

Looking Down the Duct at Plug Load Reductions

Alison Farmer, PhD

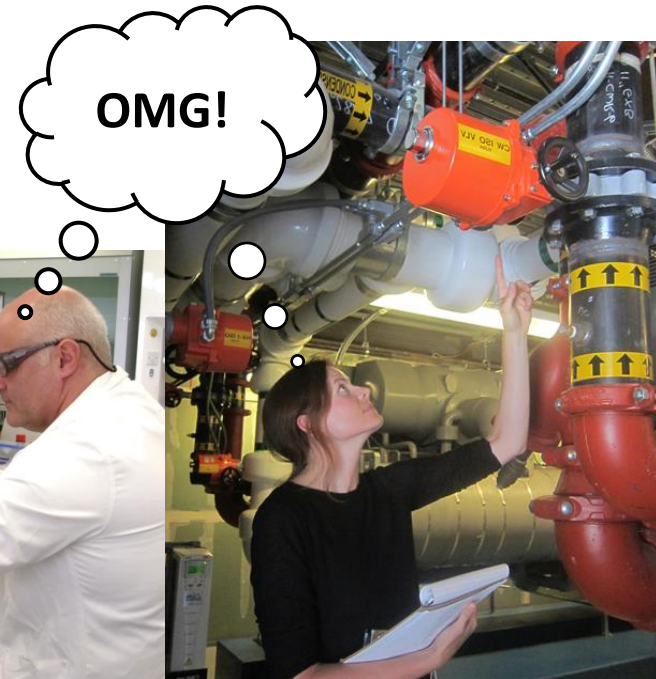


Learning Objectives

- Rank lab building energy end uses (including plug loads and HVAC systems) in order of typical annual energy consumption
- Discuss the ways in which different HVAC system types respond to plug load reductions
- Describe the demographics of lab building HVAC systems in California
- Identify the most promising targets for plug load efficiency projects

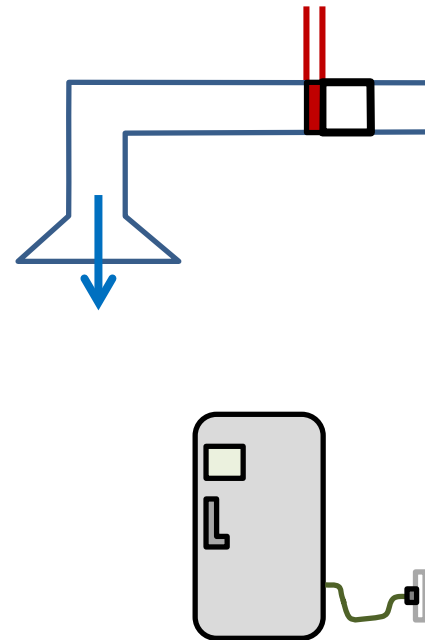
Introduction

- Occupant/facilities intersection
- Free pass for plug loads
 - Good and bad reasons
 - Excuses for inefficient operation
- Times are changing
 - Net zero
 - Lower ACH
 - Energy Star for ULTs
 - CEEL



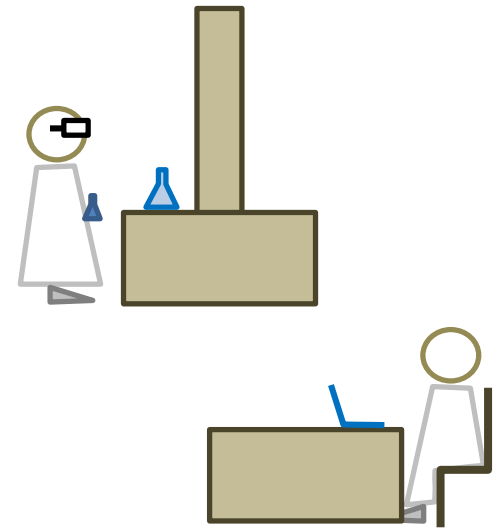
Outline

- CEEL results in context
- Typical lab building energy usage
- HVAC/plug load interactions
- Quantifying interactions for ULTs



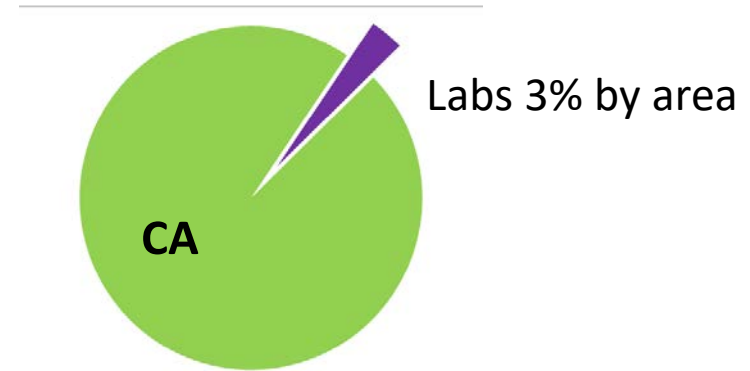
CEEL results in context

- CEEL results on total lab space:
 - 116 million sf in CA
 - Net to gross: assume 50%
 - 232 million sf of lab buildings
- National totals often quoted:
 - 1 billion sf
 - 659 million sf over 9,000 facilities
 - 177 million sf of federal lab buildings in US

