

February 19, 2018

Emerging & Commercial Ready Energy Efficiency Technologies for Businesses

PRESENTED BY

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Agenda

Emerging technologies

Commercial electric technologies

Office plug load strategies

Commercial gas technologies



Value of Emerging Technologies to Energy Efficiency Programs and Business Customers

Science Fiction to Reality



**IDEAS /
RESEARCH**

**NEW TECHNOLOGY
SOURCES**

Universities

Laboratories or research and
development divisions with
private-sector companies

Commercializing the technology
adds value so it will have social
and economic impact

**TECHNOLOGY TRANSFER
(THE BRIDGE)**

The process of transferring new technologies
from the laboratory to the marketplace

**NEW
PRODUCTS**

COMMERCIALIZATION

Conceptual system
viability proven

Prototype matching the
final configuration

Pre-manufacturing or
pre-deployment testing
and/or field testing



Emerging Technologies

Phase 1 Emerging Technology Screening - Sources

- ASHRAE research project (Max Tech, RP1651)
- Bonneville Power Administration's (BPA) Emerging Technologies Program – E3T
- Department of Defense Environmental Security Technology Certification Program (DoD ESTCP)
- The Emerging Technologies Coordinating Council
- Department of Energy High Impact Technology Catalyst
- General Services Administration Green Proving Ground (GPG) Program
- Seventhwave research projects
- Gas Technology Institute's Technology Snapshots (GTI ETP Collaborative)
- Direct dialogue with selected manufacturers

Phase 1 Emerging Technology Screening - Criteria

Technology readiness: Is the technology in development, deployed in some markets or does it need validation?

Savings potential: Could there be widespread adoption in buildings because of savings potential? Is the incremental savings from a technology worth program investment?

Cost Effectiveness: Will it pass a TRC test? The answer to this question may be subjective as cost data for emerging technologies is often incomplete or unavailable.

Other Considerations:

Barriers to adoption: Are there other barriers that will make technology adoption too risky?

The end-use function served: Does the technology have broad applicability (and therefore savings potential)?



Emerging Technologies - Highlights

Interior Low-e Storm Windows

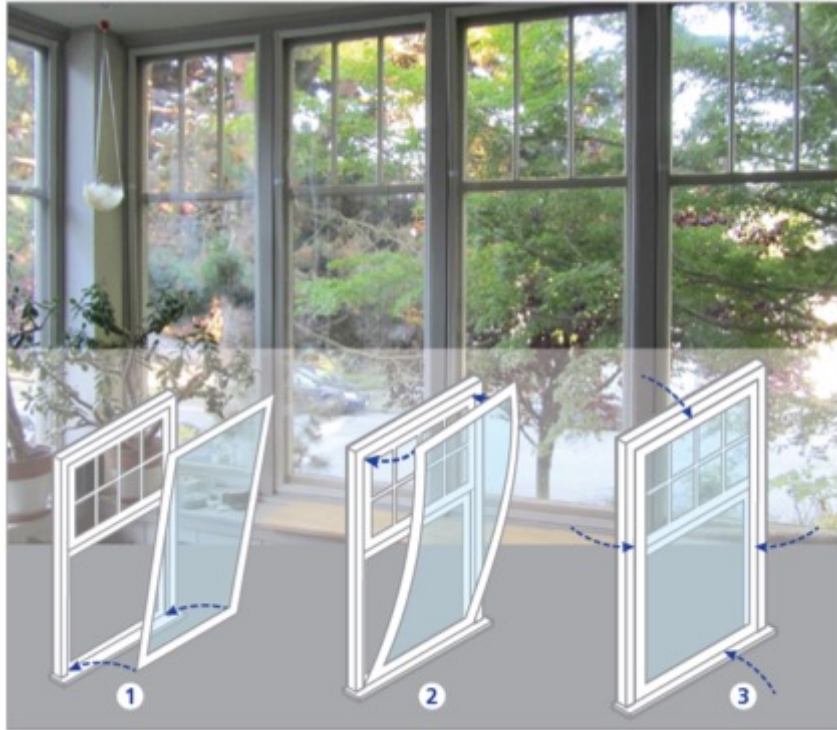


Photo: factory-made interior removable storm windows. Building America Solution Center, Pacific Northwest Laboratory (<https://bascc.pnnl.gov/images/factory-made-interior-removable-storm-windows>)

Electricity savings: 0.06 kWh/ft²

Gas savings: 0.05 therm/ft²

Cost savings: \$0.08/ft²

2017 Simple payback: 5 years

Barriers: cost, maintenance

Measure life: 15 years

Dynamic Air Flow Balancing

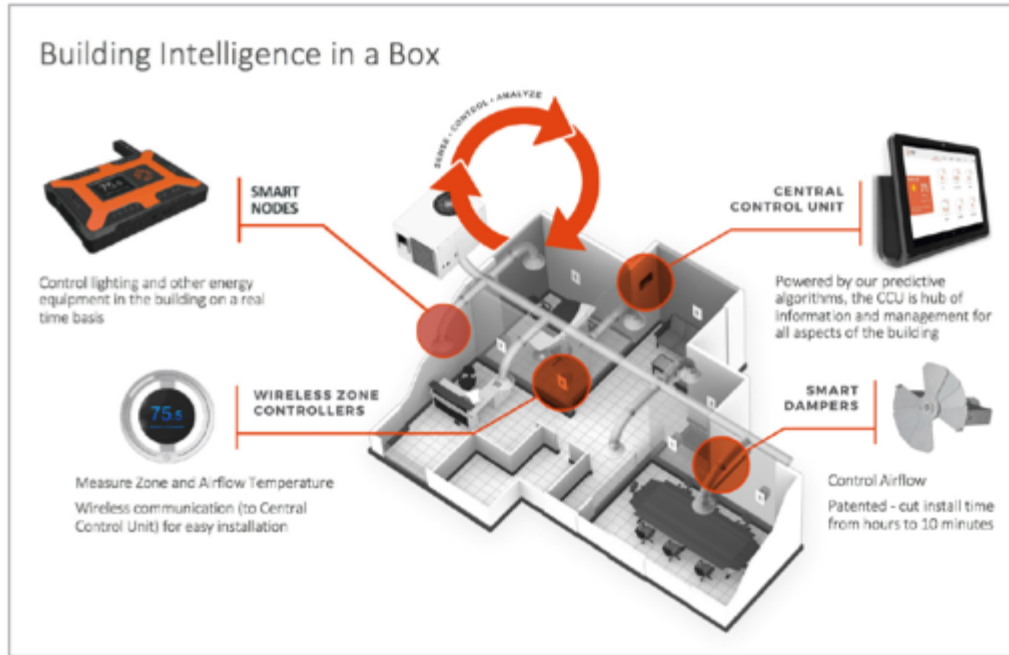


Photo courtesy of 75F

Electricity savings: 0.4 kWh/ft²

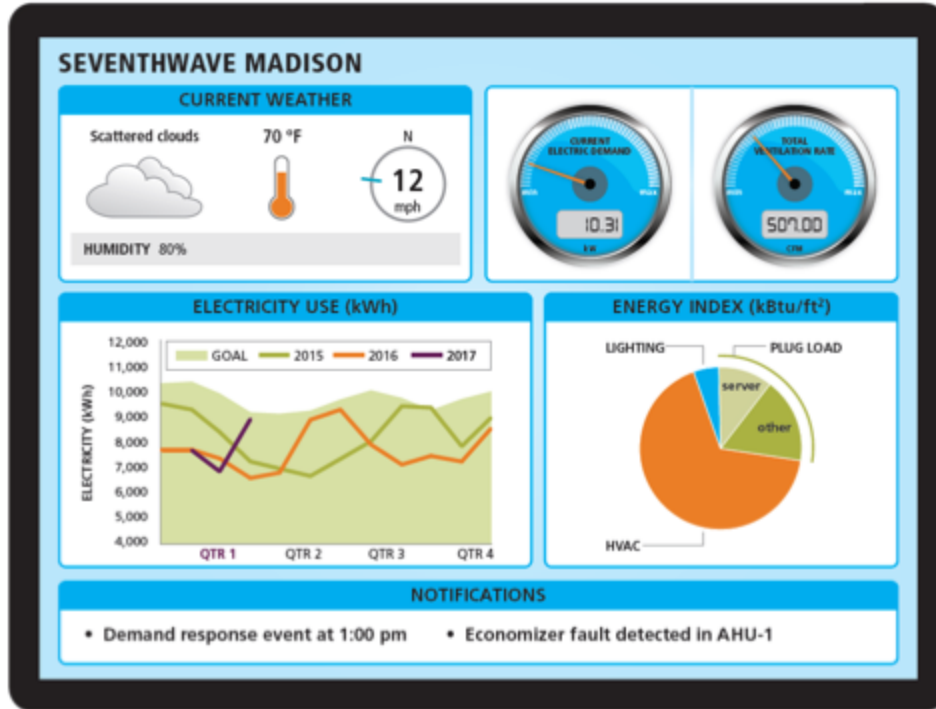
Gas savings: 0.10 therm/ft²

Cost savings: \$0.12/ft²

Barriers: cost, distribution

Measure life: 15 years

Advanced Energy Information Systems



Electricity savings: 0.47 kWh/ft²
Gas savings: 0.03 therm/ft²

Cost savings: \$0.07/ft²

2017 Simple payback: 4 years

Barriers: training, IT barriers

Measure life: 7 years

LED Retrofit with Integrated Lighting Controls



Photo courtesy of Cree

Electricity savings: 0.89 kWh/ft²

Cost savings: \$0.08/ft²

2017 Simple payback: 10 years

Barriers: cost

Measure life: 15 years

Networked Home Automation



By Bretislav Valek (Own work) [CC BY-SA 3.0 (<http://creativecommons.org/licenses/by-sa/3.0/>)], via Wikimedia Commons

