How to Optimize the Performance of Your Hospital Boiler Plant: A Case Study

HESNI Healthcare Engineers Society of Northern Illinois

HESNI Annual Conference
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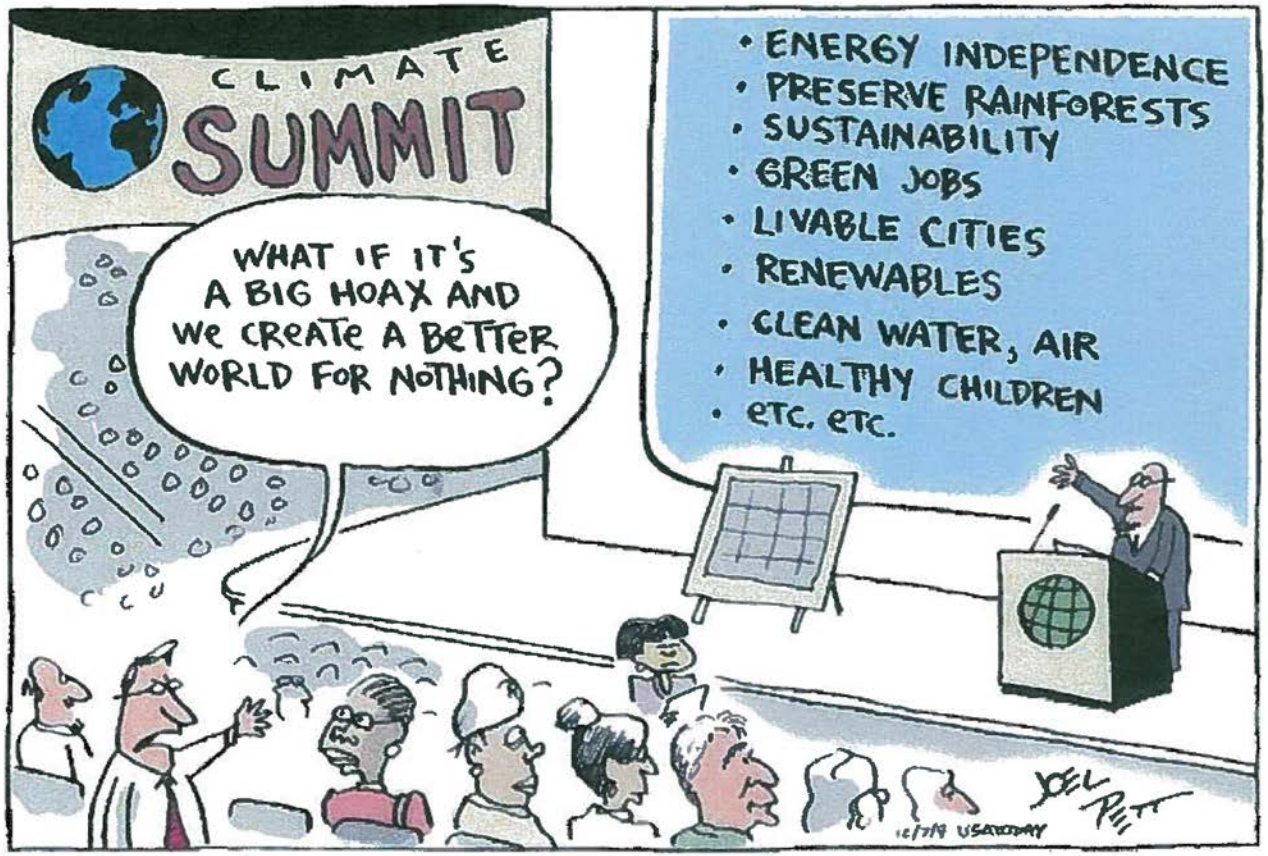
There Are Many Compelling Reasons for Hospitals to Conserve Energy (and Water)



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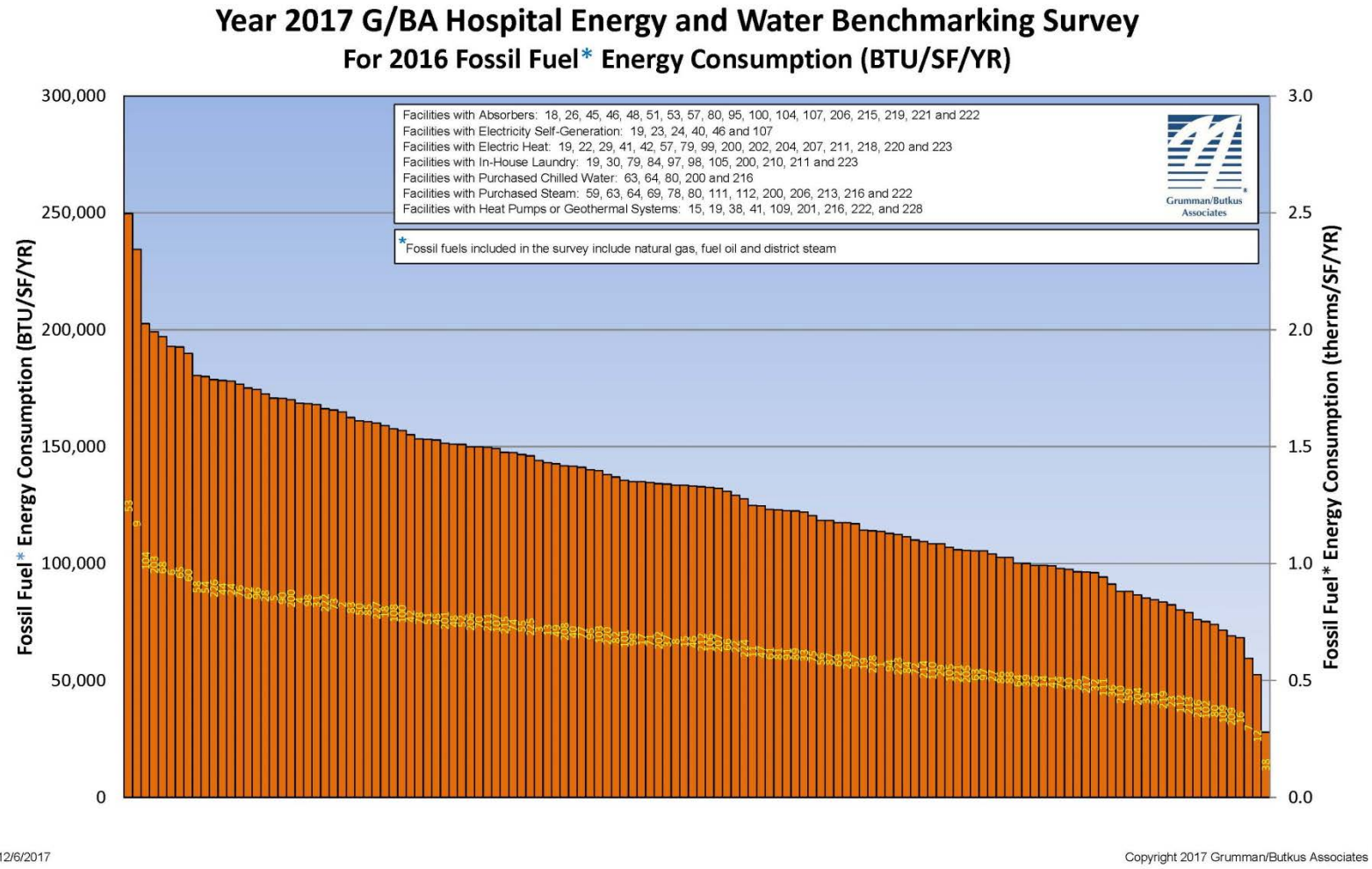
Hospital Gas Usage



12/6/2017

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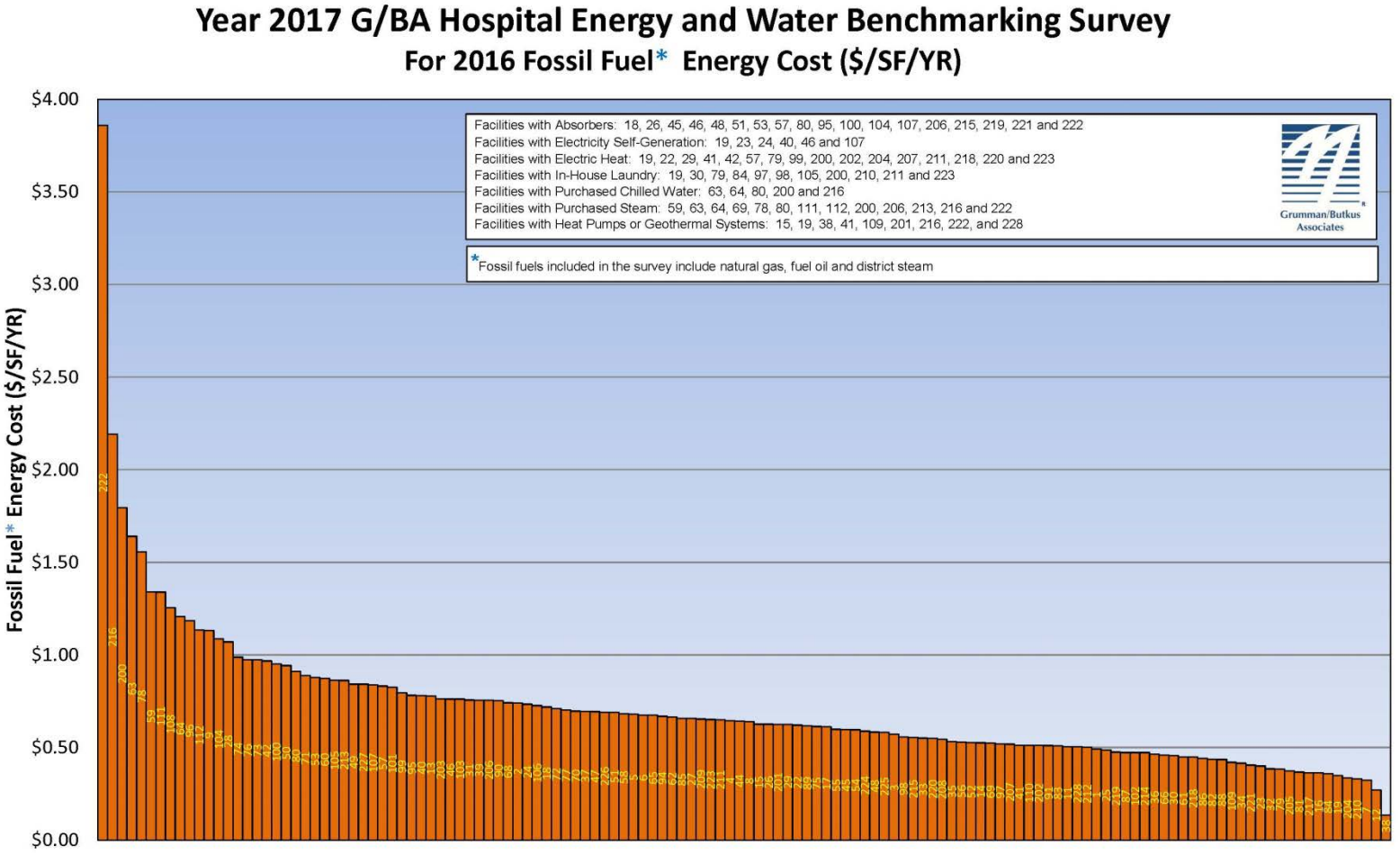
Hospital Gas Cost



