

Transforming Occupants into a Low-Cost & High Accuracy Sensor System

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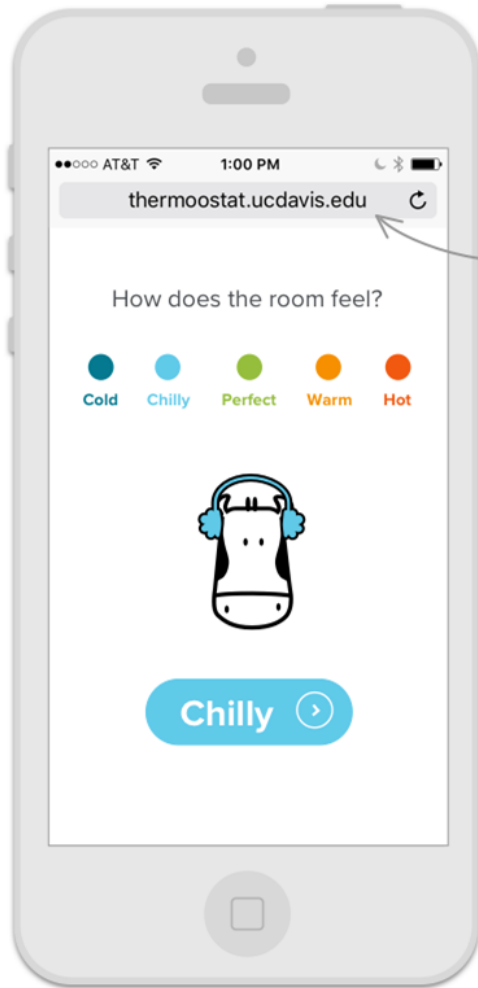
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11,677

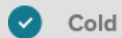
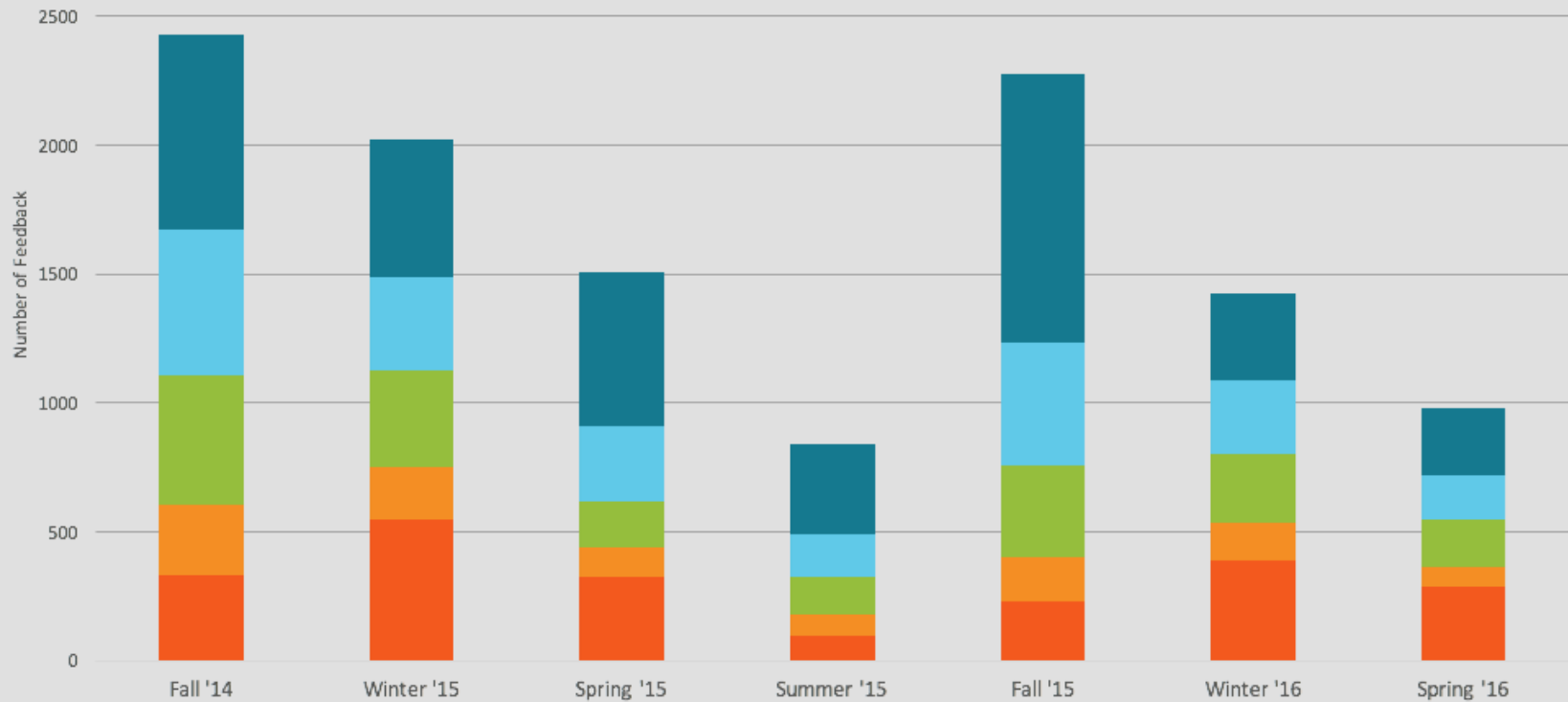
total responses from TherMOOstat



