Efficiency Vermont

BETTER BUILDINGS BY DESIGN

Mechanical System

Low Temperature Heating

Applications and Economics

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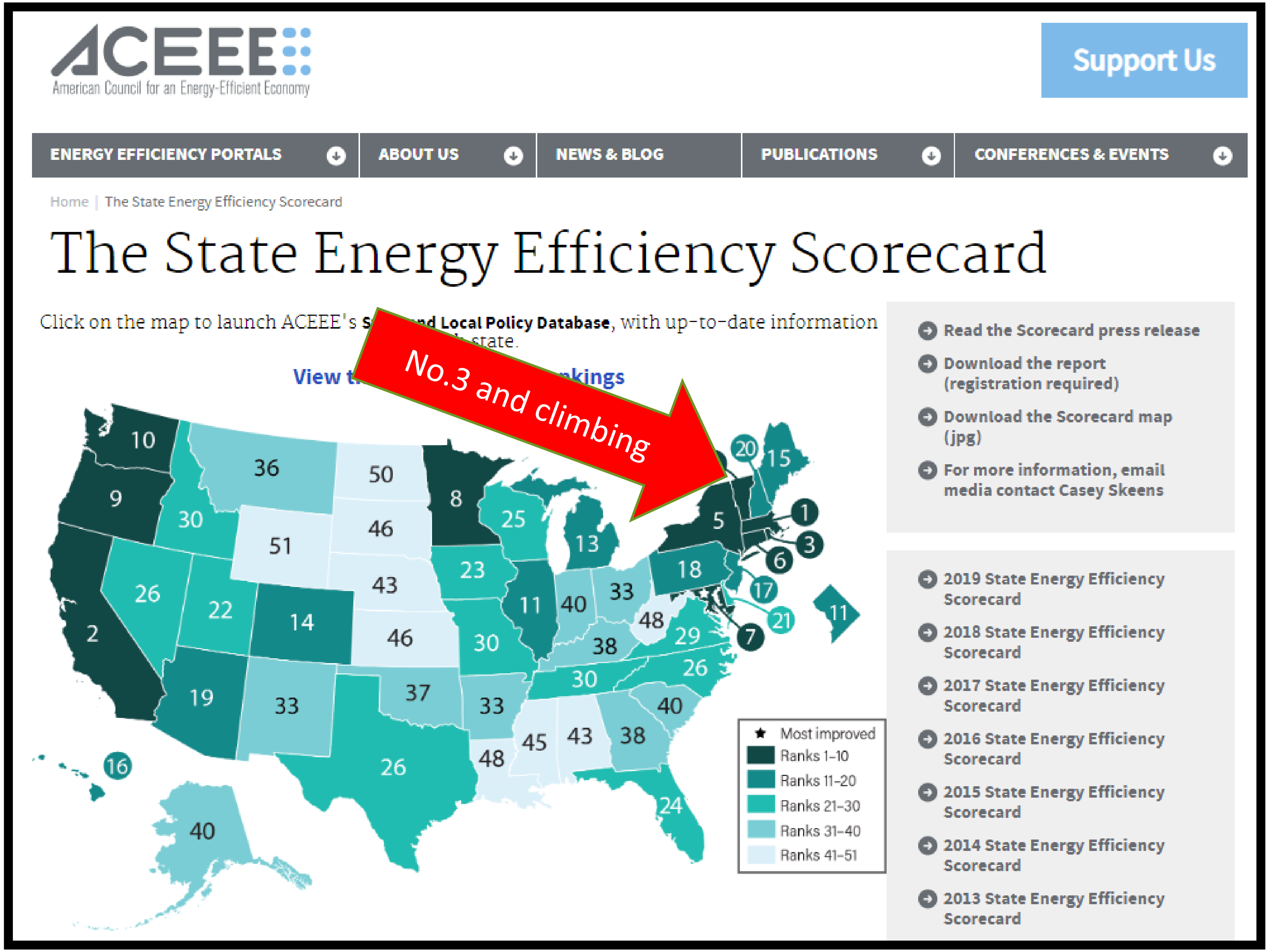


Congrats!

E^4

Energy
Efficiency
Efforts are
Effective.


It’s not easy being green.
KERMIT THE FROG
PHOTO BY CSMACLAREN

Tom Friedman

3-time Pulitzer Prize Winner

From her speech at the U.N. Climate Action Summit, September 2019

"For more than 30 years, the science has been crystal clear. How dare you continue to look away and come here saying that you're doing enough, when the politics and solutions needed are still nowhere in sight…"

My background…

Registered Professional Engineer

18 years as a facilities/maintenance engineer and plant operator

35 years as a design engineer

LEED Accredited Professional

Licensed Boiler Inspector

Certified Energy Auditor

ASHRAE Fellow

Awards

1997, 98	**Consulting Engineers of Indiana *Grand Project Award***
1998, 99	**American Consulting Engineers Council *Honor Award***
1999, 2010	**Governor's Pollution Prevention Award - Indiana**
2002	**Governor's Energy Efficiency Award - Ohio**
2007	**PM Magazine Design Excellence Award**
2009, 2013	**ASHRAE Technology Award**
2012	**Election to ASHRAE College of Fellows**
2016	**Association of Energy Engineers 2016 Achievement Award**

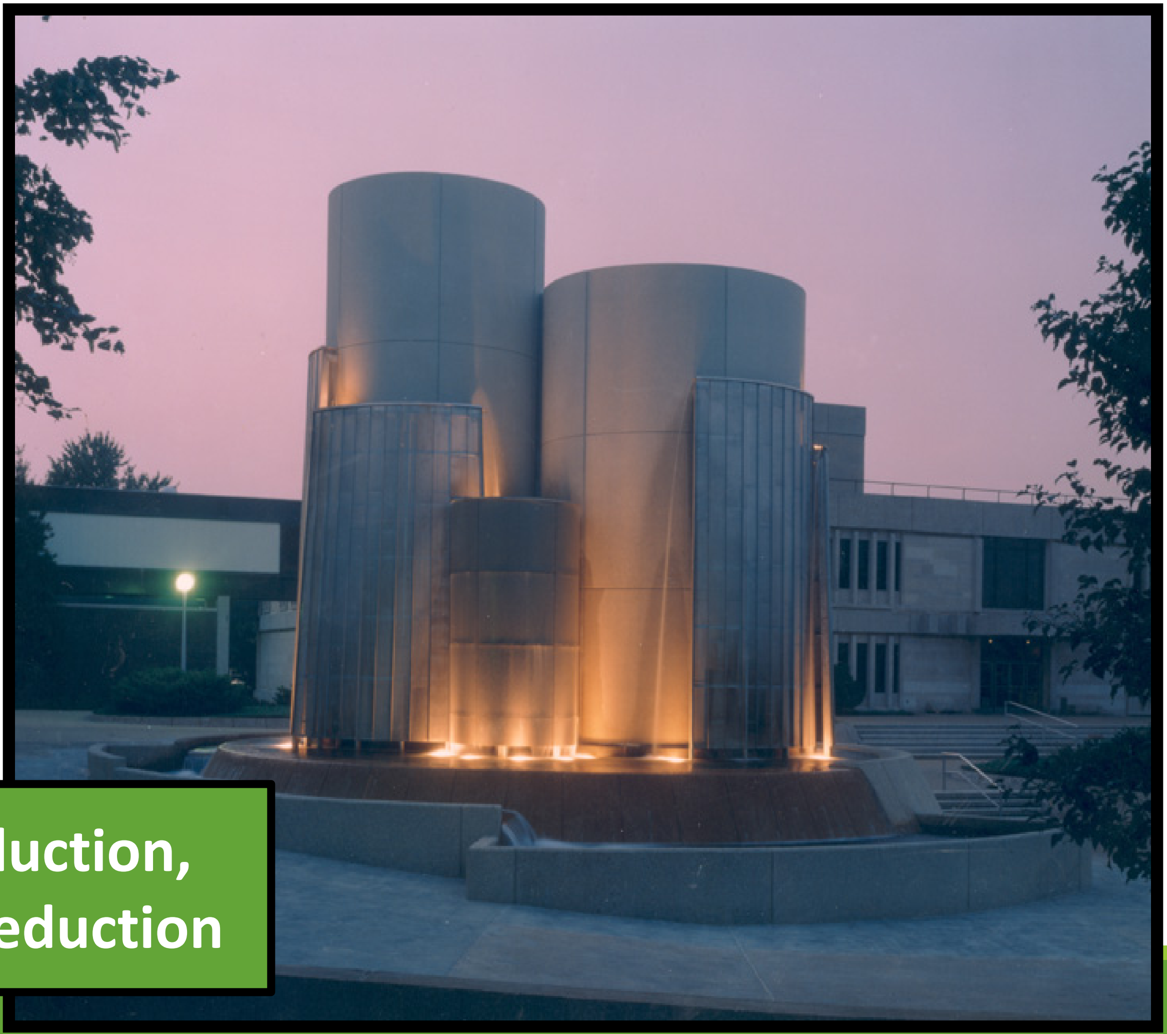
17 articles about HVAC innovations

Co-author of
HVAC Pump Handbook, Rev. 2

My Engineering philosophy

Our clients are our partners, and we are stewards of their resources.

- Up-to-date, high-performance technology, judiciously applied.
- Environmentally-friendly, energy-efficient design.
- Affordable solutions that are less expensive to build.
- Simpler solutions that are easier to operate and maintain.
- On-going relationships that our clients can trust.



60% energy reduction, 95% water use reduction

A Healthy and Effective Indoor Environment

Never Compromise

Indoor air quality

Occupant comfort

Humidity control

The Quest…

Systems that do all the above and are

Less expensive to build

Less expensive to operate, and

Easier to maintain

Energy Conservation and **Energy Efficiency**

Gas and Electric Rates

BURLINGTON Electric Co

LARGE GENERAL SERVICE (LG)

Energy usage over 3,000 kWh per month for three consecutive months in the last 12 mon

Customer Charge <= 25 KW	$13.68
Customer Charge > 25 KW	$41.04
Energy (kWh)	$0.083003 per kWh
Demand (kW)	$20.03
EEC (LG)	$0.00512/kWh + $1.3115/kW
EEC (L2, >=1000 kW Demand)	$0.00361/kWh + $1.4185/kW
Vermont Sales Tax	6.0%
City Franchise Fee	3.5% (exclusive of Vermont Sales Tax)
Local Option Sales Tax	1.0%

Vermont Gas Co.

Type	Current Rates
Daily Access Charge (per day)	$3.8388
Natural Gas Charge (per CCF)	$0.3891
Distribution Charge (per CCF)	$0.3697
Energy Efficiency (per CCF)	$0.0354
Assistance Program Fee *	$1.05

USGBC Data

39% of total US energy goes into non-residential buildings.

Gas for heating is about 60% of energy used in a building

Gas for heating is at least **25% of total energy used in the US.**

Historic Natural Gas Pricing

Where it began…Luce Library
Spencer County, Indiana
1991

Green Valley Elementary School
New Albany, Indiana

The (Inadvertent) Greening of Green Valley Elementary

"Environmental Equity" project, limited budget

From the scrap heap of history,

"The Renaissance of the 2-Pipe System"

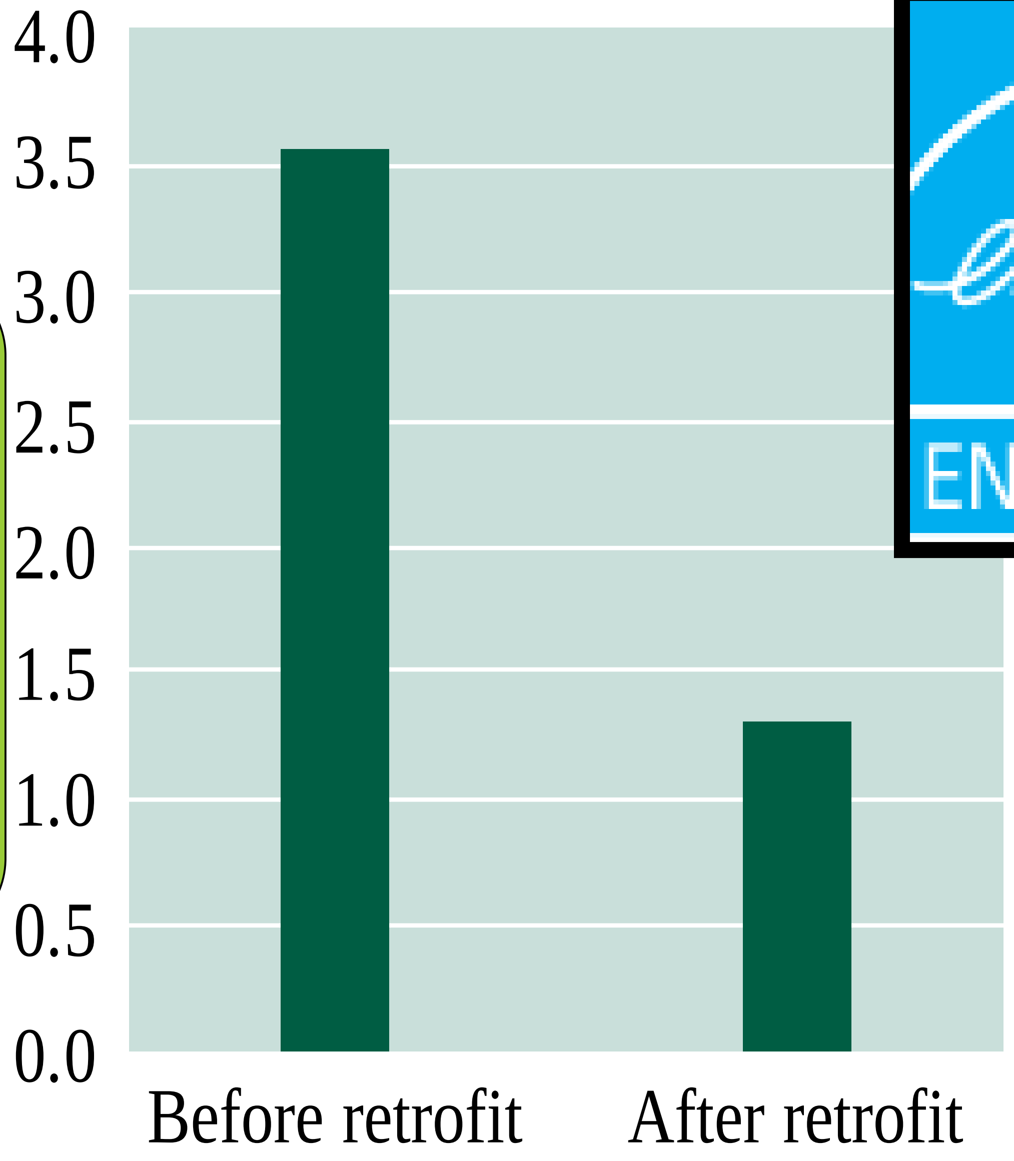
- Using a coil selected for cooling/dehumidifying to heat means the water doesn't need to be very hot and you don't need very much.
- Hence, low temperature heat from condensing boilers.

Serendipity

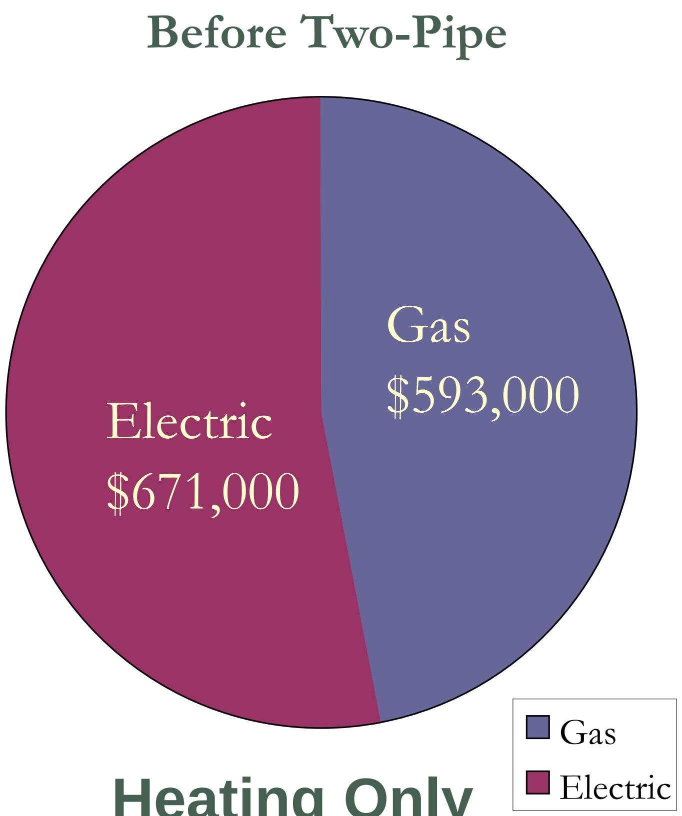
We were looking for a solution that fit the budget and solved the age-old comfort complaints without compromising IAQ,

We achieved all the above and **significant** efficiency gains.