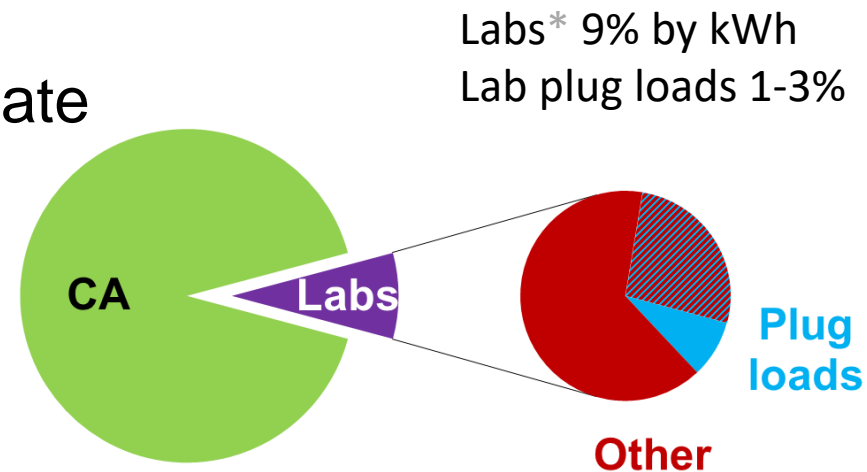


CEEL results in context

- CA results:
 - 232 million sf lab buildings
 - Plug loads 0.8-3.2 billion kWh/yr



- CA context^{**}:
 - 7 billion sf commercial real estate
 - 100 billion kWh/yr total
 - 14 billion kWh/yr plug loads



*Using Labs21 dataset ave for lab building: 38 kWh/sf/yr

** CA Commercial End Use Survey 2006

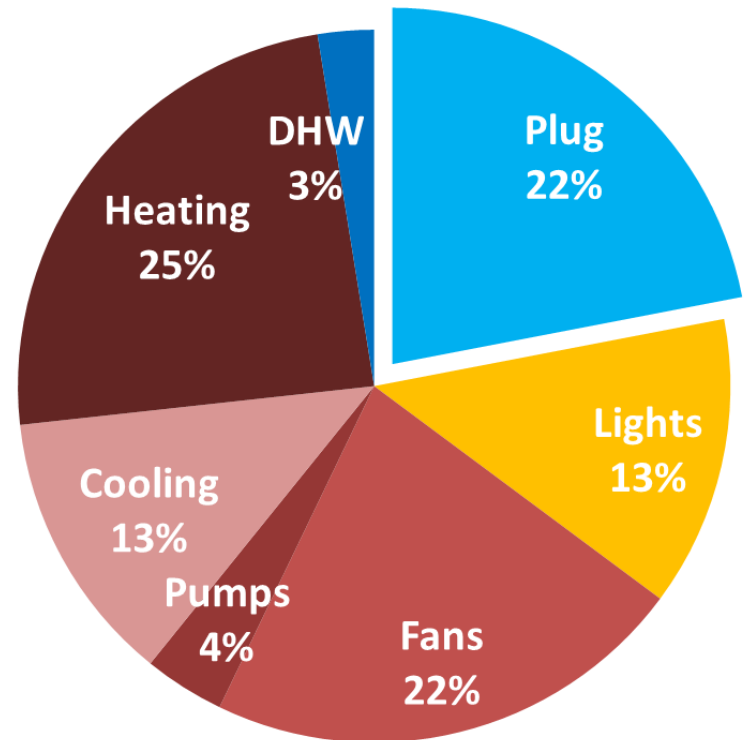
Other plug load studies

Labs21 dataset	12 kWh/sf/yr (buildings)
Stanford	7-9 kWh/sf/yr (buildings)
UC Irvine	13 kWh/sf/yr average (lab/support)
CEEL	7-28 kWh/sf/yr (labs)

- Mix of inventory and submetering studies
- Plug loads not uniformly distributed
 - UC Irvine: <1 W/sf in open labs

Typical lab building usage

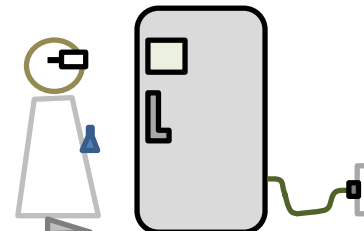
- Total site energy:
~330 kBtu/sf/yr
- Plug loads:
~30% of total elec
~20-25% of energy cost
- HVAC:
~65% of energy cost



Energy cost breakdown

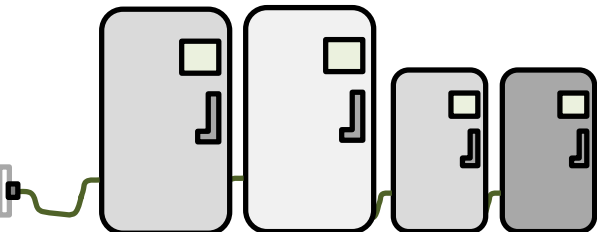
Plug/HVAC interactions

- Electrical equipment dissipates heat in space
- Reducing plug loads saves electricity
- Reduced heat dissipation means reduced space cooling load
- Bonus HVAC savings often claimed
- Not always true



Plug/HVAC interactions

- Focus on existing facilities
- Plug load reductions:
 - Replacing
 - Consolidating
 - High eff vs. base case
- Keep it simple

