Strategies for Reducing the Environmental Impact of University Campuses

Campus Sustainability Month

October 2017

buildpulse Duke UNIVERSITY my green lab.

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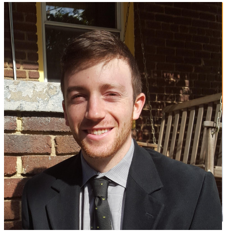

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Duke
UNIVERSITY

Duke Carbon
Offsets Initiative
DUKE UNIVERSITY

The Duke Carbon Offsets Initiative

Duke University
October 24th, 2017

For more information contact Duke Carbon Offsets Initiative staff:
Tani Colbert-Sangree, Program Coordinator, nc140@duke.edu

Duke's Goal of Climate Neutrality

- In 2007, President Brodhead signed the Second Nature Carbon Commitment (formerly the ACUPCC)
- Climate neutrality – reducing GHG emissions to ze 2024
  - Internal emission reductions
  - Off-site reductions (offsets)
  - Very ambitious target compared to other universities
- In 2009, Duke Carbon Offsets Initiative (DCOI) was created.

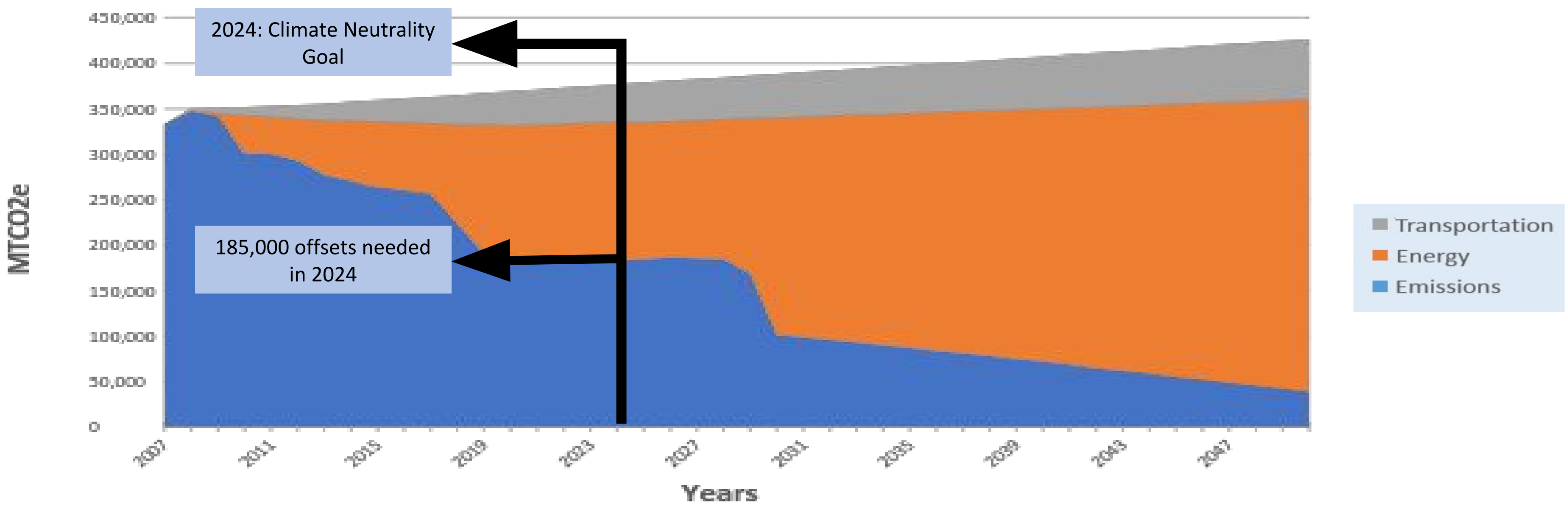
Vision and Mission of DCOI

Duke Carbon Offsets Initiative
DUKE UNIVERSITY

Vision

To make Duke University a model climate neutral institution and to lead peer institutions in their efforts to become climate neutral.

Duke's Forecasted Emissions Footprint



Vision and Mission of DCOI

Duke Carbon Offsets Initiative
DUKE UNIVERSITY

Mission

1) To meet Duke University's climate neutrality goal by 2024 by **developing and implementing the University's strategy for identifying, creating, and purchasing carbon offsets** and assisting other departments in reducing the University's emissions baseline;

2) To implement the strategy in a way that **provides educational opportunities** for students, faculty, and staff;

3) **To prioritize local, state, and regional** offsets that provide significant **environmental, economic, and societal co-benefits** beyond the benefits of greenhouse gas emission reductions; and

4) **To facilitate and catalyze high-integrity, unique offset projects** by serving as a resource for others outside of Duke University

What is a Carbon Offset?

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A carbon offset is a reduction or removal of one metric ton of carbon dioxide *equivalent* (CO_2e) greenhouse gas (GHG) emissions from the atmosphere.

Carbon offsets are used to counterbalance or compensate for ("offset") emissions from other activities. (ACUPCC, 2014)

→ **Offset** →

What is a Carbon Offset?

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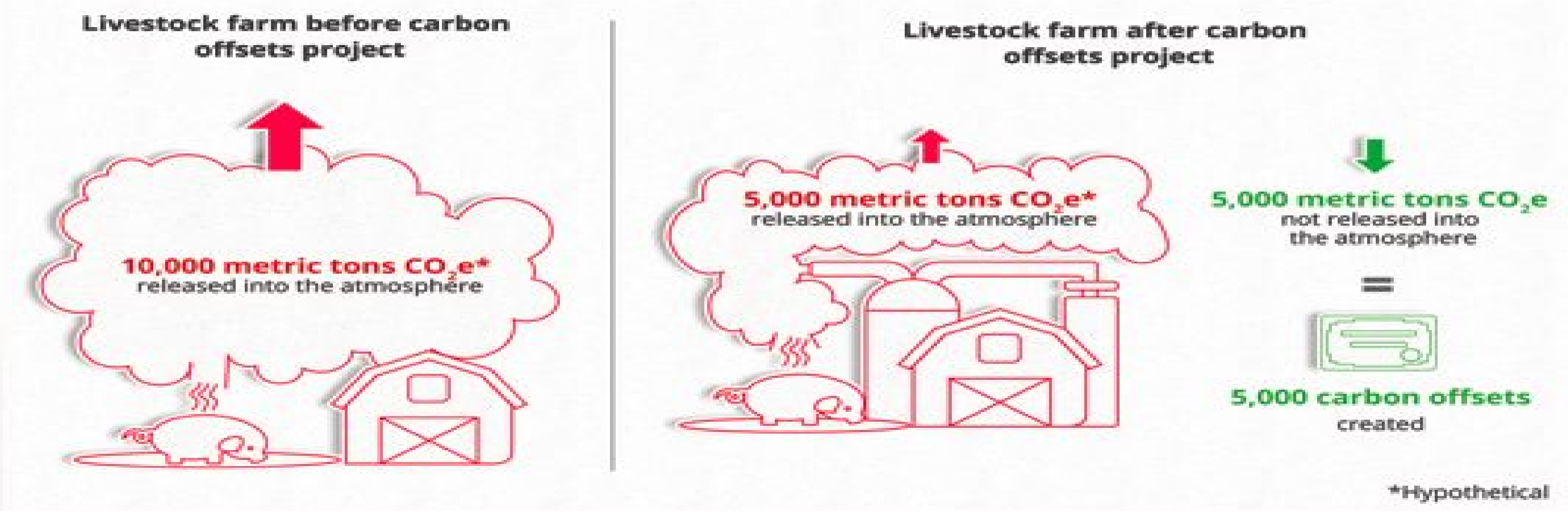

What is a Carbon Offset?

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Waste to Energy

Urban Forestry

Peatland Restoration

Avoided
Deforestation

Energy Efficiency

Residential Solar

Clean Cook-stoves

Ozone Depleting
Substance Destruction

Co-Benefits

- Educational opportunities for students, staff, and faculty
- Social engagement with local community members and organizations
- Environmental benefits for land, air, and water quality
- Scale projects up to increase the impact
- Public relations benefits and partnership building

Loyd Ray Farms – Description

Duke Carbon Offsets Initiative
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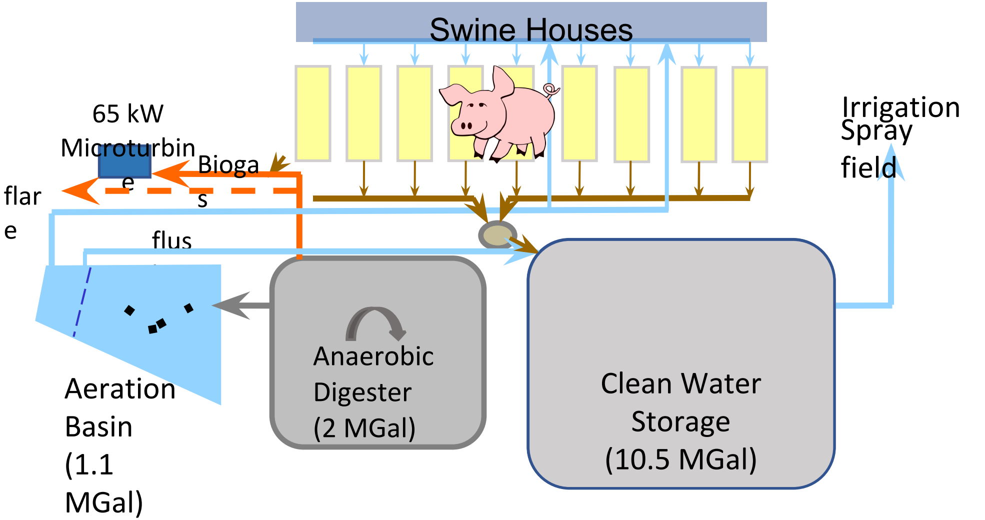
- Swine waste-to-energy system
- Captures and burns methane from the hog waste to generate electricity and offsets
  - 350 RECs per year (65 kW micro-turbine)
  - 2000 offsets per year (registered with the Climate Action Reserve)



