Next Generation Technologies for Utility DSM Programs

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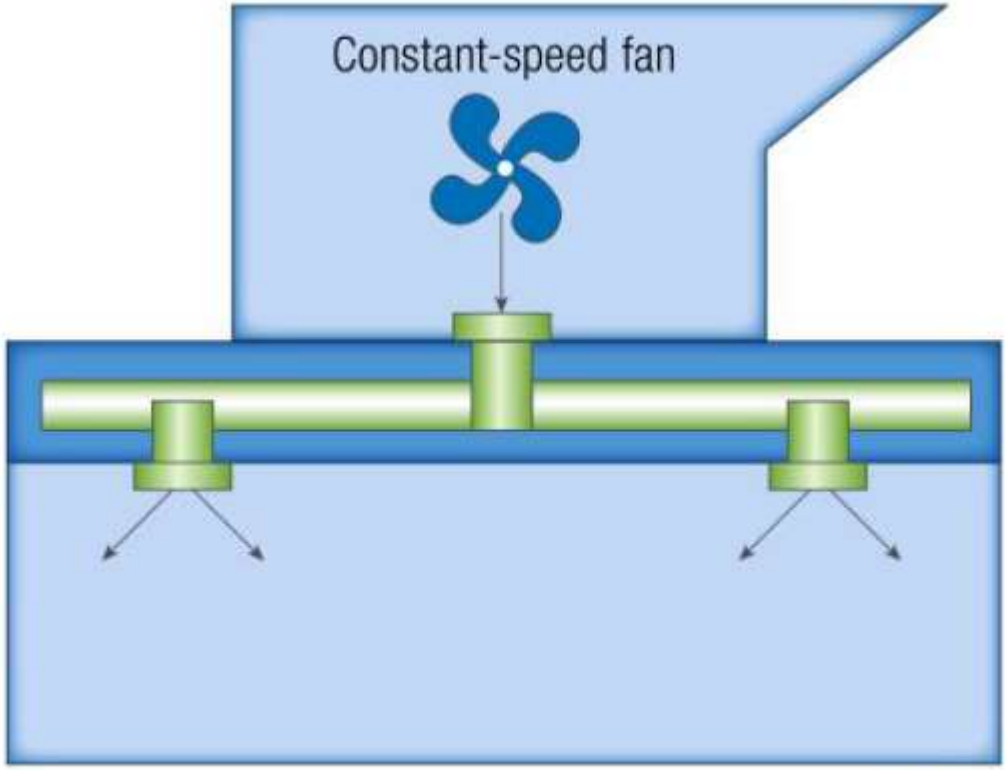
E Source

Variable Frequency Drives for Rooftop Units - Ready for Prime Time

E Source

Single Zone RTUs are UNINTELLIGENT Machines

- One zone
- Fixed fan speed
- Fan either on or off
- Ventilation kept at 100% when building is occupied



Single Zone Rooftop Units are EVERYWHERE

- About 50% of all commercial buildings have RTUs installed
- If half of those were retrofitted, would be equivalent to removing 70 coal powered power plants

RTU Variable-Frequency Drive Retrofit Devices

- Catalyst

  Transformative Wave Technologies

Source: Transformative Wave Technologies

- Enerfit

  Enerfit LLC

Source: Enerfit

- Digi-RTU Optimizer

  Bes-Tech (DTL Controls)

Source: Bes-Tech

Different Strokes for Different Folks

Product	VFD evaporator fan	VFD compressor	VFD type	Damper for coil 2
Catalyst	✓		Indexed	
Enerfit	✓		Continuous	✓
Digi-RTU	✓	✓	Continuous	

Note: VFD = variable-frequency drive.

Source: Wikimedia Commons

Source: Enerfit

All Provide Additional Features

- Demand-controlled ventilation
- Integrated economizer control
- Web control and monitoring
- Fault detection and diagnostics

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 savings when in ventilation only mode
- Average simple payback of 3 years at $0.10/kWh