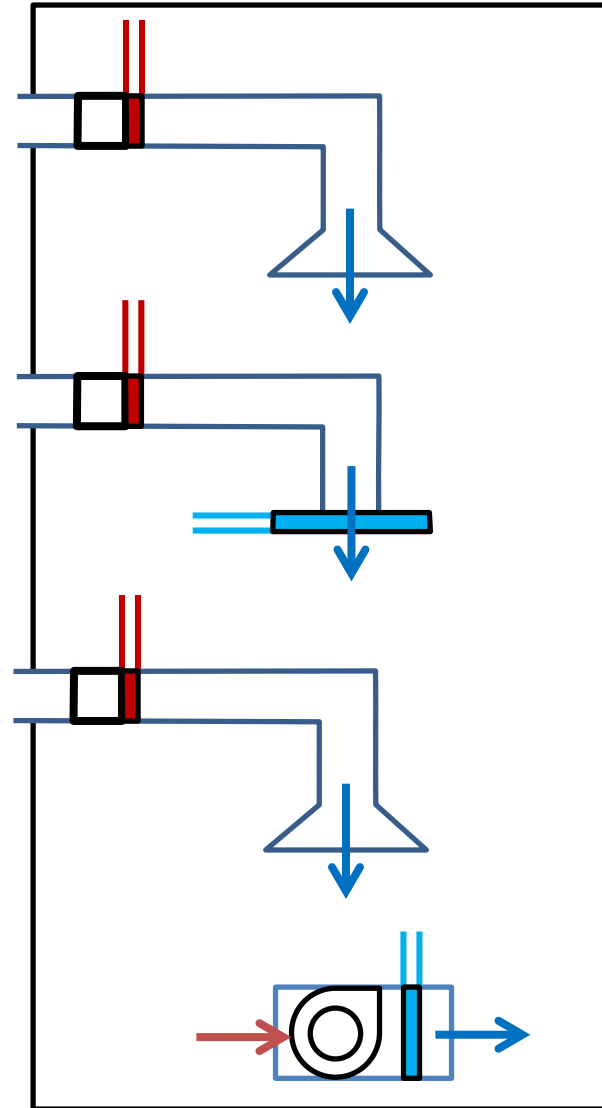


Typical HVAC systems in labs

VAV or CAV with HW reheat

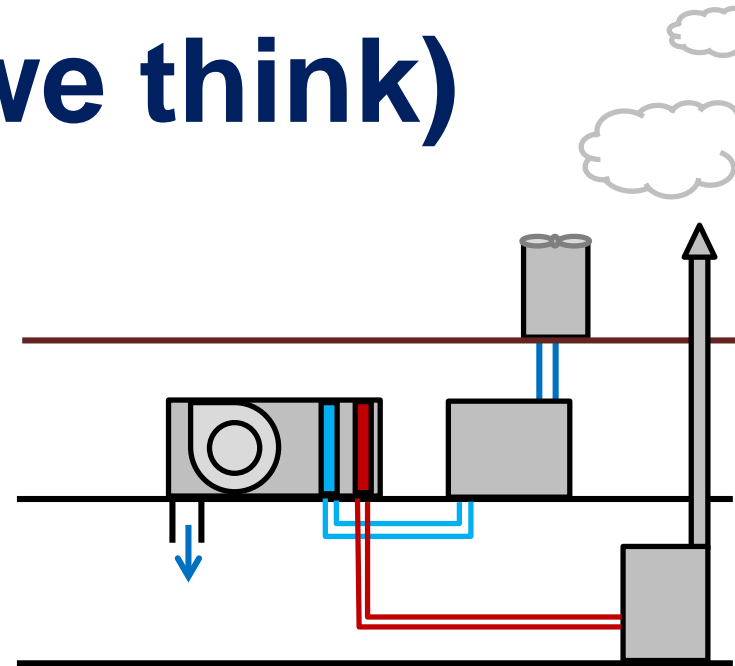
CAV or VAV + chilled beams

CV or VAV + FCUs



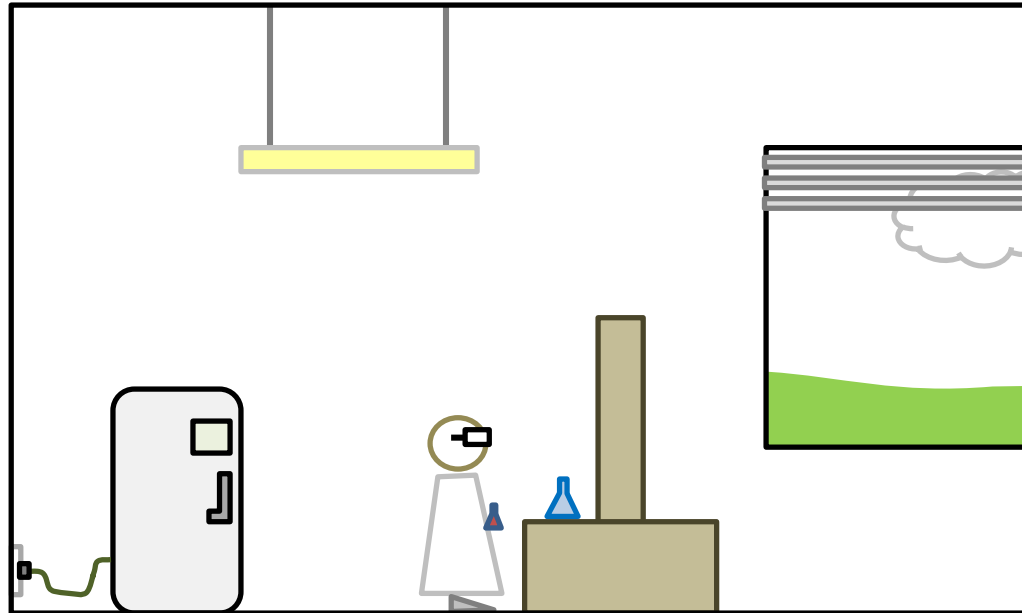
Typical features (we think)

