Putting Vacant Buildings to Sleep

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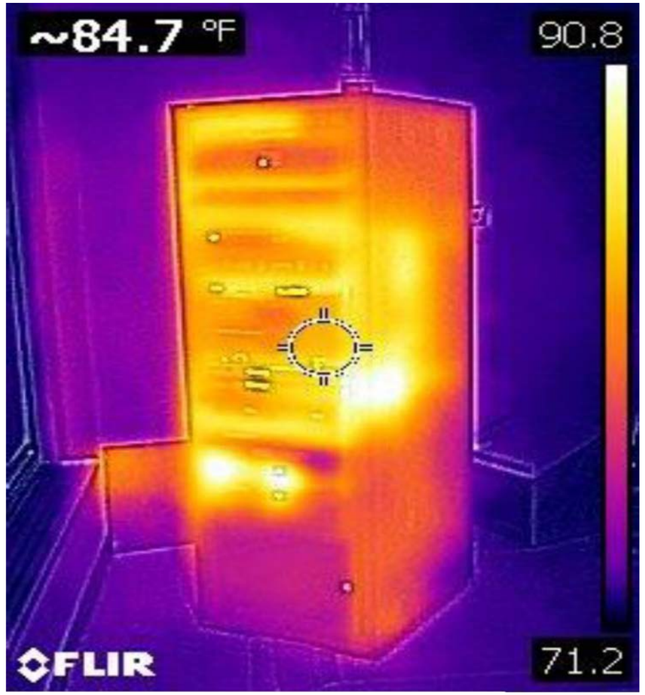
UCD Energy and Efficiency Institute & LBNL



IR photo of a UCD A/V rack in an empty classroom

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Josh Morejohn, Nico Fauchier-Magnan, Tianzhen Hong, John Elliott

Plan

1. Origins of this topic
2. Sleeping buildings research at UC Davis (mostly)
3. How the world changed and this project is pivoting

Origins

2001 Appliances: Standby power use

2014 Buildings: when nobody was there or perhaps sleeping

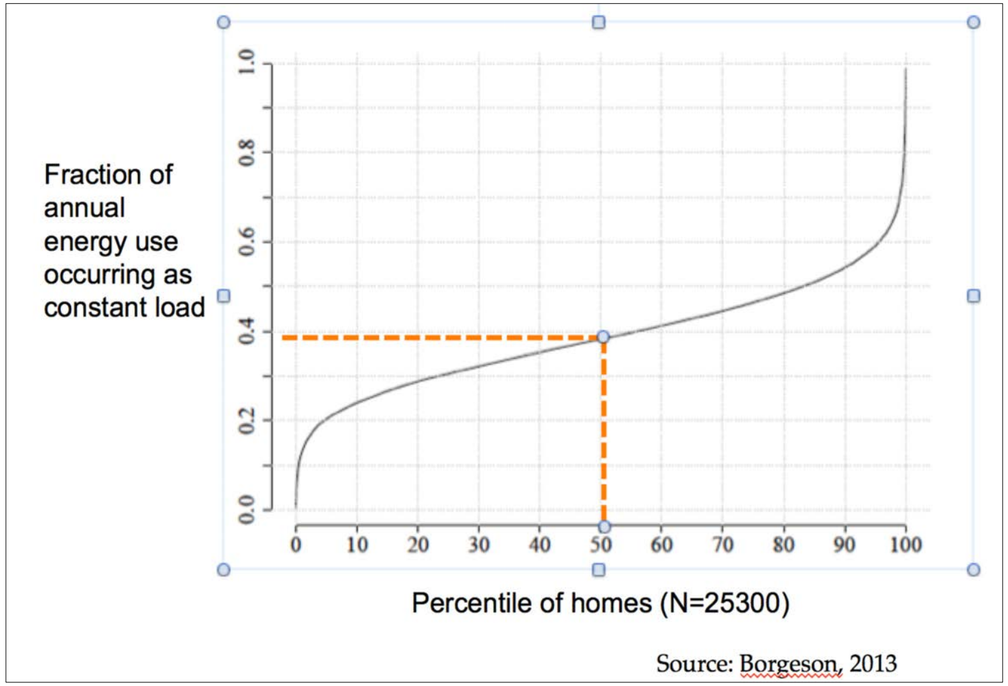
2017: UC Davis

Standby Power (2001):
- Electricity used by appliances when switched off or not performing primary function
- 5 – 10% of residential electricity use
- 1% of global CO2 emissions

"Vampires" – external power supplies, term arose because they have 2 teeth and suck electricity in the night (origin unknown)

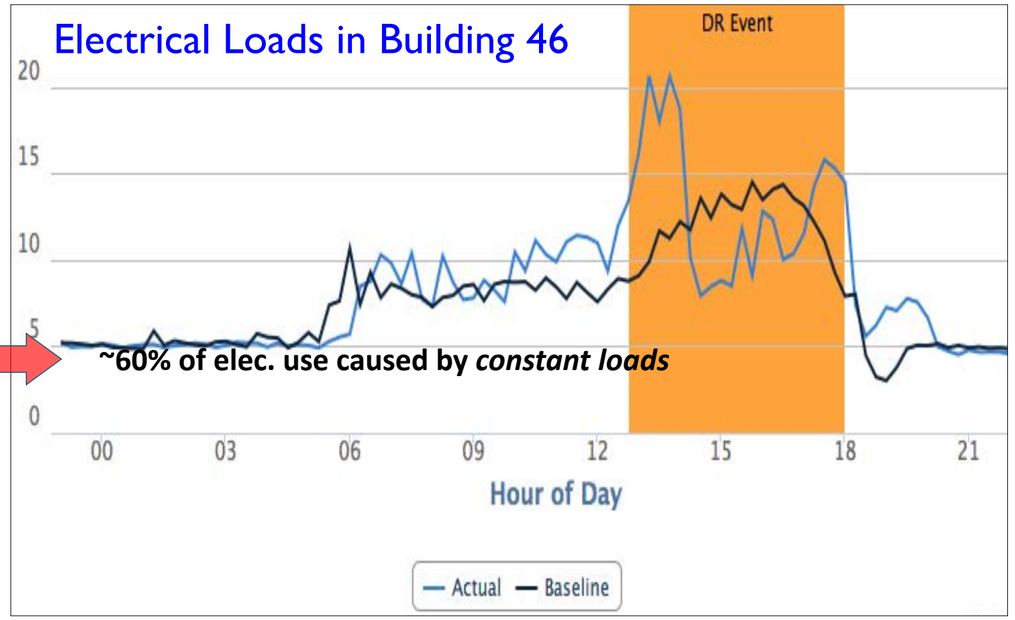
Buildings Have ”Standby” Power Use, Too

Smart meter data from 25,000 California homes



In about half of existing homes, >40% of the electricity consumption is a result of constant loads.

