

Energy Efficiency

Where is the Bang for Your Buck? | MiAPPA | 2.13.2025



People-first places.®



Introduction



JASON BAKER PE
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Overview



Building
Energy Usage



Building
Envelope



Mechanical
Systems



Controls &
Commissioning



Benchmarking

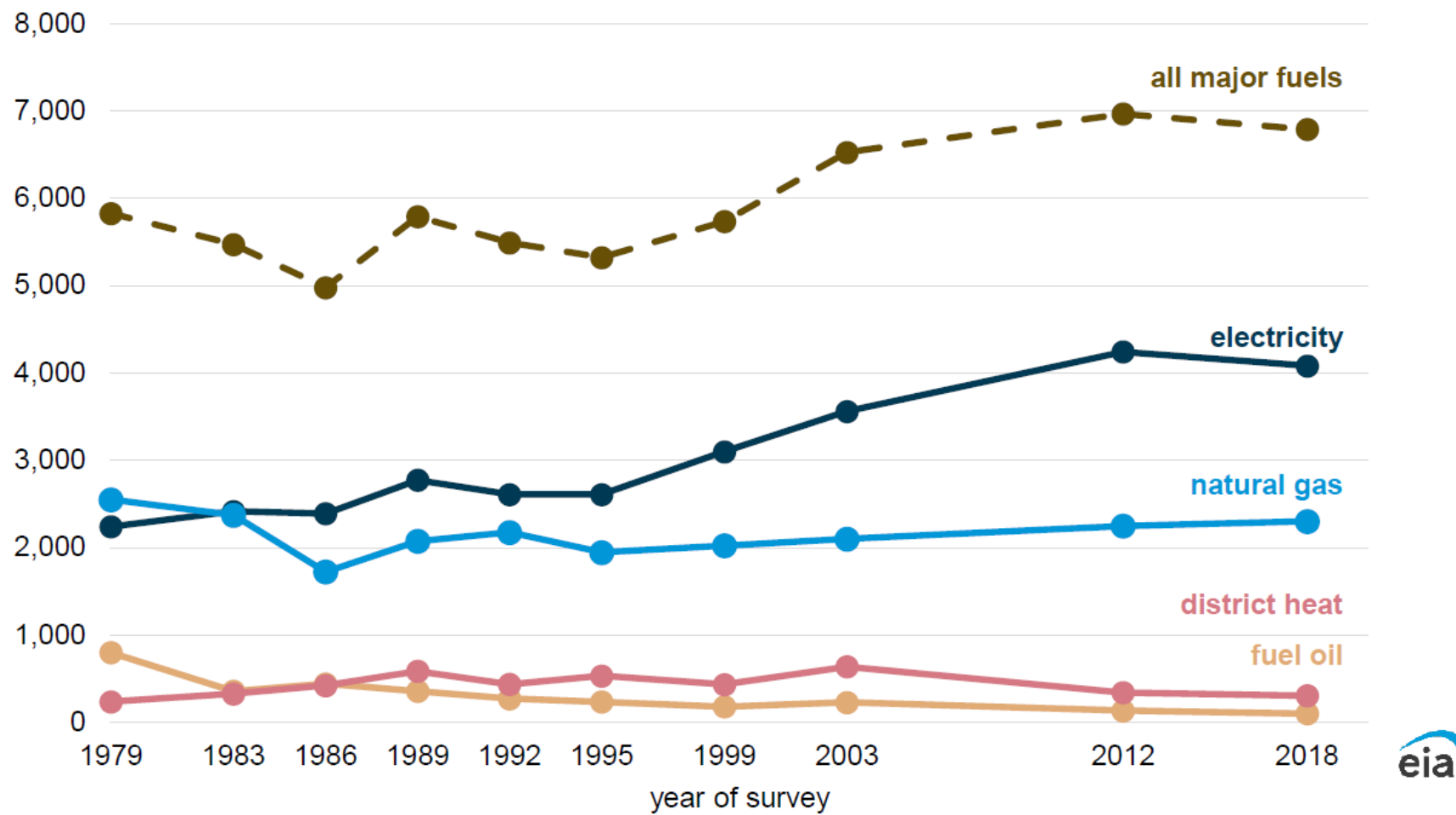
Building Energy Usage



Overall Energy Usage



Energy consumption by major fuel, 1979–2018
trillion British thermal units



Data source: U.S. Energy Information Administration, *Commercial Buildings Energy Consumption Survey*