Therms per Heating Degree Day

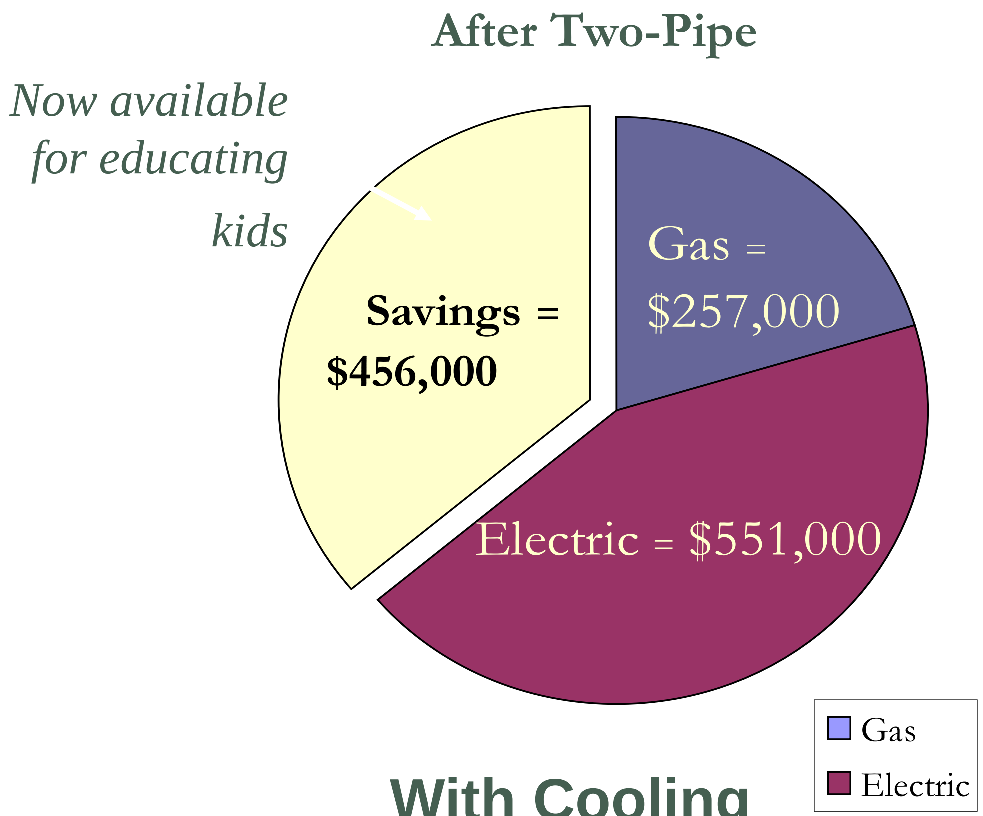


1996…20 School Buildings



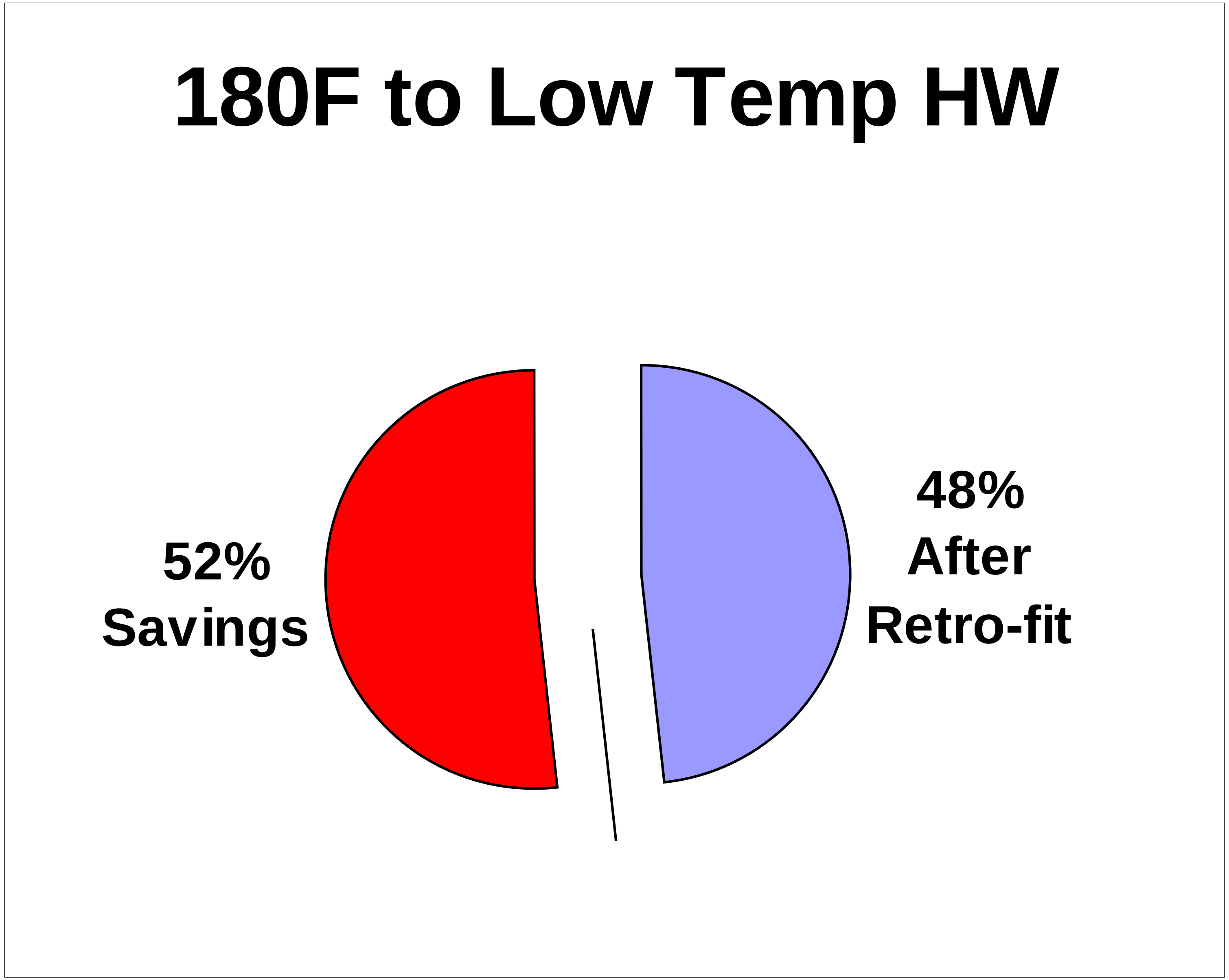
Heating Only

$1,264,000



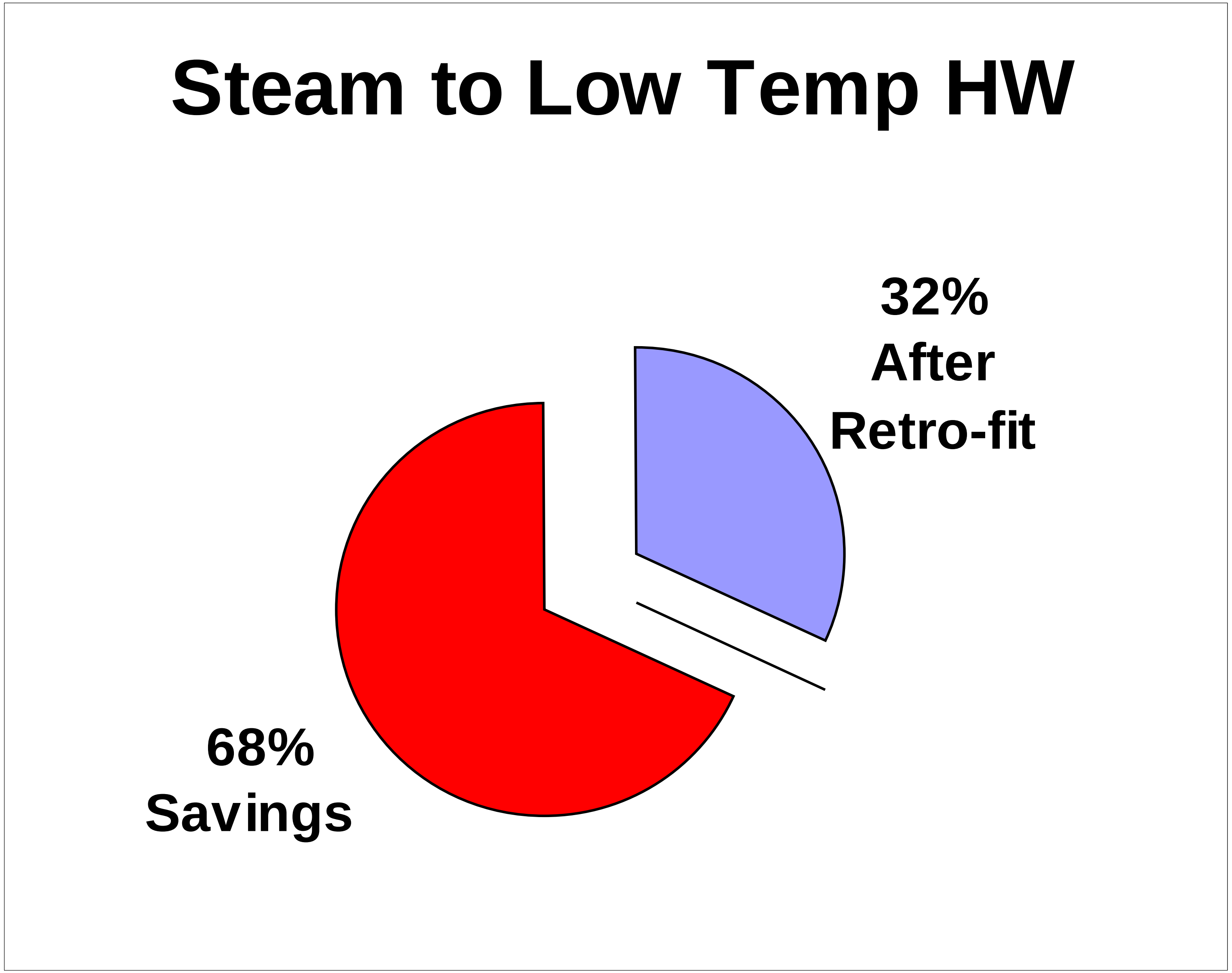
With Cooling

$808,000



Low Temperature:

HW Supply (HWS) = 90F at 60F OAT ; reset to HWS = 130F at OAT<20F



Low Temperature:

HW Supply (HWS) = 90F at 60F OAT ; reset to HWS = 130F at OAT<20F

How efficient are boilers?

Steam or HT hot water = 75 to 80%

Base efficiency (ASHRAE 90.1) hot water boilers = 80 to 83%

Mid-efficiency = 83 to 88%

Condensing boilers = 88 to 95%

Why steam?

Because that's what Grandpa did.

Lots of BTU's per pound

Low distribution energy

Process requirements like laundries, sterilizers, or humidifiers

Why not steam?

Hard to control

More maintenance

Pipes must slope

Tunnels or buried pipe

Lots of make-up, blow-down and chemicals

More operator attention

Poor part load performance

Why hot water?

Easier to control than steam.

Less expensive to operate and maintain

Why not 180F hot water?

Because there is something better.

But 180F is the industry standard?

What are we doing?

Trying to heat air to 90 - 100F.

How efficient are boilers?

Steam or HT hot water = 75 to 80%

Base efficiency (ASHRAE 90.1) hot water boilers = 80 to 83%

Mid-efficiency = 83 to 88%

Condensing boilers = 88 to 95%

How is efficiency defined?

Combustion (thermal) efficiency

Vs.

Overall efficiency

Vs.

Seasonal efficiency (AFUE)

(ASHRAE Handbook S27.5)

How is combustion efficiency measured?

ANSI Z 21.13 - 2000

- Steady state operation
- Full load
- 80F entering water

(ASHRAE Std 155P will be more reflective of actual conditions.)

What does ASHRAE say?

Standard 90.1

- Must meet the minimum efficiency requirements of ANSI Z21.13
- Select one for best efficiency at full and part load
- Operate at lowest possible water temperature

What's the lowest temperature?

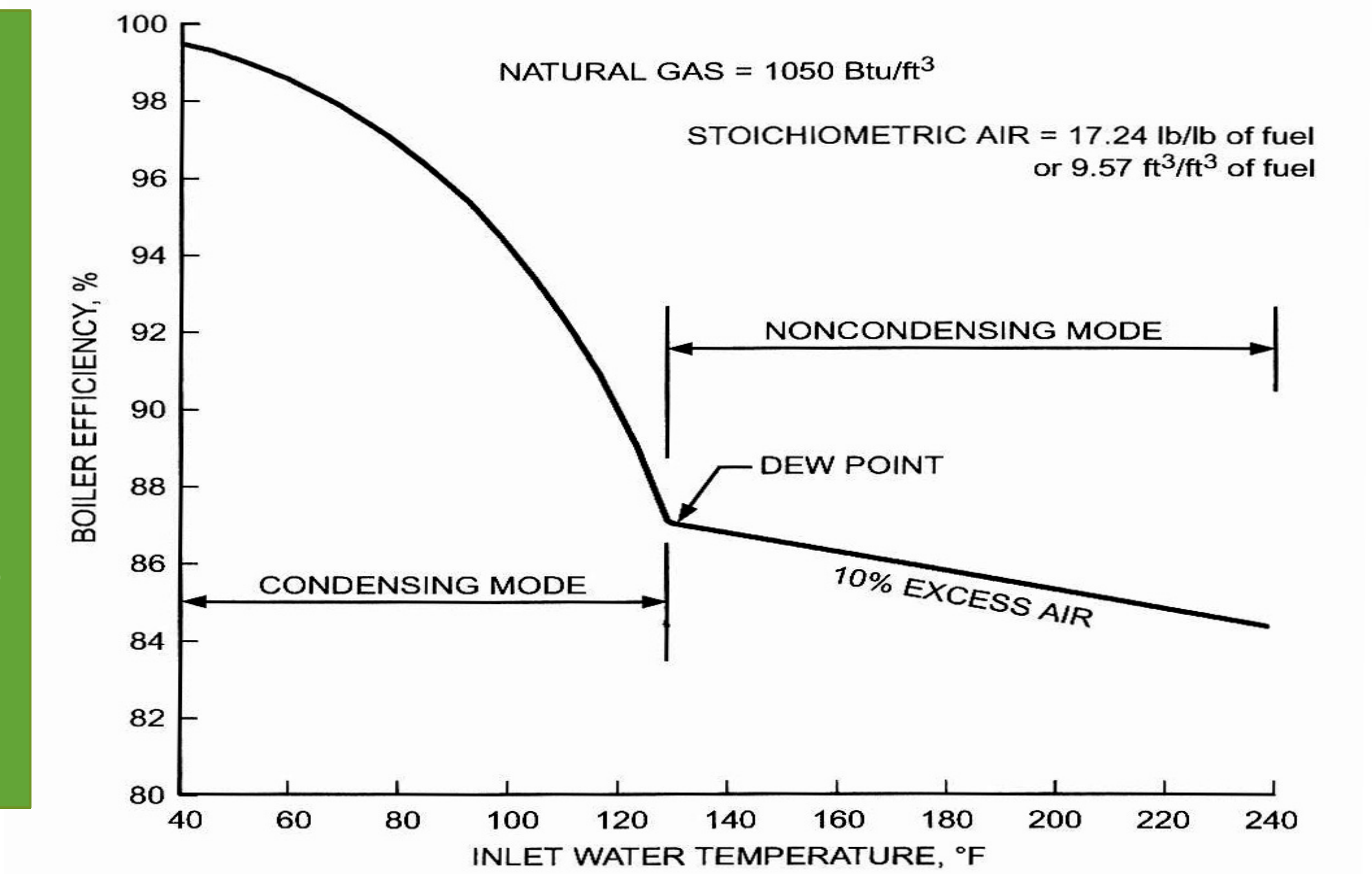
From anybody's boiler book…

"Warning: Inlet water temps below 140F (60C) can excessively cool the products of combustion in the heat exchanger and flue. Operation is that range may void the warranty"

Hence the "standard" 180F design with O/A reset.