Electricity savings: 0.15 kWh/ft²

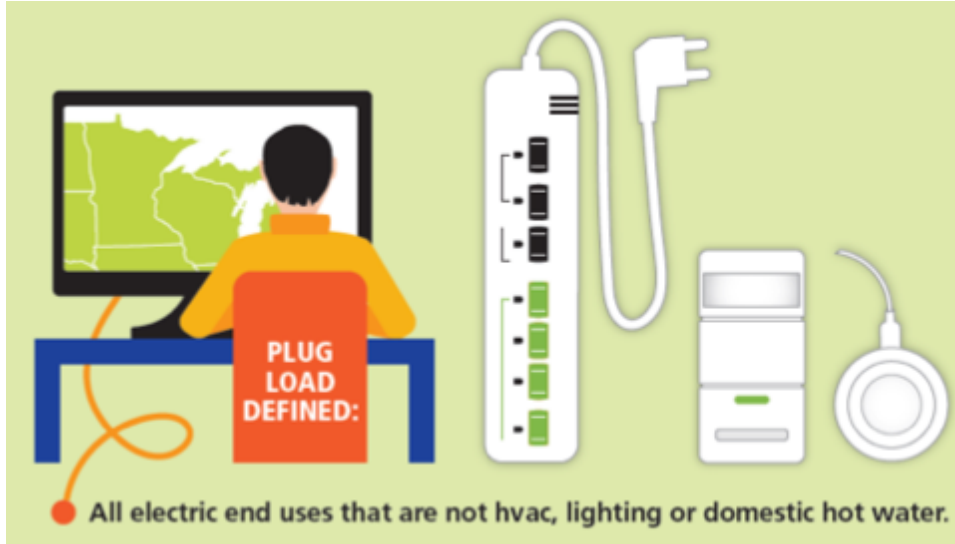
Cost savings: \$0.02/ft²

2017 Simple payback: 7 years

Barriers: complexity, training

Measure life: 8 years

Advanced Power Strips



Electricity savings: 0.12 kWh/ft²

Cost savings: \$0.01/ft²

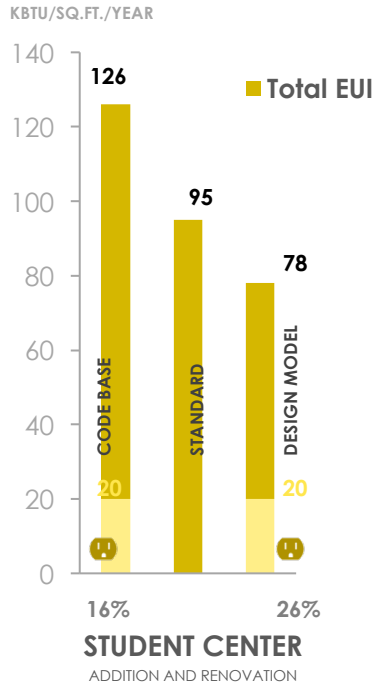
2017 Simple payback: 3 years

Barriers: IT pushback; persistence

Measure life: 4 years



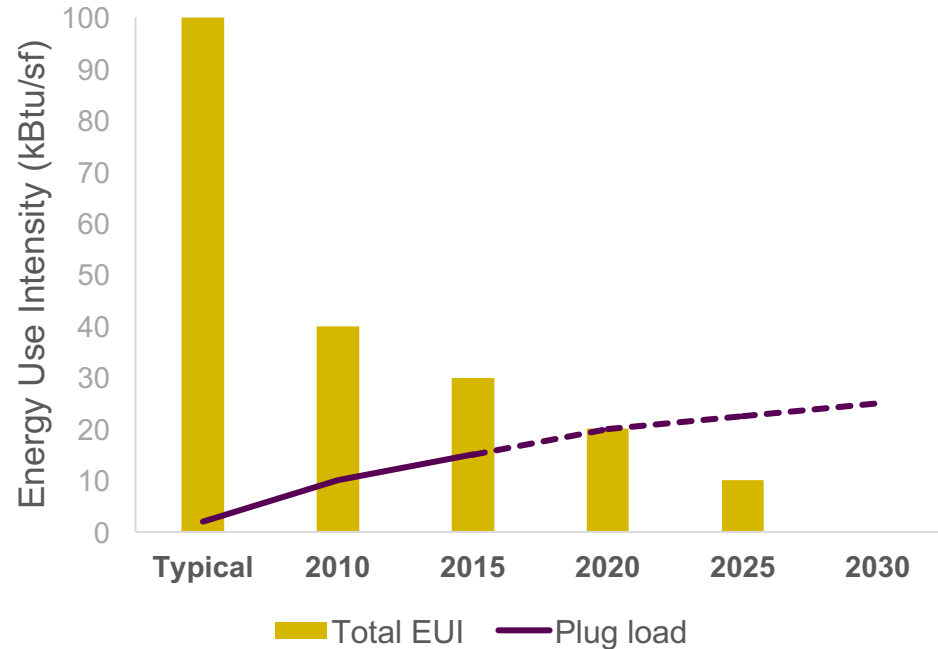
WHAT IS A PLUG LOAD?



All energy consumed by appliances, office equipment, and anything else that is not a part of the facility's primary HVAC, lighting, water heating or conveyance (elevators, escalators, etc.) systems. This includes just about anything that is actually plugged into an outlet.



WHAT'S THE PROBLEM?

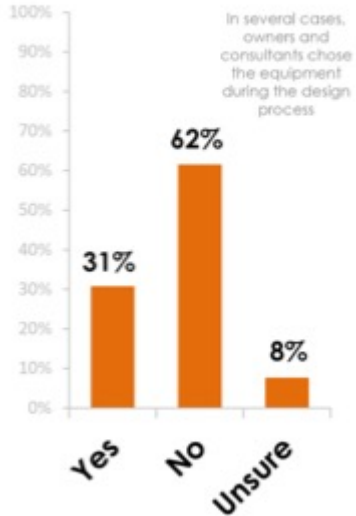


While plug loads are increasing, overall energy use intensity needs to decrease.

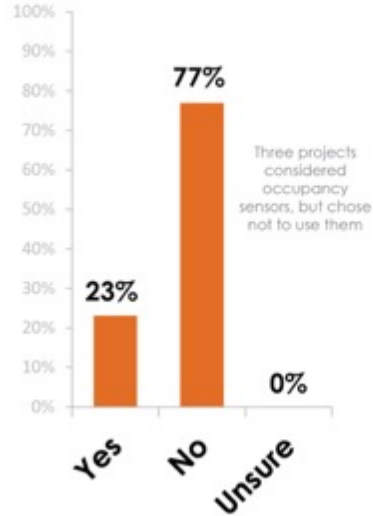


HISTORIC APPROACH TO PLUG LOADS

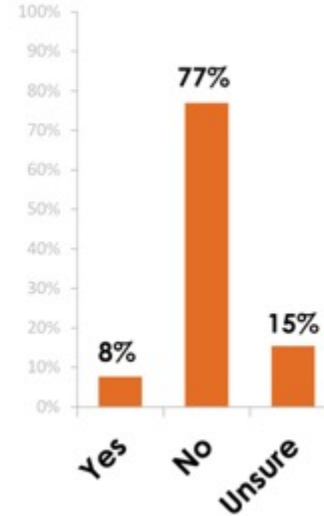
Are purchasers of equipment involved in the design and modeling process?



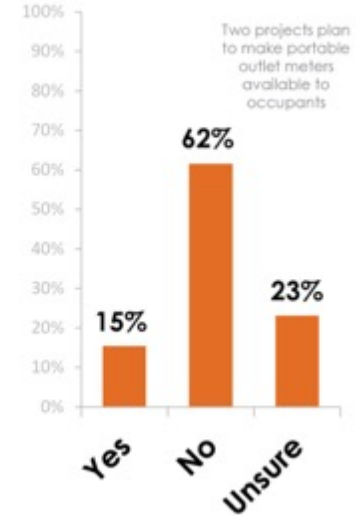
Are plug load reductions used as strategies in the energy modeling process?



Will plug loads be metered separately from other energy use in the completed building?



Is there a plan to provide plug load information to the building's occupants?



MINNESOTA ENERGY CODE



ASHRAE 90.1-2010 Prescriptive Path requires 50% of electrical outlets in offices and computer classrooms must be on automatic control so they can be switched off when the room is unoccupied

RESEARCH STUDIES



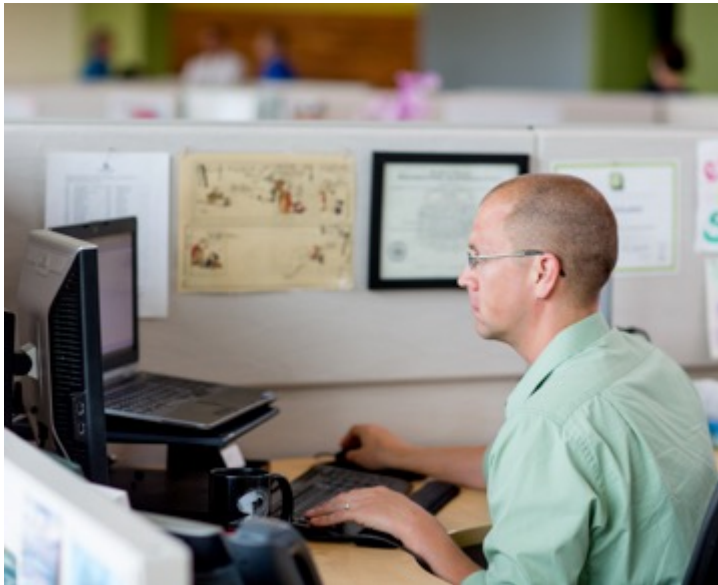
- Impacts of Office Plug Load Reduction Strategies | October 2016
- Small Embedded Data Center Program Pilot | June 2017
- Using Network Switches to Operate and Control Lighting and Plug Loads in Commercial Building | October 2020

