Buildings Are Energy Hogs:
How Energy Efficient Technologies Can Bring Home the Bacon

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President,
E Source

MLGW Key Customer Meeting
December 6, 2012

E Source

Agenda

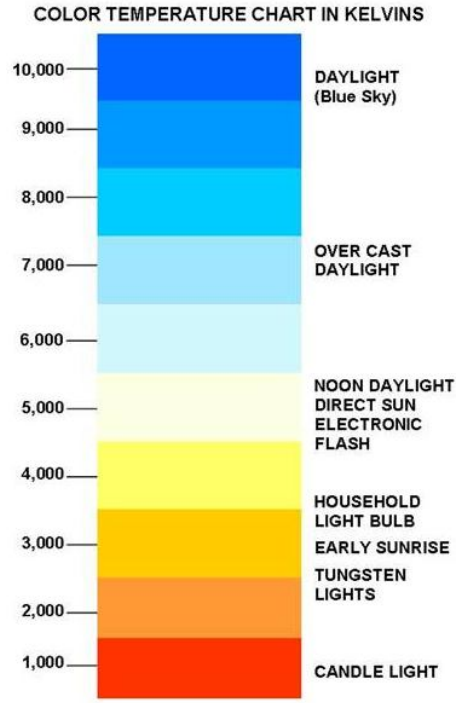
Energy efficient emerging technologies I will present

- Lighting
  - LED Lighting
  - Advanced lighting controls
  - Organic LEDs
- HVAC
  - Fault detection & diagnostics
  - Rooftop unit retrofit
- Ultrasonic leak detectors
- New age simple building analytics
- Direct Contact Water Heaters

Current Status of LEDs

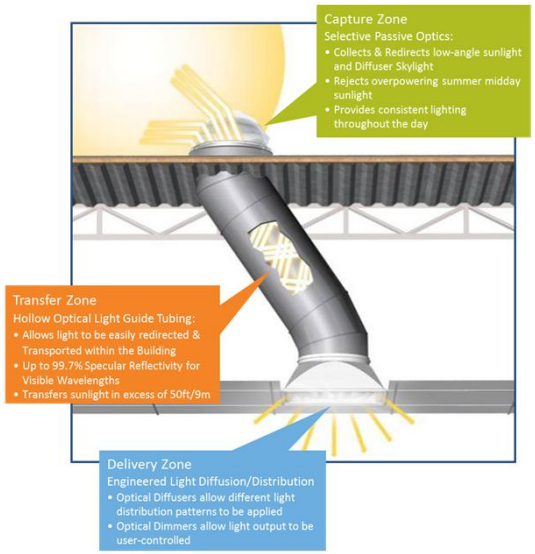
- High cost; wide variation in performance and quality
- Good applications today: outdoor, recessed cans, refrigerated cases, warehouses, task lighting, troffers
- Tough applications where thermal management a challenge especially in tight spaces
- New emerging issue with power quality, PF, & THD
- Lots of pressure and misleading information from manufacturers and sales reps
- Expect the unexpected

The *Power* of Color

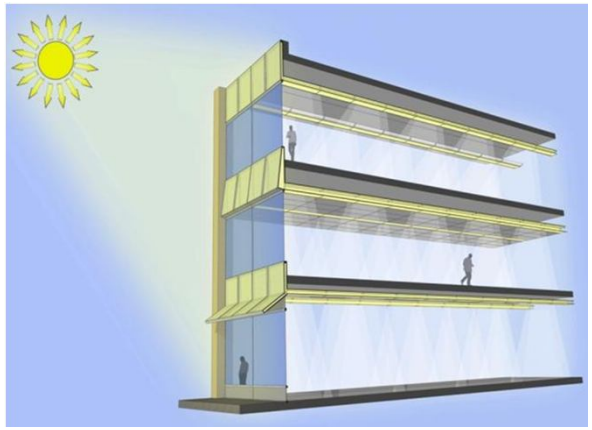


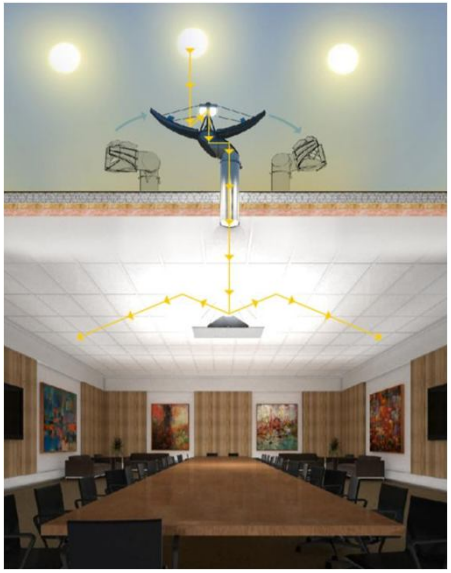
- Color temperature (Kelvin)
- LEDs provide more options
- Helps set circadian rhythms
- Lighting control options can improve mood
- More blue in light suppresses melatonin, increases feel good hormones like dopamine, serotonin, cortisol
- By installing 8,000K in an office or factory:
  - Less need for eye glasses
  - Have more personal energy; easier to work longer hours
  - Sleep better at night

Direct Solar Daylighting



Courtesy Sunflower Corp.



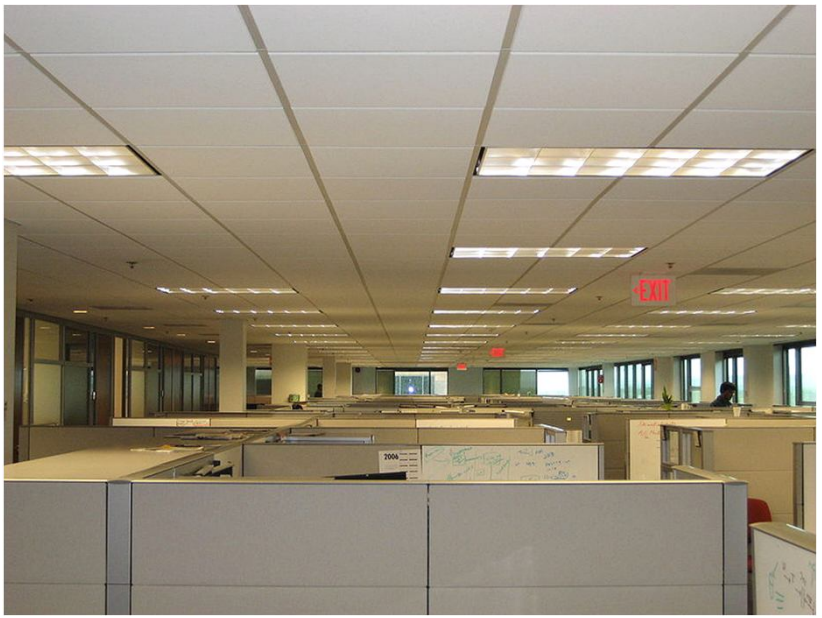


Courtesy: Sundolier

Courtesy: Solatube

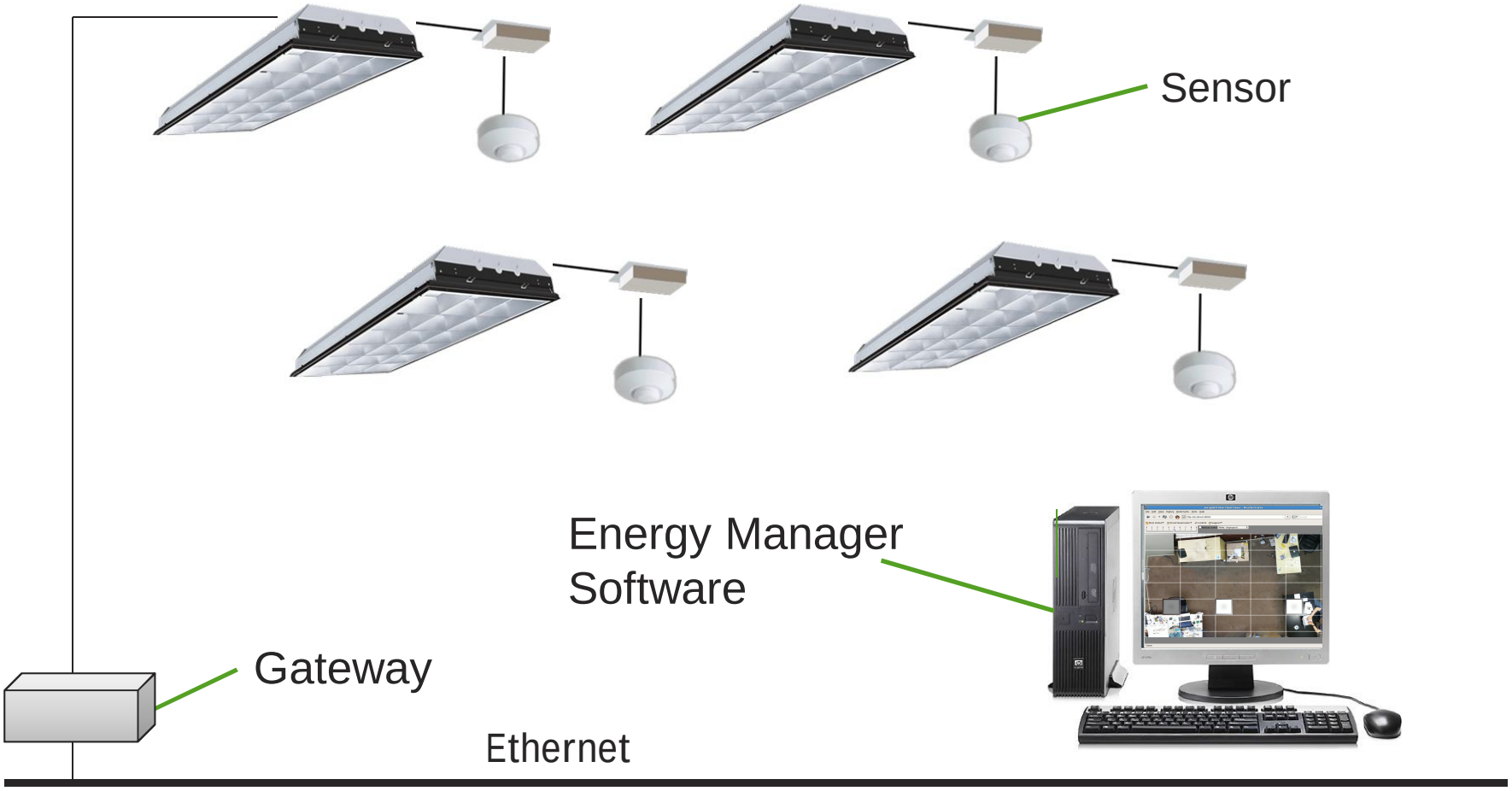
Advanced Lighting Control System

- A new approach to wireless lighting control
- Easy installation and calibration
- Flexible and autonomous
- Options for individual control
- Lighting savings ranging from 50-70% with a short simple payback



Courtesy: Wikimedia Commons

How does it work?



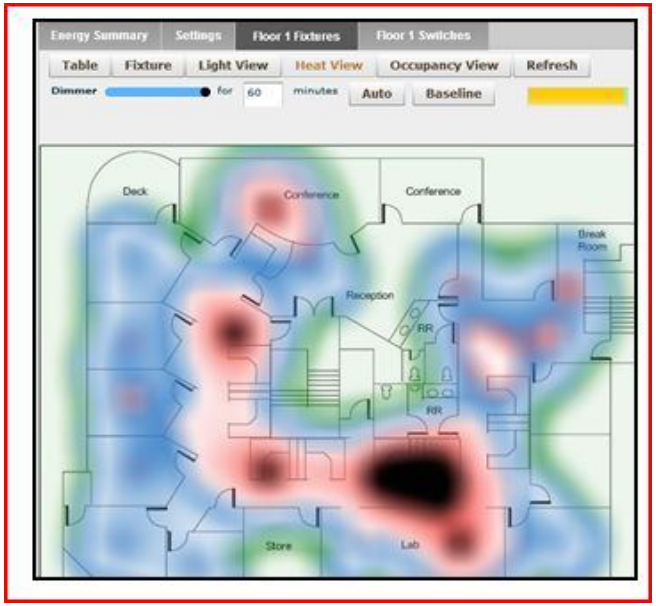
Courtesy: enLighted Inc.