Newest Results Continue to be Positive – SDG&E Study

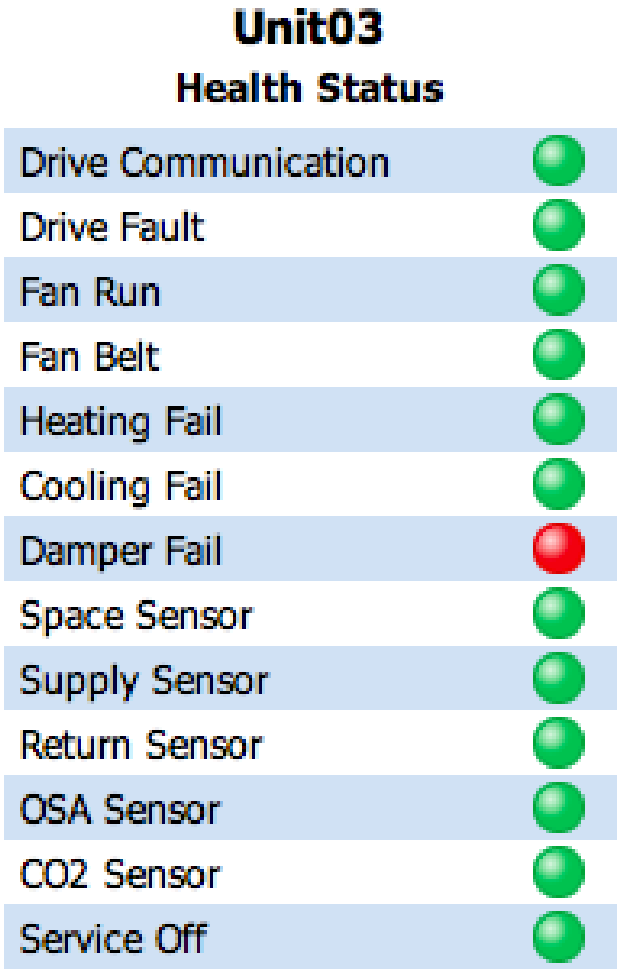
- SDG&E Study published November 2013:
  - 2 different manufacturers – kept anonymous
  - 1 installation per manufacturer
  - 1 building in San Diego, CA

Device	Variable Speed Evaporator Fan	Variable Speed Compressor	Demand Controlled Ventilation (DCV)	Economizer controls	Fault Detection and Diagnostics (FDD)	Savings
Unit 1	✓	✓				27%
Unit 2	✓		✓	✓	Some	26%

In Addition to Energy Efficiency

Courtesy: Transformative Wave Technologies

Fault Detection and Diagnostics



Courtesy: Transformative Wave Technologies

System Monitoring

72.0 °F
Clear

Scottsdale
7111 E. Mayo Blvd.

Unit Name	Serves	Comm	Mode	Health	Occ	Fan Call	Comfort Status	Space Temp	Actual Heat S/P	Actual Cool S/P	Fan Status	Fan Speed	Fan Power	Cooling 1	Cooling 2	Heating 1	Heating 2	Supply	Return	OSA	CO2	OSA Volume
Unit01	Sales Seafood							71.6 °F	70 °F	73 °F		40 %	0.34 kW					80.3 °F	77.5 °F	87.9 °F	446 ppm	-
Unit02	Main Sales Cntr							72.3 °F	70 °F	73 °F		40 %	0.33 kW					80.7 °F	77.8 °F	88.7 °F	450 ppm	-
Unit03	Sales Tapas							72.8 °F	70 °F	73 °F		40 %	0.36 kW					79.7 °F	76.7 °F	88.0 °F	473 ppm	-
Unit04	Loading Dock							70.3 °F	68 °F	71 °F		90 %	1.80 kW					53.0 °F	72.1 °F	84.2 °F	412 ppm	-
Unit05	Food Prep							71.0 °F	68 °F	71 °F		40 %	0.13 kW					82.7 °F	77.8 °F	82.7 °F	392 ppm	-
Unit06	Checkstands							70.6 °F	68 °F	73 °F		40 %	0.14 kW					82.8 °F	78.1 °F	80.3 °F	442 ppm	-
Unit07	Bakery							71.5 °F	68 °F	71 °F		40 %	0.14 kW					81.4 °F	77.6 °F	80.6 °F	472 ppm	-
Unit08	Vestibule							74.0 °F	68 °F	71 °F		90 %	0.84 kW					45.2 °F	74.0 °F	82.4 °F	-	-
Unit09	Produce							72.3 °F	68 °F	71 °F		90 %	0.46 kW					46.3 °F	76.8 °F	47.6 °F	443 ppm	-