12/6/2017

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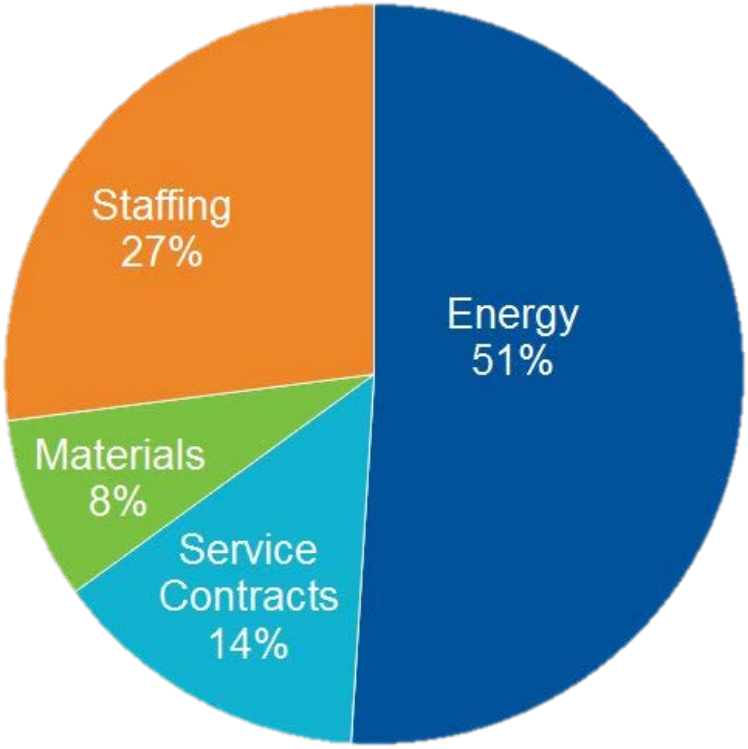
ASHE Benchmarking Data: Cost Breakdown of Facility Budgets

- Energy represents more than half of the healthcare facility budget, according to current benchmarking data from the American Society for Healthcare Engineering.
- That's more than staffing, materials, and service contracts **combined**.



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What Are Some Energy-Saving Opportunities?

- Use less steam
- Watch your water treatment
- Reduce/eliminate vented steam and condensate losses
- Minimize radiant heat losses
- Minimize steam production losses
- Maximize combustion efficiency
- Recover waste heat from flue, deaerator vent for heating domestic hot water, make-up water, boiler feedwater, or combustion air

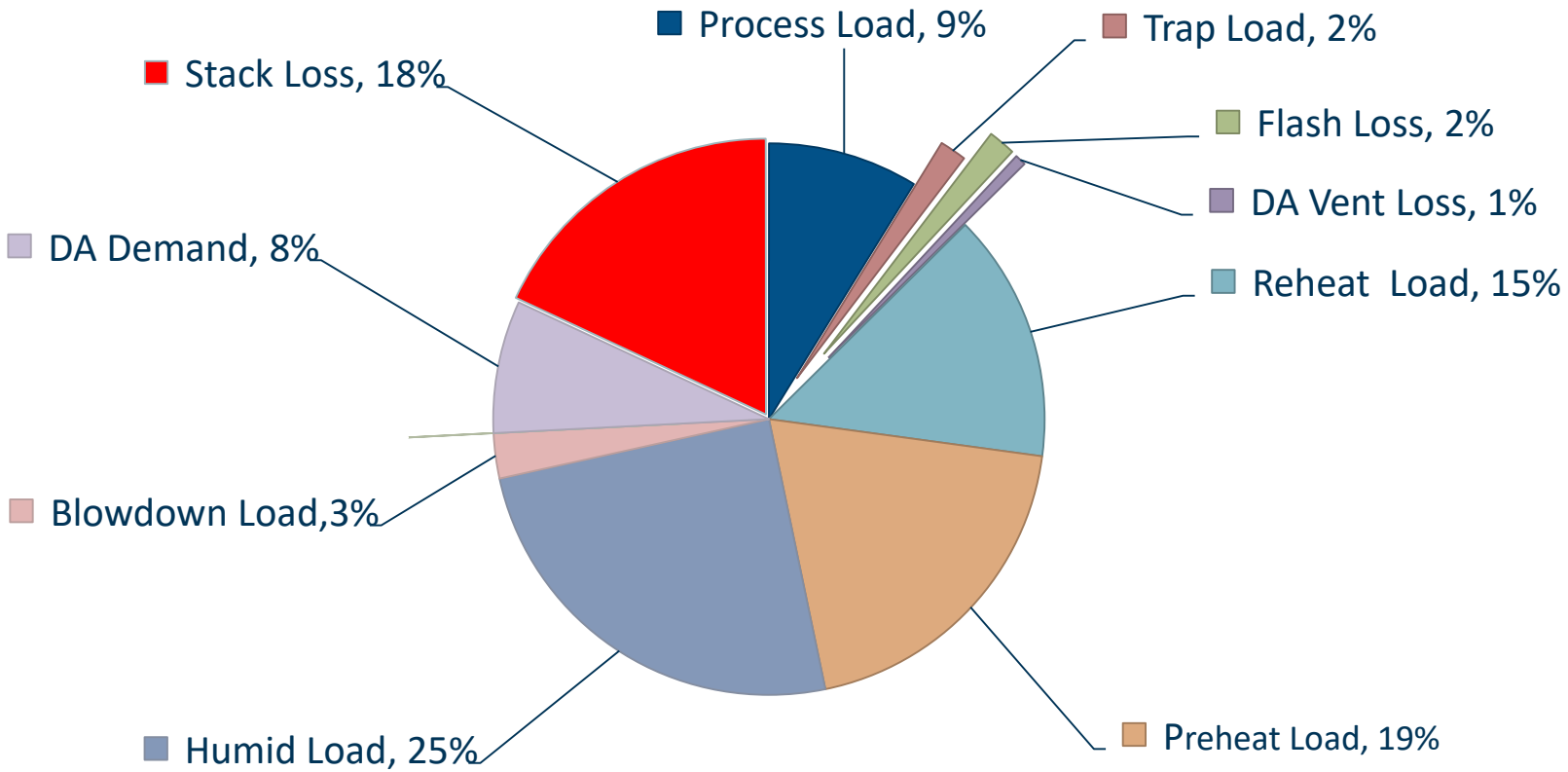
First, Some Boiler Plant Basics

- When to use steam vs. hot water
- Different boiler types
- Burners
  - Forced-draft vs. atmospheric
- Ancillary steam plant equipment
- Surge tank, condensate pumps
- Deaerator, feedwater pumps
- Flue, breeching, stack
- Steam traps

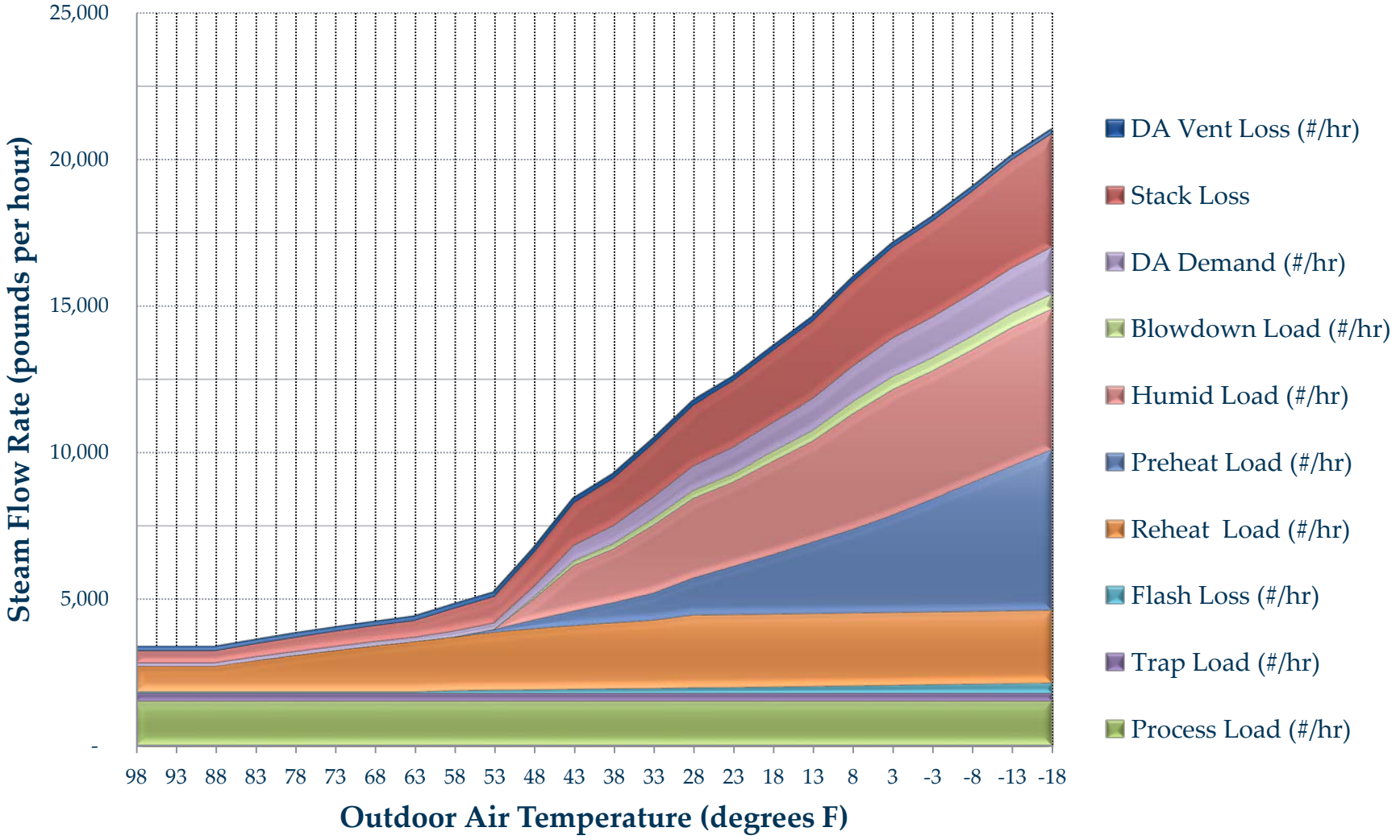
Hot Water vs. Steam

- Hot water is the best option for heating
  - Lowest maintenance cost
  - Highest efficiency
- Steam is generally used for process needs (sterilizers, humidifiers) when higher temperatures are needed or when large campus distribution is necessary.

