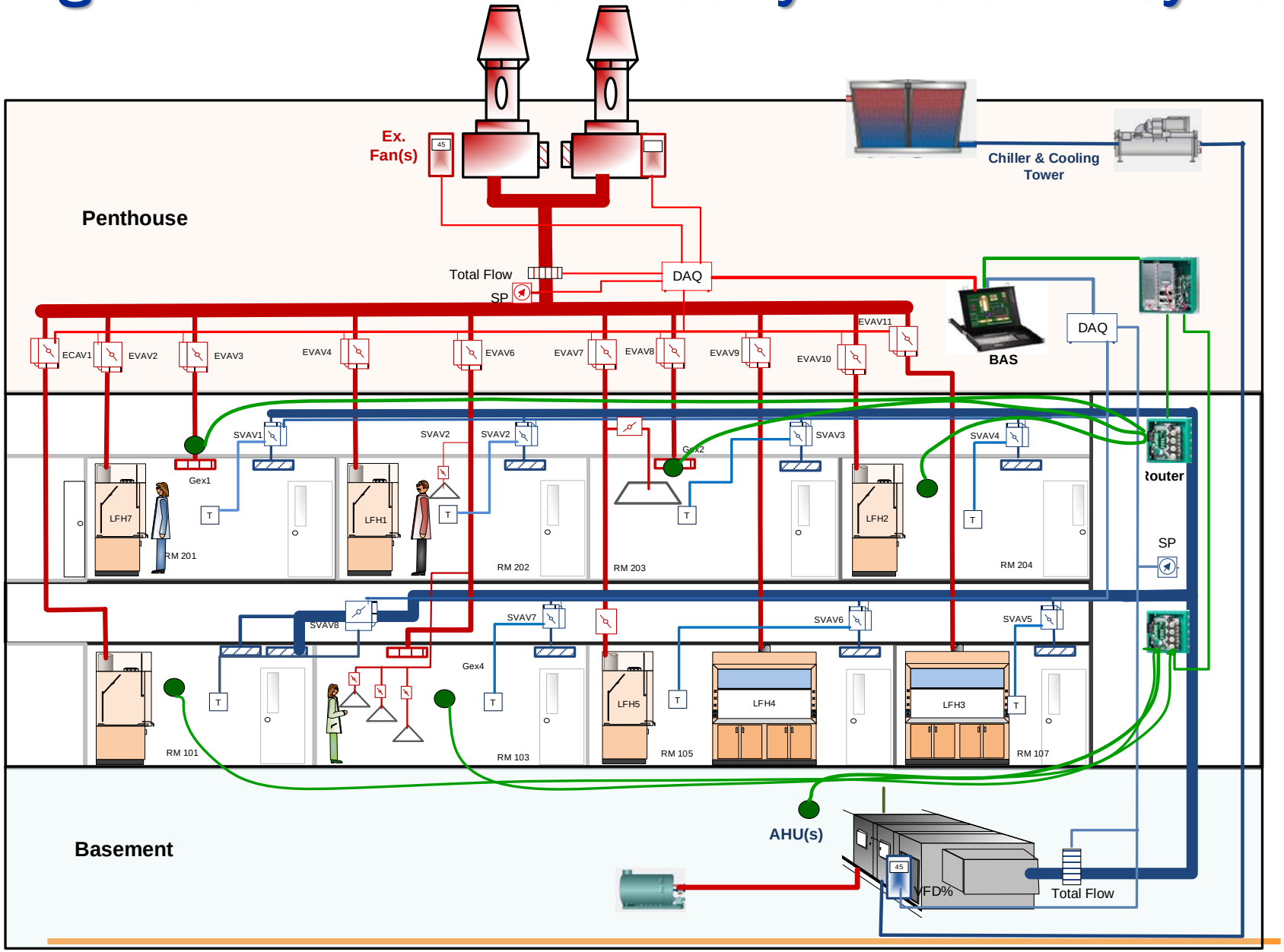
- High Energy Consumption
- Safety Concerns
- Suboptimal Fume Hoods
- Compromised Systems
- Inadequate Ventilation
- Poor Indoor Air Quality

- Upgrade Mechanical systems
- Install or Update VAV controls
- Upgrade Fume Hoods
- Install Demand Control Ventilation
- Utilize Energy Recovery
- Implement Lab Ventilation Management Program

- Safe Labs
- Effective Controls
- Energy Efficient
- Low Maintenance
- Low Operating Cost
- Sustainable

Lab Energy & Safety Optimization Process

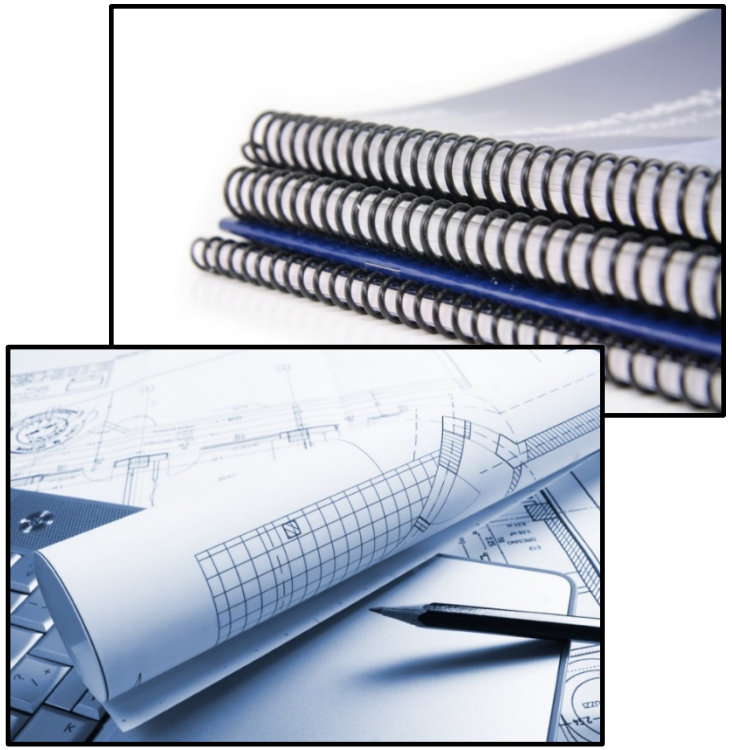
High Performance Laboratory Ventilation System