Site Data

OSA Humidity
20.5 %RH

OSA Dewpoint
39.4 °F

Space Static
0.02 in/wc

	Space Humidity	Space Humidity Setpoint	Dehumidification Cool	Dehumidification Reheat	Dehumidification Su	Dehumidification Fan Speed Setpoint	Space Dewpoint
Unit01	31.3 %RH	50.0 %				80.0 %	39.7 °F
Unit02	28.8 %RH	50.0 %			-	80.0 %	38.1 °F
Unit03	35.7 %RH	50.0 %			-	80.0 %	44.7 °F
Unit04	-	-	-	-	-	-	-
Unit05	-	-	-	-	-	-	-
Unit06	34.4 %RH	50.0 %			55.0 °F	75.0 %	41.3 °F
Unit07	34.9 %RH	50.0 %			55.0 °F	75.0 %	42.5 °F
Unit08	-	-	-	-	-	-	-
Unit09	32.7 %RH	50.0 %			55.0 °F	75.0 %	41.4 °F

Courtesy: Transformative Wave Technologies

VFD Retrofit Devices Ready for Prime Time

- Proven, significant savings
- Units that modulate the compressor have not been shown to be any more effective than fan speed modulation

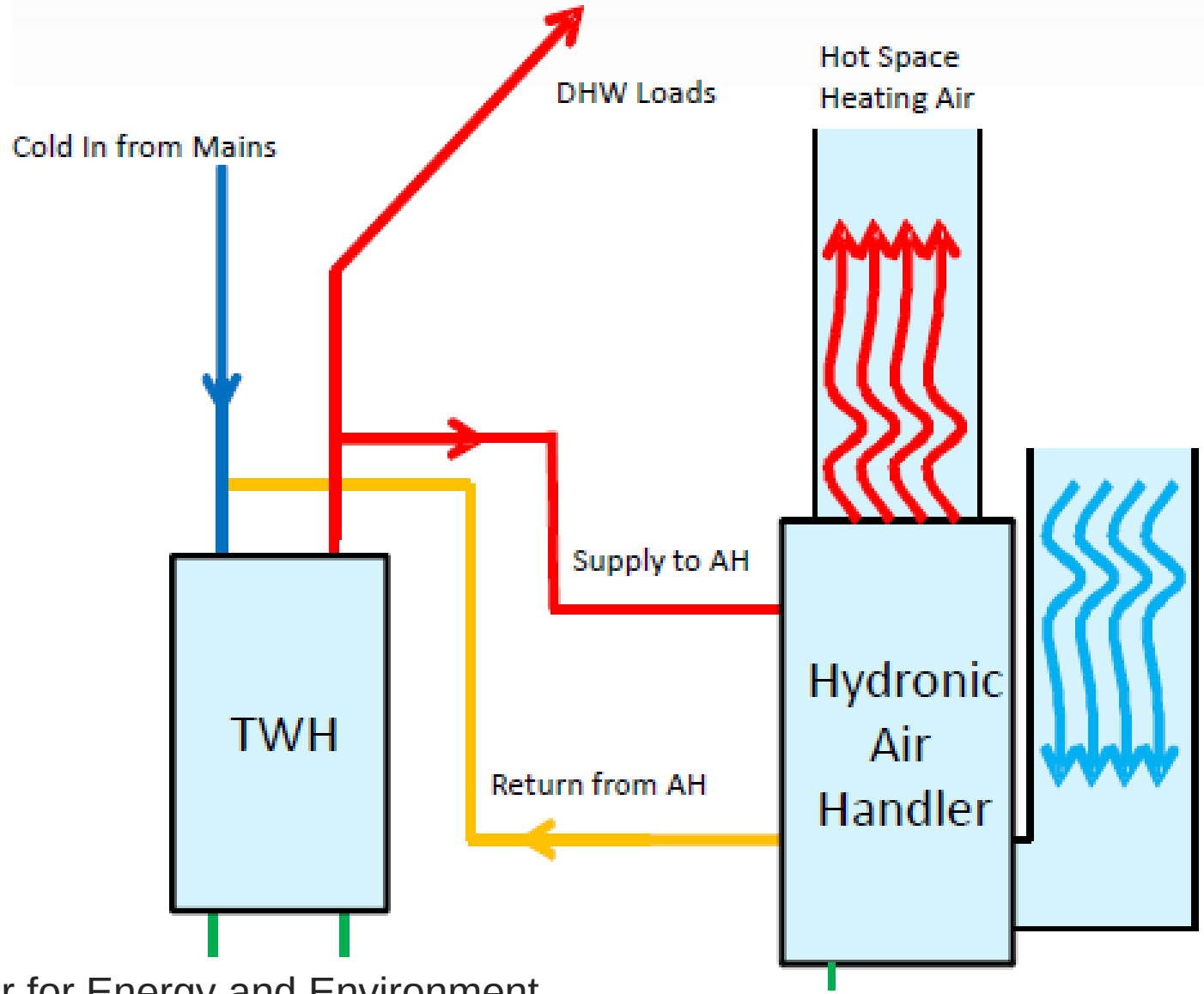
Gas “Combi” Systems

E Source

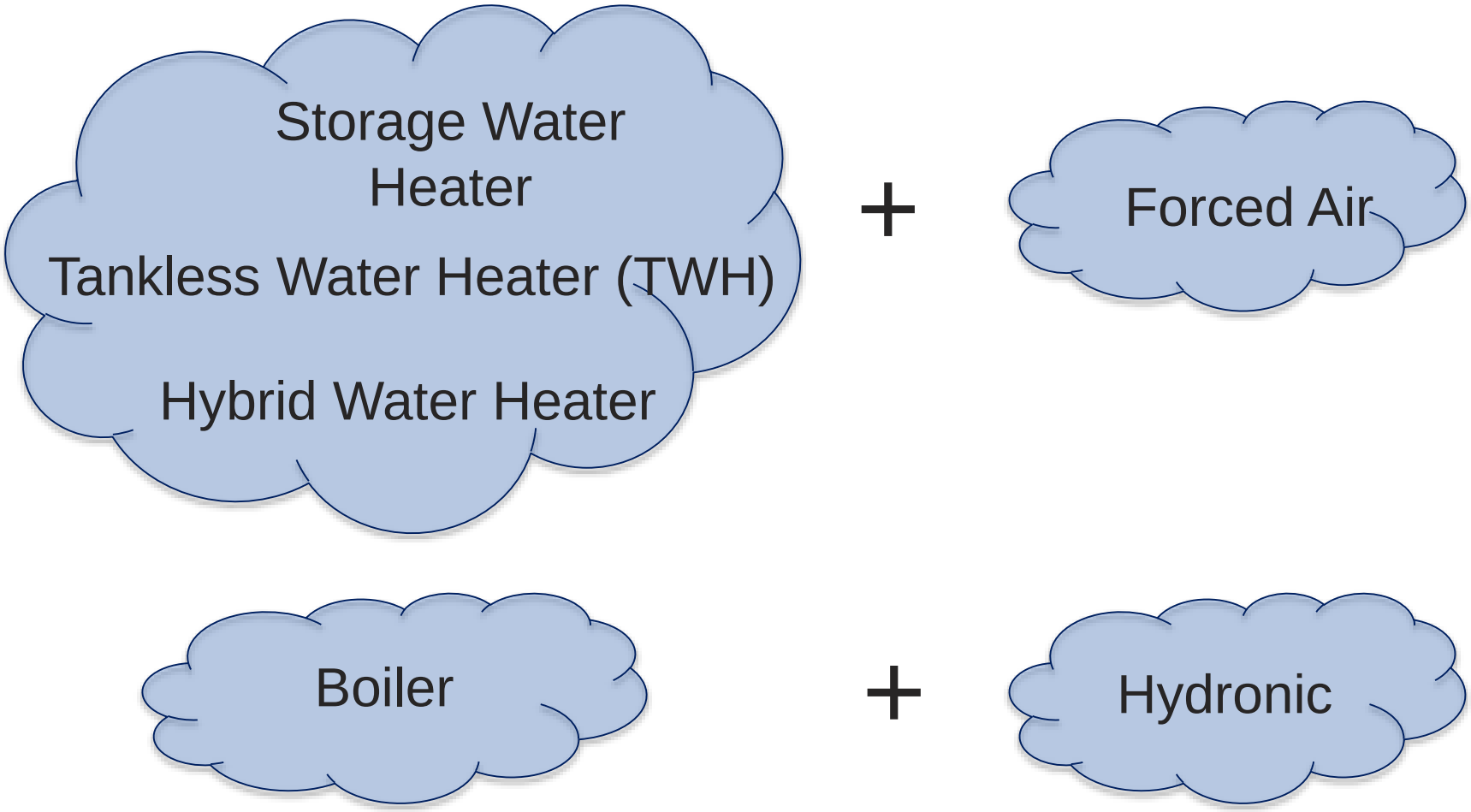
Combination Space & Water Heating

+

How it Works – One Example



Other Configurations



Works Best With…

- New construction
- Homes with relatively low heating requirements
  - Tightly sealed and/or weatherized
  - Smaller size
- Matched components that are sized correctly
  - Air handlers should be optimized to ensure condensing operation
  - Tankless water heaters better suited for forced air situations
  - Boilers better suited for hydronic systems
  - Low heat hydronic (radiant flooring, new low heat radiators) especially well suited

Why do we care?