Urban Tree Planting Projects

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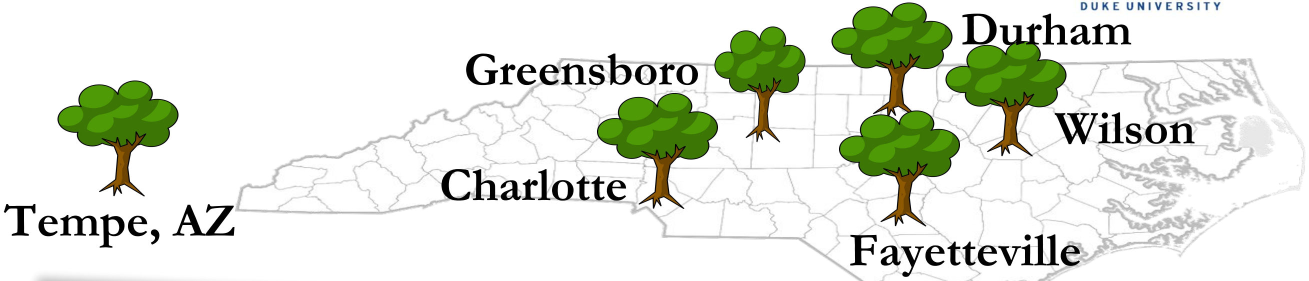
- Since 2013, the DCOI has planted over 1000 trees
- In 2016, in collaboration with Urban Offsets and ASU, the DCOI planted trees in Tempe, Charlotte, Durham, Wilson, and Fayetteville.



URBAN OFFSETS

ASU
ARIZONA STATE UNIVERSITY

Urban Forestry Market Development

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2014: Urban Forestry Protocol V1.0

2015-16: Pilot plantings with Urban Offsets

2017: Urban Forestry Protocol V2.0

2017: Offset Bundle Strategy

2017: Carbon Sink Guidance

Resource Sharing Platform

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Offsets Initiative
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Offset Network

HOME   OFFSET PROJECTS   DEVELOP A PROJECT   LOCATE A PROTOCOL   ABOUT

Carbon Offsets Done Differently

Offset Network: Projects

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Offset Network

HOME | OFFSET PROJECTS | DEVELOP A PROJECT | LOCATE A PROTOCOL | ABOUT

Offset Projects

- Loyd Ray Farms, Duke University
- Neutral UF Coalition, University of Florida
- North Fields Afforestation, Oberlin College
- Solarize Duke, Duke University
- Urban Forestry, Duke University
- DCOI Home Energy Affordability Loan (HEAL), Duke University
- West River Pilot Project, Yale University
- Programmable Thermostat Project, Yale University
- Uganda Carbon Offset Program, Clarkson University
- Patagonia Sur Carbon Offset Project, Colgate University
- Zanmi Kafe, Sewanee University of the South

Loyd Ray Farms

PROJECT DESCRIPTION & CO-BENEFITS:

Loyd Ray Farms is an 8,600-head feeder-to-finish swine operation located in Yadkinville, North Carolina. Traditional waste management systems on swine farms store waste in open-air lagoons that affect the local and global ecosystem in the form of waste runoff, the release of greenhouse gases, and odor nuisances. In collaboration with Google Inc. and Duke Energy, the Duke Carbon Offsets Initiative (DCOI) has assisted in the design and implementation of a 7,600 cubic meter anaerobic digester that converts swine waste into methane, a potent greenhouse case, which is used to generate renewable energy on-site.

Offset Network: Develop a Project

Duke Carbon Offsets Initiative
DUKE UNIVERSITY

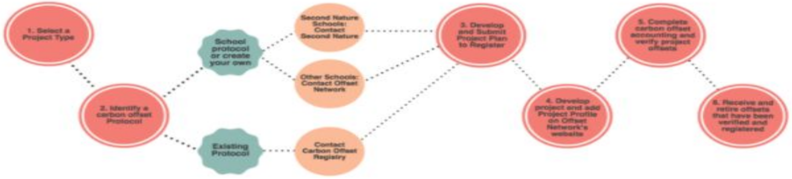
Offset Network

HOME | OFFSET PROJECTS | DEVELOP A PROJECT | LOCATE A PROTOCOL | ABOUT

Develop a Project

When developing an offset project, we encourage you to examine similar projects available through the examples on the Offset Projects page. The Offset Network helps connect institutions that are just getting started with experienced project developers to help new programs get off the ground, link you to useful resources, and foster a peer review community. Don't hesitate to reach out to other project organizers and build connections within this community of institutions striving to achieve climate neutrality.

Steps to Follow:



1. Select a project type
2. Identify a carbon offset protocol
    - Existing protocol --> contact carbon offset registry
    - School protocol or create your own
        - Second Nature schools: contact Second Nature

Carbon Offset Bundling

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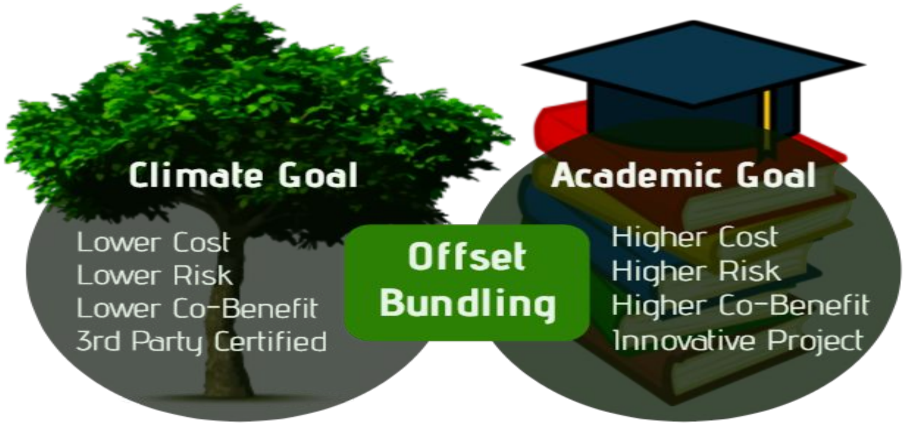
- **Climate change is already occurring. Our actions cannot wait.**
- Most climate action goals have several years before maturation.
- How can we meet our academic and research goals while having a definitive climate impact?
- Bundling couples innovative offset projects with 3rd party verified offsets, ensuring climate mitigation *now* and adaptation for future years.



DELTA

URBAN OFFSETS

Duke NICHOLAS SCHOOL OF THE ENVIRONMENT

Resources

Duke Carbon Offsets Initiative
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- Questionnaire to Guide Offset Program Creation
- Guidance documents:
  - Bundled Offset Strategy
  - Carbon Sink Guidance – plant trees on campus
- Offset purchasing guidance:
  - DCOI purchasing guide
  - RFP for external offset purchases (available by request)
  - Upcoming offset 'policies': UC-schools, Yale
- Training offered at Arizona State University Nov. 16th

Duke Carbon Offsets Initiative
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Visit sustainability.duke.edu/offsets for more information

Thank you!

For more information contact Duke Carbon Offsets Initiative:
Tani Colbert-Sangree, Program Coordinator, nc140@duke.edu

PROBLEMS

Labor

50% of time is spent in intensive manual troubleshooting

Equipment

Maintenance cycles are unrelated to actual usage

Energy

Wasted due to:

- Inefficient operating schedules
- Failing equipment
- Equipment not reviewed after changes

Comfort

Reduce complaint levels. Improve ticket resolution windows.

THE 4 STAGES OF BUILDING EFFICIENCY AS WE SEE THEM

0. **Community Engagement Dashboard** - tool to raise awareness, educate, and prompt active behavior change. Requires continued active campaigning.

1. **Utility Bill Management -** monthly aggregates by site, cohort benchmarking, EUI reporting, and looking for errors in the utility bill.

2. **Submetering (EIS) –** (AKA Real Time Production and Consumption Analytics) building or select major equipment level submetering with intervals typically in the 15 minute window, basically let's you identify anomalies.

3. **Equipment level diagnostics (FDD) -** primarily through the building control system and its plethora of sensors and state information, basically gives you a diagnosis for the healthy operation of each unit, and units in concert.

4. **Automated system optimization (ASO) -** allowing advanced computer control to mitigate spikes, disperse peak time load, take better advantage of weather, and to use the deadband in the building more like a battery.