Effect of Inlet Water Temperature

Products of combustion of natural gas are CO_2 and H_2O. As the flue gases cool, the latent heat of the water vapor (1,000 BTU/Lb) goes into the process.



It isn't just the efficiency!

The capacity will go down too!

A boiler rated at 2.0 MBH input and 1.6 MBH output will only be capable of 1.4MBH at 140F EWT.

What isn’t in the calculation?

Jacket losses

Purge losses

Combustion air and flue losses

Pipe losses

Start-up losses

Part load effect

Jacket and Purge Losses

JACKET

The difference between “combustion efficiency” and “overall efficiency”, about 2 – 4% lower than combustion efficiency.

PURGE LOSSES

Typically, five minutes at the start of a firing cycle and two minutes at the end of a firing cycle.

Essentially, pre-cooling the boiler internals at the start, and throwing away whatever heat was still in the boiler at the end of the cycle.

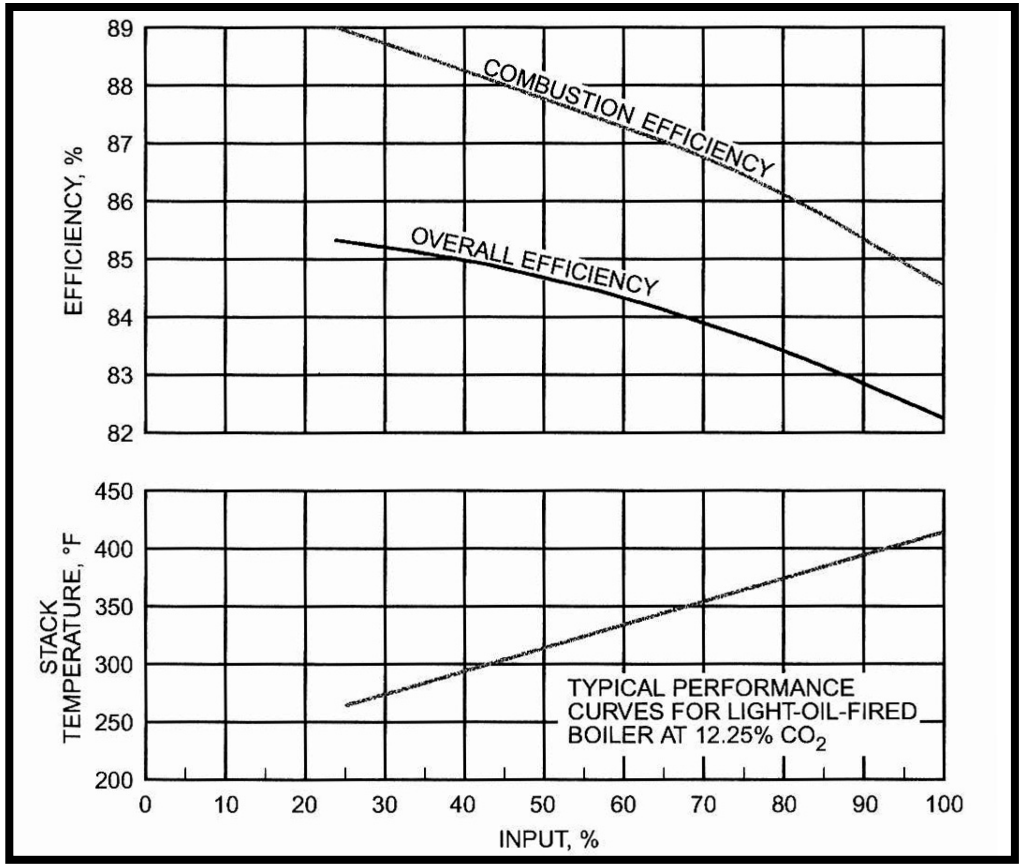
Combustion and Flue Losses

LP Steam…350F

Conventional HW…250F

Low Temp HW…130F

- Added benefit of sealed combustion



The Pipes?

Inside the building

Heat loss from un-insulated 180F pipe ~ 272 BTU/ft

Heat loss from insulated 180F pipe ~ 18 BTU/ft

Heat loss from insulated 130F pipe ~ 9 BTU/ft

At least 1% of an average heating bill and, possibly overheating the plenum (VAV systems)

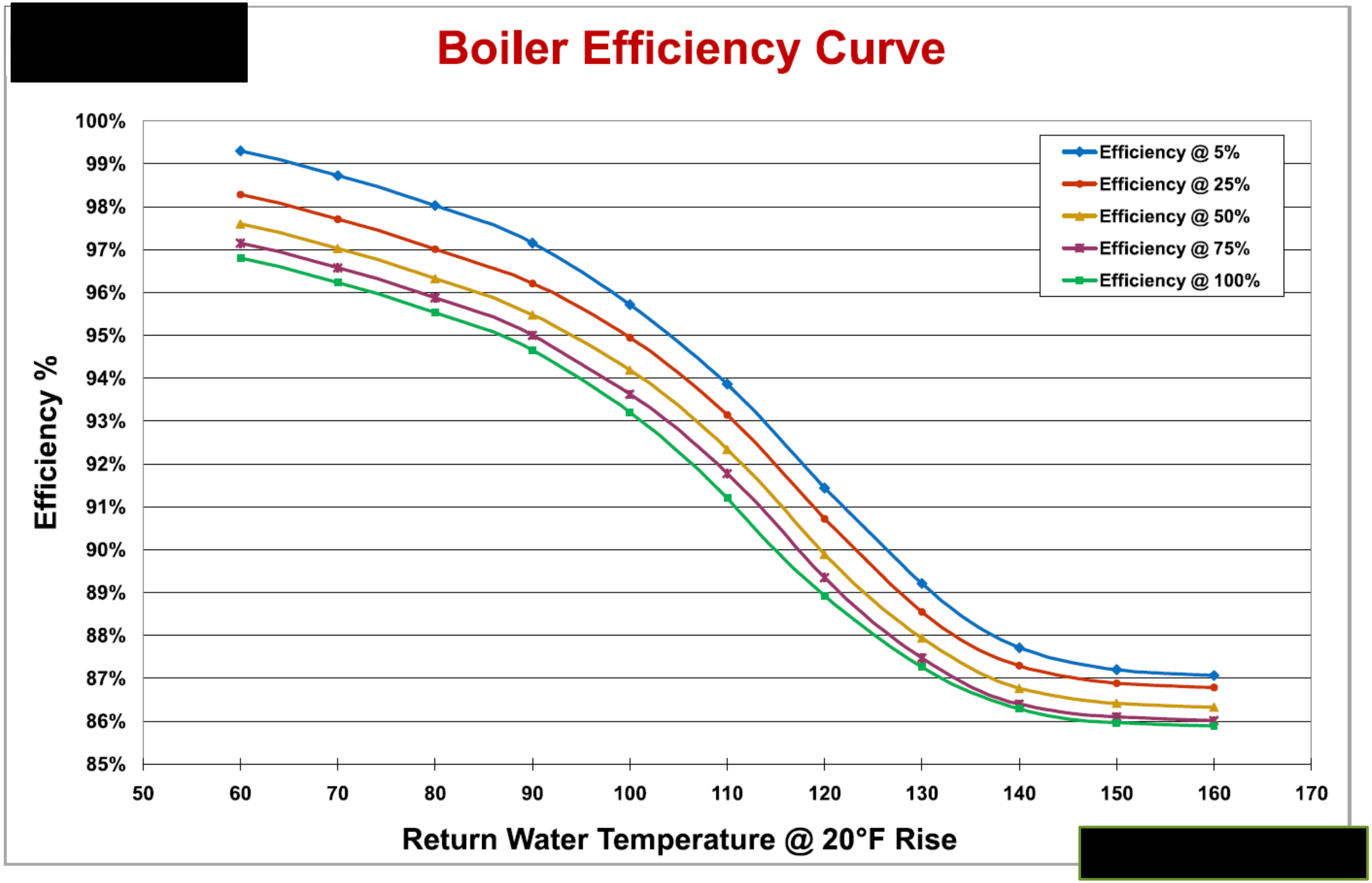
Campus Steam

Line loss = 474,000 BTUs per foot per year (8 months)

Equivalent of entire heating requirement of a 50K SF building

Part Load Effect

This is for a condensing boiler, I could not find one for a conventional boiler.



My (your?) new favorite number

130

Max HW Supply Temp, reset vs. OAT

From condensing boilers

What is a condensing boiler?

Suitable for low temperature operation, no low limit on EWT

Metallurgy immune to fire side condensation

Usually modular, low mass boilers

Usually high turndown burners

Why condensing boilers?

- Okay with water temps below 140F
- Highest Efficiency at Full and Part Load
- Size
- Simplified piping
- Perfect complement to heat recovery chillers
- Safety

Safety?

180F water = a 3rd degree burn in 1 second

130F water = a 2nd degree burn in 17 seconds

(Shriners' Hospital www.shrinershq.org)

Why not condensing boilers?

First cost.

In a retro-fit, the balance of the system isn’t designed for low temp heat.

Life expectancy = ???

What do they cost?

Conventional Boiler (82% eff.) = $5,000 per MMBTU

Condensing Boiler (92% eff.) = $12,000 per MMBTU

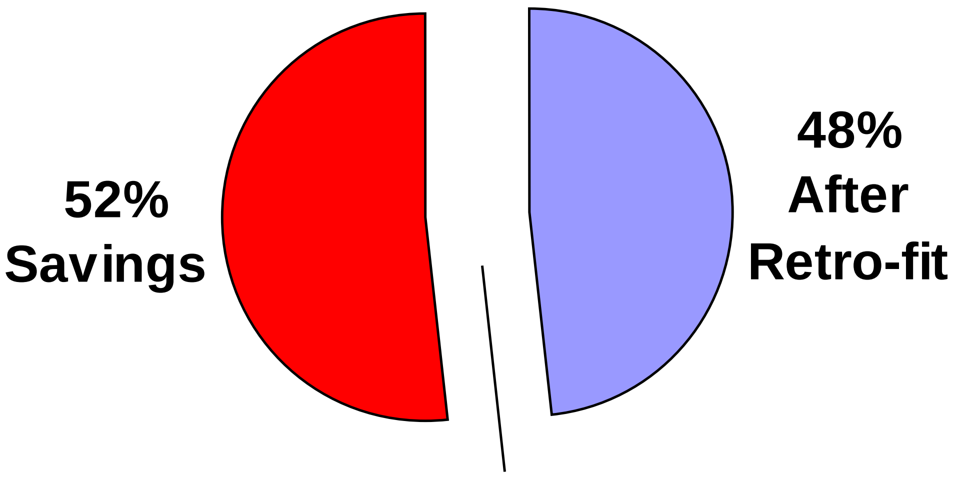
What’s the payback?

A school in Indiana costs $1.00 per SF per Year (35% gas, 65% electric) or $0.35 per SF per Year for Gas.

Conversion to Cond boilers = 12% efficiency improvement , down to $0.312 per SF per Year

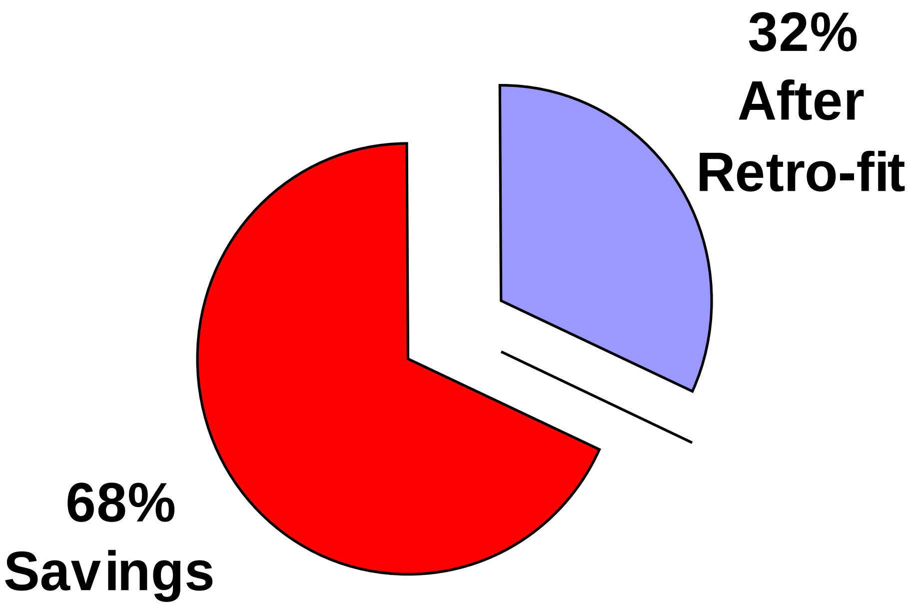
7.4 year simple payback

180F to Low Temp HW



30% better than published

Steam to Low Temp HW



50% better than published

What's the REAL payback?

A school in Indiana costs $1.00 per SF per Year (35% gas, 65% electric) or $0.35 per SF per Year (Gas)

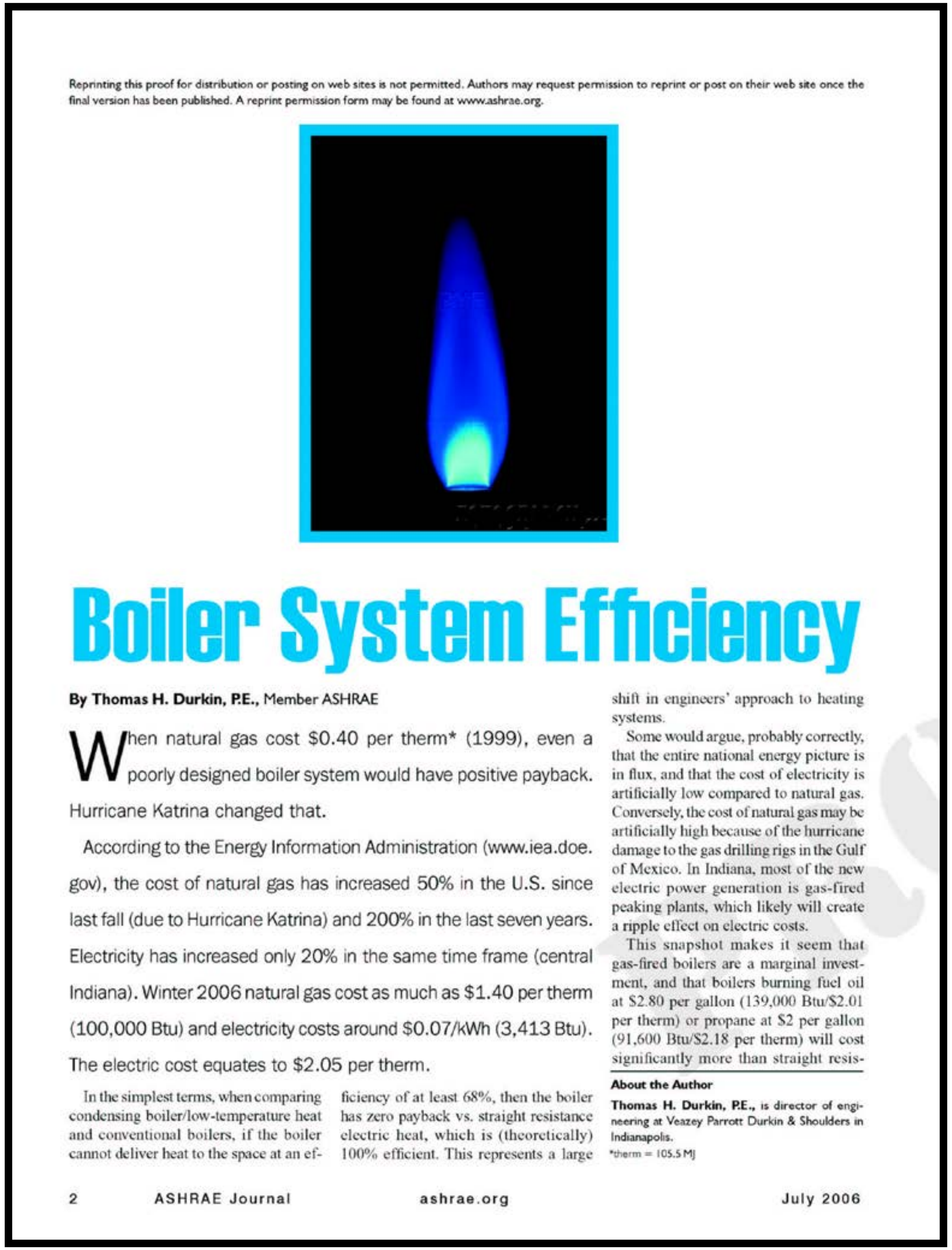
Conversion to Cond boilers = 50% efficiency improvement , down to $0.175 per SF per Year

1.6 year simple payback

Many load models do not reflect this reality!