- The Center for Energy and the Environment installed 15 combo systems in low income weatherized homes in Minnesota
- Replaced storage water heaters (EF ≈ 60%) and gas furnaces (AFUE ≈ 80%)

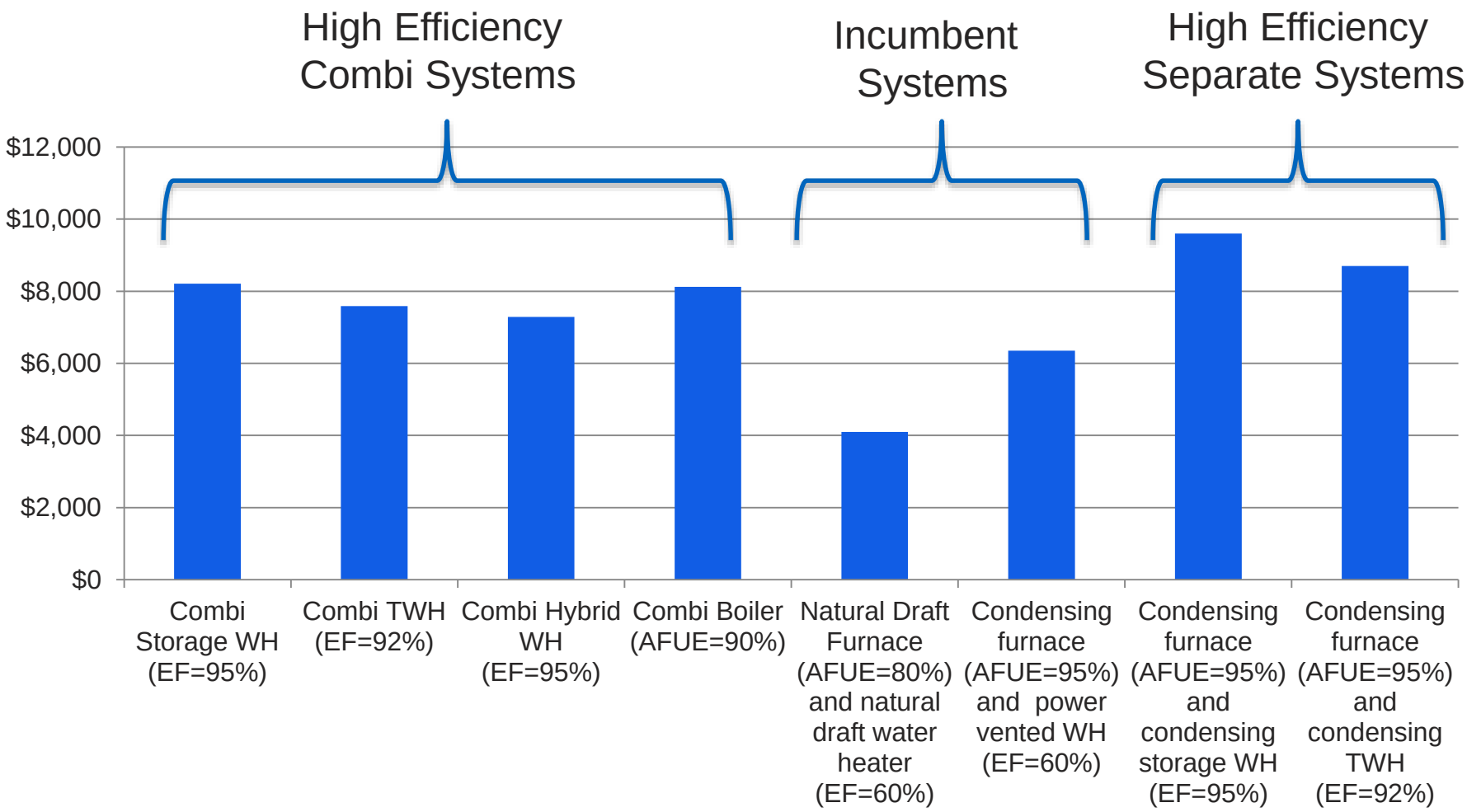
System Type	Efficiency Increase	Gas Savings
Storage Water Heater	19%	22%
Tankless Water Heater	16%	18%
Hybrid Water Heater	21%	24%
Boiler	16%	20%

Why do we care (Cont'd)?