TYPICAL IMPACTS

- **50%** improvement in HVAC related O&M hours
- **30%** average decrease in duration of HVAC related problems
- **40%** reduction in HVAC related complaints
- **5-10x** average first year energy ROI. 2x steady state
- **10%** Reduced asset breakdown and increased asset lifetime
- Improved sustainability scores

BUILDING COMMISSIONING STARTS WITH

FOUNDATION

- Setpoints
- Scheduling
- Sequences

TOP 12 ISSUES

1. HVAC system operates continuously during unoccupied period
2. Lighting system illuminating space during unoccupied period
3. HVAC system improperly balanced
4. Improper refrigerant charge
5. Economizer dampers operating incorrectly
6. Insufficient evaporator airflow
7. Improper controls setup
8. Control component failure or degradation
9. Software programming errors
10. Improper controls hardware installation
11. Air-cooled condenser fouling
12. Valve leakage

Reference: PNNL - A Guide to Building Commissioning

CLIENT EXAMPLE

How long does it take to?

- Test Every Sensor, Valve, Damp
& Relay
- 90 buildings
- 2 Dedicated Techs

AUTOMATION THAT DRIVES EFFICIENCY

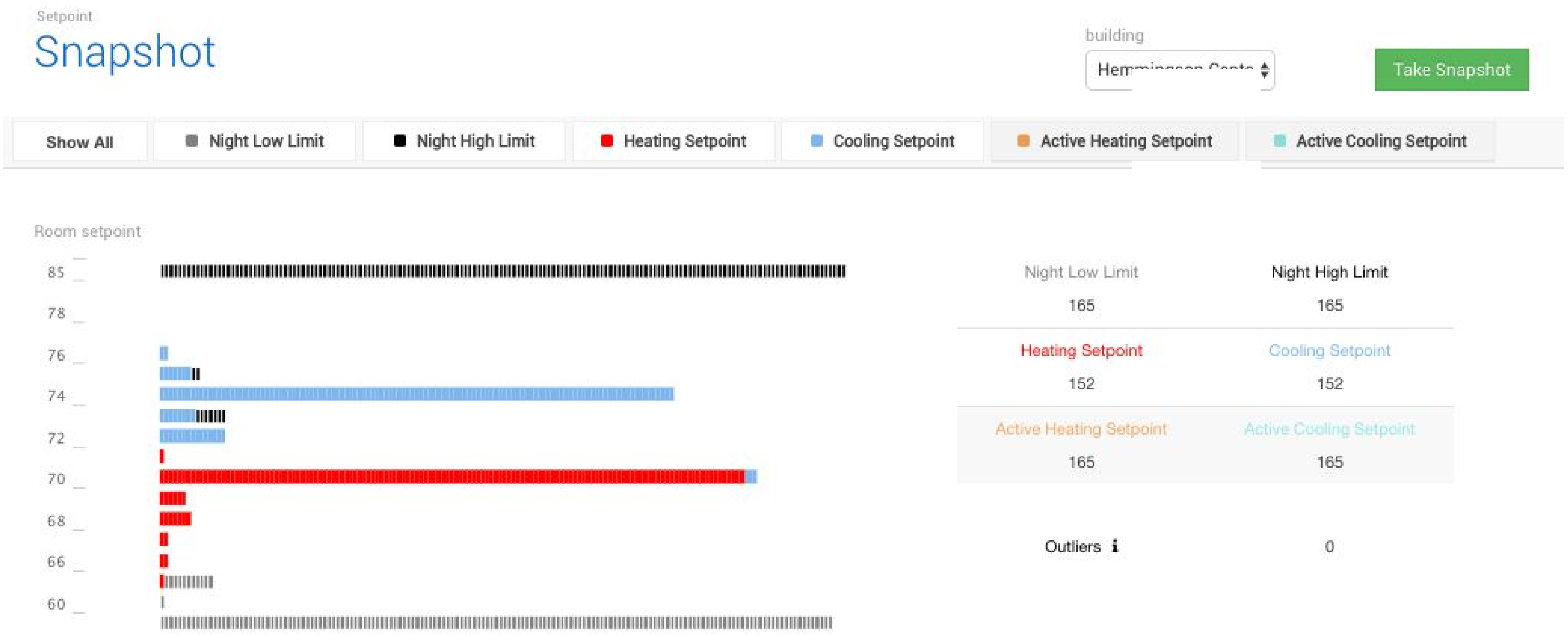
- Analytics automates the manual processes and audits that we don't have time for.

- 4 Man Years

or 5 Minutes

- Manual Inspection still requires verification

SETPOINTS
TYPICAL SETPOINT MANAGEMENT



SETPOINTS

Band Aid Fixes

Raising or lowering the setpoint so the unit is always heating or cooling is not addressing the actual issue. Consider resetting all setpoints during unoccupied hours.

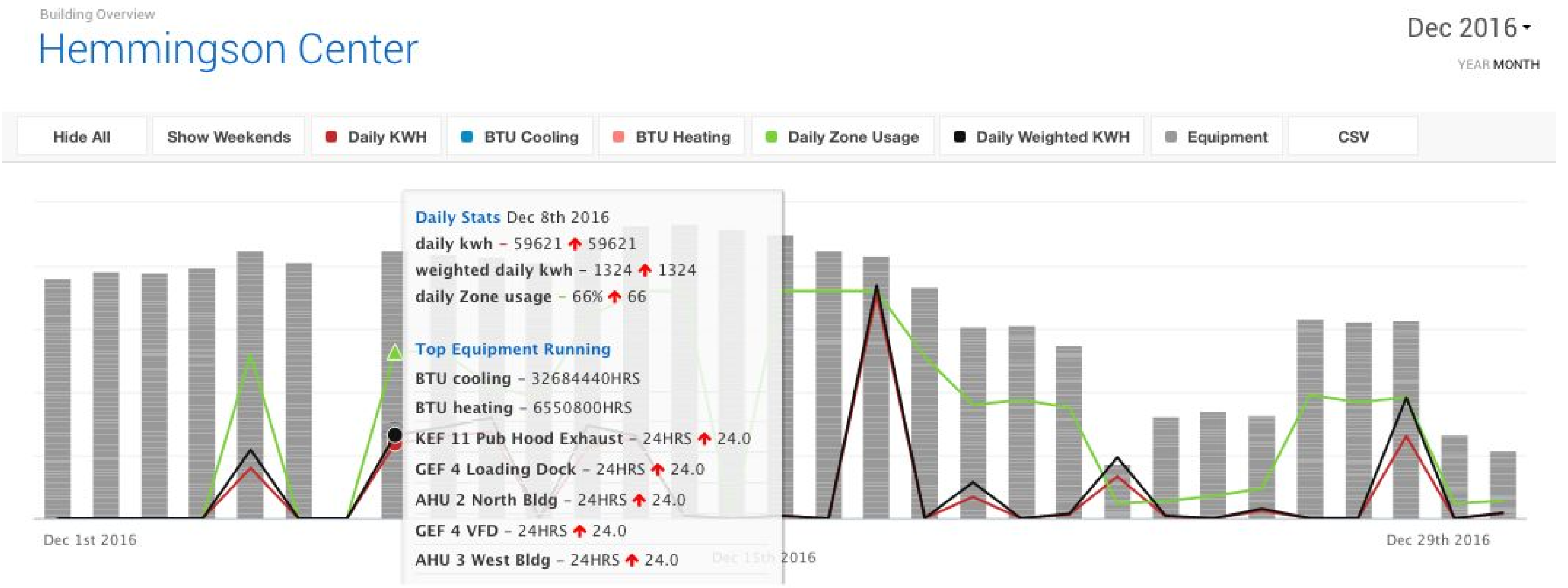
Apply Minimums and Maximums

Deadbands should not just be +/- one or two degrees on a general setpoint. Do not allow heating setpoints above 70 or 72, and do not allow cooling setpoints lower than 74 or 76.