PLUG LOAD REDUCTIONS

This project was supported in part by:

Minnesota Conservation
Applied Research and
Development (CARD) Grant





CREDIT: Samsung

PLUG LOAD ENERGY IN A TYPICAL OFFICE

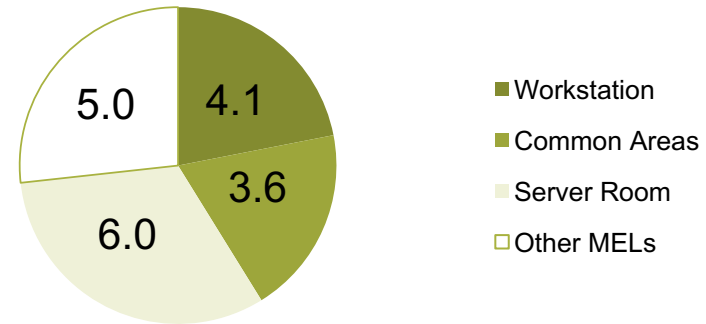




CONTROLLABLE PLUG LOADS

- Over 40% of typical office plug load is controllable
- Workstations make up 53% of controllable load
- Common area is the rest
 - Office equipment 30%
 - Break room 16%

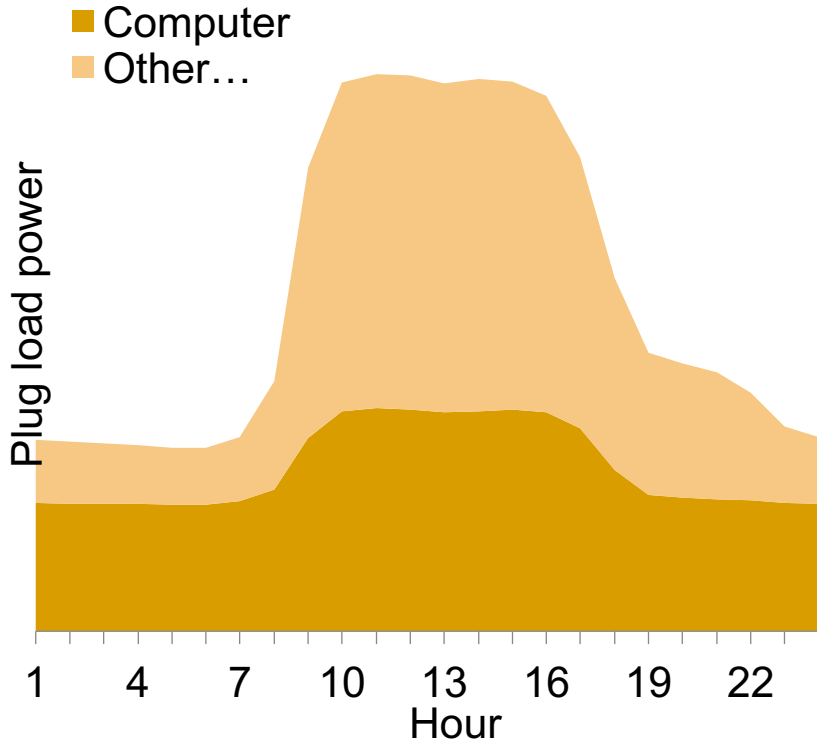
**Plug Load EUI \approx 19
kBtu/sq.ft.**



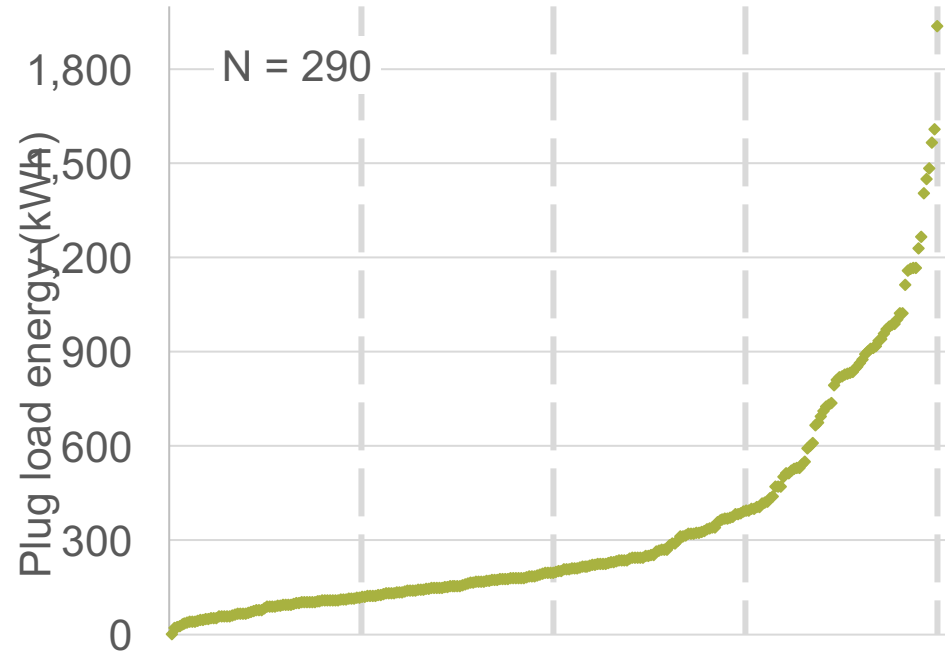


TYPICAL LOADS

By day...



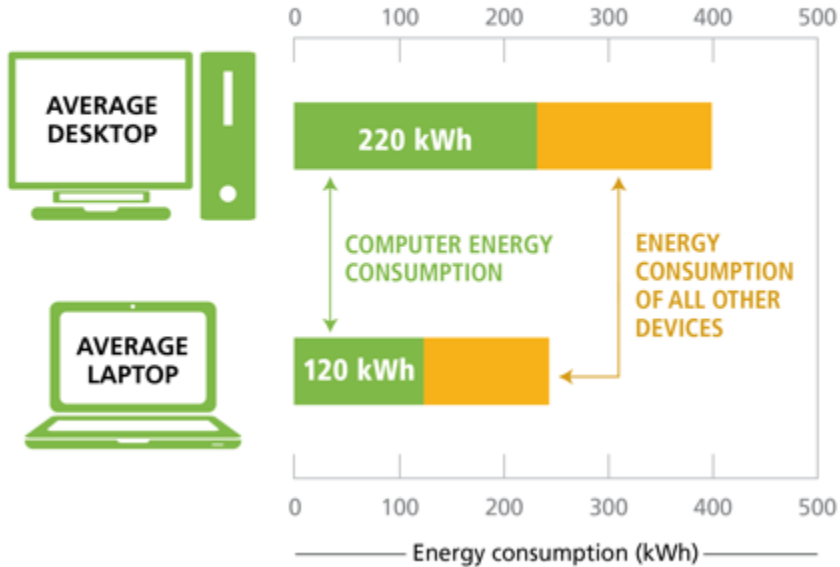
...and for the year.





TYPICAL LOADS - TRENDS

Increasing use of laptops saves energy



ENERGY SAVING STRATEGIES



Advanced power strips:

- APS – Occupancy sensor
- APS – Foot pedal

Computer power management

Behavior campaign + APS

Common area equipment: Basic timer

ENERGY STAR recommendations

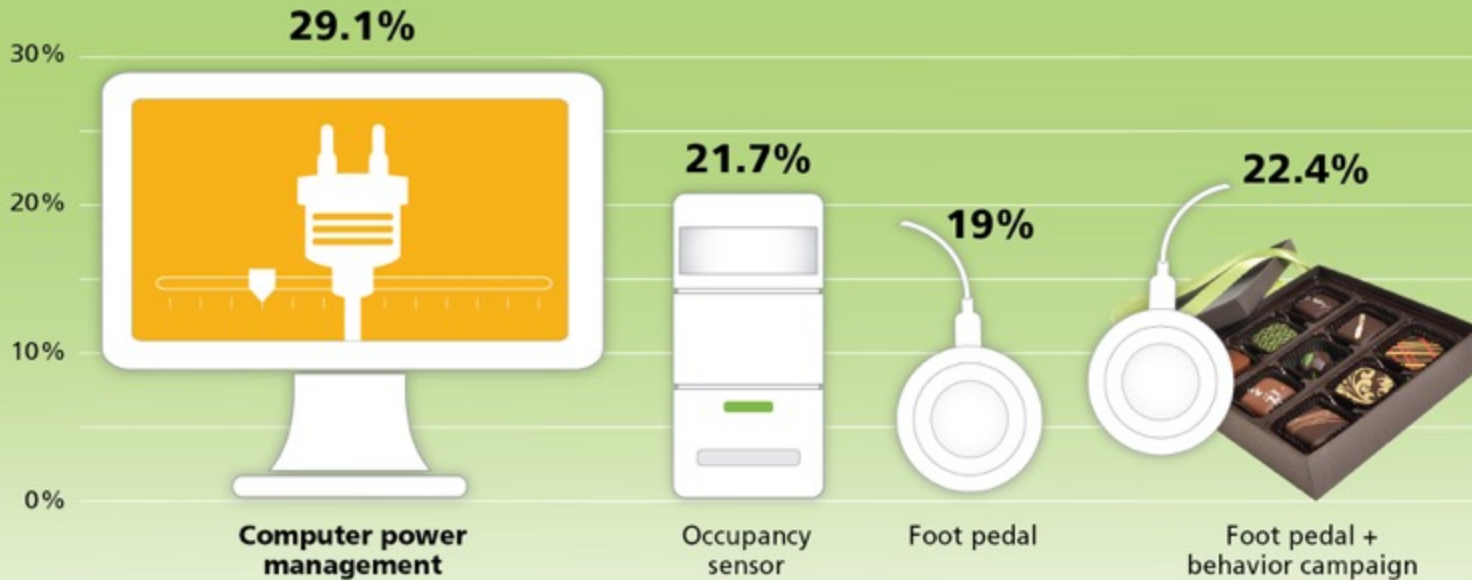


CREDIT: Tricklestar



WORKSTATION SAVINGS

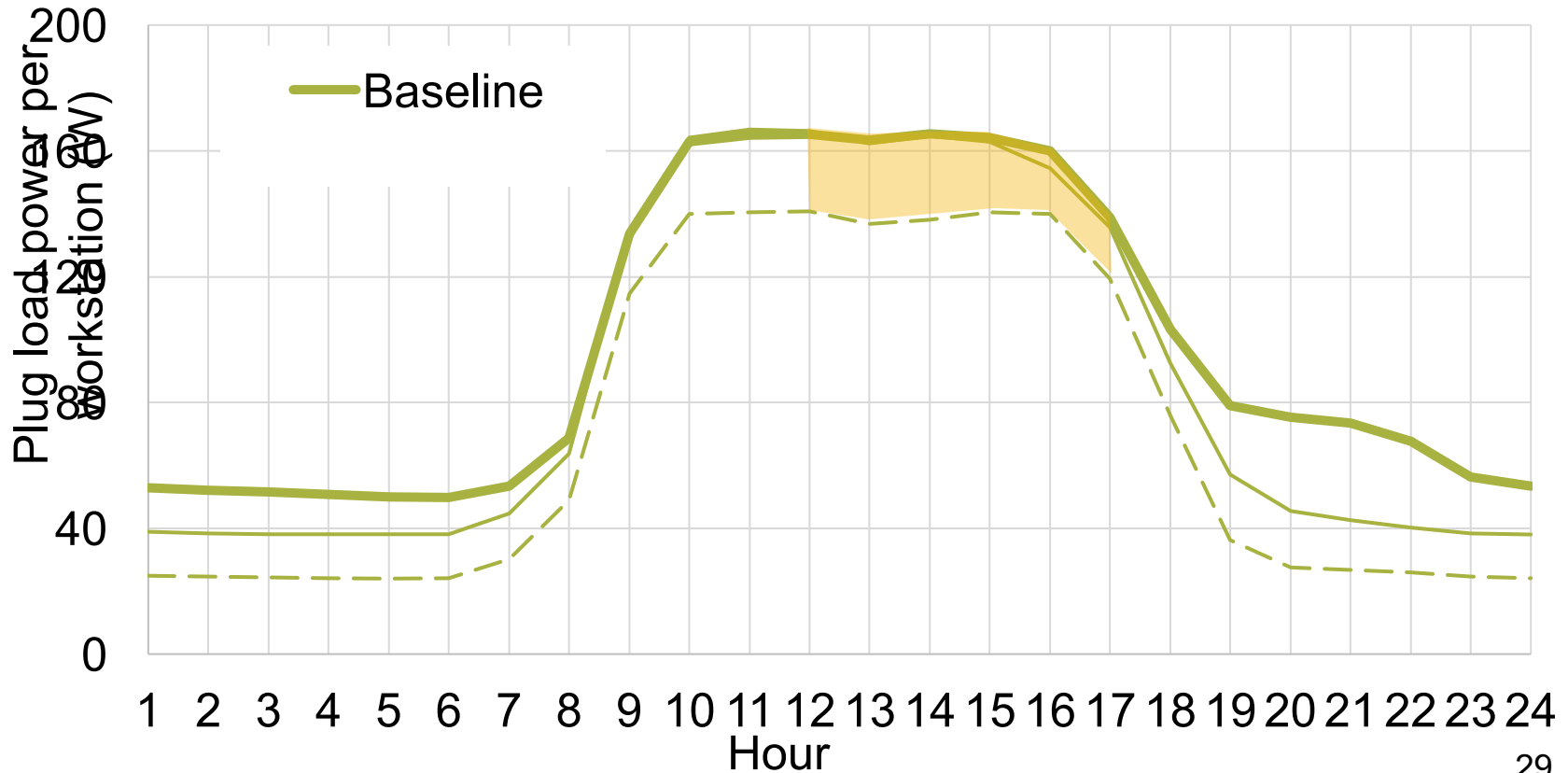
Computer power management saved the most



Other three were all variations on advanced power strips

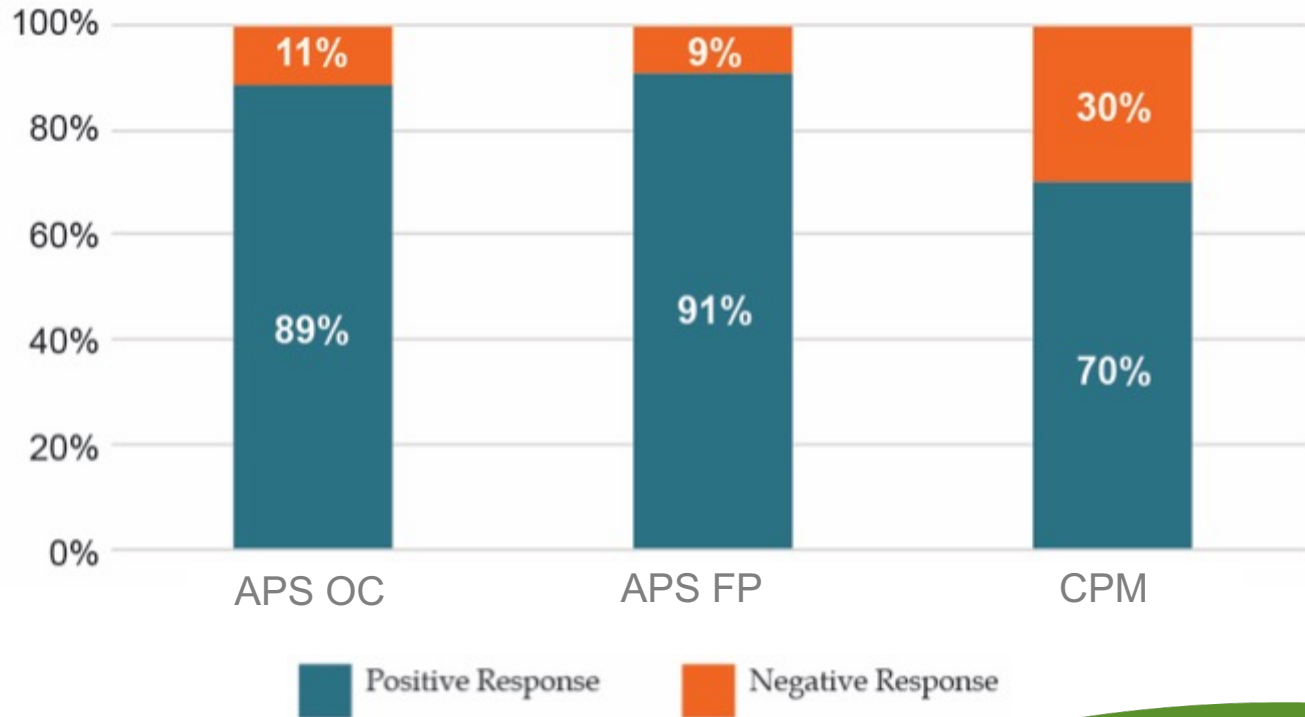


PEAK DEMAND IMPACT





PARTICIPANT FEEDBACK



COMMON AREA EQUIPMENT



Evaluate needs!

	Annual energy usage
	kWh
Desktop printers	170
Medium-sized MFDs	352
Coffeemakers	548
Televisions	67
Water coolers	386



PHOTO CREDIT: Wikimedia commons

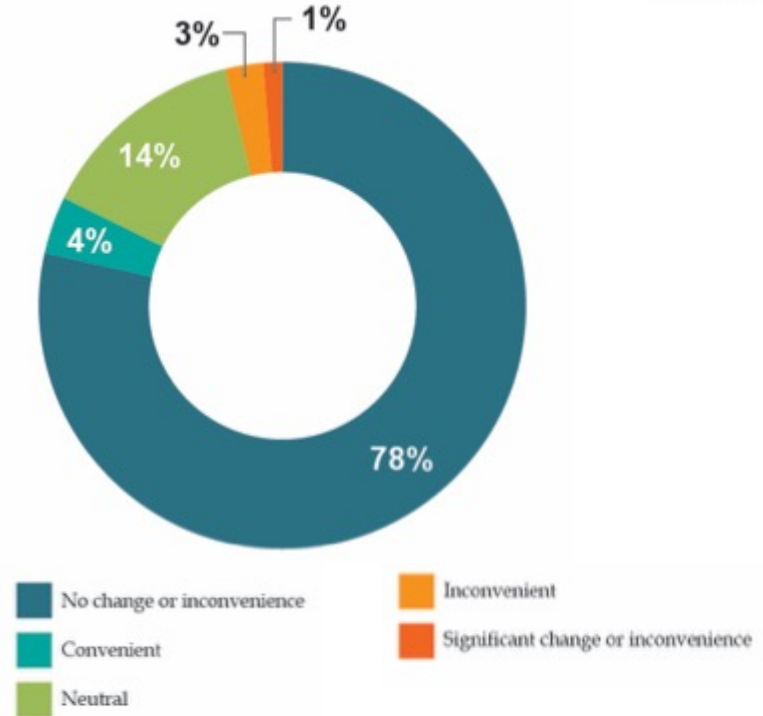


PARTICIPANT FEEDBACK

Common area equipment timers:

96% of respondents indicated that they did not notice any change/inconvenience

Most issues were related to equipment that is not designed for hard shutdown (MFDs, video conferencing equipment, etc.)





BEHAVIOR CAMPAIGN + APS

POWER DOWN

TOGETHER, WE CAN REDUCE PLUG LOAD ENERGY USAGE IN THE 1902 BUILDING.