Typical \$/SF for Buildings



Release date: December 2022

Table C6. Expenditures by census region for sum of major fuels, 2018

	Sum of major fuels expenditures (million dollars)				Sum of major fuel expenditures (dollars)							
					Per million British thermal units				Per square foot			
	North-east	Mid-west	South	West	North-east	Mid-west	South	West	North-east	Mid-west	South	West
All buildings	\$27,427	\$35,506	\$47,198	\$31,106	\$22.37	\$18.40	\$20.10	\$24.23	\$1.73	\$1.39	\$1.37	\$1.62
Principal building activity												
Education	\$3,127	\$3,962	\$5,969	\$2,817	\$16.78	\$15.69	\$19.82	\$24.74	\$1.23	\$1.03	\$1.20	\$1.24

Typical EUI/SF for Buildings



Release date: December 2022

Table E2. Major fuels consumption intensities by end use, 2018

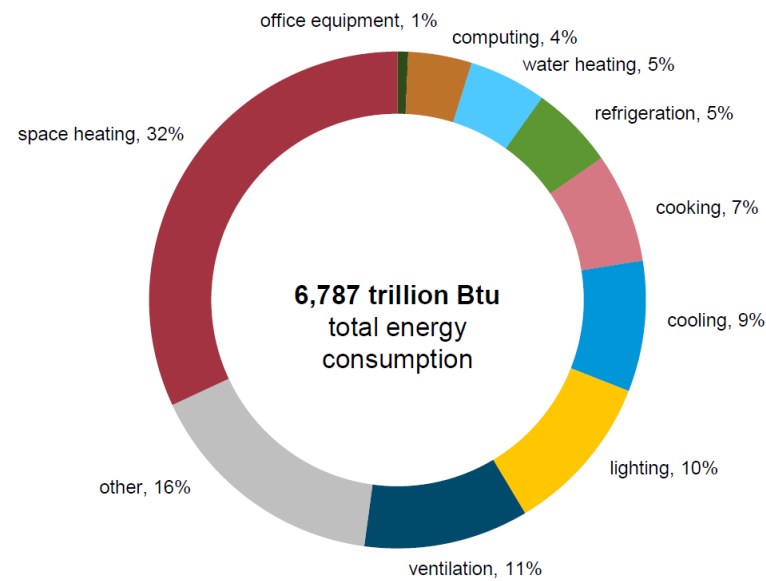
Major fuels energy intensity^a
(thousand Btu/square foot in buildings using any major fuel for the end use)

	Total	Space heating	Cooling	Ventilation	Water heating	Lighting	Cooking	Refrigeration	Office equipment	Computing	Other
All buildings	71.6	25.0	7.0	8.0	4.0	7.5	11.4	4.8	0.5	3.1	11.4
Principal building activity											
Education	62.7	27.6	7.3	4.8	3.7	5.5	3.3	1.8	0.5	2.4	8.8

How Do You Use Your Energy?



Major fuels consumption by end use, 2018
share of total



Data source: U.S. Energy Information Administration, *Commercial Buildings Energy Consumption Survey*
Note: Btu = British thermal units

Release date: December 2022

Table E2. Major fuels consumption intensities by end use, 2018

Major fuels energy intensity^a
(thousand Btu/square foot in buildings using any major fuel for the end use)

	Total	Space heating	Cooling	Ventilation	Water heating	Lighting	Cooking	Refrigeration	Office equipment	Computing	Other
All buildings	71.6	25.0	7.0	8.0	4.0	7.5	11.4	4.8	0.5	3.1	11.4
Principal building activity											
Education	62.7	27.6	7.3	4.8	3.7	5.5	3.3	1.8	0.5	2.4	8.8



What is Using Your Energy?