Use Minimum Percentage for Parent Mode

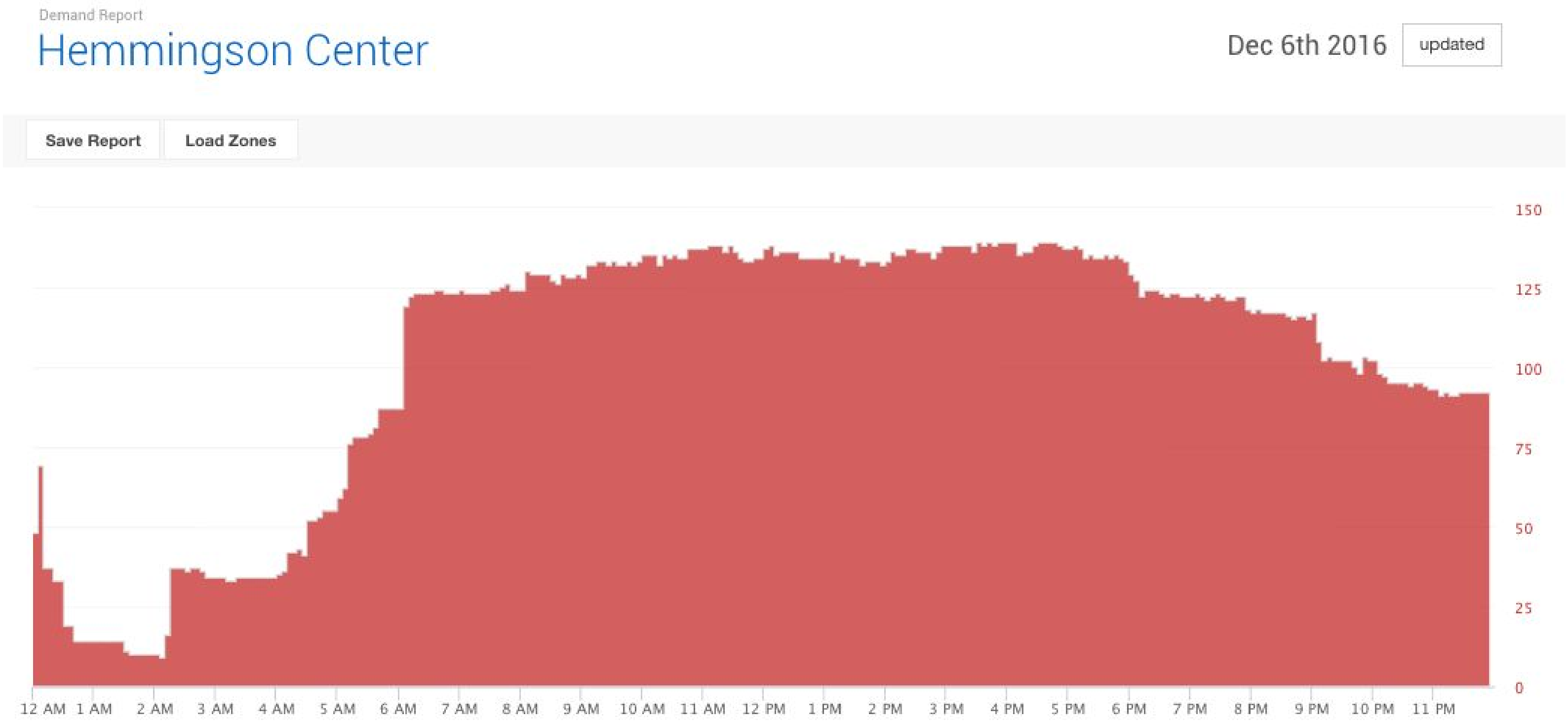
Instead of determining mode based on a single minimum zone requirement, use an average of all or require that at least 20% of the served equipment is calling for the highest energy mode. For example cooling in winter.

SCHEDULES
QUICKLY AUDIT EQUIPMENT RUNTIME



SCHEDULES

IDENTIFY ANOMALIES



SCHEDULES
IDENTIFY ANOMALIES

SCHEDULES

Confirm with Equipment

Just because the schedule is set correctly does not meant the equipment is following it, verify schedule adherence with runtime data from the equipment.

Maximum schedule resolution

When ever possible use zone level scheduling, avoid a single schedule for the entire building. Holiday and Exception scheduling can be nested to apply global changes from one location.

Optimal Start / Stop

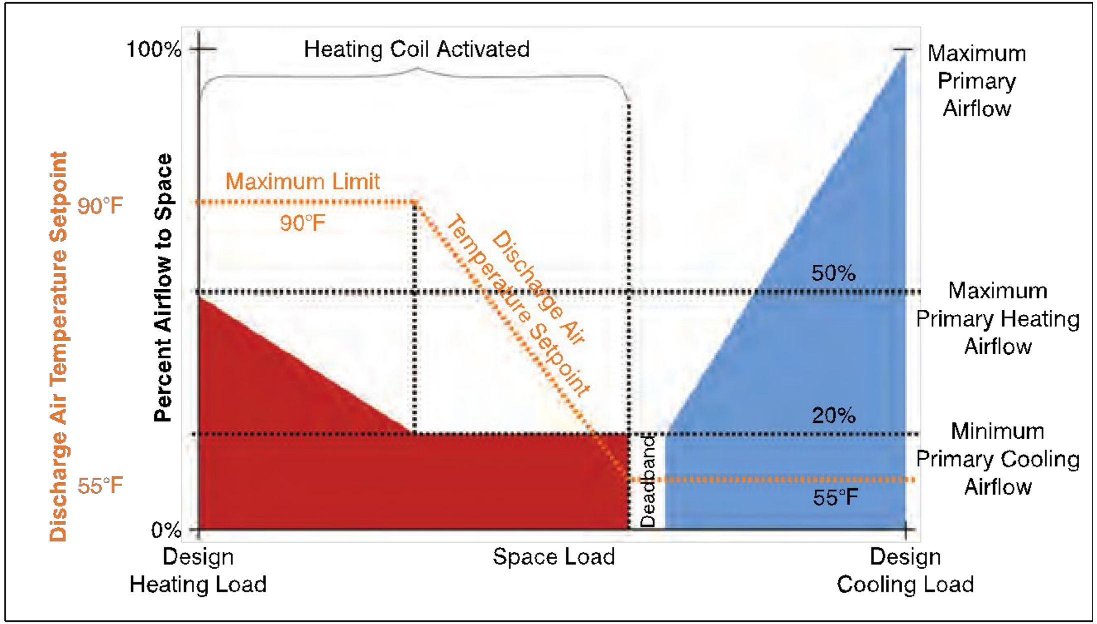
Effective optimal start maintains a memory and trains itself to heat or cool based on the individual zones rate of change in heating or cooling mode.

FAULTS & DEVIATIONS

SOURCE WATER PUMP VFD OPERATING

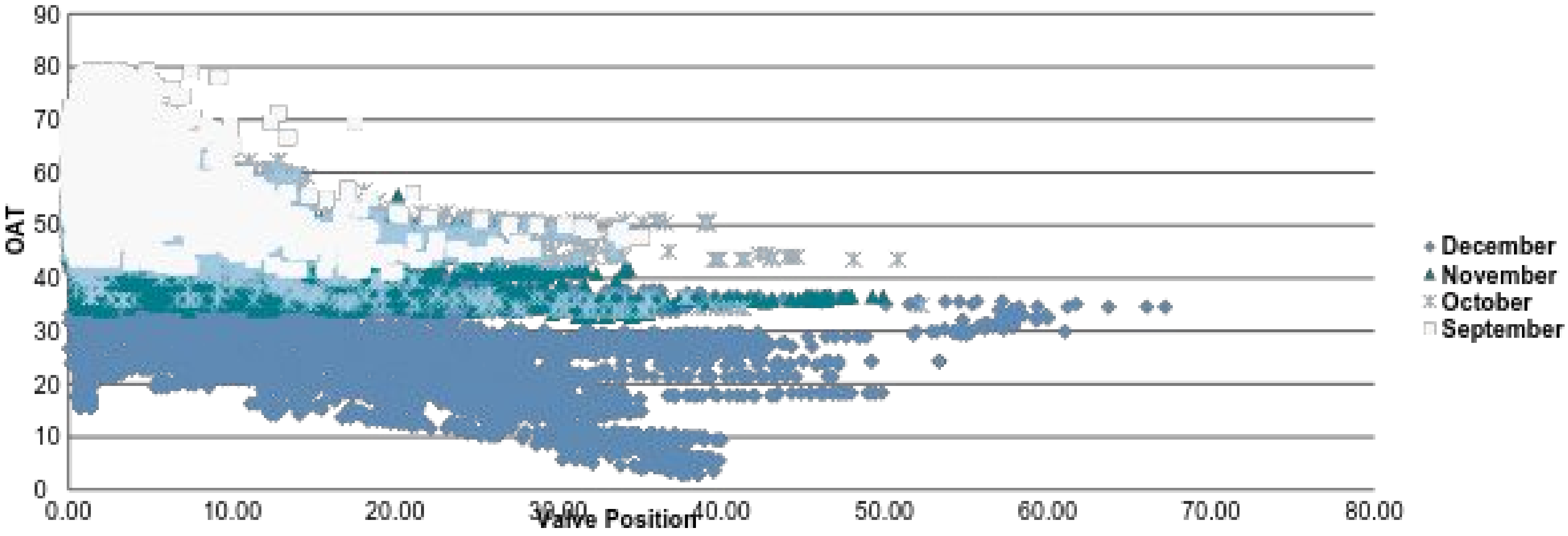
SIMPLE SEQUENCES

CONTROL OF A VAV REHEAT TERMINAL TO VARY AIRFLOW DURING HEATING



ASHRAE High Performance VAV Systems, ASHRAE Journal Oct 2011, John Murphy

HW VALVE POSITION



transforming research labs into sustainable spaces

my green lab.

