Better Buildings Alliance
Plug and Process Loads (PPL) Team Webinar

Technical Lead: Kim Trenbath, NREL

January 22, 2020

Agenda

- BBA PPL Team Updates
  - About us
  - Publications
  - Upcoming Events
- Technical Presentations
  - Device-Level Plug Load Disaggregation in a Zero Energy Office Building & Opportunities for Savings
    Bennett Doherty, National Renewable Energy Laboratory
  - Energy Reporting: Device Demonstration, Communication Protocols, & Codes and Standards
    Bruce Nordman, Lawrence Berkeley National Laboratory
- Q&A
- Member Updates

Team Players

Technical Team Lead:
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National Renewable Energy Laboratory (NREL)
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Bennett Doherty
NREL

Katie Vrabel
Waypoint Energy

Carly Burke
Waypoint Energy

Team Players – Plug and Process Loads

Technical Team:

Amy LeBar
National Renewable Energy Laboratory
Research Engineer
Amy.LeBar@nrel.gov

Overarching Goal

Contribute to making U.S. commercial buildings more efficient through plug and process loads.

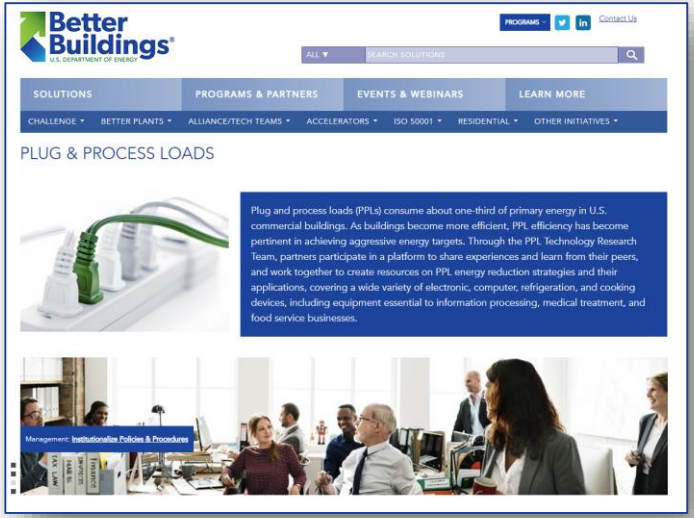
Research + Applied Approaches

Get Involved

- Stay up to date on latest research and resources
- Collaborate with PPL network
- Participate in bi-annual technical calls
- Share updates and best practices

Visit the PPL webpage to learn more

Or contact us at ppl@waypoint-energy.com



Publications

Emerging Technologies for Improved Plug Load Management Systems: Learning Behavior Algorithms and Automatic and Dynamic Load Detection

- In progress technical report
- Bennett Doherty, Kim Trenbath, Katie Vrabel, & Carly Burke

Publications

[Device-level plug load disaggregation in a zero energy office building and opportunities for energy savings]

- *Energy and Buildings*
- Bennett Doherty & Kim Trenbath
- October 2019

Resources

Visit our webpage

How to Assess and Reduce Plug Loads

Utility Incentives List

How To Use Advanced Power Strips in an Office Setting Fact Sheet

Each advanced power strip has three outlet types for equipment with various electricity needs. This infographic describes the uses for each outlet type.

Assessing and Reducing Plug and Process Loads in Office Buildings Fact Sheet

Using the process and strategies outlined in this brochure, the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) was able to drastically reduce its PPL energy use in the Research Support Facility (RSF).

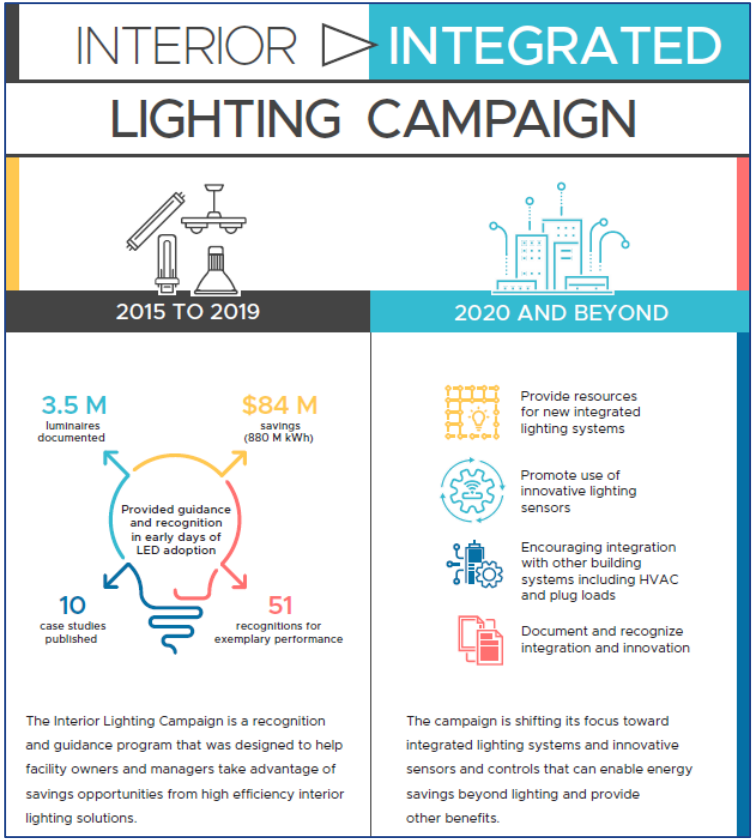
Plug Load Efficiency Utility Incentives Policies and Incentives

Download this list of incentives and rebates for plug and process load controls that are offered by utilities across the country.

Case Study: Plug Load Strategies for Zero Energy Buildings Case Study

The U.S. General Services Administration (GSA) successfully renovated the historic Wayne N. Aspinall Federal Building and U.S. Courthouse. GSA's goals were to preserve the building's historic features, and achieve Zero Energy Building (ZEB) status.

Collaborations



Share your experiences, express your interest, or request technical assistance by contacting:

integratedlighting@pnnl.gov

Upcoming Events - BTO Lighting Workshop

Going? Contact Kim: Kim.Trenbath@nrel.gov

2020 SUMMIT

JUNE 8–10
ARLINGTON, VA

- Hyatt Regency Crystal City (Arlington, VA)
- Registration now open; early-bird discounts available
- More information here

Upcoming 2020 Better Buildings Webinars

SAVE MONEY AND BUILD RESILIENCE WITH DISTRIBUTED ENERGY TECHNOLOGIES

Tue, Feb 4, 2020 | 3:00 - 4:00 PM ET

REGISTER TODAY

FINANCE + RESILIENCE:

INSIGHTS FROM INDUSTRY LEADERS

Tue, Apr 1, 2020 | 3:00 - 4:00 PM ET

COMING SOON

BUILDING VALUE:

ENERGY EFFICIENCY'S IMPACT ON FINANCIAL PERFORMANCE

Tue, Mar 3, 2020 | 3:00 - 4:00 PM ET

REGISTER TODAY

GET SMART (LABS):

RESULTS FROM THE SMART LABS ACCELERATOR

Tue, May 5, 2020 | 3:00 - 4:00 PM ET

REGISTER TODAY

Technical Presentation

Bennett Doherty
National Renewable Energy Laboratory
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NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Device-level plug load disaggregation in a zero energy office building and opportunities for energy savings

