New & Emerging Energy Efficiency Technologies for C&I Customers

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President, E Source

MLGW

Key Accounts Conference

4/25/14

Agenda

- Lighting; LEDs
- Daylight Redirecting Film
- HVAC
- Variable Refrigerant Flow (VRF) Systems
- Condensing Gas RTUs
- Direct-Contact Water Heating
- Fault Detection & Diagnostics
- Energy Data Analytics
- Cloud-based Smart Thermostats
- Plug loads
- Liquid CO2 Textile Cleaning
- Gas Condensing Unit Heaters
- Miscellaneous Potpourri

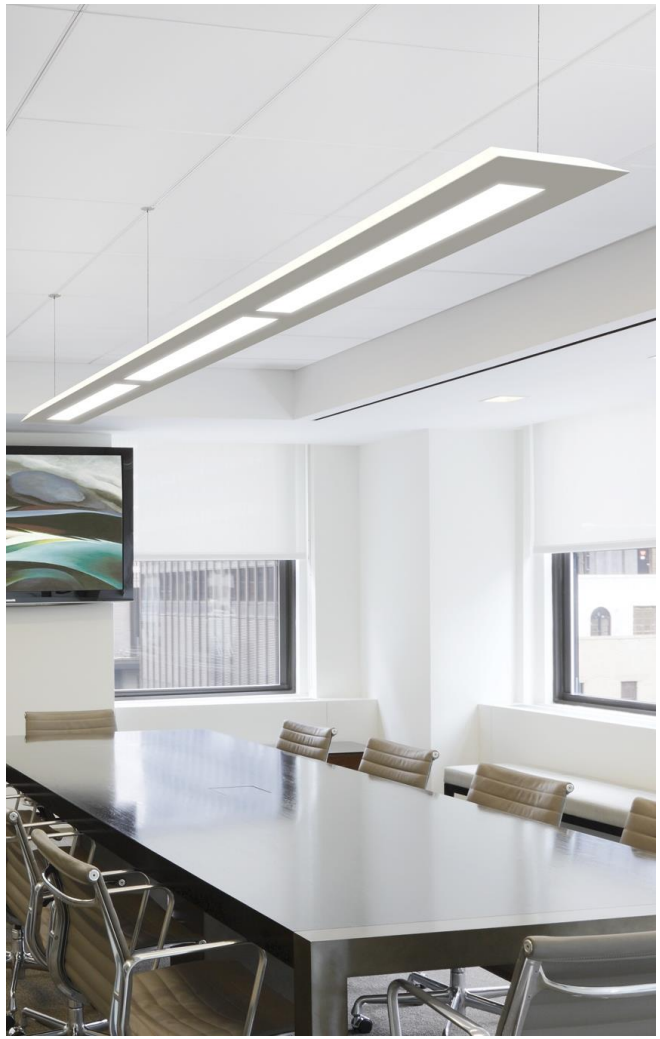
Lighting

Current Status of LEDs

- High cost; performance and quality getting better
- Increasing number of products
- Good applications today: outdoor, refrigerated cases, warehouses, task lighting, troffers
- Tough applications where thermal management a challenge especially in tight spaces
- Lots of pressure and misleading information from manufacturers and sales reps
- Some dimmer compatibility issues

LEDs: The Big Picture

- LEDs may cut lighting energy use by 1/3 by 2025, and account for >50% of light produced (per DOE)
- Global growth projection for 2014: 68% YoY; 72% in North America
- 70% of lighting business by 2020
- 60-watt replacement lamp cost: was $50, now under $10
- High-bay costs fell 30% to 50% in one year



Source: Philips

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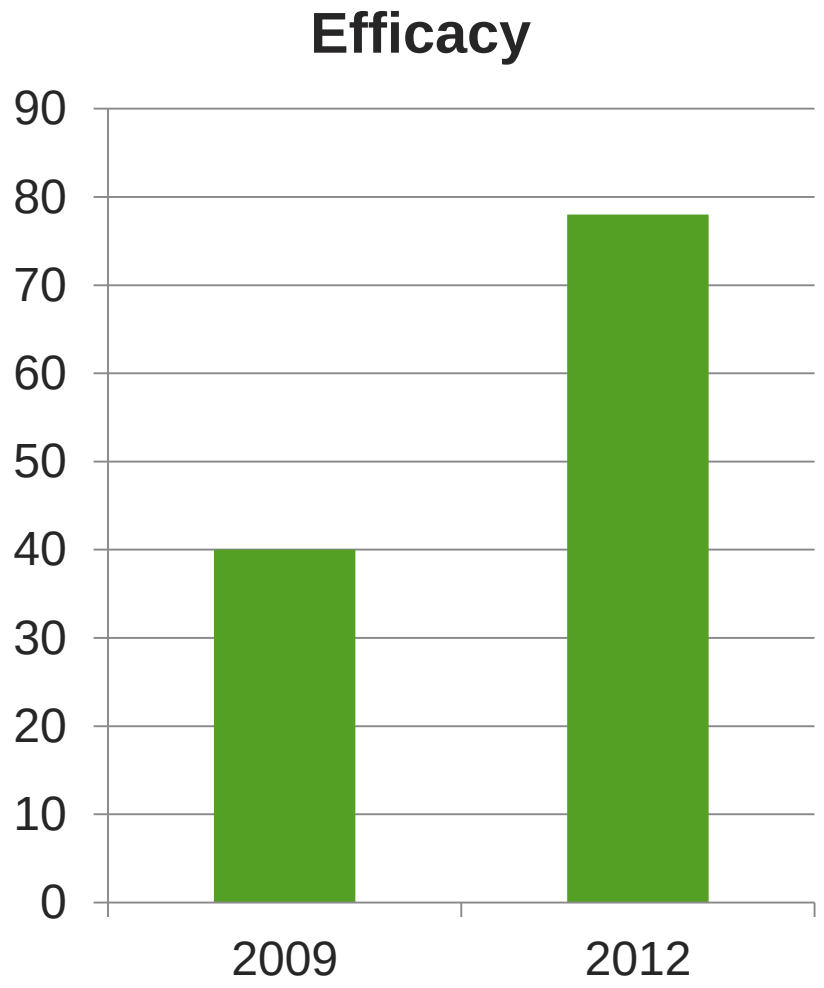
LED Performance Up, Costs Down

Since 2009:

- Efficacy doubled
- Costs dropped 85%
- Number installed grew from 400,000 to 49 million



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LEDs in Common Applications

Application	2012 penetration (%)	Number installed (millions)
Troffers and tubes	<0.1	0.7
High-bay	<1	0.3
A lamps	<1	19.9
Downlights	<1	5.5
Parking lots	1	0.2
Streetlights	2	1
Directional	4.6	11.4
MR16	10	4.8

Data from DOE, Adoption of Light Emitting Diodes in Common Applications

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LED Troffers Are Coming of Age

Troffers are the most common fluorescent fixture:

- Operate 10.5 hours/day
- Contribute to peak load
- Draw 25 to 113 watts
- Millions of installed fixtures
- 42% of lighting energy
- ~87 terawatt-hours per year

© E Source

Why LEDs for Troffers?

- Performance improving, prices falling
- Better efficacy than fluorescents
- More controllable, longer life
- 2012: 700,000 installed (40,000 in 2010)
- Supported by DOE study: http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/caliper_recessed-troffer_2013.pdf

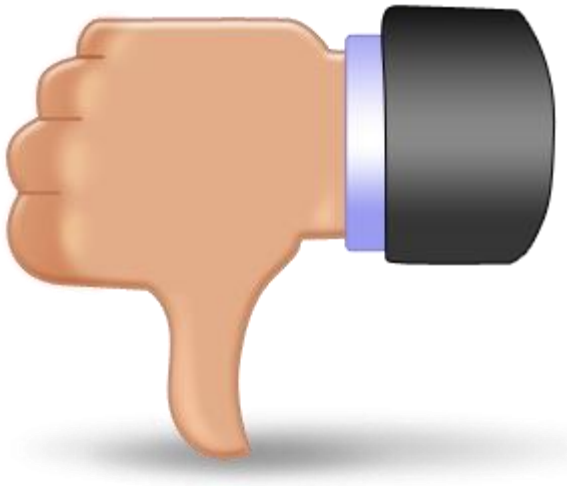
© E Source

DOE Conclusions

Troffers: can compete on efficiency, life, and quality

Tubes: have problems with dark spots, glare, efficiency, and safety

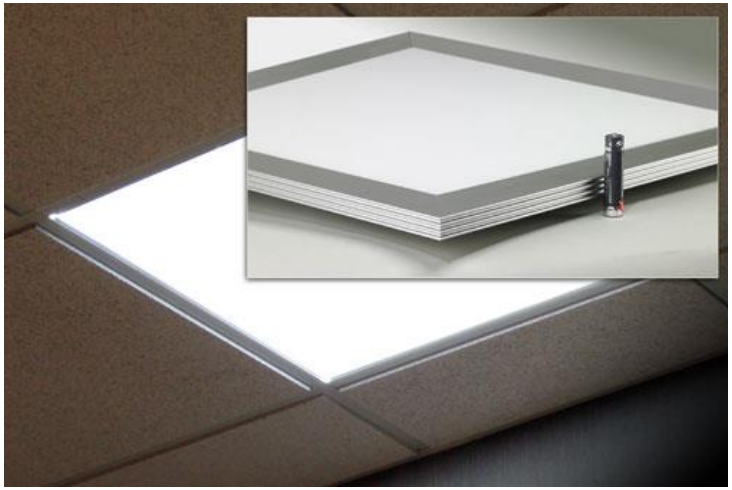
[but tubes are getting better]



A Wealth of Products

- DesignLights Consortium Qualified Products List (QPL)
  - >900 products
  - http://www.designlights.org/QPL/
- Minimum requirements
  - At least 85 lumens per watt
  - 50,000-hour life
  - 5-yr warrantv

Source: Finelite



Source: GLT

Source: GE Lighting

Tubular LED Products

- Cree: UR Series
- Installs in 10 minutes
  - Magnetic attachment
  - Quick-connect wiring
- Good light distribution
- CRI 80, 102 lm/W, 50,000 hour life, 7-year warranty
- External driver
- UL label
- Estimated cost: <$100

Source: Cree

LED Replacement Tube - What We've Been Waiting For?

- Philips InstantFit LED
  - Fits in T8 sockets; uses existing instant-start EB
  - 83 CRI; 40,000 hr; 95-116 lm/W
  - $24 to $39
- Concerns
  - Persistence of savings
  - 12.5 to 20 W, only 1300-2100 lm
  - External ballast/driver runs cooler so more output
  - Photometric distribution likely different

Source: Philips

Comparing Fluorescent T8 with InstantFit

	High performance T8	InstantFit LED
CRI	80s	83
Life, hrs	24,000-75,000	40,000
Efficacy, lm/W	98	95-116
Cost, $	5	24-39

Note: different definitions of “life” for LEDs, fluorescents

Source: E Source

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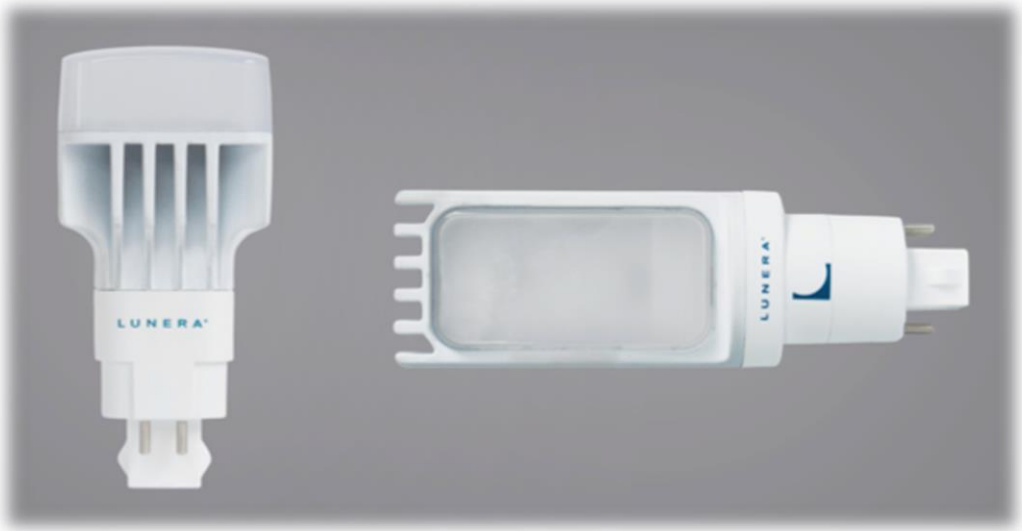
LEDs replace CFLs in recessed cans

- The Helen Lamp, Lunera
- Replaces pin-base CFLs (26, 32 or 42 W)
- Uses existing 4-pin e-ballast
- No dimming
- Specs:
  - 13W/900 lm
  - 84 CRI
  - 50,000 hr. life
  - 2700, 3000, 3500, or 4000 K



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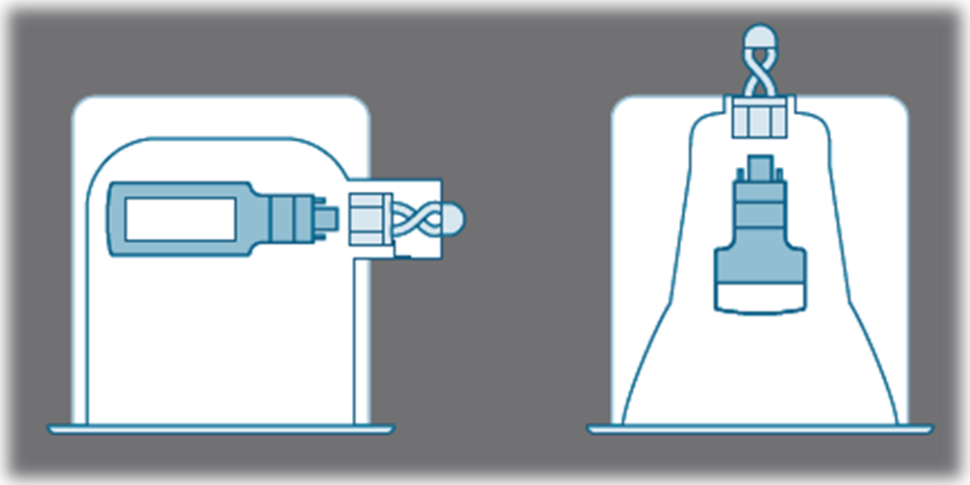
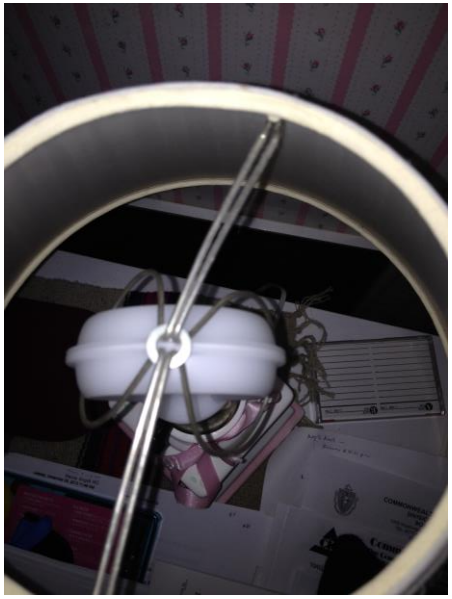
More About Helen