Operating Manual for Building Systems

Performance Management Plan

- **Accurate Drawings / Diagrams**
- **Up to Date Equipment Inventories**
- **Lab Ventilation Risk Matrix**
- **Appropriate Flow Specifications**
- **Control Sequences and Parameters**
- **Operational Boundary Conditions**
  - System Flow
  - Key Metrics and Parameters
- **Standard Operating Procedures**
  - Routine Tests & Maintenance Tasks
- **Training for Stakeholders and Staff**



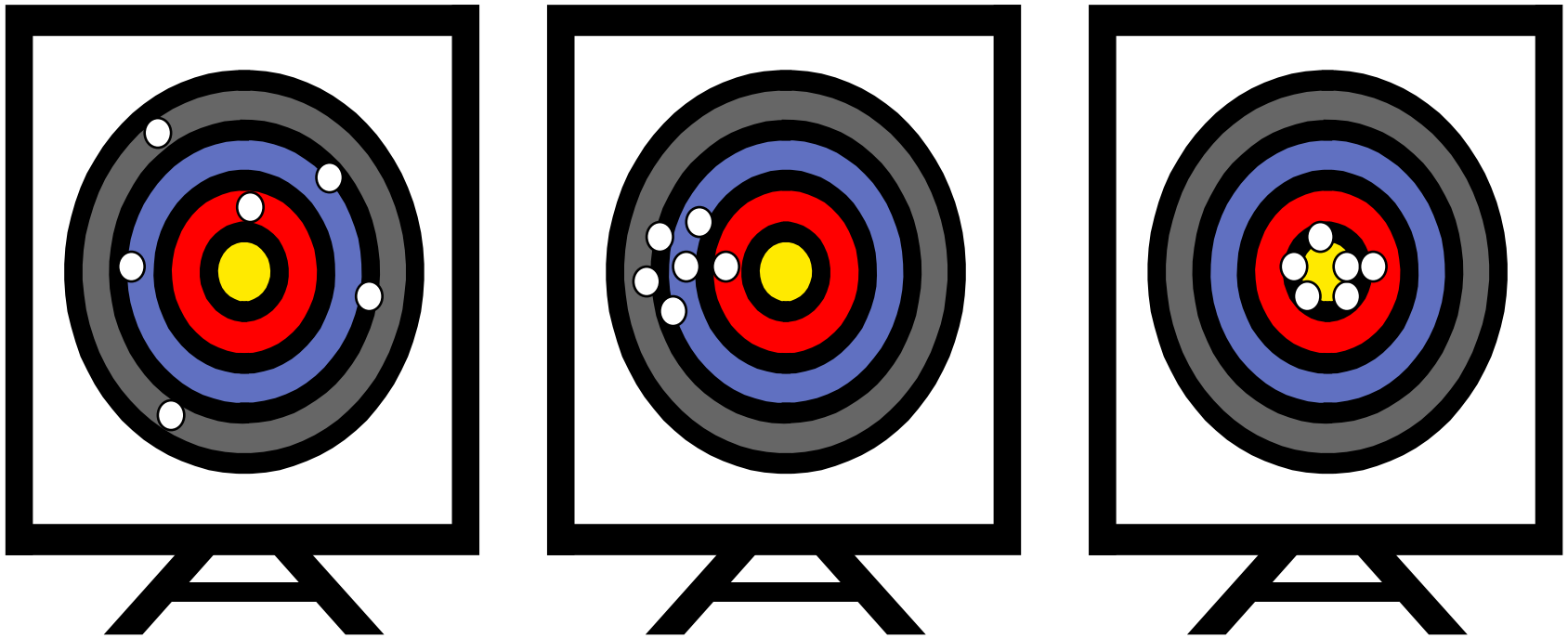
Wishful Thinking???

Ongoing Challenges

- Dynamic Research & Change in Processes
- Ongoing Risk Assessment
- System Modifications
- Component Degradation
- Component Failures
- Diminished Service and Support
- Consistency and Quality of Maintenance

Ensuring lab safety and energy savings is not "sustainable" without ongoing risk assessment, management of change and Training!