go to: **therMOOstat.ucdavis.edu**

When you send us feedback:

- you uncover comfort issues and potential energy-savings,
- contribute to our campus-wide comfort database,
- and help us optimize the buildings where you work and study!



Cold



Chilly



Perfect



Warm



Hot



FALL 2015



WINTER 2016

Visualizing feedback with TherMOOmap.

Transforming Occupants into

Low - Cost

- Using people already in the buildings
- Tech is adaptive to changing needs
- Hot/cold work orders can cost up to \$800

High Accuracy

- Thermostats have precision but not necessarily accuracy
- Secondary data set makes data more reliable

Sensor Systems

- Humans sense thermal comfort
- Crowd-sourced fault detection

What do we look for?

- Sudden increases in feedback: from one person in an office or from multiple people in a classroom
- Consistent feedback over 1-4 weeks (feedback isn't "retired" until 3 weeks with no new feedback)
- Descriptive comments: drafty/ wind blowing, stuffy/ stagnant air, muggy/ humid
- Misconceptions about HVAC systems: "it's cold outside and the AC is on"

How we do it

Incoming data is viewed via an in-house website, tracked via AirTable and investigated via the building automation system.

	Main View	1 hidden field	1 filter	Apply sort	SHARE	🔍	🔄	
	Room	Building	Feedback	Feedback Trend	Verification	Action	Notes	Mechanical Notes
1	3149	Ghausi	Hot	To be determined	Room temp at set point	Email response from Kiernan	6/8 As of now Doc has adjusted...	Offices are on DCV - when in occupan
2	1405	Tupper	Cold	Consistent cold	Room temp at set point	Email response from Kiernan Site Vis	Office is tied to other offices in ...	3/28 Tupper complained it was too ho
3	Rec Pool ...	Rec Pool Lodge	Cold	To be determined	Room not found	Email response from Kiernan Investig	6/9 2:41 pm chilly (room labeled...	
4	1003	SCC	Cold	To be determined	Room temp at set point	Email response from Kiernan Investig	VAV boxes in smaller offices are...	
5	73	Hutchison	Cold	Consistent cold	Not visible in Siemens/...	Email response from Kiernan Resolv	5/26 5 pm cold...	73 has local controls
6	1137	PES	Cold	Consistent cold	Room temp at set point	Site Visit Scheduled Investigation fro	Site Visit: 5/11 12:40-1:20 - GIS ...	5/18 John raises heating set points in
7	12	Mrak	Chilly Warm	To be determined		Site Visit Scheduled Monitor for tren	6/1 1:20 chilly...	
8	3117	Math Science	Cold	To be determined	Room temp at set point	Site Visit Scheduled Monitor for tren	6/10 10:49 am cold...	4/28 rooms registering as unoccupied
9	3147	Ghausi	Warm Hot	Consistent hot	Room temp at set point	Site Visit Scheduled Monitor for tren	5/25 9:34 am hot...	Offices are on DCV - when in occupan
10	2110	Kemper	Cold Hot	To be determined		Investigation from John	5/31 7:35 pm chilly "moo"...	Not visible in Siemens/Johnson
11	1020	Valley Hall	Chilly	Consistent cold	Work order open	Investigation from John	5/12 9 am chilly...	3/24 Work orders open for failed therm
12	27	Olson	Cold	To be determined	Room temp not at set ...	Investigation from John	5/25 shops haven't looked at it ...	
13	2308	PES	Chilly	To be determined	Room temp at set point	Investigation from John	From John: BMS control shop ...	5/18 John raises heating set points in
14	1227	Haring	Warm Hot C	Variable	Room temp at set point	Investigation from John	5/31 3:10 pm hot "Soooo hot in ...	Not visible in Siemens \$90 million pro