Conclusion:

"…the old standard can be significantly improved…if a building is to be heated hydronically, use low temperature water from condensing boilers."



Boiler System Efficiency

By Thomas H. Durkin, P.E., Member ASHRAE

When natural gas cost $0.40 per therm* (1999), even a poorly designed boiler system would have positive payback. Hurricane Katrina changed that.

According to the Energy Information Administration (www.iea.doe.gov), the cost of natural gas has increased 50% in the U.S. since last fall (due to Hurricane Katrina) and 200% in the last seven years. Electricity has increased only 20% in the same time frame (central Indiana). Winter 2006 natural gas cost as much as $1.40 per therm (100,000 Btu) and electricity costs around $0.07/kWh (3,413 Btu). The electric cost equates to $2.05 per therm.

In the simplest terms, when comparing condensing boiler/low-temperature heat and conventional boilers, if the boiler cannot deliver heat to the space at an efficiency of at least 68%, then the boiler has zero payback vs. straight resistance electric heat, which is (theoretically) 100% efficient. This represents a large shift in engineers' approach to heating systems.

Some would argue, probably correctly, that the entire national energy picture is in flux, and that the cost of electricity is artificially low compared to natural gas. Conversely, the cost of natural gas may be artificially high because of the hurricane damage to the gas drilling rigs in the Gulf of Mexico. In Indiana, most of the new electric power generation is gas-fired peaking plants, which likely will create a ripple effect on electric costs.

This snapshot makes it seem that gas-fired boilers are a marginal investment, and that boilers burning fuel oil at $2.80 per gallon (139,000 Btu/$2.01 per therm) or propane at $2 per gallon (91,600 Btu/$2.18 per therm) will cost significantly more than straight resis-

About the Author

Thomas H. Durkin, P.E., is director of engineering at Veazey Parrott Durkin & Shoulders in Indianapolis.

*therm = 105.5 MJ

They made me an offer I couldn't refuse…

OPEN MEETING – COMMERCIAL SYSTEMS GROUP – ***<u>Open to All Annual Meeting Registrants Having An Interest</u>***

- Roundtable Market Discussion
- Speaker: *"Staying Relevant In A Green Era"*
  Tom Durkin, PE, Veazey Parrott Durkin & Shoulders

How efficient are boilers?

Steam or HT hot water ~ 80%

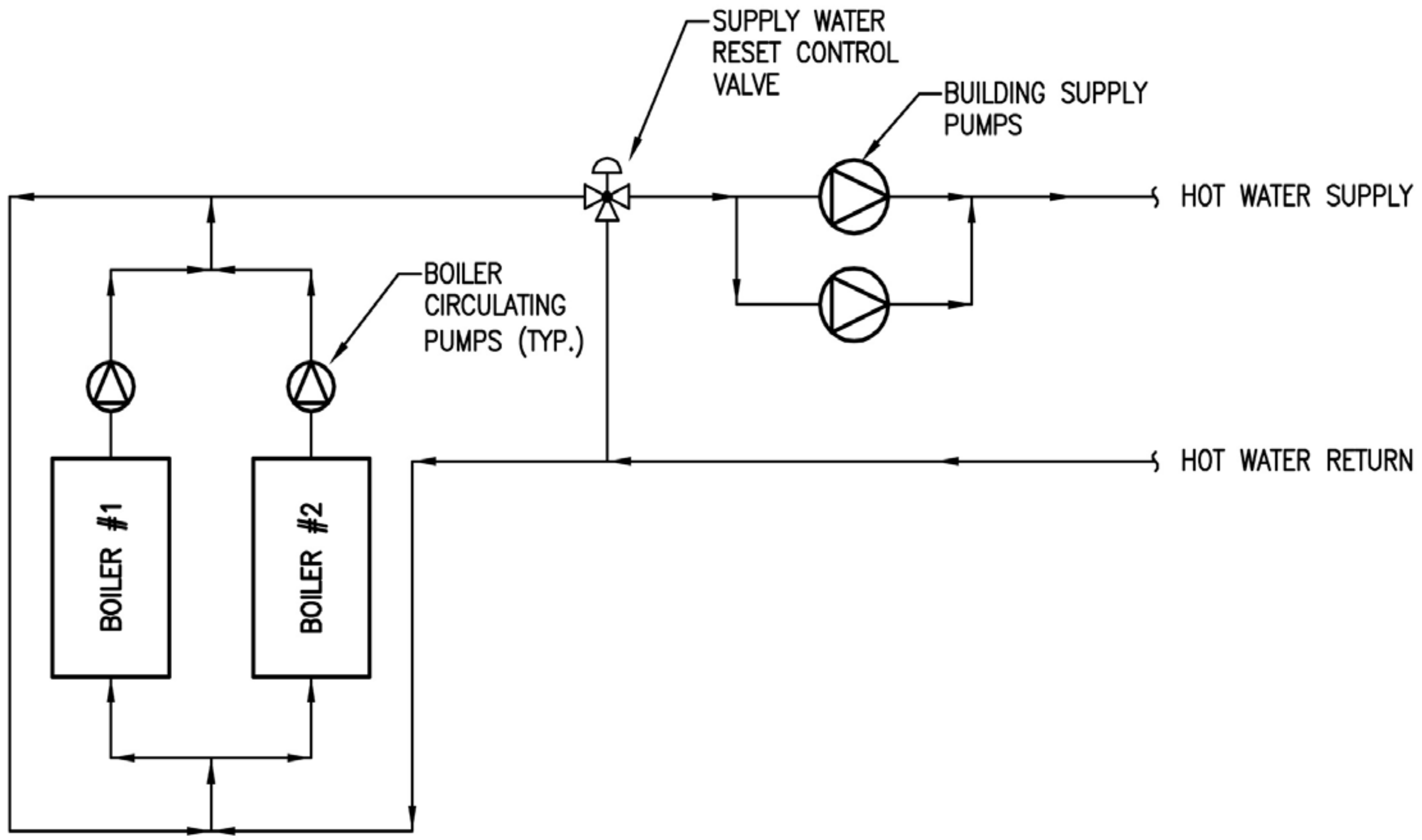
Base efficiency (ASHRAE 90.1) hot water boilers = 80 to 83%

Mid-efficiency = 83 to 88%

Condensing boilers = 88 to 95%

Pole vaulting or limbo dancing?

A Typical Conventional Boiler System



Variable speed building pumps

Reset HW supply temp, 3-way valve controls

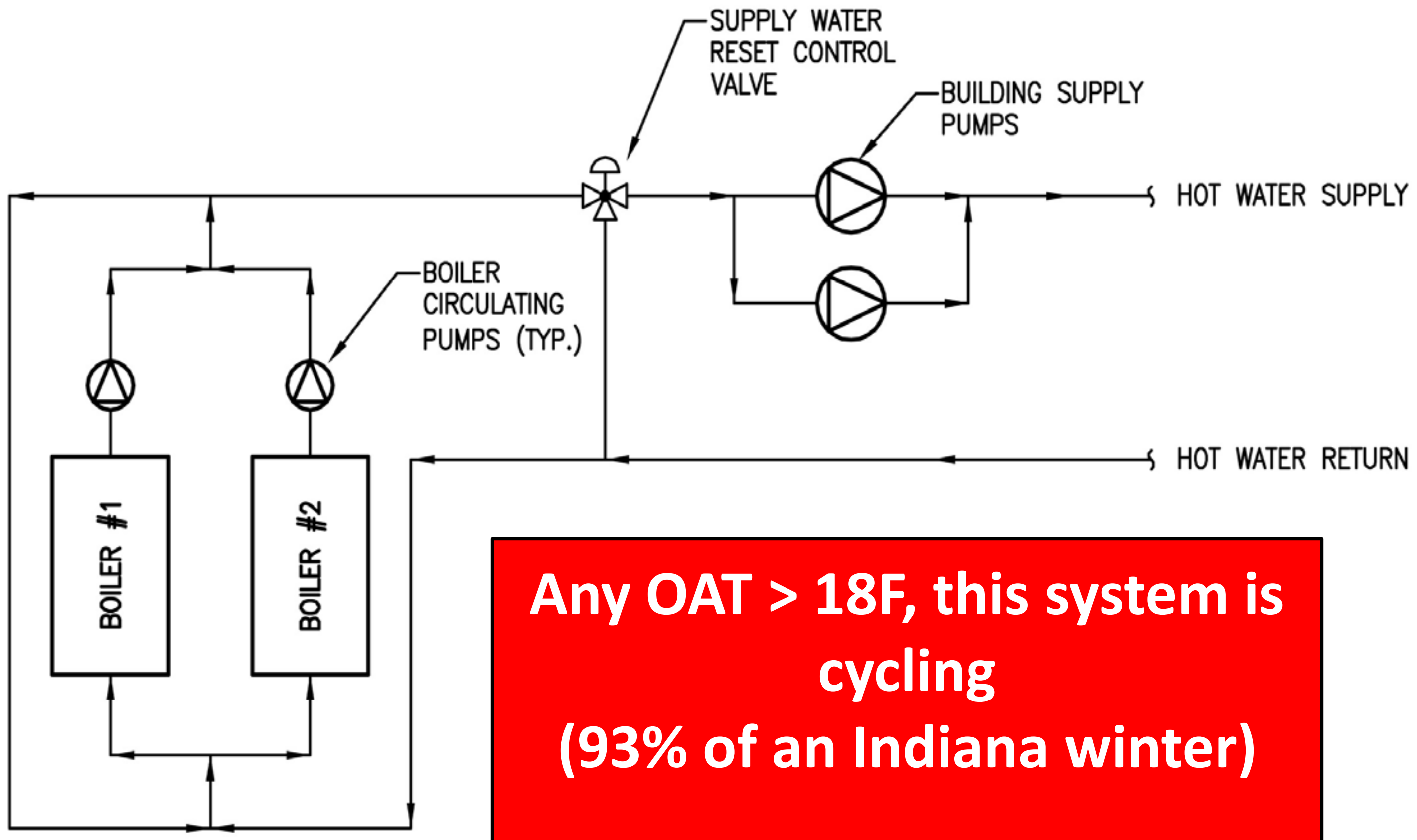
Boilers sized for 75% of peak demand

4:1 turn down on boiler

20F Delta-T system design

Low Delta-T on building loop, 15F average

A Typical Conventional Boiler System



Any OAT > 18F, this system is cycling
(93% of an Indiana winter)

Variable speed building pumps

Reset HW supply temp, 3-way valve controls

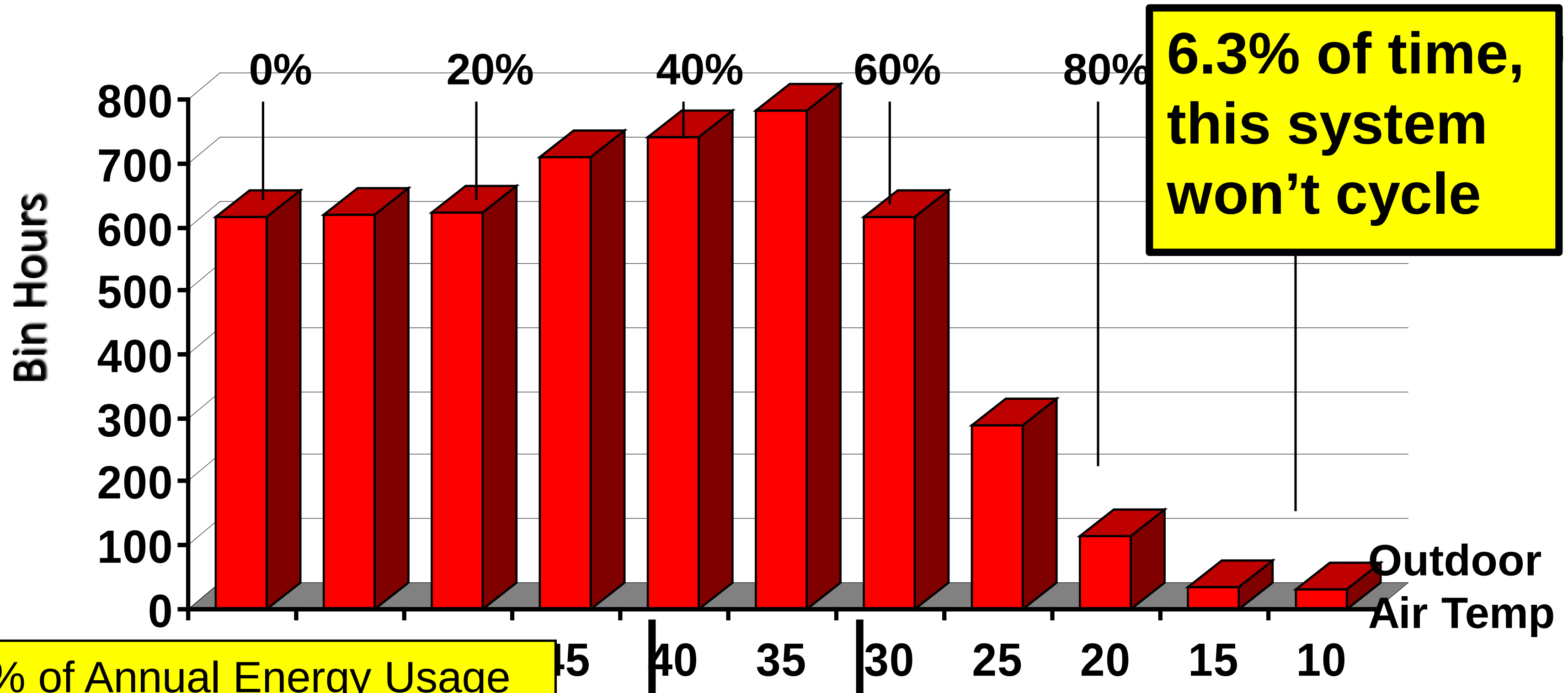
Boilers sized for 75% of peak demand

4:1 turn down on boiler

20F Delta-T system design

Low Delta-T on building loop, 15F average

Part Load Effect



38% of Annual Energy Usage during less than 40% of Building Heating Load

80% of Annual Energy Usage during less than 60% of Building Heating Load (above 30F outdoor air temp.)