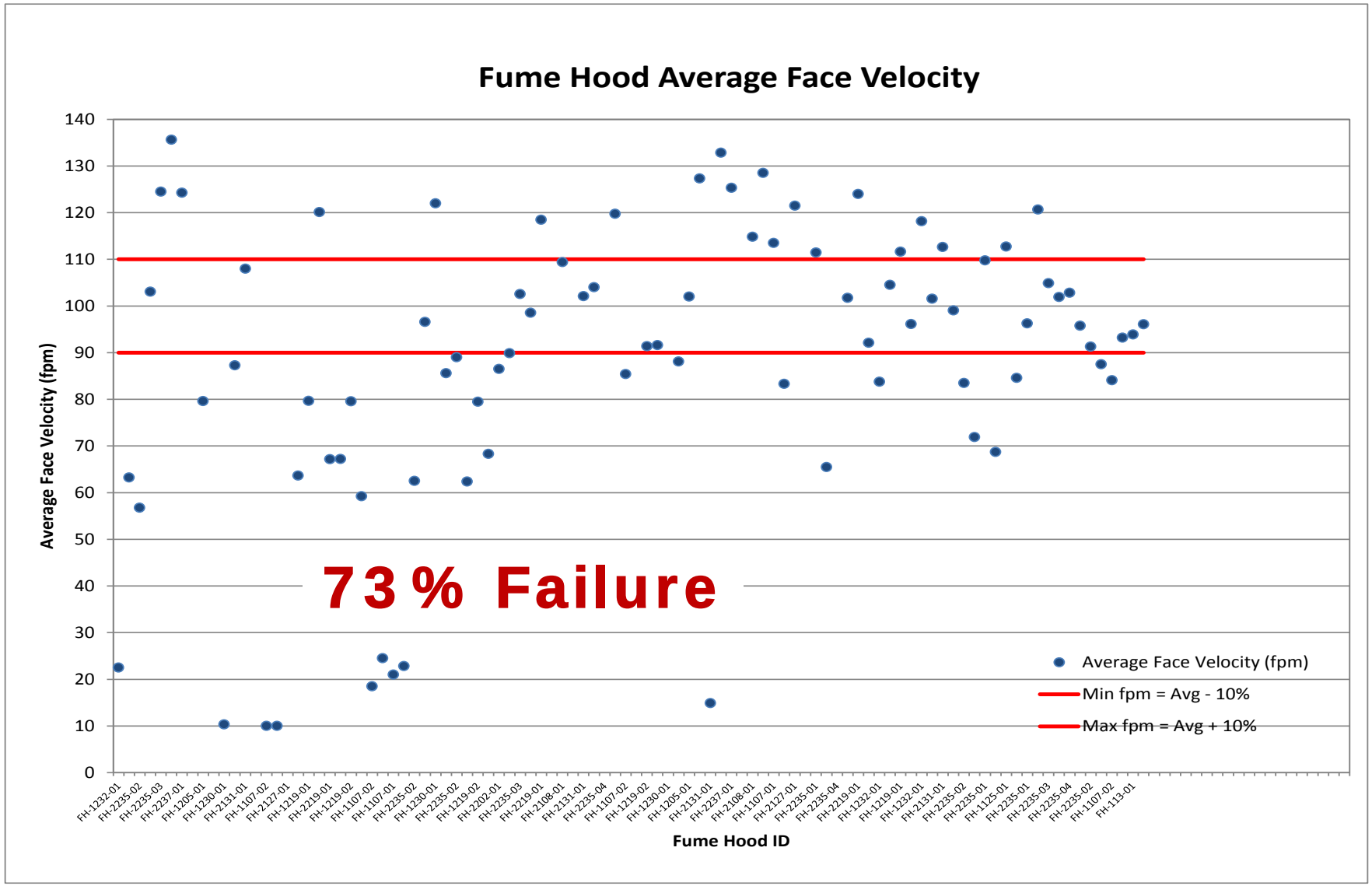
Quality Data - Accuracy and Precision



Lab Vent Systems Can degrade

30-50% within 5 years

Fume Hood Face Velocity Control



I2SL - Lab O&M Training Survey

2012 Survey "Exploring the benefits for proper training of high tech facility operations and maintenance professionals"

Highlights:

- **70% indicated detailed knowledge of ventilation system design, engineering and activities of the users are necessary.**
- **> 70% indicated O&M and PM responsibilities involve understanding the role of lab ventilation for managing risk**
- **>70% indicated facility leadership do not understand the importance and complexities of high performance systems and do not allocate sufficient resources**

Technology outpacing knowledge, skills, and resources of Facilities, EH&S and O&M Staff

Training for Implementation and Sustainability of High Performance Lab Ventilation Systems

Training for High Performance Lab Ventilation Systems

I	• Benefits of Lab Ventilation Management Program for High Performance Lab Facilities
II	• Implementation of Lab Safety and Sustainability Program
III	• Fundamentals of High Performance Lab Ventilation Systems
IV	• Management and Maintenance of High Performance Lab Ventilation Systems

Training for High Performance Lab Ventilation Systems

- **Course 1 - Benefits of Lab Safety and Sustainability Programs for Research Facilities**
  - 2 hours, In Person or Instructor Led Web Course
  - Impact, Costs, Benefits and Leadership Requirements
- **Course 2 - Implementation of Lab Safety and Sustainability Programs**
  - 4 to 8 hours, In Person or Series of Instructor Led Web Course
  - Process for Evaluating and Optimizing Lab Systems
  - Components of High Performance Building Management Programs
  - Methods of Implementation
- **Course 3 - Fundamentals of High Performance Lab HVAC Systems**
  - 8 hours, In Person or At Your Own Pace Web Based Course
  - Design and Operation of High Performance Lab HVAC Systems
  - Includes Exam to Qualify Personnel as High Performance Lab Specialists
- **Course 4 –Management and Maintenance of High Performance Lab HVAC Systems**
  - In Depth, 3 Day Training at Special Lab Training Venue
  - Design, Commissioning, Testing, Diagnostics and Repair of Critical Components
  - Written and Practical Exams for Certificate

Training for High Performance Lab Ventilation Systems

Value and Timing

- Protect Return On Investment
- Continue Energy Conservation Efforts
- Increase Building Lifecycle
- Safer and more productive labs
- Increase skills and job responsibilities
- Job Creation