Bennett Doherty

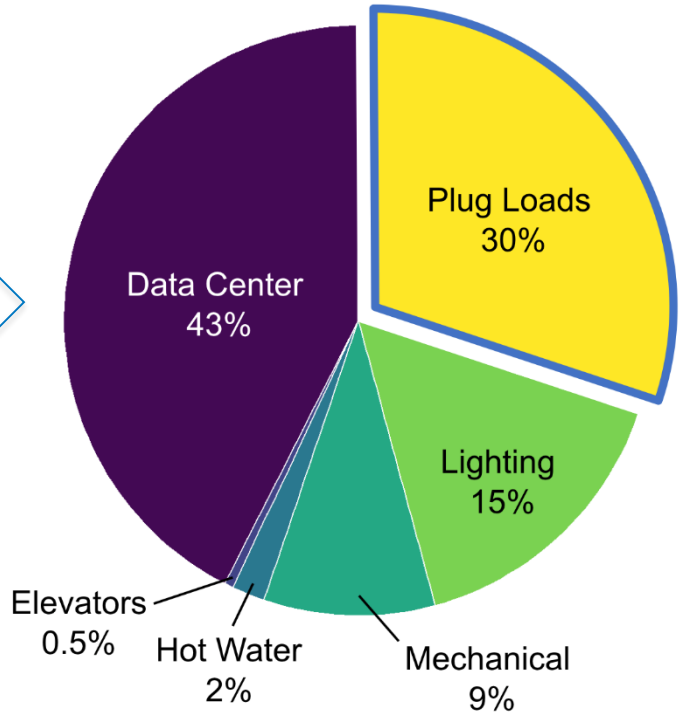
Better Buildings Alliance
Plug and Process Loads Technical Research Team Call
January 22, 2020

Motivation for Disaggregation

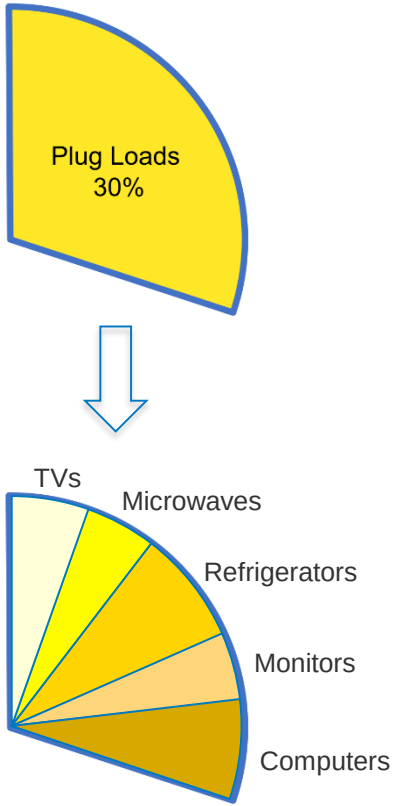
Typical Buildings

Whole Building
Energy Consumption

RSF Submetered by End Use



Motivation for Disaggregation



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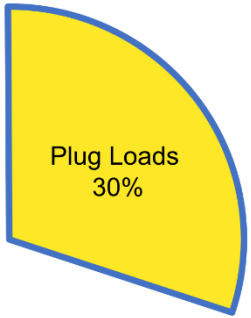

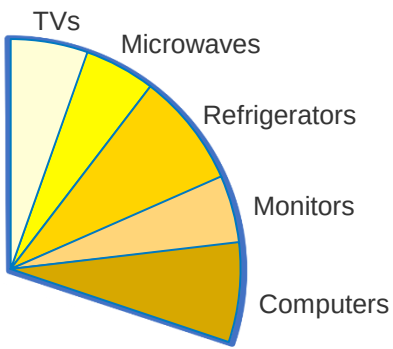

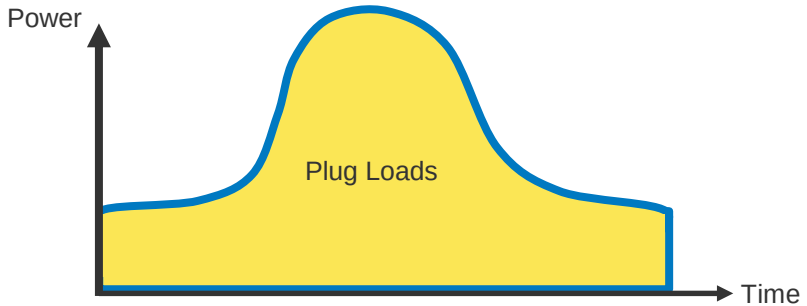

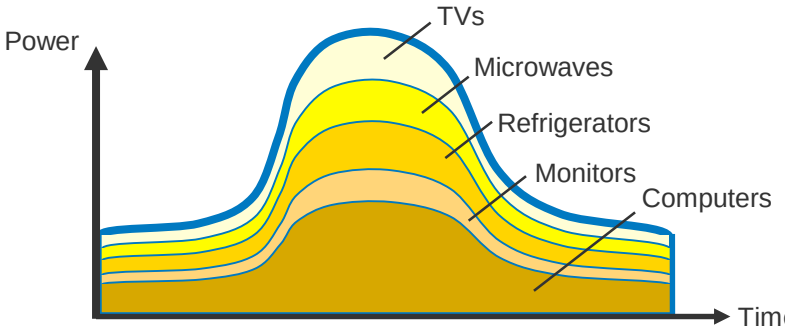

How do we access device-level energy consumption?

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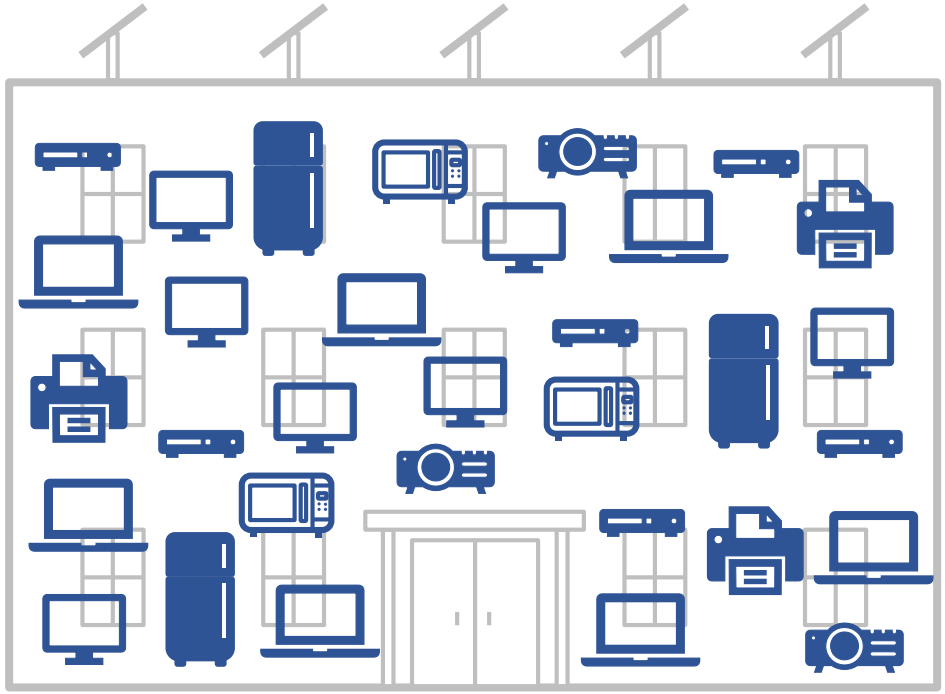