System Checksums

By Design Collaborative

AHU-2

Variable Volume Reheat (30% Min Flow Default)

COOLING COIL PEAK				CLG SPACE PEAK		HEATING COIL PEAK			TEMPERATURES		
Peaked at Time: Mo/Hr: 7 / 16				Mo/Hr: 9 / 16		Mo/Hr: Heating Design			Cooling Heating		
Outside Air: OADB/WB/HR: 88 / 76 / 121				OADB: 83		OADB: 0			SADB 55.0 97.3		
Space Sens. + Lat. Btu/h	Plenum Sens. + Lat. Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)	Space Peak Space Sens Btu/h	Coil Peak Tot Btu/h	Percent Of Total (%)	Return	Ret/OA	Fn MtrTD
Envelope Loads											
Skylite Solar	0	0	0	0	0	0	0	0.00	76.1	63.4	0.0
Skylite Cond	0	0	0	0	0	0	0	0.00	78.2	48.2	0.0
Roof Cond	0	24,173	24,173	5	0	0	-33,495	8.76	0.2	0.0	0.0
Glass Solar	140,393	0	140,393	29	157,530	56	0	0.00	0.5	0.0	0.0
Glass/Door Cond	27,829	0	27,829	6	16,537	6	-126,098	32.99	1.6	0.0	0.0
Wall Cond	8,750	7,064	15,813	3	7,392	3	-21,110	9.99			
Partition/Door	0	0	0	0	0	0	0	0.00			
Floor	0	0	0	0	0.00	0	0	0.00			
Adjacent Floor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
Infiltration	0	0	0	0	0	0	0	0.00			
Sub Total ==>	176,972	31,236	208,208	43	181,459	65	-147,209	51.74			
Internal Loads											
Lights	21,816	5,454	27,270	6	21,816	8	0	0.00			
People	59,911	0	59,911	12	33,202	12	0	0.00			
Misc	30,545	0	30,545	6	30,545	11	0	0.00			
Sub Total ==>	112,272	5,454	117,726	24	85,563	30	0	0.00			
Ceiling Load											
Ventilation Load	7,497	-7,497	0	0	5,524	2	-19,789	0.00			
Adj Air Trans Heat	0	0	130,534	27	0	0	0	26.02			
Dehumid. Ov Sizing	3,082	0	3,082	1	3,082	1	-2,926	1			
Ov/Undr Sizing	0	0	0	0	0	0	0	0.00			
Exhaust Heat	45	0	45	0	5,434	2	0	0.00			
Sup. Fan Heat	0	-3,538	-3,538	-1	0	0	5,080	-1.33			
Ret. Fan Heat	0	0	32,242	7	0	0	-38,692	10.12			
Duct Heat Pkup	0	0	0	0	0	0	-27,529	7.20			
Underflr Sup Ht Pkup	0	0	0	0	0	0	-20,964	5.48			
Supply Air Leakage	0	0	0	0	0	0	0	0.00			
Grand Total ==>	299,867	25,655	488,298	100.00	281,061	100.00	-169,924	-382,270	100.00		

AIRFLOWS

	Cooling	Heating
Diffuser	13,453	5,465
Terminal	13,453	5,465
Main Fan	13,453	5,465
Sec Fan	0	0
Nom Vent	2,171	1,311
AHU Vent	2,171	1,311
Infil	0	0
MinStop/Rh	5,465	5,465
Return	12,792	4,975
Exhaust	1,510	821
Rm Exh	521	350
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	16.1	24.0
cfm/ft²	1.21	0.49
cfm/ton	330.61	
ft²/ton	272.81	
Btu/hr-ft²	43.99	-35.44
No. People	133	

	Total Capacity		Sens Cap.		Coil Airflow		Enter DB/WB/HR		Leave DB/WB/HR	
	ton	MBh	MBh	MBh	cfm	°F	°F	gr/lb	°F	°F
Main Clg	40.7	488.3	365.4	13,075	78.2	63.9	67.4	52.8	51.1	53.9
Aux Clg	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	40.7	488.3								