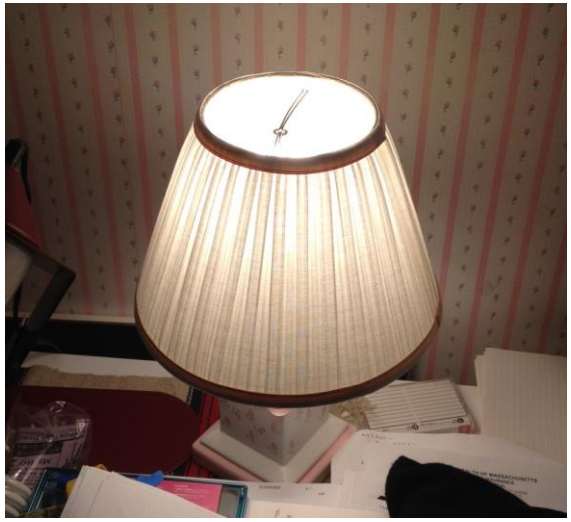
- Cost: $40-45
- Several utilities have paid prescriptive rebates
  - E.g. PG&E, happy university user
- Concerns:
  - No dimming: coming soon
  - Persistence of savings
  - Quantity of light
  - Limits on compatible ballasts: more coming
  - No DLC category, but LDL listed



Look ma, no fins!

- Philips SlimStyle
- Ring of LEDs distributes light and dissipates heat
- 60W eq: 10.5W/800 lm
- Low price ($9.97)
- 80 CRI, 2700 K
- Dimmable
- 25,000 hrs
- Less shelf space; less shipping volume and weight





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Comparing 60W Equivalent Lamps

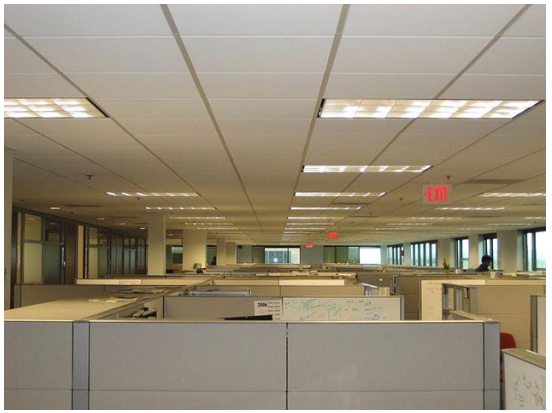
	Cree	Philips SlimStyle
Power (W)	9.5	10.5
Efficacy (lm/W)	84	76
Life (hrs)	25,000	25,000
Color Temp (K)	2700	2700
CRI	82	80
Dimmable	Y	Y
Price ($)	12.97	9.97
Warranty	10 yr	3 yr
Shape	bulb	disk

Source: E Source

LEDs with Advanced Controls

LEDs easier to control than HID or fluorescent

- A new approach to wireless lighting control
- Instant response
- Lamp life not decreased by frequent on/off cycling
- Options for individual control
- Easy to dim; dimming may increase lamp life
  - Check for compatibility; some problems with incandescent dimming
- Can change color temperature
  - Mimic incandescent dimming
  - Health and productivity impacts



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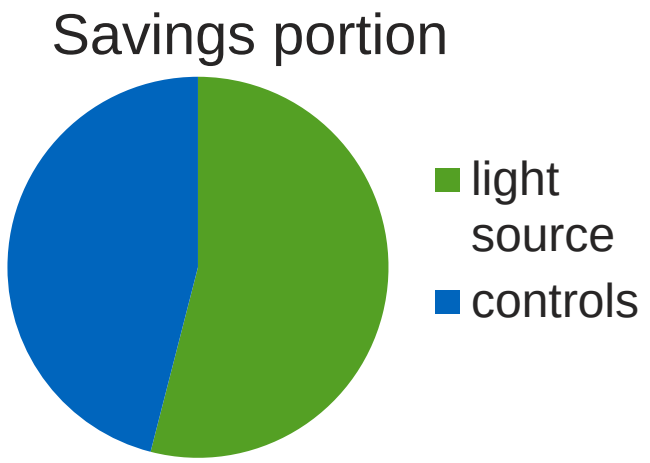
LEDs: Big Savings with Controls

- Daylight dimming, occupancy sensing, task tuning, scheduling by zone, flexible zones, monitoring status, demand response
- kWh: 50% to 90% reduction
- kW: 50% to 80% reduction
- Best paybacks with long hours, little existing controls, and big savings per fixture; good in industrial/warehouse
- Longer paybacks in office buildings (shorter hours, already doing daylight dimming, occupancy sensing)



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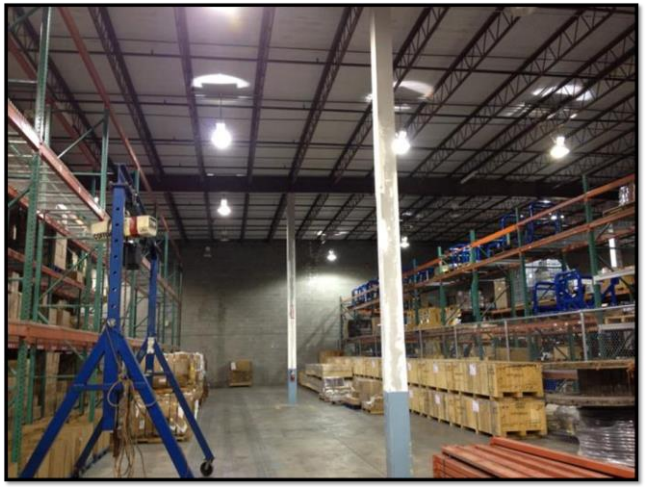
LEDs: Good Application for Industrial & Warehouse Facilities

- Many 250W to 400W HID systems
- Long operating hours (6,000 to 8,760 hrs/year)
- Few have occupancy sensors or daylight harvesting due to re-strike requirements associated with HIDs
- Individual fixture control easier to justify
- Original lighting system often does not align with current facility usage patterns
- Expected savings over 80%



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LED High-Bay Case Study: Ace Hardware

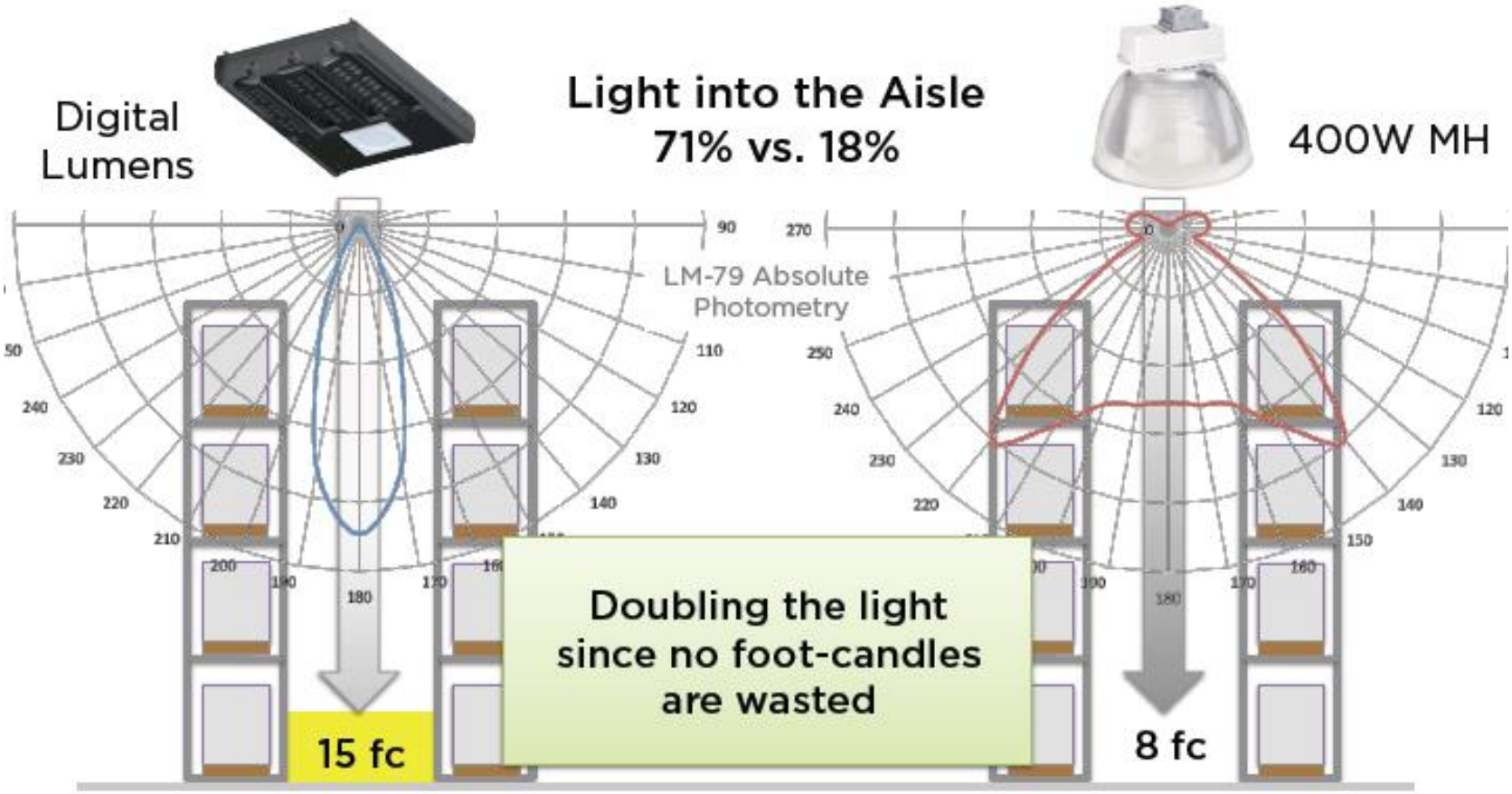
- 44,800 sq ft section of warehouse
- Baseline: metal halide, no automatic controls
- Installed: Intelligent LED fixtures
  - Networked, software, sensors, wireless communications
- 93% energy savings (50% light source, 43% controls)
- 3.6 yr payback

Source: Digital Lumens

Project with PG&E, CA ETCC; Digital Lumens

Report available online at: http://www.etcc-ca.com/sites/default/files/reports/ET12PGE3361%20LED%20High-Bay%20Lighting%20and%20Controls%20Assessment.pdf

Putting Light Where It's Needed



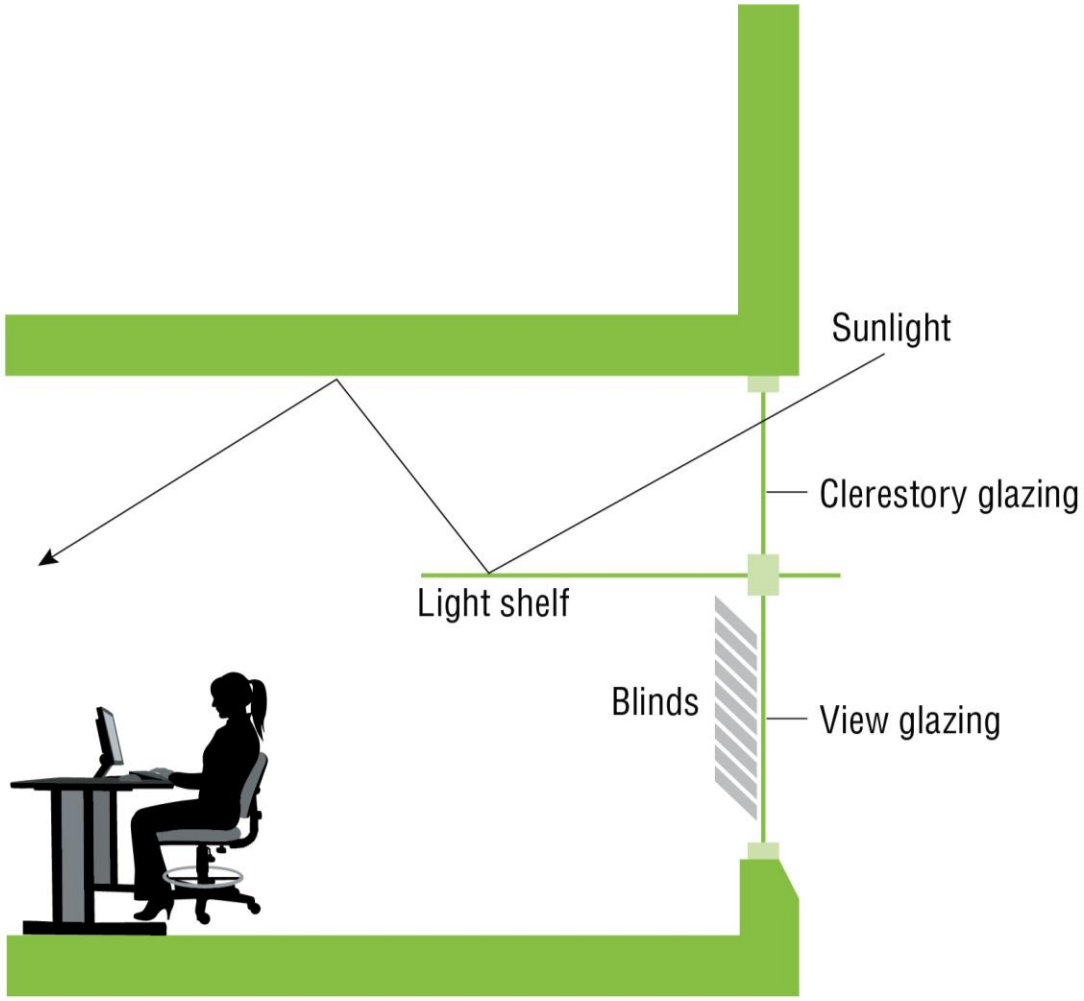
Courtesy: Digital LUmens

Daylight Redirecting Film

What's the Matter with Daylighting?