allison paradise, executive director

sustainability in labs: areas of focus

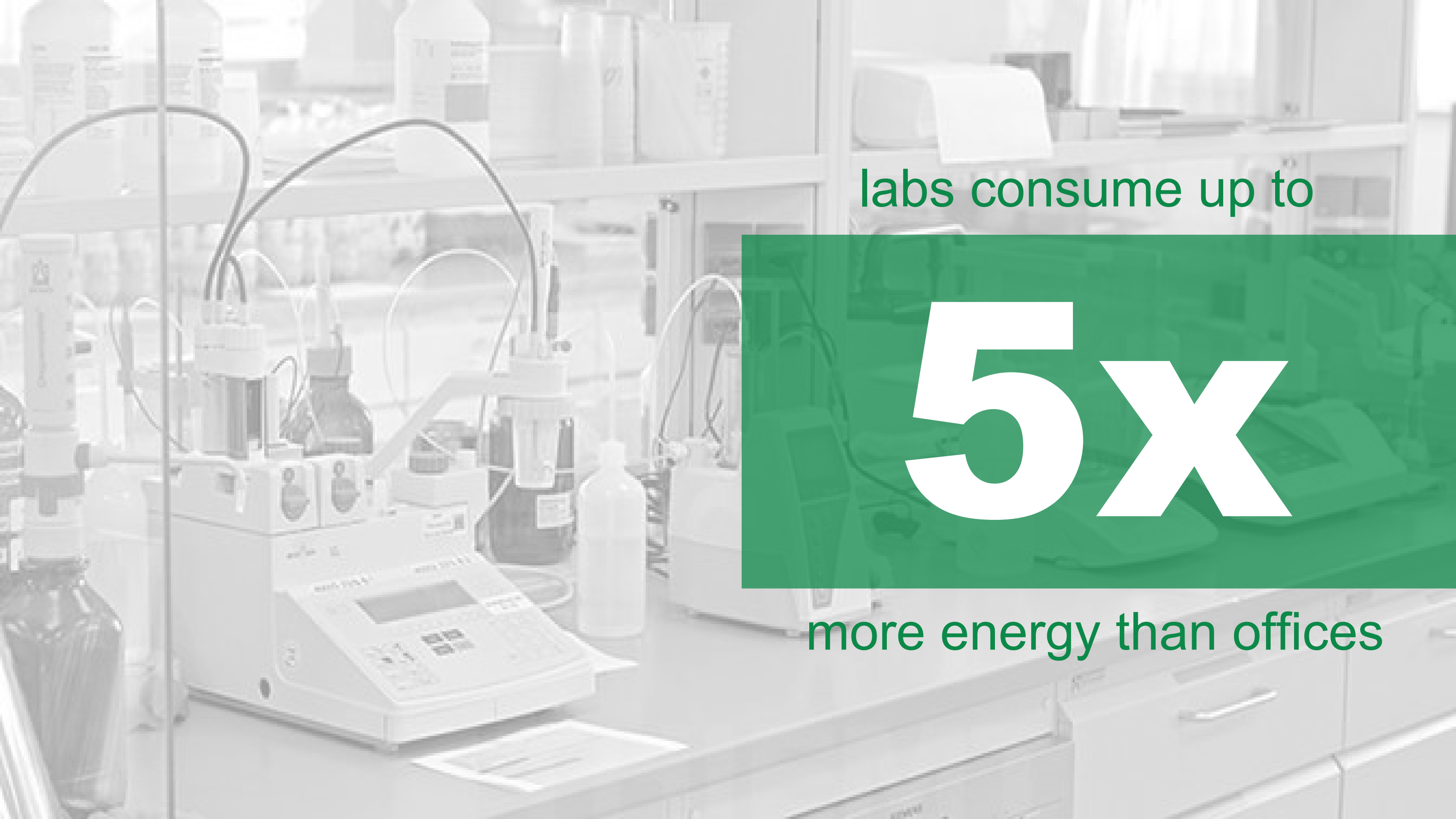
- disposal
- energy
- water
- chemicals

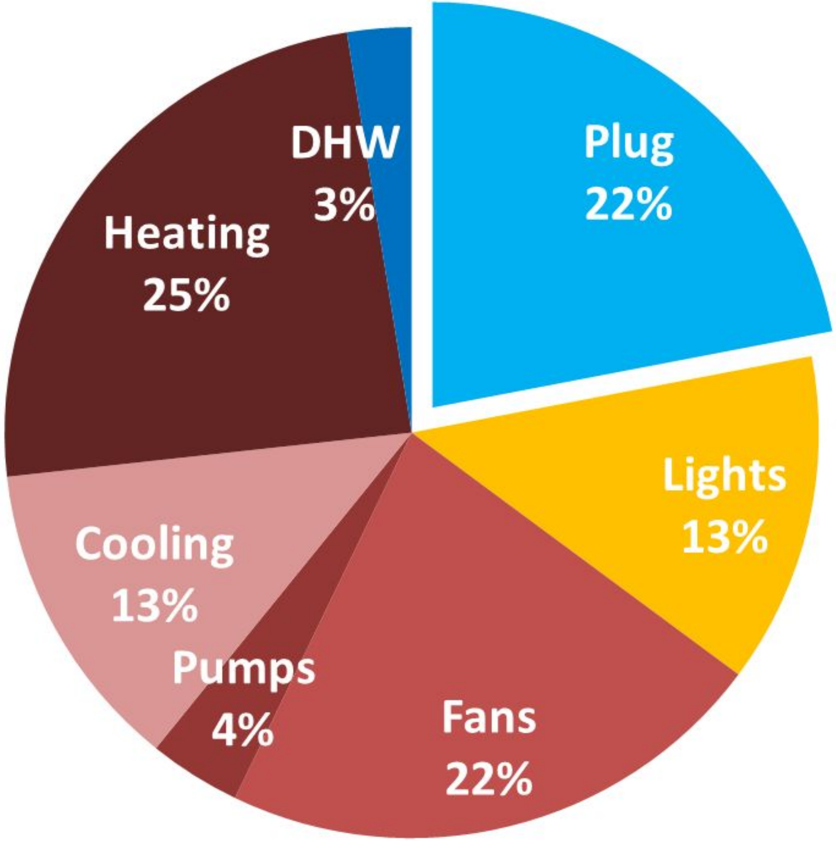

did you know...?

12,100,000,000

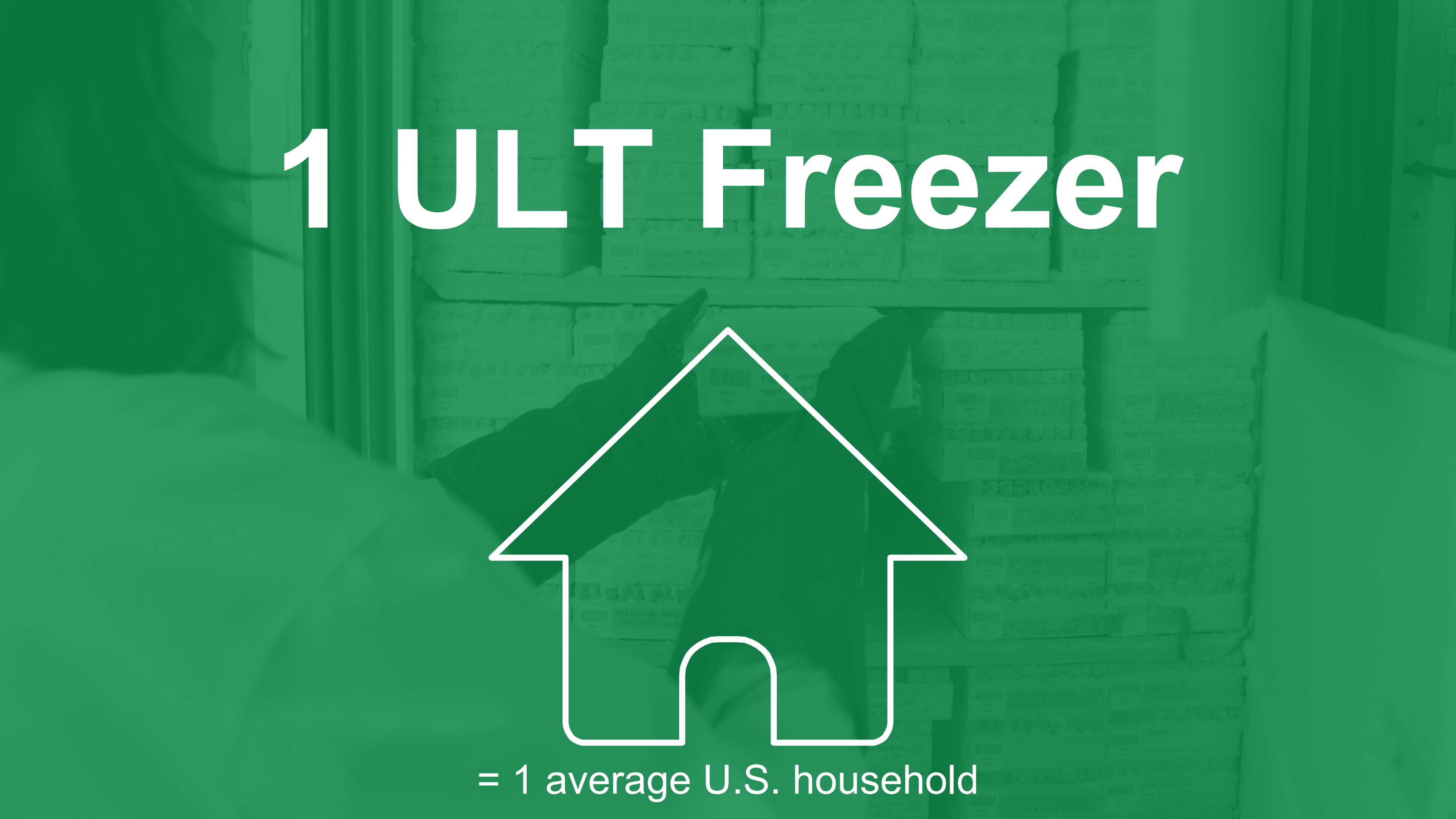
pounds of lab plastic waste worldwide in 2014