Typical Hospital Steam Energy Balance



Typical Hospital Boiler Steam Demand Distribution vs. Outdoor Air Temperature



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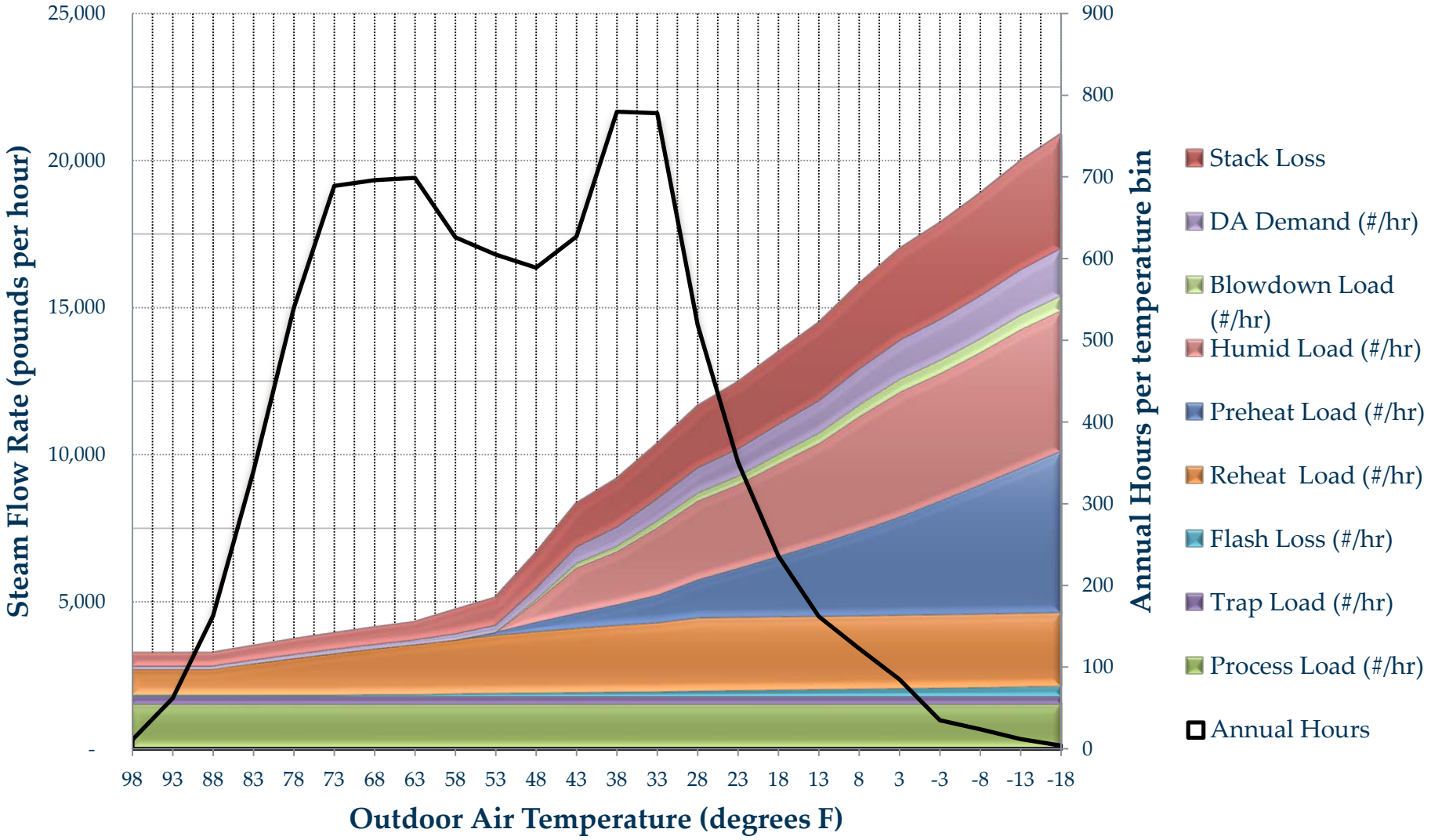
Typical Hospital Boiler Steam Demand Distribution vs. Outdoor Air Temperature with Temperature Bin Hours



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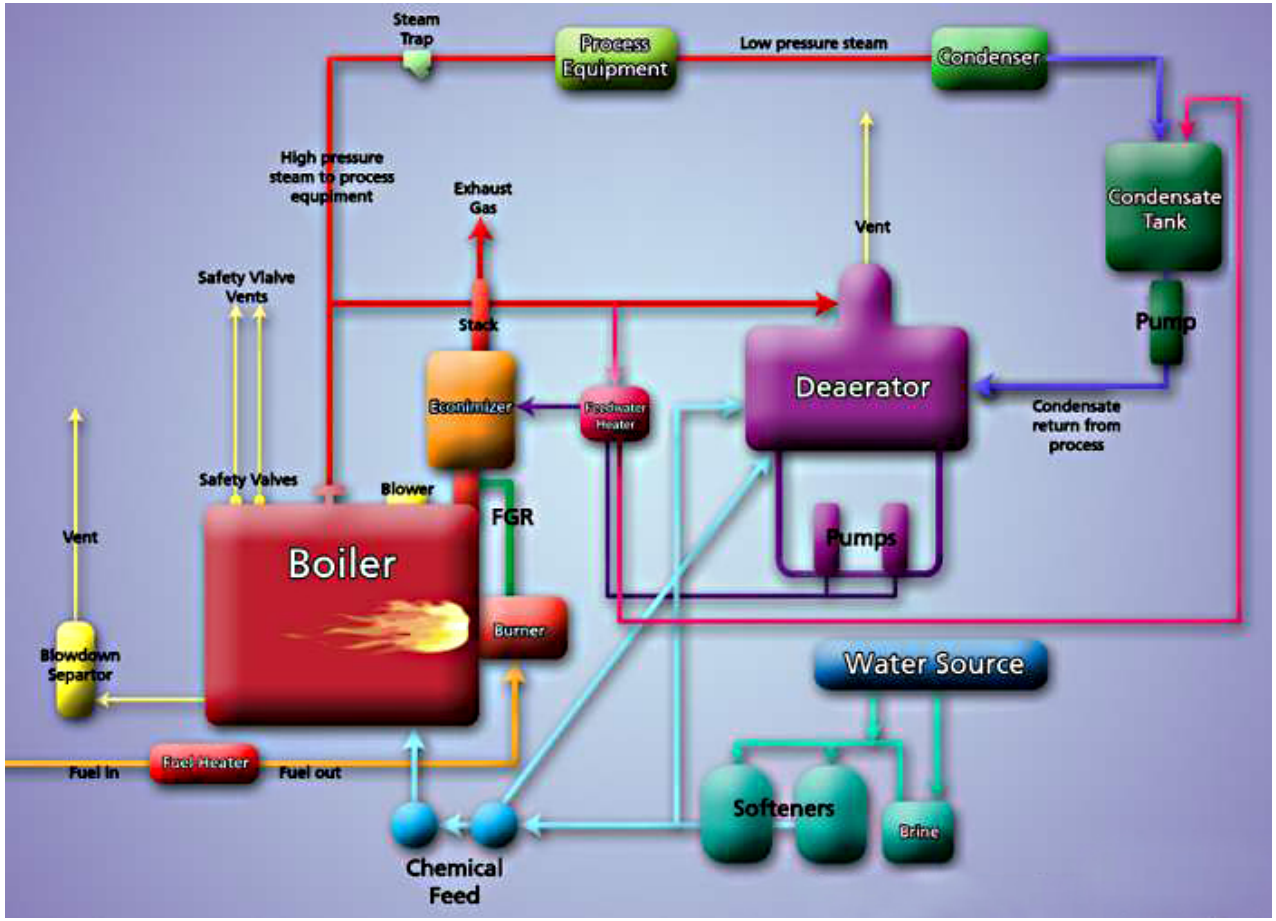
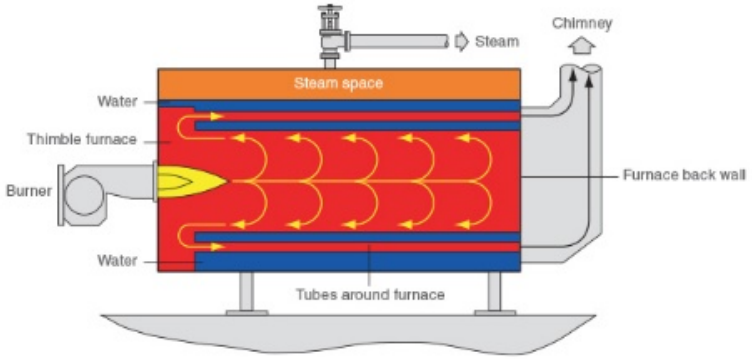
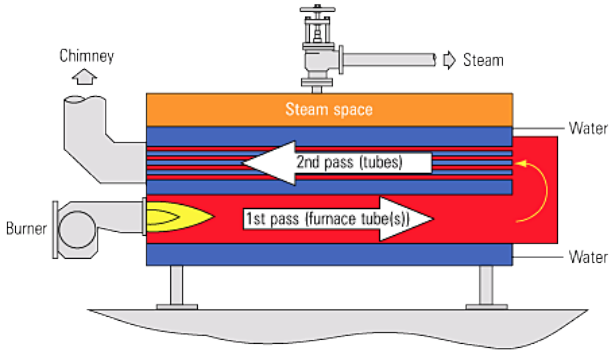
A Typical Steam Plant Configuration



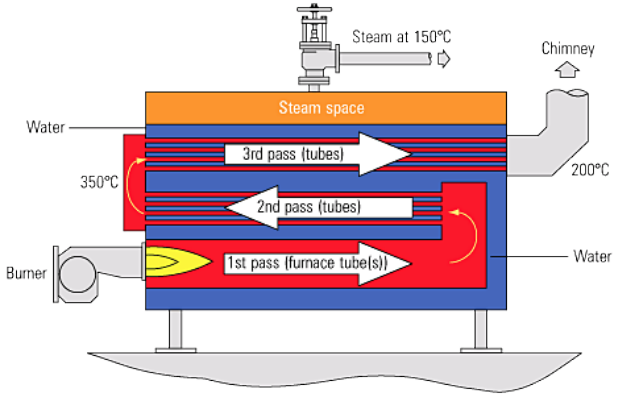
What Are the "Passes" in a Firetube Boiler?