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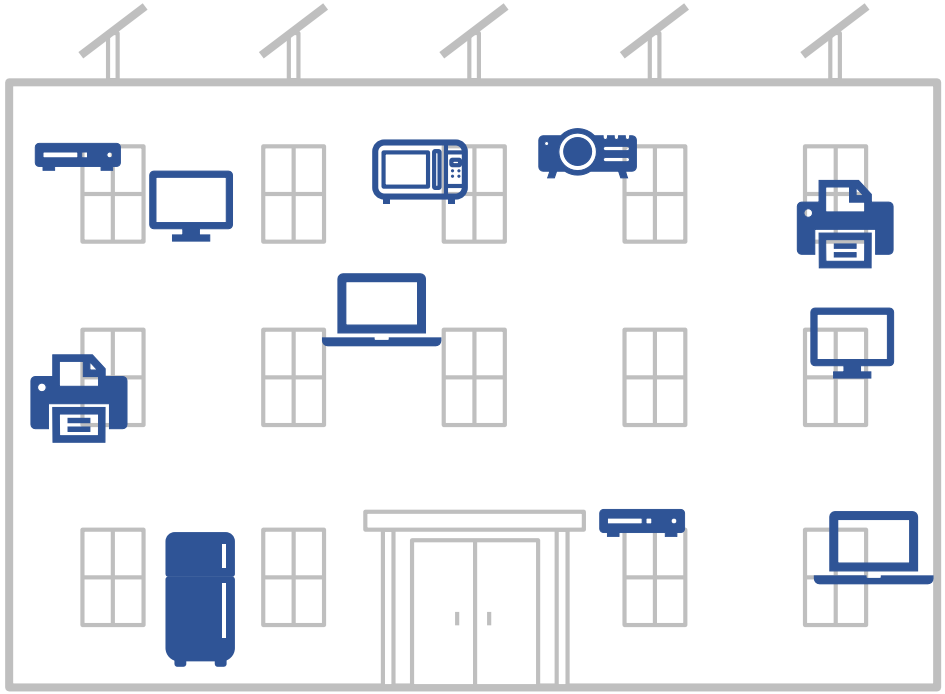
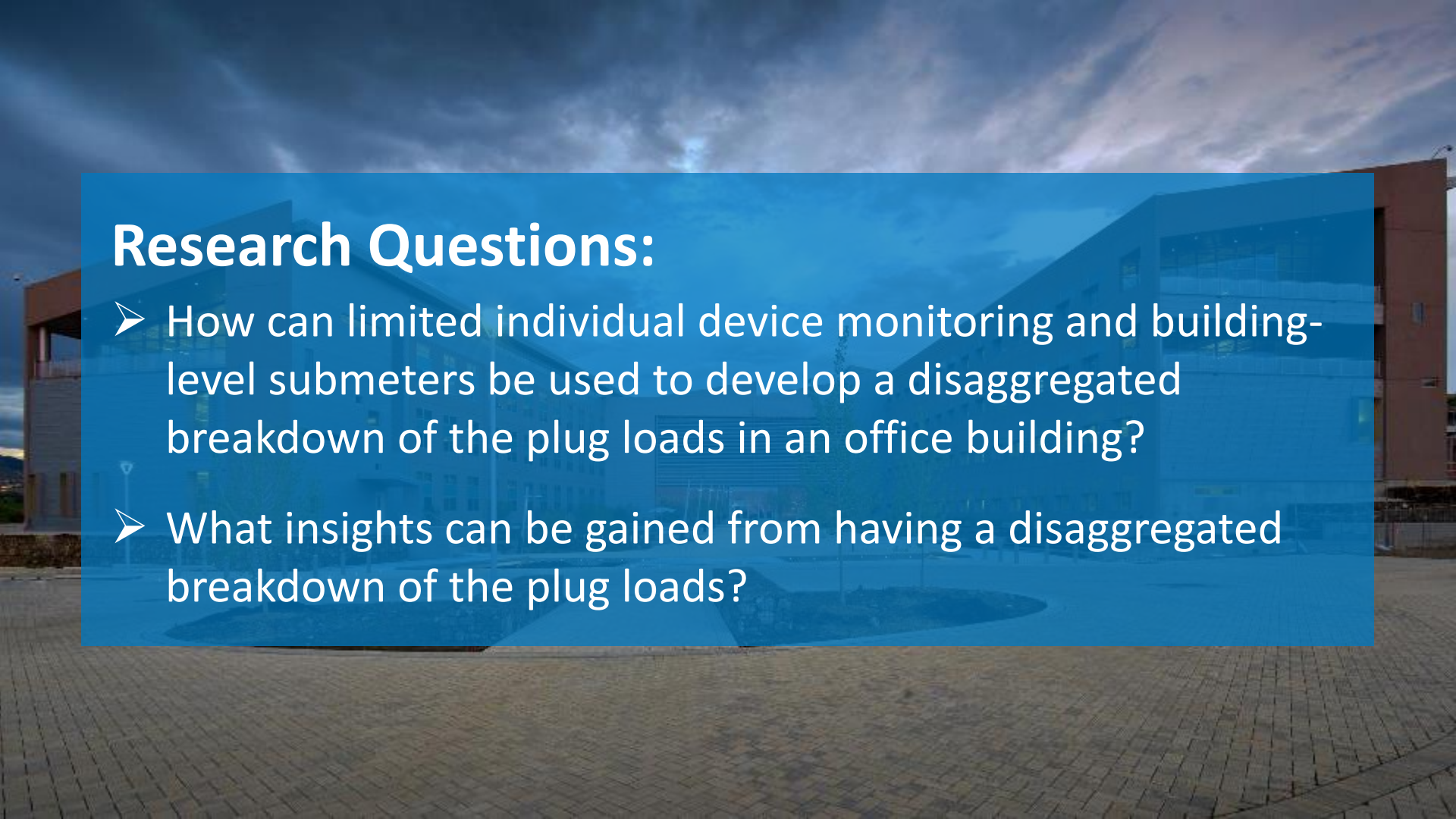
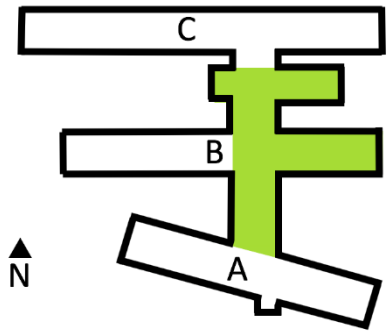




Research Questions:

- How can limited individual device monitoring and building-level submeters be used to develop a disaggregated breakdown of the plug loads in an office building?
- What insights can be gained from having a disaggregated breakdown of the plug loads?

B Wing East in NREL's Research Support Facility



Space Types in B Wing East		
Workstation	**Non-Workstation**	
Open Offices	Break Rooms	Lobby
Private Offices	Copy Rooms	Lounge
	Collaboration Rooms	Library
	Large and Small Conference Rooms	Central Monitoring Station (Surveillance)
	Exercise Room	