- VAV reheat
- 100% outside air
- Chilled water plant
- Hot water plant
- Supply air temperature 55-60°F
- Air change rates 6-8 ACH (with tails)
- Room air mixed (not direct exhaust)

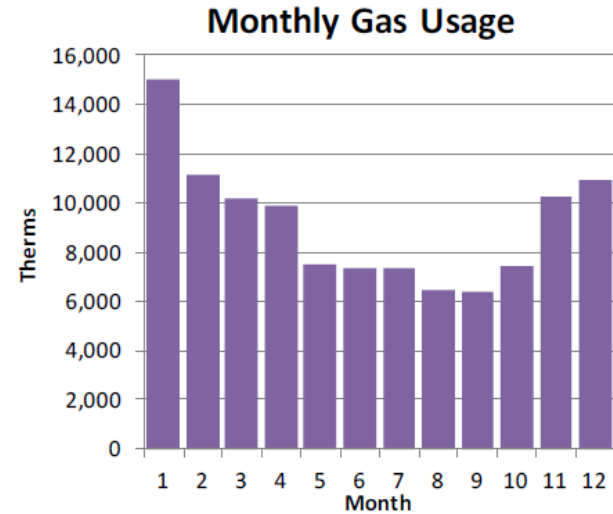
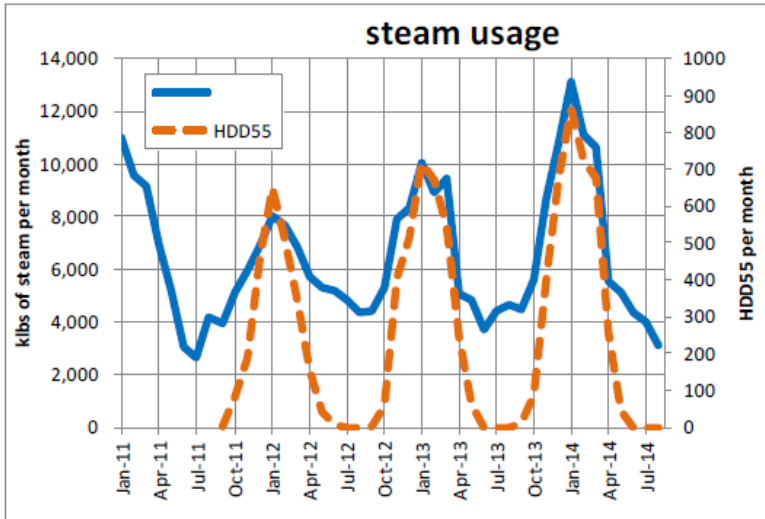


Plug loads are “free” heat

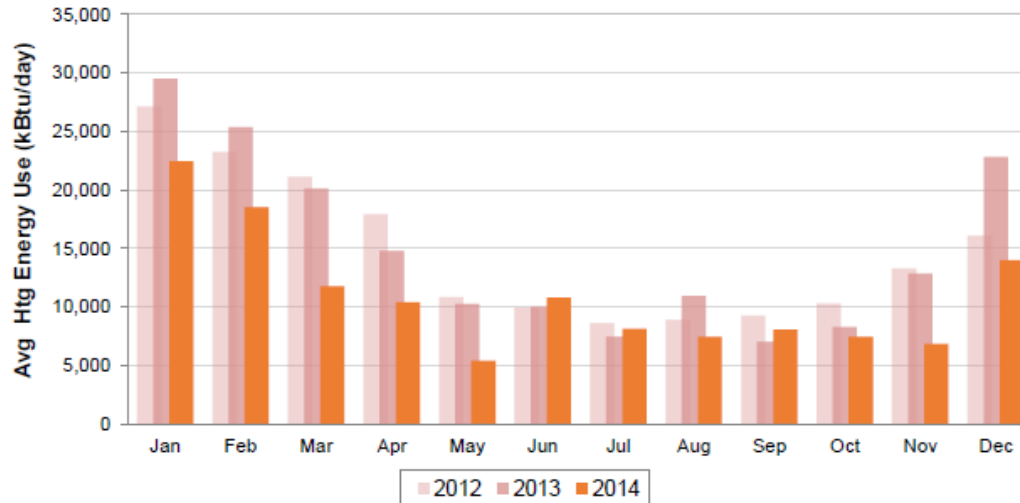
- 6 ACH of air at 55°F cools approx. 6 W/sf
- Typical cooling loads:
 - Lights 1 W/sf
 - People 0.5 W/sf
 - Solar 0-few W/sf
 - Plug 0-20 W/sf
- Lots of reheat