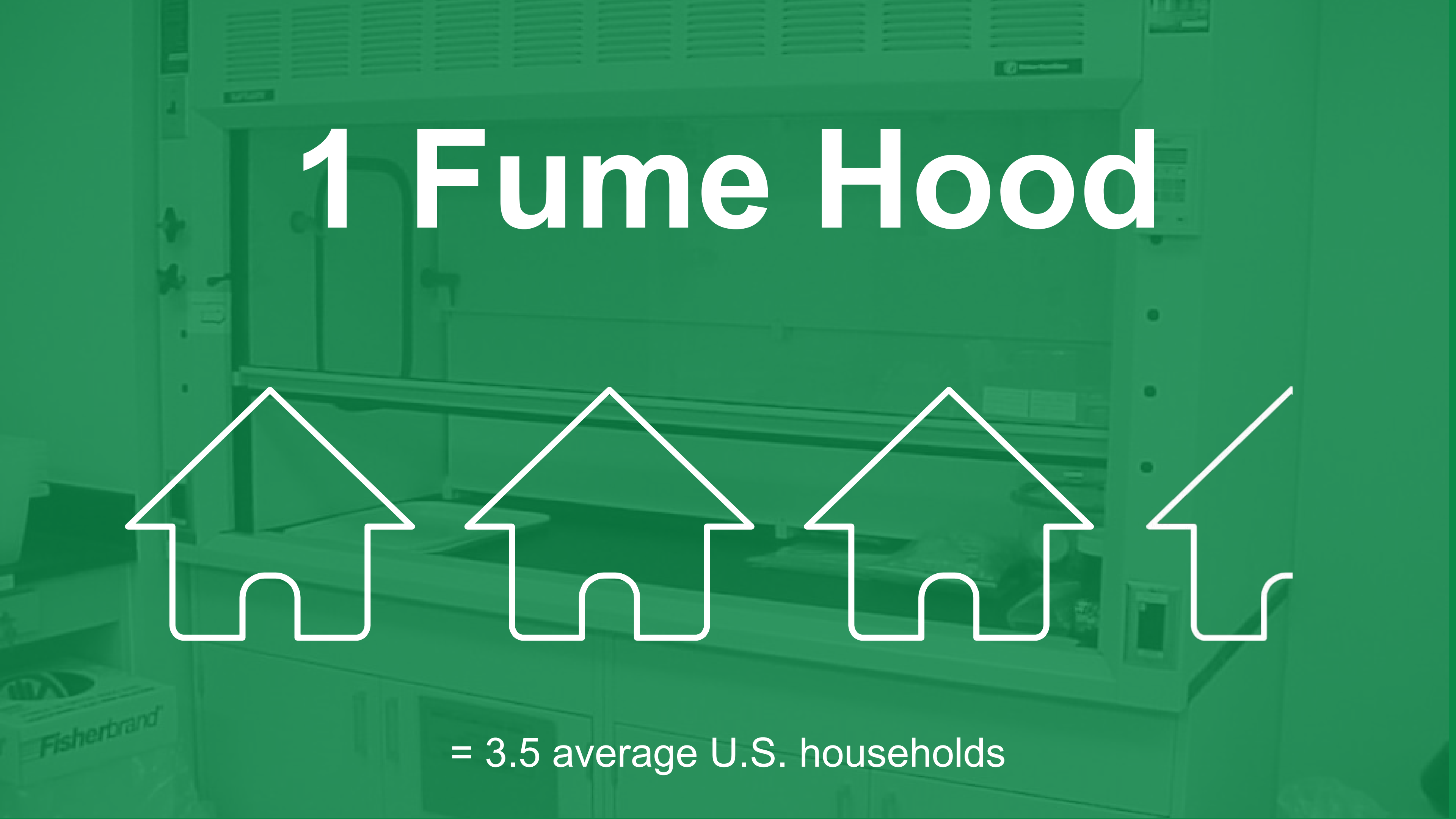

that is equivalent to
434 BILLION
plastic water bottles


labs consume up to
5x
more energy than offices



Alison Farmer, kW Engineering

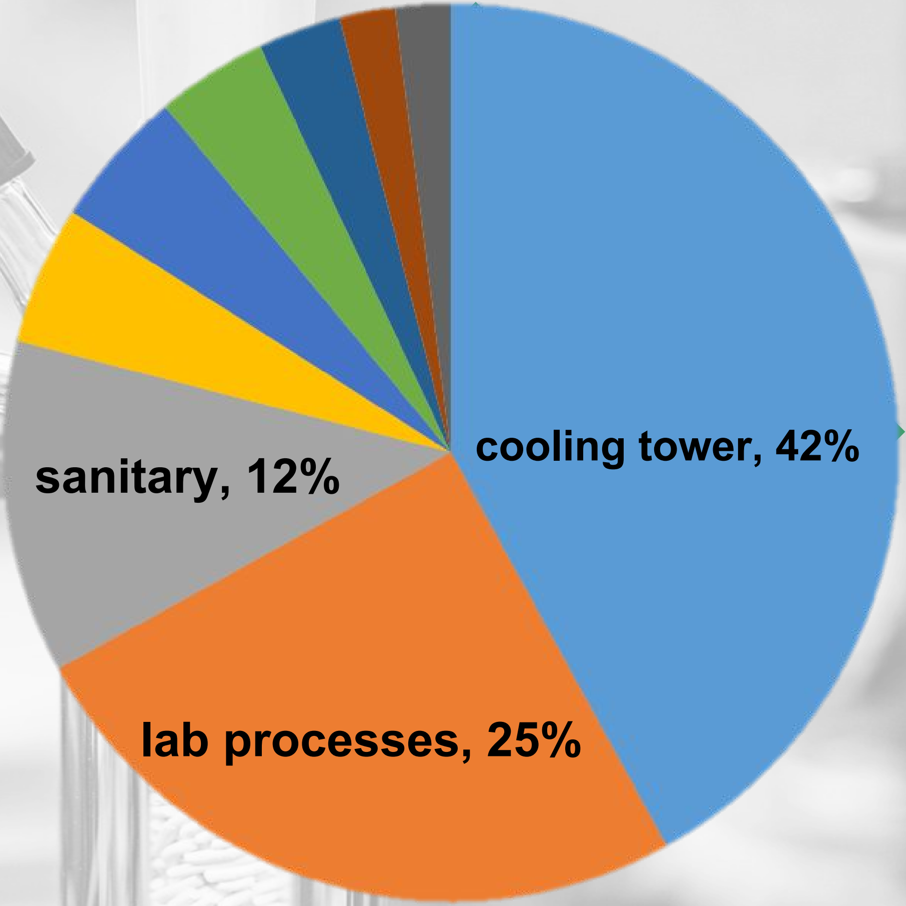

1 ULT Freezer
= 1 average U.S. household


1 Fume Hood
= 3.5 average U.S. households
Fisherbrand

a typical lab building uses

>2m

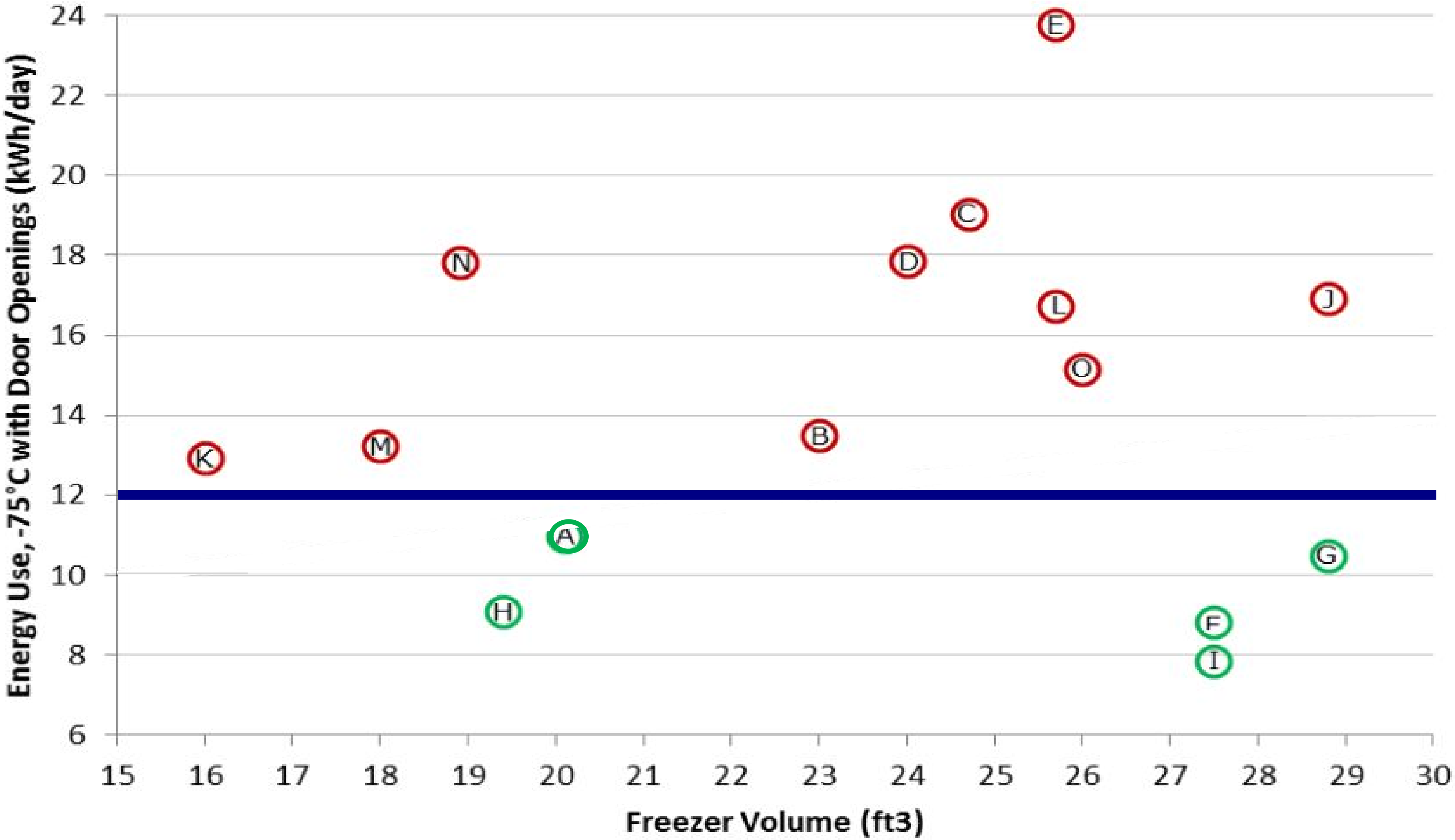
gallons of water each year


cooling tower, 42%
sanitary, 12%
lab processes, 25%

but it doesn't need to be this way

together we can ensure that resources are used responsibly


-80c
REVCO



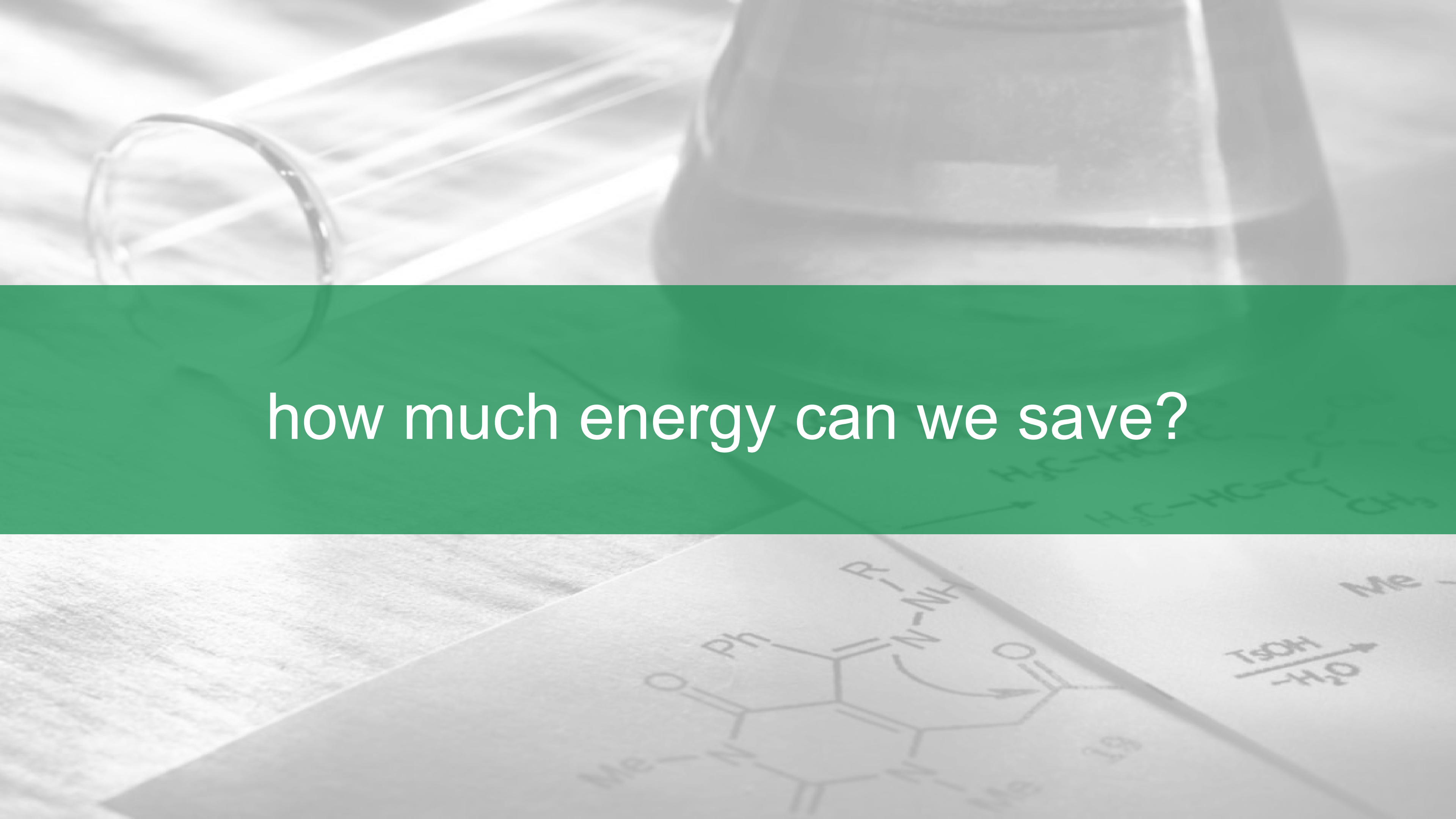
Energy Use, -75°C with Door Openings (kWh/day)
Freezer Volume (ft3)
24
22
20
18
16
14
12
10
8
6
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
E
C
N
D
L
J
O
B
M
K
A
G
H
F
I

submitted data to the EPA and CA utilities

EPA issues ENERGY STAR specification for ULT freezers

ENERGY STAR

0.55 kWh/ft^3/day



how much energy can we save?

energy savings estimates for 100 ULT freezers

	direct savings	**total savings**