We metered individual devices in the B Wing East

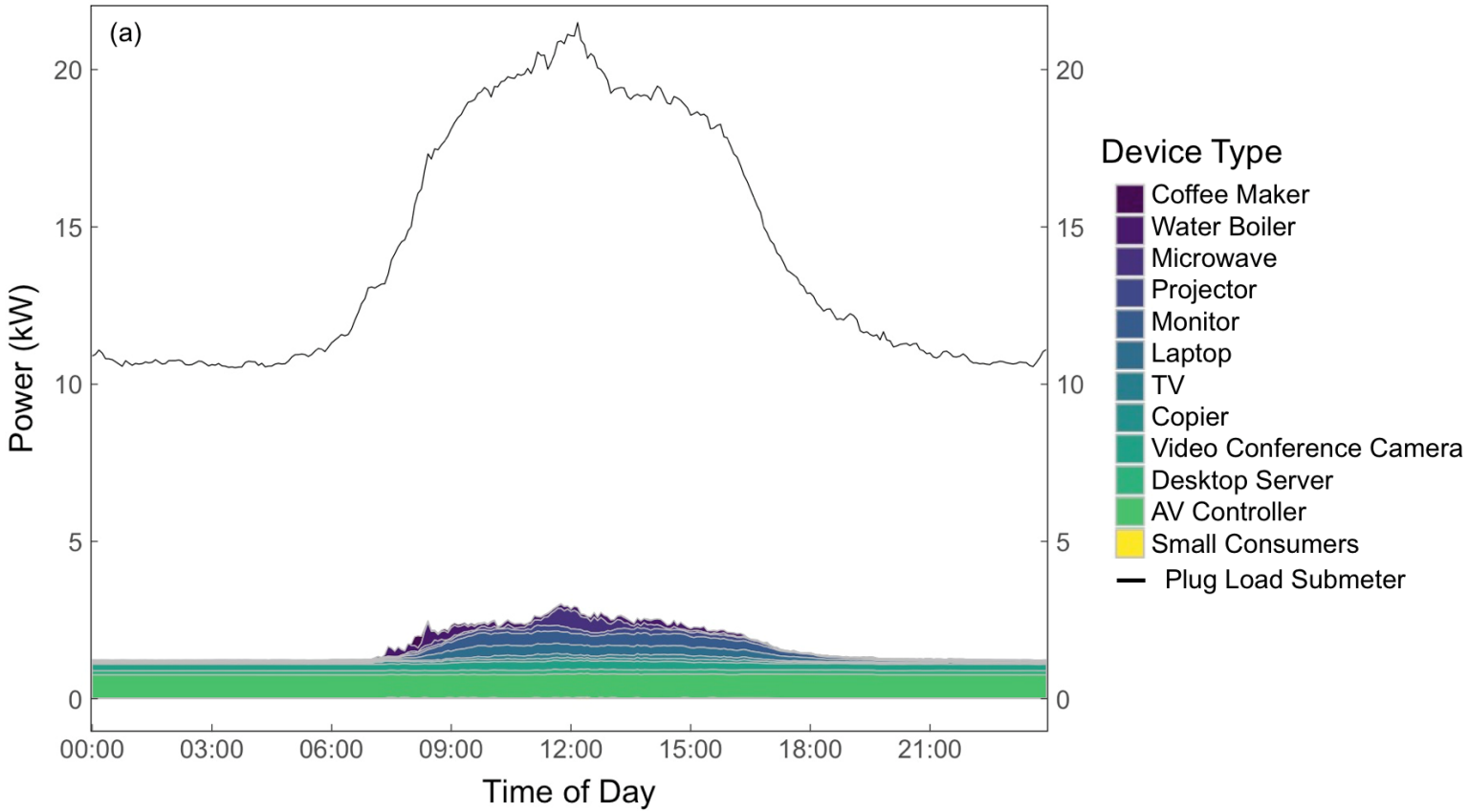
Device Metering		
Device Type	**Space Types Device Located In**	**Number of Devices Metered**
AV Controller	Non-Workstation	1
Coffee Maker	Non-Workstation	1
Copier	Non-Workstation	1
Desktop Server	Both	1
Headset	Workstation	5
Lamp	Both	19
Laptop Computer	Both	24
Microwave	Non-Workstation	4
Monitor	Both	51
Phone Charger	Workstation	1
Projector	Non-Workstation	2
Toaster Oven	Non-Workstation	1
TV	Both	4
Video Conference Camera	Non-Workstation	1
Water Boiler	Both	2
TOTAL		118

3 months of data (Oct-Dec 2017)

5-minute granularity

Weekends and holidays were omitted

Raw Metering Results



Estimating the number of devices in the wing

$$\boldsymbol{Workstation\ Total} = \sum_{workstation\ space\ types} \left(\frac{Device\ Count}{Workstations\ Inventoried} \times Active\ Employees \right)$$

$$\boldsymbol{Non\text{–}Workstation\ Total} = \sum_{non-workstation\ space\ types} \left(\frac{Device\ Count}{Rooms\ Inventoried} \times \#\ of\ Rooms\ in\ Wing \right)$$

$$\boldsymbol{Estimated\ \#\ of\ Devices\ in\ B\ Wing\ East} = Workstation\ Total + Non\text{–}Workstation\ Total$$

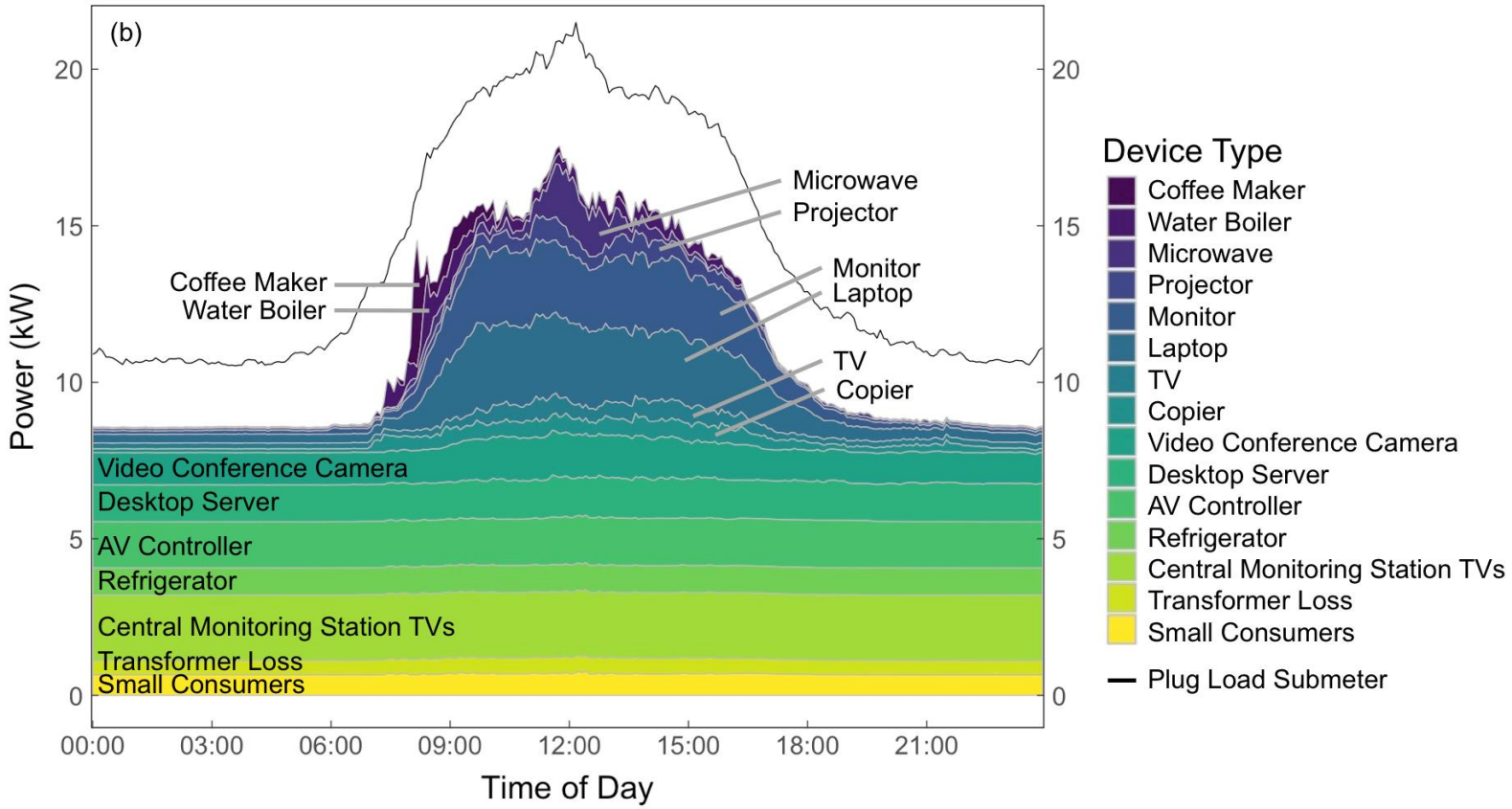
Estimating the number of devices in the wing

Device Metering and Inventory				
Device Type	Space Types Device Located In	Number of Devices Metered	Estimated Number of Devices in B Wing East	Estimated Percent of Devices Metered in B Wing East
AV Controller	Non-Workstation	1	2.0	50%
Coffee Maker	Non-Workstation	1	10.4	10%
Copier	Non-Workstation	1	6.0	17%
Desktop Server	Both	1	9.0	11%
Headset	Workstation	5	71.2	7%
Lamp	Both	19	146.3	13%
Laptop Computer	Both	24	195.9	12%
Microwave	Non-Workstation	4	12.9	31%
Monitor	Both	51	327.3	16%
Phone Charger	Workstation	1	25.8	4%
Projector	Non-Workstation	2	12.2	16%
Toaster Oven	Non-Workstation	1	2.9	34%
TV	Both	4	21.6	19%
Video Conference Camera	Non-Workstation	1	5.0	20%
Water Boiler	Both	2	5.7	35%
TOTAL		118	854.2	14%