Part Load and Turndown

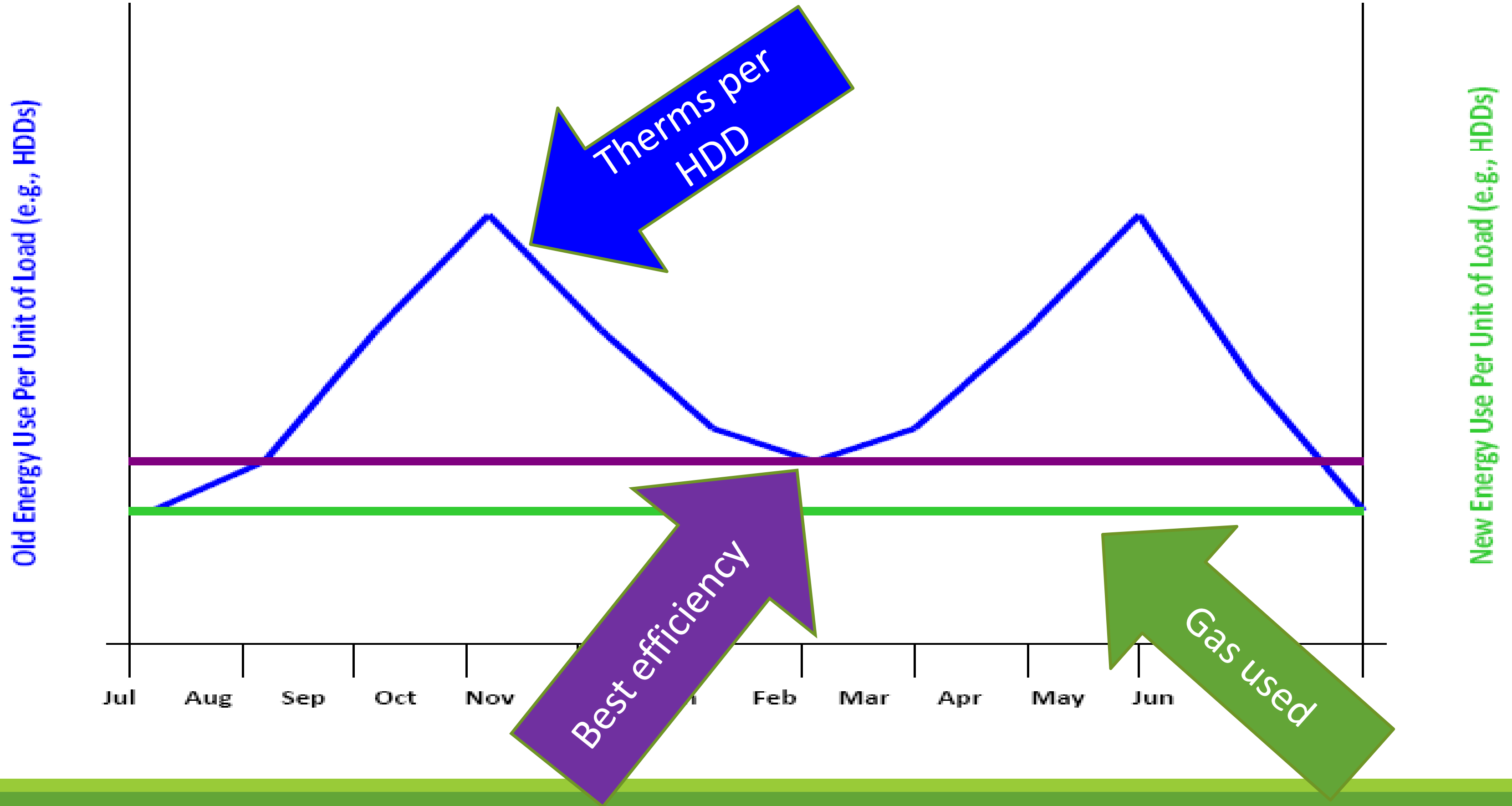
Cycle Efficiency Curve (Nichols-McKeegan Curve)

<u>Therms</u> per <u>heating degree day (HDD)</u> plotted by month for heating season

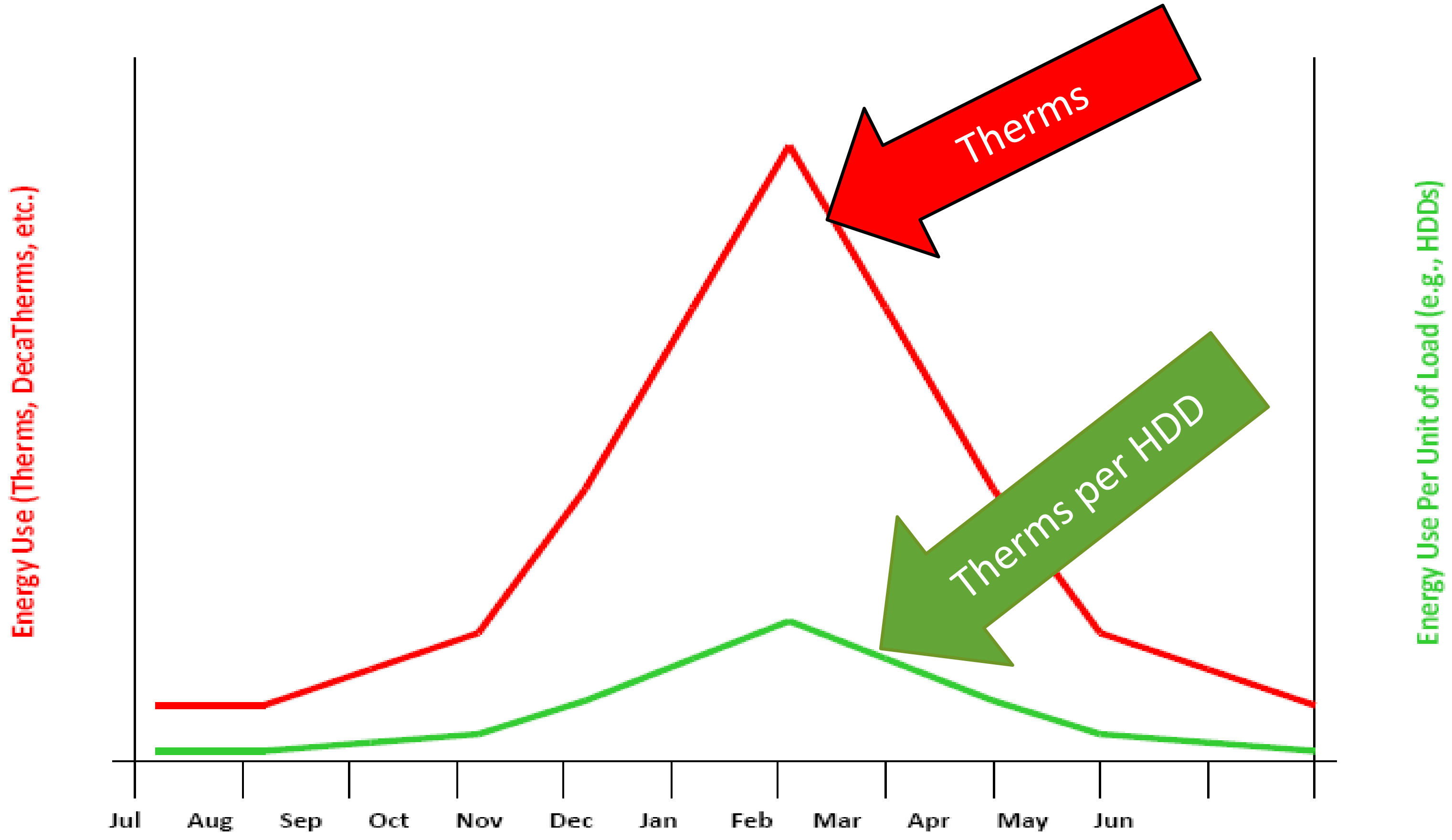
- An easy check on how efficient your entire heating system is, not just the boiler.
- A measure of system efficiency versus component efficiency

When a boiler cycles, there is a pre-purge and post-purge. Both are significant energy wasters.

Therms per HDD (theory)



An ideal curve…



Therms per HDD Analysis

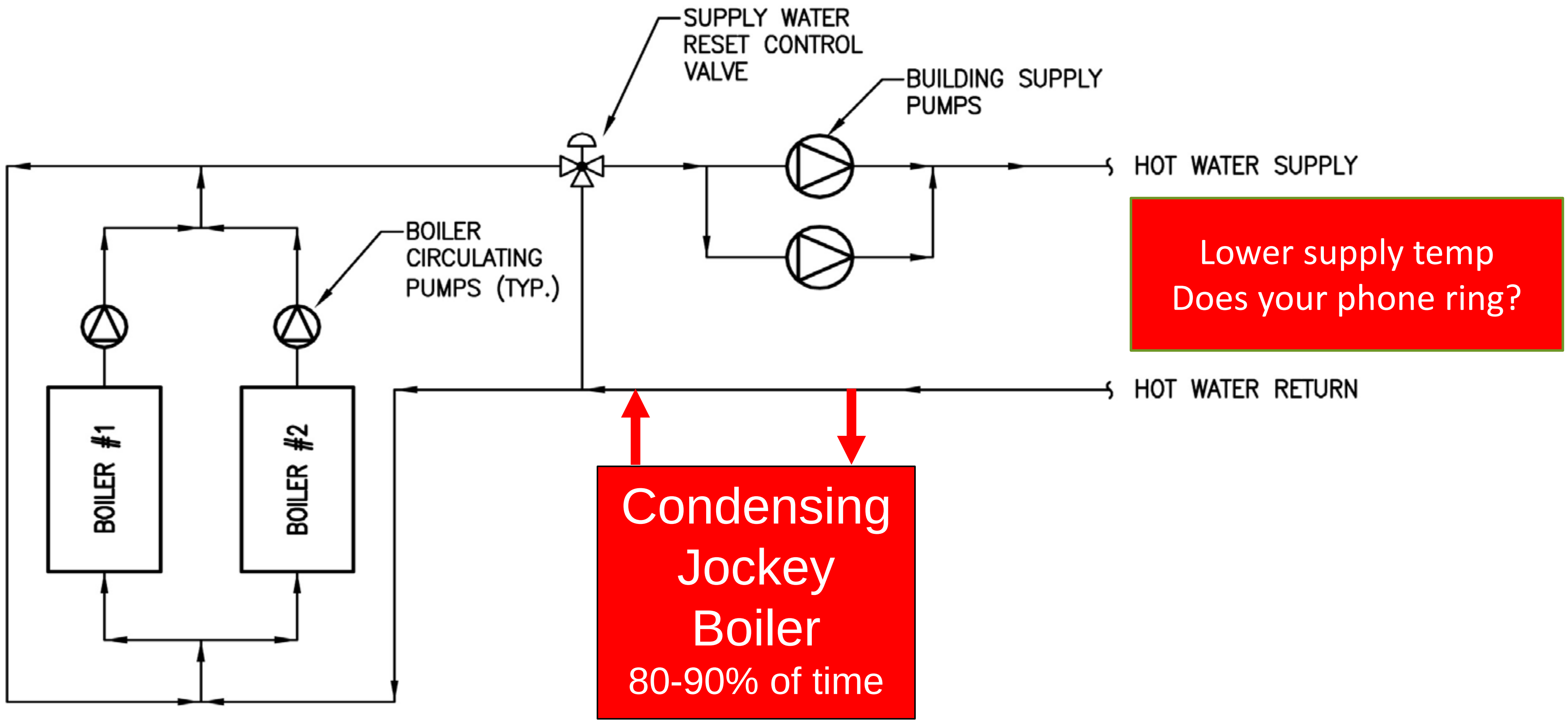
Month	Therms	$	$/Therm	HDD	Therms/HDD
May	3349	$2878	$0.86	158	21.20
April	5332	$4568	$0.86	371	14.37
March	7042	$6027	$0.86	435	16.19
February	7823	$5515	$0.70	1149	6.81
January	7748	$5462	$0.70	1422	5.54
December	7170	$5056	$0.71	983	7.29
November	3981	$2468	$0.62	731	5.45
Total	42,445			5,249	8.09

Potential savings

33% of gas

$11,920/7-months

How do we fix it?



Six Principles of Cycle Efficiency Improvement

1. Peak heating loads occur very rarely. Boilers must be able to meet small loads at high efficiency.
2. Boiler plant should be designed to increase efficiency as load decreases.
3. Boiler plant must "load match." It must be able to operate efficiently no matter how mild the weather or small the load.

Six Principles of Cycle Efficiency Improvement

4. It is easier to achieve high cycle efficiency with low mass boilers rather than high mass boilers.
5. Boiler modulation should not be at the expense of combustion efficiency.
6. Boiler plant control has to optimally match real time load.

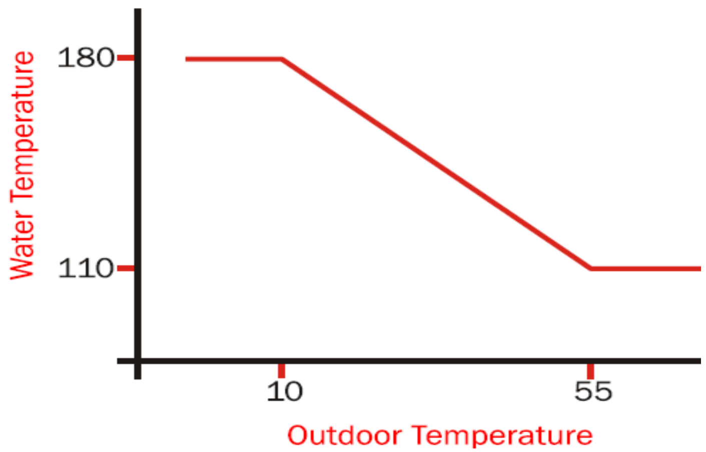
Healthy Heating Systems

The bottom line on cycle efficiency…

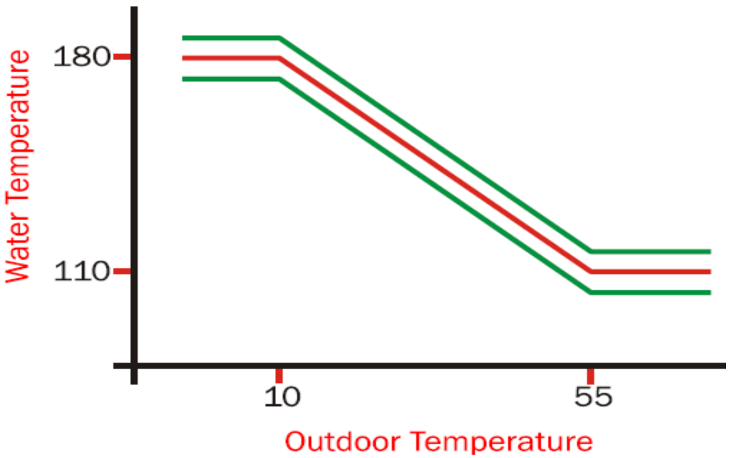
- Starts per hour? One per day is good.
- What's the real turndown? Not as % of boiler capacity, but as a % of actual (not peak) load.
  - Traditional boiler: 4:1
  - Condensing boiler: 25:1
- How is it being controlled? Wide dead band (20F min) on supply temp.

HW Supply Reset Schedules

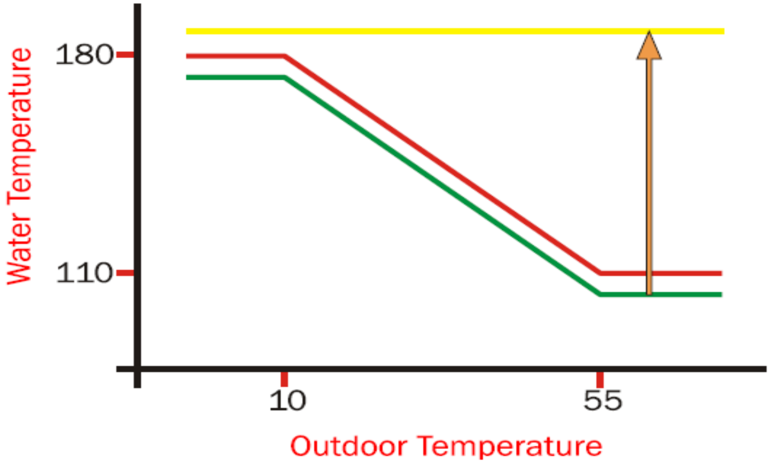
(if we can't get feedback from the building)



Typical



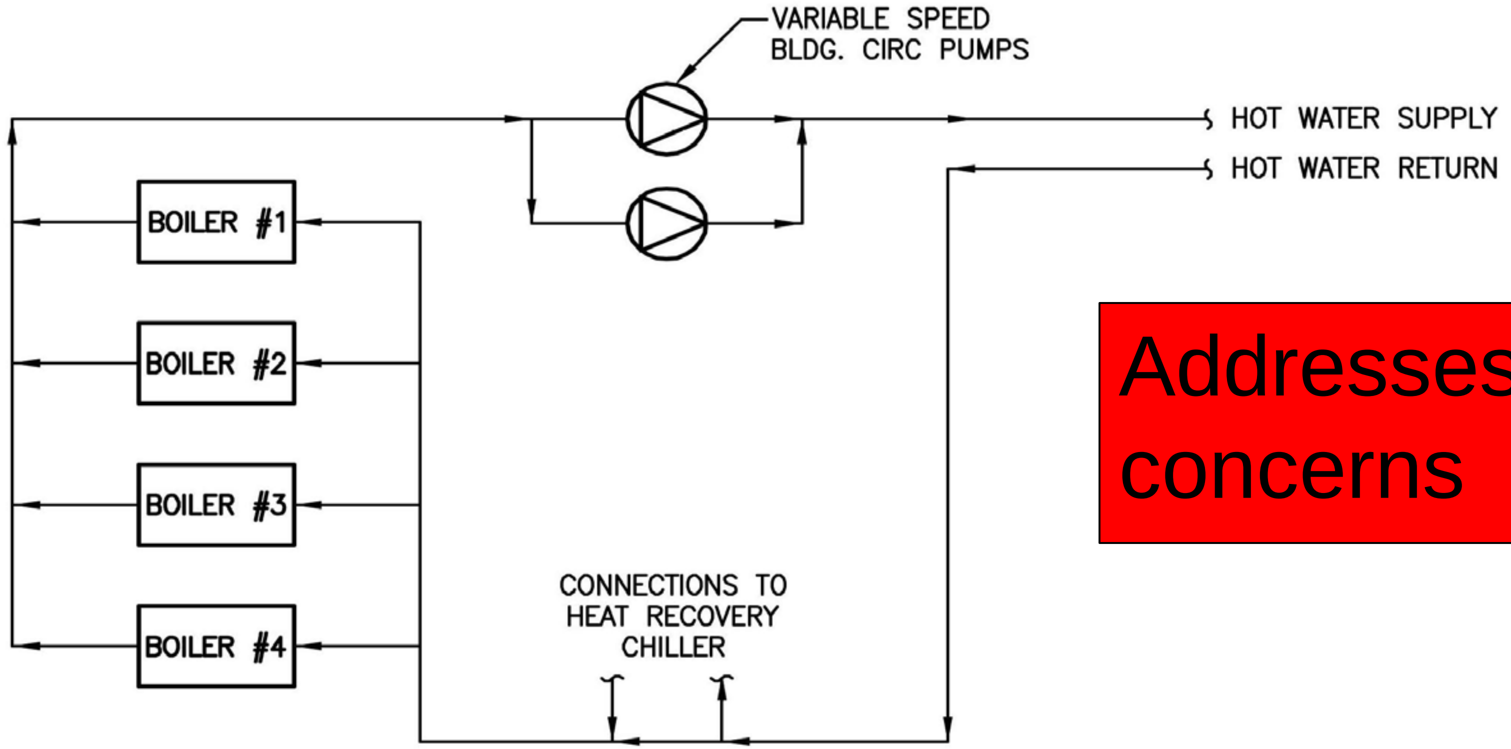
Better: +/- 10F dead band



Recommended: once it starts, let it run.