Lots of reheat



(Nov 2011-Oct 2012 gas usage)



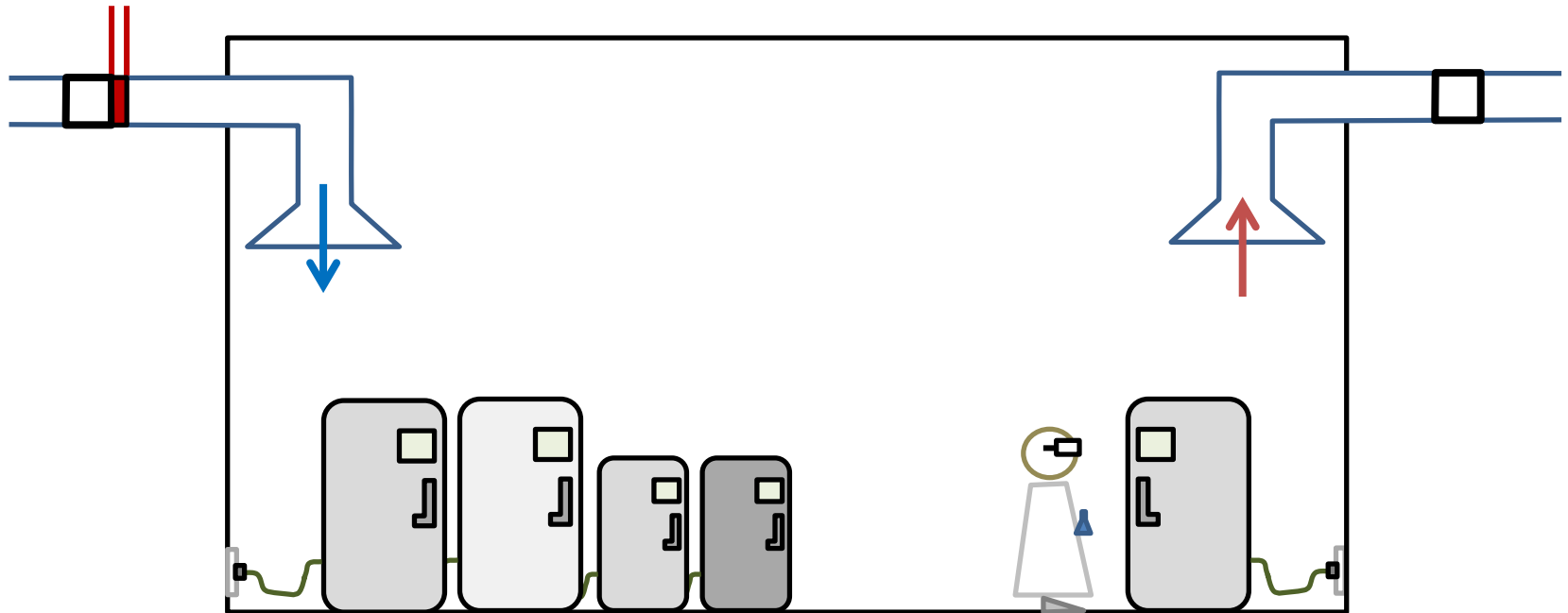
“Worst” case

- High air change rate
- Low supply air temp
- Electric resistance reheat
- No net savings



“Best” case

- Demand-based SAT reset
- Equipment room is rogue zone
- Reduced plug load allows SAT to rise
- Maybe 100x net savings



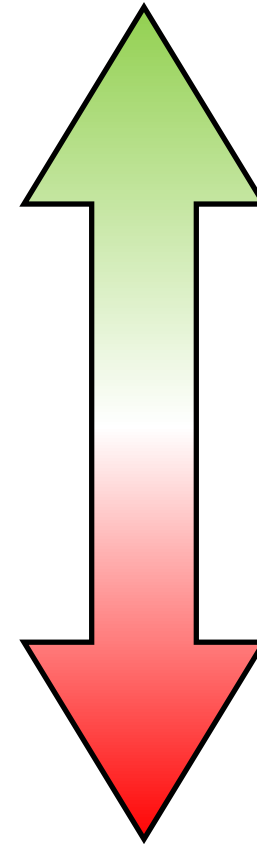
More common cases

Cooling-dominated VAV

Cooling-dominated with zonal cooling

Direct exhaust of hot air

HW reheat-dominated



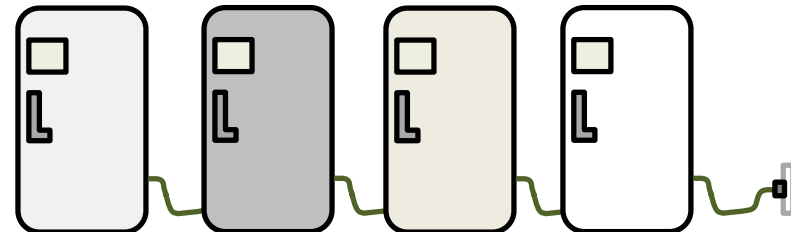
+30% cost bonus
(more in hot climates)

-30% cost penalty

- Overall savings: $\frac{2}{3}$ to $\frac{4}{3}$ of plug savings
- Factor of 2 difference