savings over existing freezers	780,000 kWh/year	858,000 kWh/year
savings over new freezers	230,000 kWh/year	253,000 kWh/year

submitted data to the EPA and CA utilities

utility rebates!

PG&E now has rebates for ULT freezers:

$600 for 23 – 30 cf

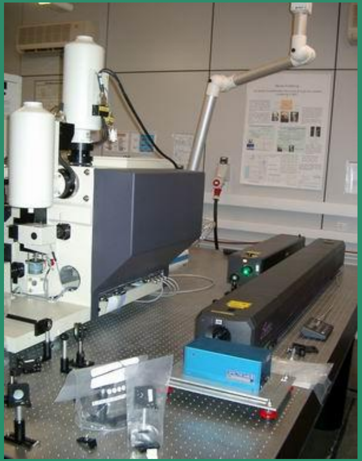
$300 for 15 – 22 cf

‘-70 is the new -80’

energy savings estimates for 100 ULT freezers

	direct savings	total savings
savings over existing freezers	780,000 kWh/year	858,000 kWh/year
savings over new freezers	230,000 kWh/year	253,000 kWh/year
adjusting freezer set points	415,000 kWh/year	456,000 kWh/year

energy: other lab equipment



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

turn off equipment

standard faucet: 4 gpm

faucet aerator: 0.5 – 1.5 gpm

Hardware Description	Unit Price	Total Units Installed	Sum of Cost
Aerator, Standard, F, 2.2 GPM	$1.39	96	$133.44
Aerator, Standard, F, 1.5 GPM	$1.73	41	$70.93
Adaptor, Standard	$6.69	20	$133.80
Total Cost			$338.17
Total Aerators Installed		137	
Percentage of Faucets with New Aerators			**58%**
Estimated Water Savings, Annually			**481,318 gallons**