- Gas Technology Institute (GTI) modeled whole-home energy savings for tankless combi systems at 95% EF
- Baseline homes based on Building America prototype homes

	Whole Home Energy Savings (%)		
	Home Built Before 2000	Home Built to 2010 Standards	Home Built with Better Efficiency than 2010 Standards
Chicago	9	9	12
Atlanta	9	10	11
Houston	7	8	9
Phoenix	5	6	7

Installed Costs from CEE Study



NREL/GTI Research Findings

Storage

- Supplies more-stable water temperatures during short draws
- Delivered varying water temp for long draws due to stratification within tank
- Relatively high standby losses

Hybrid

- Often delivers the best of both worlds

Tankless

- Low standby losses
- May suffer from water temperature fluctuations during short draws
- Provides more-stable temperatures during long draws
- In GTI field tests, consistently provided higher efficiencies than storage systems when return water temperatures enabled condensing operation

For More Information

- See our report Combining Space and Water Heating (2014)
- Laboratory Evaluation of Gas-Fired Tankless and Storage Water Heater Approaches to Combination Water and Space Heating (2013), U.S. DOE
- Residential Space and Water Heating: The Combined Approach (2012), Center for Energy and the Environment
- Tech Roundup – December 2010, E Source
- Integrated Heat Pumps for Combined Space Conditioning and Water Heating, Oak Ridge National Laboratory

LED Tubes Coming of Age

Fluorescents Everywhere – What's an Energy Geek to Do?

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 percent of lighting energy
- ~87 terawatt-hours per year

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

Philips InstantFit LED

CREE T8 replacement LED

- Fit in T8 sockets; uses existing instant-start EB
- Safety issues have been addressed
- Come from major vendors
- Competitive on efficiency and quality

Supported by new DOE study:

http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/caliper_21_t8.pdf

Source: Philips

Comparing Fluorescent T8 with InstantFit and CREE

Property	High performance T8	InstantFit LED	CREE
CRI	80s	83	90
Life, hrs	24,000-75,000	40,000	50,000
Efficacy, lm/W	98	95-116	100
Cost, $	5	24-39	≈30

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

For Now, LED Troffers Still Better Than LED Replacement Tubes

- Better efficacy than LED replacement tubes (and fluorescents)
- Better light distribution
- Better heat dissipation
- Supported by DOE study: http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/caliper_recessed-troffer_2013.pdf

Samples from the QPL

Brand Name	Model	Luminaire efficacy (lm/W)	Rated lifetime (hours)	Measured CRI
Lithonia Lighting	2RTL	104	60,000	81
CREE LED Lighting	CR24	130	>51,000	92
Finelite Inc.	HPR	96	100,000	87
Hubbell/Columbia	LEPC	108	50,000	83
Fluorescent—top 25 percent		**>74.0**	**40,000+**	**85.0**

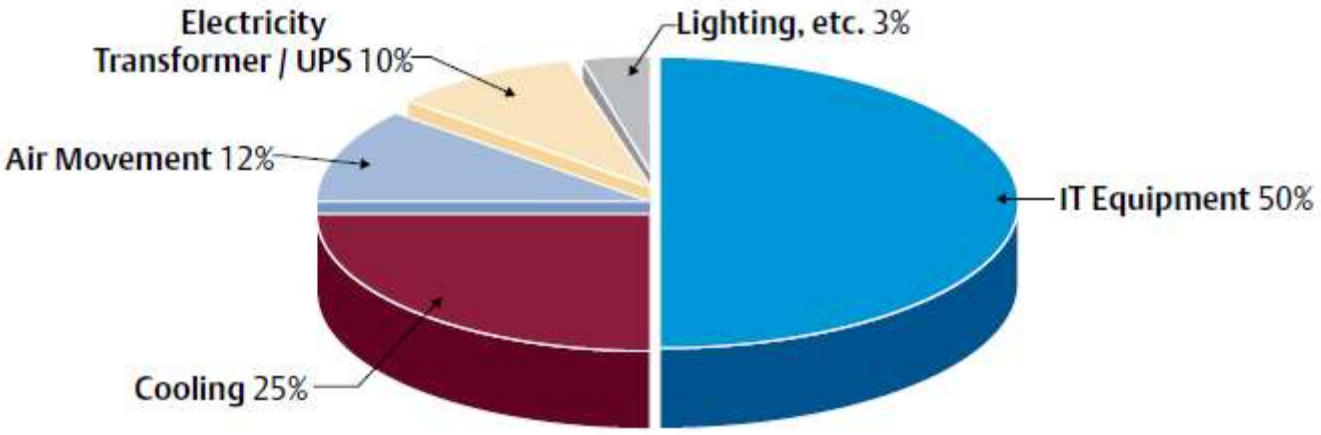
Note: CRI = color rendering index.