What types of sensors are used?

- Occupancy
- Daylight
- Thermometer
- Power meter

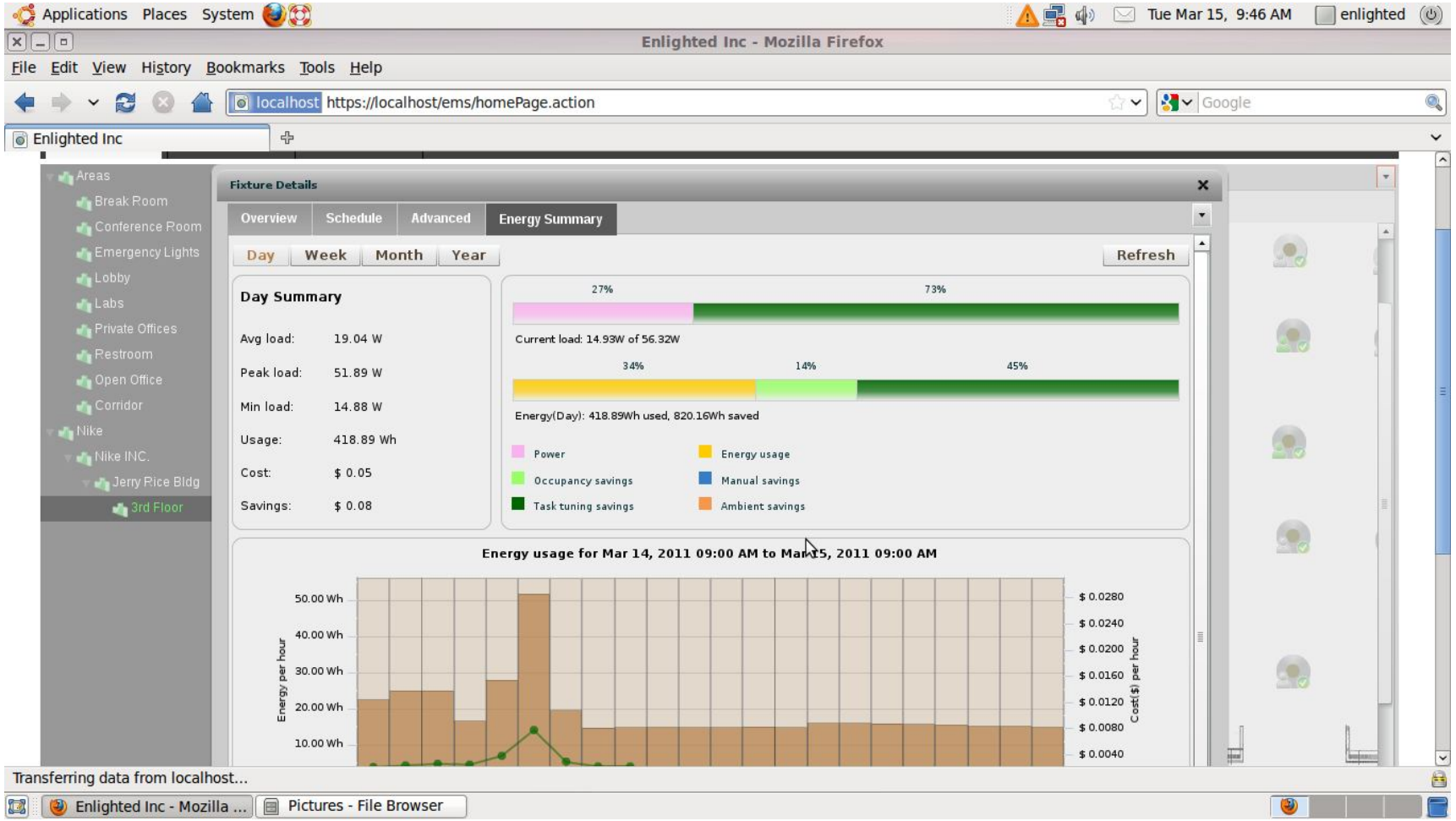
Courtesy: enLighted Inc.

Sensor data mapping



Courtesy: enLighted Inc.

Dashboard: Savings Tracking



Courtesy: enLighted Inc.

Economics

Retrofit Building 25K sq ft	California	Massachusetts	New York	Oregon
Electricity Rate (cents/kWh)	12.98	18.01	14.99	7.95
Annual Lighting Electricity Cost	$22,000	$31,000	$25,000	$14,000
enLighted Lighting Energy Savings (71%)	$15,513	$21,859	$17,628	$9,872
enLighted Annual Operational Savings (Bulb life + HVAC effects)	$4,989	$5,954	$5,375	$4,025
Total Annual enLighted Savings	**$20,502**	**$27,813**	**$23,003**	**$13,896**
Total Solution Cost (includes ballast and labor)	**$36,630**	**$36,630**	**$36,630**	**$36,630**
Federal Tax deductions for lighting controls	**$5,250**	**$5,250**	**$5,250**	**$5,250**
ROI (months) (includes utility rebates)	**13 months**	**10 months**	**12 months**	**19 months**
ROI w/o rebates/incentives (months)	**18 months**	**13 months**	**16 months**	**27 months**

Courtesy: enLighted Inc.

Additional benefits

- Demand response
  - Enables participation in demand response programs (either automatic or manual)
  - Intelligent dimming of lights
- Possible BAS integration
  - HVAC
  - Security
  - Fire
- LEED compliant
  - Adds ~6-10 points in a typical open-plan commercial lighting space with T8 fixtures
- Averts integration headaches
  - To get a comparable system, you need to combine multiple different systems and create a brand new control box

Advanced Lighting Controls Systems Many Qualified Products

- Adura Technologies
- CAN2GO
- Daintree Networks
- Delta Controls
- Digital Lumens
- Encelium
- enlighted
- Lumenergi
- Lutron Electronics Co, Inc.
- nLight (SensorSwitch, Acuity)
- Philips OccuSwitch Wireless Controls
- Synergy Lighting Controls (Acuity)

Good Application for Industrial 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

High Bay LED with Wireless Control

LEDs: More lighting, less Costly

Parameter	HID	Fluorescent	LED
Power, kW	455	230	**~180**
initial lumens	43,000	20,000	**15,000**
EOL lumens	27950	18000	**10,500**
Fixture efficiency	0.7	0.92	0.95
EOL lm/W	43	72	**58**
Controllability	poor	good	best
Lamp life, hrs	20,000	24,000-40,000+	50,000
Fixture cost, $	$135	$150	**~$1080**

Improved LED High Bay Products

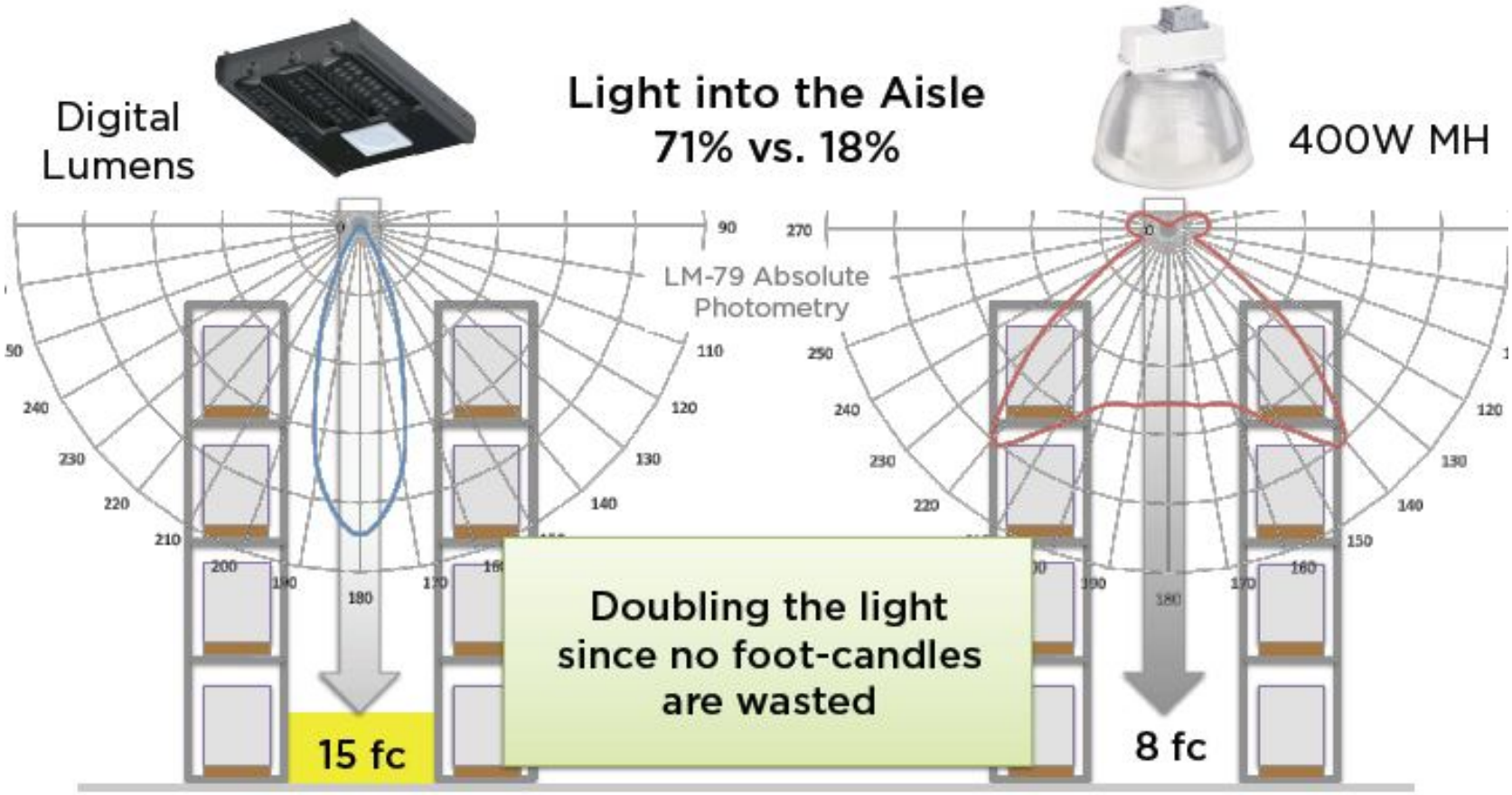
- Aimable light bars
- Thermal Design for longevity, performance
- Built-in intelligence

Courtesy: Digital Lumens

- Able to participate in AutoDR
- Up to 45 ft with sensors; 80 ft without
- Temperature range: -40 F to 100 F
- QPL-listed (Qualified Products List)

LED high-bay fixture from Digital Lumens www.digitallumens.com

Putting Light Where It's Needed



Courtesy: Digital LUmens

LEDs: The Light That Came into the Cold

Leading application: Cold storage warehouse

- Fluorescent output decreases in the cold
- Fewer lamp changes with LEDs
- HVAC savings, too!

- Maine Paper and Food Service
  - One-for-one w/400W HPS
  - Lighting energy use cut by 87%

Courtesy: Digital Lumens

LED Troffers Are Coming of Age

- Troffers are the most common fluorescent fixture
- LEDs in troffer form: edge lit, light bars, blocks, etc.

Source: Lithonia

© E Source

LED T8 Replacements Aren't Ready Yet

LED T8s:

- Still expensive
- Inadequate light distribution and light levels
- Similar life
- Could compromise UL

Source: Ledtronics

OLEDs: The "Other" Solid-State Lighting

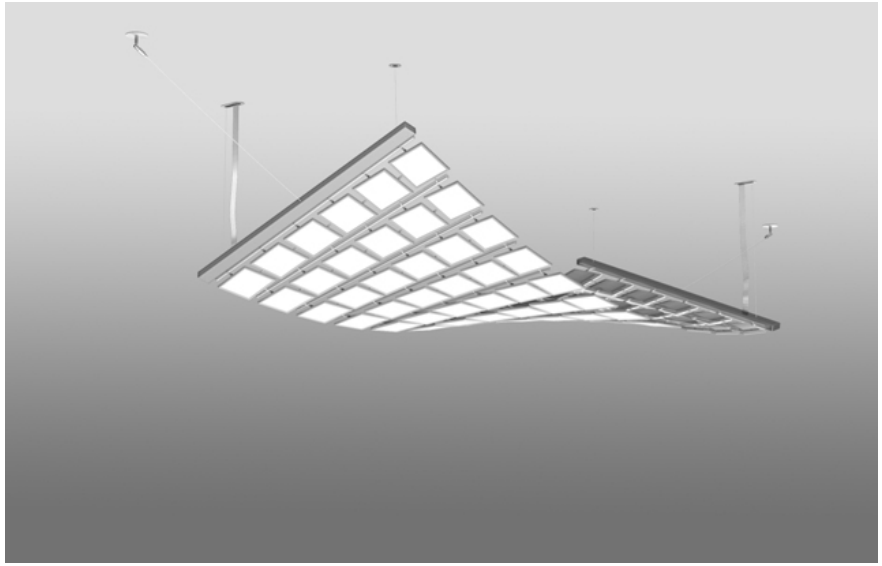
What is an organic light-emitting diode?