AS A CITY, we have made great strides in reducing our environmental footprint—but we can do more—especially in the area of plug load energy.

As part of this effort to improve, you'll notice we've tried some technological strategies (and are measuring those as part of a research project) to reduce plug loads at some of the workstations in the 1902 Building. **But now it's time to get EVERYONE involved in trying to save energy through individual actions.** As part of this effort, you'll notice some workstations have received blue, microwatt LEDs to remind occupants to turn off their equipment. We hope these will also serve to remind us ALL to turn equipment and lights off.



To help inspire everyone, **your efforts will be rewarded by treats** (in addition to that warm, fuzzy feeling) if we catch you in the act of saving energy!

TO GET STARTED, SOME ACTIONS YOU CAN TAKE INCLUDE

- **"Hit the switch"** to turn off unneeded plug loads whenever leaving your desk
- **Unplug** any electronics that are only rarely used (printers, radios, chargers)
- At the end of the day, **shut down or hibernate** your computer (when you won't need remote access)
- **Brag** about your energy-saving actions to co-workers and get them saving too!





CHECK THE CLOSET



PHOTO CREDIT: Samsung



KEY TAKE-AWAYS

- Though some loads are moving out of the workstation, significant savings remains
- Relatively simple solutions are available to save 30% or more
- Energy efficiency advocates should make an ally in IT
- There is value in discussing behavior
- There is value in targeting plug load during design

PLUG LOAD CASE STUDY

LHB OFFICE

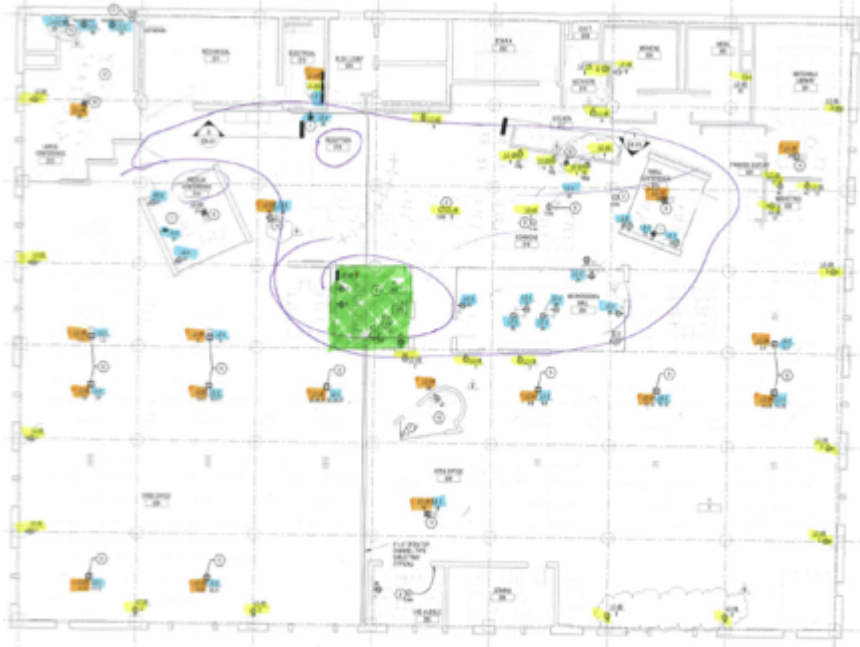


PROCESS



- Create an Energy Management Team
- Submeter plug loads to create a baseline
- Set goals
- Take action and record as “Events” in B3 Benchmarking
- Track results

SUBMETERS



(LC-2A) FURNITURE PLUG LOADS (LC-2B) (SHAPE METER)

PARSONS SAFETY FIRST
Arc Flash & Shock Hazard
Appropriate PPE Required

Panel Name: LC-2A Volts: 120/208 208/120V 480/277V
 Ampacity: 225 Phase: 3 Black A Phase Brown B Phase Blue C Phase White Neutral Grey Ground

Wire: 4				Wire: 4			
Description	Amp Pole	Ckt	Ph	Ckt	Amp Pole	Description	Amp Pole
Furniture - 226	201	1	A	2	201	Furniture - 226	
Furniture - 226	201	3	B	4			
Furniture - 226	201	5	C	6	201	Furniture - 226	
Furniture - 226	201	7	A	8			
Furniture - 226	201	9	B	10	201	Furniture - 226	
Furniture - 226	201	11	C	12			
Furniture - 226	201	13	A	14	201	Furniture - 226	
Furniture - 226	201	15	B	16			
Furniture - 226	201	17	C	18	201	Furniture - 226	
Furniture - 226	201	19	A	20			
Furniture - 226	201	21	B	22	201	Floor Box - 219	
Furniture - 226	201	23	C	24	201	Floor Box - 221	
Furniture - 226	201	25	A	26	201	Receipts - 220, 221, 222	
Furniture - 226	201	27	B	28			
Furniture - 226	201	29	C	30			
Furniture - 226	201	31	A	32	201	Space	
Furniture - 226	201	33	B	34			
Furniture - 226	201	35	C	36			
Furniture - 226	201	37	A	38	201	Space	
Furniture - 226	201	39	B	40			
Furniture - 226	201	41	C	42			

PARSONS SAFETY FIRST
Arc Flash & Shock Hazard
Appropriate PPE Required

Panel Name: LC-2B Volts: 120/208 208/120V 480/277V
 Ampacity: 225 Phase: 3 Black A Phase Brown B Phase Blue C Phase White Neutral Grey Ground

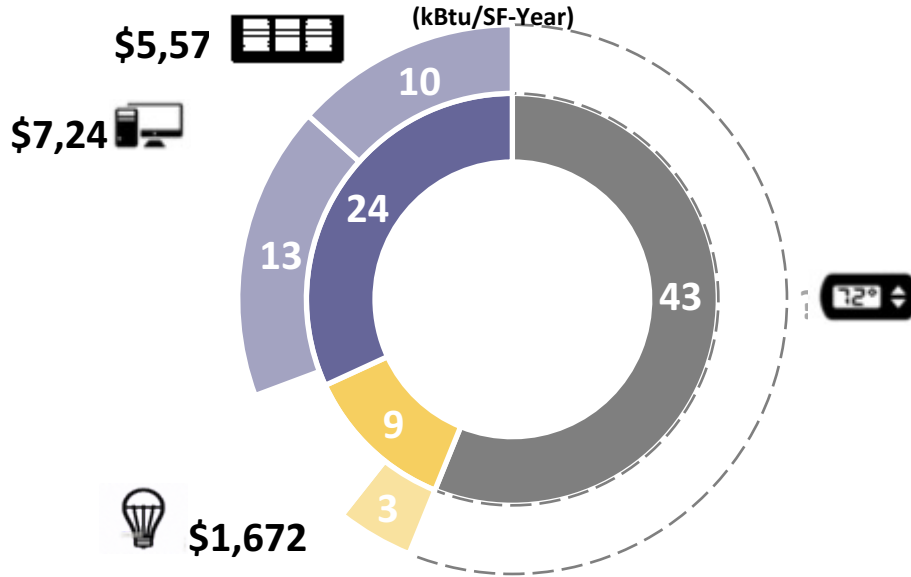
Wire: 4				Wire: 4			
Description	Amp Pole	Ckt	Ph	Ckt	Amp Pole	Description	Amp Pole
Receipts - 226	201	1	A	2	201	Receipts - 226	
Receipts - 226	201	3	B	4	201	Receipts - 218	
Ceiling Fans - 218	201	5	C	6	201	Receipts - 218	
Receipts - 226	201	7	A	8	201	Refrigerator - 218	
Receipts - 217	201	9	B	10	201	Dishwasher - 217	
Dishwasher - 217	201	11	C	12	201	Dishwasher - 217	
Microwave - 217	201	13	A	14	201	Microwave - 217	
Microwave - 217	201	15	B	16	201	Refrigerator - 217	
Receipts - 222	201	17	C	18	201	Refrigerator - 217	
Microwave - 217	201	19	A	20		Type 1.5 Lights	
Hand Dryer	201	21	B	22			
Hand Dryer	201	23	C	24			
Hand Dryer	201	25	A	26	201		
Hand Dryer	201	27	B	28			
Hand Dryer	201	29	C	30			
Hand Dryer	201	31	A	32	201		
Hand Dryer	201	33	B	34			
Hand Dryer	201	35	C	36			
Hand Dryer	201	37	A	38	201		
Hand Dryer	201	39	B	40			
Hand Dryer	201	41	C	42			

*BEH DOWNSIDE
NEW CIG BURN
FLY GFI
BATH LIGHTS*



BASELINE

ANNUAL DISTRIBUTION & COST OF OFFICE ENERGY USE



NATIONAL AVERAGE

77 EUI

AVERAGE OFFICE (CBECs 2012)

ELECTRIC EUI 33

LHB-MSP OFFICE (2016)

ELECTRIC EUI 27

LHB-MSP Energy Update - January 2017



GOALS

Data Center:

15% reduction

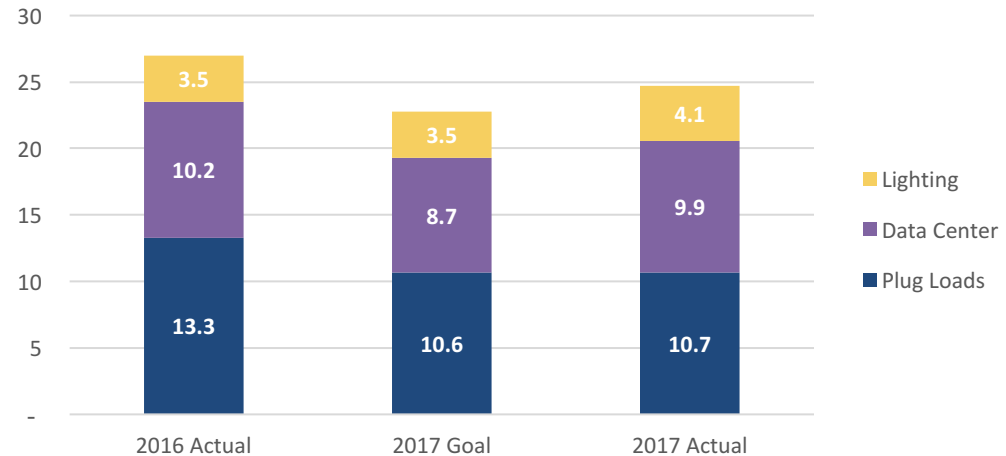
Plug loads:

20% reduction

Total Electricity:

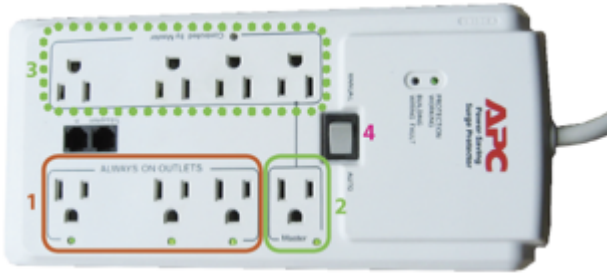
16% reduction

LHB-MSP Electricity Use Intensity
(kBtu/sf)





ACTIONS



1. ALWAYS ON OUTLETS

Plug anything that must remain on at all times into these outlets
(Optional: CPU if you use remote desktop, headsets)

2. MASTER

Select one device at your desk to be a control. Plug this control device into the "Master" outlet. When you turn this device off, power to the "Controlled" outlets will be turned off. (If you use your computer when you do a "shut down" at the end of the day everything else will turn off. This device could also be your primary monitor)

3. CONTROLLED BY MASTER

Plug anything that can be powered down in the "Controlled" outlets. When you shut down your control, or "Master" device, power to these outlets will be cut off. Think of it as "hitting the switch" on a typical power strip.

(phone chargers, computer monitors, etc.)

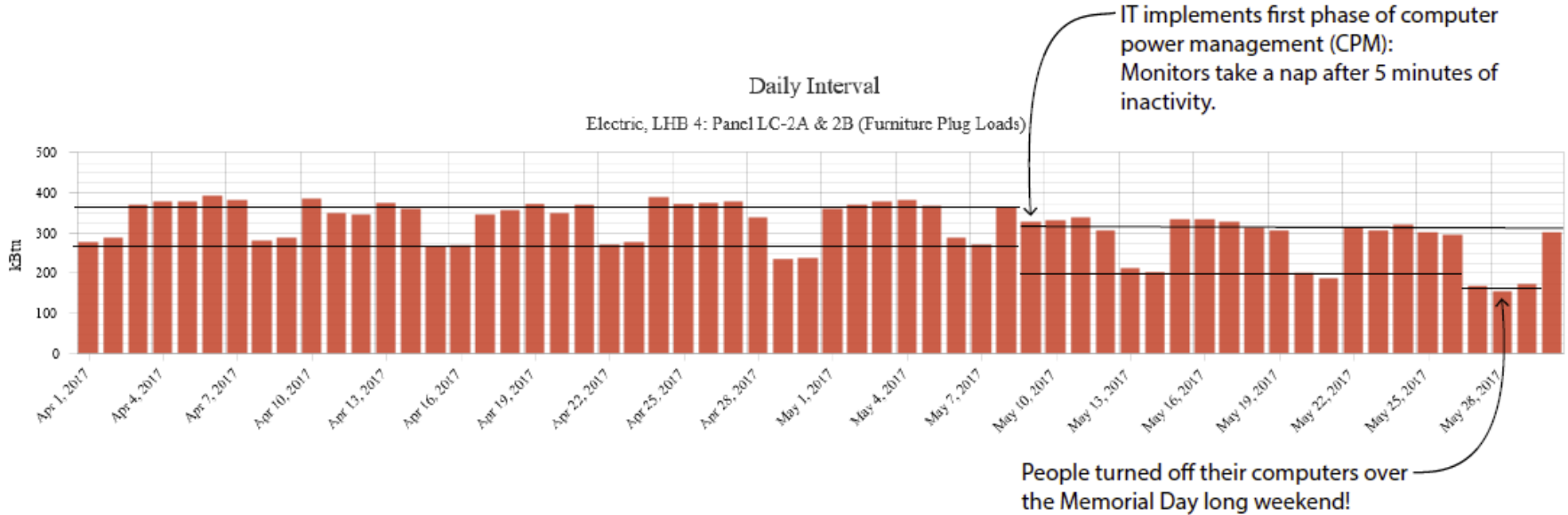
NOTE: DO NOT PLUG YOUR COMPUTER TOWER INTO THE CONTROLLED OUTLETS

4. SWITCH

Flip the switch to "Auto" to enable the advanced power control in your smart power strip.

- Computer power management
- Advanced power strips
- Behavior campaign
 - Updates at staff meeting
 - Education on use of advanced power strips
 - Feedback meters
 - Outreach prior to holiday weekends

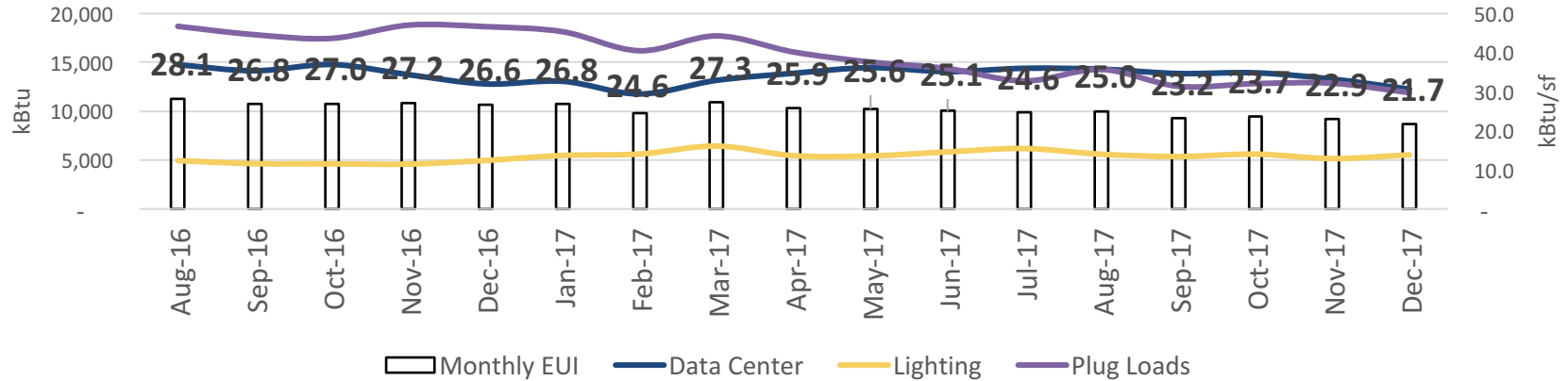
RESULTS



RESULTS



LHB-MSP Electricity Use 2016-2018
(kBtu)



19.8% reduction in plug loads



FOR MORE INFORMATION

Control guidance:

- Computer power management: ENERGY STAR Low Carbon IT Campaign
- Advanced power strips: Better Buildings: Myth Busting Market Barriers to APS

Design: Lobato et al, 2011

Plug load management: NBI: Plug Load Best Practices Guide

Guidance for researchers: Lanzisera et al, 2013



NEED MORE DETAIL?

Duluth Energy Conference

Advancing the Last Frontier – Reduction of Commercial Plug Loads

1:00 – 2:30 | Feb 20, 2018 | French River Room

Download the study

See a fact sheet and the full report: seventhwave.org/commercial-plug-load-study

Contact us:

Rick Carter, LHB, rick.carter@lhbcorp.com

Chris Plum, Center for Energy and Environment, cplum@mncee.org

Residential Cold Climate Ductless Heat Pump



(above) Photo credit: Zia Fang, <http://images.nrel.gov/viewphoto.php?imagelid=6309977>

(inset) Photo credit: Seventhwave

Electricity savings: 2.47 kWh/ft²

Cost savings: \$0.32/ft²

2017 Simple payback: 15 years

Barriers: cost, stigma?