Courtesy: National Renewable Energy Laboratory

Old Solution: Light Shelves



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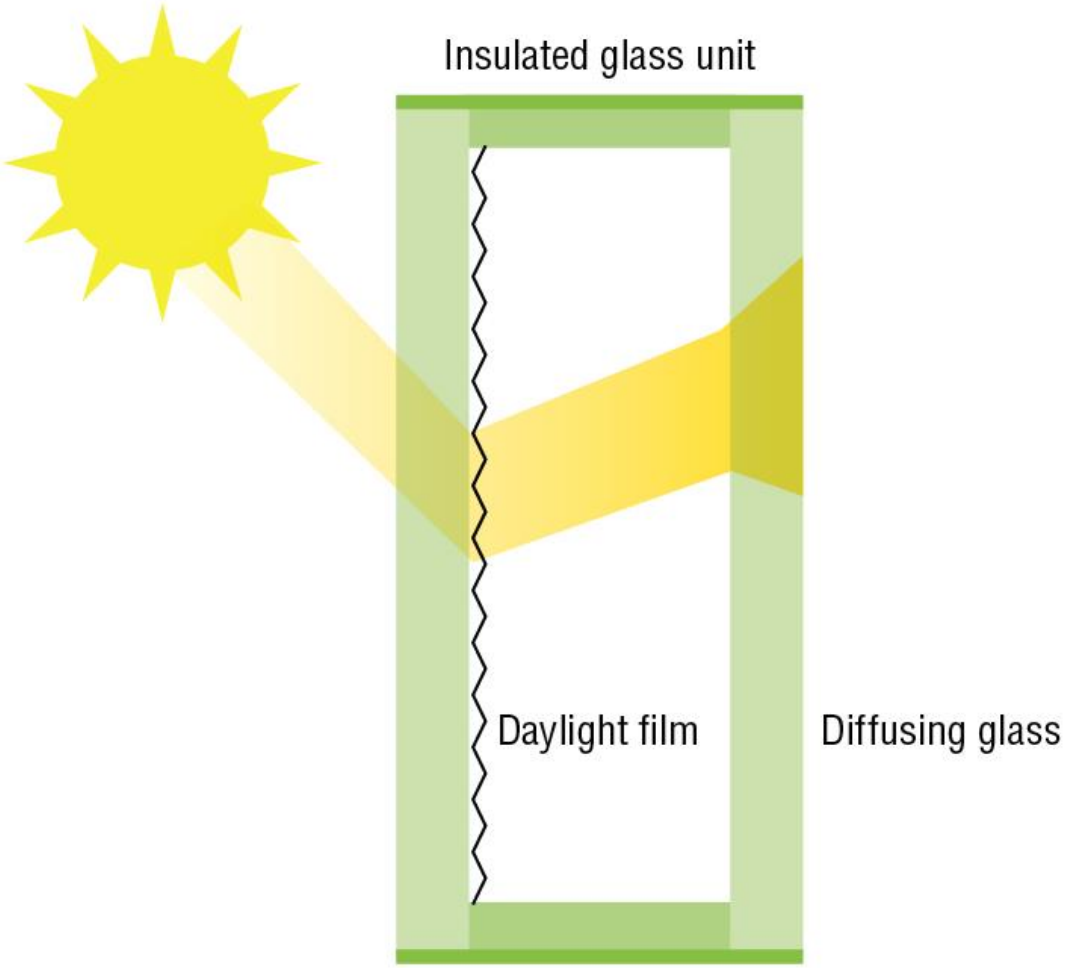
New Solution: 3M Daylight-Redirecting Film

Source: Sacramento Municipal Utility District

How It Works



Source: 3M

Cheaper and Deeper

Source: Sacramento Municipal Utility District

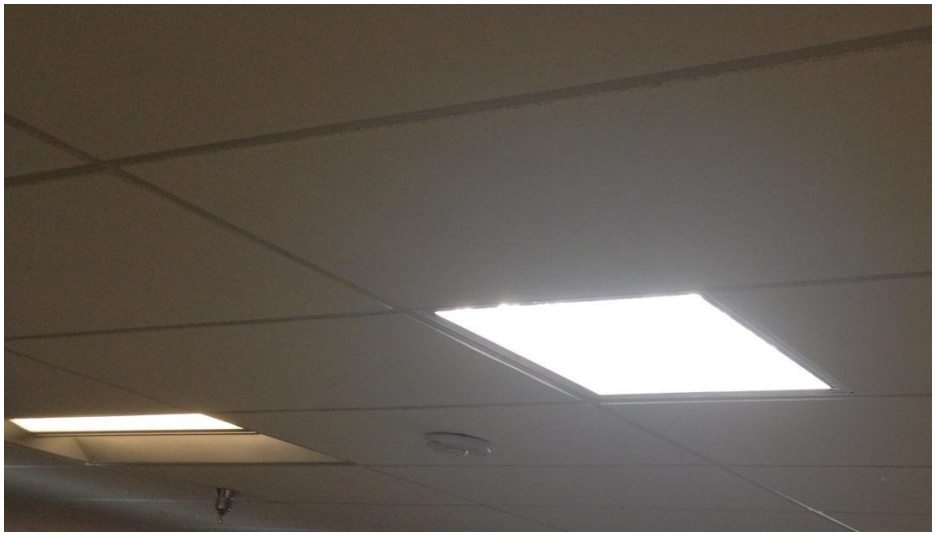
Looks Like a Winner

Metric	Minimum	Maximum
Cost ($ per square foot)	$30	$35
Energy savings (%)	39%	43%
Simple payback period (years)	1.5	4.5

© E Source; data from Lawrence Berkeley National Laboratory and 3M

Tubular Skylights

- Daylighting without heat or glare
- Clear plastic dome, reflective tubes, diffusers
- Used with daylight sensors to dim electric lights

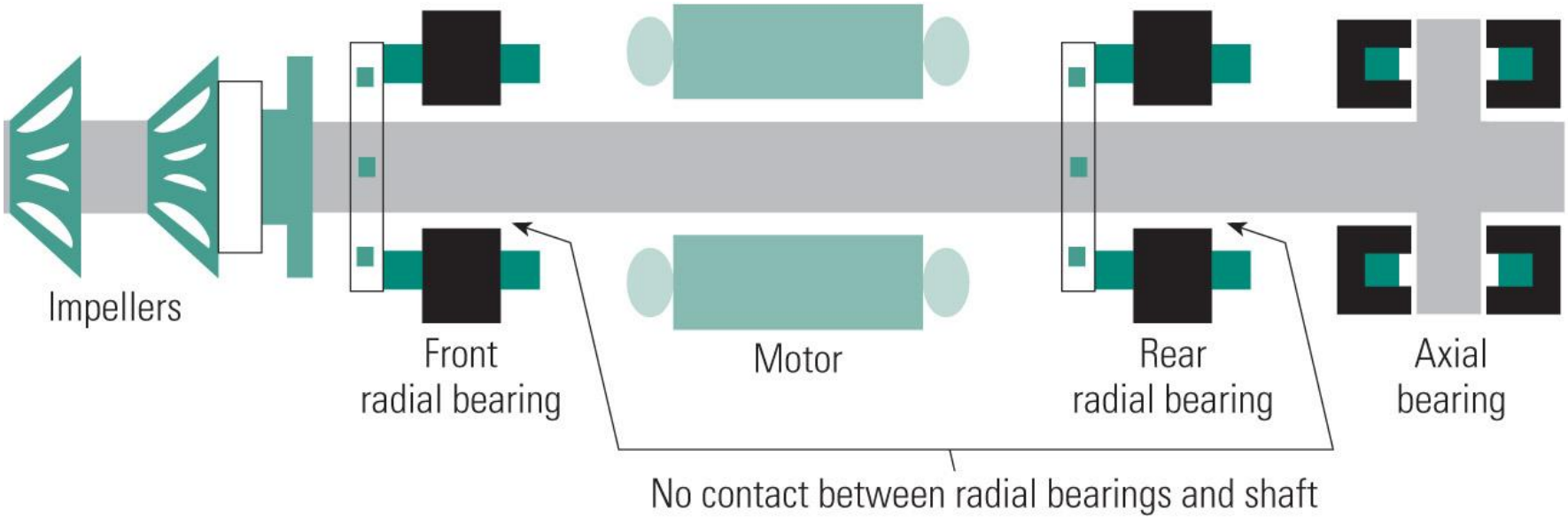


HVAC

Turbocor Chiller Compressor

Courtesy: Danfoss Turbocor

Turbocor Uses Magnetic Fields to Levitate the Compressor Shaft



Courtesy: Turbocor

Benefits

33% Improvement in IPLV	• IPLV: Integrated Part Load Value • Reduced friction • Variable speed operation
Reduced Maintenance/Installation Costs	• No mechanical bearings so no oil is needed • Smaller, lighter, generates less noise • Modular; retrofit and OEM
Reduced Startup current	• 2 amps instead of 100-500 to startup • Much quieter startup

Example Rough Paybacks

	City[a]			
	Miami, FL	Phoenix, AZ	Stockton, CA	Minneapolis, MN
Equivalent full-load cooling hours	3,931	2,141	1,148	662
Energy use of an average screw (kWh)	339,049	184,661	99,878	57,098
Energy use of McQuay WMC-150 (kWh)	221,119	120,431	65,138	37,238
Savings (kWh)	117,930	64,230	34,740	19,860
Simple payback period (years)	1.6	2.9	5.3	9.3

Notes: IPLV = Integrated part load value

a. These examples assume a screw chiller cost of $280/ton, a cost premium of 35 percent for the WMC-150, and an electricity rate of $0.08/kWh.

Source: E SOURCE; data from manufacturers

Variable Refrigerant Flow (VRF) Systems

Variable Refrigerant Flow (VRF) Systems

- Circulate refrigerant instead of water or air
- Promise lower operating cost, greater comfort, and several other benefits over conventional HVAC systems
- Even looks like traditional AC

Courtesy: Daikin AC

www.daikinac.com

Mitsubishi Hyper-Heat Line

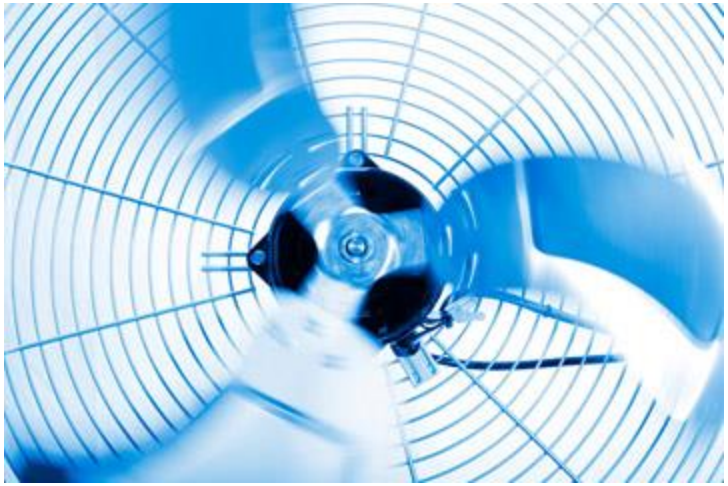
	Commercial (variable refrigerant flow)		Residential (ductless heat pump)
	City Multi	**P-Series**	**M-Series**
Tested to (°F/°C)	–13 / –25	–13 / –25	5 / –15
Operation limit (°F/°C)	–18.4 / –28	–33 / –36	–18 / –28
Cooling capacities (tons)	6, 8, 12, 16	2.5, 3	0.75, 1, 1.5
Heating capacities (kW at 47°F)	23, 32, 47, 63	9.4, 11	3.3, 4, 6.5
Number of indoor units	41	1 or 2	1

© E Source; data from manufacturers

At 0°F/ –18°C, traditional heat pumps can lose half or more of their capacity and net (heat pump + backup heat) COPs approach 1.0.