- A sandwich of organic molecules layered on a glass substrate that emits light from its surface when voltage is applied.

Is OLED lighting coming of age?

- Efficacy: 60 lumens/watt (lm/W); 80 lm/W by the end of 2012
- 15,000-hour life; expected to be at 25,000 hours
- Color temperature of 3,500 kelvin (K)
- CRI > 80
- Diffuse, even lighting
- Unique forms

Canvis: OLED Product Introduced at LightFair 2012



Source: Acuity

To see a cool video http://vimeo.com/41590155

OLEDs: The "Other" Solid-State Lighting (cont'd)

Costly, but potential for prices to fall

- DOE study: now $1,700+/klm

Lamp type	Cost ($/klm)
Halogen	2.5
CFL	2
Fluorescent T8	4
LED (60W A19)	30
OLED luminaire	1,700

Source: E Source, data from DOE

If the Fan Belt Breaks on the Rooftop, Does Anyone Hear It?

The Importance of Fault Detection and Diagnostics

E Source

How Much do you Trust your HVAC Technician?

	Technician identifier												
Task description	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**
Thermostat													
Registers													
Air filter													
Temperature split across coil													
Furnace													
Electrical													
Line and duct insulation													
External static pressure													
Airflow													
Ducts													
Condenser coil													
Motor amps													
Biological contamination (mold)													
Refrigerant charge													
Evaporator coil													

This is What They Attempted to Look at

O Task attempted

	Technician identifier												
Task description	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**
Thermostat	O	O	O		O		O	O					
Registers		O		O		O			O	O			
Air filter	O	O	O		O		O	O	O		O	O	
Temperature split across coil	O	O				O		O		O		O	
Furnace	O		O	O	O							O	
Electrical	O		O	O	O	O	O	O	O		O		
Line and duct insulation		O	O	O	O	O		O	O		O	O	
External static pressure	O	O											
Airflow	O	O											
Ducts	O	O	O	O	O	O			O		O	O	
Condenser coil			O	O	O	O	O				O	O	
Motor amps	O			O	O	O	O	O			O		
Biological contamination (mold)		O	O	O	O		O		O				
Refrigerant charge	O	O			O	O	O						
Evaporator coil													

But Minimal Success

● Task done correctly ○ Task attempted, but not done correctly

	Technician identifier												
Task description	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**
Thermostat	●	●	●		●		○	●					
Registers		●		○		●			●	●			
Air filter	○	○	●		○		●	○	○		○	○	
Temperature split across coil	●	●				○		○		○		○	
Furnace	●		○	●	○							○	
Electrical	●		○	○	○	○	○	○	○		○		
Line and duct insulation		○	○	●	○	○		○	○		○	○	
External static pressure	●	○											
Airflow	●	○											
Ducts	○	○	○	○	○	○			○		○	○	
Condenser coil			○	○	○	○	○				○	○	
Motor amps	○			○	○	○	○	○			○		
Biological contamination (mold)		○	○	○	○		○		○				
Refrigerant charge	○	○			○	○	○						
Evaporator coil													

This is What They Missed

● Task done correctly ○ Task attempted, but not done correctly ■ Did not attempt

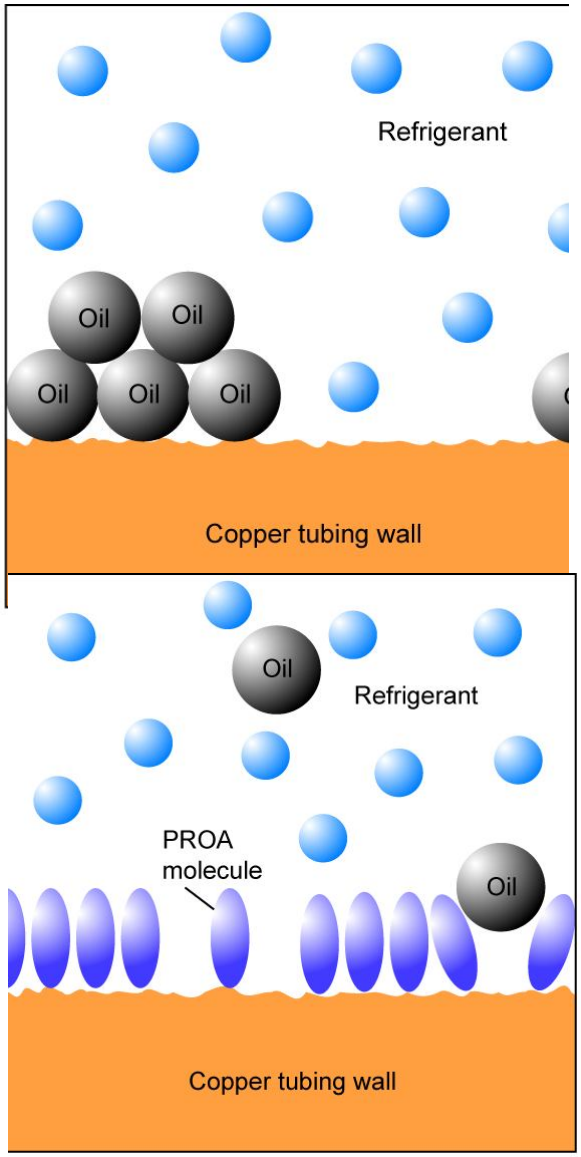
	Technician identifier												
Task description	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**
Thermostat	●	●	●		●		○	●					
Registers		●		○		●			●	●			
Air filter	○	○	●		○		●	○	○		○	○	
Temperature split across coil	●	●				○		○		○		○	
Furnace	●		○	●	○							○	
Electrical	●		○	○	○	○	○	○	○		○		
Line and duct insulation		○	○	●	○	○		○	○		○	○	
External static pressure	●	○											
Airflow	●	○											
Ducts	○	○	○	○	○	○			○		○	○	
Condenser coil			○	○	○	○	○				○	○	
Motor amps	○			○	○	○	○	○			○		
Biological contamination (mold)		○	○	○	○		○		○				
Refrigerant charge	○	○			○	○	○						
Evaporator coil													

Polarized Refrigerant Oil Additives

BEWARE

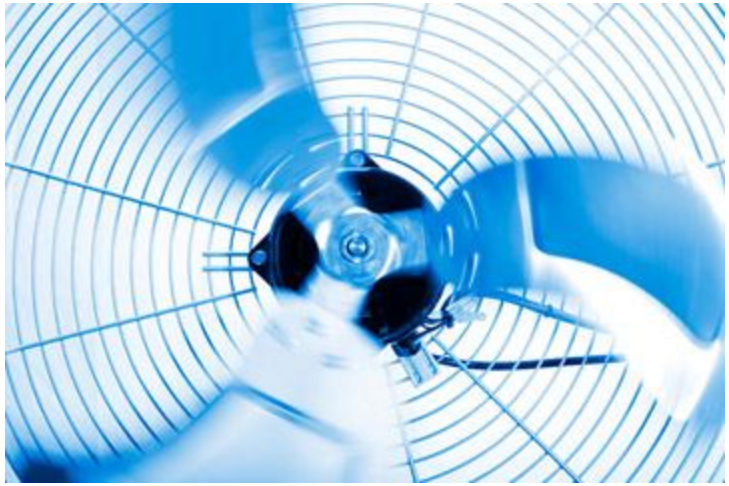
- Allegedly boosts heat transfer by displacing oil film
- Vendors claim 5-30% energy savings
- Theoretically possible savings only approach 2%, unsubstantiated in reality
- At typical costs ($50-100/ton cooling), a 2% payback is not cost-effective

By the way, general maintenance of a RTU alone can save 11% to 42%



Fault Detection & Diagnostics (FDD) for HVAC

Low cost minimalist diagnostics that work



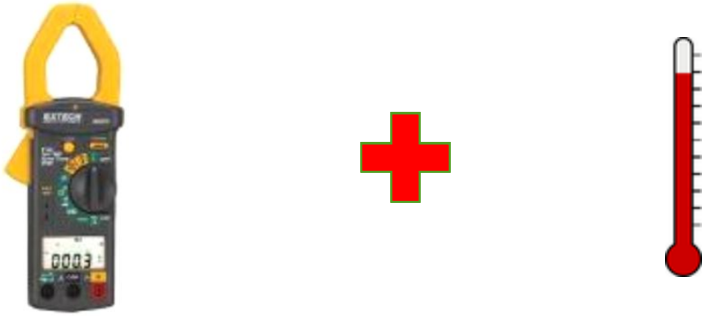
Minimalist Approach: Using Sound

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

Minimalist Approach: Using Power

- SMDS (Smart Monitoring and Diagnostic System)
  - Northwrite/Pacific Northwest National Laboratory
  - True power meter + outdoor air temperature => finds faults, estimates waste
  - Less than $200 installed
  - Release: end of 2012 or early 2013



Source: Extech Instruments, Open Clip Art Library; Courtesy: Northwrite

Fault-Finding Made Easy

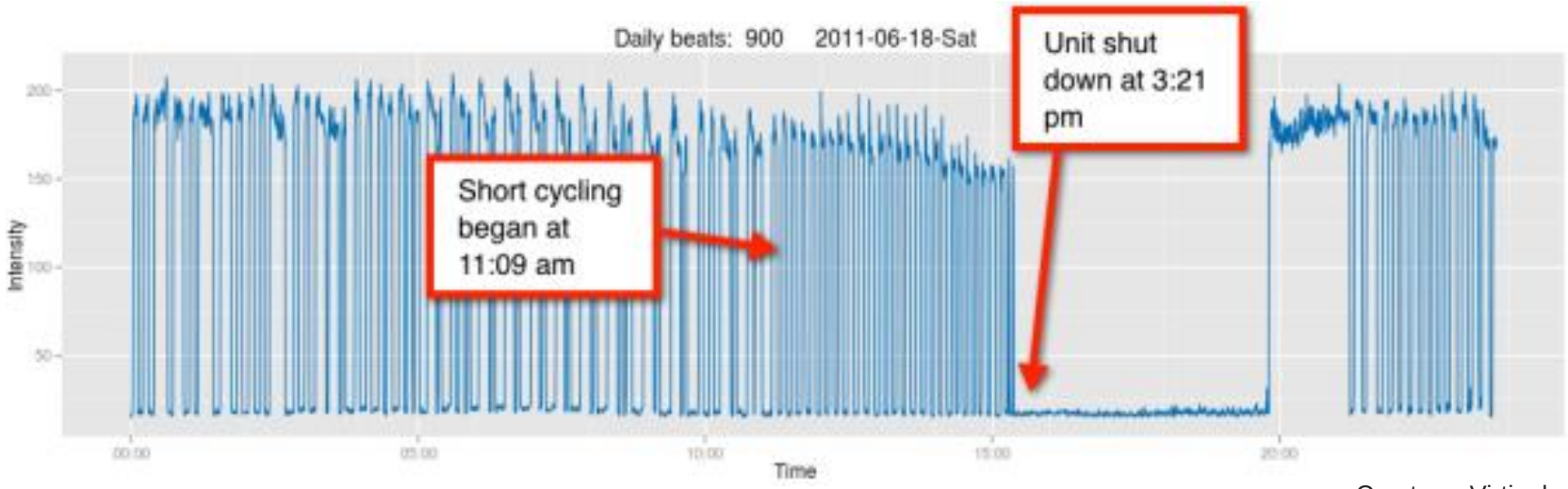
- Runtime outside business hours
- Economizer opportunities
- Short cycling
- Condenser fan failure
- Compressor failure
- Refrigerant leaks
- High head-pressure faults

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

RTU VFDs and Controllers

- Catalyst

  Transformative Wave Technologies

- Enerfit

  Enerfit LLC

- Digi-RTU Optimizer

  DTL Controls

- Unnamed controller (available late 2012)

  Optimum Energy

Sources: Transformative Wave Technologies, Enerfit, and DTL Controls

Variable-Frequency Drives (VFDs)

Product	Evaporator fan	Condenser fan	Compressor
Catalyst	✓		
Enerfit	✓		
Digi-RTU	✓		✓
Optimum's controller	✓	✓	✓

Source: Wikimedia Commons

Built-in Controls

Product	DCV	Economizer controls	Web interface	FDD
Catalyst	✓	✓	Optional	Some
Enerfit	✓	✓ (V2)	Optional	Some
Digi-RTU	IP	IP	Optional	IP
Optimum's controller	IP	IP	Standard	Some

Notes: DCV = demand-controlled ventilation; FDD = fault detection and diagnosis; IP = in progress; V = version.