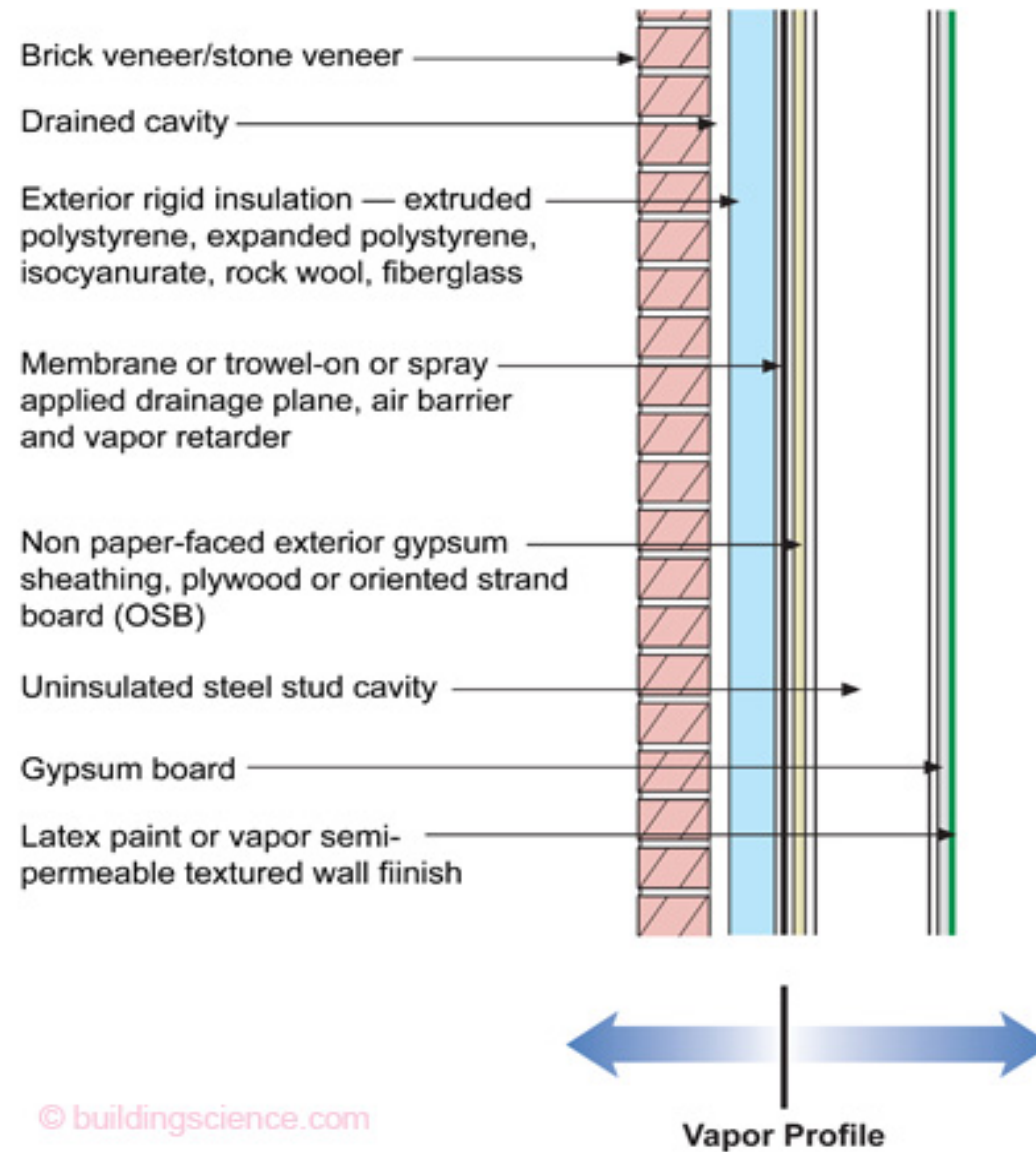
	Gross Total		Glass	
	ft²	(%)	ft²	(%)
Floor	11,101		0	0
Part	0		0	0
Int Door	1		0	0
ExFlr	0		0	0
Roof	11,101		0	0
Wall	9,808		4,055	41
Ext Door	0		0	0

	Capacity		Coil Airflow		Ent		Lvg	
	MBh	cfm	cfm	cfm	°F	°F	°F	°F
Main Htg	-267.5	5,465	52.8	97.3				
Aux Htg	0.0	0	0	0				
Preheat	-125.9	2,171	0	52.8				
Reheat	-97.6	5,465	52.8	69.0				
Humidif	0.0	0	0	0				
Opt Vent	0.0	0	0	0				
Total	-393.5							

Building Envelope



Just Add More Insulation, Right?