Responding to feedback

Snapshot in time: tracking 105 rooms in AirTable

- 10% communication with users: how the HVAC system works in their building and what we do with their feedback
- 6% site visits: interview with users, tracking room temperatures with data loggers, confirming results
- 22% in open investigation with building automation system/ data loggers (48% of the rooms are at their set point, 40% not visible in BAS) and HVAC technicians (13% of feedback triggers a work order)
- 62% in monitoring status, waiting for a trend in the feedback (consistently hot/ cold)

Our Results: Case Studies

No. 1: using student feedback to identify a mis-categorized lab

No. 2: using staff feedback to find a hallway thermostat

No. 3: using student feedback to inform maintenance

No. 4: using staff feedback to find the source of a cold room

Plant & Environmental Sciences

Year Constructed: **2002**

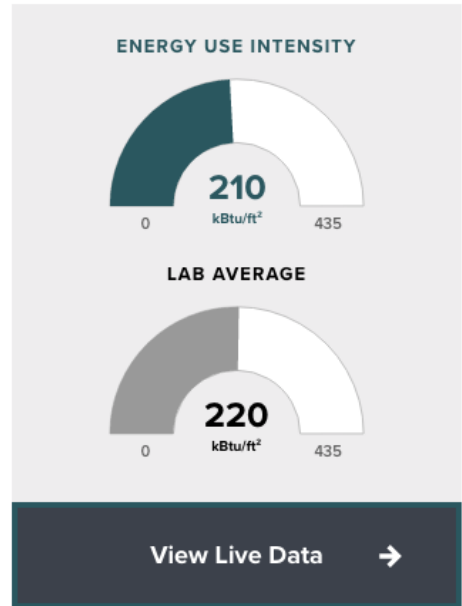
Square Footage: **141,214 FT²**

Annual Usage: **29,654,940 KBTU/YEAR**

Annual Cost: **\$365,221**

Primary Use: **LAB (78%)**

Secondary Use: **OFFICE (20%)**

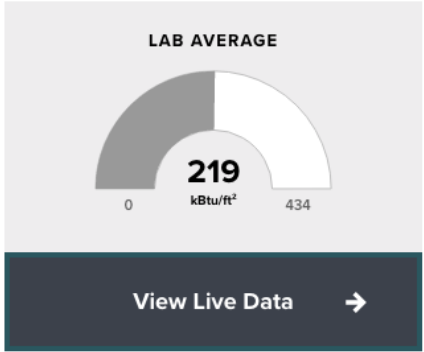


“Seriously, we are all freezing. There is a 3 hour lab in here. It is 90 outside, and people are trying to use their backpacks and random bits of paper for warmth.”

-UCD Student

Tupper Hall

Year Constructed: 1977
Square Footage: 237,714 FT²
Primary Use: LAB (72%)
Secondary Use: OFFICE (22%)