Manufacturer's Claims

Product	Annual HVAC Energy Savings (%)	Simple Payback Period (years)	Cost ($)
Catalyst	25-40%	2	$4,000 (15 ton)
Enerfit	50-70%	1-3	$4,700 (20 ton)
Digi-RTU	45-64%	1-4	$3-10,000 (<20 ton) $5-20,000 (>20 ton)
Optimum's	25-45%	NA	NA

Plus:

- Better humidity control
- Reduced maintenance

What We Knew from Last Year

Testing organization	Product	Savings/payback	Sample size
Omaha Public Power District (OPPD)	Digi-RTU	41% kW, 52% kWh 20–60% range	24 RTUs, 2010 +6 RTUs, 2011
Snohomish County PUD	Catalyst	48% kWh	1 facility
TES Engineering	Enerfit	2.0- to 3.5-year payback: ➡ 9 of 11 buildings Not cost-effective: ⟶ 2 of 11 buildings	

Notes: kW = kilowatts; kWh = kilowatt-hours.

Source: Wikimedia Commons

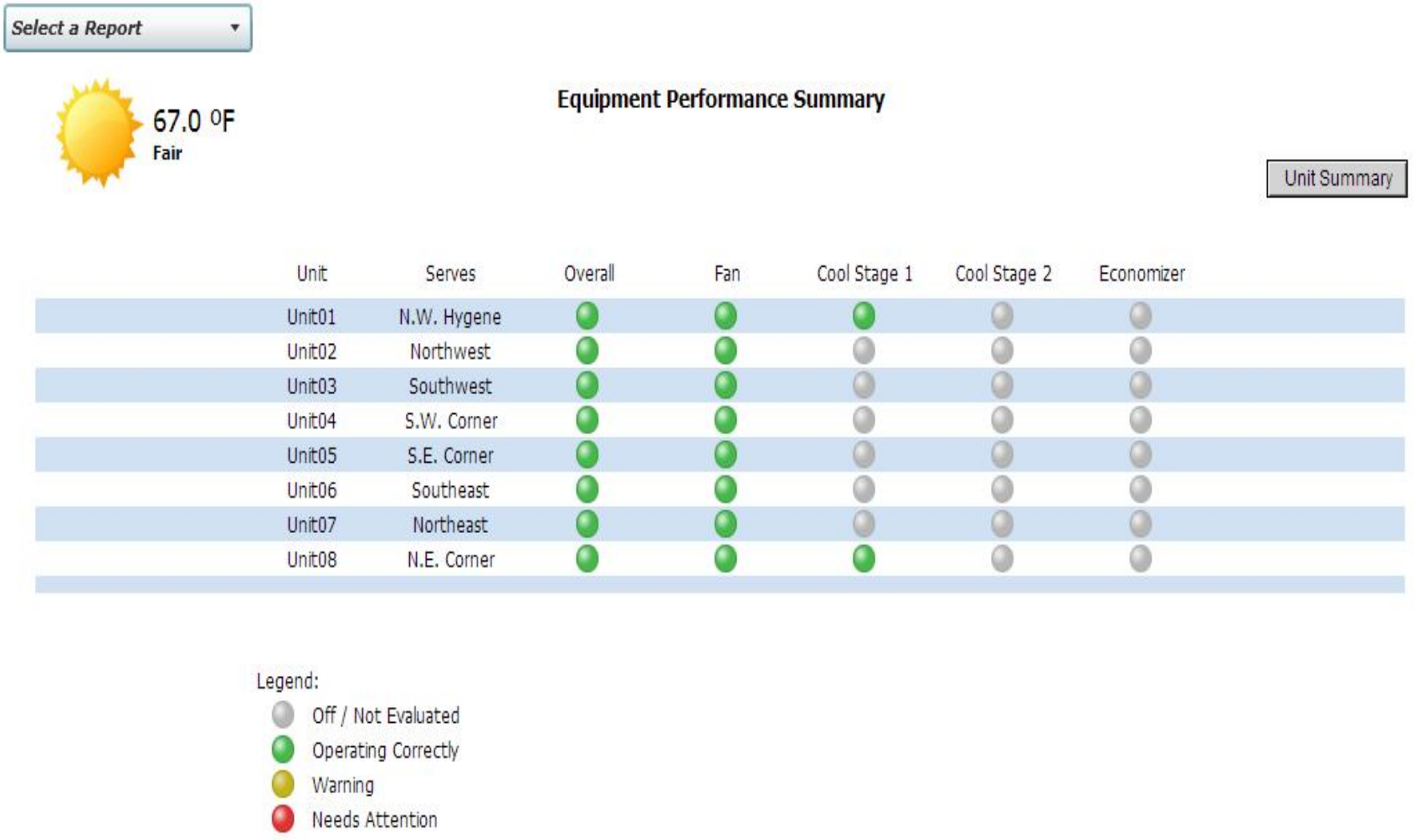
Latest Results

Testing organization	Product	Savings	Sample size
Snohomish County PUD	Catalyst	17–18% kW, ~20% kWh	2 Drugstores
Southern California Edison	Catalyst	12–35% fan electricity savings	3 RTUs
National Renewable Energy Lab	simulation	29–75% annual fan electricity savings	16 U.S. cities, big-box retail
Pacific Northwest National Lab	simulation	14–56% annual HVAC energy savings	16 U.S. cities, 4 building types

Notes: kW = kilowatts; kWh = kilowatt-hours.

Source: Wikimedia Commons

Catalyst Fault Detection & Diagnostics Dashboard



Courtesy: Transformative Wave Technologies

Catalyst FDD: Details

Cumulative faults for this site from 9/23 thru 9/30

Filter current faults by rule > [▾] Reset Filter

Current Faults	Unit	Duration	Definition
MixedTempConstant	Unit 2	21:57	If MaTemp does not change for 1 hour
FanStatusFailure DriveLock	Unit 4	17:03	If FanStatusFailrue = true
InsufficientRiseOnHeatStage1	Unit 3	19:00	If DaTemp does not change by 5 Deg after Heat1 Call
InsufficientRiseOnHeatStage2	Unit 3	23:21	If DaTemp does not change by 5 Deg after Heat2 Call
DischargeTempBelowLimit	Unit 1	3:48	If DaTemp < 40

Fault Detection Rules applied to this Site

Rule Name	Definition
CO2 Constant	CO2 Value Does not Change for more than 2 hours
CO2HighDamperNotOpen	If CO2 > 1000 PPM, and OSA Volume < 20%
CO2HighAirVolumeLow	If CO2 > 1000 PPM, and OSA Volume < 20%
CO2OverLimit	If CO2 > 1500 PPM
CO2UnderLimit	If CO2 < 300 PPM
ControllerDown	If ControllerDown = True, enabled even when the fan is off
CoolCallDurationExceeded	If CoolCall is True > 45 Min

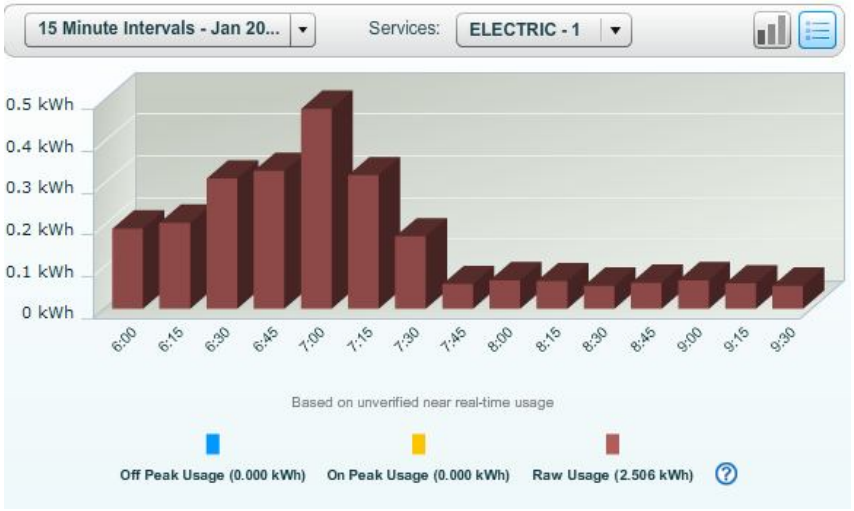
Courtesy: Transformative Wave Technologies

Ultrasonic Leak Detectors

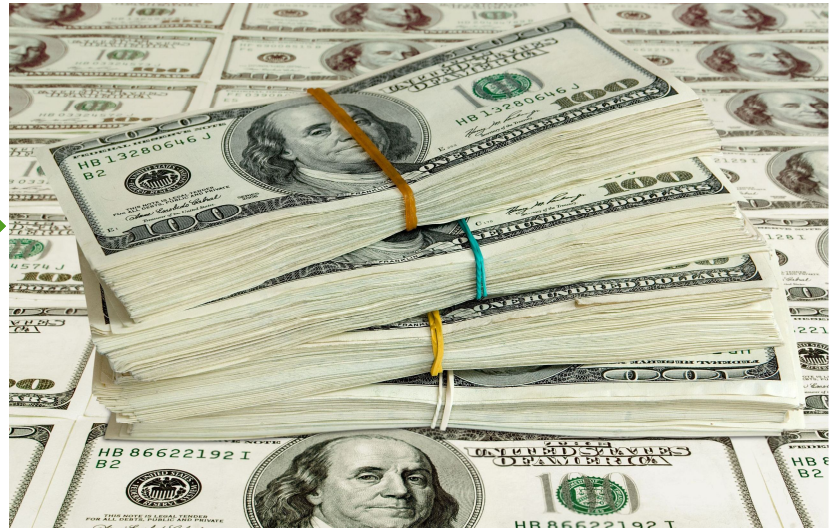
- Compressed air system leaks waste 20% to 30% energy
- Use acoustic sensors to detect sounds in the ultrasonic frequency range and can identify and locate leaks
- Portable and easy to use
- Cost $1,000 to over $15,000
- Payback typically measured in weeks