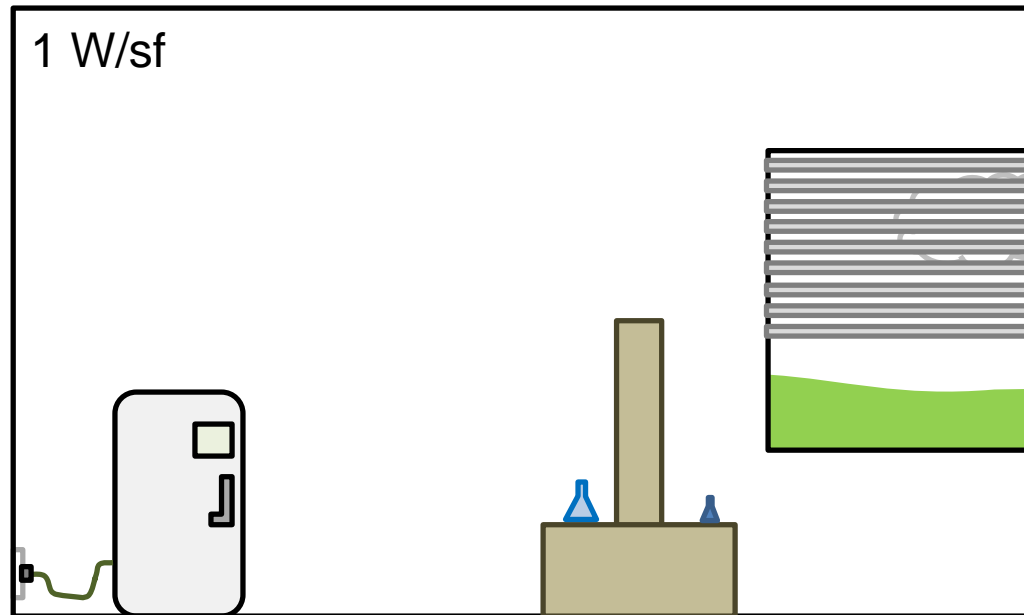
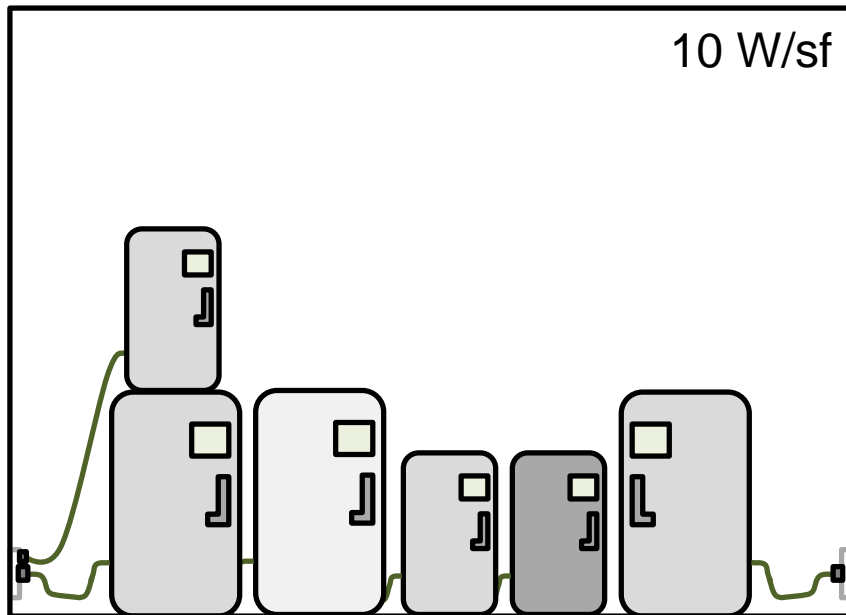
ULT demographics

- Work just beginning
- CEEL work on Energy Star and incentives for ULTs
- Impact of improving freezer efficiency on HVAC energy consumption in CA
- Longer term:
 - Develop “typical lab” model
 - Evaluate other efficiency measures
- Preconceived notions of what’s normal
- Collecting data on locations and HVAC environments