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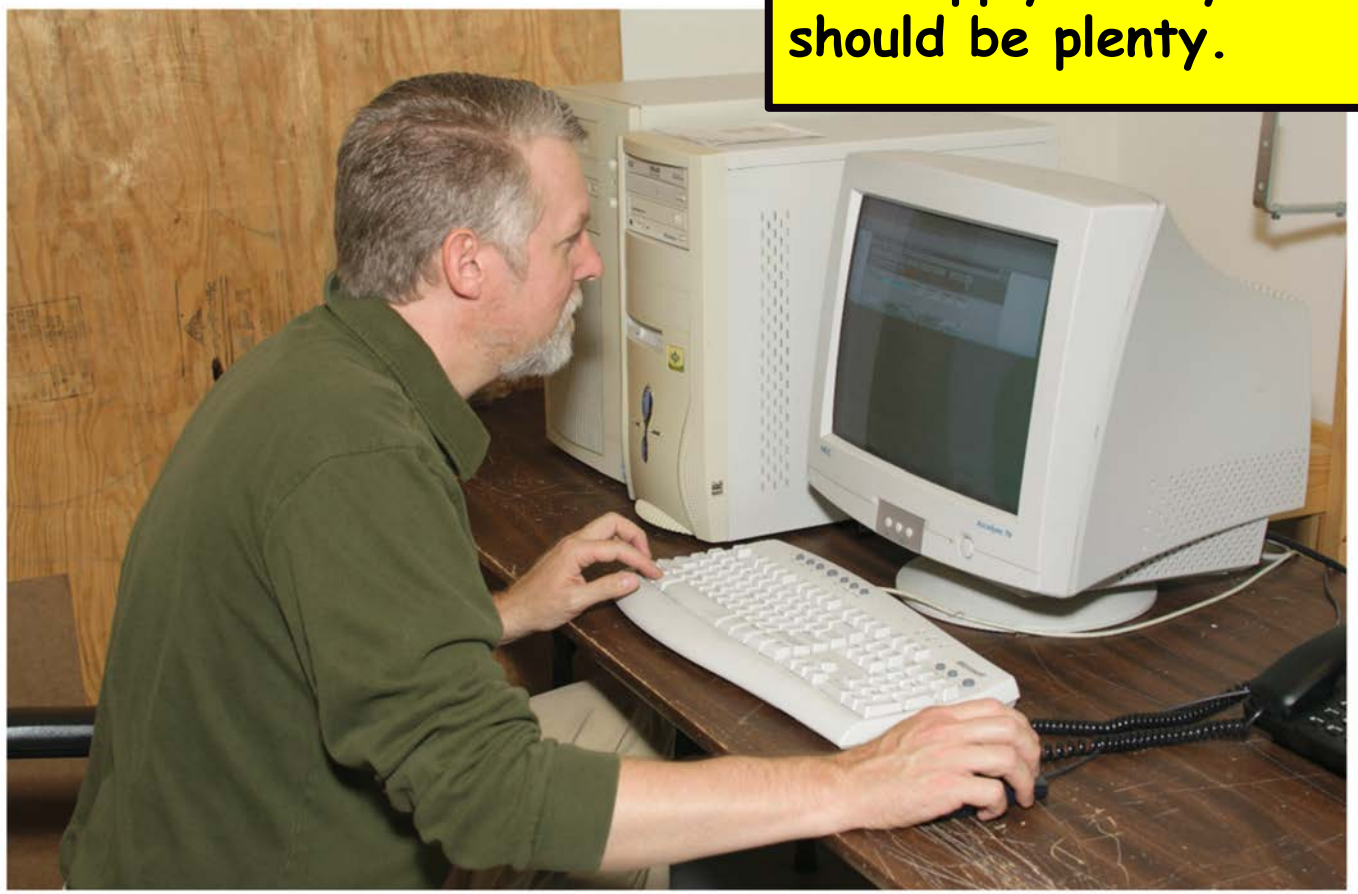
Questions?