A nothing-special commercial building at LBNL, with continuous loads responsible for 60% of annual electricity use

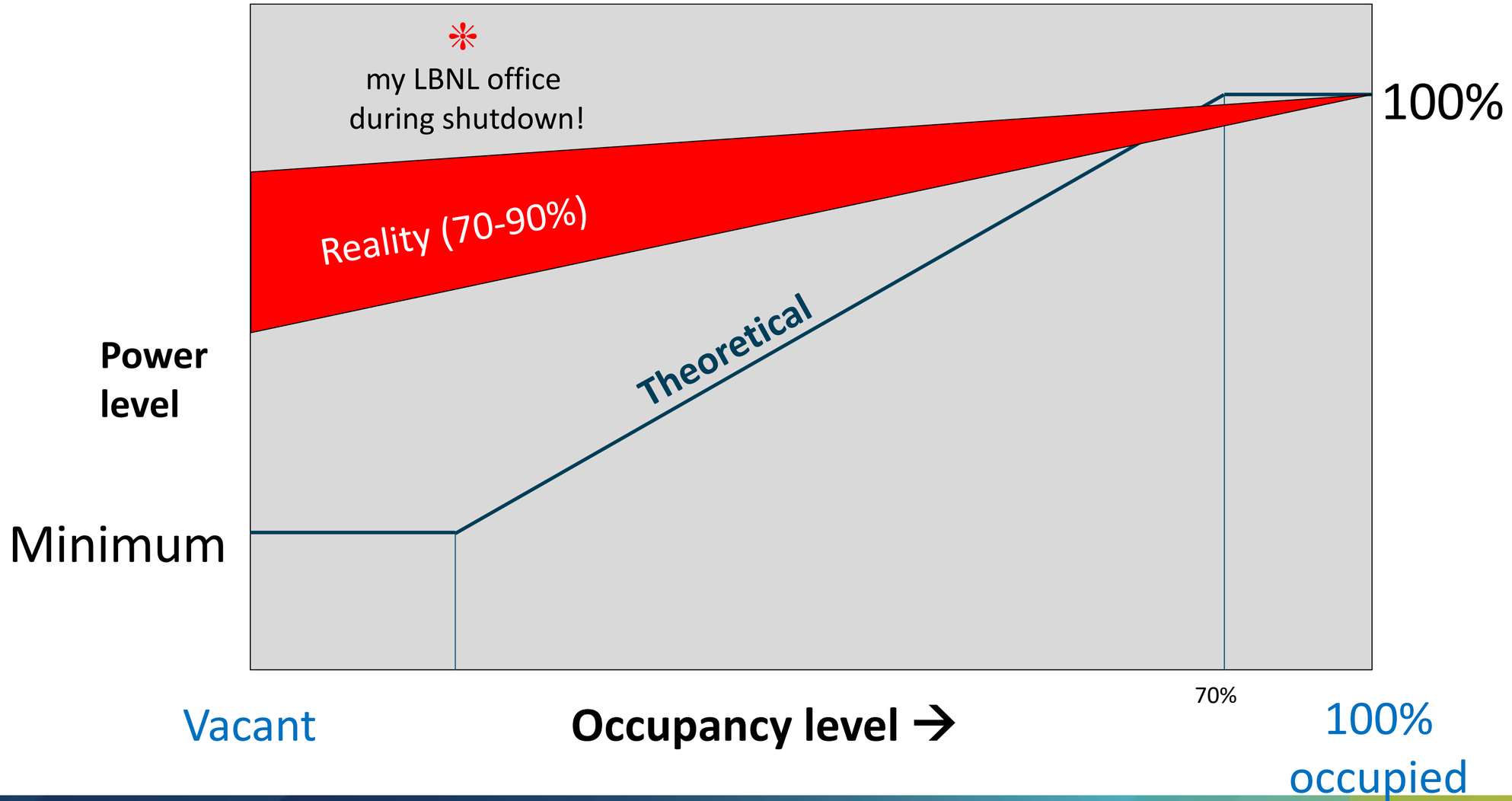


Tip: Use your smart meter to view your 3AM consumption

Initial Target: Saving energy in buildings when nobody was in them

- Some buildings are vacant for more hours than they are occupied (nights + weekends + vacations + holidays)
- No occupants there to complain
- More aggressive measures were possible
- New approaches to saving energy in vacant buildings?
- Clues to waste in *occupied* buildings?

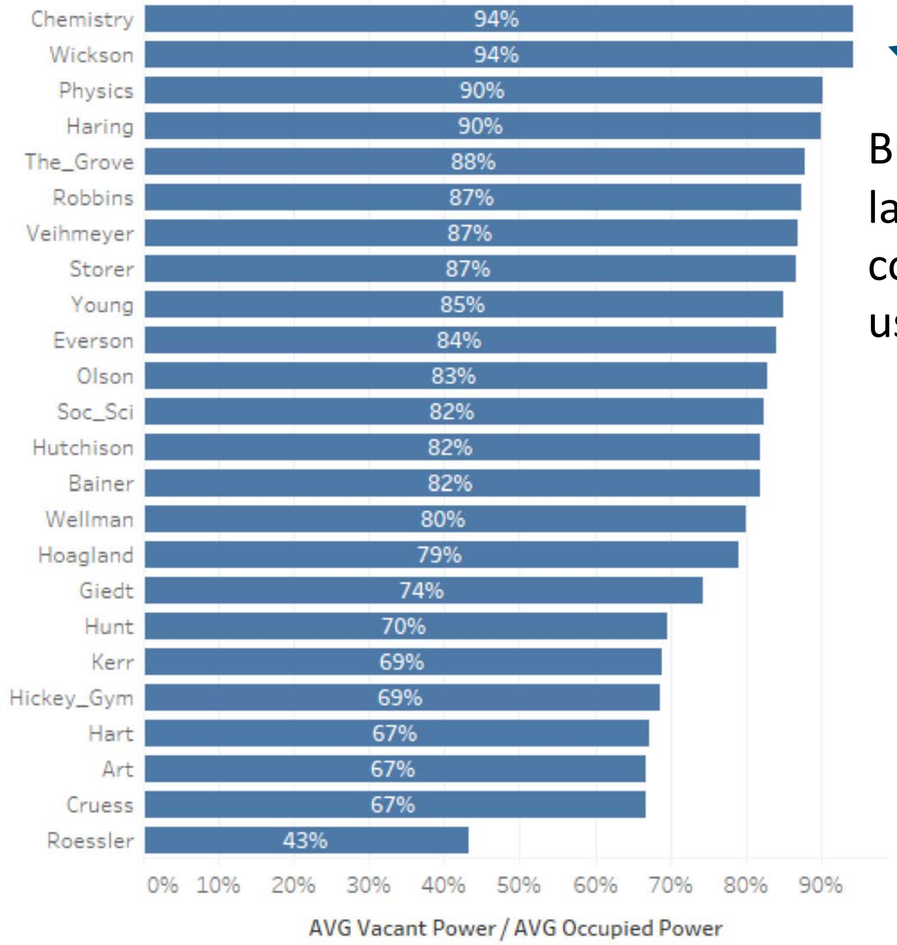
Relationship Between Occupancy Level and Electricity Use



The Problem at UCD

Electricity use in most UCD buildings never falls below 50% of their occupied levels, even during nights, weekends, holidays, or pandemics.