Minimize the number of starts.
(Few numbers we work with matter less than HW supply temp)

Condensing Boiler Arrangement



Addresses all concerns

In the Building, what has to change?

Pumps, piping and valves are the same (20F Delta-T)

Coils have to be deeper, 3 or 4 row versus 1 or 2 row
($300 per AHU, $30 per VAV)

AHU's require additional static ~ 0.10 in.

VAV boxes require additional static downstream ~ 0.25 in.

Radiation and convection need fan assist

Any other benefits?

- Boiler room gets smaller
- Piping gets simpler
- Fewer pumps
- No boiler room louvers, easy venting
- Minimized start-up losses
- Better turn-down
- Safety
- Quieter

Any limitations?

- In retro-fits, what's the **threshold of pain**
- 3rd party boiler controls
- Some are not true condensing boilers
- Some have high internal pressure drops
- Boiler minimum flow

  Avoid the noise

My (your?) new favorite number

130

Max HW Supply Temp, reset vs. OAT

From condensing boilers

Expanded Applications

Integration with:

- Heat Recovery Chillers
- Geothermal

What is a Heat Recovery Chiller?

Water cooled chiller

Elevated condensing temperatures = 130F

Condenser connection to building heating system

Applicable and **cost effective** any time there are concurrent heating and cooling loads

Coefficient of Performance

Approximate seasonal averages, equipment only, not system COP

Central Steam COP = 0.86 at building

Site generated LP steam COP = 0.5

Conventional 180F boiler COP = 0.66

Condensing boiler COP = 0.9

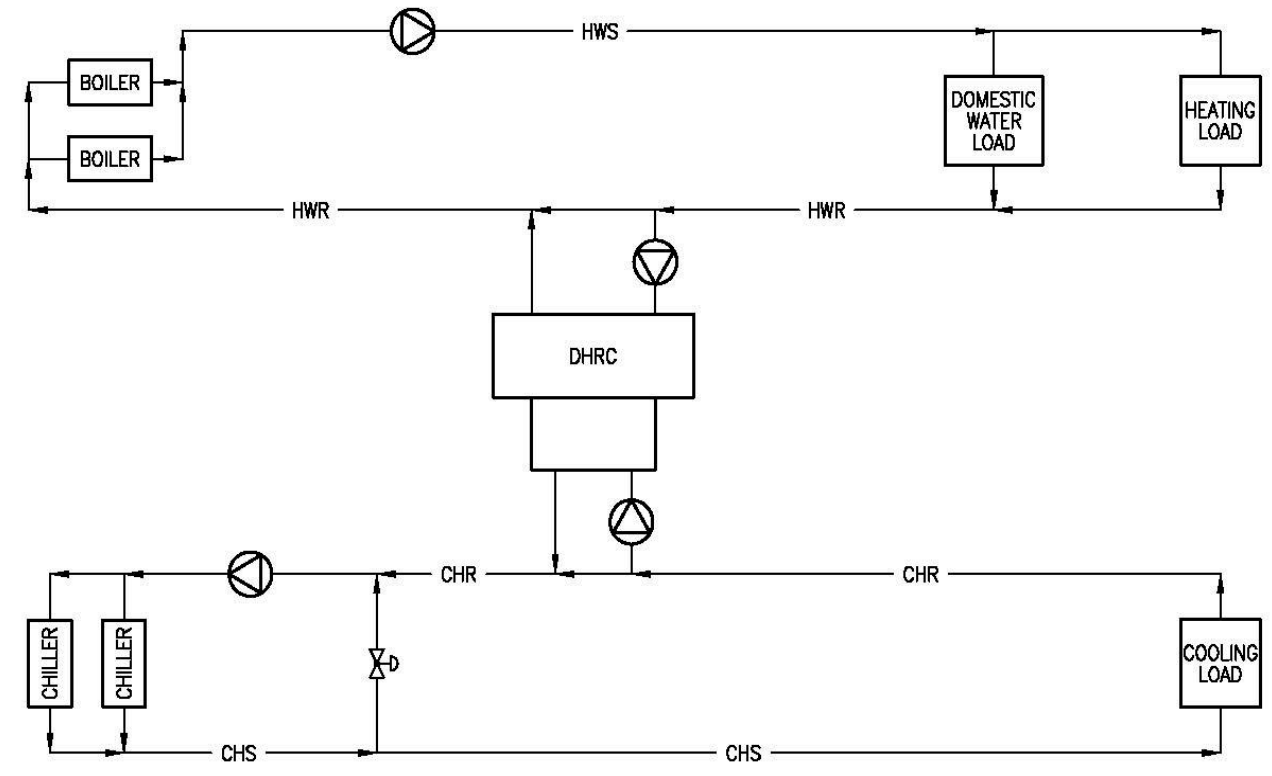
Geothermal COP = 4.2

HRC COP = **7.7** (Htg and Clg)

At average Indiana rates, per therm, electricity is 3.5 times more expensive than gas.

Heat Recovery Chiller

Sized for the larger of the winter cooling load or the summer heating load.



Heat Recovery Chiller in a 4-Pipe System

HRC Efficiency

Dependent on temperatures:

- Evaporator inlet, higher is better
- Condenser inlet, colder is better

HW Reset Schedule

120F HWS at OAT >60F

Reset to

180F HWS at OAT <0F

(DHRC available about 6,500 hours/year in Indy)

Revised HW Reset Schedule

(Building designed for low Temp heat)

90F HWS at OAT >60F

Reset to

130F HWS at OAT <20F

(DHRC available about 8,760 hours/year)

HW Reset Non-Schedule

180F HWS at All times

(DHRC available zero hours/year)

A Concurrent Heating/Cooling Load:

Scenario 1

Campus Cooling = $0.06/T-Hr

= $0.50/100 MBTU

Campus Heating = $0.57/Therm

Total = $1.07

A Concurrent Heating/Cooling Load:

Scenario 2

Economizer Cooling = Free (outside air)

Campus Heating = $0.57/Therm

Total = $0.57/Therm

A Concurrent Heating/Cooling Load:

Scenario 3

HR Chiller Cooling = @0.85 kw/Ton

= $0.32/100 MBTU

HR Chiller Heating = Free (rejected condenser heat)

Total = $0.32

A Concurrent Heating/Cooling Load:

Totals

(100 MBTUs HW & CHW)

Scenario 1 = $1.07

Scenario 2 = $0.57

Scenario 3 = $0.32

A Concurrent Heating/Cooling Load:

Totals

(100 MBTUs HW & CHW)

Scenario 1 = $1.07

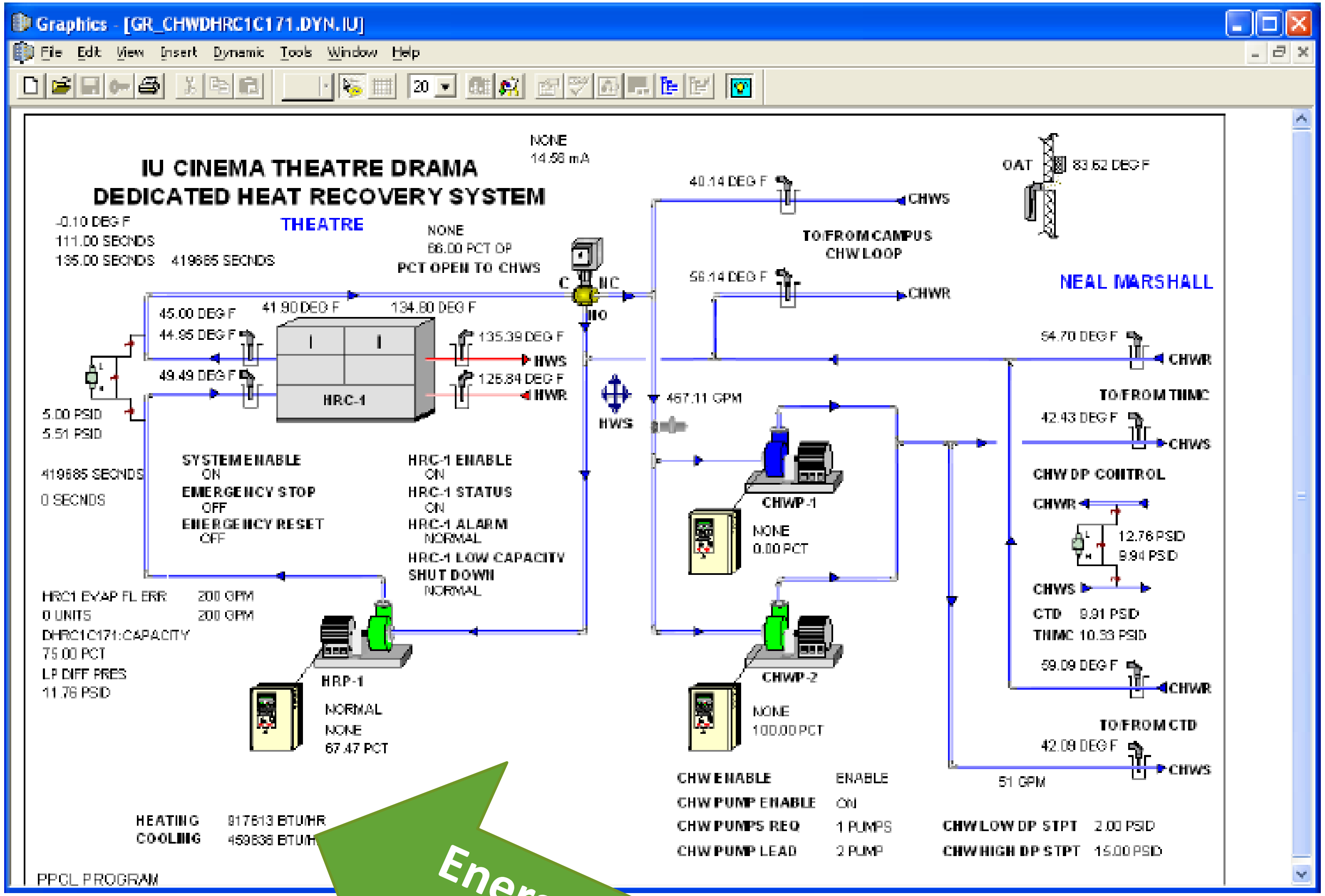
Scenario 2 = $0.57

Scenario 3 = $0.32

Scenario 3a = <$0.18>

Result of Previous Analysis

Heat recovery chiller and low-temp heating were bid as an alternate, $159,000 premium, 4.7 Yr projected pay-back, actual pay-back = **2.3 Yrs.**



Energy Recovered = $67,800/Yr

Great idea and Compelling Economics, but…

You have to have a place to put the hot water in summer

- VAV reheat
- Domestic water heating
- Swimming Pools

You have to have a place to put the chilled water in the winter

- Computer centers
- Economizer coordination, if gas prices are high enough.

In-Patient Psychiatric Hospital

BTU Meter calculates recovered heat

April to August 2006 = 1,386.4 MMBTU recovered

Value of recovered heat = $18,500 plus $585 chiller efficiency differential

Payback when planned…..............6 yrs

As operated (Katrina Effect) …..**1.9 years**

Tri-North Middle School

Utility Costs

Electric was $0.55/kWh, up to $0.63/kWh

Gas was $0.54/Therm, up to $1.09/Therm

Normalized for Utility Cost and HDD

2005…………………………………..$94,700

2002 usage at 2005 rates…… ….$143,907

Payback……………………………… **2.0 years**

Maximize the Investment

- Run as many hours as possible.
- Don’t over ventilate in winter. (“Free Cooling” isn’t always free)
  - My scenario 2 vs. 3
- Domestic hot water.
- Swimming pool.

A Chiller Retro-Fit

Chiller Plant Conventional		With HRC	
Chiller size	2 @ 375T	Chiller size	2 @ 325 plus DHRC @ 100T
CHL	$445,000	CHL	$432,000
Cont.	$178,000	Cont.	$219,000
		Add'l Piping	$6,200
		DHRC	$85,000
	$623,000		$742,000

0.5% of total project budget

$26K/Yr summer gas bill = 4.6 Yr paybackl

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		DHRC	$85,000
	$623,000		$742,000
Pool Dehumid	$135,000	HW/CHW AHU	$40,000
Total	$758,000	Total	$782,000

0.5% of total project budget

$26K/Yr summer gas bill = 4.6 Yr paybackl

0.1% of total project budget, payback = 11 months

We recognize the value of low temperature heating, but we want Geothermal because…

- It will lower operating costs
- It is a good long-term investment…a properly designed geo field has a 50+ year life expectancy
- It will reduce air pollution and green house gasses
- There may be incentives from the government or local utility
- It would be an excellent addition to the science curriculum

Cooling Efficiency

Cooling Source	Full Load EER	Part Load EER
Air Cooled Chiller	9.60	15.0
Water Cooled Chiller	17.1	15.2
Geothermal	**21.0**	**21.0**

Based on mid-efficiency equipment.