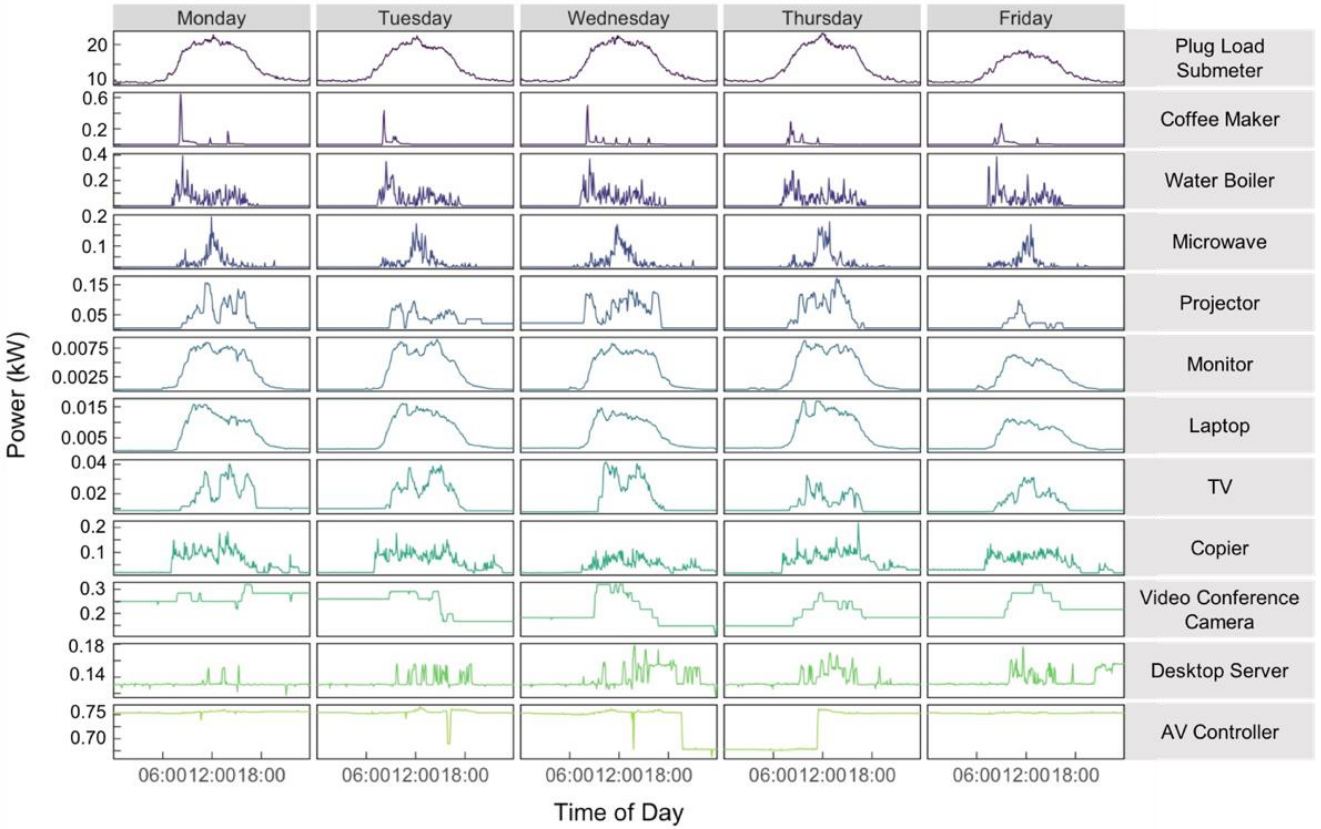
Supplemental estimates for devices that were not metered

Supplemental Devices			
Device Type	Single Device Power Estimate (W)	# of Devices	Total Power Estimate (kW)
Conference Podium Equipment (iPad)	2.37	6	0.014
Refrigerators	65	13	0.845
Microphone Charging Equipment	10	6	0.06
Treadmills and Ellipticals	9.2	7	0.067
Central Monitoring Station TVs	139.6	15	2.094
Automatic Door Openers	8	17	0.136
Exercise Room Fans	100	2	0.2

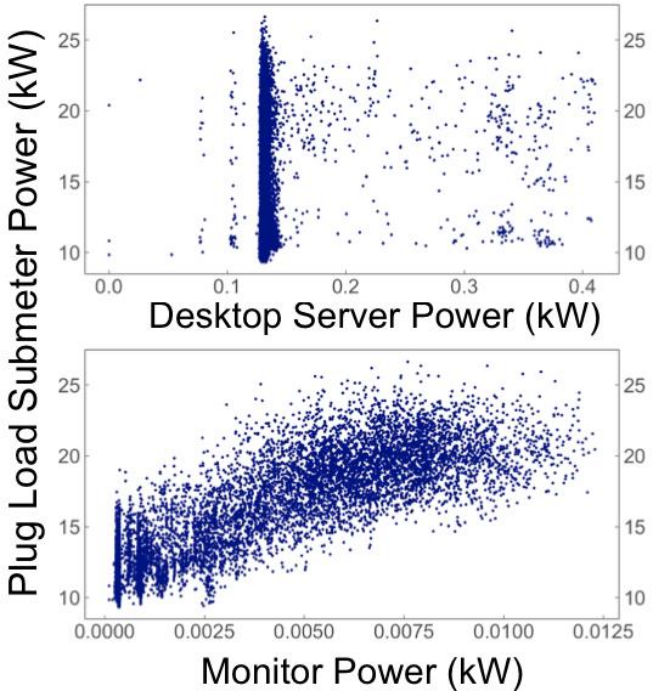
Full disaggregated plug load breakdown for the B Wing East