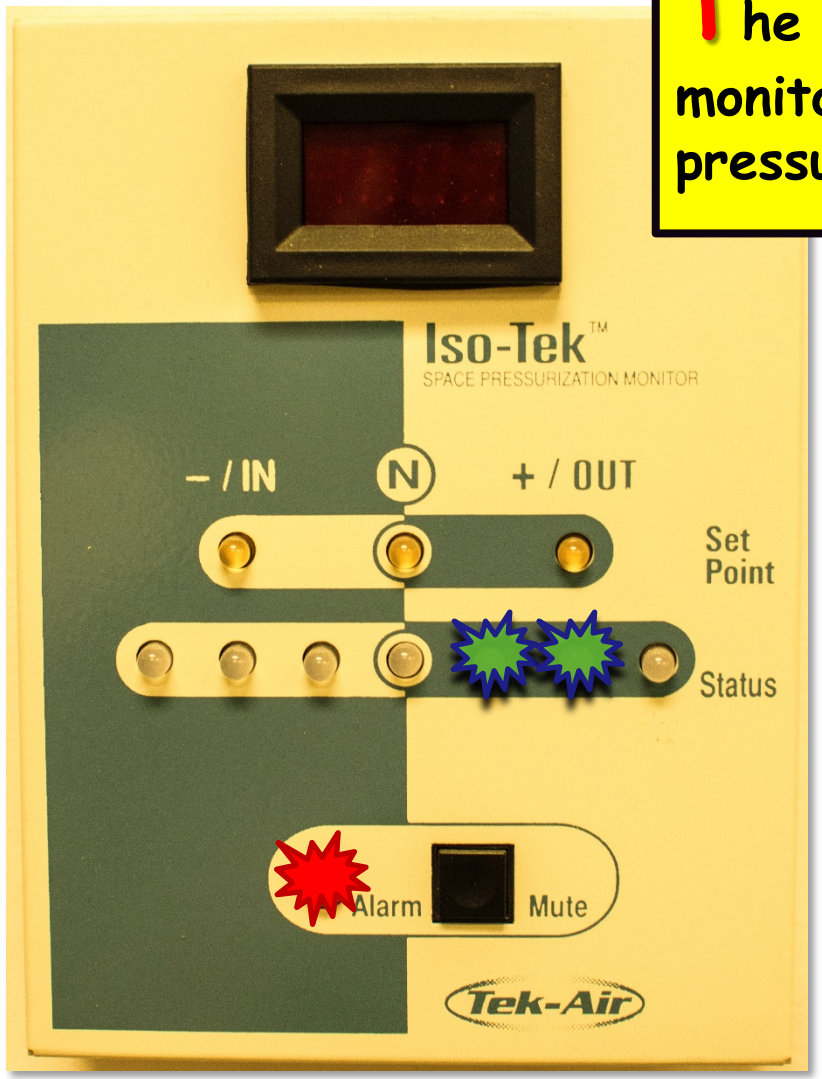
Importance of the Training

System Operation and Management of Change

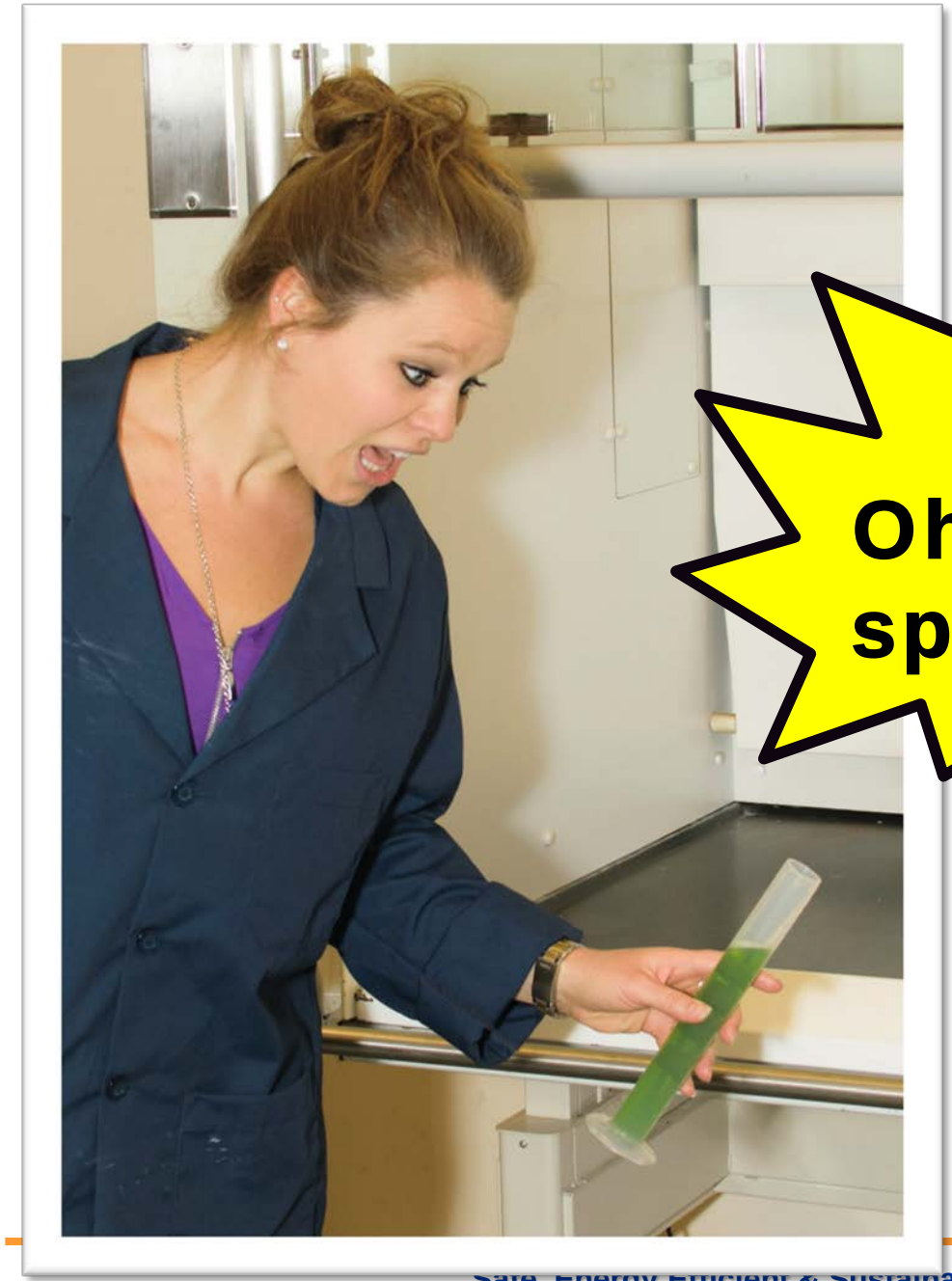

My lab is really hot!
I'll take care of it.

Our technician decides the lab needs more air, so he increases the supply air by 200 cfm. This should be plenty.