Fault Detection & Diagnostics (FDD) for Commercial HVAC

Rapidly emerging low cost minimalist diagnostics that work



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Minimalist Approach: Using Sound

Virtjoule

- Monitors sound for faults and degradation
- Savings: 5 to 8 percent kW and 15 to 20 percent kWh (vendor-reported)
- $150 to $300 installed

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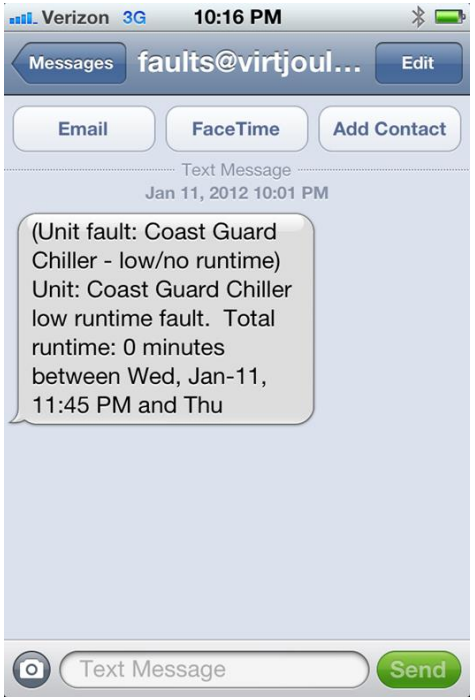
Fault-Finding Made Easy

- Runtime outside business hours
- Economizer opportunities
- Short cycling
- Condenser fan failure
- Compressor failure
- Refrigerant leaks
- High head-pressure faults

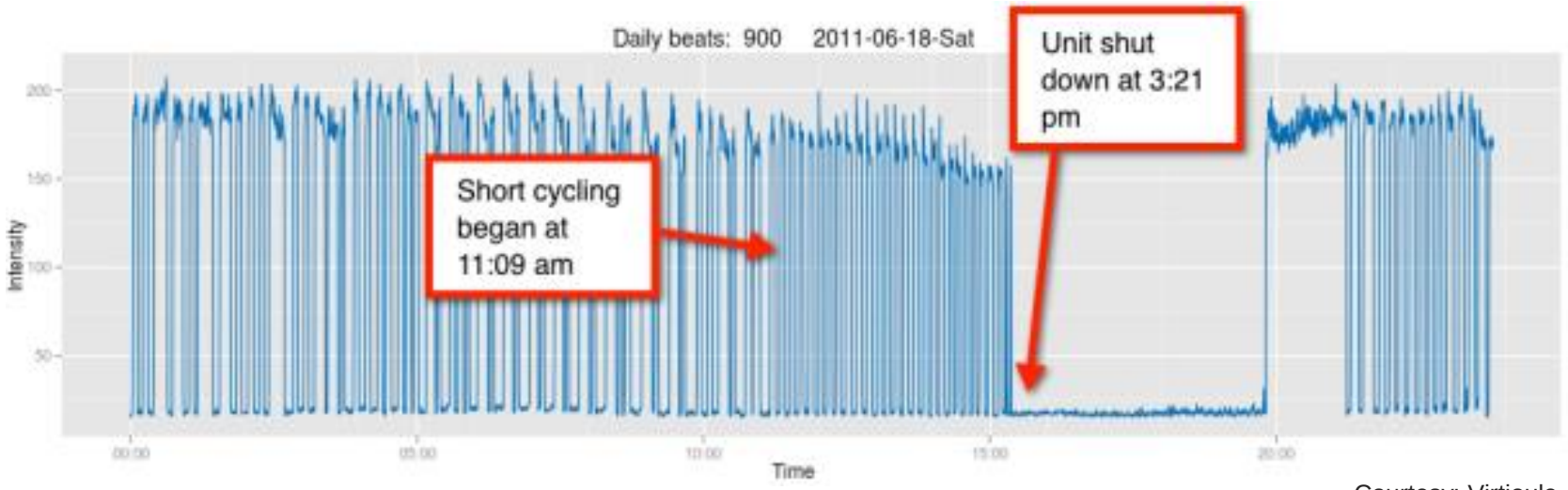


Courtesy: Virtjoule

- Sends you a text or email

Best Applications

- Performance monitoring for HVAC equipment with limited or antiquated energy management systems
- Attractive option for monitoring tenant HVAC
- Critical-system monitoring for large HVAC, server rooms, and refrigeration



Courtesy: Virtjoule

RTU Retrofit with Big Savings

VFD Retrofit Devices for RTUs: What's Under the Hood

- Designed for existing single speed, single zone RTUs
- Packaged rooftop units (RTU) are used in 46% of all commercial buildings in the US
- Site energy consumption of 230 Trillion Btus annually

Product	VFD – Evaporator Fan	VFD – Compressor	DCV	Economizer controls	FDD
Catalyst	Y		Y	Y	Some
Enerfit	Y		Y	Y	Some
Digi-Rtu	Y	Y	IP*	IP*	IP*

*IP = in progress

Newest Results Continue to be Positive - PNNL Study

- PNNL Study published July 2013:
  - 66 Catalyst units
  - 8 different buildings (retail, shopping mall, office, food sales, healthcare)
  - 4 climate zones (warm coastal, mixed humid, mixed marine, cool moist)
- **Average savings of 57%!**
- Mostly due to fan energy
- Average simple payback of 3 years at $0.10/kWh

Newest Results Continue to be Positive – SCE Study

- SCE Study published November 2013:
  - 4 different manufacturers – kept anonymous
  - 1 installation per manufacturer
  - 1 building in San Diego, CA
- 2 units were duty cycling controllers!
- 1 unit modulated supply fan speed (mostly)
- 1 unit modulated compressor speed (mostly)
- 24-27% savings

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VFD Retrofit Devices Are Ready for Prime Time

- Proven, significant savings
- Compressor modulation not shown to be any more effective than fan speed modulation

Condensing Gas RTUs

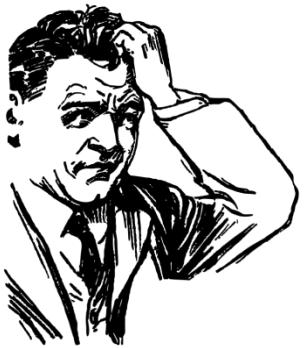
Gas Heating Rooftop Units (RTUs), a.k.a. “gasPACs”

Source: Wikimedia Commons

The workhorses of commercial buildings

Source: U.S. National Archives and Records Administration

The Problem:



GasPACs are only 80% efficient!

Help is on the way….

Source: Open ClipArt Library

The (Emerging) Solution:

Condensing Gas RTUs (gasPACs)

Recover latent and sensible heat from flue gas

Can deliver 90+ percent efficiency

What's Held It Back So Far?

- Technical challenges with condensing RTUs
  - Freezing condensate
  - Acidic condensate
- Economic challenges—increased costs for:
  - Condensing heat exchanger
  - Fan energy penalty from increased pressure drop
  - Maintenance (acid-neutralizing agent)

Net operating cost savings are key, so need to be selective with applications

Available Products

- Engineered Air
  - RTU with condensing gasPAC
  - 90 percent efficiency
  - DJX series
- Modine
  - RTU/dedicated outdoor air system (DOAS) with condensing gasPAC
  - 90 percent efficiency
  - Atherion line with Conservicore
- Munters
  - DOAS with condensing gasPAC
  - Not officially released yet

Courtesy: Engineered Air

Courtesy: Modine

Identifying Cost-Effective Applications

- Gas Technology Institute (GTI) and Consortium for Energy Efficiency (CEE) joint research project
- Monitored more than 105 gasPAC units in 11 Chicago-area commercial buildings
  - RTUs serving perimeter run more than those for core
  - Runtime patterns were repeated in big-box retailers with similar RTU layout
- Two big-box store tests are underway in Chicago and Minnesota; expect energy and cost savings data next year

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Best Opportunities for Upgrading

- Northern US and Canada (5,000 or more annual heating degree days)
- High-runtime RTUs (likely serving perimeters, vestibules, or 24/7 operations)
- DOASs
- High-make-up air volumes
- Variable or 2-speed fan units (reduces pressure drop losses)

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Time to Replace the Water Heater?

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Direct-Contact Water Heating

No heat exchanger

- Water comes into physical contact with combustion gases

Hot water produced as needed

- Minimal standby loss

Up to 99.7 percent efficient!

- Can yield energy savings of up to 60 percent in the right applications

Courtesy: Ludell Manufacturing

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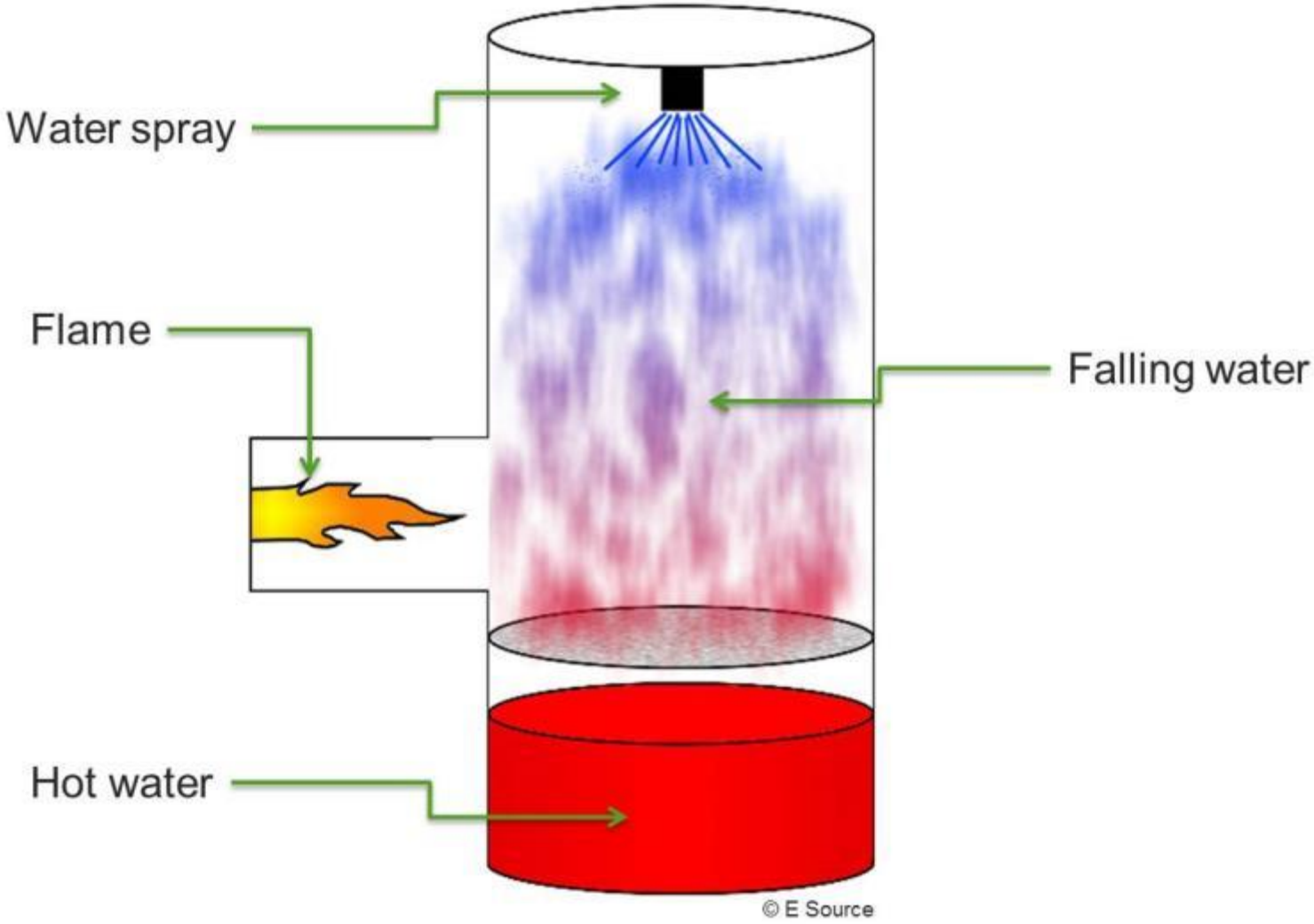
How It Works



Minimal Maintenance Requirements

- No heat exchanger
- Available in all-stainless-steel construction
- Little calcination or scale buildup
- Long life expectancy

Source: Department of Agriculture

Some Important Differences

Hot water is unpressurized

- Differs from a standard boiler or tank heater
- Requires pumping to the end use

Capacities of up to 54 million Btu per hour

- Can produce lots of hot water very quickly

Incomplete combustion can hurt water quality

- However, several models do meet bottled water and food ingredient water standards for direct use without additional filtration

Low-temperature exhaust

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Industries That Could Benefit

Pharmaceuticals

Textiles

Laundry

Greenhouses

Warehouses

Courtesy : EC Systems

Materials production

- Metals
- Molded plastics
- Synthetic rubber
- Synthetic fibers
- Concrete

Food processing

- Meat
- Dairy
- Beverages
- Sugar refining
- Raw food

Case Study: Cambridge Towel Corp.

Background

- Located in Ontario, Canada
- Makes terrycloth towels
- Operates four days a week, employing over 200 people

Retrofit details

- Replaced an inefficient steam water-heating system with a direct-contact water heater
- Cost for the water heater: approximately $150,000

Results

- Went from a thermal efficiency of 60.0 percent up to 99.7 percent
- Savings of $8,400 per month ($100,800 annually)
- Simple payback period of 1.5 years
- Resulted in the shutdown of one of the plant's two boilers

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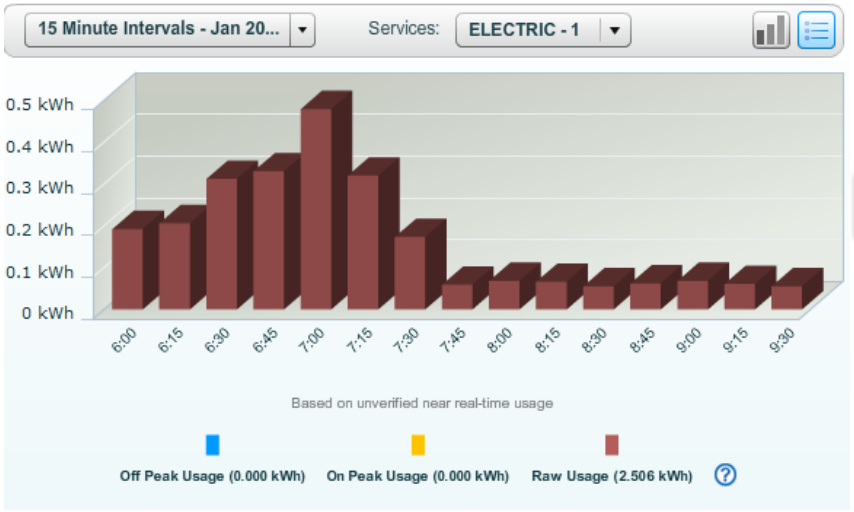
Who Makes Them?