single pass cooling

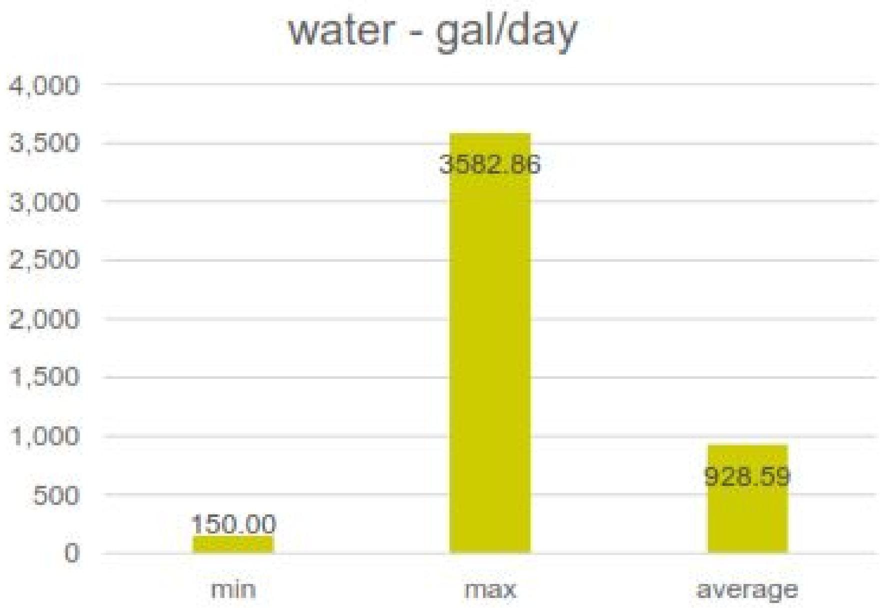
4-7 L/min

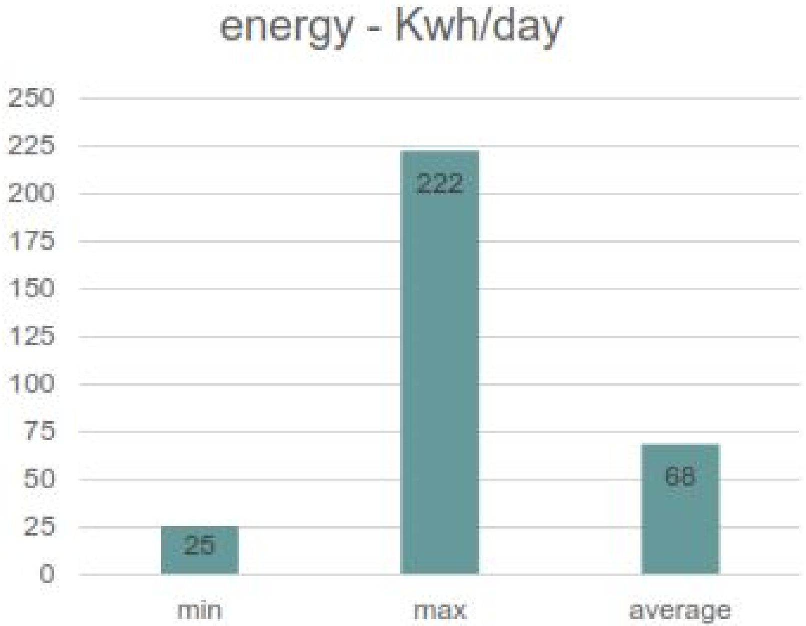
alternatives to single pass cooling

recirculating water bath

air-cooled condenser,
e.g. findenser

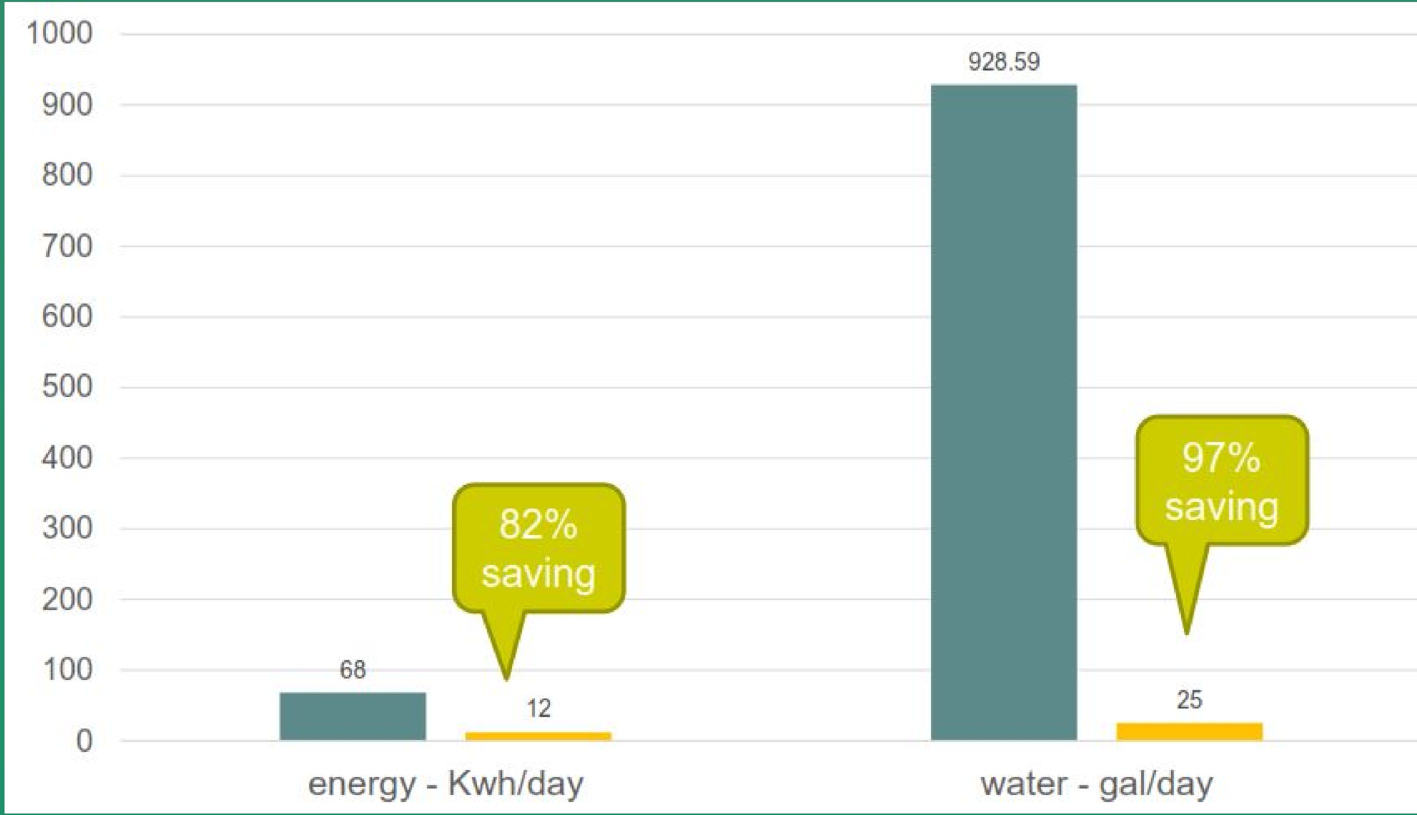
autoclaves





data from UC Riverside

autoclaves



data from UC Riverside

Estimated Savings

on a per lab basis

reduced energy: 10,000 kWh/year

reduced water: 5,000 gallons/year

reduced waste: 500 pounds/year

estimated savings: $1,000/year

together we can ensure that resources are used responsibly

Thank You

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@My_Green_Lab

Q&A

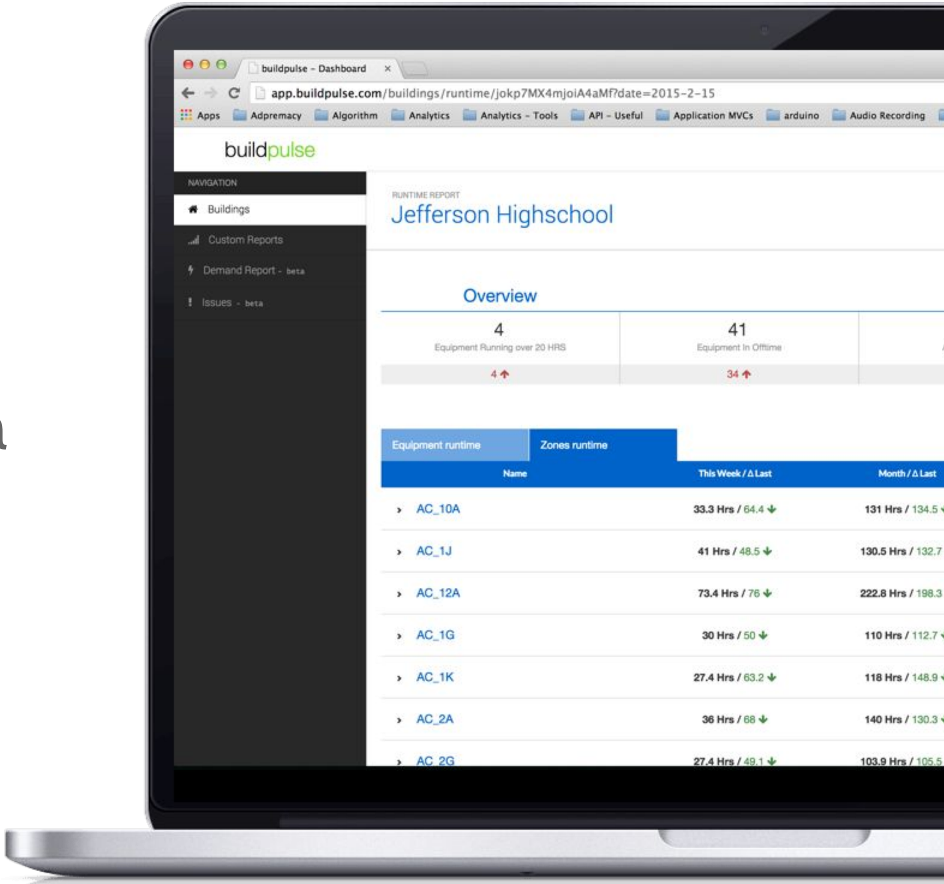
Duke UNIVERSITY

buildpulse

my green lab.

Next Steps

1. Please complete the quick survey after logging off
2. Receive webinar recording via email tomorrow!



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