Measure life: 18 years

LED T8 Lamp Replacement



Photo courtesy of Cree

Electricity savings: 0.48 kWh/ft²

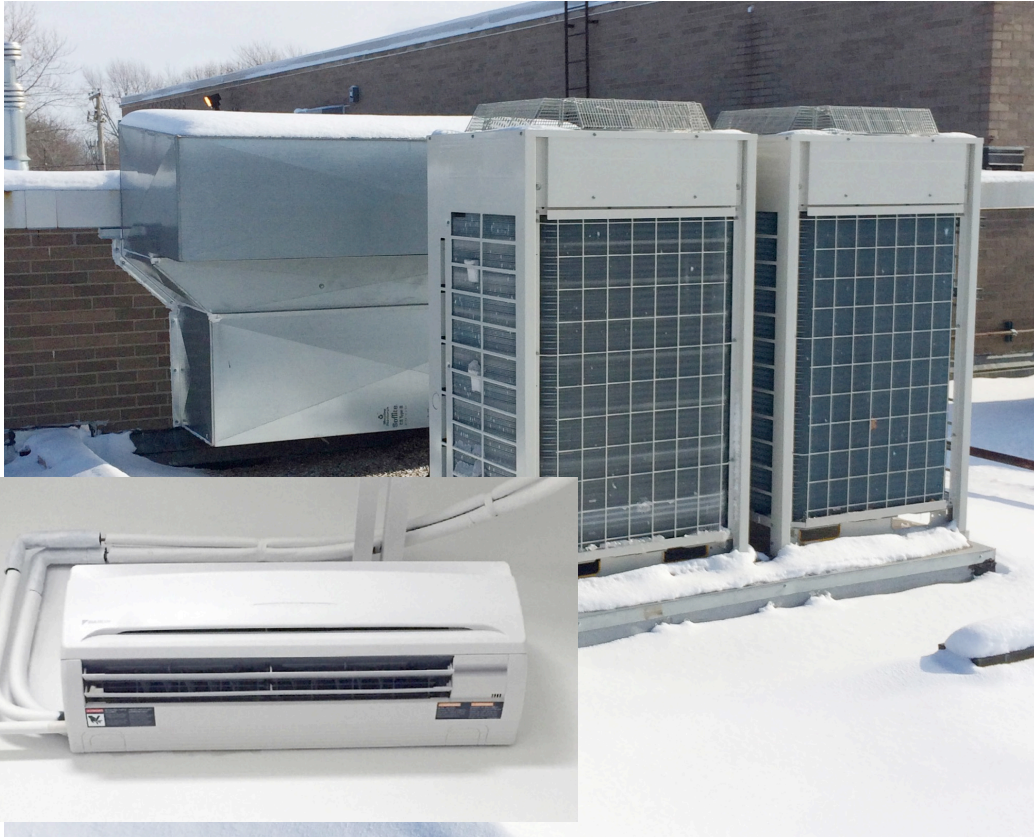
Cost savings: \$0.04/ft²

2017 Simple payback: 10 years

Barriers: light quality

Measure life: 16 years

Cold Climate Variable Refrigerant Flow



Electricity savings: 1.42 kWh/ft²

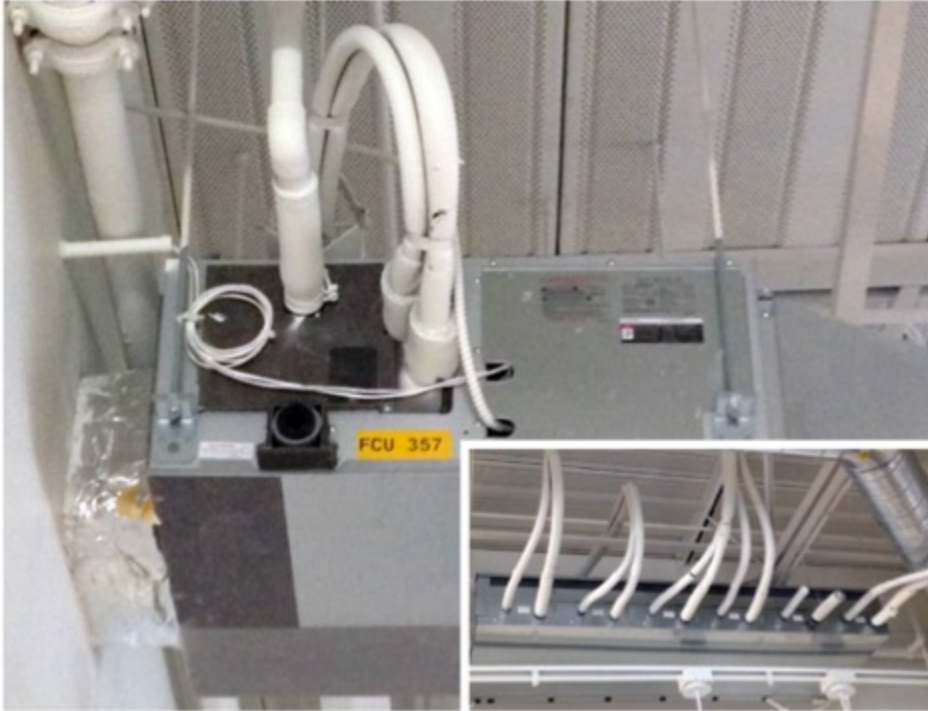
Cost savings: \$0.12/ft²

2017 Simple payback: 10 years

Barriers: cost

Measure life: 15 years

Commercial Ductless Heat Pump / VRF



(above and inset) Photo credit: Seventhwave

Electricity savings: 1.42 kWh/ft²

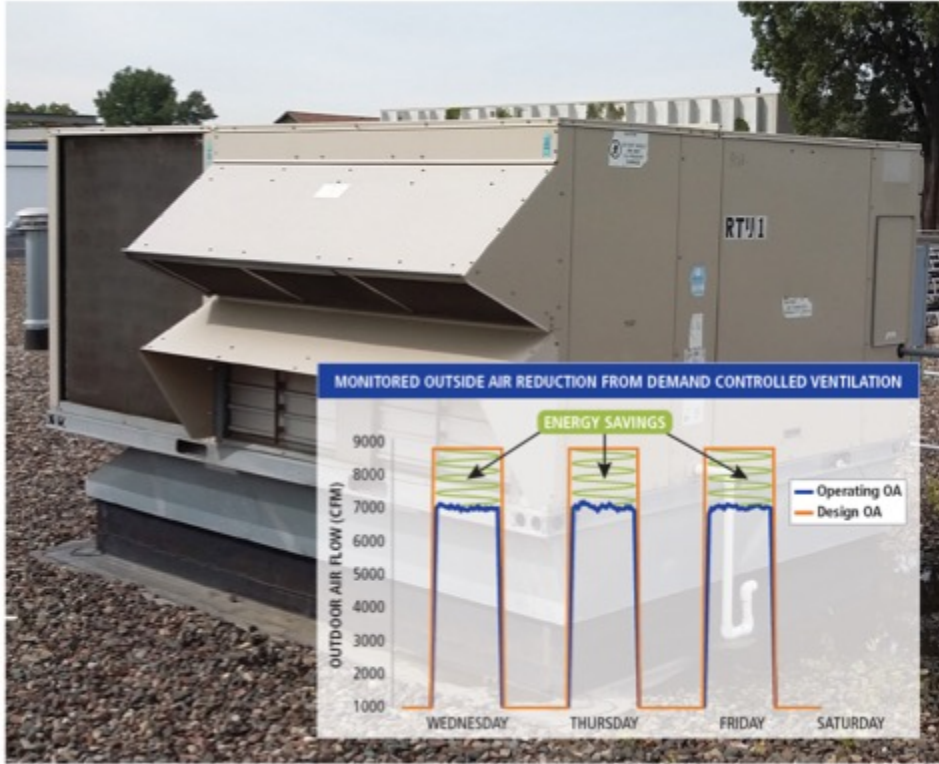
Cost savings: \$0.12/ft²

2017 Simple payback: 10 years

Barriers: low gas prices

Measure life: 15 years

Advanced Rooftop Unit Controls



Electricity savings: 1.55 kWh/ft²
Gas savings: 0.14 therm/ft²

Cost savings: \$0.24/ft²

2017 Simple payback: 3 years

Barriers: trade ally training, scale

Measure life: 25 years

Ventilator Exhaust Economizer Box (VEEbox)



Unit ventilators in areas of high density often heat, cool, vent.

Retrofit passive air distribution box helps eliminate stratification.

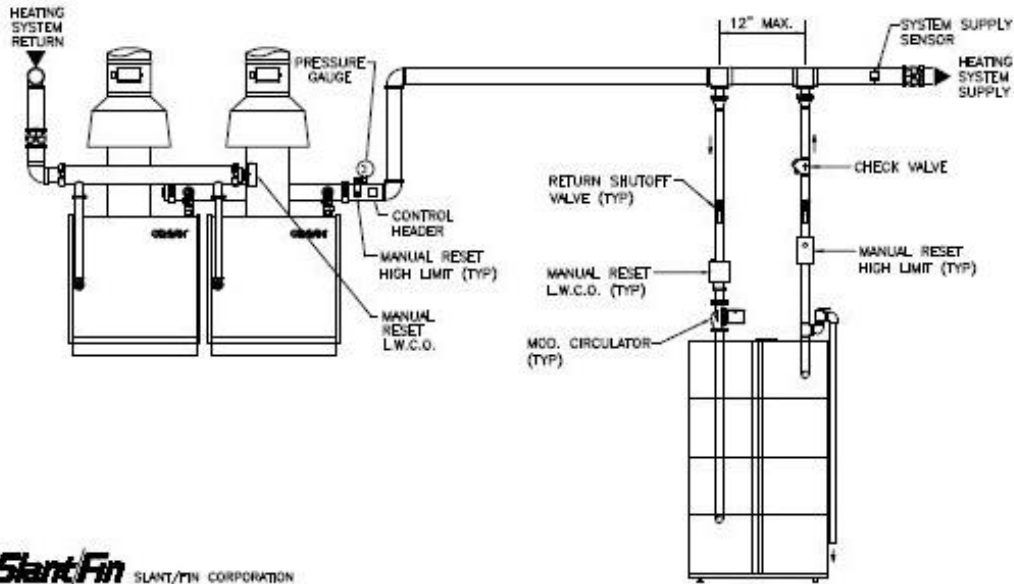
10%-15% savings being field validated with 30 sensors

\$400 cost, 3 year payback

Measure life: 20 years

Hybrid Boiler Plant Design

Both condensing and non-condensing boilers



“Best of both worlds”

Condensing boiler used down to 32 degree air (<130F RWT), non-condensing for higher loads (<160F RWT)

Reduced boiler cycling and increased thermal efficiency

18-20% energy savings

4-7 year payback

SlantFin SLANT/FIN CORPORATION

FIGURE 19
HYBRID CONDENSING / NON-CONDENSING

Commercial Dryer Retrofit: Moisture Sensors



Determine when the load is dry and shut off the dryer before additional energy is used.