- Armstrong International
- Heatec
- Kemco Systems
- Ludell Manufacturing
- QuikWater
- Sofame Technologies
- Thermal Engineering of Arizona

Courtesy: Ludell Manufacturing

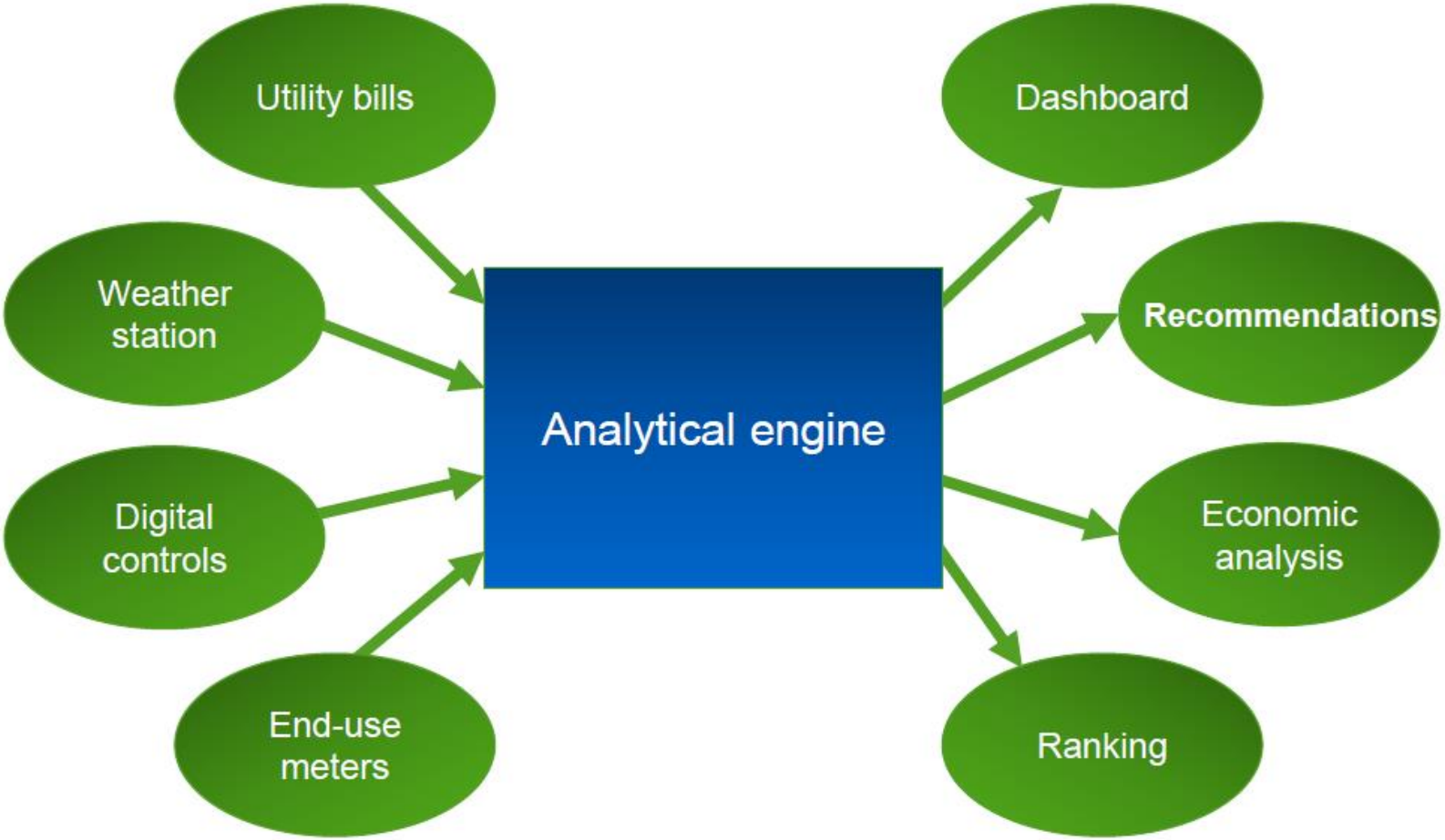
New Simple Building Energy Analytics: Turning Big Data into Savings



Source: Xcel Energy

Source: 123RF.com

How They Work



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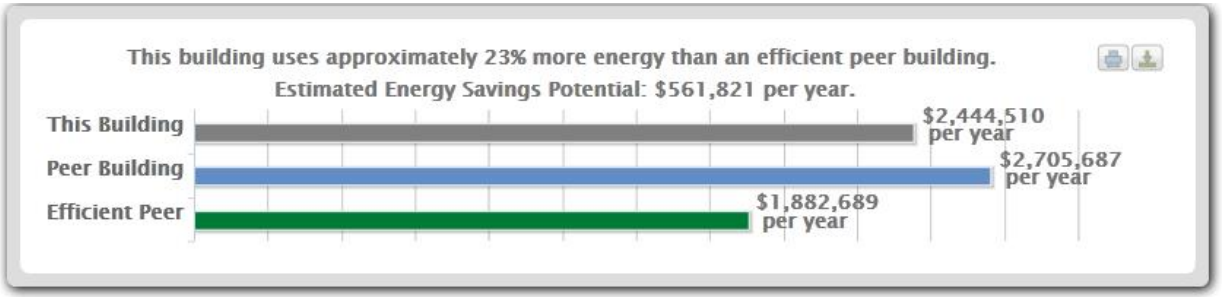
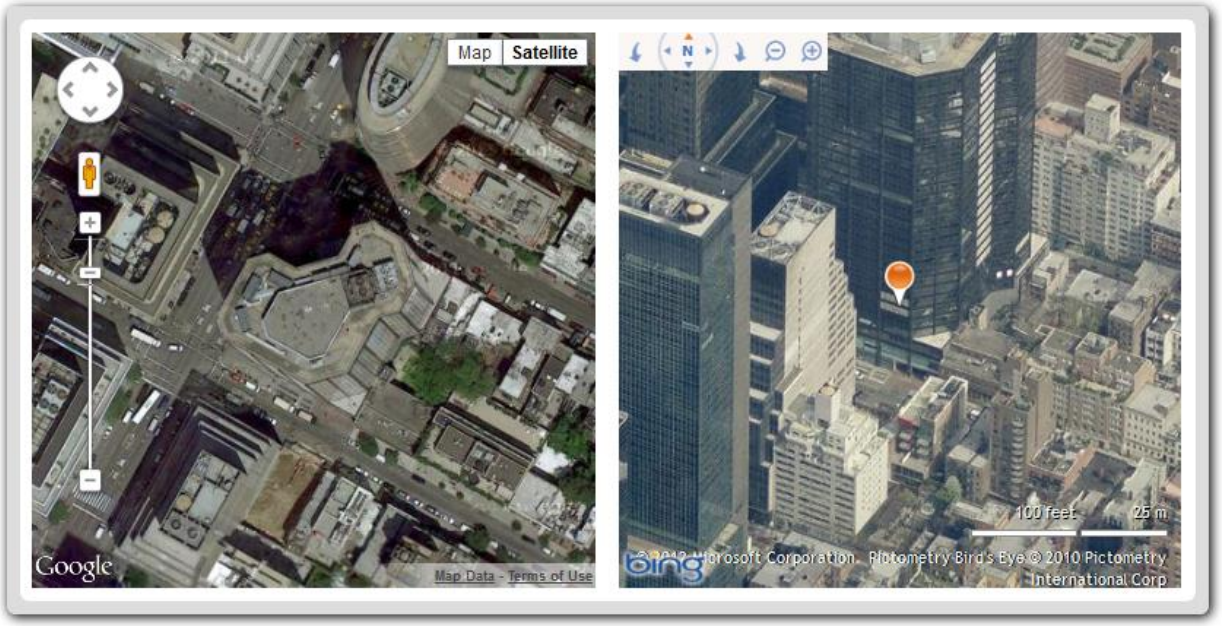
No-Touch Audits

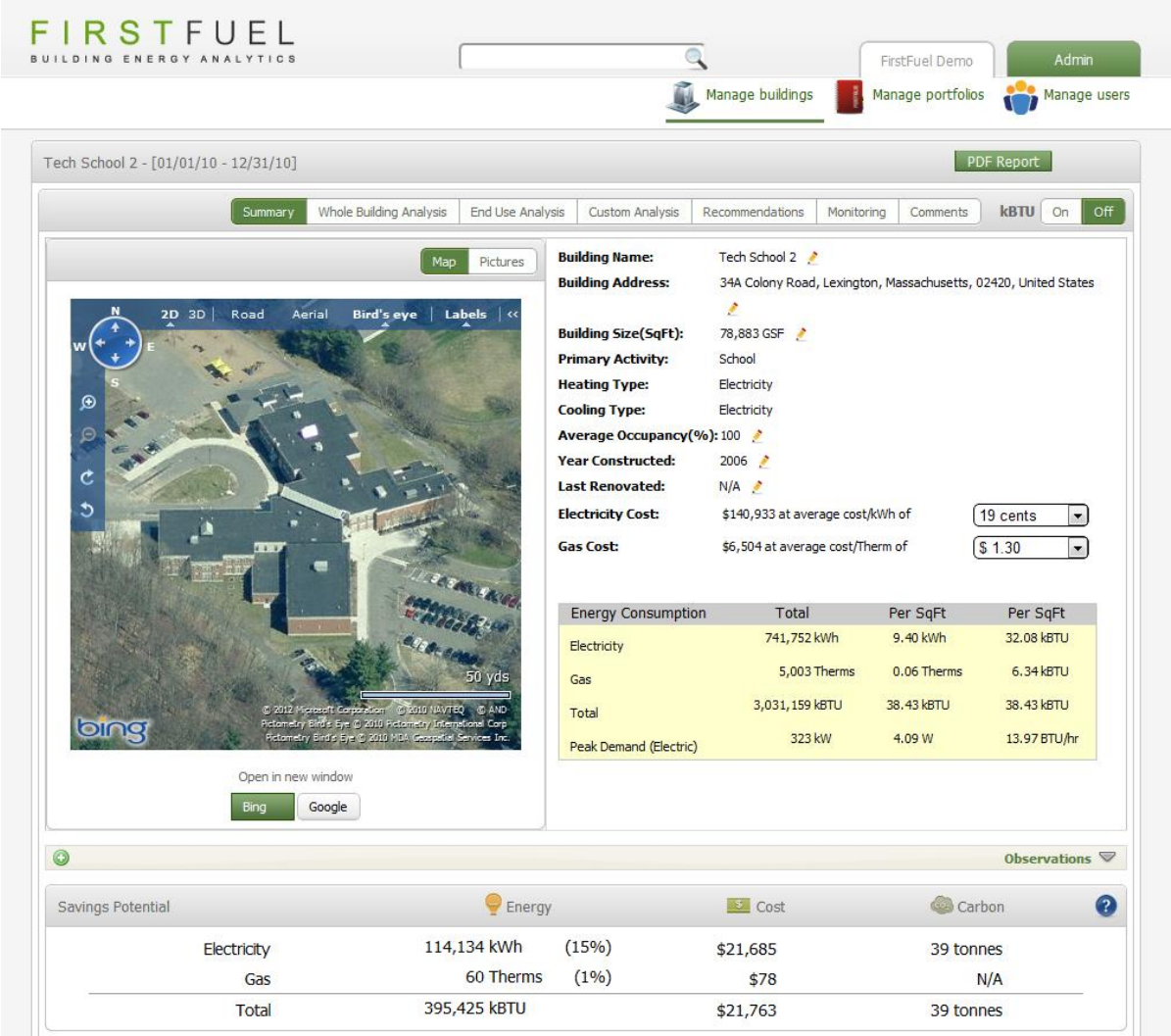


Energy Savings		% kWh Reduction		Seasonal Peak kW Reduction		Dollar Savings		
Annual	Lifetime	Total	During Peak (8am-11pm)	Summer Peak (1-5pm)	Winter Peak (5-7pm)	Annual	Lifetime	CO2E
2,675,336 kWh	21,402,691 kWh	22.98%	80.90%	114 kW	550 kW	$561,821	$4,494,565	22.98%



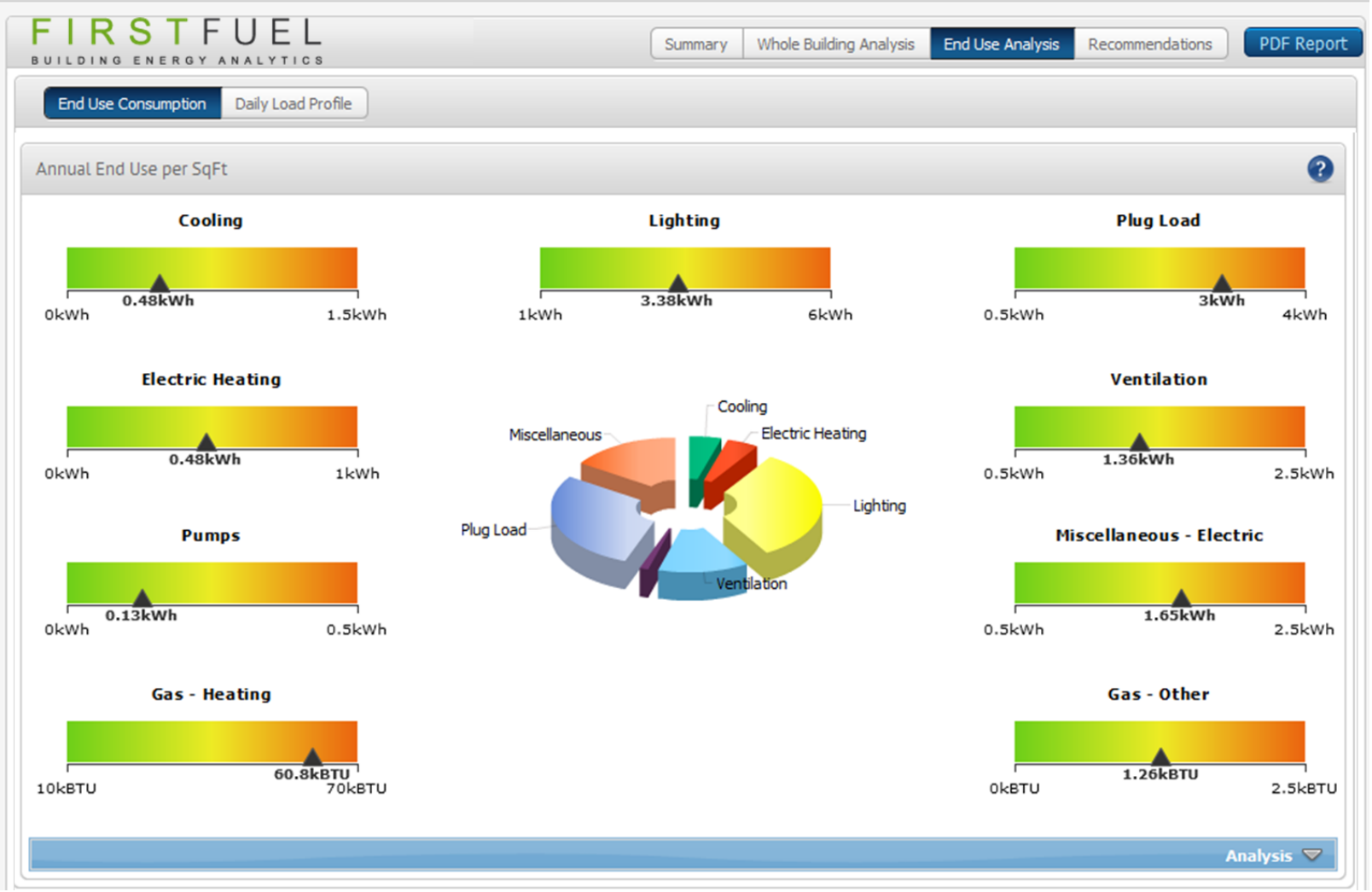
Courtesy: Retroficiency

Minimal Data Inputs Needed



Courtesy: FirstFuel

End-Use Benchmarking



Courtesy: FirstFuel

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Many Products to Choose From!