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

New Age Simple Building Analytics Turning Data into Easy Savings

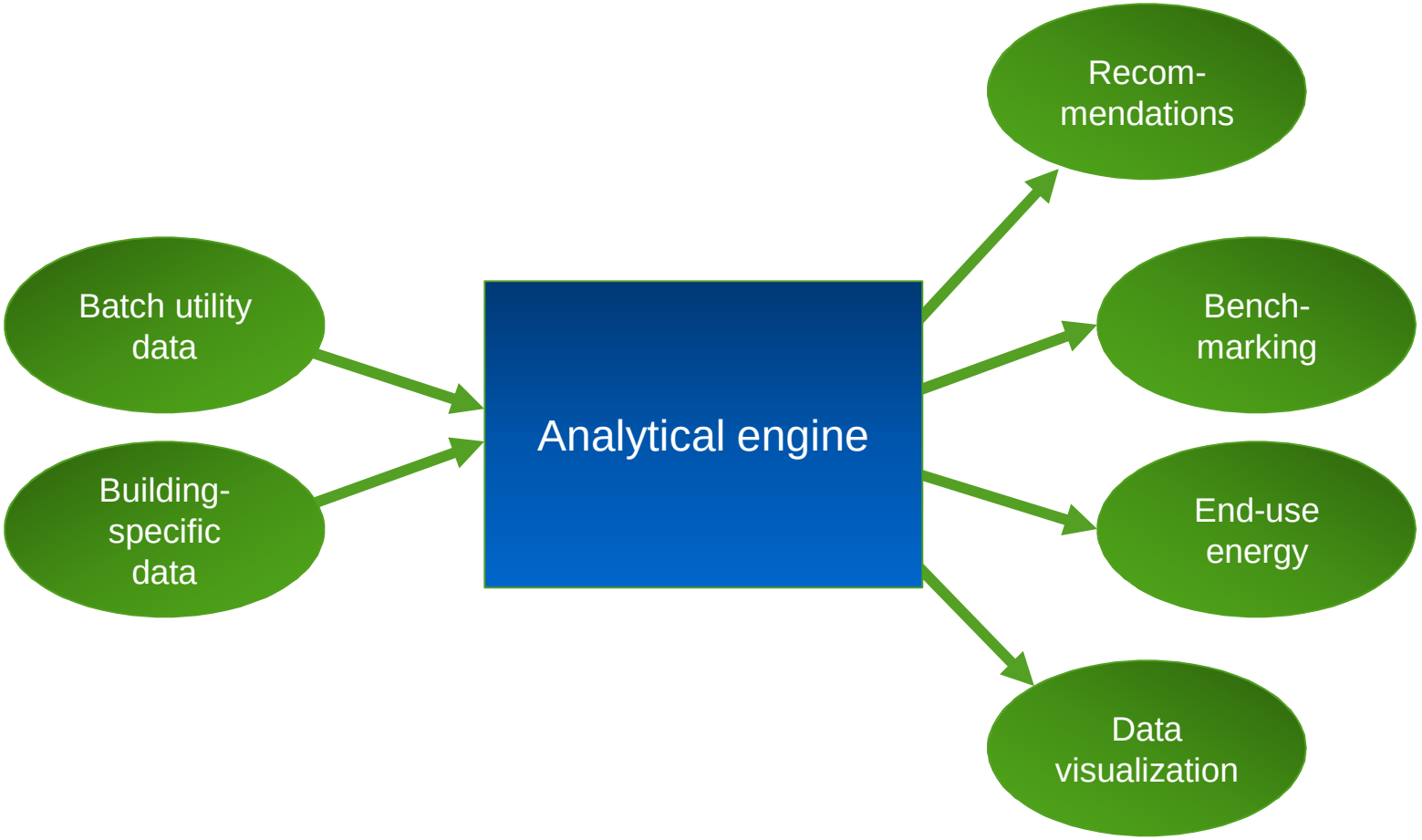


Source: Xcel Energy

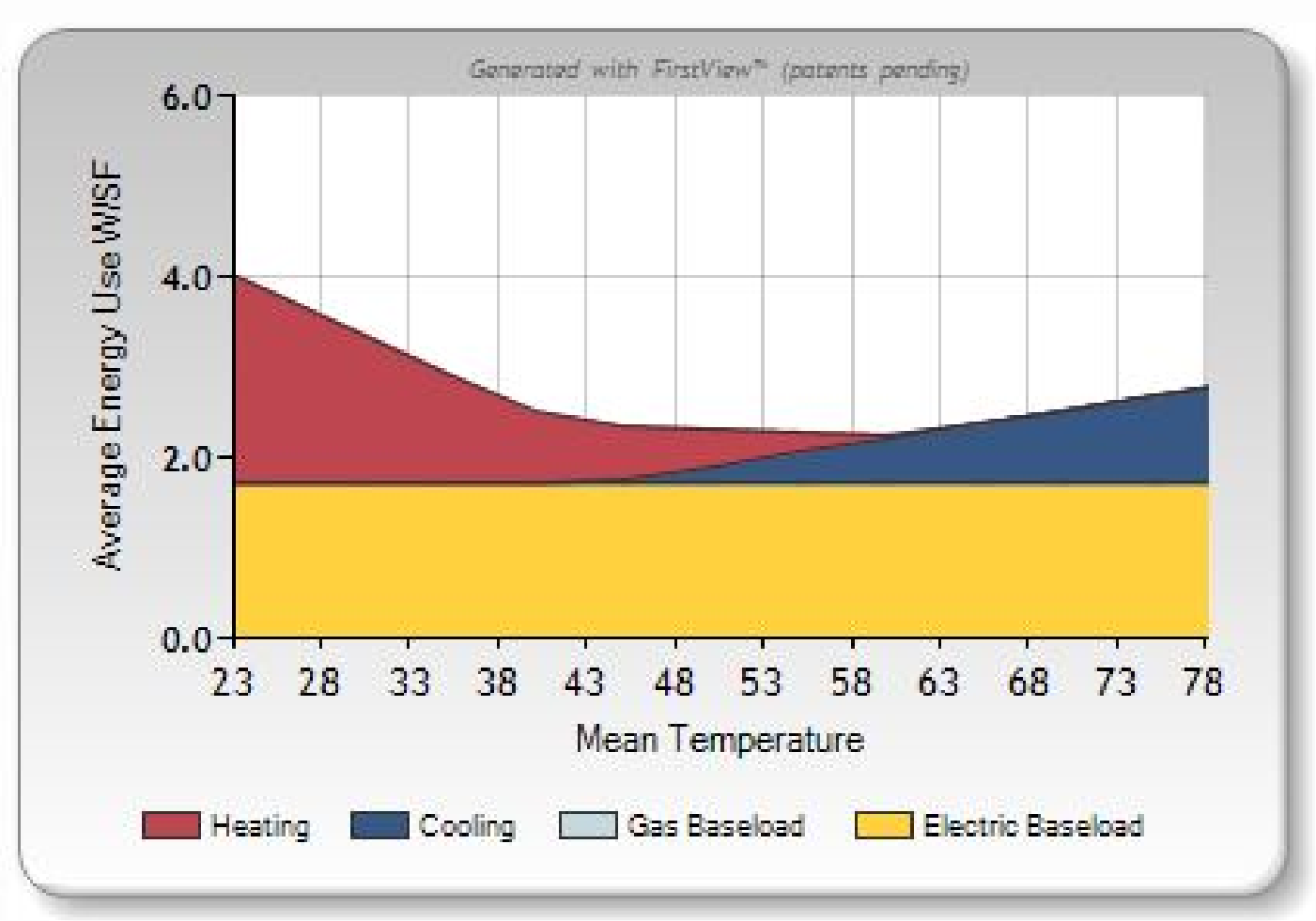


Source: 123RF.com

How It Works

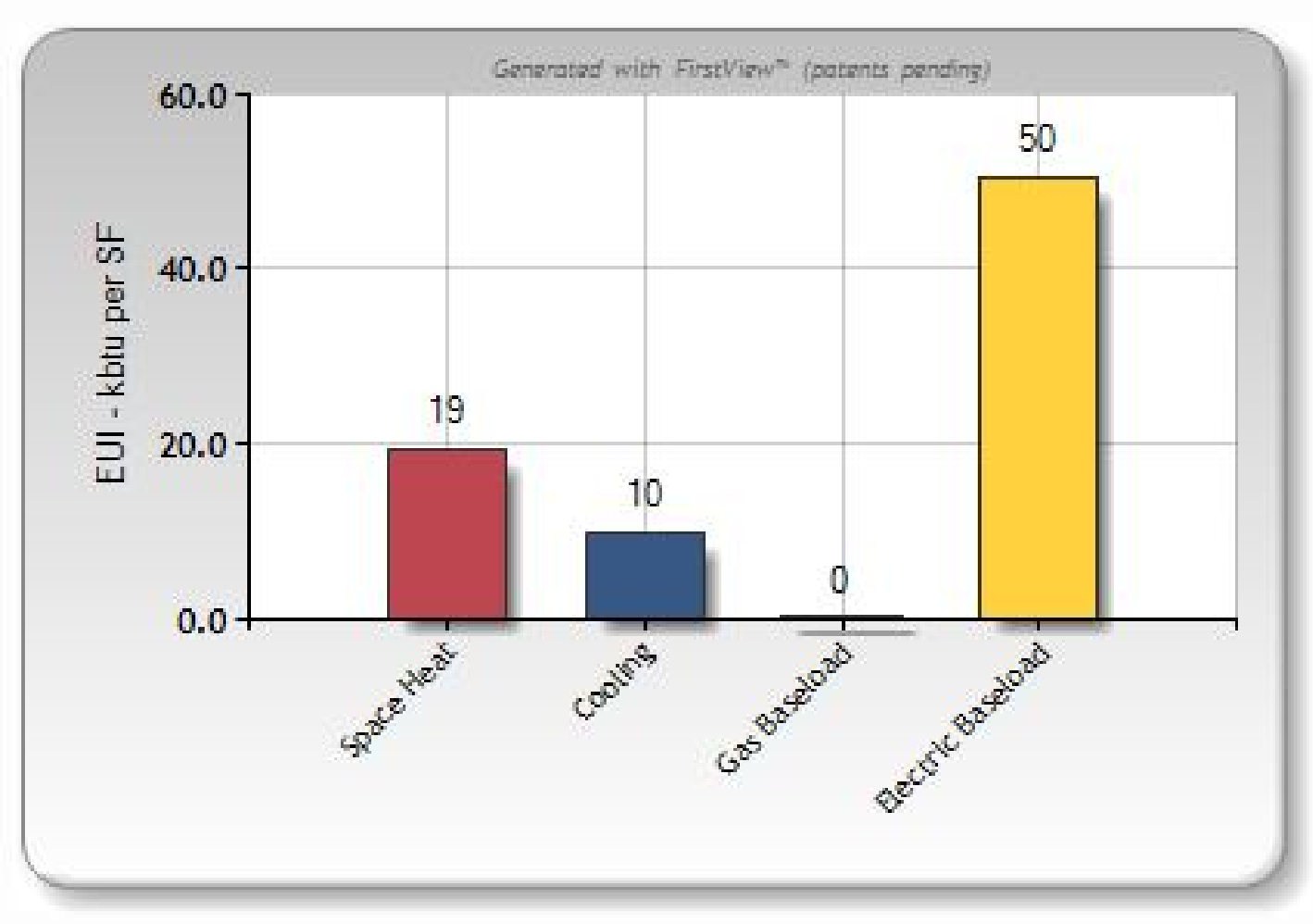


The Energy Signature



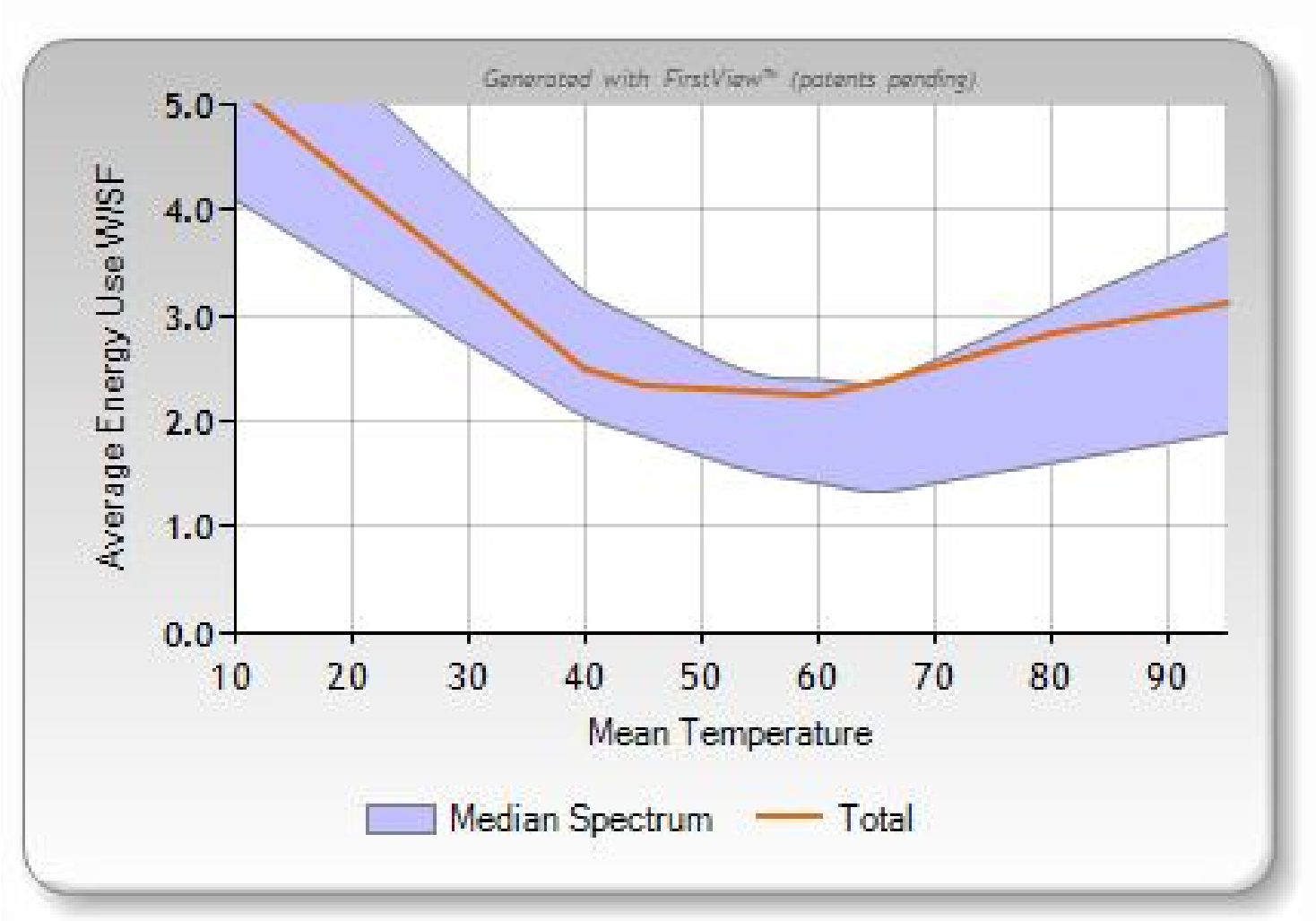
Source: New Buildings Institute