Few commercial dryers include

Easy installation, but not on mechanical timer dryers

21.7% savings field validated with sites in MN and IL

\$200-500 cost, 3 year payback

Commercial Dryer Retrofit: Modulating Gas Valve



Two-stage modulating gas valve, temperature sensor, control unit

Programmable design provides maximum flexibility & savings

No manufacturer temperature or safety controls are ever by-passed

13% savings field validated with sites in MN and IL

\$525 cost, 2-5 year payback depending on usage

Natural Gas Standby & Emergency Power

Resiliency



Using natural gas for demand response or diesel backup

Working with NFPA 70, AHJs, and DOD to permit pipeline natural gas as alternative to requirements for onsite diesel storage.

For more information:

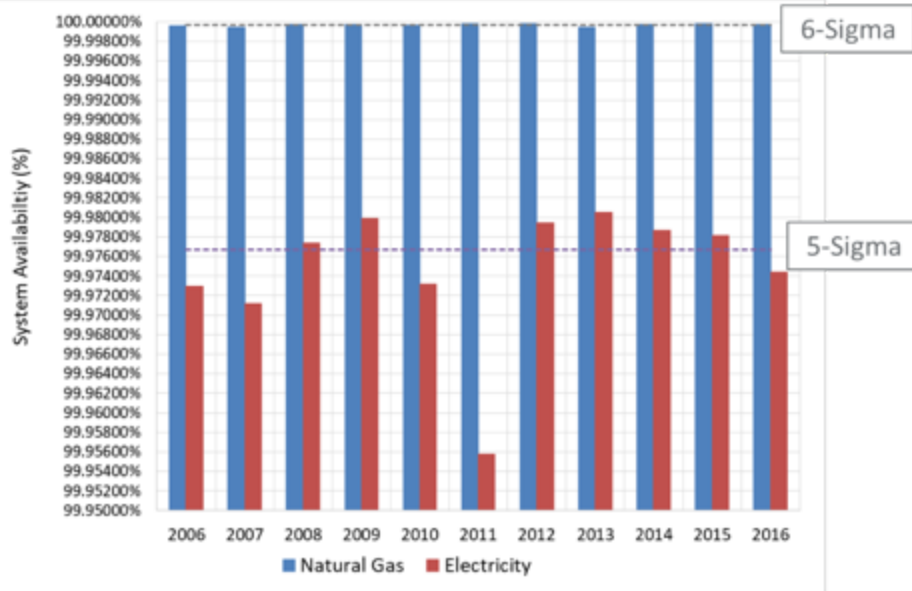
<http://www.generac.com/Industrial/all-about/natural-gas-fuel>

<http://www.generac.com/Industrial/all-about/natural-gas-fuel/natural-gas-performance>



Resiliency of Natural Gas and Electric Systems

Reliability, Availability, Outage Rates



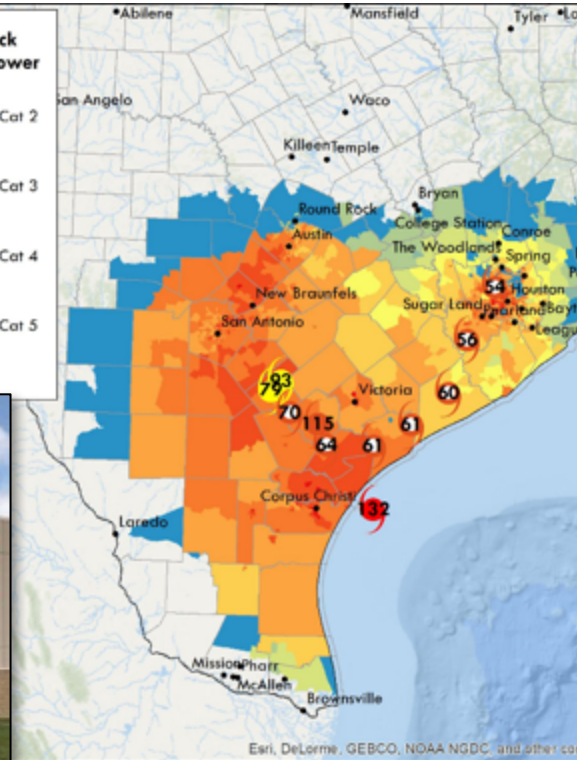
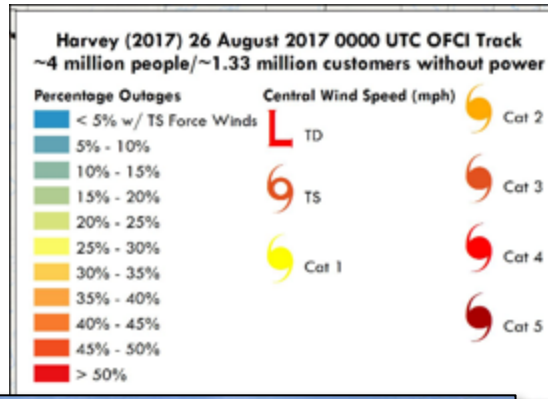
Example annual results for major California electric utility (SCE) and North American gas utility (over 15 billion customer hours/year)

“Islands” of Power after a Natural Disaster

“Microgrid System Keeps Houston Grocery Stores Open in Wake of Harvey”

Aug 29, 2017 Power Magazine

- 18 H-E-B grocery stores remained open after Hurricane Harvey flooding knocked out power in surrounding areas for days.
- Natural gas underground pipeline used as “off-site battery”.
- One store used to house first responders, as it was the only nearby facility with power.



Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors

Combined Heat and Power (CHP)



Replaces DHW, genset, and HP

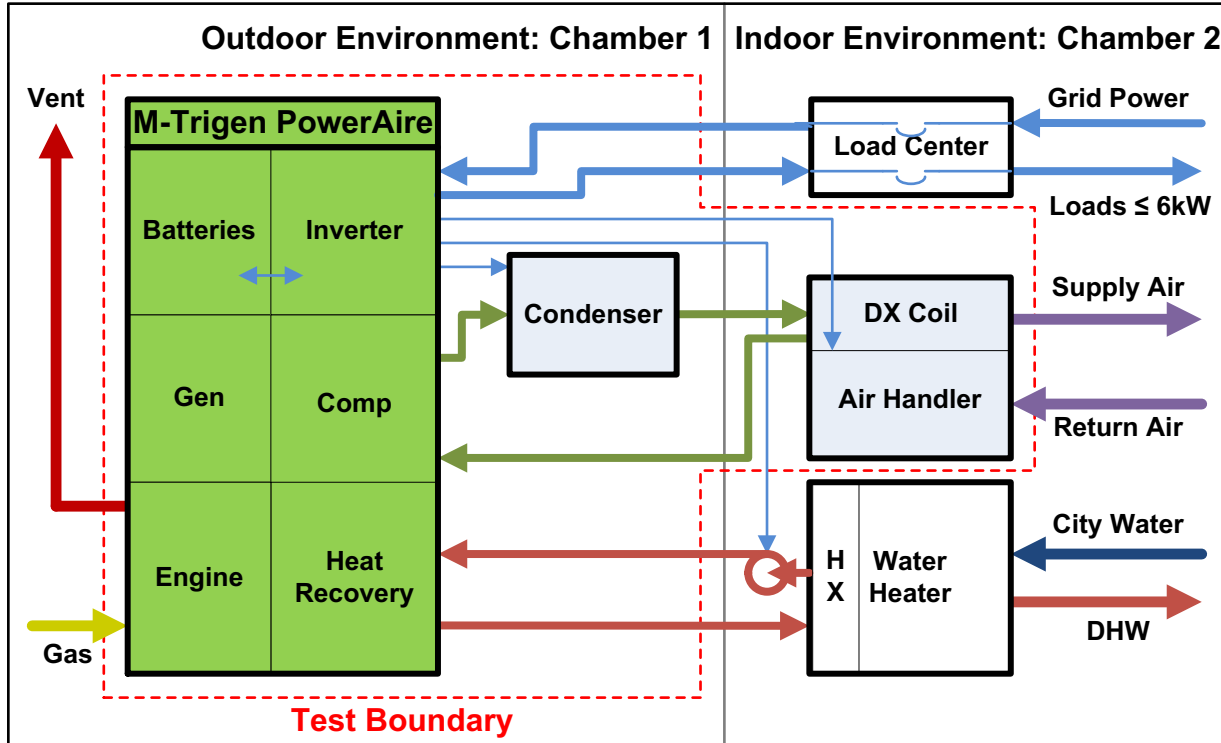
Self-powered HVAC/DHW including HP, AHU, DHW

6kW / 5 tons / 68,000 BTUH
10kW / 15 tons / 132,000 BTUH

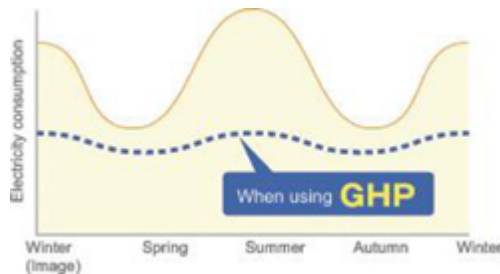
Peak demand strategy or
Microgrid component

Economic benefits are site-specific
Natural gas or propane

System Block Diagram (6kW Unit)



Natural Gas Engine Heat Pumps (GEHP)



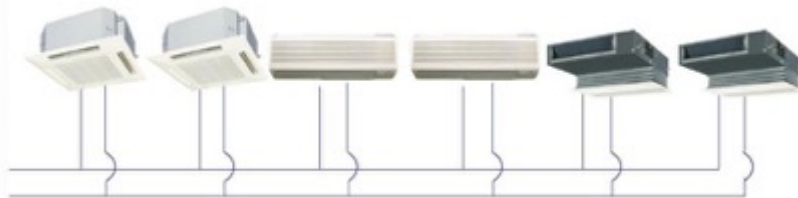
GEHP employ similar technology to ASHP; same Daikin VRF fan coils.

Engine heat recovery increases heating capacity at low temps (cold climates)

Peak electric demand reduction (up to 50%)

Lower energy costs; lifecycle cost savings

Some utilities offer \$1,500 per ton





Discussion

Thank you

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