But Do They Save Energy?

- Vendors claim up to 30% energy reduction

LBNL case studies:

Site	EIS used	Action/observation	Energy impact
UC Merced	Automated Logic Corp.'s WebCTRL	Excessive overnight gas use due to nonzero pressure at steam boilers	30% reduction in average daily gas use; avoided cost of $4,500/month
Sysco	NorthWrite's Energy WorkSite	Retrocommissioning and refrigeration tune-ups	36% reduction in site energy use
UC Berkeley	No central EIS	Lighting retrofit and ventilation schedule change	30% reduction in whole-building energy use

Depends on:

- Skill/motivation/ability/authority of users
- Building type
- Building performance before energy analytics

© E Source

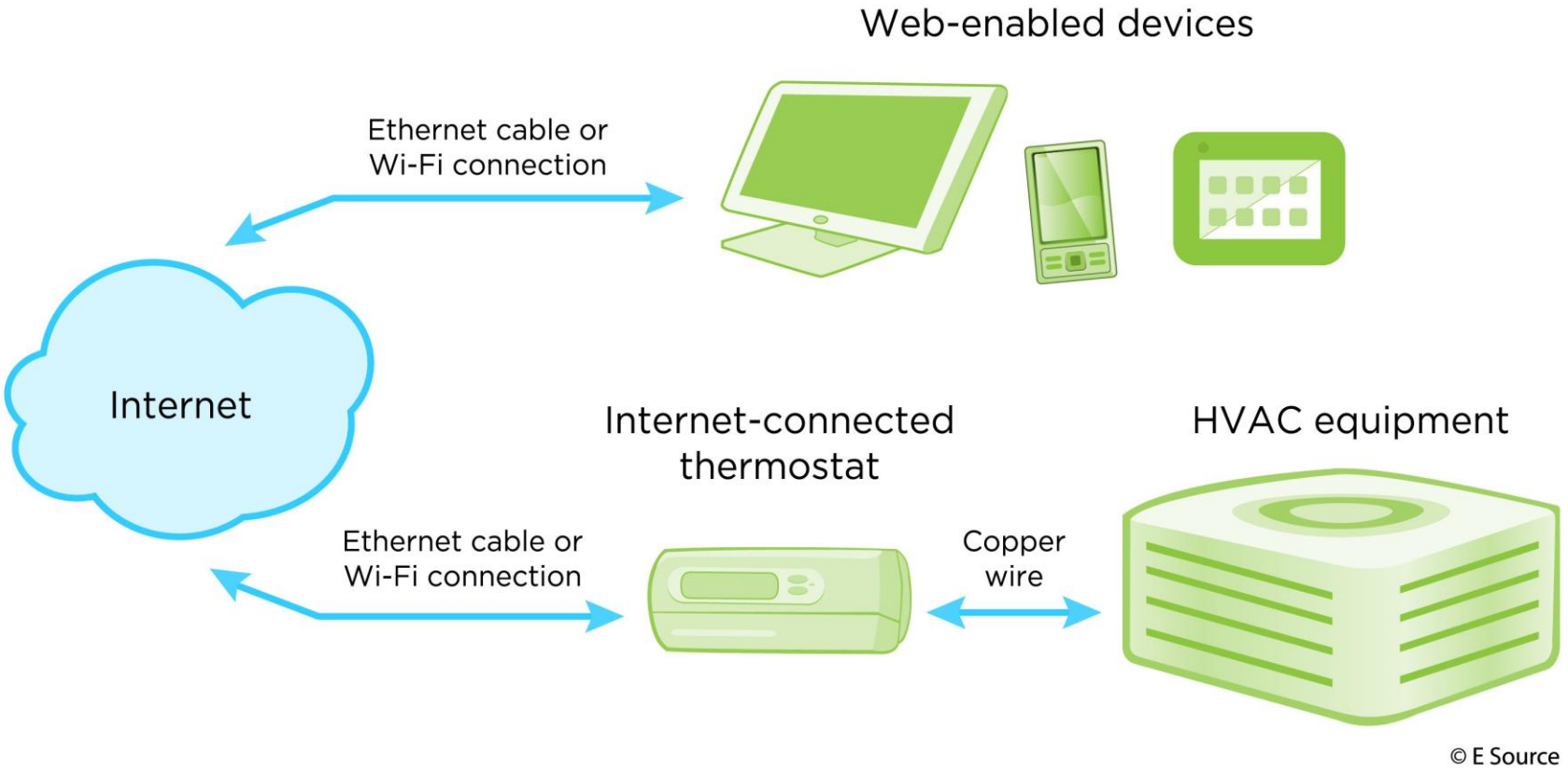
Source: CKSinfo.com

Cloud Thermostats:

“Poor Man’s Energy Management System”

Source: photoeverywhere.co.uk

Here's How They Work

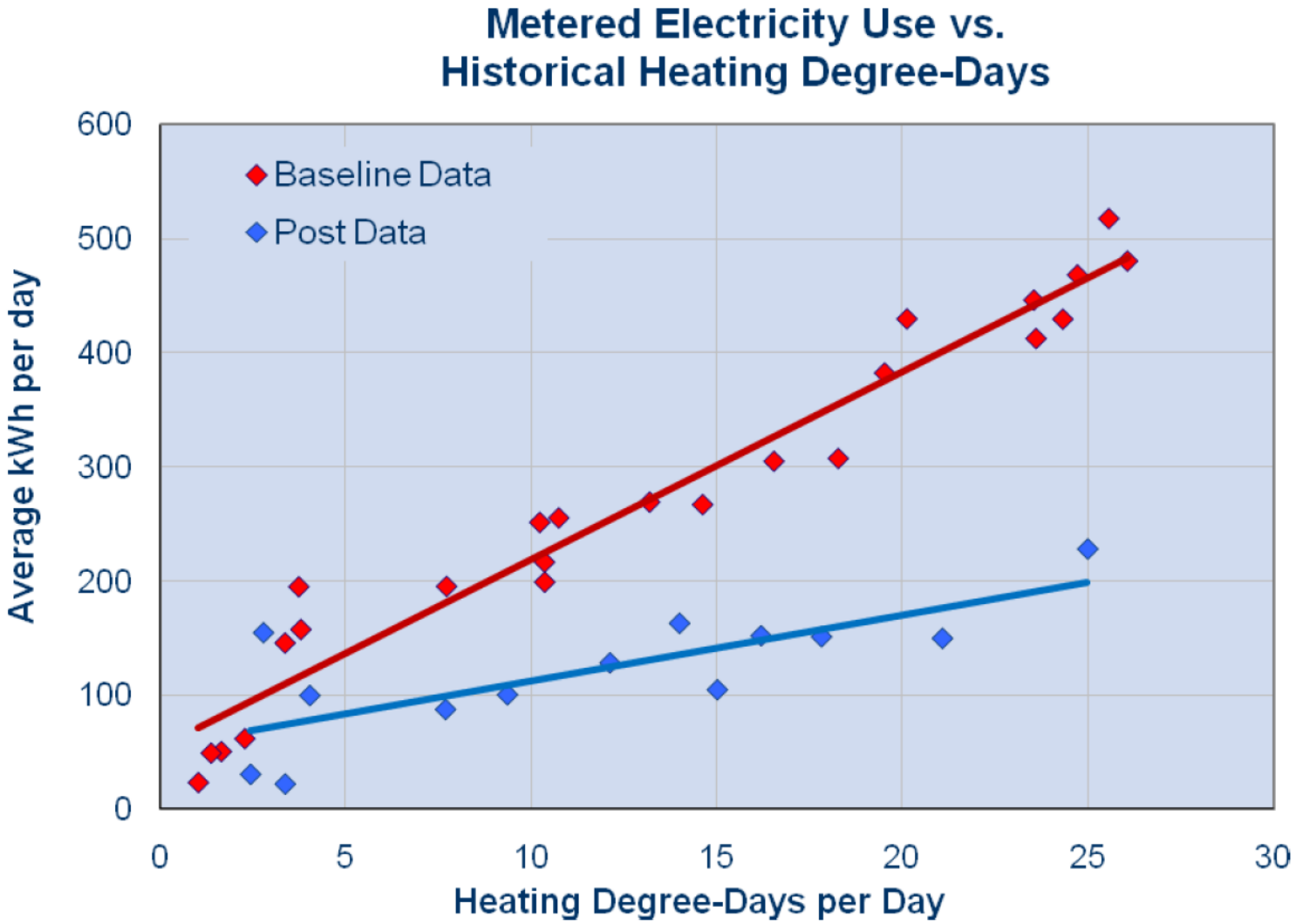


Costs and Benefits

Item	Value
First costs	$500 to $1,000 per thermostat installed
Annual costs	$36 to $75 per thermostat
Energy savings	10% to 50% of overall energy costs
Other benefits	Reduced O&M costs

© E Source

Cloud Thermostats Go to School(s)



Source: Quantum Energy Services and Technologies

The Thermostats

Vendors:

- Proliphix
- Bay Controls
- Radio Thermostat
- Viconics

Courtesy: Proliphix

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Thermostat Features

- Built-in web server
- Wired or wireless connectivity
- Multiple stages (3 heat, 2 cool)
- Password protected
- Automatic daylight savings time correction
- 366 day programming
- 5-year holiday scheduling
- Humidity and other additional sensing (3 sensor inputs)
- 2 auxiliary relays
- Intelligent recovery
- Built-in alarms

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The Auxiliaries

Source: Xytronix Research and Design, Inc.

Application Features

- Access from any web connected browser, including smart phones and tablets
- Data storage
- Graphing
- Alerts
- Thermostat programming and scheduling
- Reporting
- Demand response

Now, the Fine Print

Source: CKSinfo.com

- Few independent savings analyses
- Ability of vendors to manage quality and reliability undetermined
- Ability of building staff to use systems undetermined
- Potential savings vary widely depending on baseline conditions

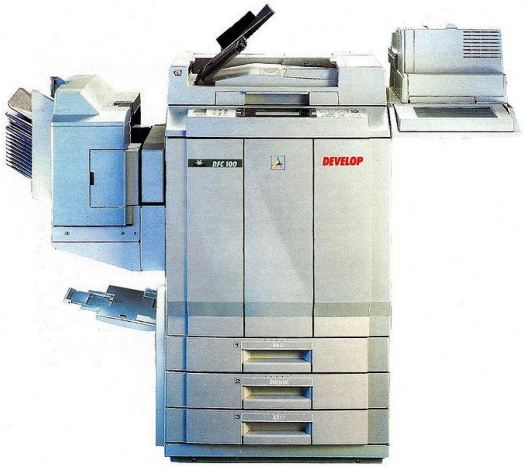
Plug Loads

Why Care About Plug Loads?

- Plug loads are huge!
  - As much as 15% of the electricity consumed in homes
  - Up to 20% of electricity consumed in commercial offices
  - Phantom power accounts for 3% to 10% of all electric consumption
- Largely underserved by utility programs, nor a focus of many customers

Image Courtesy WPClipart

Commercial Plug Loads Are a Big Deal!