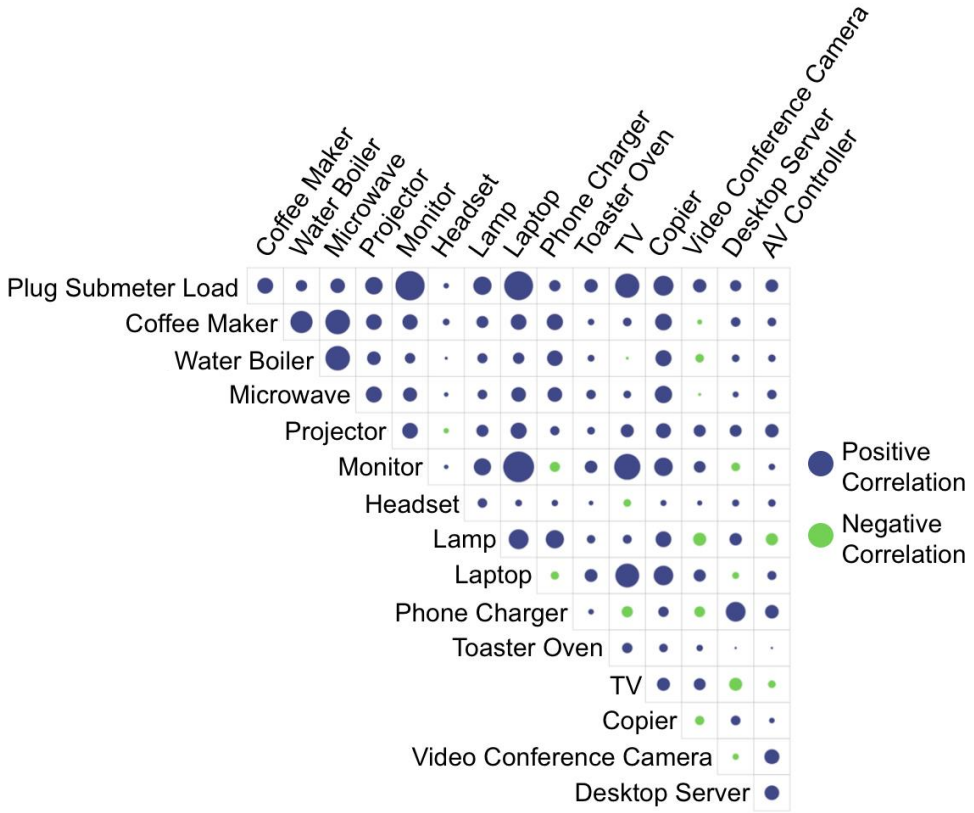


Average load profiles for select devices

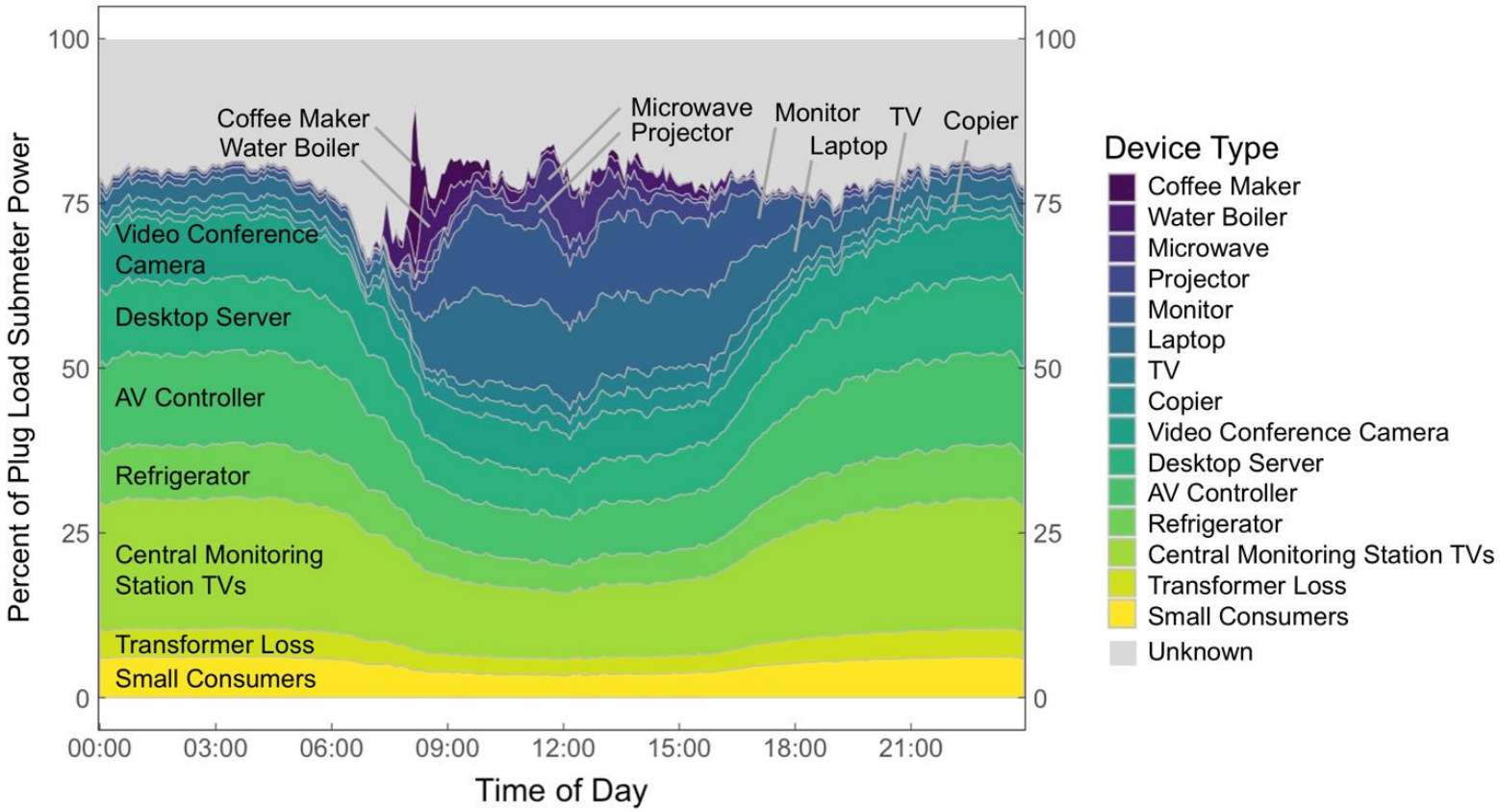


Correlation of power between devices and plug load submeter

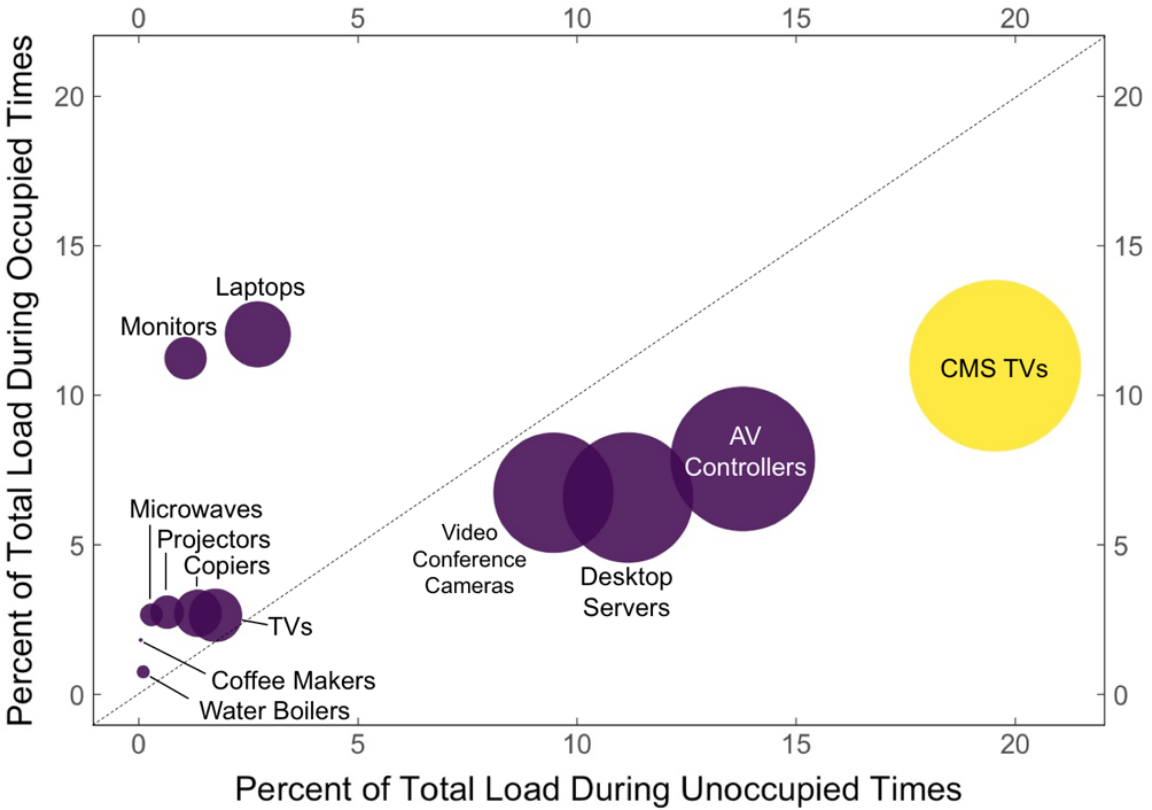




Power consumption as a percentage of the total plug loads



Power consumption during occupied vs unoccupied times of day



Summary of Key Takeaways

Our disaggregation method was effective but there are still unknowns as not everything was accounted for

Laptops and monitors are most strongly correlated with the overall plug load submeter

Building plug load efficiency policies must stay up to date as devices and people change

Lunchtime peak was due to the microwaves, which is a building-specific characteristic