Ratio of Vacant Power to Occupied Power

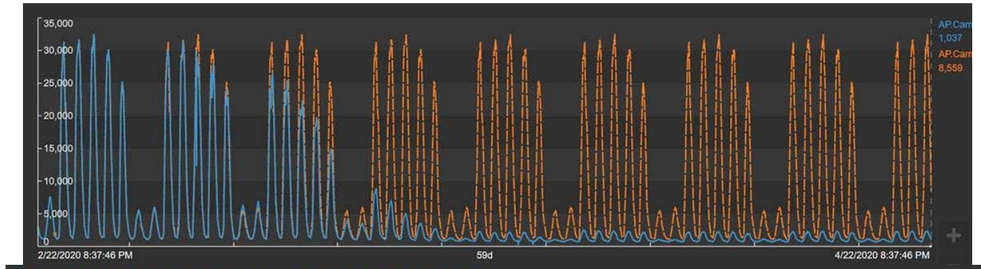


Buildings with labs have nearly constant power use

Campus Shutdown During the Pandemic

Occupancy (blue line)

Wifi connections

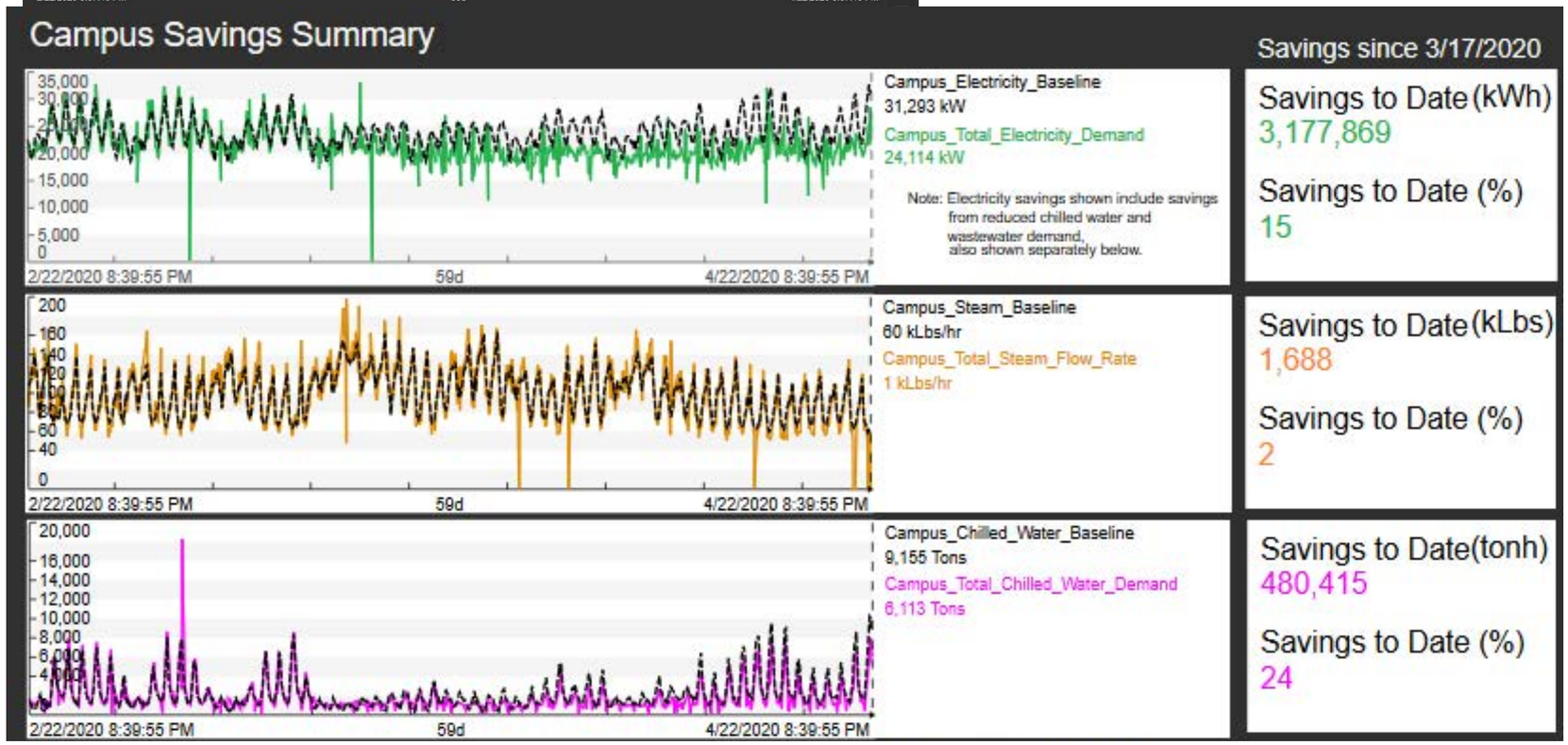


UC Davis:
90% reduction in occupancy, but only 15% reduction in electricity use

Electricity

Steam

Chilled water

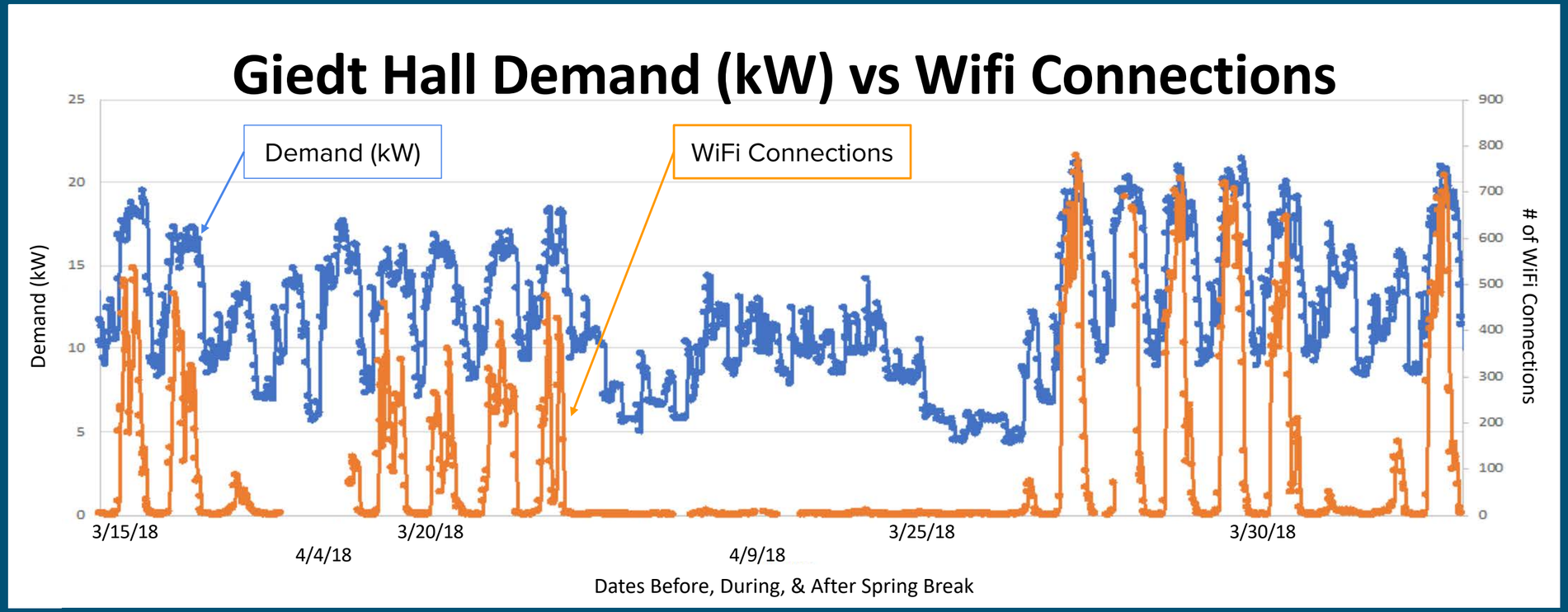


Source: UC Davis

Case Study: Giedt Hall

Mostly lecture halls inside

Building Example - Giedt Hall



Electricity load profile for Giedt Hall – a building with mostly classrooms – during a week where the Facilities Department shut off the HVAC during the weekend.

What's On? (examples from UCD & LBNL)