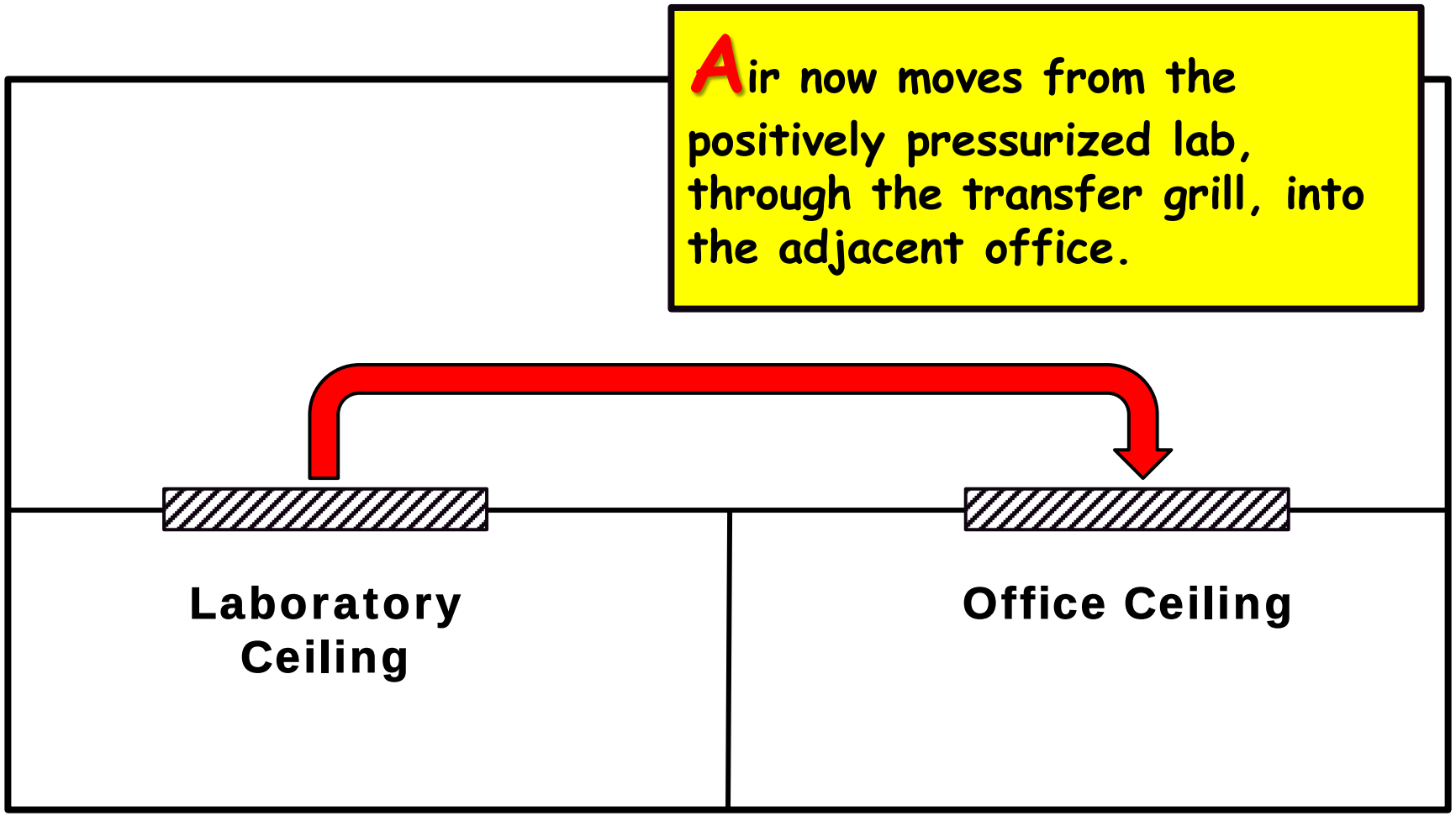


The differential pressure monitor is now indicating positive pressure.

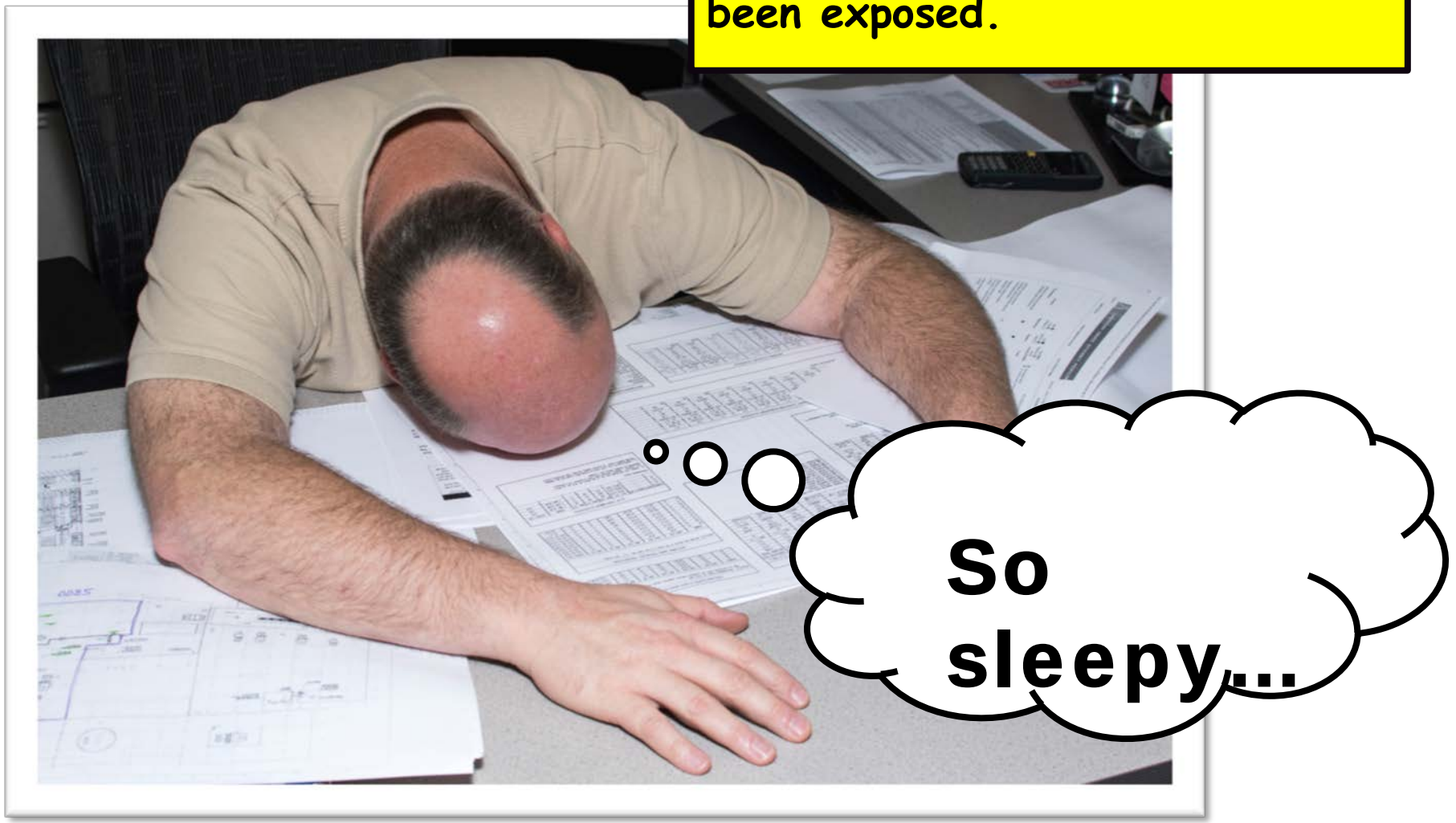


Oh No!! A spill…

It's much cooler now...