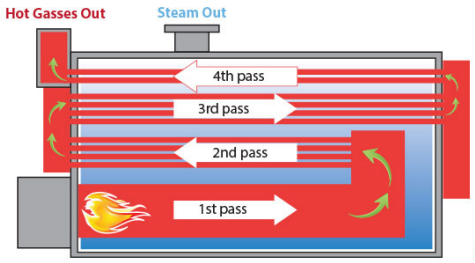
One-Pass



Two-Pass



Three-Pass



Four-Pass

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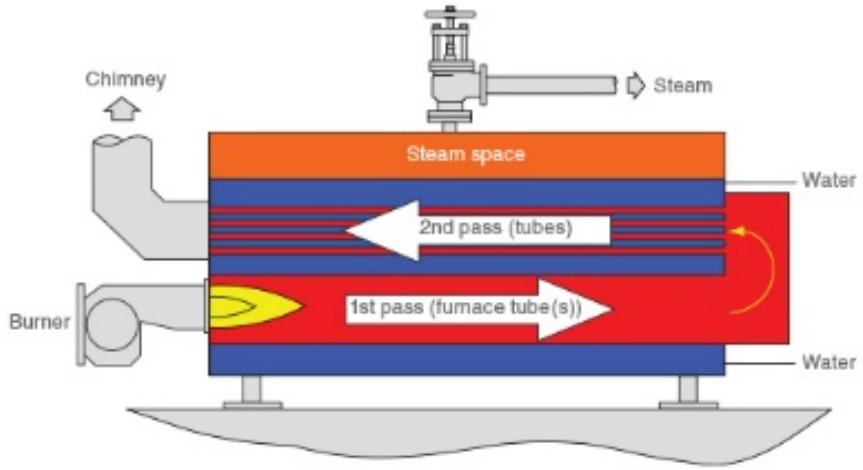
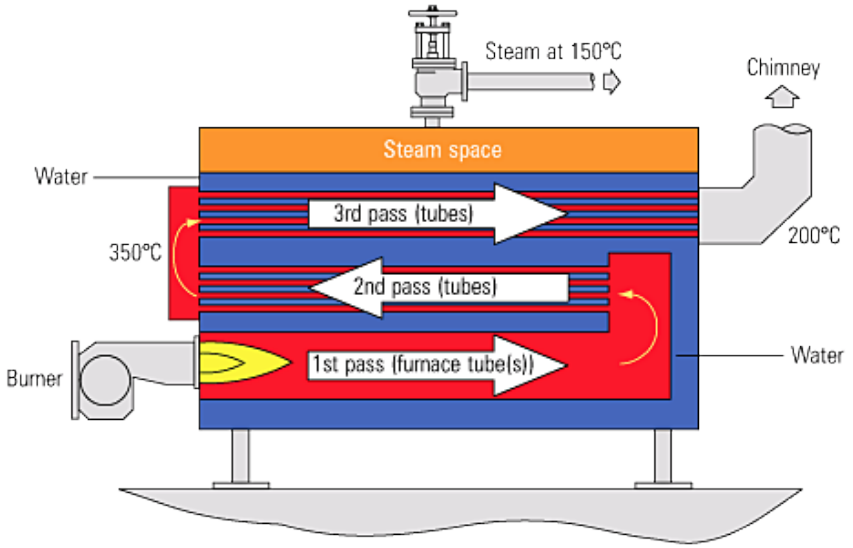
Different Types of Firetube Boilers



Dry-Back Firetube Boiler

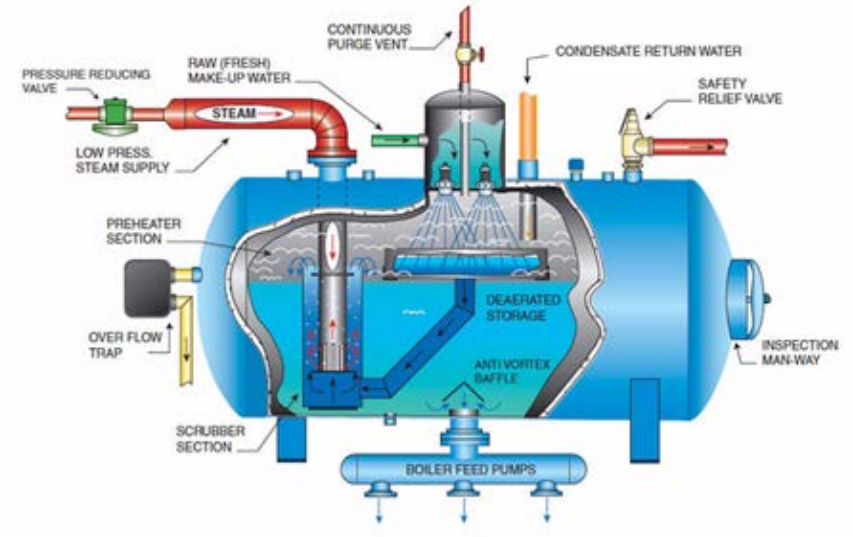


Wet-Back Firetube Boiler

Water-Tube Boilers

Water-Tube Boilers

The Deaerator



Typical Deaerator

Condensate Receiver/Deaerator Combo

What Are Some Energy-Saving Opportunities?

- Use less steam
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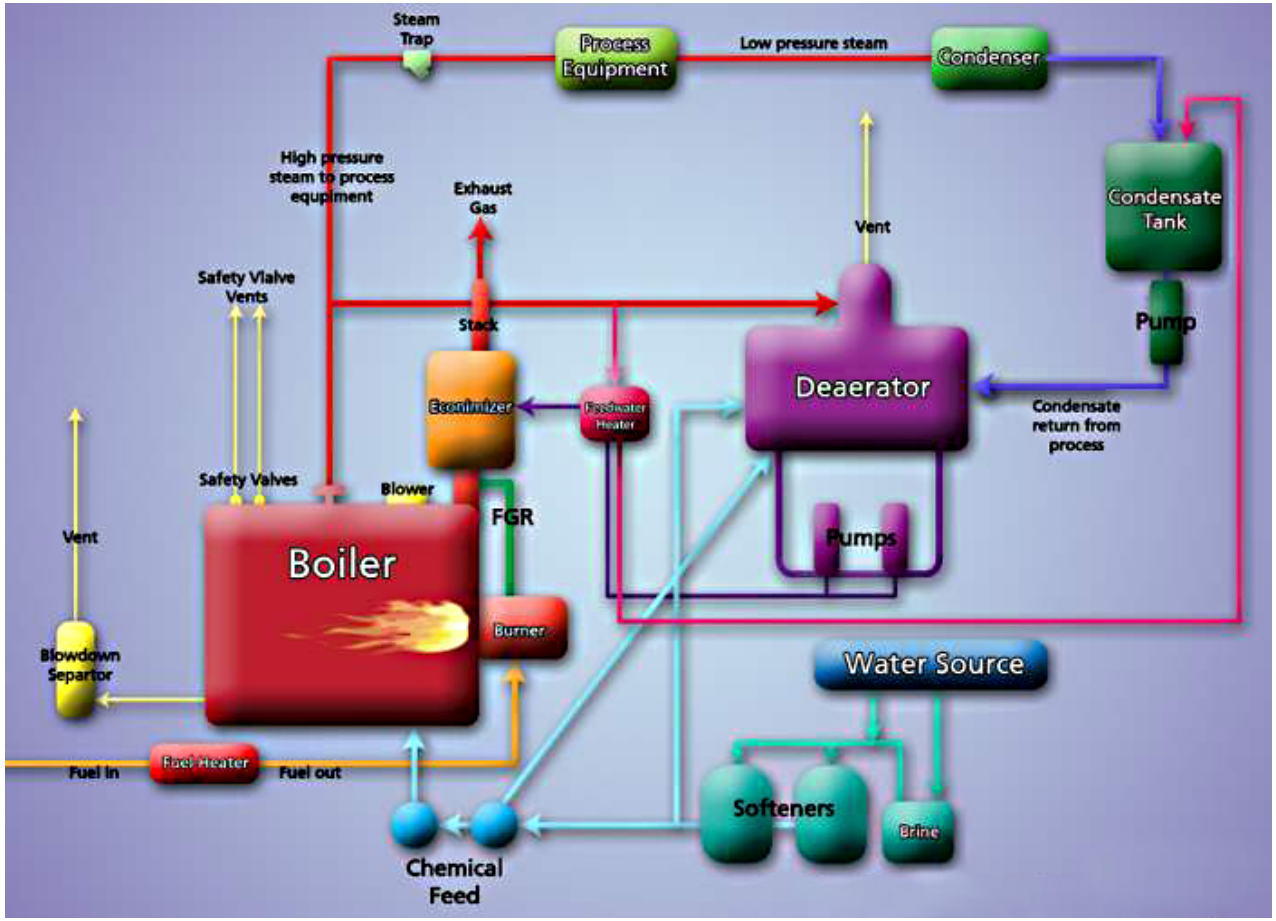
- Maximize combustion efficiency
- Recover waste heat from flue, deaerator vent for heating domestic hot water, make-up water, boiler feedwater, or combustion air