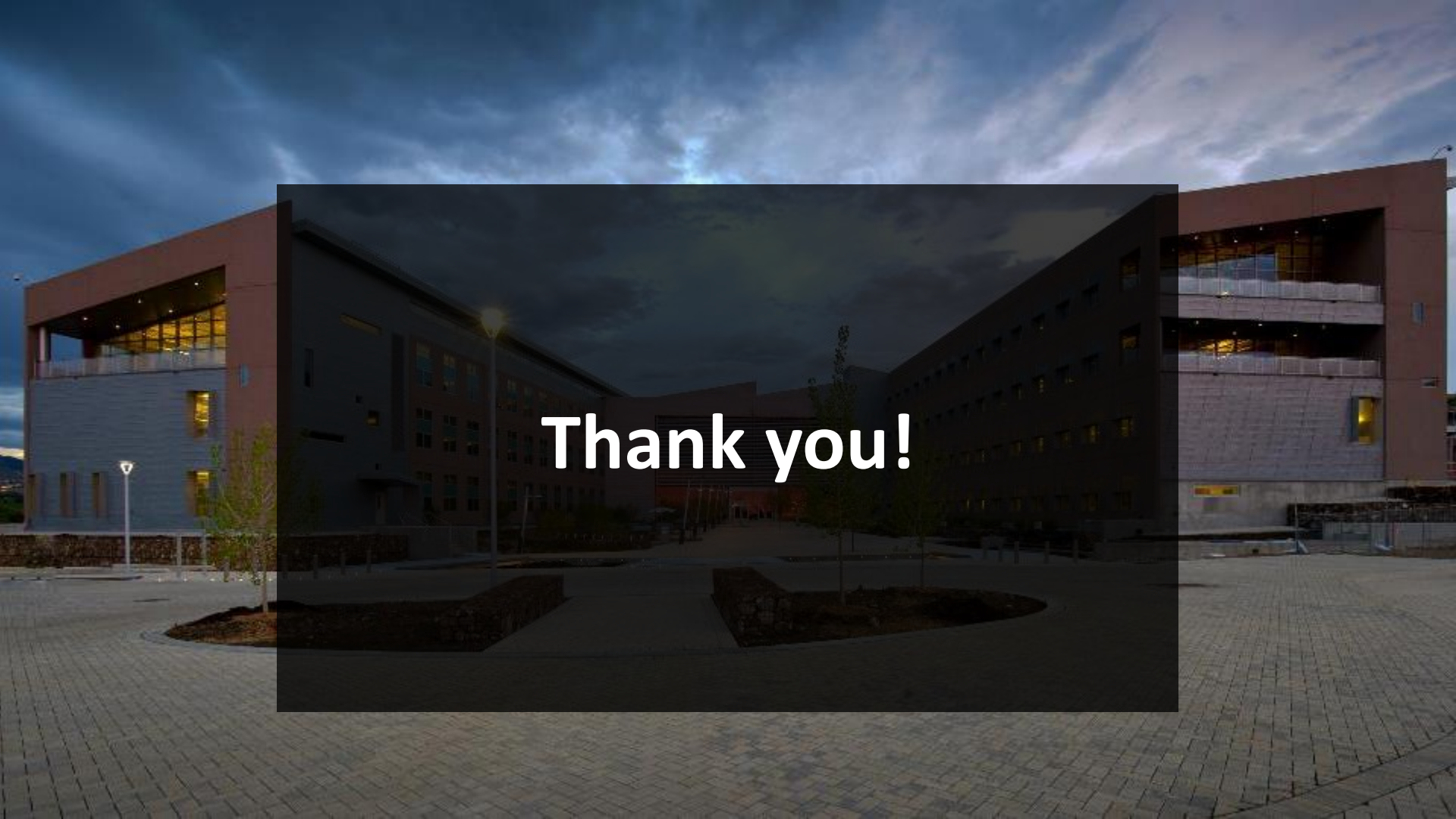
AV controllers account for a significant portion of the unoccupied load. Disaggregation allows for targeted savings.

Recommendations for future studies

1. **Identify and understand all plug load sources in the building.**
2. **Consider conducting a one- to two- week pilot study.**
3. **Select devices to monitor based on the intent of the study.**
   - Pay attention to major loads and loads with high variance
4. **Take note of high energy consumers, especially during unoccupied hours.**
   - These could be candidates for controls, which require occupant engagement and education
5. **During analysis, consider unique occupant schedules.**

Full Report:

Bennett Doherty & Kim Trenbath (2019): Device-level plug load disaggregation in a zero energy office building and opportunities for energy savings, *Energy and Buildings,* 1 December 2019*,* https://doi.org/10.1016/j.enbuild.2019.109480


Thank you!

Guest Presentation

Bruce Nordman

Lawrence Berkeley National Laboratory

bnordman@lbl.gov

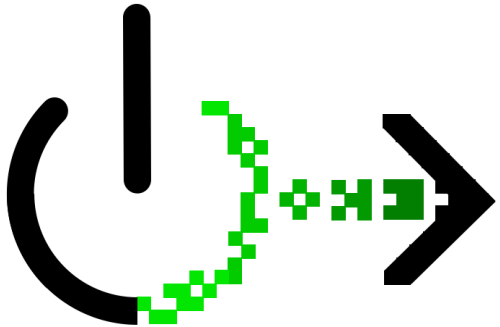
Energy Reporting: Device Demonstration, Communication Protocols, and Codes and Standards

Bruce Nordman, LBNL

January 22, 2020

Agenda

- Why
- **Energy Reporting** architecture
- End-use devices
- Data model and protocols
- Management system
- Codes / standards
- Next steps



ENERGY STAR

STATE OF CALIFORNIA
ENERGY COMMISSION
SINCE 1975

BERKELEY LAB
ENERGY TECHNOLOGIES AREA
BUILDING TECHNOLOGY & URBAN SYSTEMS DIVISION

ENERGY SOLUTIONS

Why Energy Reporting?

- People **rarely know how much energy** end-use devices use, individually or collectively
- Current solutions expensive, cumbersome, non-interoperable
  - Not much used

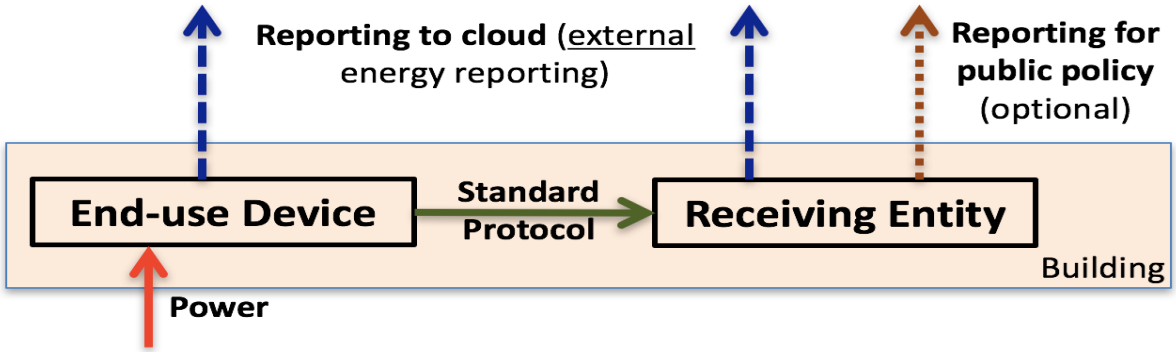
Solution

- Enable devices to track / report their own energy use

  => “Energy Reporting”

- Do this at no incremental cost
- Disperse the technology to all energy-using devices