Other manufacturers include GE (Lumination), Philips (Daybrite), Cooper Lighting, Maxlite, Albeo, and Lunera

A Cool New Way to Use Hot Oil

The Problem - Data Centers use tons of energy

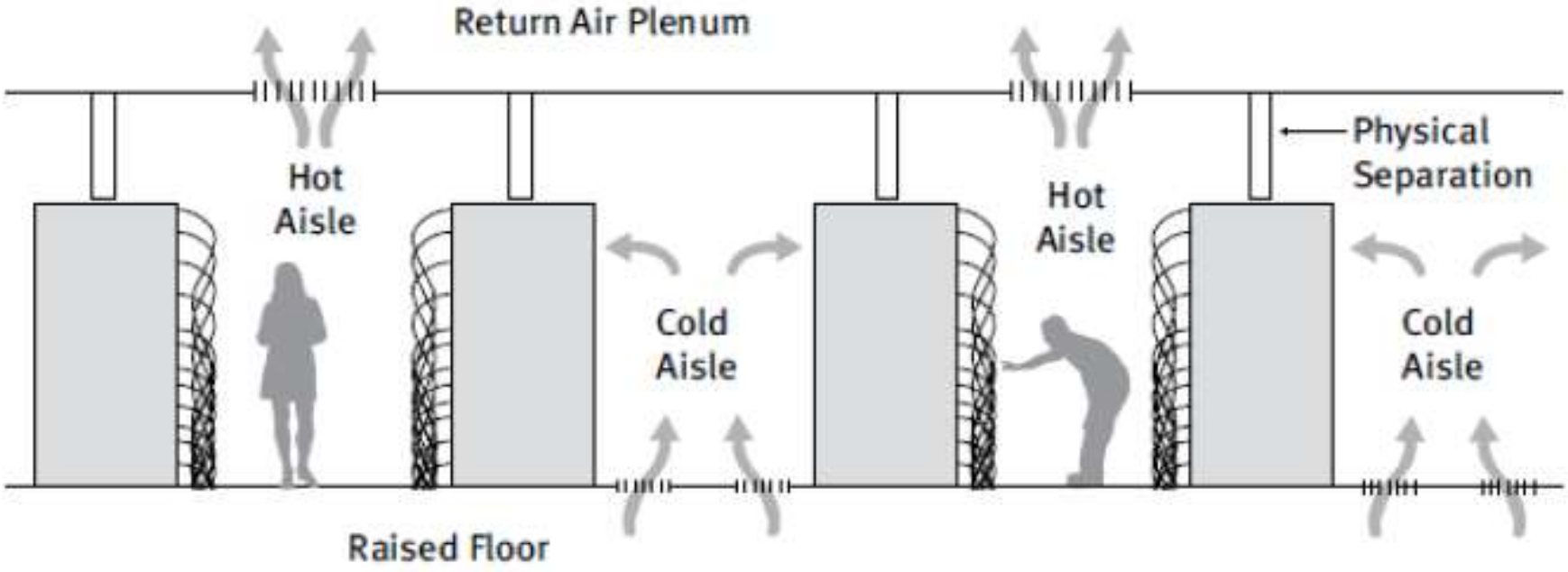
- 1.5% of all energy worldwide consumed by datacenters
- Worldwide, datacenters use about 30 GW of electricity, roughly equivalent to the output of 30 nuclear power plants