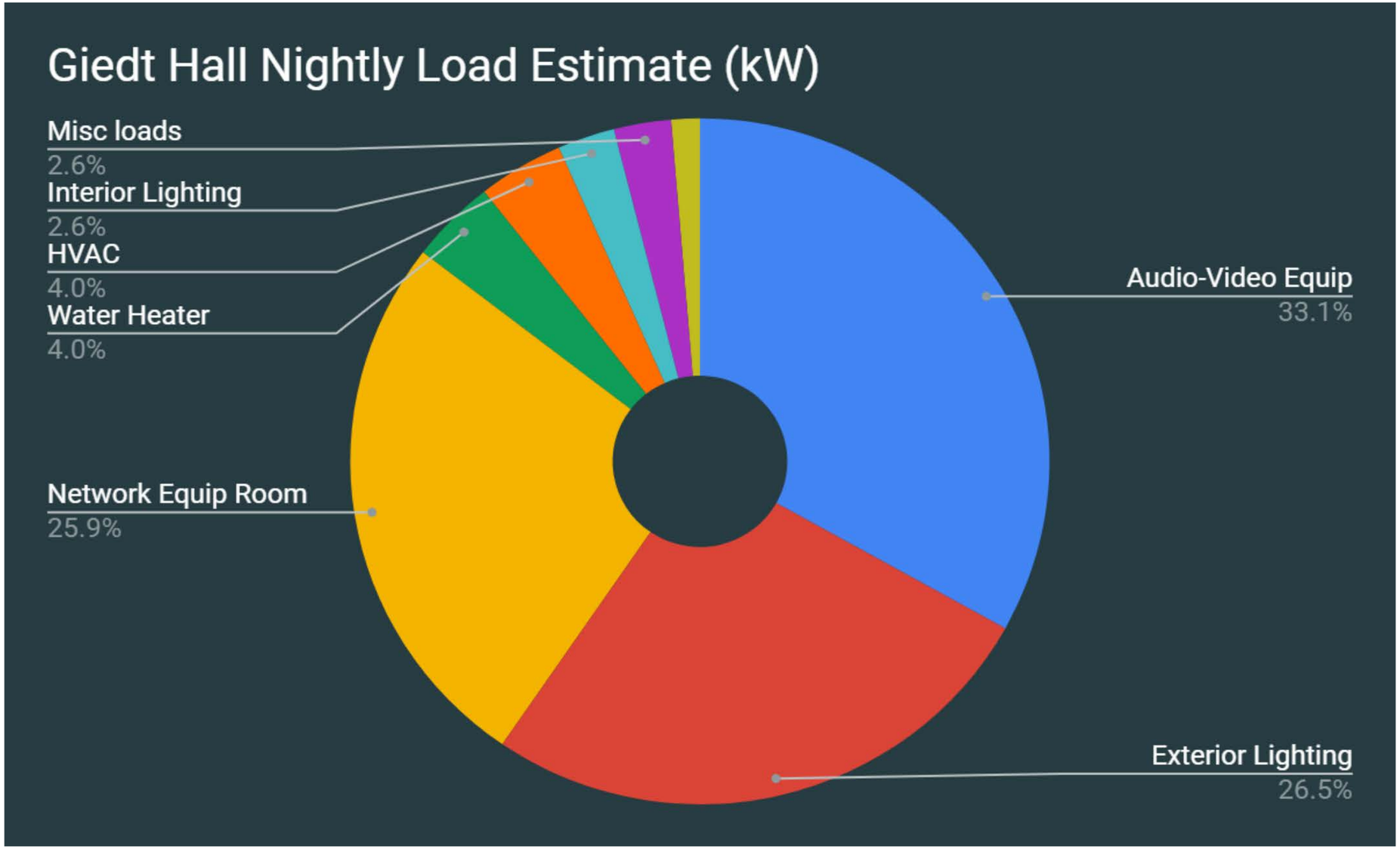
Miscellaneous Electrical Loads

MELs

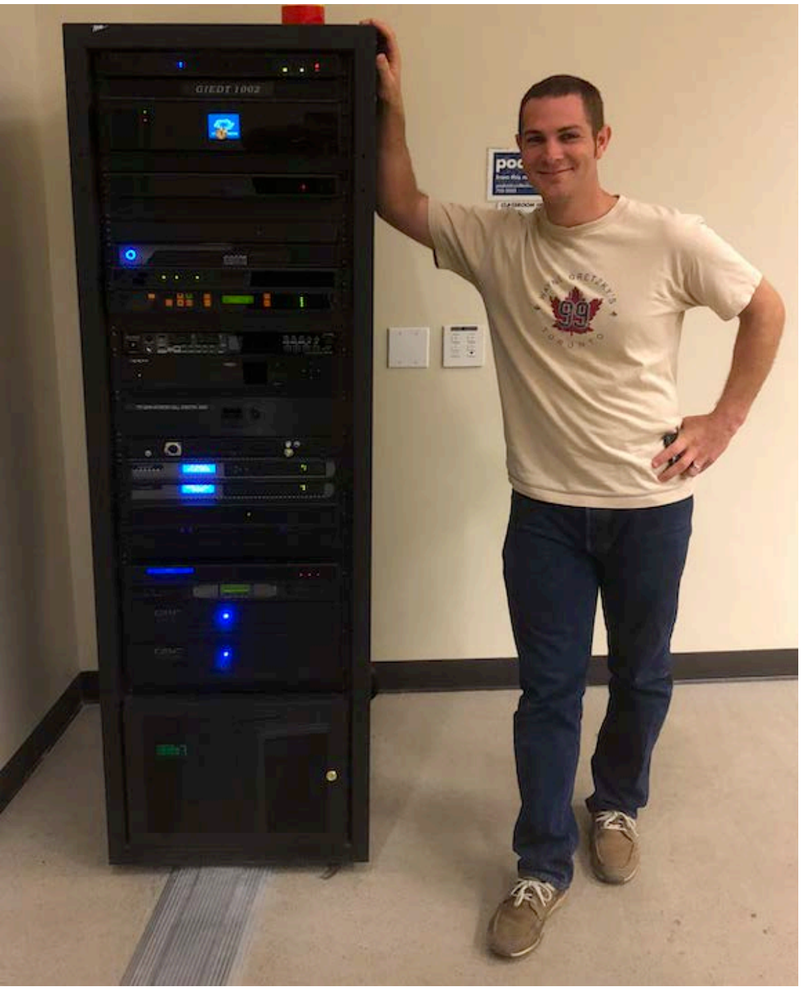
MELs are responsible for about 1/3 of electricity use in US buildings

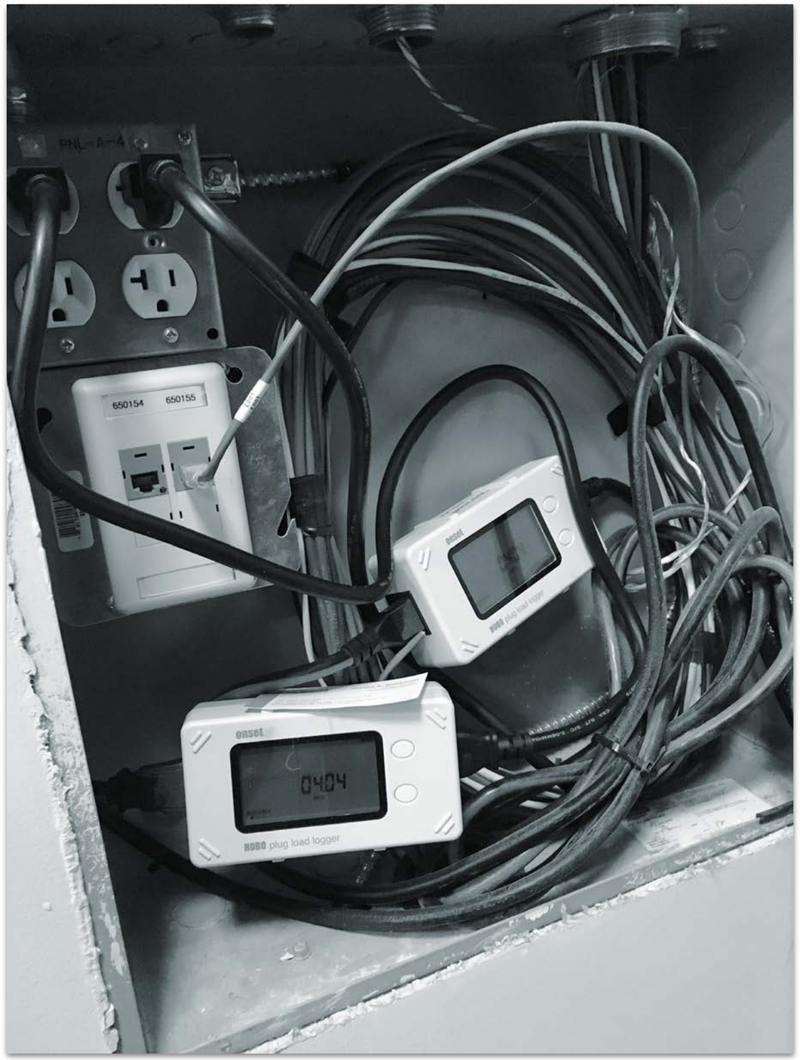
- Uncontrolled HVAC
- Hot water circulation pumps
- **Computers, screens, printers, etc.**
- Network equipment
- Drinking fountains and dispensers
- Elevators
- Lights
- Water heaters (electric)
- AV equipment
- Parking lot lighting
- Fan coil units
- Vacuum pumps
- Vending machines and coffee makers

What's on in Giedt Hall?