Air now moves from the positively pressurized lab, through the transfer grill, into the adjacent office.
Laboratory Ceiling
Office Ceiling

Our office worker has now been exposed.



This never would have happened with a well trained Lab Specialist.

North American Freezer Challenge

Liz York, Emily Hays, CDC
Allison Paradise, My Green Lab
Allen Doyle, UC-Davis
Kathy Ramirez-Aguilar, CU-Boulder
Kristi Budzinski, Genentech
Phil Wirdzek, I²SL

Why Lab Freezers?

- Large consumers with often irreplaceable samples

- US Laboratory Equipment Study by My Green Lab
  - ~440,000 to 890,000 Ultra Low Temperature (ULT) freezers
  - ~620,000 to 1,250,000 freezers at -20°C
  - ~810,000 to 1 million refrigerators

  - Perhaps ~7,000 GWh/yr (or ~7 TWh/year)
  - ~0.8 GW (40% peak power of Hoover Dam)

Great Opportunity to Reach Out

and begin to address issues

It is not uncommon for lab freezers to lack an inventory, resulting in difficulties finding samples or even knowing what is in a freezer.

Lab freezers frequently house samples that are expired, no longer needed, or cannot be identified.

Samples are often stored at colder temperatures than necessary.

Forgotten or abandoned “zombie” freezers.

We don’t need an entire ULT freezer, but have to buy one since we don’t have access to ULT freezer space elsewhere.

Rather than figure out if samples are still needed or who they belong to, it is easier to just buy another freezer and leave the old freezer plugged in.

History of Freezer Challenge

UCDAVIS

First Challenge 2011

University of Colorado Boulder

UCDAVIS UNIVERSITY OF CALIFORNIA

UCSB

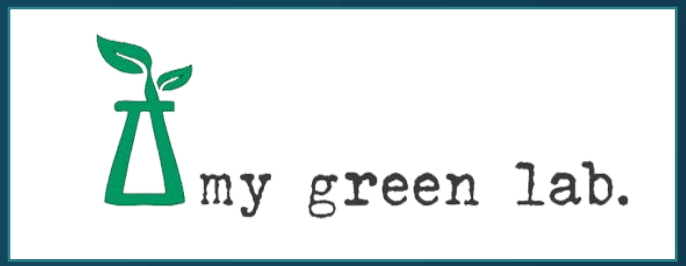
Penn University of Pennsylvania

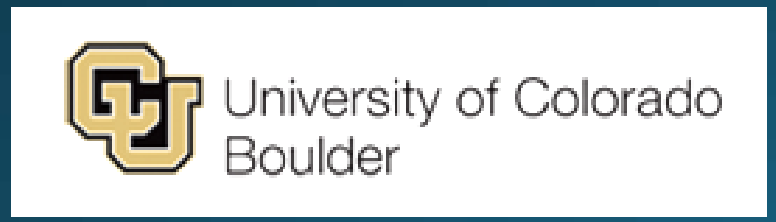
Genentech + Others

CDC Centers for Disease Control and Prevention

2016

After success in higher education, government, & pharmaceutical sectors: 2016 Collaborative Effort





Laboratory Freezer Manufacturers and Distributors

North American Freezer Challenge
Vision and Mission Statement

Vision:

Efficient, Effective Sample Storage for North American Laboratories

Mission:

The North American Freezer Challenge promotes sample accessibility, sample integrity, reduced costs, and energy efficiency by harnessing a spirit of competition within and between laboratories. Challenge participants use well-evidenced criteria and best practices that support science quality and resilience while minimizing total costs and environmental impacts in sample storage.

Contest that bundles the best practices of cold storage into one package

Categories of actions:

- Temperature Tuning
- Retire and Replace
- Sample Management
- Cutting Edge
- Data Collection

Scoresheet with actions:

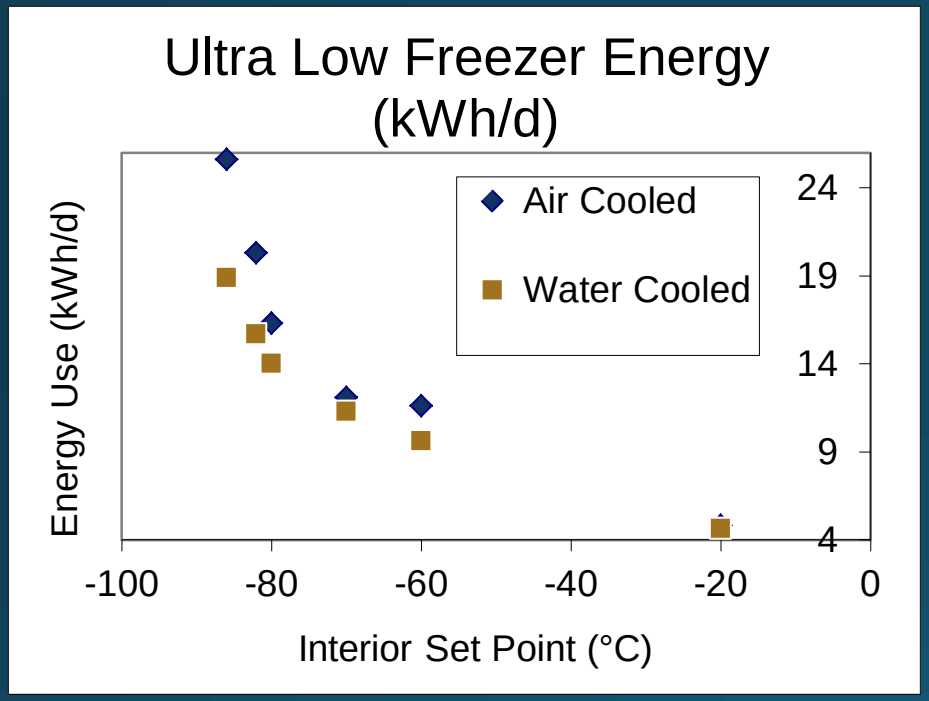
1 point ≈ 1 kWh/day

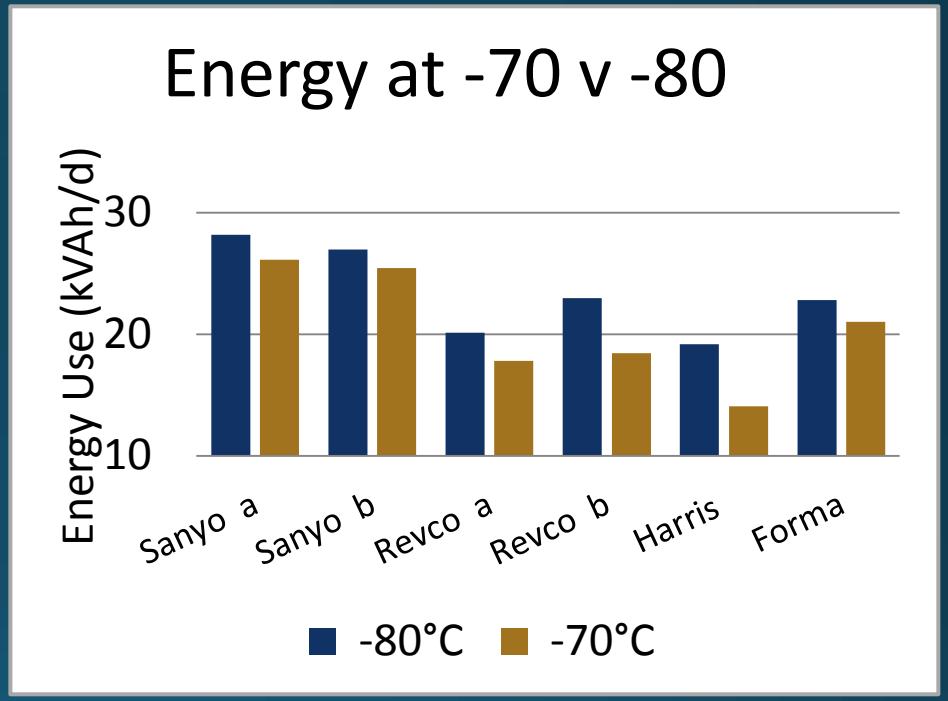
Categories of winners:

- Between Institutions
- Within Institution
- Fun Awards

Temperature Tuning

- **Chill Up! -70°C saves 4 kWh/d**





- **Proper temperature selection (DNA at -20°C)**

"We expect DNA to be a robust polymer and always store it at -20. We have never had any problems."

J. Yee, California National Primate Research Center

Retire and Replacement

Freezer “Amnesty” at UC Davis Vet School

Good Management

- Defrosting, cleaning coils/filters
- Cleaning out unneeded samples
- Organizing, Labeling, Inventorying
- Consolidating

Cutting Edge

- Sharing!
- Room Temperature Sample Storage (RTSS)
- Bar Coded Inventory

Example of Impact: CU-Boulder

- Improved Sample Access
- Improved Freezer Performance
- Energy Conservation
- Gift Cards, Pizza Parties
- It is the RIGHT THING TO DO

~50 CU-Boulder labs participated over two years, two contests
~300 MWh/year saved or $24,000/year saved in electricity

Good Management
Retiring or replacing inefficient units

- 170 cu.ft. material disposed
- 64 units inventoried/organized
- 36 units retired (7 ULT freezers)
- 24 replaced with Energy Star
- 68 units preventative maintenance

Temperature Tuning And Cutting Edge

- 45 ULT freezers moved to -70°C
- 45 cu.ft. moved to warmer temps
- 5 labs RTSS test
- 6 shared ULT freezers
- Data collected on temperature choice

Background graphic from U. of Michigan

Long Term Impacts at CU-Boulder

CU Green Labs: the go-to place for freezers

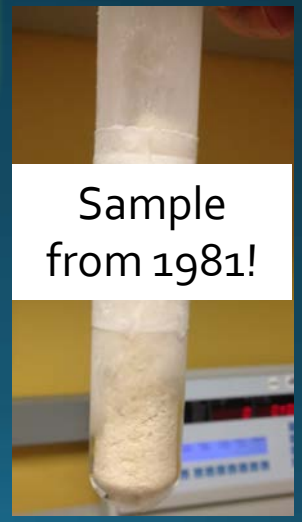
- Incentives
- Free disposal if conservation
- Efficient purchases
- Back-up freezers & mobile freezers
- Sharing
- Emergency Plans

Example of Impact: Genentech

FREEZER CHALLENGE

- Improved Sample Access
- Sample retention guidelines
- Long term freezer clean out program
- Energy usage awareness
- Better freezer management

25 Genentech labs participated
Upgraded 32 ULT freezers to energy efficient models
~480 MWh/year saved



Sample from 1981!

Example of Impact:
Centers for Disease Control and Prevention (CDC)

CDC Campus 1 has ~1,500 cold storage units (nearly 1000 freezers including 580 ULT freezers). The first Freezer Challenge aimed to:

1. Increase efficient use of cold storage
2. Improve sample access, security, and cost savings
3. Strengthen CDC's public health mission

Results:

- 68 laboratory professionals participated in 8 CDC lab groups
- "Chilled Up" 60 freezers from -80 to -70 Celsius or higher
- Inventoried over 300 freezers and transferred 85 to barcoded inventory systems
- Unplugged 44 of CDC's oldest freezers
- ~ 320 MWh/year saved

Coming this Fall! North American Freezer Challenge!

Be ready to sign-up when the contest opens!

QUESTIONS?

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