Electric Base Load Looms Large



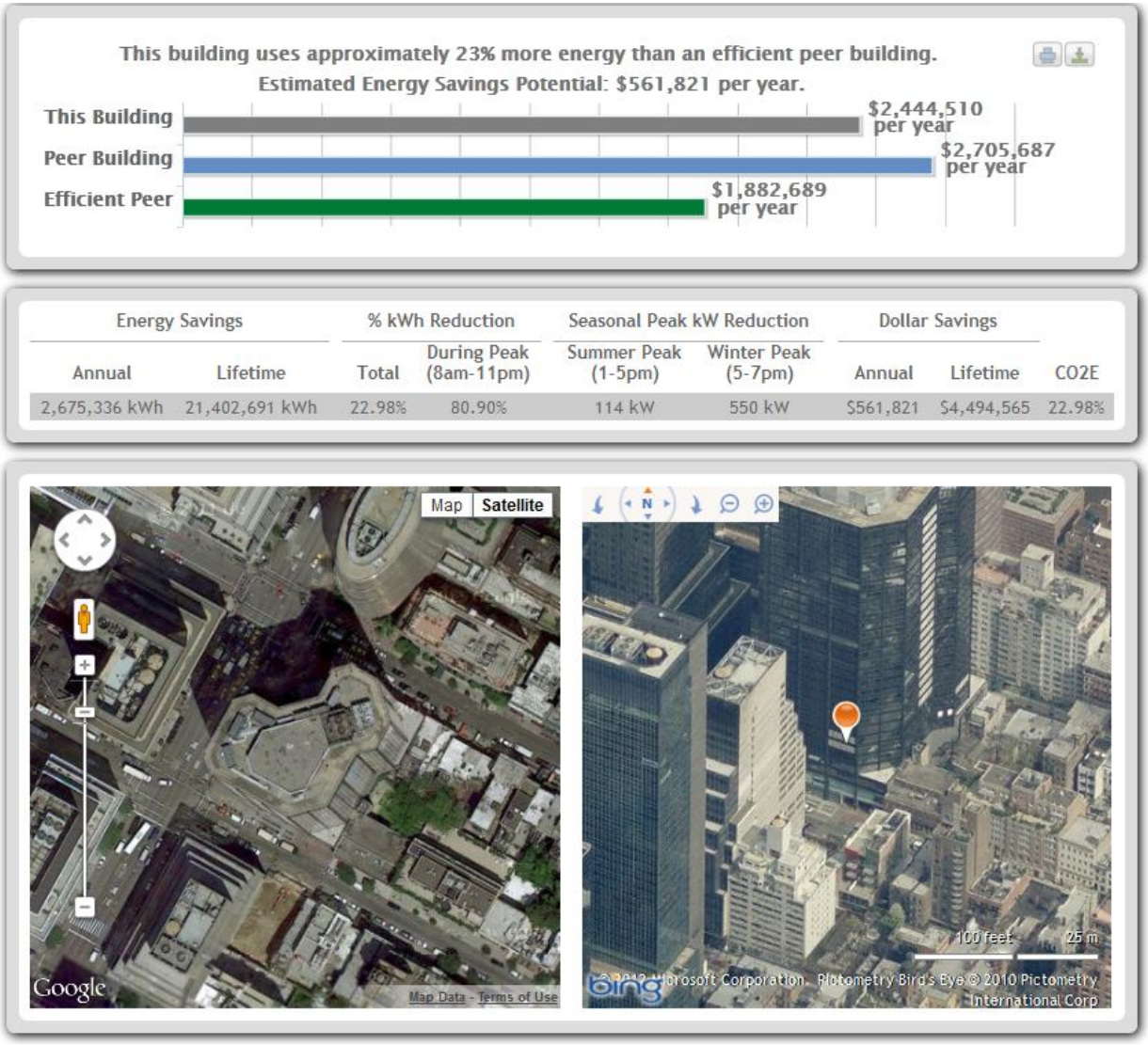
Source: New Buildings Institute

Looks Like AC Is a Problem



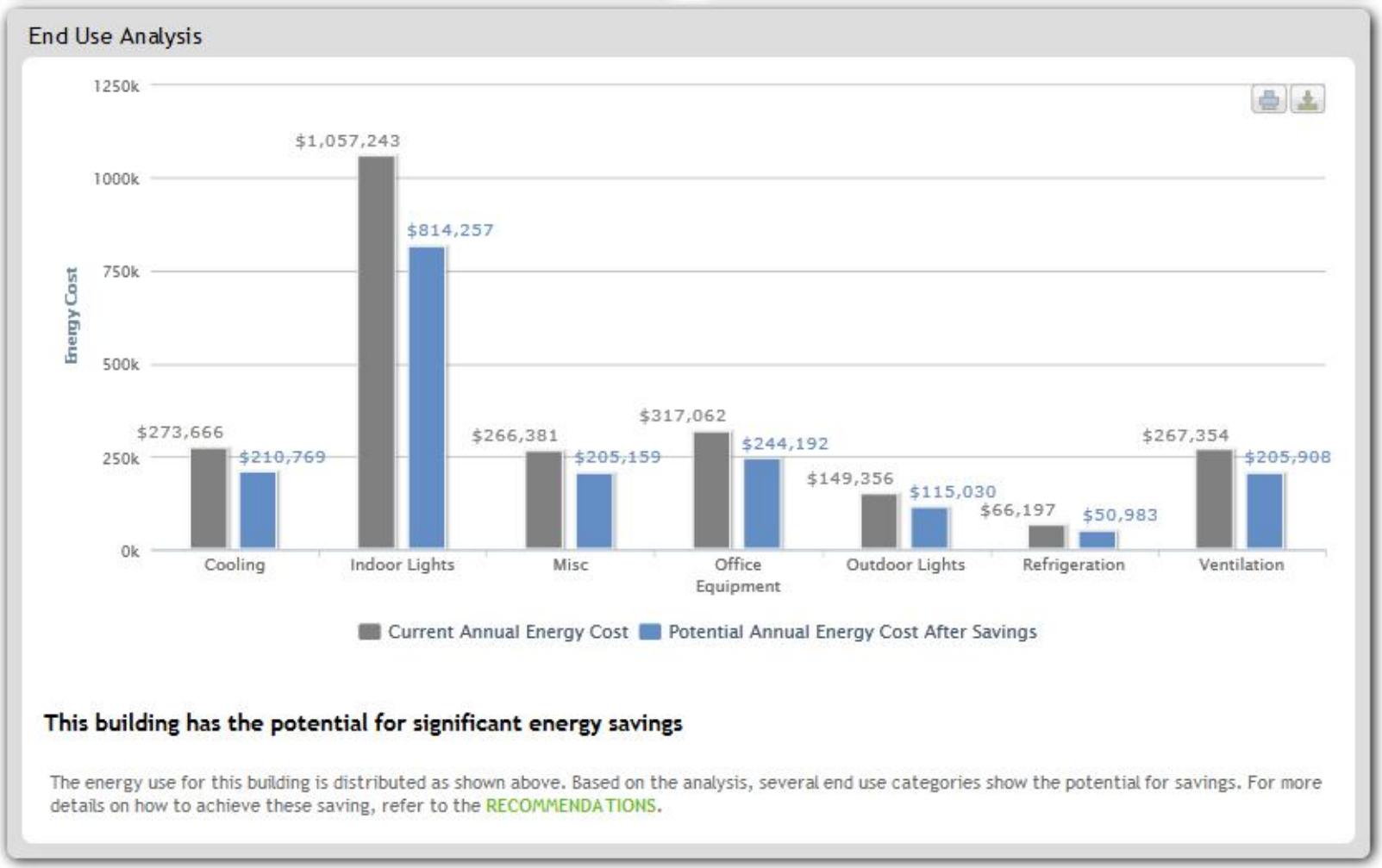
Source: New Buildings Institute

A Product From Retroficiency



Courtesy: Retroficiency

Maybe Lighting Is a Good Place to Start



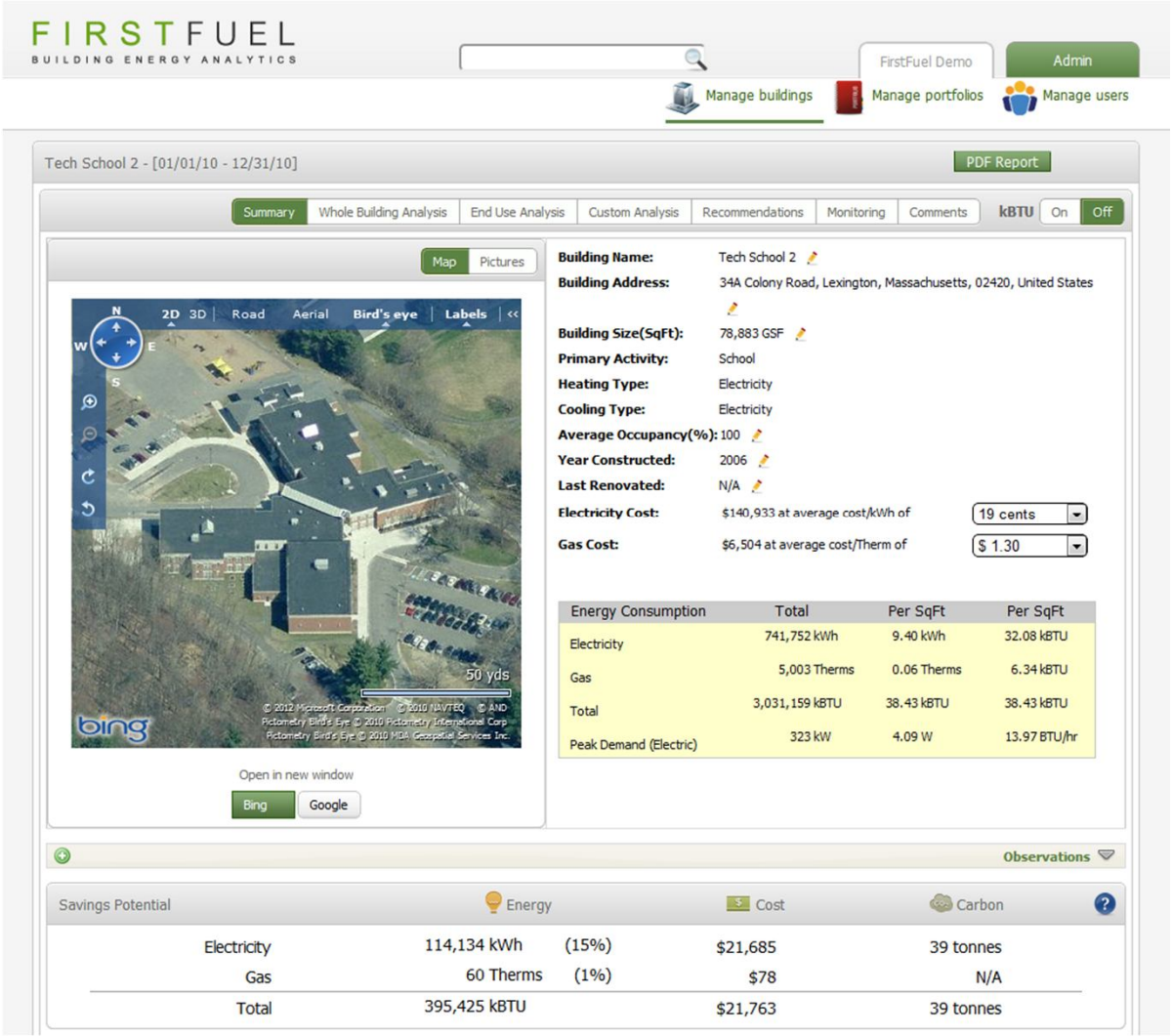
Courtesy: Retroficiency

Who's Leaving the Lights On?