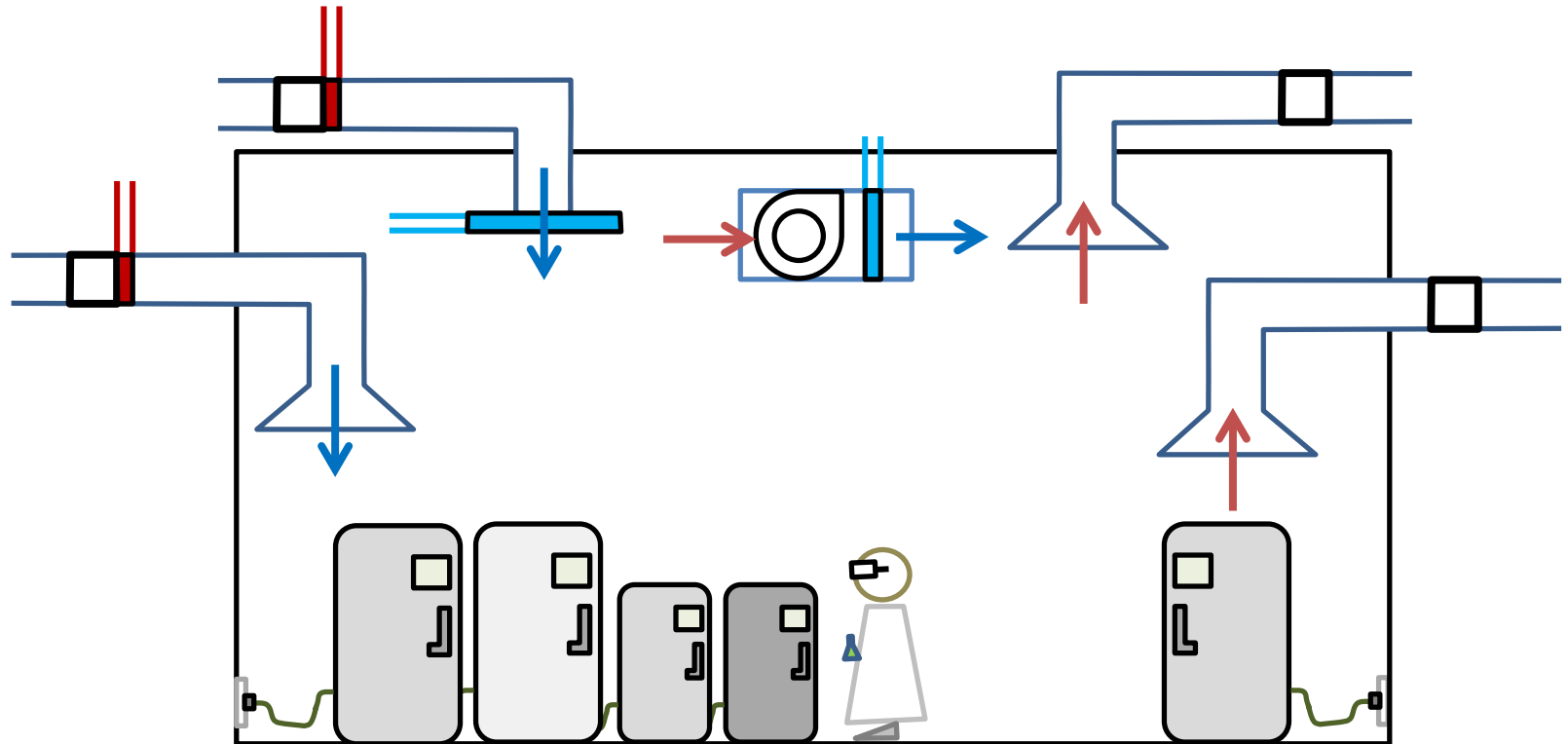
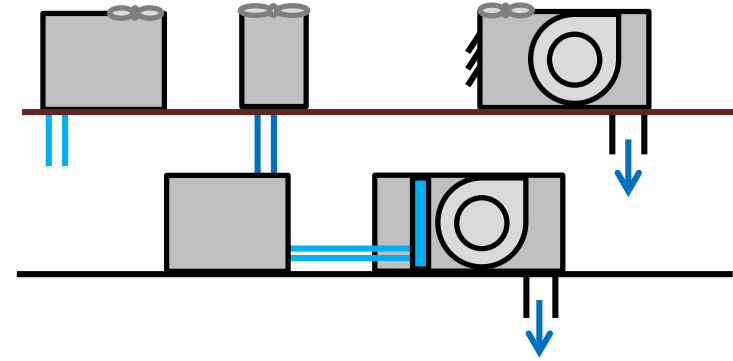
Where are ULTs located?

- Equipment rooms
Cooling dominated
4/3 of direct savings
- Open labs
Reheat dominated
2/3 of direct savings
- Freezer farms?