A Typical Steam Plant Configuration



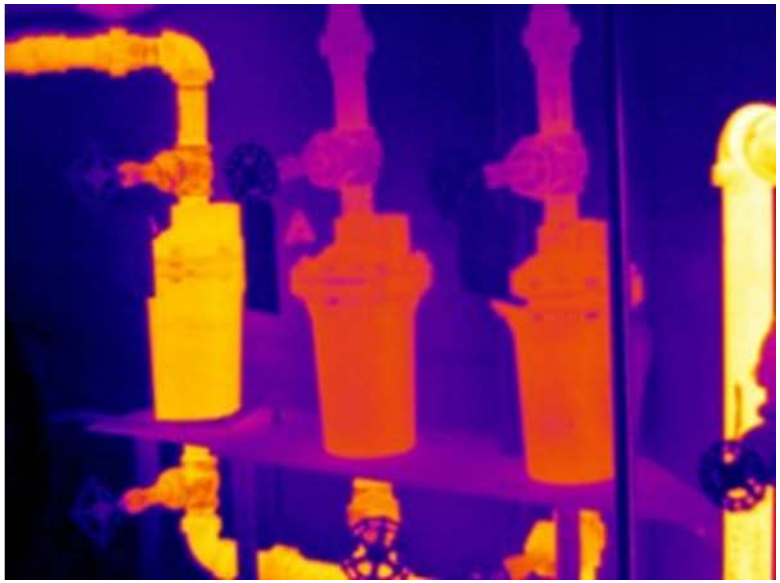
Pay Attention to Your Water Treatment

Reduce/Eliminate Vented Steam, Condensate Going to Drain

- Looking for leaking steam traps, PRVs, condensate being dumped

Reduce/Eliminated Vented Steam, Condensate Going to Drain

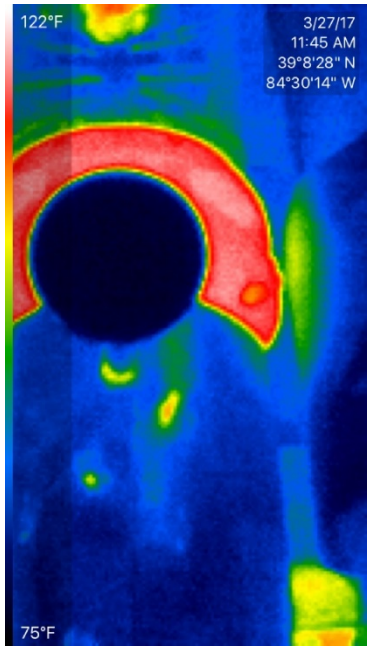
- Looking for leaking steam traps, PRVs, condensate being dumped



Leaking Steam Trap

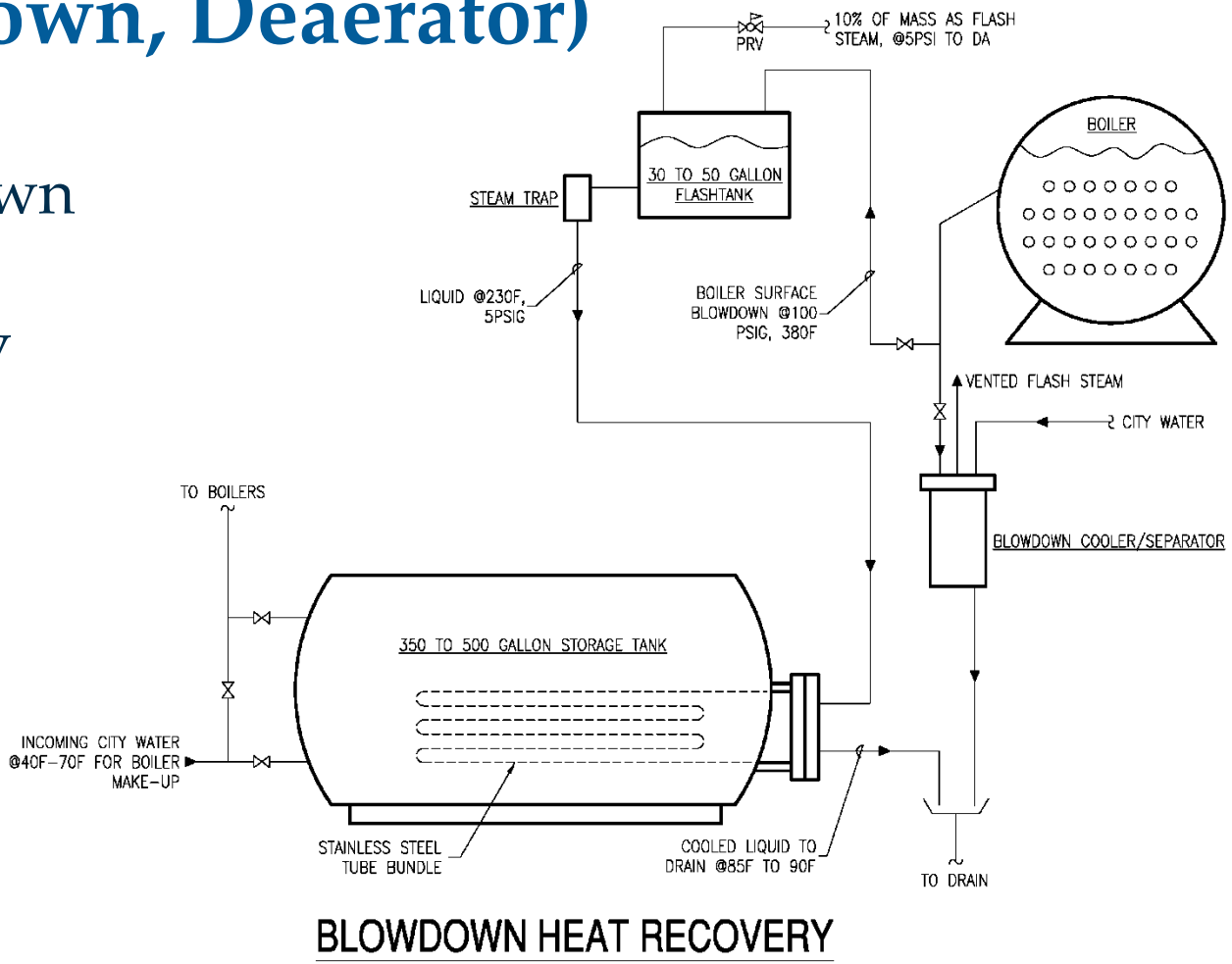
Minimize Radiant Heat Losses

- Lower operating pressure (governed by process requirements)
- Repair damaged or missing insulation on piping and heated vessels



Minimize Steam Production Losses (Blowdown, Deaerator)

- Blowdown heat recovery



BLOWDOWN HEAT RECOVERY

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RO System for M-U Water Treatment

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Maximize Combustion Efficiency

- Minimize O_2 / excess air without sooting

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Boiler Flue Stack Economizers

- Where to use recovered heat?
  - Boiler feedwater
  - Boiler make-up water
  - Domestic hot water

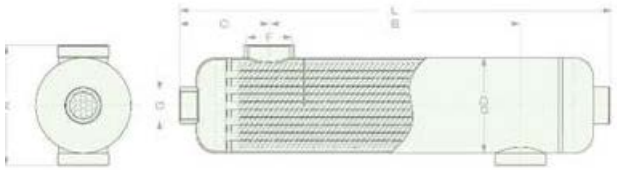
Recover Heat From DA Vent

Engineering Data

Table 4 Heat Exchanger Nominal Performance

Heat Exchanger Type	Nominal Capacity		Hot Water				Cold Water			
			Flow		Pressure drop		Flow		Pressure drop	
	kW	Btu/hr	L/min	USGPM	kPa	psig	L/min	USGPM	kPa	psig
B 45	13	45.000	23	6.08	6.2	0.90	150	39.63	7.4	1.07
B 70	20	70.000	25	6.60	7.5	1.09	170	44.91	9.2	1.33
B 130	38	130.000	27	7.13	8.1	1.17	200	52.83	11.4	1.65
B 180	53	180.000	30	7.93	2.7	0.40	210	55.48	7.5	1.10
B 250	73	250.000	35	9.25	4.2	0.60	270	71.33	12.0	1.70
B 300	88	300.000	40	10.57	6.4	0.90	300	79.25	17.0	2.50
B 400	117	400.000	46	12.42	7.8	1.13	342	90.10	20.0	2.90
B 500	146	500.000	55	14.53	9.2	1.30	360	95.10	22.0	3.20
B 1000	293	1.000.000	95	25.10	16.2	2.35	705	185.24	29.1	4.22

Nominal values are based on 60°C (140°F) temperature difference between incoming heating and heated water



Standard Materials:

316 L Stainless Steel,
Titanium

Maximum Allowable Working Pressure:

SS 316 L 1.03 MPa (150 psig)
Titanium 1.03MPa (150 psig)

Maximum Allowable Working Temperature:

SS 316 L 208°C (406°F)
Titanium 190°C (375°F)

Table 5 Advanced B Series Stainless Steel - 316L

Type	L	A	B	C	D	F	G	Heat Transfer Area
	mm (in)							m²(sq ft.)
B 45	267 (10.51)	106 (4.17)	111.5 (4.39)	77.5 (3.05)	80 (3.15)	1"	3/4"	0.183 (1.97)
B 70	345 (13.58)		175 (6.89)	85 (3.35)				0.259 (2.79)
B 130	395 (15.55)		225 (8.86)					0.307 (3.30)
B 180	383 (15.08)		193 (7.60)			1-1/2"		0.465 (4.91)
B 250	513 (20.20)	128 (5.04)	323 (12.72)	95 (3.74)	101.6 (4.0)		1"	0.677 (7.29)
B 300	632 (24.88)		442 (17.40)					0.871 (9.38)
B 400	747 (29.41)		557 (21.93)					1.058 (11.39)
B 500	1085 (42.72)		884 (34.80)	100.5 (3.96)		2"	2"	1.609 (17.32)
B 1000	917 (36.10)	167 (6.57)	676.5 (26.63)	120 (4.72)	139.7 (5.5)			2.200 (23.68)

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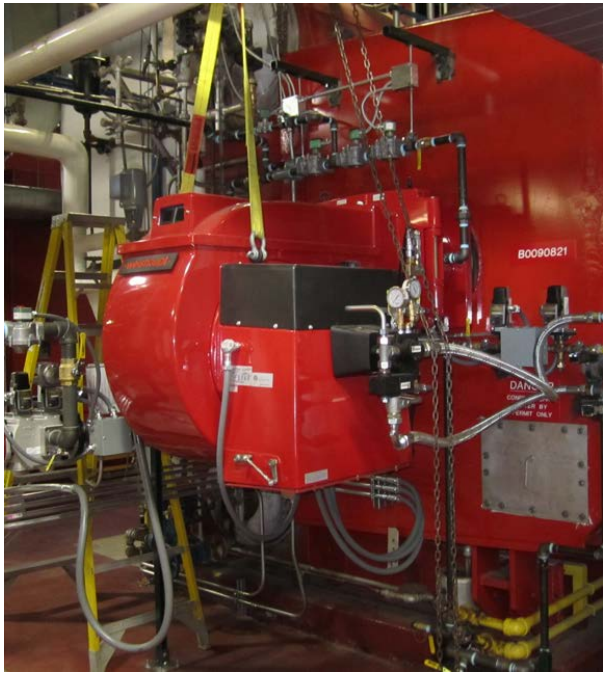
Case Study: Advocate Health Care Phase 1