Multiple Dynamic Variables

Heating Efficiency

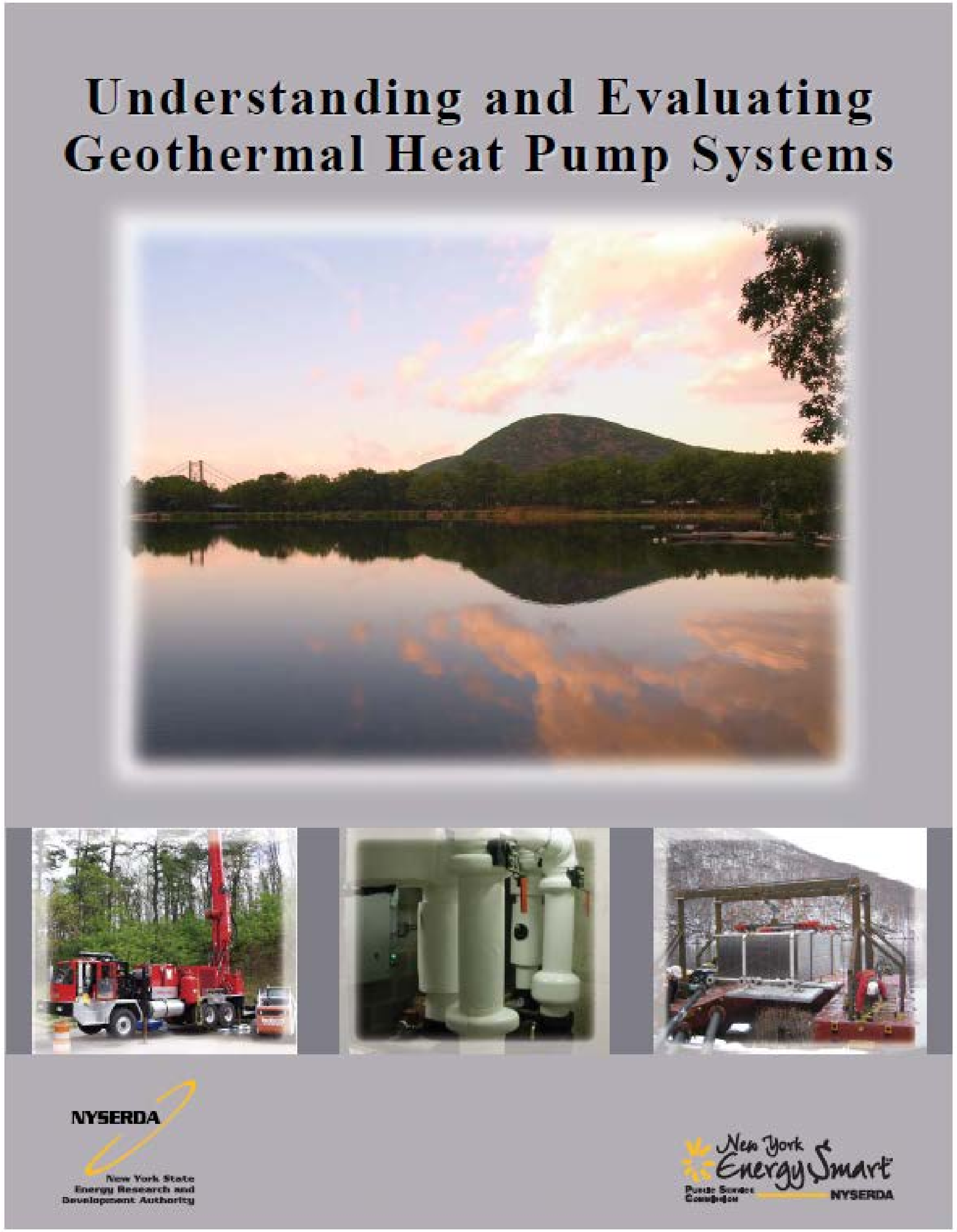
Heat Source	Efficiency AFUE
Electric	100%
Steam Boiler	50%
Conventional Boiler	66%
Condensing Boiler, Low Temp Operation	90%
Geothermal	**360%**

Gas

Electric

Multiple Dynamic Variables

One of many design guides available on the web



Some definitions…
ASHRAE Applications Handbook

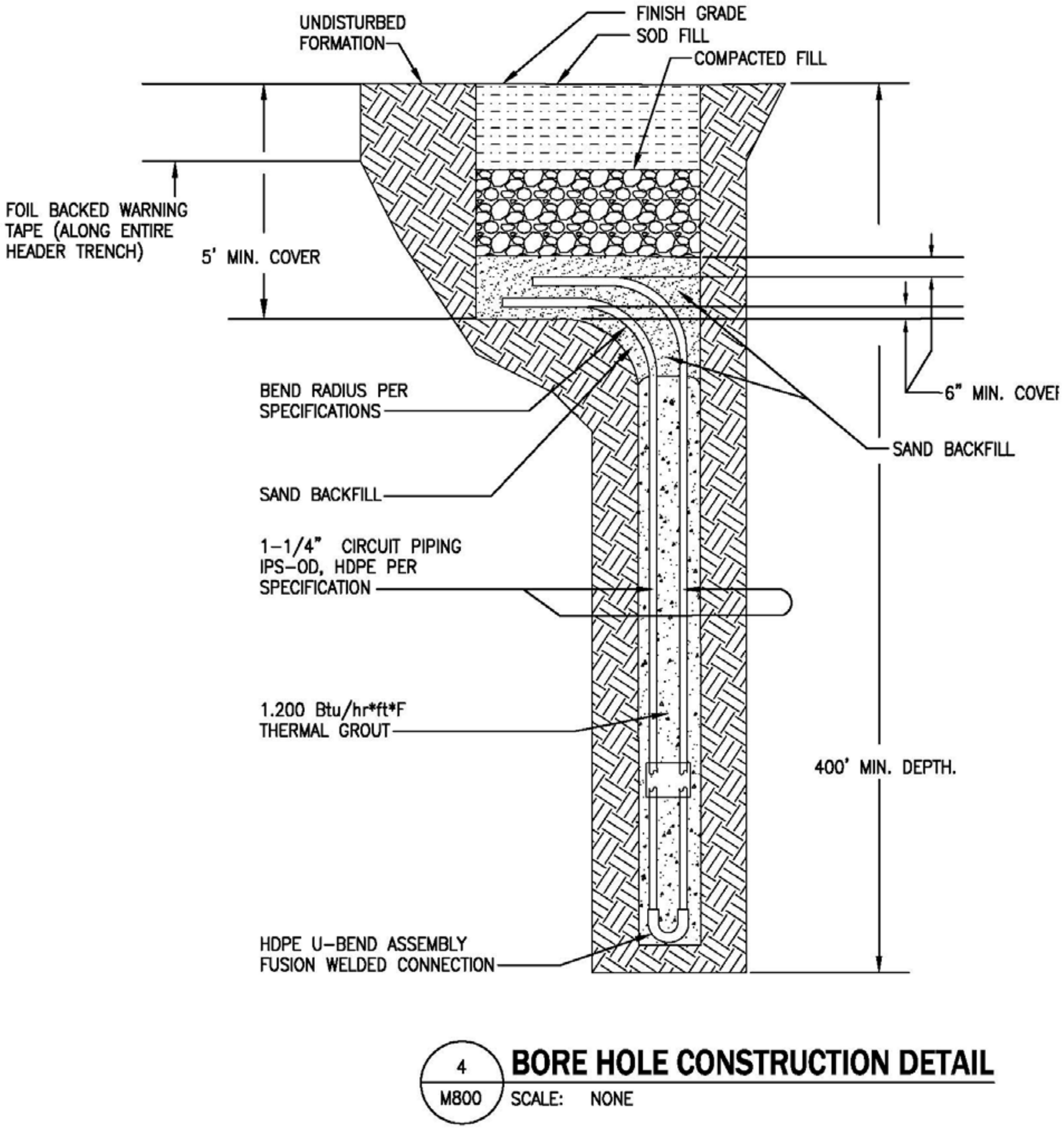
Geothermal: Using the earth as a heat source and heat sink

Closed loop systems: circulate an engineered heat transfer solution through either

Bore holes (wells)

Horizontal loop

Open Loop systems: using ground water, lakes or ponds



“Rules of Thumb” for Geothermal

- One borehole equals two tons of cooling *
- One borehole equals 20 MBH of heating *
- One borehole per 800 SF of school
- One borehole costs $5,000
- One football field equals 150 boreholes
- Premium cost of $6.25 per SF of building

*Caution…performance can be highly variable!

Impediments to Implementation

- Premium Cost (+$6.25/SF) = Long Payback
- Tight Construction Budgets…the educational program always comes first
- Perceived (or real) maintenance and noise concerns
- Electricity cost is increasing
- Cost of natural gas is dropping…

  paybacks getting longer

  - 2005 = $1.40/Therm
  - 2010 = $1.00/Therm
  - 2020 = $0.50/Therm

Heating Cost (2010)

(Gas at $1.00/Therm, Electricity at $0.085/kWh)

Heat Source	Efficiency AFUE	Cost per Therm
Electric	100%	$2.49
Steam Boiler	50%	$2.00
Conventional Boiler	66%	$1.52
Condensing Boiler, Low Temp Operation	90%	$1.11
Geothermal	**360%**	**$0.69**

(multiple dynamic variables)

Heating Cost (2020)

(Gas at $0.70/Therm, Electricity at $0.105/kWh)

Heat Source	Efficiency AFUE	Cost per Therm
Electric	100%	$3.08
Steam Boiler	50%	$1.40
Conventional Boiler	66%	$1.06
Condensing Boiler, Low Temp Operation	90%	$0.77
Geothermal	**360%**	**$0.85**

(multiple dynamic variables)

The Most Dynamic Variable
Geothermal Performance

Bore field temperature

Defines the Capacity and Energy Efficiency Ratio (EER) in cooling

- Cooler are better for cooling

Defines the Capacity and Coefficient of Performance (COP) in heating

- Warmer are better for heating

Geothermal Well Temperature

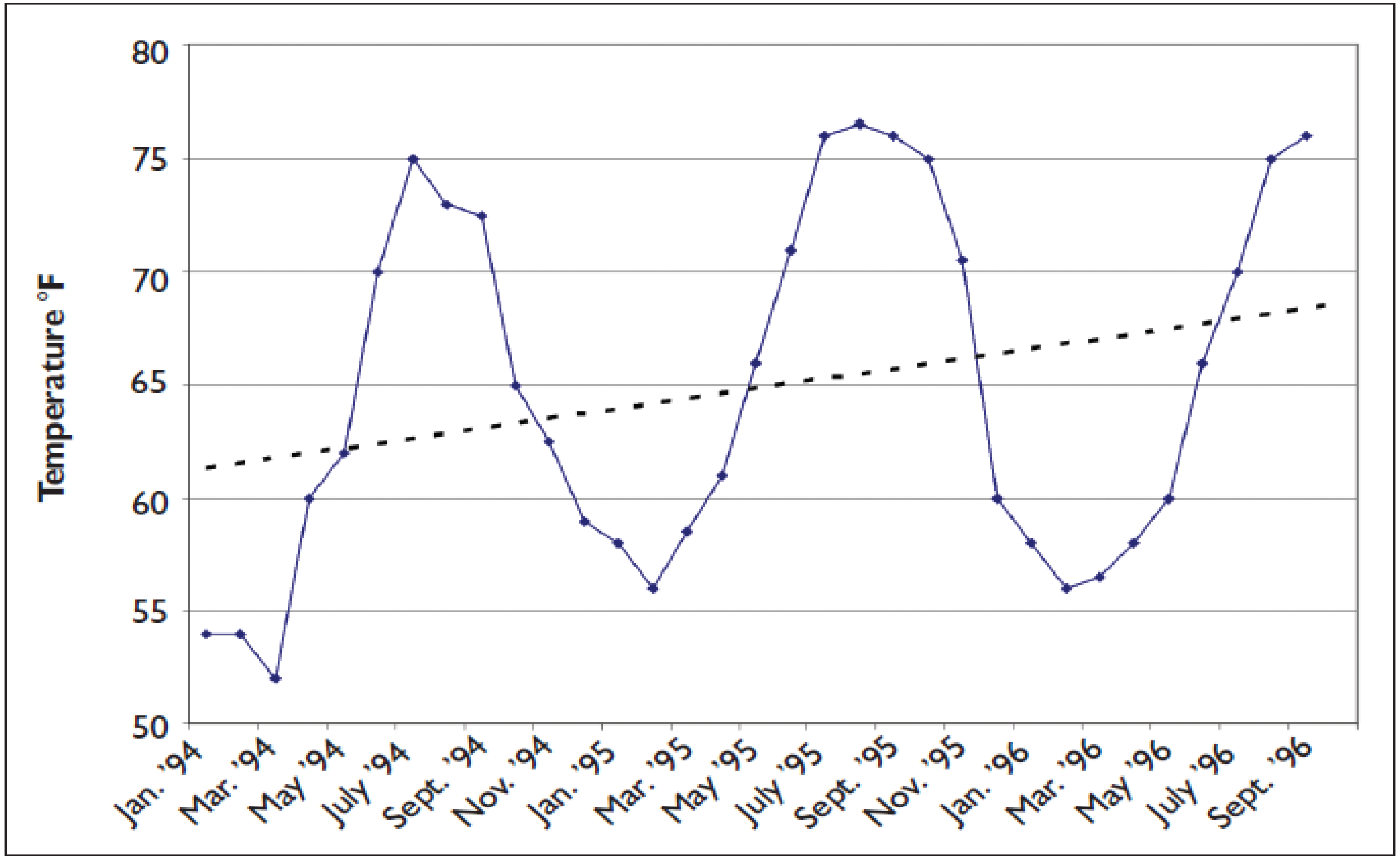


Figure 4: Borehole field return temperatures.

Well Temperature vs. COP, Capacity and EER

Bore Field Return Temperature	COP (heating)	Heating Capacity	EER (cooling)	Cooling Capacity
30	3.7	67%	41.9	
40	4.3	78%	40.7	
50	4.8	90%	36.3	107%
60	5.4	100%	31.0	105%
70	5.9	110%	25.8	100%
80	6.4		21.0	94%
90	6.9		16.9	86%
100	-		13.4	78%

BUT, WHEN YOU NEED IT THE MOST, YOU GET THE LEAST

Cost per Therm for GEO Heat

Electricity per kWH	Well Temperature 70F	60F	50F	40F
$0.07	$0.38	$0.43	$0.50	$0.57
$0.08	$0.44	$0.50	$0.57	$0.65
$0.09	$0.49	$0.56	$0.64	$0.73
$0.10	$0.55	$0.62	$0.71	$0.81
$0.12	$0.66	$0.75	$0.86	$0.98
$0.15	$0.83	$0.93	$1.07	$1.22

Consider adding a low temperature condensing boiler to keep well temps above break-even temp.

Be careful not to heat up the loop so much it affects cooling capacity.

Bottom Line in 2020

- If gas is available, and if you have modern boilers, you may not save $ on your heating vs. geothermal
- You will always save on your cooling
- If gas isn't available, you'll save big with Geo
- Geo will have a lower carbon footprint

Implementation Strategy

Heat Pumps (HPs or GSHPs)

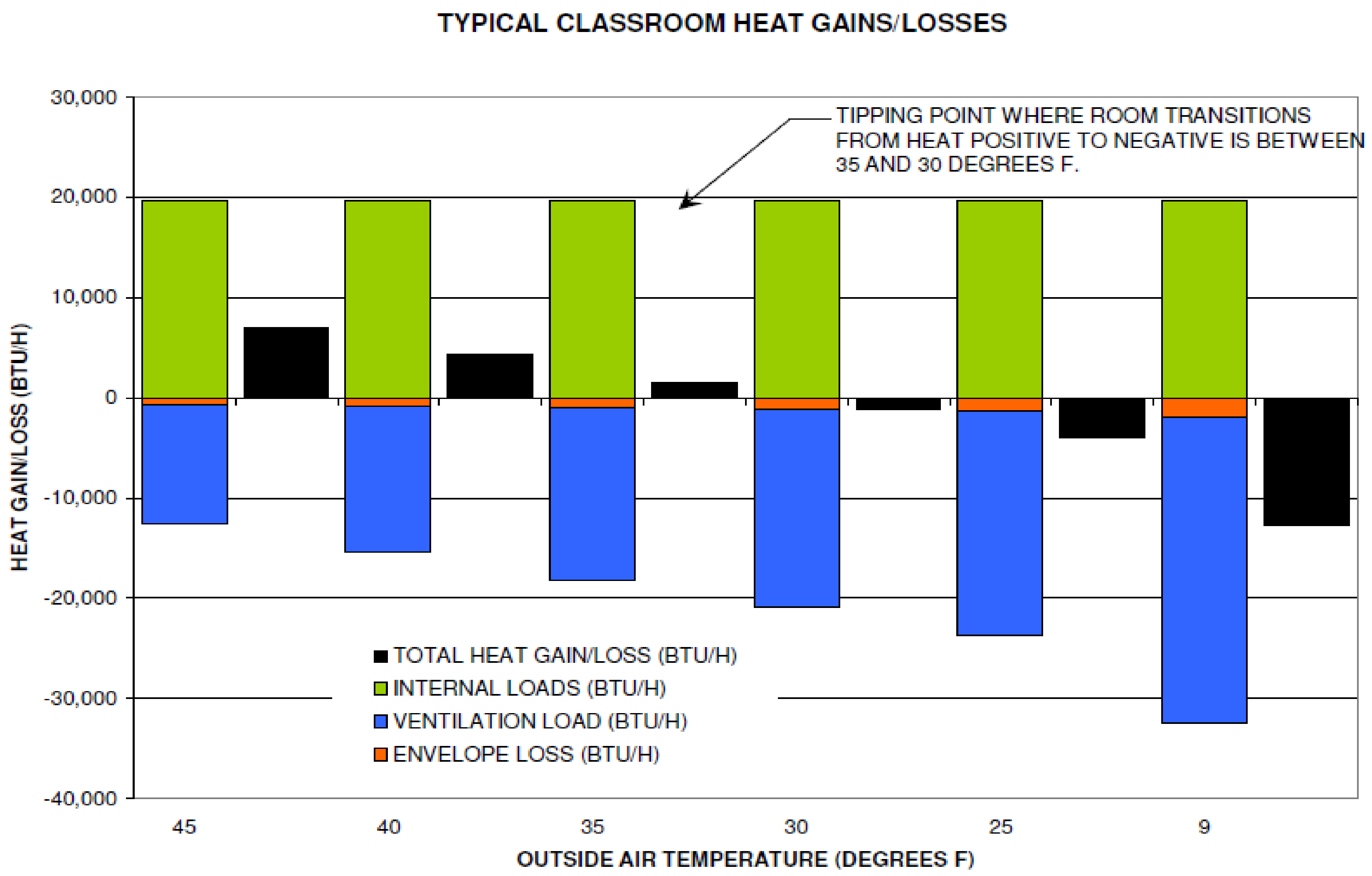
distributed throughout building, one per space connected to the well field by piping loop. This is the traditional geo approach, circa 1980.