Source: EYP Missions Critical Facilities Inc., New York

Traditional Data Center Cooling

- Air cooling: 0-10 kW/rack
- Chilled rack “in-row” cooling: 10-30 kW/rack

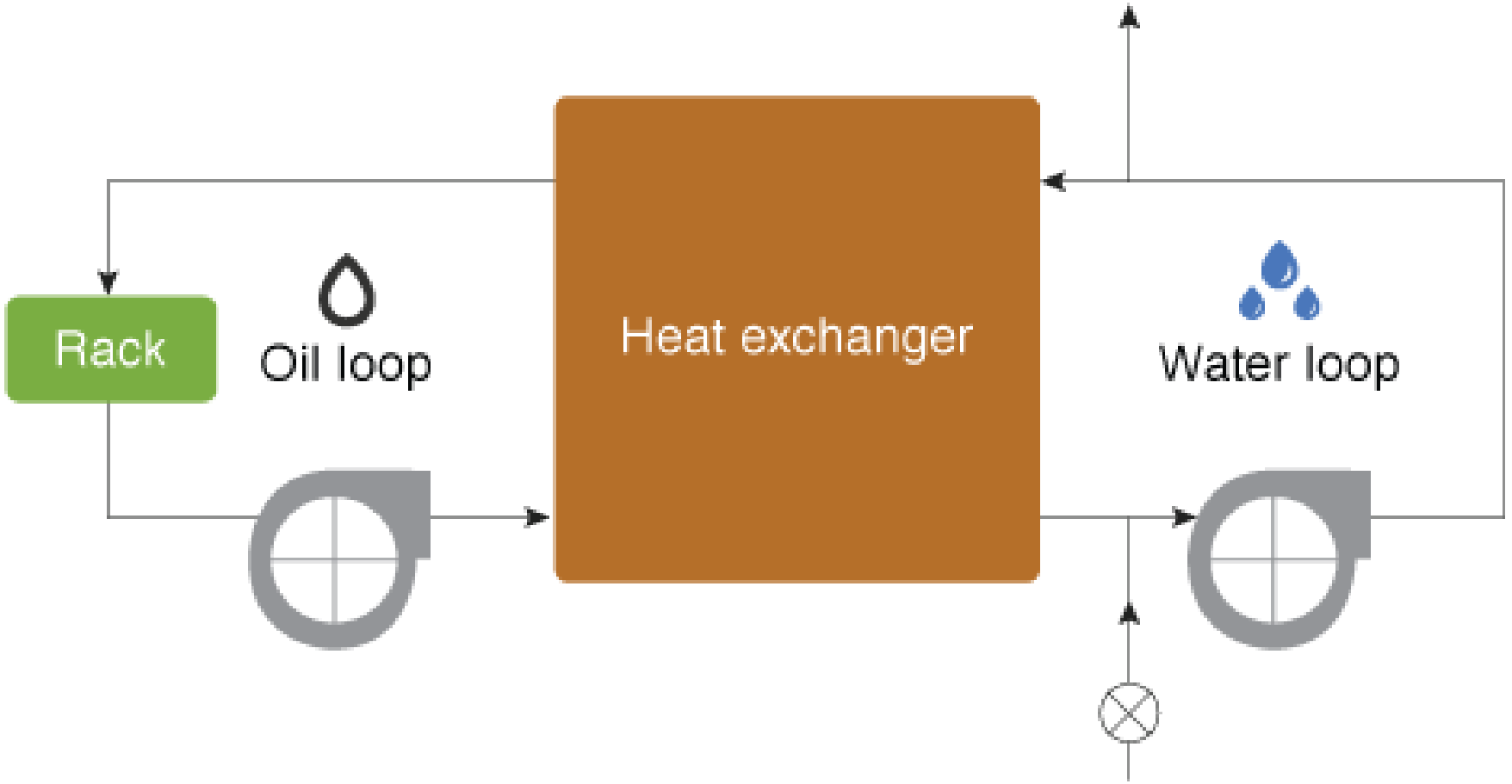


Source: Pacific Gas & Electric Company

Newest Solution for Data Center Cooling…

Source: Green Revolution Cooling

How it Works



Savings Potential is Huge

- Manufacturer claims:
  - Reduce data center cooling power by up to 95%
  - Reduce data center build-out costs by up to 60%
  - Reduce total data center power by up to 50% ongoing
- PG&E study: Submersion Cooling Evaluation (2014)
  - Savings of 82% across the board (energy, demand, and annual cost)
  - Simple Payback < 5 yrs

Market Barriers

- Requires the use of solid state drives
- No “off the shelf” products currently available
- Warranty issues
- Network gear manufacturers are lagging behind server manufacturers
- Cost
- Site plumbing issues

For More Information

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