- New burners on 10 boilers at six hospitals



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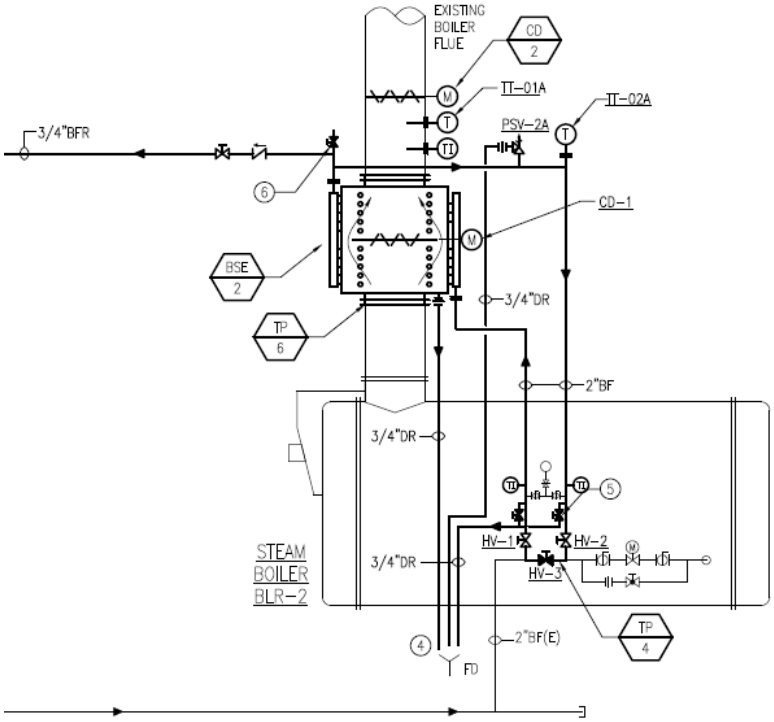
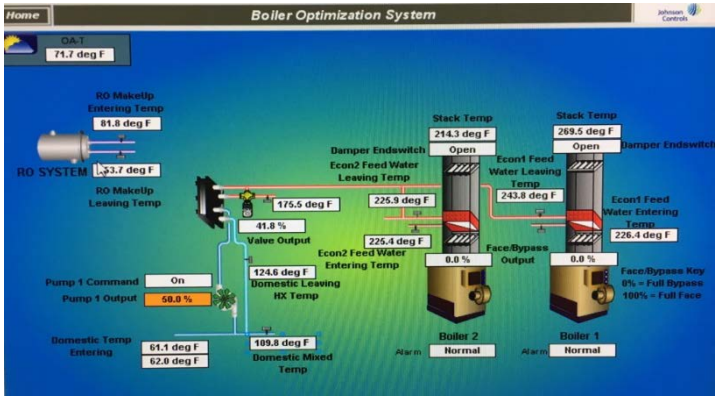
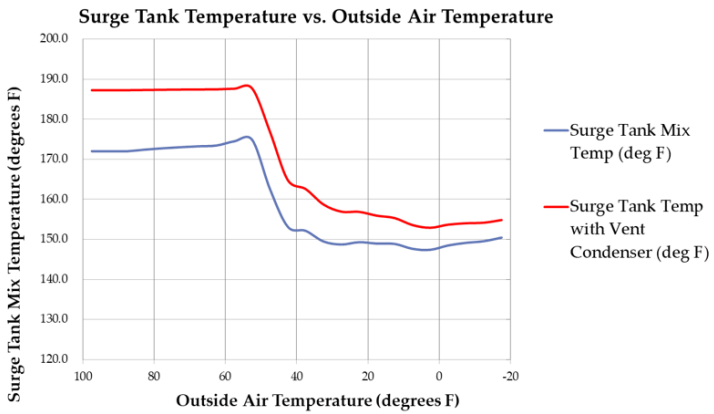
Case Study: Advocate Health Care Phase 2

- Recover heat from flue gas and DA vents at 10 hospitals







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Originally Planned Scope of Project for Individual Sites

BroMenn Medical Center	Vent Condenser	(1) Stack Economizer (1) Steam Boiler	Domestic Water Heating	
Christ Medical Center	Vent Condenser	(3) Stack Economizers (3) Steam Boilers	Domestic Water Heating	
Condell Medical Center	Vent Condenser	(1) Stack Economizer on common vent with (2) Boilers	Domestic Water Heating	
Good Samaritan Hospital	Vent Condenser	(2) Stack Economizers (2) Steam Boilers	Domestic Water Heating	
Good Shepherd Hospital	Vent Condenser	(2) Stack Economizers (2) Steam Boilers	Domestic Water Heating	
Illinois Masonic		(1) Stack Economizer (1) Steam Boiler		Feedwater Heating
Lutheran General Hospital	Vent Condenser			
South Suburban Hospital	Vent Condenser	(2) Stack Economizers (2) Steam Boilers		Feedwater Heating
Sherman Hospital	Vent Condenser	(2) Stack Economizers (2) Steam Boilers		Feedwater Heating
Trinity Hospital	Vent Condenser	(1) Stack Economizer (1) Steam Boiler	Domestic Water Heating	

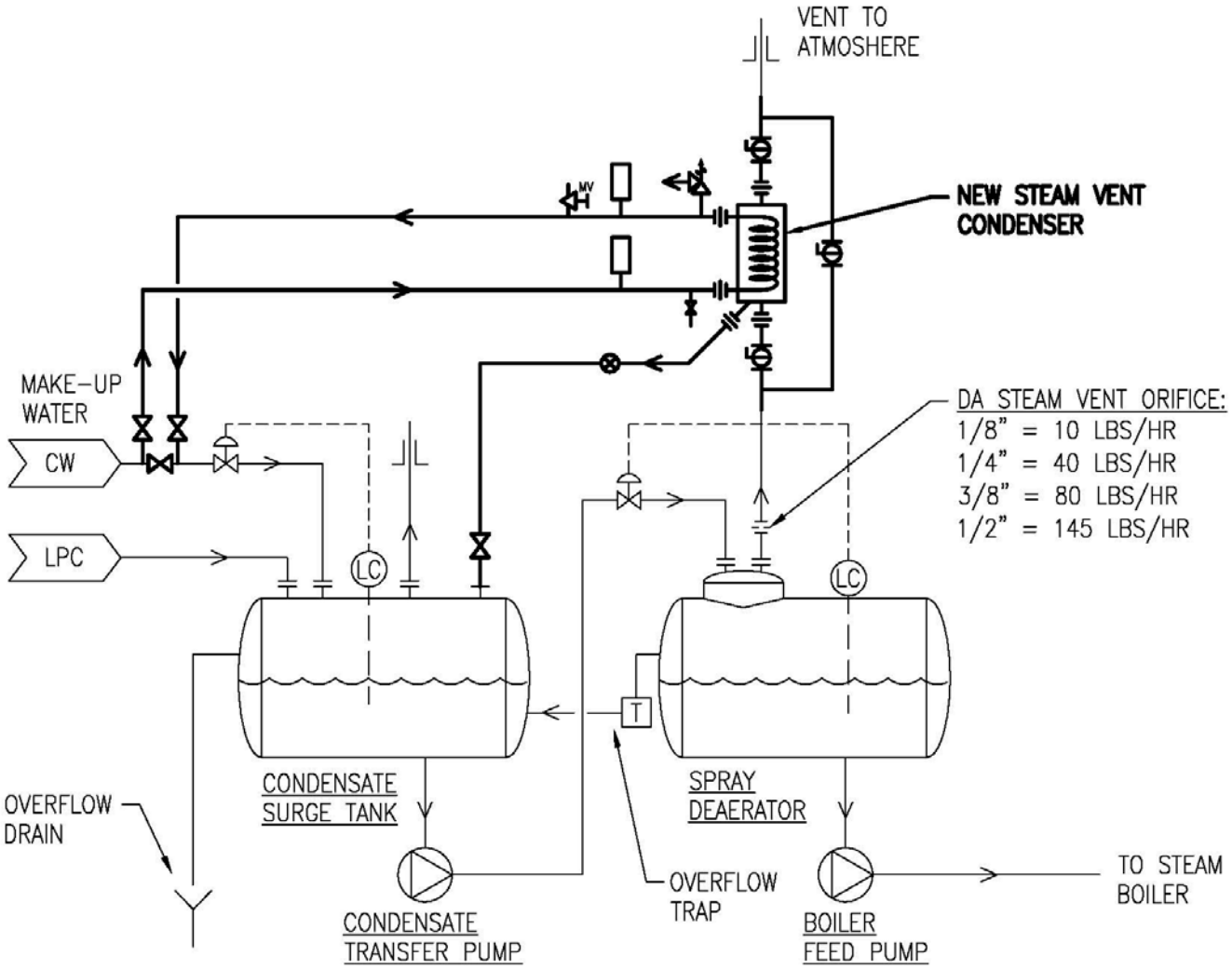
Scope of Project as Actually Implemented

BroMenn Medical Center	Vent Condenser	(1) Stack Economizer (1) Steam Boiler	Domestic Water Heating	
Christ Medical Center	Vent Condenser	(1) Stack Economizers (1) Steam Boilers	Domestic Water Heating	
Condell Medical Center	Vent Condenser	(1) Stack Economizer on common vent with (2) Boilers	Domestic Water Heating	
Good Samaritan Hospital	Vent Condenser	(2) Stack Economizers (2) Steam Boilers	Domestic Water Heating	
Good Shepherd Hospital	Vent Condenser	(2) Stack Economizers (2) Steam Boilers	Domestic Water Heating	
Illinois Masonic		(1) Stack Economizer (1) Steam Boiler		Feedwater Heating