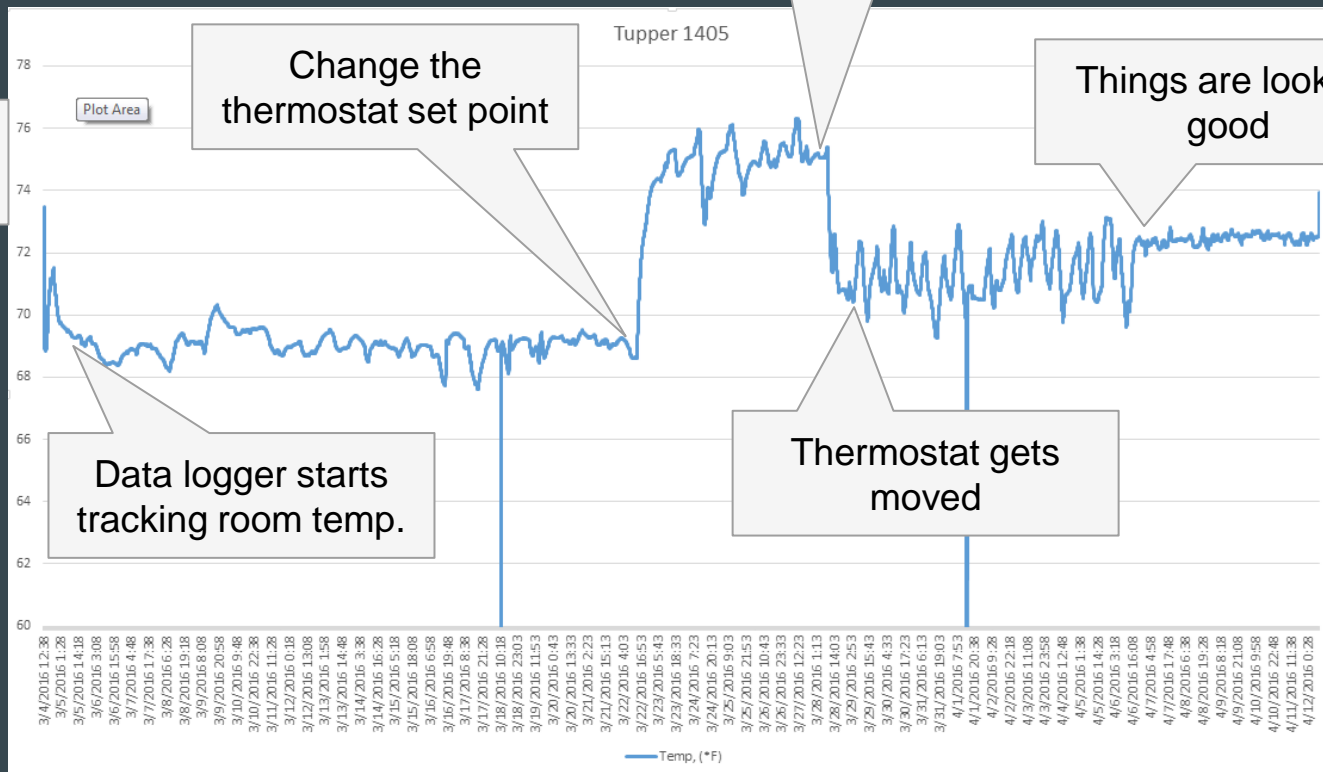


One thermostat was controlling 6 offices, but located in the hallway...

→ Facilities HVAC shop relocated the thermostat into an office



Cold TherMOOstat
Feedback



Data logger starts
tracking room temp.

Change the
thermostat set point

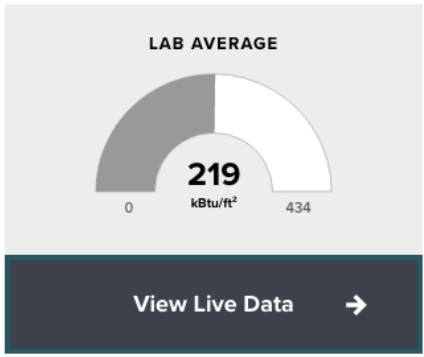
Work order called in

Thermostat gets
moved

Things are looking
good

Haring Hall

Year Constructed: **1949**
Square Footage: **160,171 FT²**
Primary Use: **LAB (60%)**
Secondary Use: **OFFICE (15%)**



17 hot + 6 warm
in first two weeks of May

Mathematical Sciences Building



Year Constructed: **2005**
Square Footage: **65,691 FT²**

Annual Usage: **4,664,061 KBTU/YEAR**
Annual Cost: **\$63,019**
Primary Use: **OFFICE (84%)**
Secondary Use: **LAB (12%)**

ENERGY USE INTENSITY



OFFICE AVERAGE



[View Live Data](#) →

“Our office has the thermostat controller, but is usually too cold for all of us.” -TherMOOstat user



What we've learned

- Don't trust the thermostat
- Data loggers are useful
- There's a whole new set of data out there!
- Some people don't know (or care) how their building works
- BUT some people do care (and are willing to learn) when it's about their comfort
- Using an existing campus portal is a good idea

What's next for us?

- Expanding the app to include questions about draft, physical activity and time of feedback submission
- Upgrading the in-house website for easier analysis for our staff
- Integrate with the Facilities call center, work order system and HVAC technicians workflow

Thank you!



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Energy Conservation Office