Source: Wikimedia Commons

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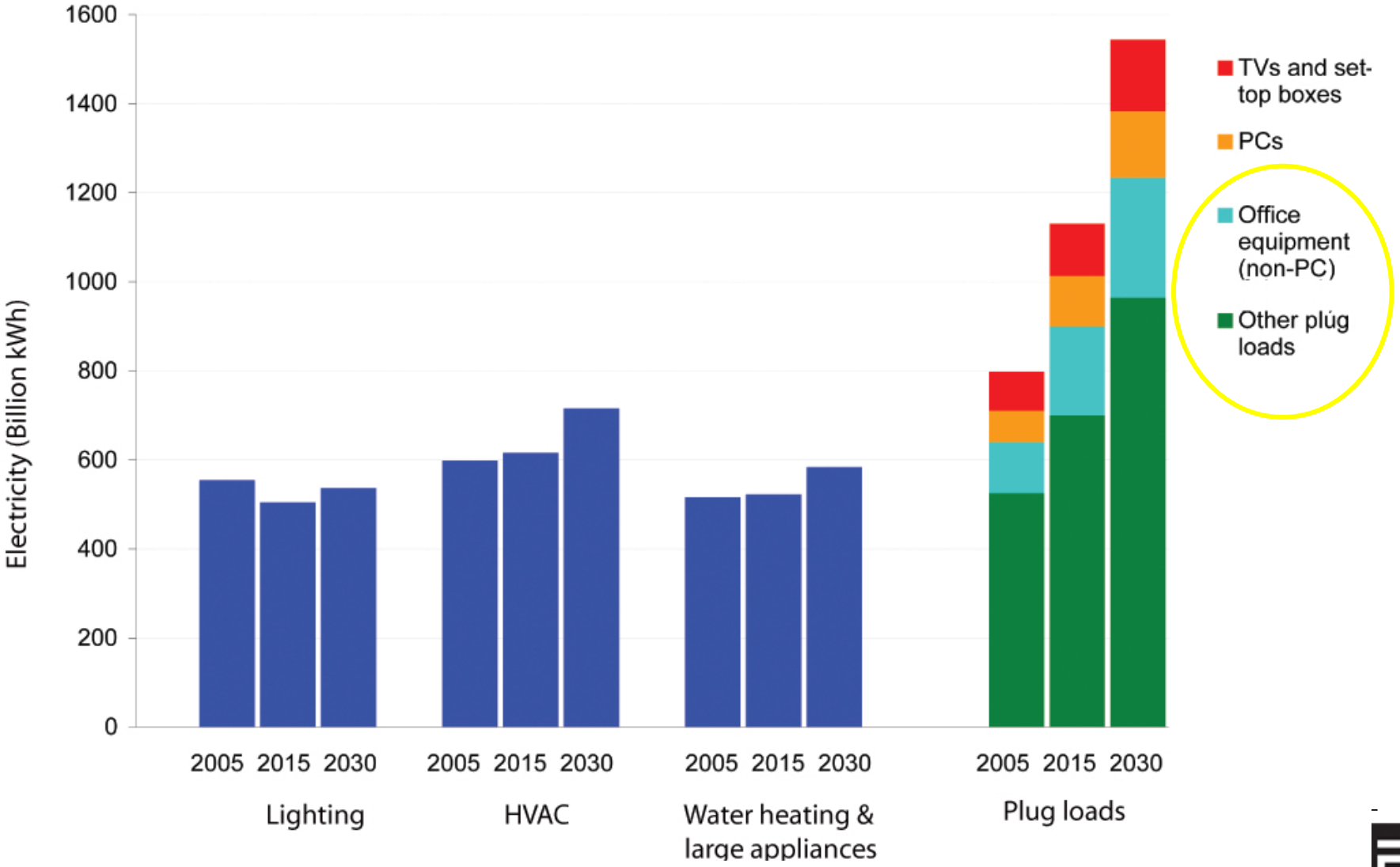
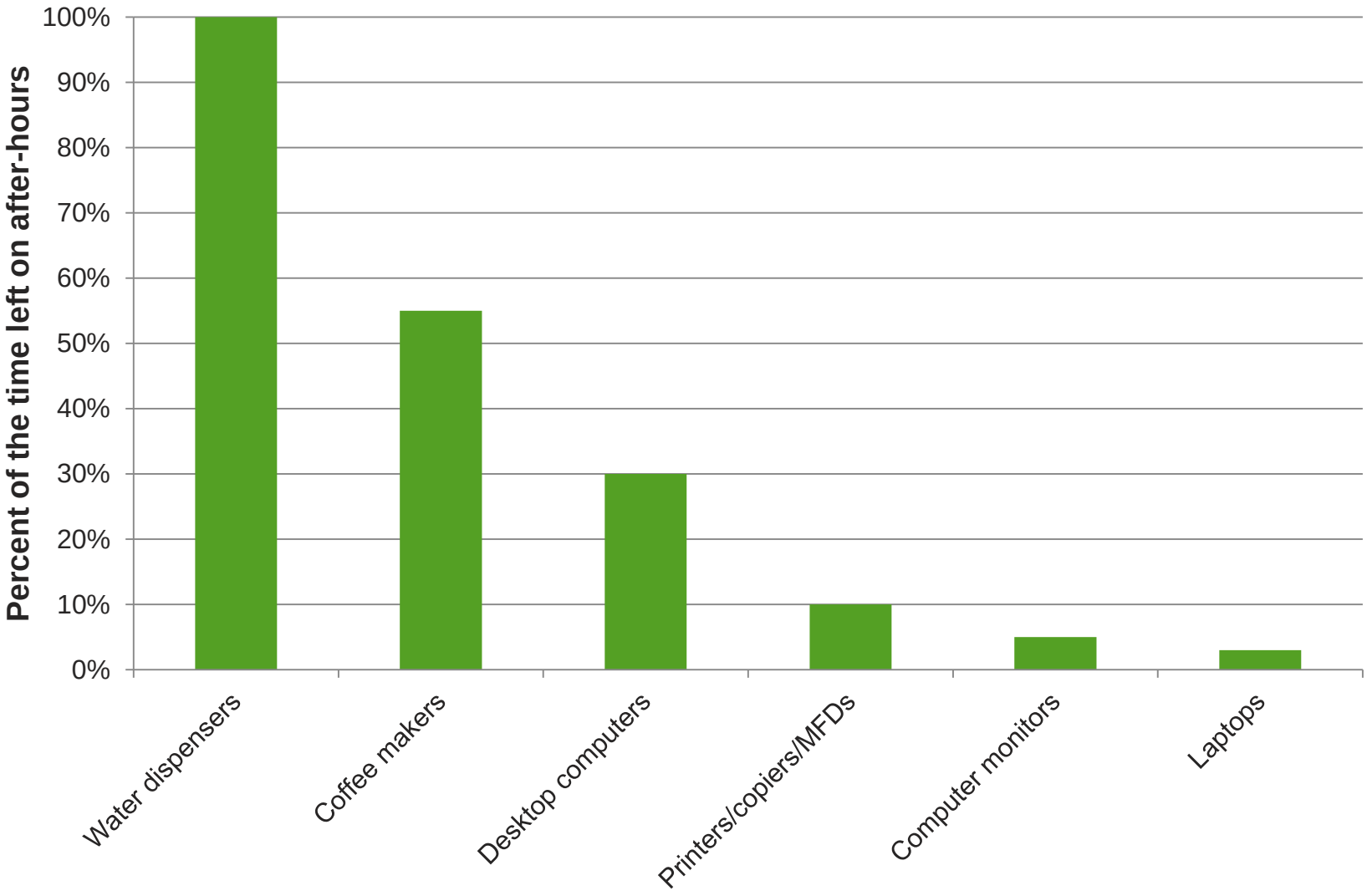
Plug loads: One of the Largest and Fastest Growing End-Uses



Source: Graph created by Ecova with data from EIA 2008 Annual Energy Outlook

What's Left On Most Often?



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Smart Power Strips Are Supposed to Help, But They Can Present Challenges

- Difficult to determine the best strategy for a given plug load
- Companywide installation can be challenging
- Tough to determine savings
- Employees can change settings or unplug the smart strip altogether
- Little to no demand-response capabilities

Source: Wikimedia Commons

Enmetric

Courtesy: Enmetric Systems

Enmetric Systems

What Makes It Different?

- Multiple control strategies for up to four plugs
  - Scheduled and load-sensing control options
- Communicates wirelessly
  - Uses a centralized web portal
  - All settings can be adjusted in one place
  - Easy monitoring and reporting
  - Simplifies installation and setup of power strips
- Can intelligently reduce peak load
  - OpenADR-compliant for use with demand response
- Designed to monitor and control hundreds of plug loads in commercial settings!

Modlet

- No mere smart strip
  - WiFi-enabled smart plug
  - Highly controllable
  - Built-in power meters
- For residential and commercial applications
  - Something tenants can do to reduce energy use!
- Four main benefits
  - Individualized feedback
  - Automated savings
  - Behavior change
  - Smart demand response

Courtesy: ThinkEco, Inc

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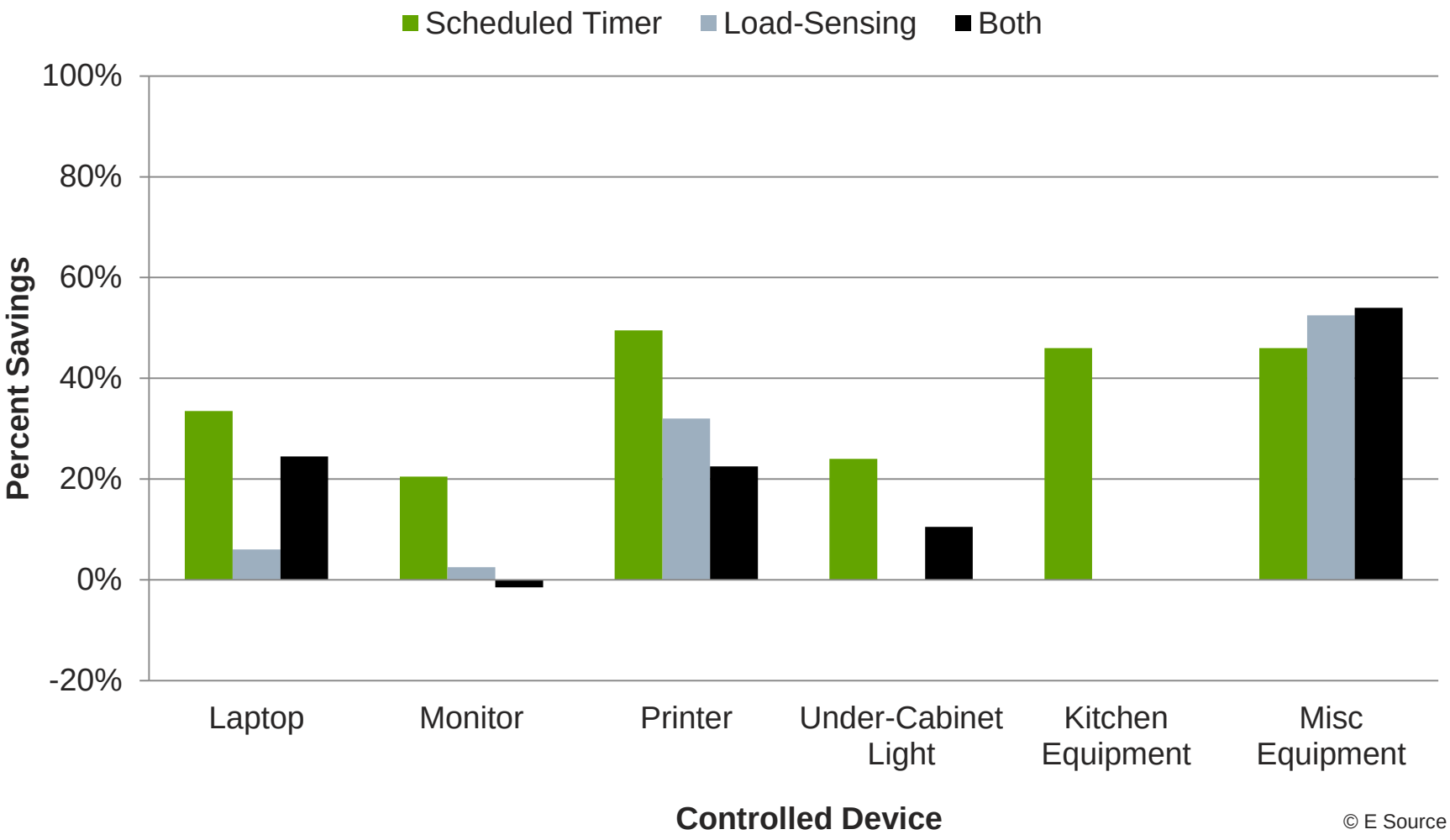
Some Independent Test Data

- National Renewable Energy Laboratory (NREL) tested the Enmetric smart strips in eight buildings
  - Baseline was a standard “dumb” power strip
  - Studied nearly 300 devices
- Control strategies used included:
  - Submetering only
  - Schedule timer
  - Load-sensing
  - Schedule timer and load-sensing

Source: Wikimedia Commons

Measured Savings



© E Source

Economics

- Installed costs vary
  - Estimated $100 per strip
- Simple payback periods can vary widely
  - Can range from <1 to nearly 50 years

Source: Wikimedia Commons

Lessons Learned

- Plug loads comprise 10%-40% of electricity use in small offices
- Smart controls can reduce consumption by up to 10%
- Modlet and Enmetric can be used to turn stuff off during DR events
  - Something that tenants can do to reduce energy use!
- Corporate leadership, culture shift, and behavior change are vital to realizing savings
- Gamification can help spur education and make it fun to reduce energy consumption

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Liquid CO_2 Textile Cleaning

How Does Liquid CO_2 Clean?

Gas at room temperature	Liquid at higher pressures	Solid at atmospheric pressure and below (-)109° F
		
Carbonation	Liquid	Dry ice

Courtesy (left to right): Quinn Dombrowski, Mr. Thomas, and Michael Melgar

Carbon-dioxide (CO_2) solvent properties compared to water:

- Lower viscosity and surface tension
- Improved small pore penetration
- **Cleans better and more quickly**

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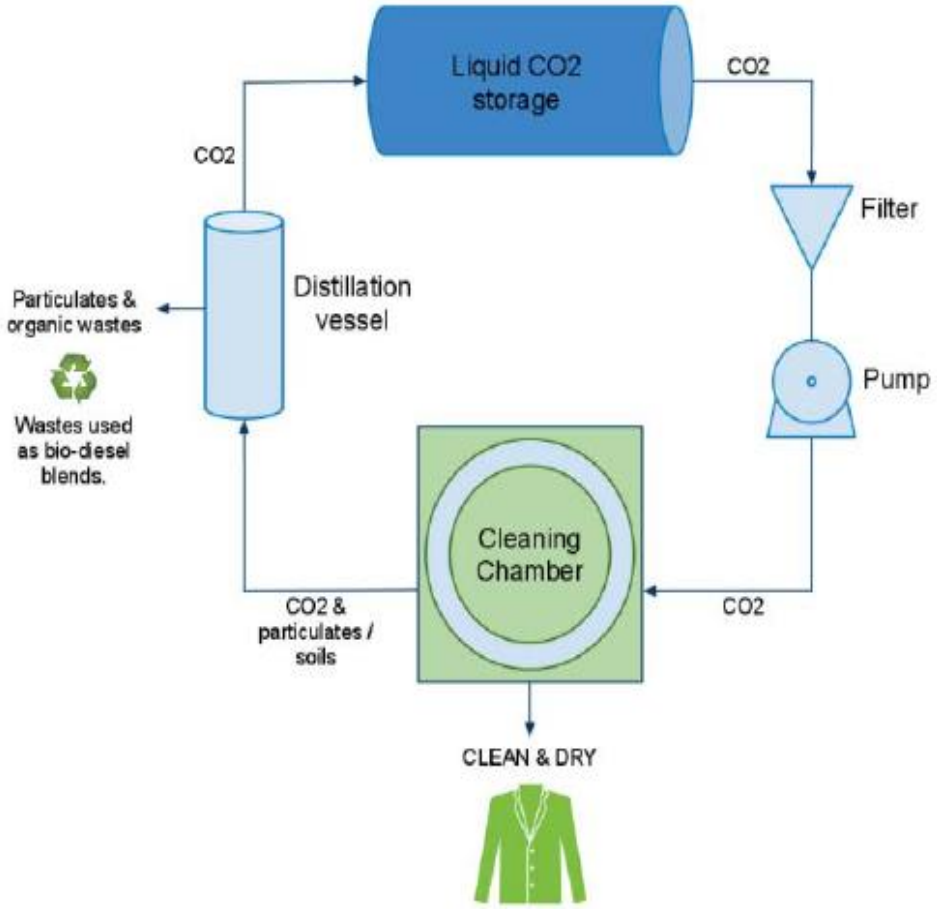
How the Process Works