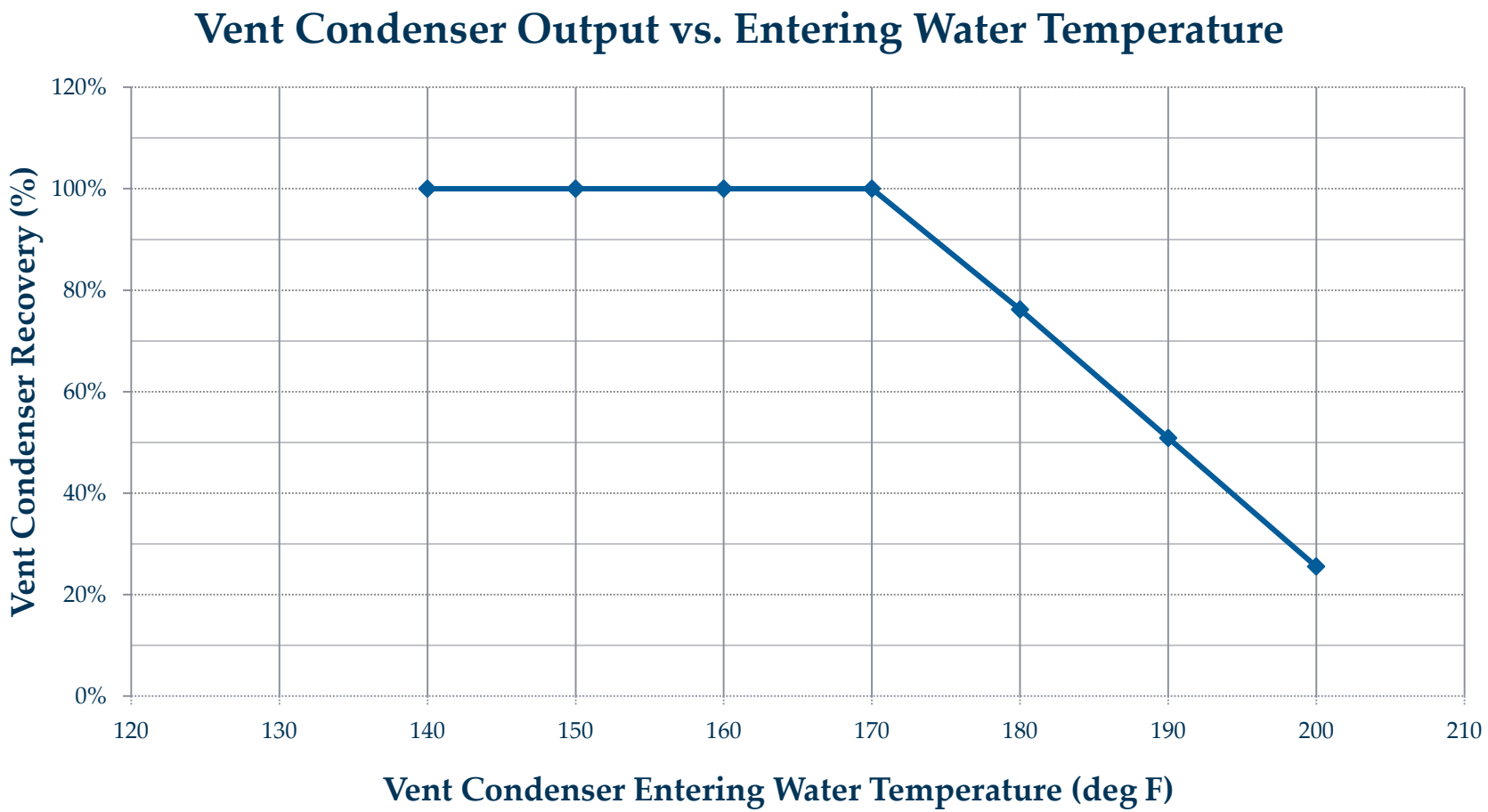
DA Tank Vent Condenser

- DA vent releases dissolved gasses to atmosphere
- Normally based on 0.5% of total mass flow rate of DA tank
- Established and set at maximum design condition but operates at same flow rate at all reduced conditions
- Recovery fluid is heated from condensing vent steam
- Recovery fluid can overheat and “steam” if flow is stopped or too low
- Heating untreated make-up water above 180°F can scale the heat exchanger

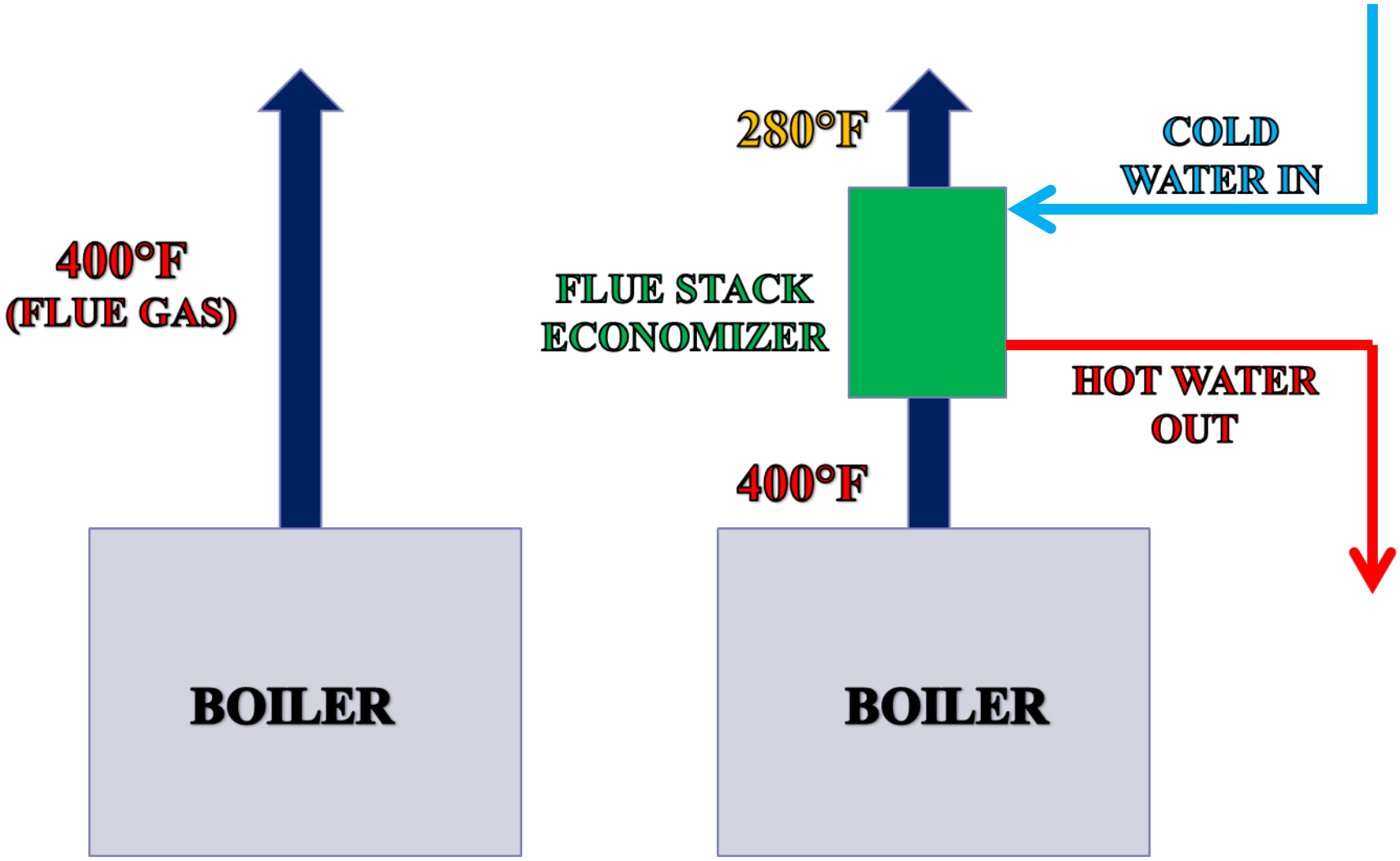
DA Tank Vent Condenser



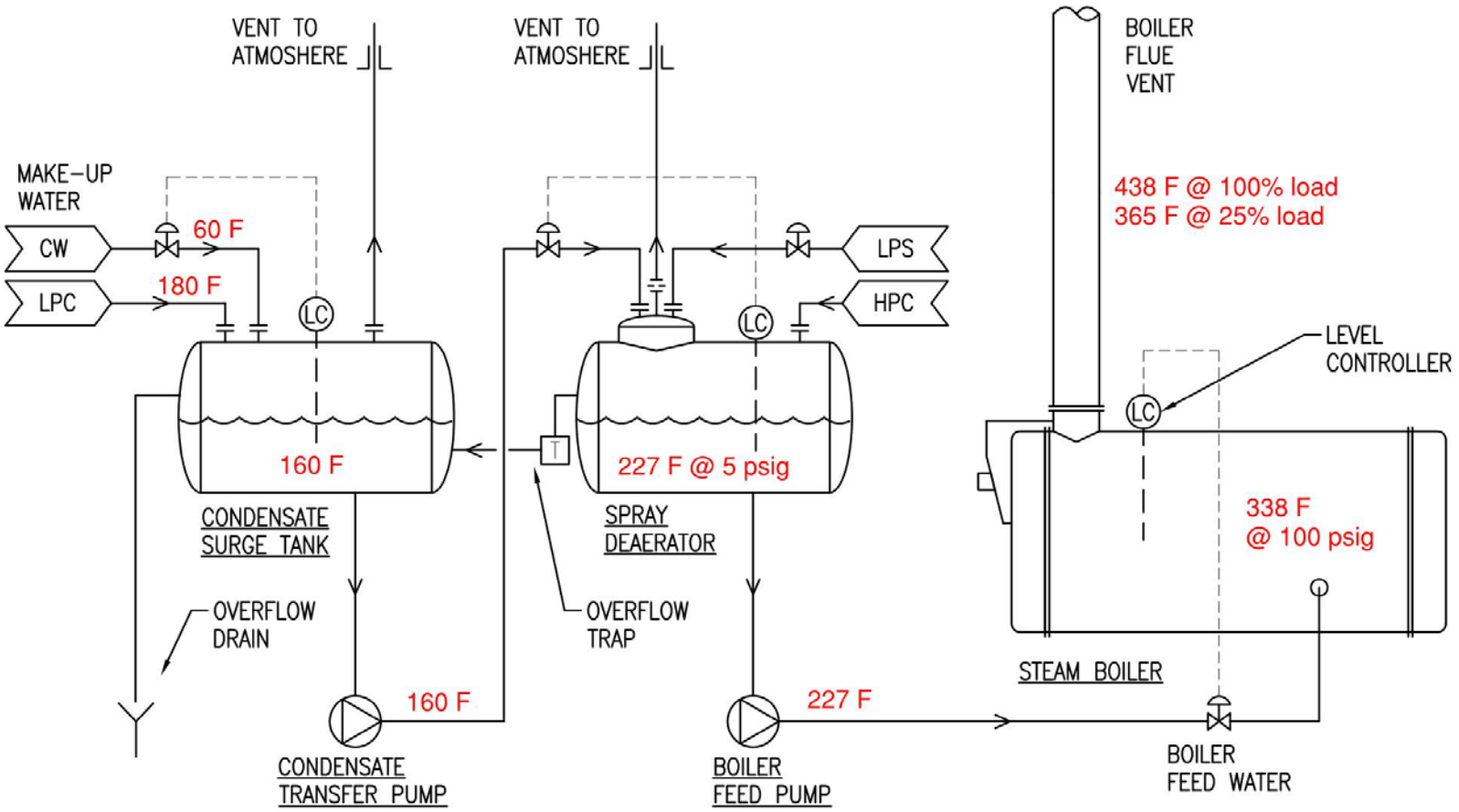
Effect of Entering Water Temperature on Vent Condenser Effectiveness