Downside of GSHPs

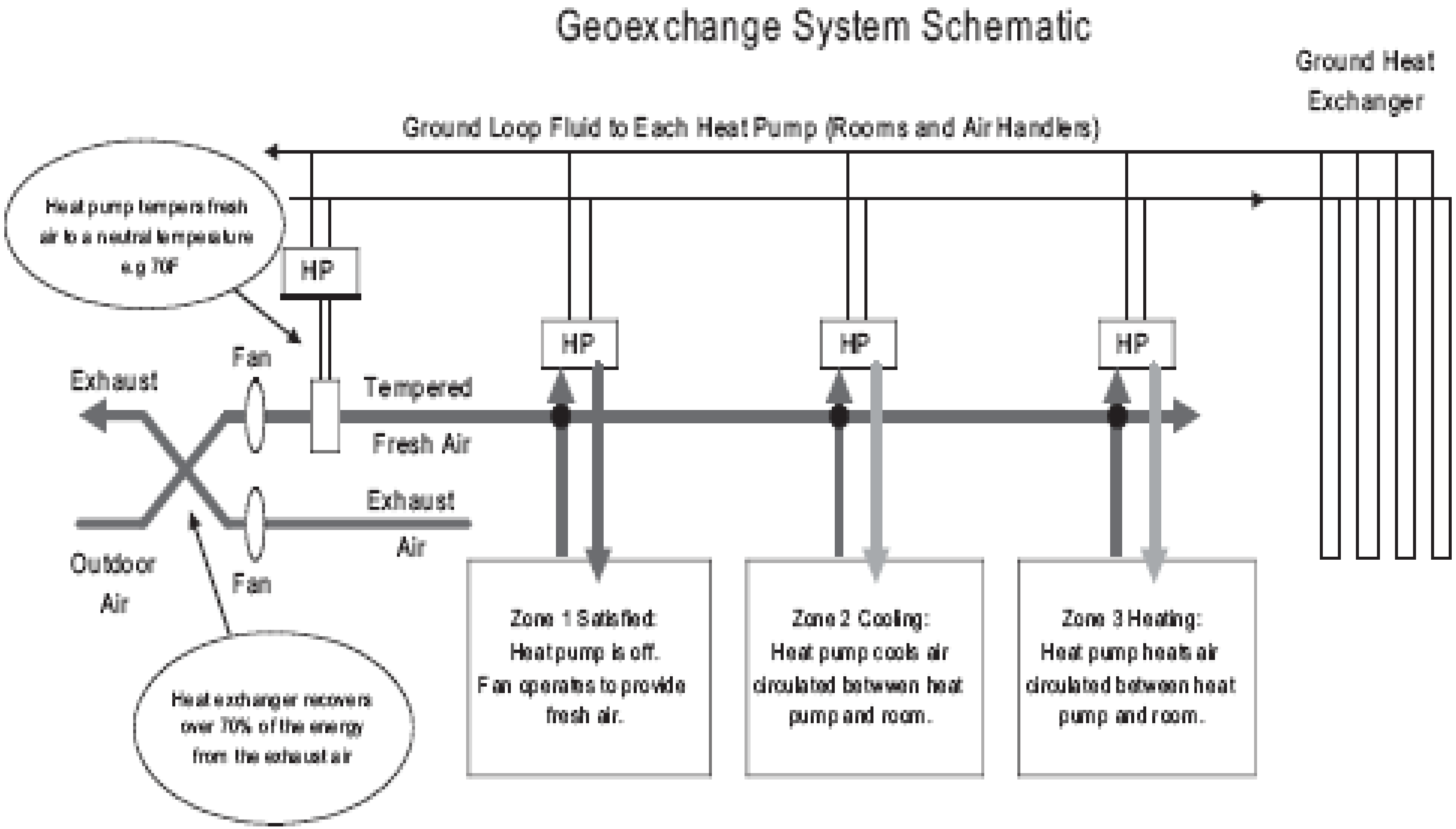
1) They cannot dehumidify high O/A fractions
2) They cannot handle cold O/A fractions

   For these two reasons, they require a separate make-up air system (DOAS), a significant first cost addition.

3) Because of the DOAS, they cannot run economizers



Operating cost penalty (3,445 hours/Yr in Indianapolis).



It takes two compressors to move heat

$1.49/day for 2 HPs

$0.78/day for 1 HP and economizer

A Second Implementation Strategy

An earth coupled heat recovery chiller (GEO-H/C)

Evaporator connected to building cooling system

Condenser connected to building heating system

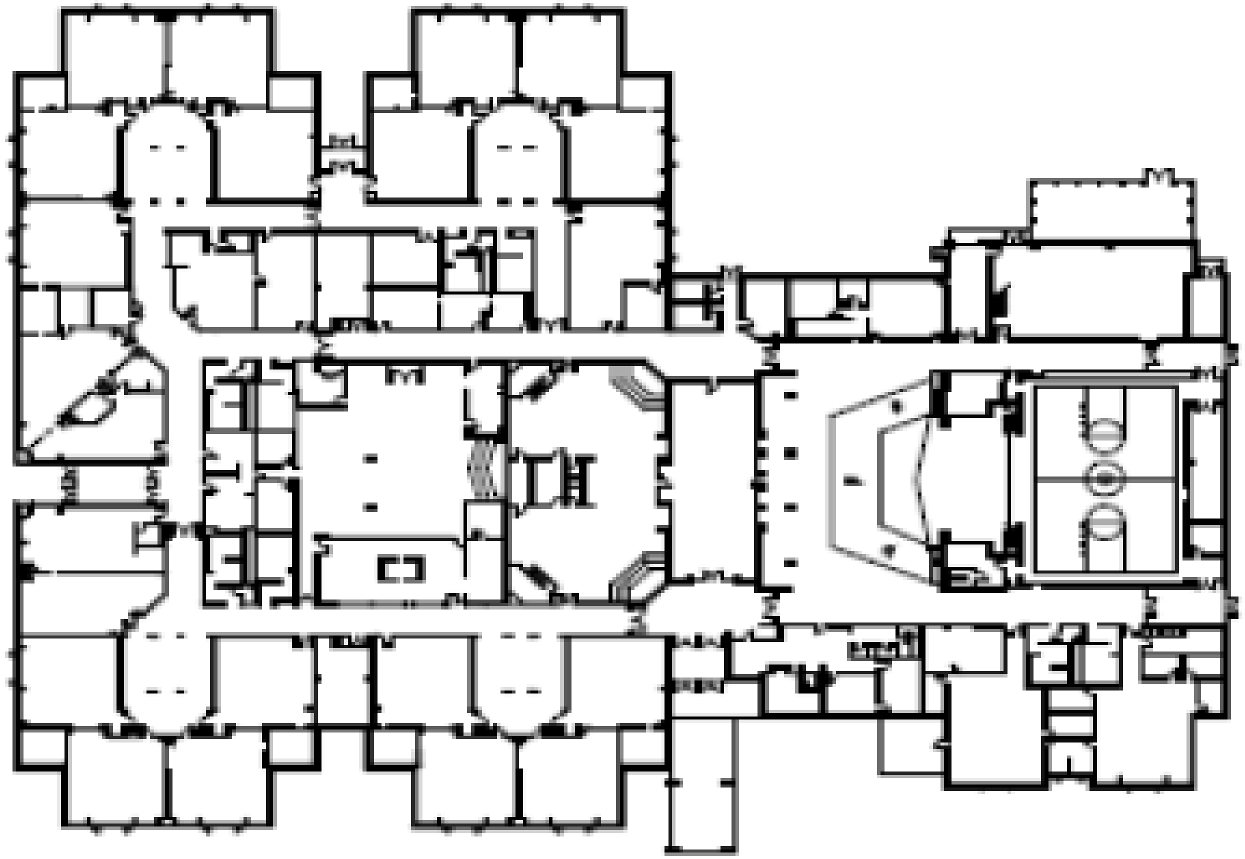
Concurrent htg/clg w/one compressor (HRC mode)

Earth coupled for heat rejection and absorption

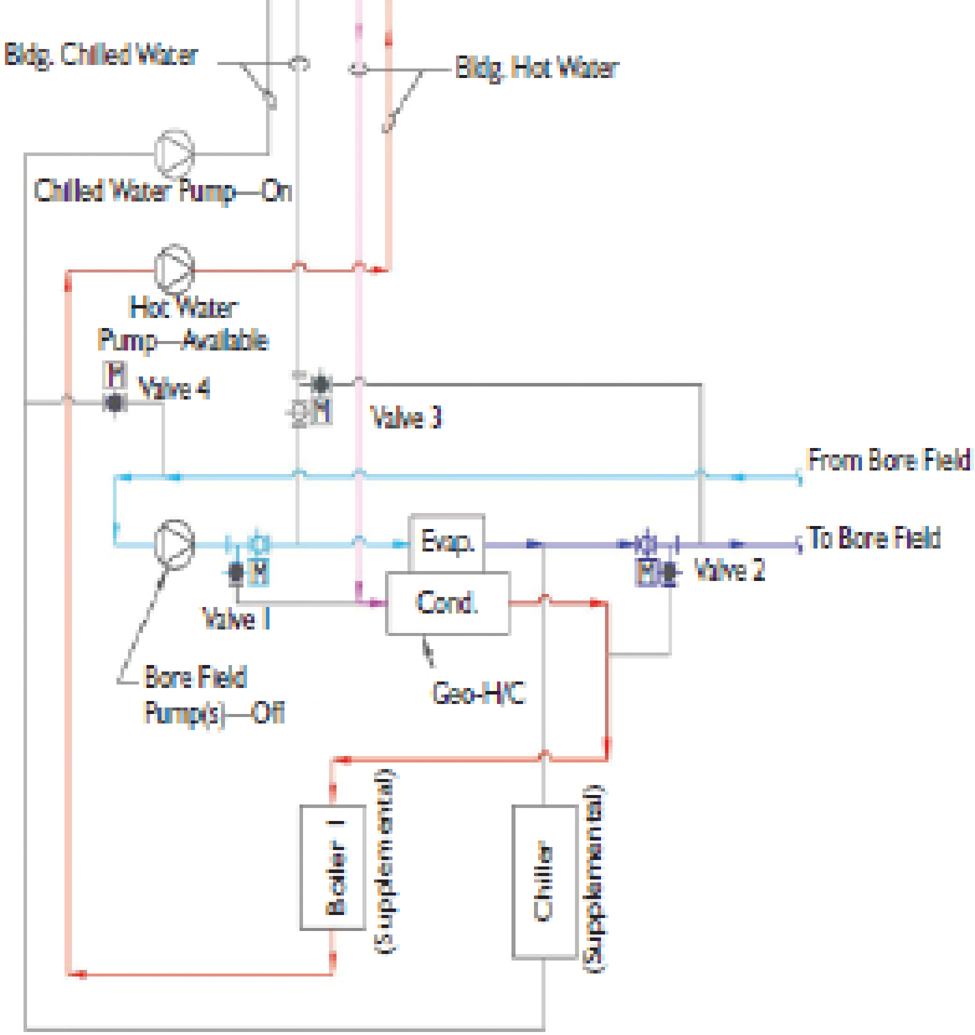
Conventional air side equipment (AHUs, UVs, FCUs, VAVs) with air side economizers, DOAS not required.

Can be retro-fitted into existing buildings

Can be an easy alternate for tight budgets



Floor Plan



System Schematic

20% lower installation cost than GSHPs

40% energy savings = $32,385/yr (1½ aides)

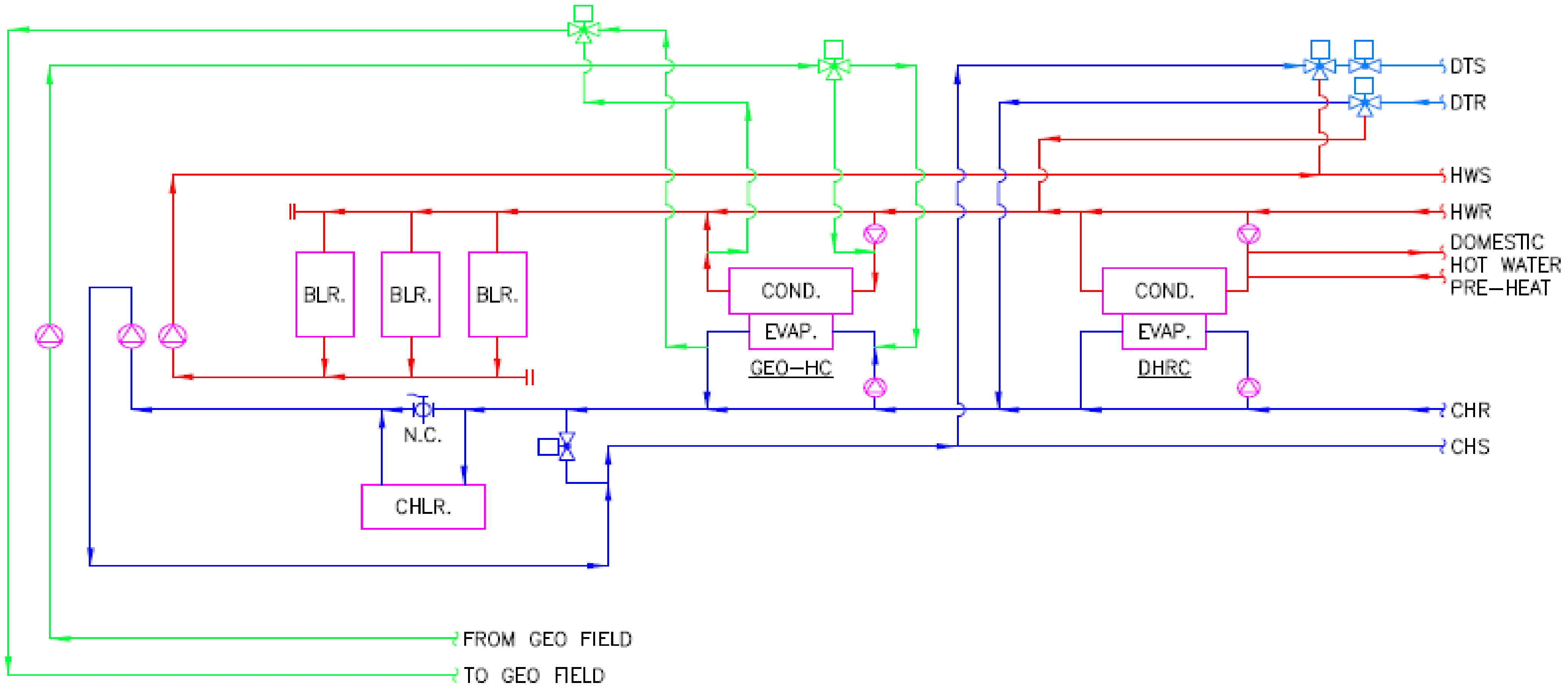
Hybrid (Partial) Geothermal

- 90 Hrs/Yr above 65% of peak cooling load (1% of total hours, 4% of school days)
- 30 Hrs/Yr above 65% of peak heating demand
- 140 Hrs/Yr above 50% of peak heating demand
- The system must be able to cover 100% of peak load

- A supplemental boiler and chiller can reduce the well size by 1/3rd and improve system redundancy

Hybrid Geo-Thermal with HRC

Kankakee Valley HS



KVHS

Governor's Award for Environmental Excellence

25% Energy Reduction, after air conditioning two gyms and the auditorium

$112,462/Yr utility cost saving

1.8 Million Lbs/Yr green house gas reduction

8.0 Yr payback on energy

What KV did…
When the cost of gas went down, they re-sequenced their system to put the boilers in the lead when the well field temperature went below the break even COP.

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$0.12	$0.66	$0.75	$0.86	$0.98
$0.15	$0.83	$0.93	$1.07	$1.22

You’ll know you’re on the right track when…

The gas company changes the meter.

Twice.

The Herald-Times

REGION

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October 10, 1997
Bloomington, Indiana

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C
Section

Schools’ new heat, air mean savings

Elementary schools’ new systems use less gas

By Sean O’Brien
H-T Staff Writer

“When the board voted to do this, our primary goal was that all kids attend air-conditioned schools. It was great that we could save money at the same time.”

Efficiency Vermont
BETTER BUILDINGS BY DESIGN

Mechanical System

Low Temperature Heating

Applications and Economics

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