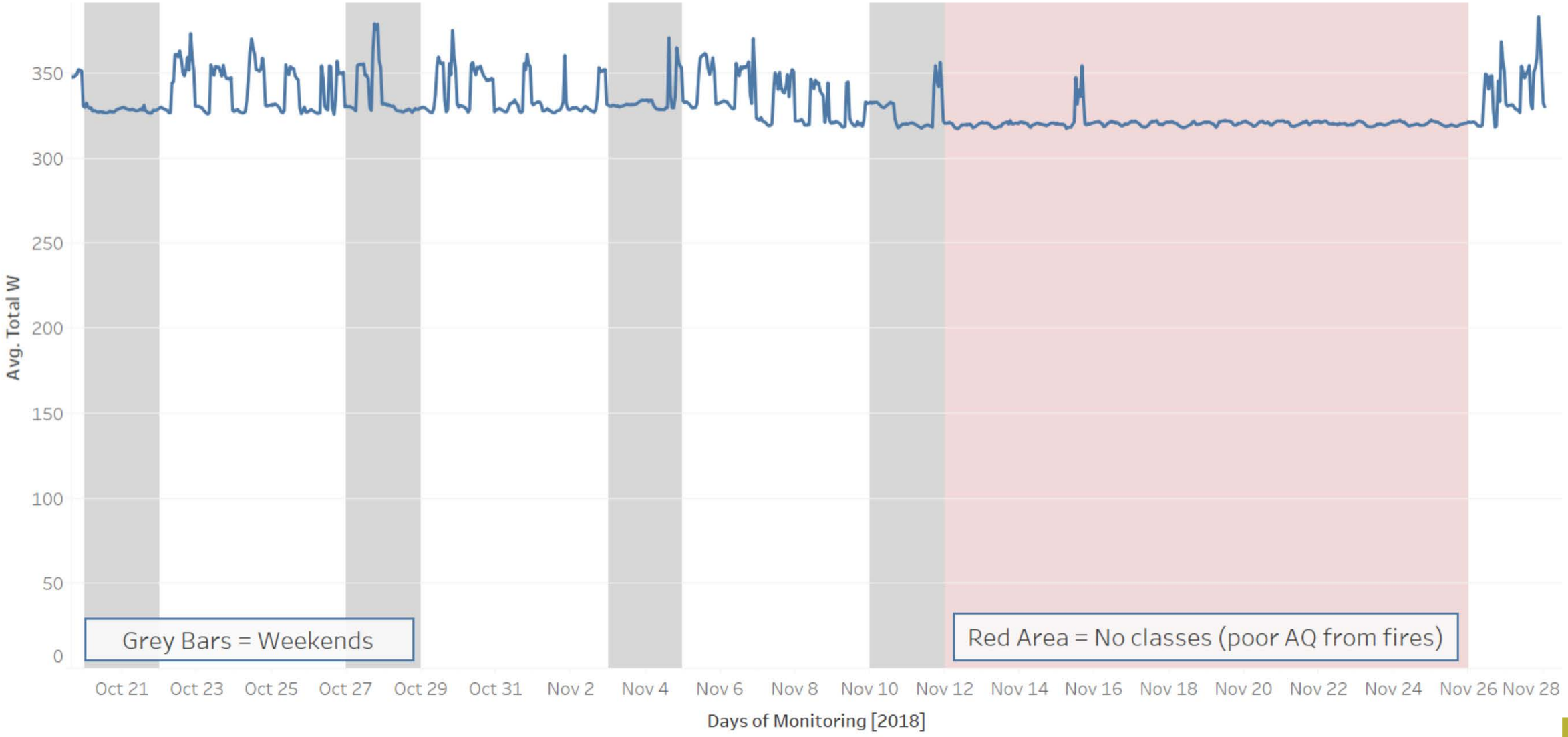


A/V Equipment





A/V Monitoring - Giedt 1006



Evolution of Audio/Video Rack Power Use

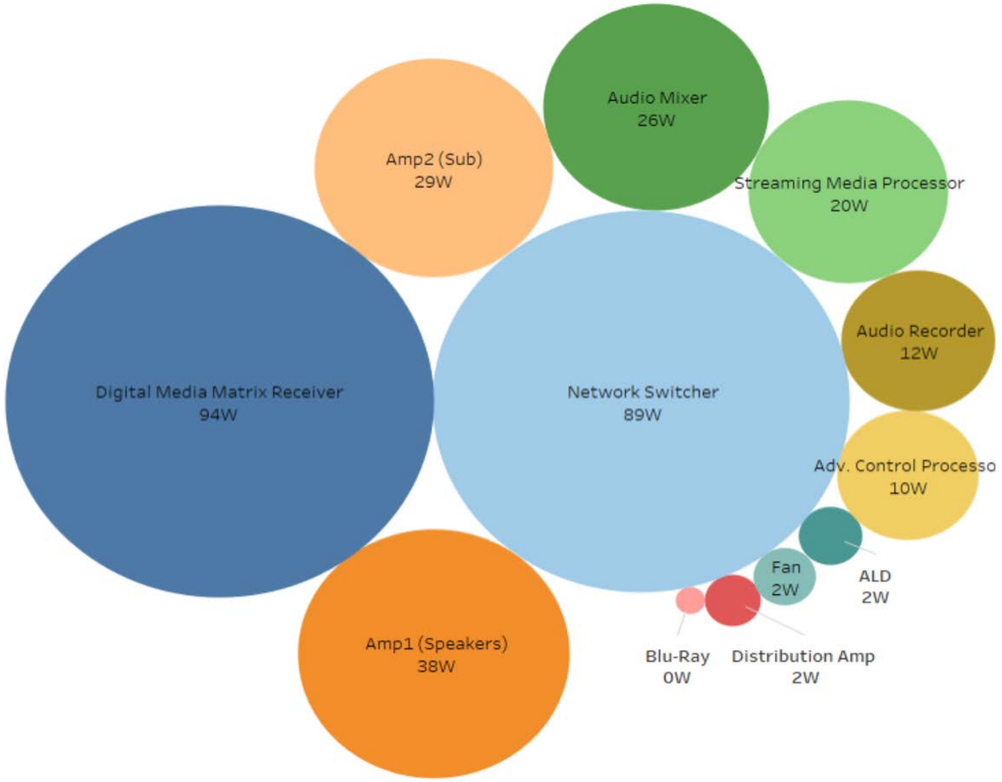


Rack Generation:	GEN 1	GEN 2	GEN 3	GEN 4A	GEN 4B
Control System:	Smart Panel	Extron	Crestron	Crestron	Crestron
Full Use (Watts):	100	110	245	345	680
Unused (Watts):	60	90	220	325	615
Unused as % of full use:	60%	82%	90%	94%	90%

Source: Alex Sloan

Reducing A/V Rack Power Use is Difficult

- Many components
  - But few are frequently used
- Few are able to “sleep”
- Switching on is more challenging than switching off
- IT Dept discourages switching off the racks
  - Failure to reboot
  - Reduced lifetimes?
  - No incentives



We need more robust solutions to reliably switch off—and then on—integrated systems