	Annual Dollar Savings	Annual kWh Savings	Annual Energy Savings	Annual COE2 Savings
Lighting Controls				
 This building appears to have above average energy consumption associated with lighting during unoccupied hours. The annual average power density of this building for indoor lights during unoccupied hours is approximately 0.76 W/ft². A detailed Lighting specific controls audit, daylighting study, and/or retro-commissioning study is recommended. This suggests energy savings are associated with this indicator.	$78,808	375,278	3.2%	375 tons
Ventilation Equipment				
 Based on the interval data and our relativity database of similar buildings, this building appears to have considerable energy consumption associated with the ventilation equipment during occupied hours. The annual average power density of this building for ventilation during occupied hours is approximately 0.29 W/ft². We recommend a detailed HVAC equipment audit, including variable flow air side measures. This suggests significant potential for energy savings associated with this indicator.	$31,267	148,892	1.3%	149 tons

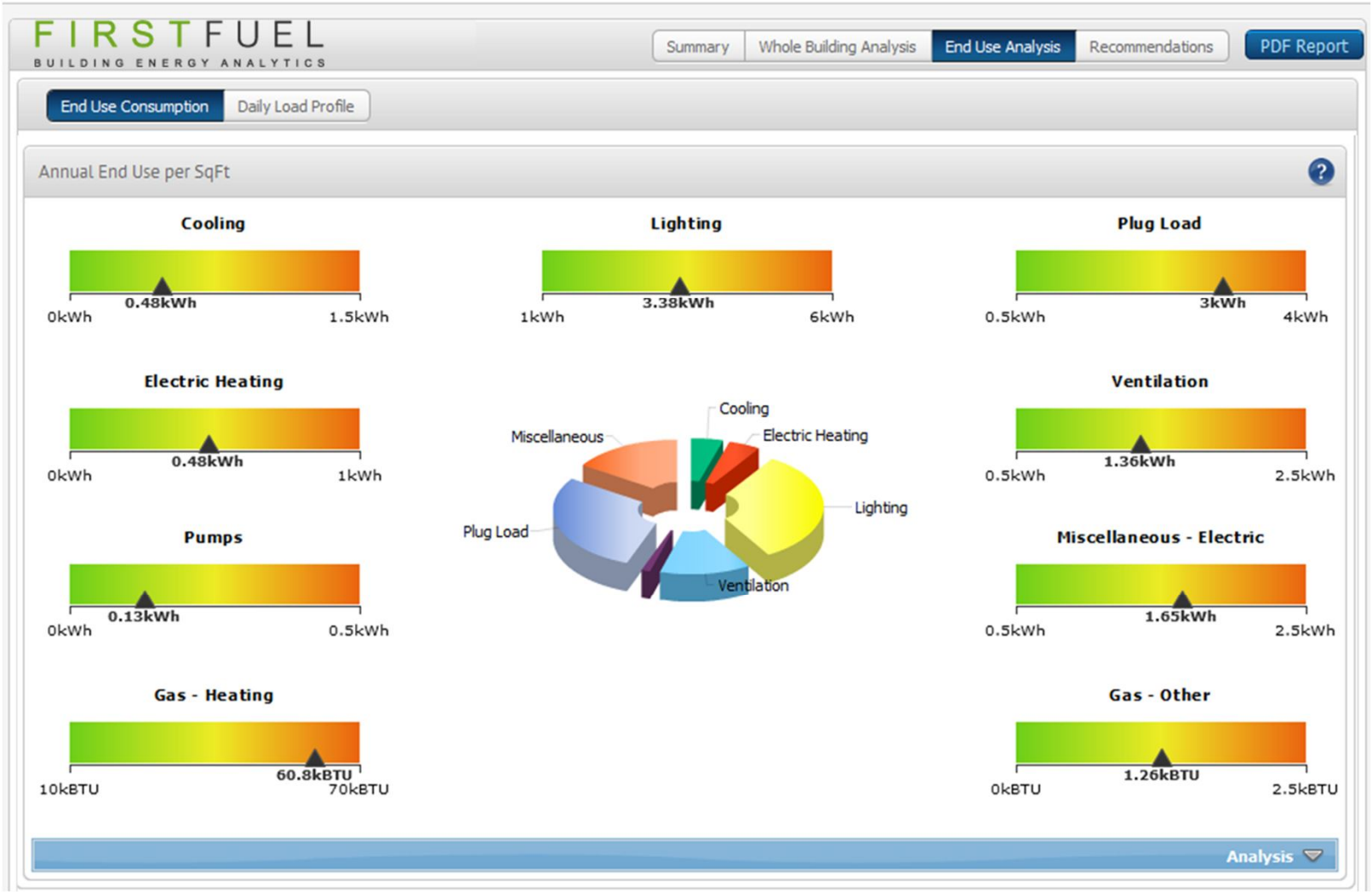
Courtesy: Retroficiency

Bird's-Eye View



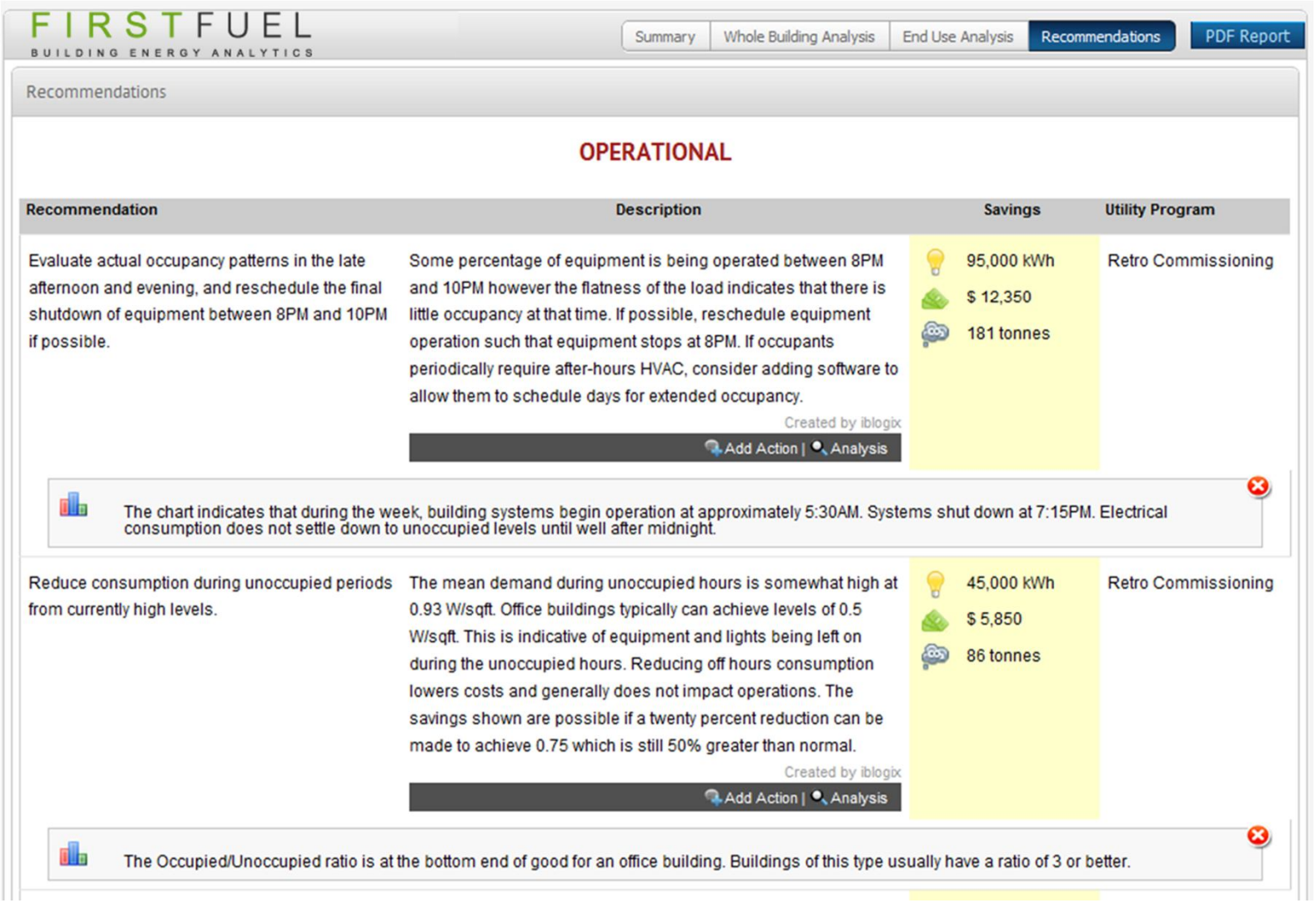
Courtesy: FirstFuel

End-Use Benchmarking



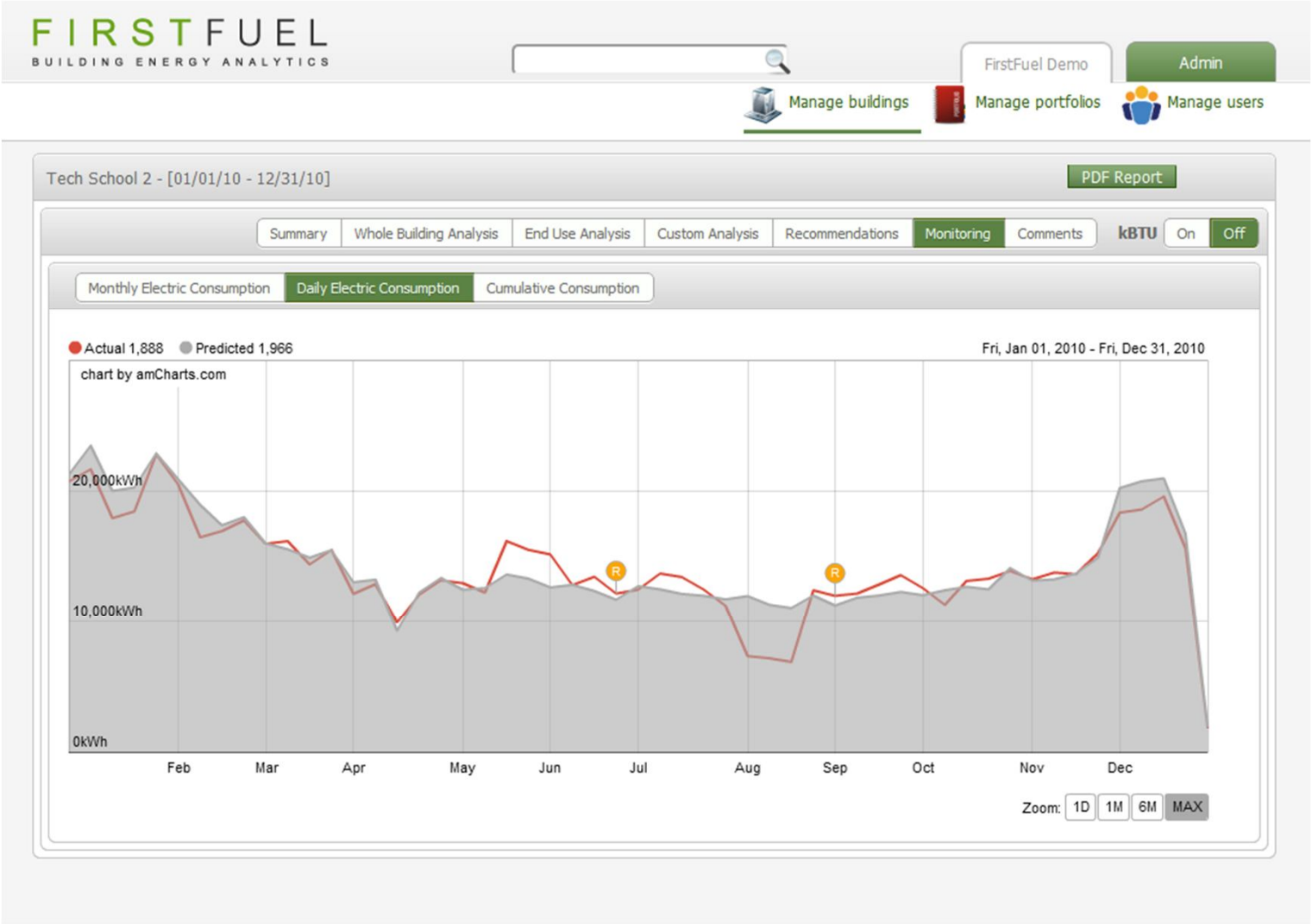
Courtesy: FirstFuel

Candidate for a Midnight Audit?