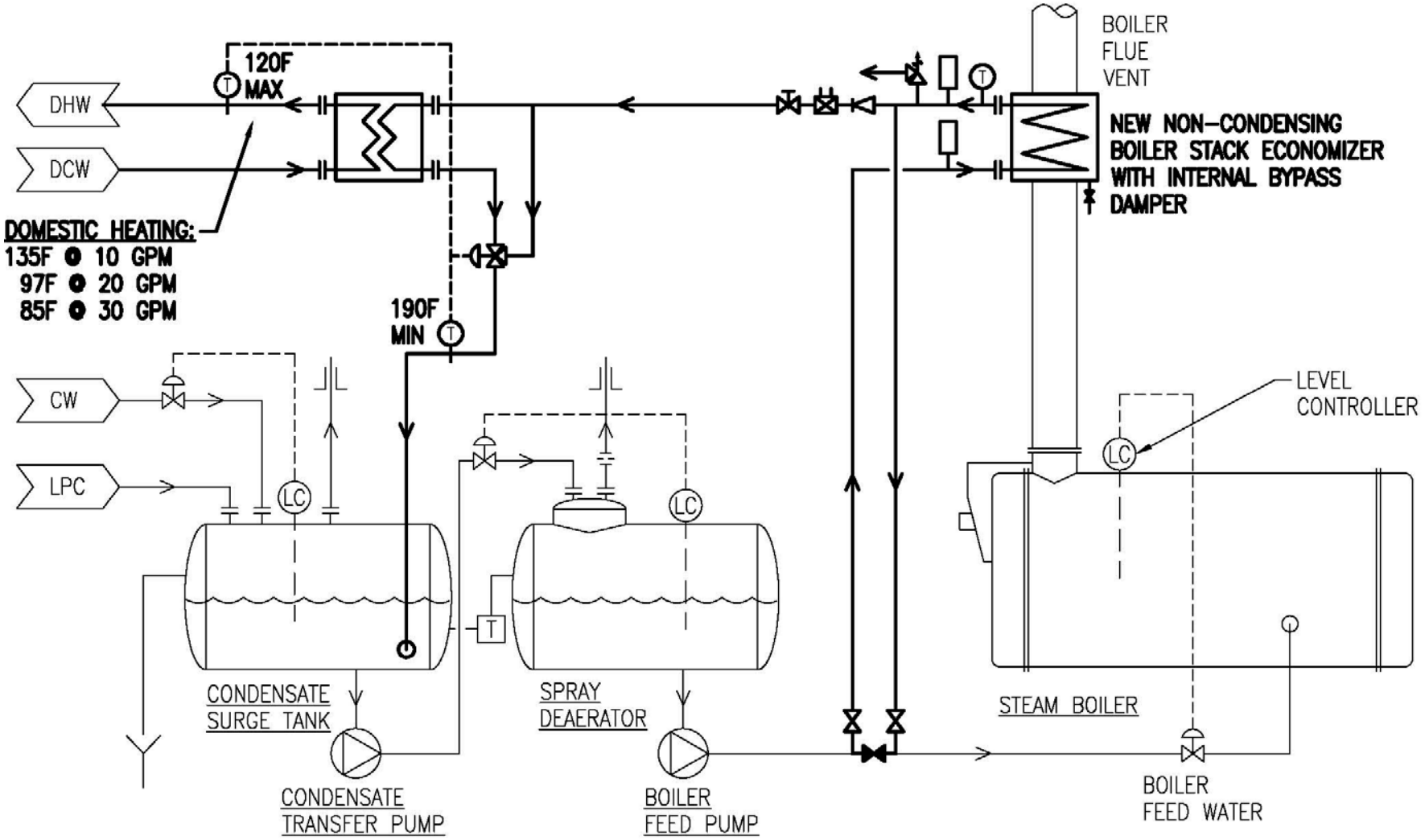
Boiler Flue Stack Economizers



Typical HP Steam Plant Operating Parameters



Domestic Water Heating

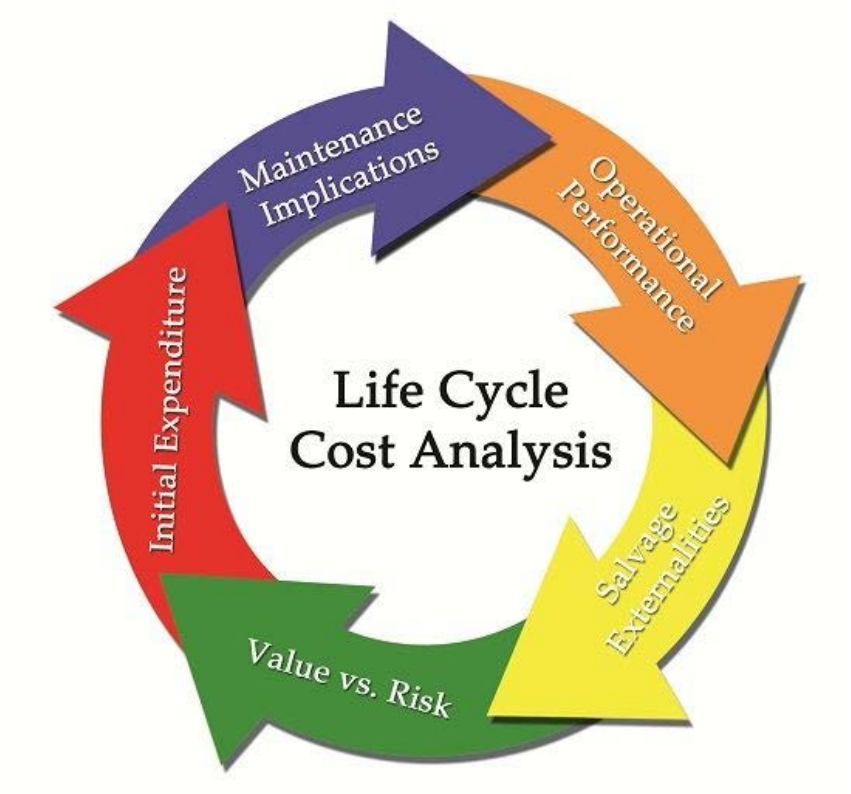


Some Lessons Learned…

- Do one measure at multiple sites in lieu of multiple measures at one site
  - Pros:
    - Get better pricing
    - Dealing with single vendor/contractor
    - Consistency of approach/implementation across all sites
  - Cons:
    - Managing/coordinating with multiple boiler room operators, each with different ideas and preferences
    - Coordinating project at multiple construction sites simultaneously

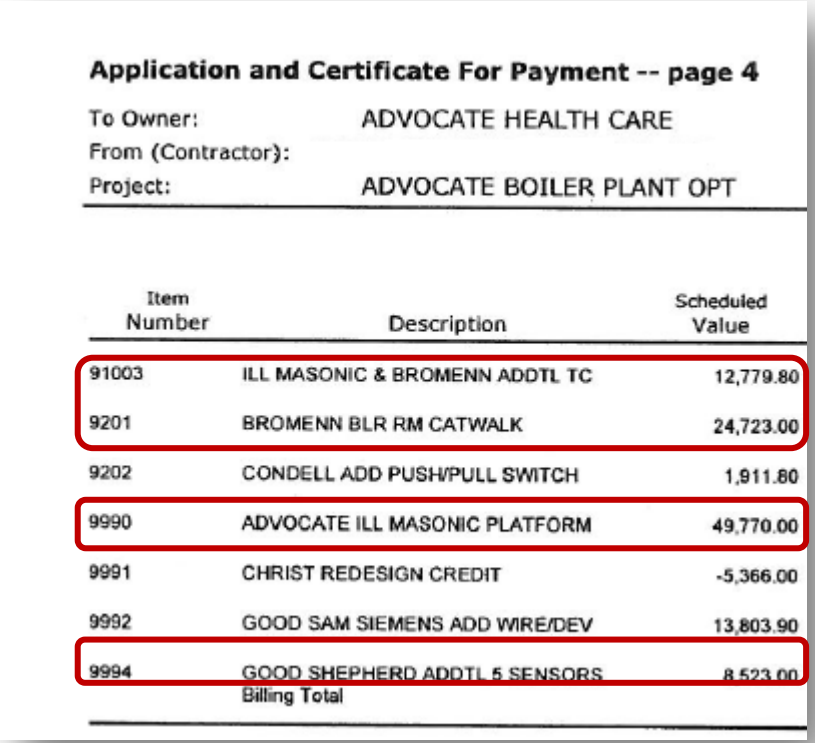
Some Lessons Learned…

- Pre-purchase major equipment
  - Get a single manufacturer
  - Owner picks "best value" product instead of contractor selecting lowest price
    - Life Cycle vs. First Cost
  - Cuts delivery time



Some Lessons Learned…

- Limit Change Orders
  - Budget for control points!
    - Sensors (inlet/outlet of every heat recovery device)
    - BAS trend setup
    - You need to be able to verify/prove savings to justify investment to senior leadership
  - Maintenance
    - Discovered potential accessibility issues for routine maintenance
    - Added steel platforms/catwalks at half of the sites



Application and Certificate For Payment -- page 4

To Owner: ADVOCATE HEALTH CARE
From (Contractor):
Project: ADVOCATE BOILER PLANT OPT

Item Number	Description	Scheduled Value
91003	ILL MASONIC & BROMENN ADDTL TC	12,779.80
9201	BROMENN BLR RM CATWALK	24,723.00
9202	CONDELL ADD PUSH/PULL SWITCH	1,911.80
9990	ADVOCATE ILL MASONIC PLATFORM	49,770.00
9991	CHRIST REDESIGN CREDIT	-5,366.00
9992	GOOD SAM SIEMENS ADD WIRE/DEV	13,803.90
9994	GOOD SHEPHERD ADDTL 5 SENSORS	8,523.00
	Billing Total	

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Some Lessons Learned…

- Miscellaneous
  - Spend more time and money up front to better detail scope/budget
  - Carry some contingency funds
    - Operators at each site have different needs and ideas
    - Carrying some extra money to accommodate reasonable requests creates good will, helps get buy-in

Some Lessons Learned…

- Maximize utility incentives
  - Burners
    - Total project cost: $1.6 million
    - Utility incentives: $830,700
  - Heat Recovery
    - Total project cost: ~ $1.9 million
    - Utility incentives: **$281,266**

Utility Incentives	
Nicor	**$555,300**
Peoples Gas	**$202,000**
North Shore Gas	**$53,400**
ComEd	**$20,000** (for new VFDs on fan meters)
Total	**$830, 700**

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Some Lessons Learned…

- Metering
  - Install extensive boiler plant metering to be able to closely track gas/steam usage, blowdown, make-up water. This is essential to allow the team to run trends and track boiler plant efficiency
- Use blowdown and M-U meters to get a reduced sewer bill

Thank You……Questions?

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