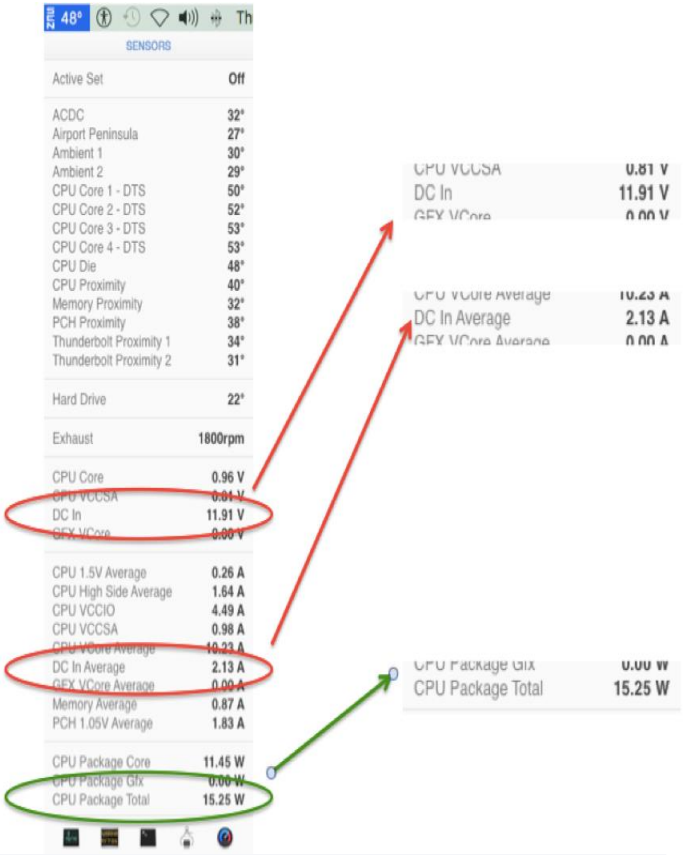
Energy Reporting Architecture



- Most devices will estimate energy use
  - Use network connection already present
- Basic capability only within building
  - Privacy, security
- Also provide other info
  - Brand, model, etc.
- Data “pulled” from end-use device
- Only management system tracks time-series data

Existing Devices with Energy Reporting Capabilities

- Data centers – servers, network equipment
- Lighting control systems
- Thermostats (Internet connected)
- Mobile (battery) devices
- Power over Ethernet devices
- Power strips; external meters
- …



Demonstration End-use Devices

- Products for sale today that do Energy Reporting





- Modified by manufacturer



- Modified by LBNL

Demonstration End-use Devices (2)

- Measured
- Estimated
- Inferred












Demonstration End-use Devices (3)

End uses:

- HVAC

- Lighting

- Electronics / Other

- External meter

Demonstration End-use Devices (4)

- Price-based control

- Other network control

End-use Devices - Results

- Energy Reporting applicable to ~~many~~ all device types
- Good accuracy
  - Easily sufficient for decision-making
- Standard protocols really do help
  - Much easier integration
- Static data challenging
  - Little reporting of these
- Modest effort needed to integrate ER into products
  - ER should not be burdensome for manufacturers

Data Model Needs

Categories

- Identification
  (unique, general)
- Classification
- Local Data
  (name, location)
- Accuracy
- Energy Reporting
  (energy, power)
- Timestamps
- Power States
- Sensors
  (temperature, occupancy)
- Price

Table 8: Detailed Energy Reporting Values (Black - Highest priority; Red - Medium; Blue - Lowest)

	Data Type	Comment
Static Data		
Identification		
UUID	uuid	128 bits (16 bytes)
LocalIdentity	Text	list of "keyword=value;" e.g., IP address or MAC address, serial number
EntityManufacturer	Text	name of manufacturer, generally without suffix (e.g., Inc.)
EntityBrand	Text	name of brand if different from manufacturer, otherwise empty
EntityModel	Text	model number/name
EntityIdentityGeneral	Text	list of "keyword=value;"
EntityURL	Text	
DeviceType	Enumeration (0..92)	Universal Device Classification (B. Nordman and H. Y. Cheung 2013)
Local Data		
LocalName	Text	locally determined name
LocalOtherInfo	Text	list of "keyword=value;"
LocationLocal	Text	list of "keyword=value;"
LastStaticDataChangeTime	Float or text	Unix time or RFC 3339 time
Accuracy		
RangeMax	Float	Maximum power value in W
AccuracyRange	Float	Accuracy as fraction of range
AccuracyReading	Float	Accuracy as fraction of value
AccuracyTypical	Float	Accuracy as fraction of typical energy use
Dynamic Data		
Energy Reporting		
PowerLevel	Float	current electrical power in W
CumulativeEnergy	Float	accumulated energy use in Wh
Other Data		
TimeStamp	Float or text	Unix time or RFC 3339 time
PowerState	Enumeration (0..5)	
Temperature	Float	Current temperature in Celsius
Occupancy	Text	list of "keyword=value;"
Price	Float	Index of current electricity price

Translate data from any protocol into reference data model

Actual ER data

Data Model - Protocols

- Goal: Make a murky situation less murky …..
  Establish a **reference data model -** (CTA-2047)

- Define how to translate between various protocols and our data model
- Identify preferred / more important protocols
- Use our data model in new standards

- Intel, Cisco, Google, Comcast, Samsung, Schneider, Signify, Honeywell, NXP, Qualcomm, Landis+Gyr, Somfy, Danfoss, Proctor & Gamble, Haier, Hagar, …
- OCF, Zigbee, Thread, EnOcean, oneM2M, GSMA

Connected Home over IP

amazon · Google · zigbee alliance · IKEA · legrand · LEEDARSON · MMB NETWORKS · NXP · resideo · SmartThings · Schneider Electric · signify · SILICON LABS · somfy · Wulian

Demonstration Management System

- Key Mgmt. System functions
  - Acquires Energy Reporting data using multiple protocols
    - CTA-2045, Bluetooth/serial, REST API, Zigbee
  - Intwine Gateway: Ethernet, Wi-Fi, REST, Cellular
  - Translates to common format and stores
  - Displays multiple ways for user / building owner
  - Instantaneous power (dial), accumulated energy,
    graph of power over time

- Outstanding Issue
  - How to limit data sharing to within building

Codes and Standards

- Energy codes and standards can encourage or require energy reporting capability
  - Mostly for devices which can communicate for other purposes
- Explored / defined how California could spur Energy Reporting
  - Policies / goals (energy, climate)
  - Building codes
  - Appliance standards
  - Voluntary programs

ENERGY SOLUTIONS

Applications

- Energy accounting
  - To make decisions about equipment replacement, repair, operation, etc.
- Billing
  - Billing of tenants or vendors
- Building operation
  - Better controlling energy use for local or grid concerns
- Monitoring and verification
  - Comparing actual energy use to that estimated in design
- Asset management
  - Tracking presence, location, and identity of devices

Next Steps

Technology development

- Establish a reference (common) “data model” – CTA-2047
- Minimize number of application layer protocols used
  - Using Internet Protocol, any physical layer technology OK
- Harmonize protocols to reference data model (as feasible)
- Continue research on acquiring Energy Reporting data
- Provide free reference Management System software
- Ensure that technology does not require compromising Privacy or Security

Deployment / demonstration

- Create/maintain a database of products that do Energy Reporting
- Assess what devices you have that do Energy Reporting
- Find or acquire a management system
- Start collecting data
- Use external meters as appropriate
- Make Energy Reporting capability a priority in purchasing

Everyone

- Popularize concept

Thank You!

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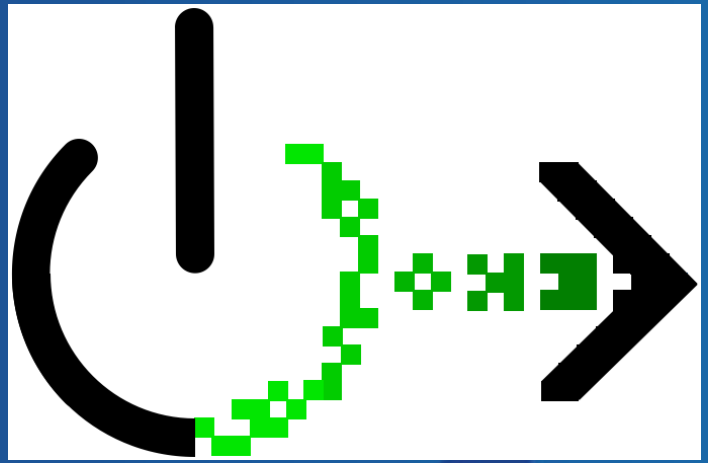

U.S. DEPARTMENT OF ENERGY

Q&A

U.S. DEPARTMENT OF ENERGY

Member Updates

U.S. DEPARTMENT OF ENERGY

Please contact:

ppl@waypoint-energy.com

Thank You!

U.S. DEPARTMENT OF ENERGY