Network Equipment Can’t Power-Scale

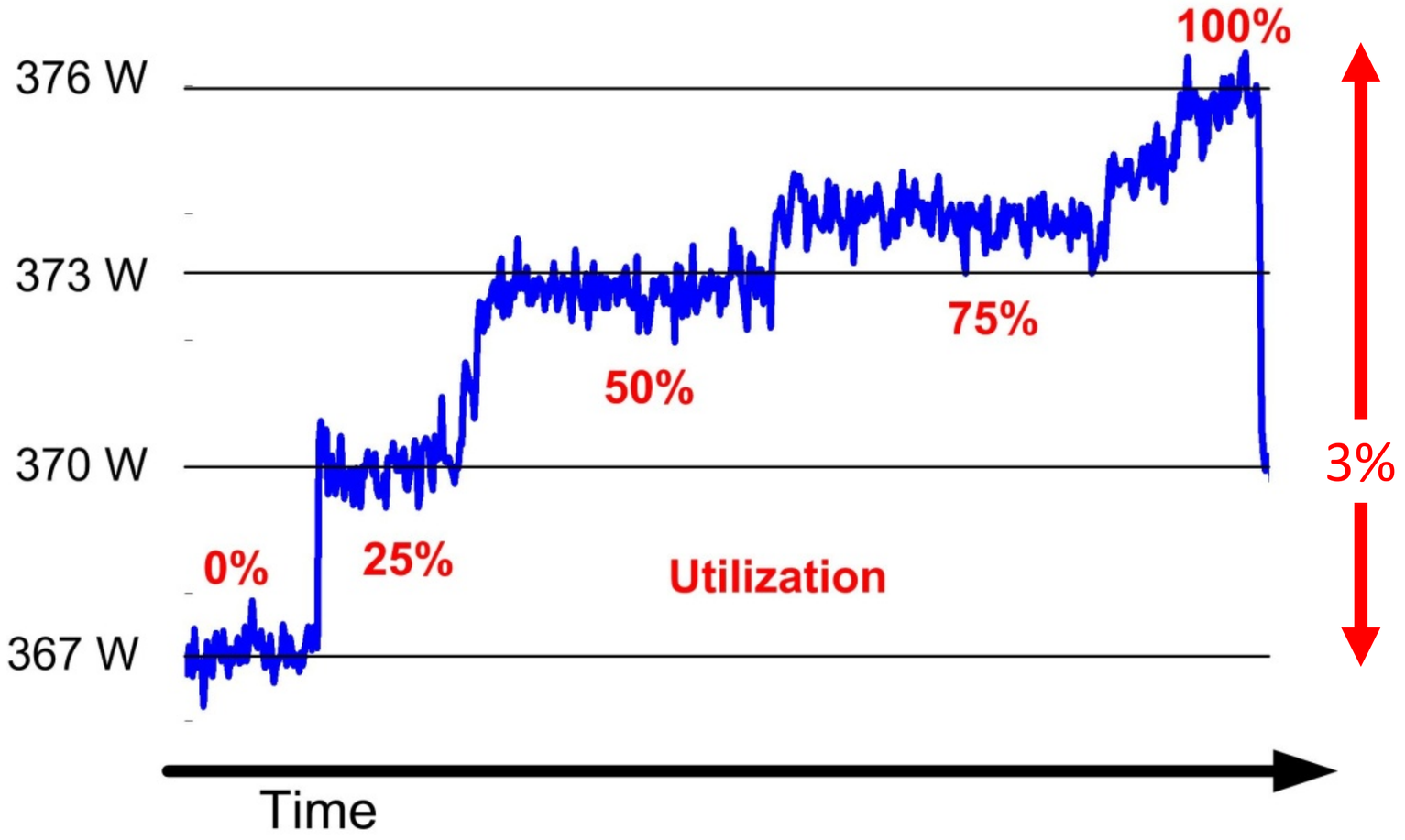
Ethernet switches are key components in networks

Data throughput scarcely affects power consumption

100% reduction in utilization reduces power use only 3%

Wifi routers have similar performance

Power Consumption of an Ethernet Switch



Saving Energy in Buildings When Nobody is in Them

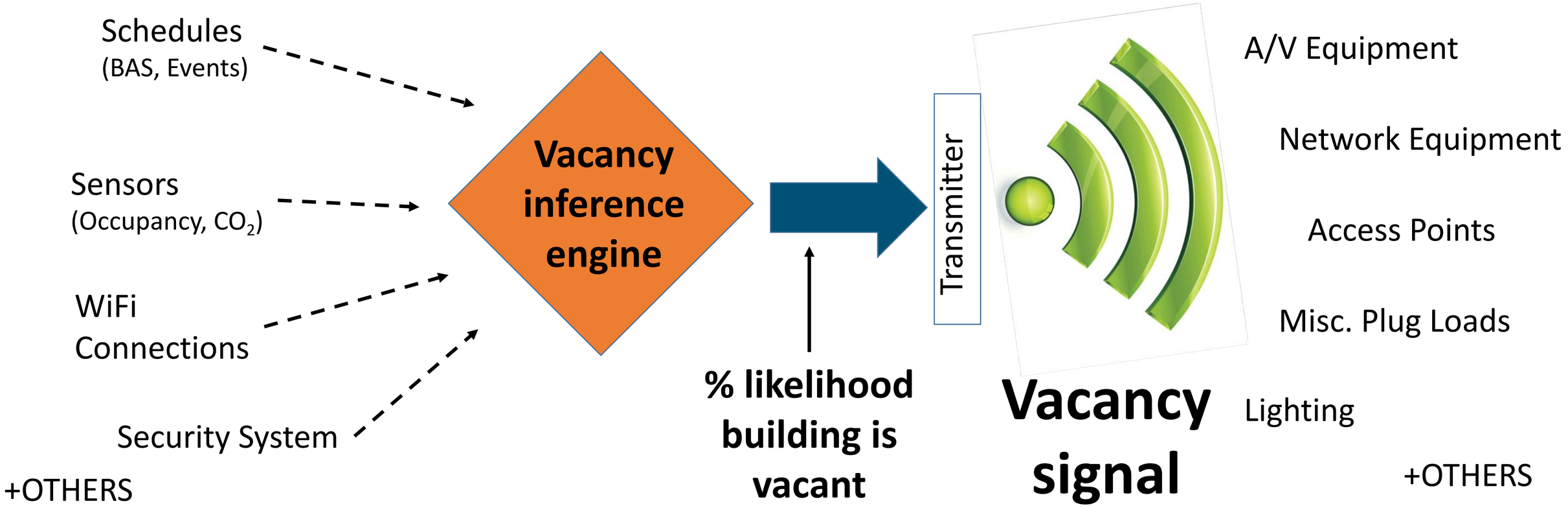
1. Determine when the building is vacant
2. Signal equipment to enter vacancy mode
3. Signal equipment to “wake up” when somebody enters the building

Inferring Vacancy

- Vacancy and Occupancy are different
  - Occupancy is continuous but Vacancy is binary
  - Occupancy can be sensed but Vacancy must be inferred
- We created a “vacancy inference engine” to estimate probability that the building is vacant
  - Inference draws upon multiple sensors (wifi, motion, CO2, electricity, etc.)
- Sensor fusion techniques used to calculate probability of vacancy