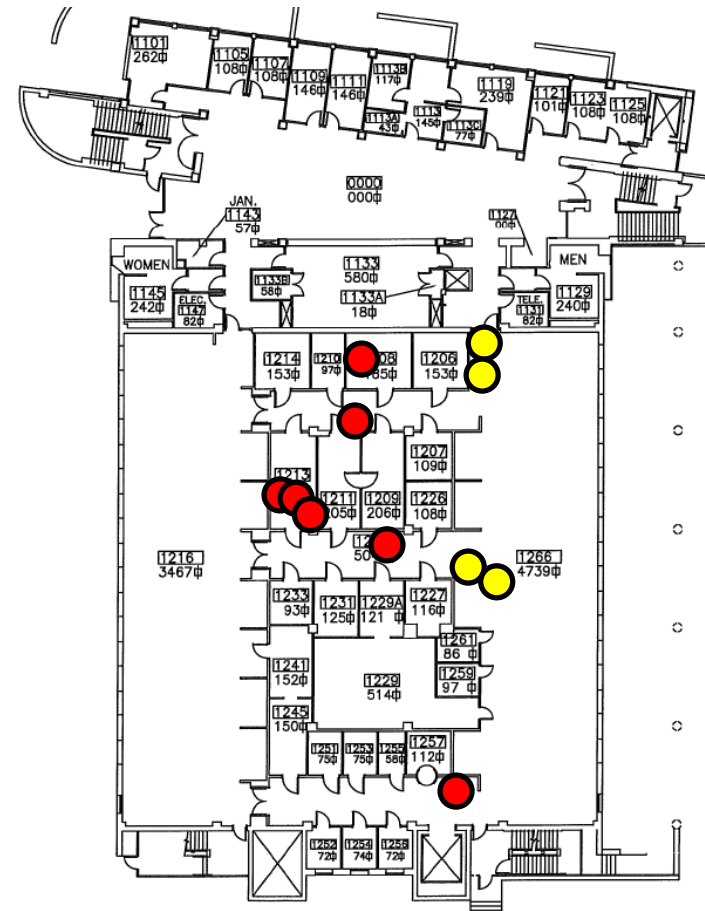
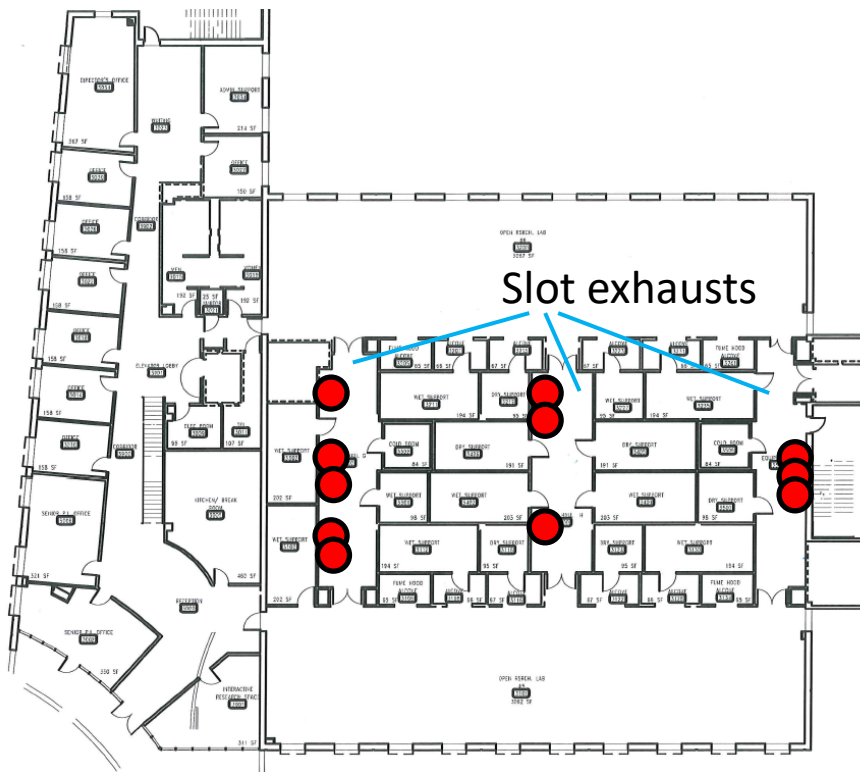
How is the heat removed?

- ACH
- SAT
- Zone temp
- HVAC equipment



Mapping ULT locations and HVAC environments

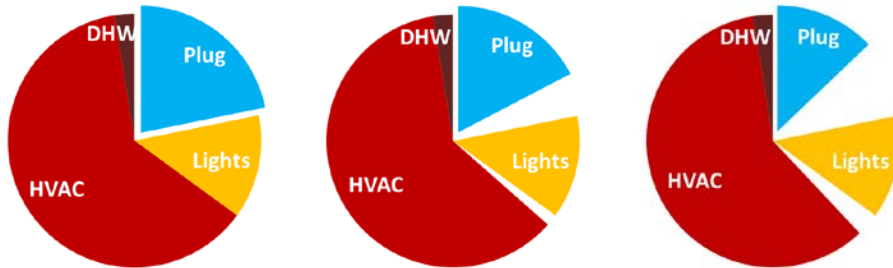
- Getting underway



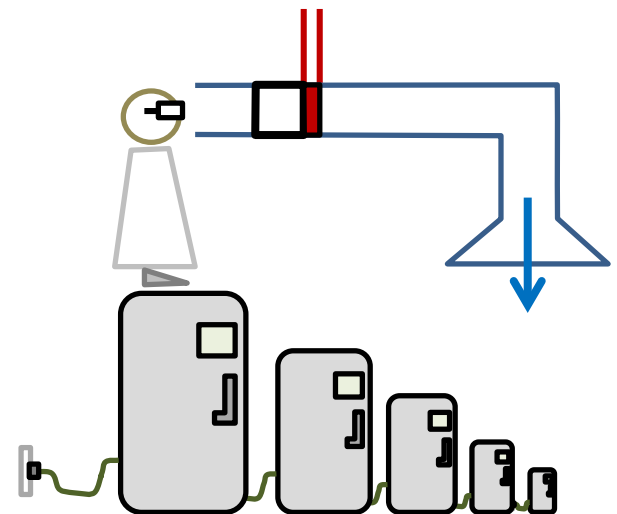
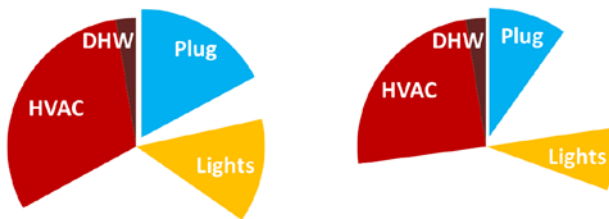
- Freezer locations typ. for convenience

Looking down the duct

- Prioritize opportunities to optimize savings



- Broaden scope of CEEL...



Questions?

Alison Farmer
afarmer@kw-engineering.com