Courtesy: FirstFuel

The Model Versus Reality



Courtesy: FirstFuel

Caution

Source: CKSinfo.com

- Lack of independent cost and savings information
- Confusion about quality
- Savings depend on motivation and skill
- Savings depend on building characteristics

Direct Contact Water Heaters

How Efficient is Your Water Heater?

Courtesy Sir Iwan

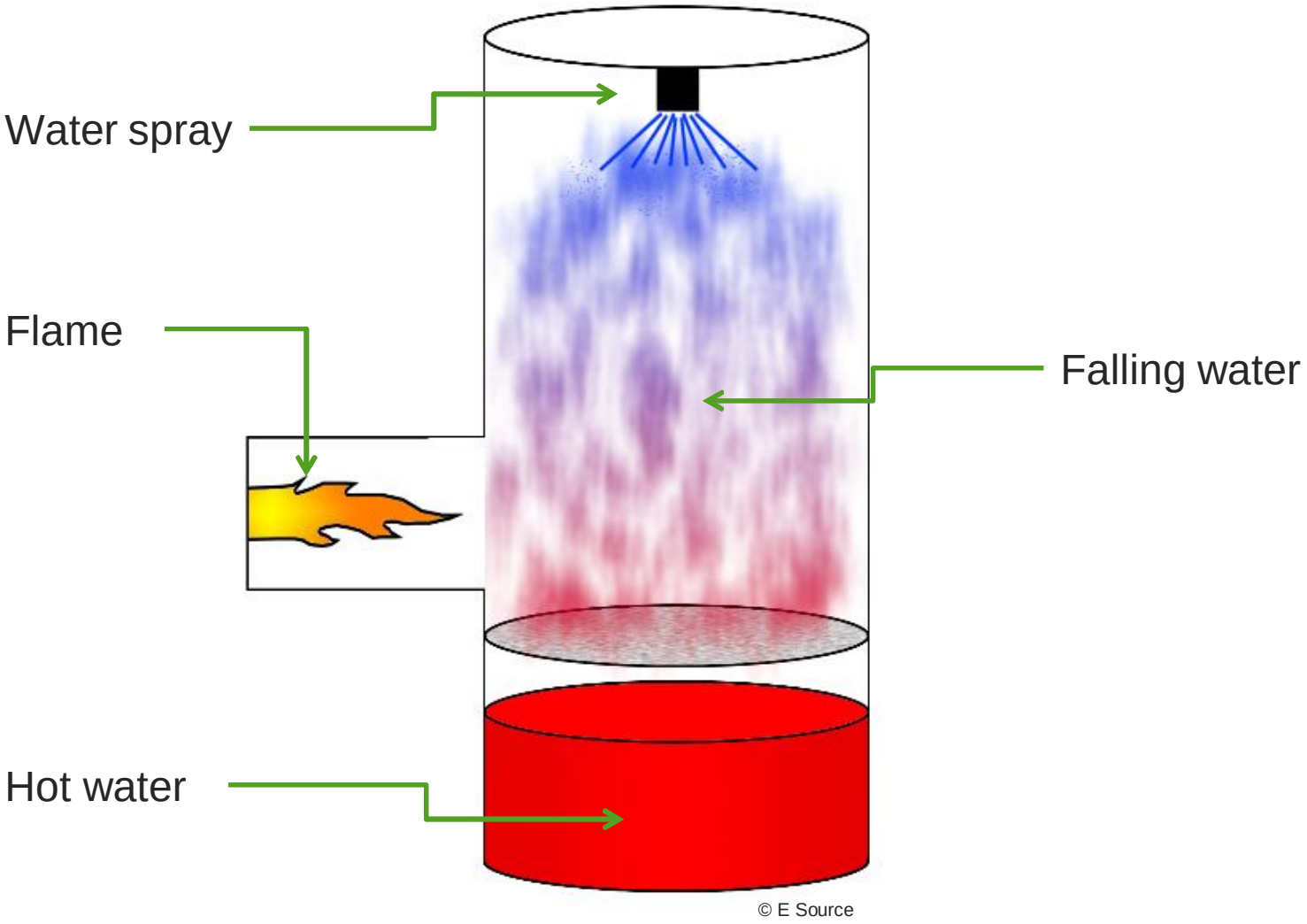
If you're using conventional equipment, you may be missing out on large cost-effective energy savings.

What is a Direct Contact Water Heater?

- No heat exchanger
  - Water comes into physical contact with combustion gases
- Hot water produced as needed
  - Minimal standby loss
- Up to 99.7% efficient!
  - Can yield energy savings of up to 60% in the right applications

Courtesy Ludell Manufacturing

How it works



Minimal maintenance requirements

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

Courtesy Department of Agriculture

Some Important Differences…

- Incomplete combustion can hurt water quality
  - However, a number of models do meet bottled water and food ingredient water standards for direct use without additional filtration.
- Capacities of up to 54 MMBTU per hour
  - Can produce lots of hot water very quickly

- Low-temperature exhaust
- Hot water is unpressurized
  - Differs from a standard boiler or tank heater
  - Requires pumping to the end use

Image Courtesy the Tango Project

What are some good applications?

- Boiler make-up water
- Washing/flushing
  - Equipment “clean-down” and sanitizing
  - Continuous washing operations
  - Flushing process piping and batch equipment (particularly for operations using the same process lines/equipment to produce slightly varying products)
- Heating jackets for vessels/operations
- Space heating
- Hot water used as a solvent
  - Raw material preparation
  - Leaching
  - Separations/extractions
  - Emission control operations

Some Industries That Could Benefit

- Pharmaceuticals
- Textiles
- Laundry
- Greenhouses
- Warehouses

Courtesy NVO

- 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 terry cloth 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: ~$150,000
- Results
  - Went from a thermal efficiency of 60% up to 99.7%
  - 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.

Who makes them?

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

Courtesy Ludell Manufacturing

Turbo Pot

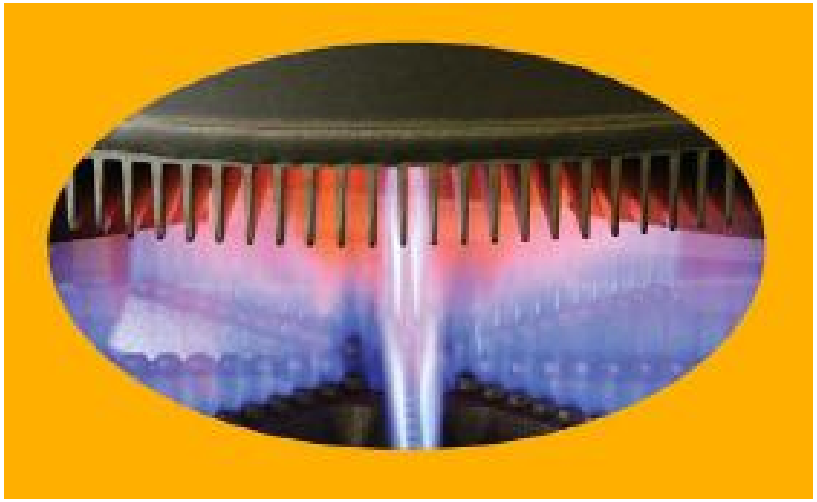
Courtesy: Eneron, Inc

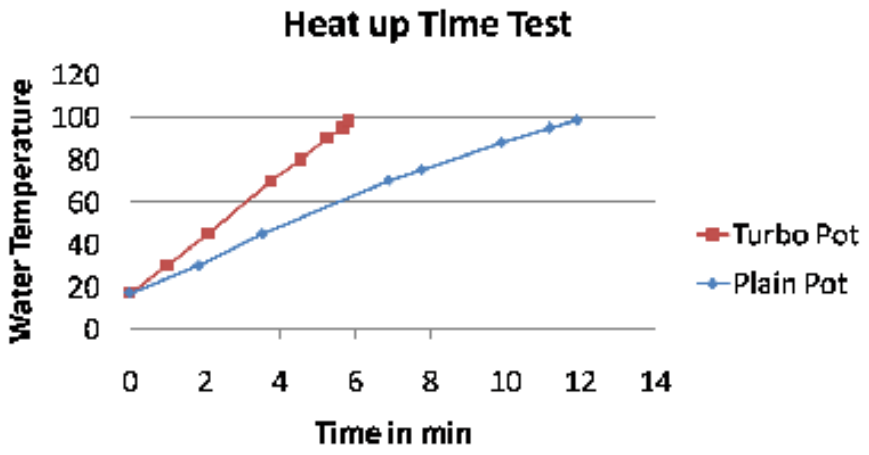
- Affixes heat transfer fins to standard commercial cooking pots.
- Fins guide flames into channels, create turbulent flow
- Increases heating surface area and heat transfer efficiency
- Can boost energy efficiency 50% – 60%

Performance

Cooks faster using less energy

- Turbo Pot consumed 28% less energy than the standard pot
- Boosts a 35% efficient gas range to nearly 60% efficiency
- And, it boils water faster!





Courtesy: Eneron, Inc

Thank You!

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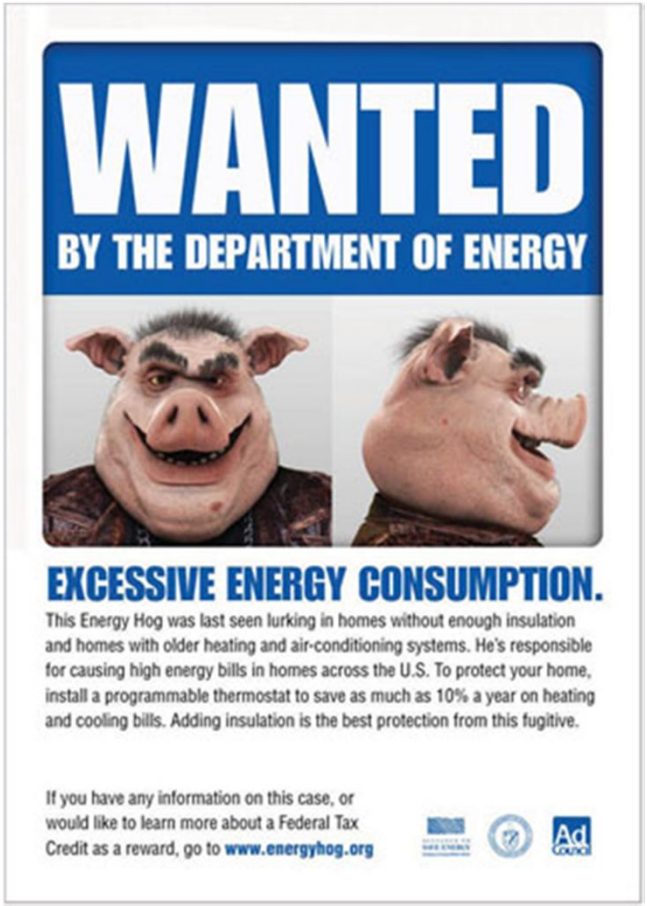

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