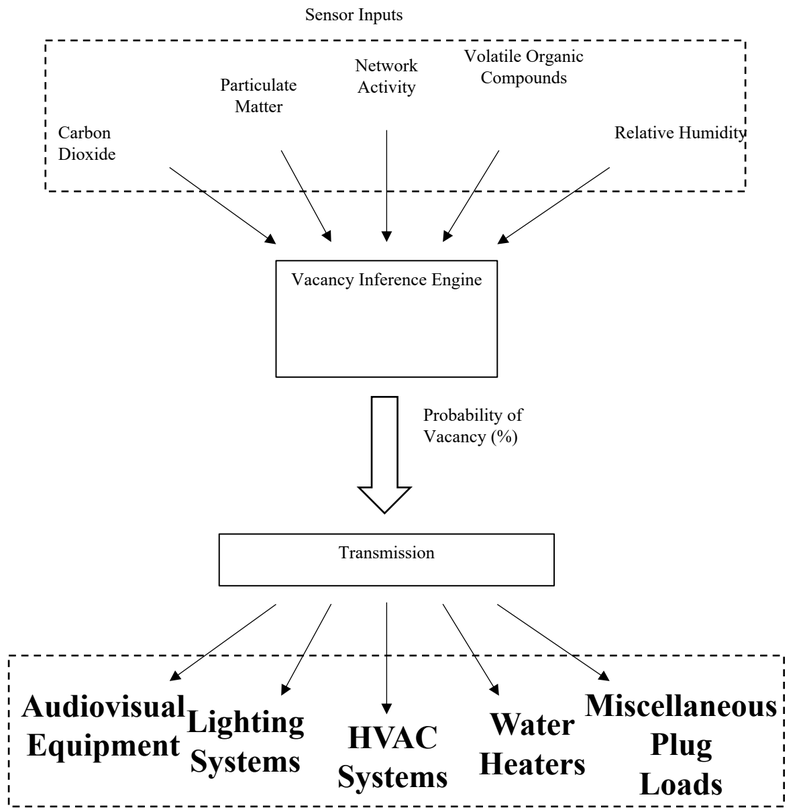
Vacancy Inference Platform

Sensors | **Vacancy Inference Engine (Sensor Fusion)** | **Devices with vacancy mode**



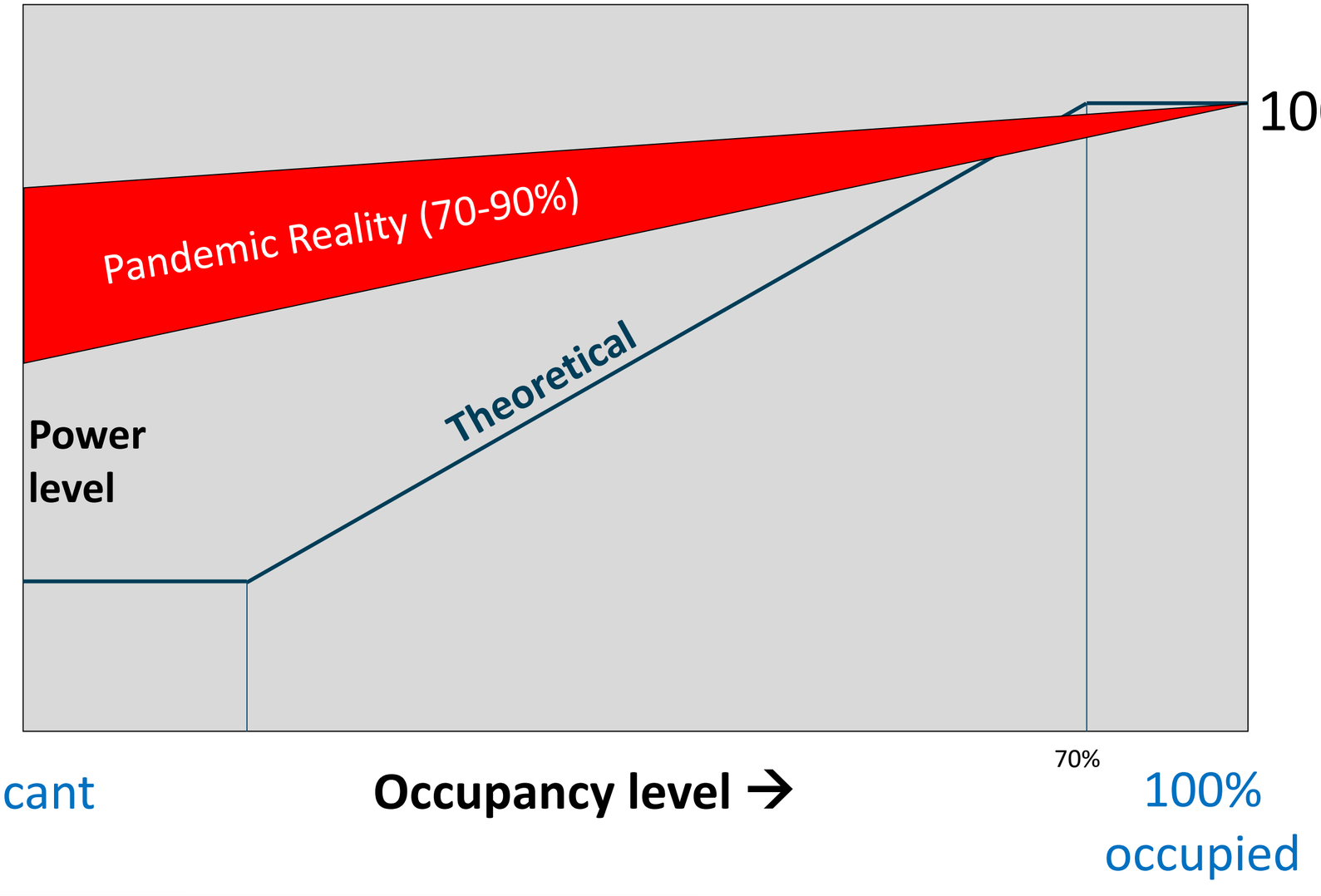
Adding Vacancy Modes to Equipment to Save Electricity

- Significant equipment modifications will be required
  - New, lower power “vacancy modes” when the building is vacant
  - Communications capabilities to receive vacancy signal
- Some devices are nearly there
- Others need retrofits



The Pandemic Pivot?

- Energy use while buildings are vacant is a more visible problem now, but …
- New task is achieving efficiency in low-occupancy or variable-occupancy buildings



Future Work at UC Davis

- How much energy can be saved?
  - Audit buildings to determine what's actually on during vacant periods
  - Manually place them in "vacancy mode"
  - Observe energy savings
- Improve vacancy inference engine and transfer to Facilities Office
- Develop vacancy modes in equipment
  - A/V equipment
  - Network equipment
  - Pumps and water heaters

Conclusions

- Electricity use in buildings has become de-coupled from the amount of services they provide
  - MELs are responsible for much of this de-coupling
- We need new strategies to make buildings more responsive to the number of people in a building and the services they actually need
- These strategies will require novel applications of sensing, controlling, and design of equipment