1. Cleaning chamber purged of air
2. Liquid CO_2 pumped into cleaning chamber
3. Wash – liquid is recirculated
4. Distillation –residual body oils, detergent, other soils are captured for disposal
5. Clean liquid moved back to storage and ready for next cycle

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Liquid CO_2 Cleaning Process

Benefits

- CO_2 is recycled, recaptured, and reused
- No water, no hazardous chemicals, no secondary waste stream
- Particulates/organic wastes are captured and recycled
- Clothing comes out clean and dry
- Increased garment life
- 20 minute cycle times
- High throughput (100-300 lbs/hour)
- CO_2 is non-toxic; non-hazardous; non-flammable; cheap & inexhaustible

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Liquid CO_2 Cleaning Process

Processing advantages

- Continuous filtration throughout washing cycle
- High penetration capacity into textile
- Less abrasive = Increased Fabric/Garment life
- Clothing comes out clean and dry
- No Shrinkage / No Color Bleeding

Cleans a wide variety of fabrics

- Kevlar
- Oil rags
- Wool / Uniforms
- Fabrics with Special Coatings / Treatments

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Savings vs. Incumbent Water-based System

Process Consumption

	Water-based system	CO2-based system	% Reduction
Water	4M gallons	0 gallons	100%
Energy	4000 GJ	1800 GJ	55%
Chemicals	30,000 lbs (disposed in municipal water system)	9000 lbs	70%
Garment Life	50+ cycles	2-3 x longer life	

© E Source: Data from CO_2Nexus, Inc

Based on 1.2 million lbs of garments throughput /year

Current CA Energy Commission Pier Project: Garment Cleaning for Cleanrooms

Cleanroom requirements

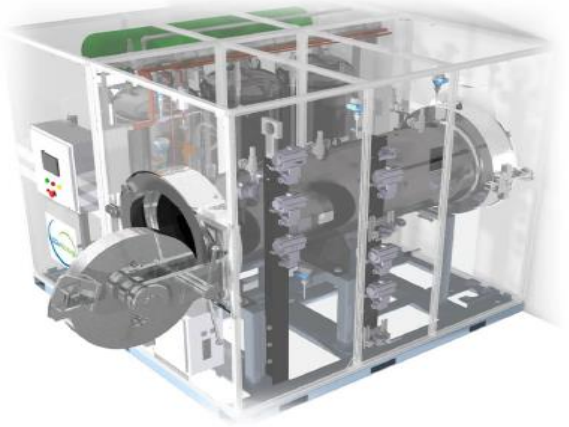
- Cleanrooms classified based on particles in the air
- Static-charge control is critical
- Minimal biological contamination

CO_2 system advantages versus a water-based system

- 60 percent fewer particles
- Reduces static buildup
- 25 percent less bio-burden

Current field testing

- Aramark Cleaning Services in LA
- Testing to be completed March 2014



Courtesy: CO_2Nexus

Gas Condensing Unit Heaters

Gas Condensing Unit Heaters

- Applications
  - Warehouses
  - Industrial facilities
  - School/government garages
  - Greenhouses
- Benefits
  - Energy efficient
  - Easy to install (no ductwork)
  - Durable in corrosive environments
- Drawbacks
  - Requires a condensate drain and noncorrosive venting

Courtesy: Modine

Unit Heater Efficiency

Heater type	Thermal efficiency (%)	Seasonal efficiency (%)
Gravity vented	80	65
Power vented	80	78
Condensing	91 to 93	~91

© E Source; data from Focus on Energy

Unit Heater Economics

Courtesy: Modine

Simple payback period example

Building type	MBh required	Condensing unit heater incremental additional cost	Annual natural gas savings (therms)	Annual energy cost savings	Simple payback period
Auto garage	(2) 241	$7,200	2,772	$3,049	2.4
Warehouse	109	$2,850	698	$768	3.7
Greenhouse	260	$3,600	1,386	$1,524	2.4

Note: MBh = thousand Btu per hour.

© E Source; data from Focus on Energy

For More Information

- Modine Effinity 93 High Efficiency Natural Gas-Fired Unit Heaters

- Reznor Ultra High Efficiency Condensing Gas Fires Unit Heaters

Here are a Potpourri of Other Technologies

Ultrasonic Leak Detectors

- Compressed air system leaks waste 20% to 30% energy
- Use acoustic sensors to detect sounds in the ultrasonic frequency range and can identify & locate leaks
- Portable and easy to use
- Cost $1,000 to over $15,000
- Payback typically measured in weeks

Facility	Annual energy savings (kilowatt-hours)	Annual dollar savings ($)	Simple payback (years)
Rochelle Foods	308,602	22,951	0.40
Chrysler Transmission Plant	227,483	17,737	0.60
Southern Clay Products	170,745	11,952	0.80
Superior Graphite	155,804	7,728	0.97

© E Source; data from the U.S. Department of Energy

Electrochromic Windows

Before

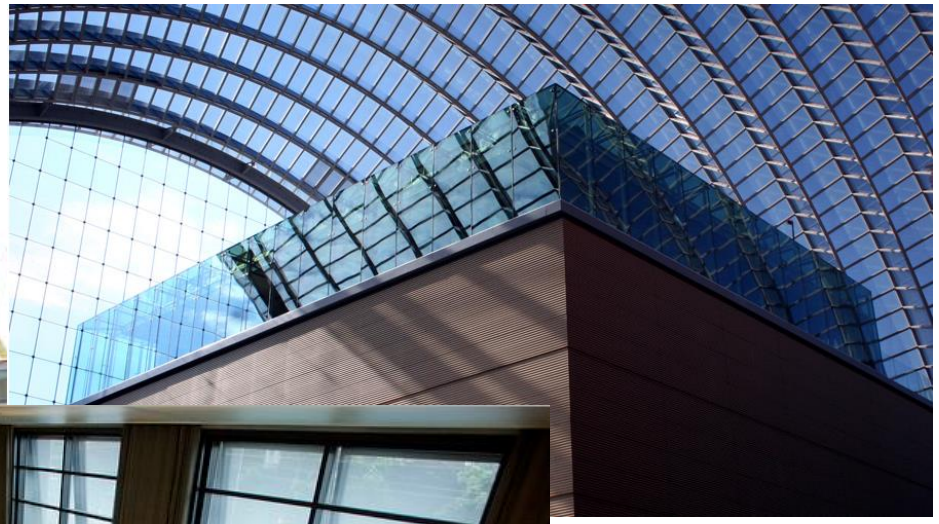
After

Source: Sage Electrochromics

A Problem Solver but not a Great Energy Efficiency Measure

Source: glassmagazine.com

Colorado State University Morgan Library



Source: sageglass.com

Kimmel Center for the Performing Arts in Philadelphia

Source: forbes.com

W Hotel in San Francisco

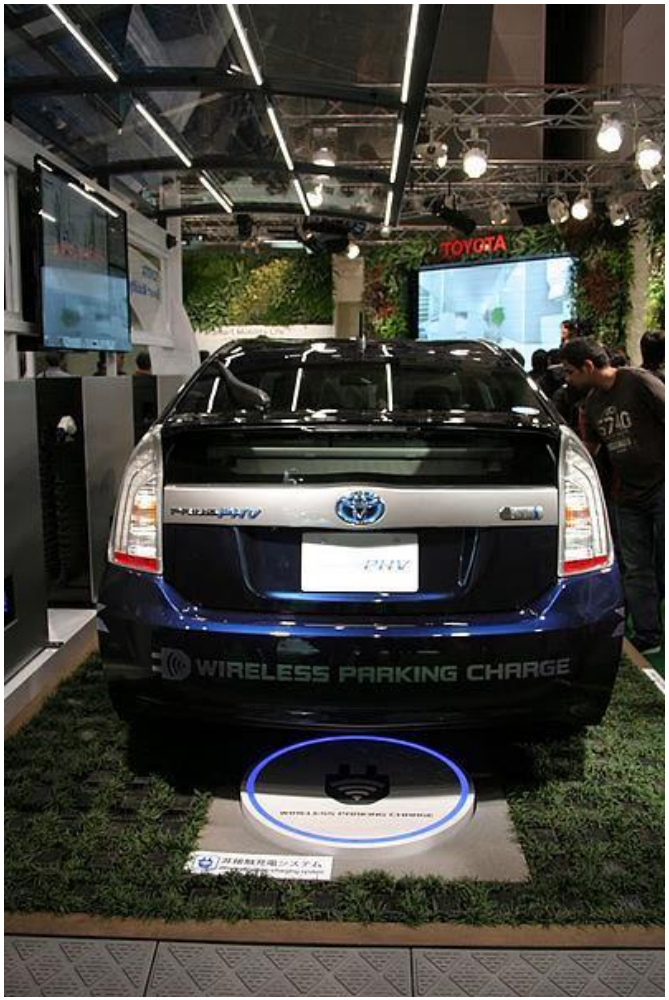
www.esource.com || © 2014 E Source

Wireless Charging: Convenience at the Expense of Energy Consumption

- No wires = useful for charging consumer electronics
  - Electric toothbrushes
  - Smart phones
  - Tablets
- BUT typical transmission efficiency is only ~70%
- For comparable performance, input power must be increased by almost 1.5 times compared to a wired system!

Image courtesy: LGEPR, via Wikimedia Commons

Beware Wireless EV Charging



- Bosch and others are touting wireless electric vehicle charging systems
- Is the convenience really worth it?
  - Upfront costs of ~$3,000
  - Significant increase in power draw—at 7 kW for a normal Level 2 charger, this is a big deal
- EV owners should know what they're getting into

Image courtesy: Njo, via Wikimedia Commons

Liquid Submersion Cooling for Computers

- Liquid submersion cooling for data center servers from Green Revolution Cooling
- Liquid similar to mineral oil. Pump circulates the hot oil to either a coolant-to-water heat exchangers or an air radiator system
- 10%-20% reduction in server power use
- 90%-95% reduction in cooling energy use

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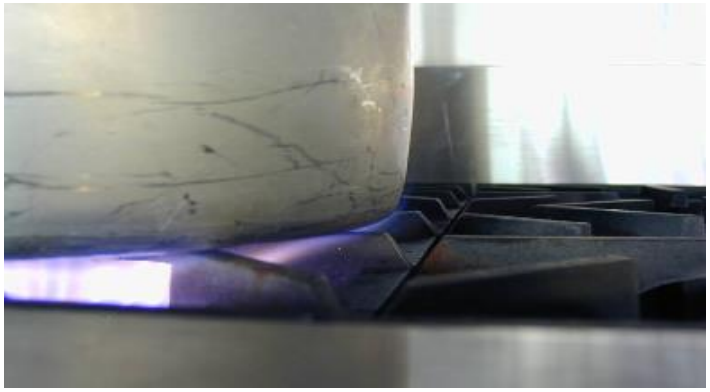
Have a Gas Cooktop? Consider a Turbo Pot!

The problem



The solution

Images courtesy Eneron Inc.

- A pot with fins
  - More heating surface area
  - Better heat-transfer efficiency
  - And, it boils water faster!
- Can increase cooktop efficiency by 49% to 80%

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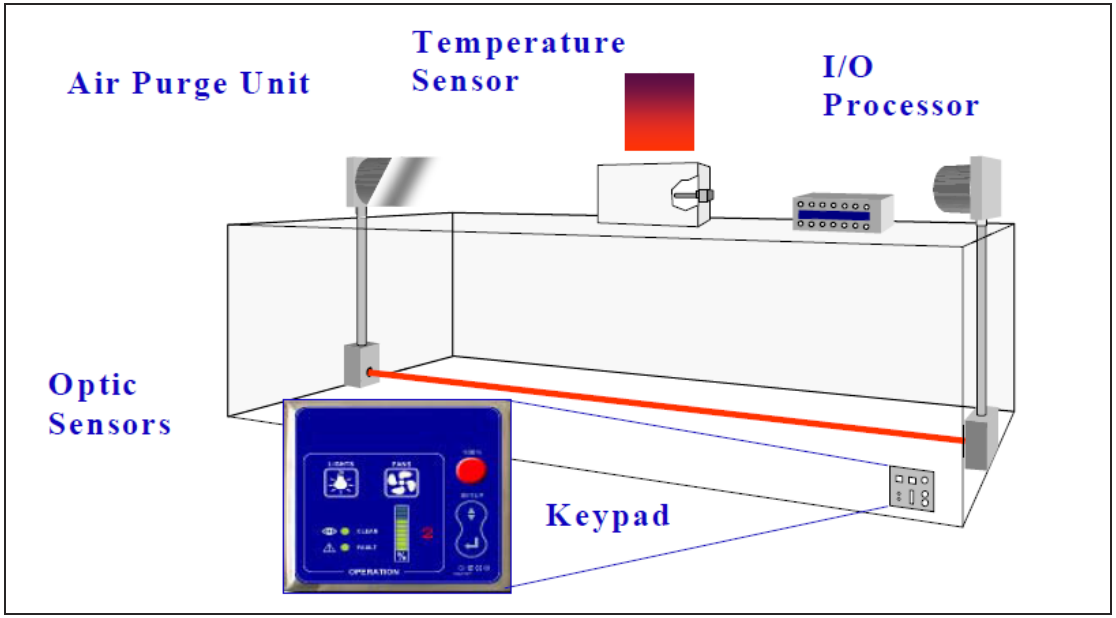
Next Generation Demand-Controlled Ventilation (DCV) in Commercial Kitchens

- Saves 40% to 70% on hood fan energy
- Saves an additional 15% to 40% in building HVAC losses
- Unobtrusive design
- Less fan noise
- Decreased fire risk
- No sacrifice to indoor air quality



Sources: Melink, PG&E Food Service Technology Center

Drain Water Heat Recovery

Courtesy: RenewAbility Energy Inc.

Energy savings: 30% to 50% per shower

Doubles the first-hour rating of water heater

No moving parts

Use in homes, motels/hotels, dormitories, health clubs

Payback: 2 to 6.5 years in new Construction

Retrofits also possible

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Thermal: The Other On-Site Storage

- Lightweight construction reduces thermal mass
  - Increases heat transfer
  - Heating/cooling loads go up
- Thermal storage options
  - Phase-change material
  - Water or ice storage
  - Seasonal thermal storage
- What's holding it back?
  - Industry standards
  - Cost and performance
  - Invisible; lacks "sexiness"

Source: Wikimedia Commons

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