Just Add More Insulation, Right?



MONTHLY UTILITY COSTS

By Design Collaborative

Utility	Jan	Feb	Mar	Apr	----- Monthly Utility Costs -----				Sept	Oct	Nov	Dec	Total
					May	June	July	Aug					
R-5 Insulation in Walls													
Electric													
On-Pk Cons. (\$)	1,057	952	1,086	1,070	1,393	1,824	1,855	1,951	1,560	1,220	1,018	1,035	16,022
On-Pk Demand (\$)	270	273	274	435	607	687	749	718	676	533	330	271	5,821
Total (\$):	1,327	1,225	1,360	1,505	2,000	2,511	2,603	2,669	2,236	1,753	1,349	1,305	21,843
Gas													
On-Pk Cons. (\$)	1,234	872	743	294	130	67	61	78	123	292	624	952	5,471
Monthly Total (\$):	2,561	2,097	2,103	1,800	2,130	2,579	2,664	2,748	2,359	2,044	1,973	2,257	27,315

Building Area = 22,966 ft²
 Utility Cost Per Area = 1.19 \$/ft²

R-15 Insulation in Walls													
Electric													
On-Pk Cons. (\$)	1,073	971	1,115	1,100	1,440	1,856	1,879	1,981	1,604	1,252	1,041	1,051	16,361
On-Pk Demand (\$)	272	275	275	435	591	666	721	698	656	531	332	272	5,724
Total (\$):	1,344	1,245	1,390	1,535	2,031	2,522	2,600	2,679	2,259	1,783	1,372	1,323	22,085
Gas													
On-Pk Cons. (\$)	952	673	562	223	112	65	59	74	112	230	482	742	4,286
Monthly Total (\$):	2,296	1,918	1,952	1,758	2,144	2,586	2,659	2,754	2,371	2,013	1,854	2,065	26,371

Building Area = 22,966 ft²
 Utility Cost Per Area = 1.15 \$/ft²

3.5% Savings

What About HP Glass?



What About HP Glass?



MONTHLY UTILITY COSTS

By Design Collaborative

Utility	Jan	Feb	Mar	Apr	----- May	----- June	----- July	----- Aug	Sept	Oct	Nov	Dec	Total
2013 Code Minimum Glass													
Electric													
On-Pk Cons. (\$)	1,048	946	1,081	1,069	1,401	1,815	1,842	1,940	1,564	1,218	1,014	1,028	15,966
On-Pk Demand (\$)	271	274	274	432	594	670	727	702	660	529	331	271	5,736
Total (\$):	1,319	1,220	1,355	1,501	1,995	2,486	2,569	2,642	2,224	1,747	1,345	1,299	21,702
Gas													
On-Pk Cons. (\$)	1,030	729	615	246	119	67	61	77	117	251	524	804	4,640
Monthly Total (\$):	2,348	1,948	1,971	1,747	2,115	2,553	2,630	2,719	2,342	1,998	1,869	2,103	26,343

Building Area = 22,966 ft²
Utility Cost Per Area = 1.15 \$/ft²

High Performance LowE Glass													
Electric													
On-Pk Cons. (\$)	1,068	967	1,112	1,083	1,387	1,760	1,787	1,880	1,529	1,223	1,038	1,048	15,882
On-Pk Demand (\$)	271	273	274	403	544	619	674	650	603	489	322	271	5,392
Total (\$):	1,339	1,240	1,386	1,487	1,931	2,378	2,461	2,530	2,132	1,712	1,360	1,319	21,275
Gas													
On-Pk Cons. (\$)	700	475	387	150	80	51	49	55	80	153	329	516	3,023
Monthly Total (\$):	2,039	1,714	1,773	1,637	2,011	2,430	2,510	2,586	2,212	1,864	1,689	1,835	24,298

Building Area = 22,966 ft²
Utility Cost Per Area = 1.06 \$/ft²

7.8% Savings

Air Leakage



Affects of Infiltration and Average Construction



MONTHLY UTILITY COSTS

By Design Collaborative

Utility	Jan	Feb	Mar	Apr	----- Monthly Utility Costs -----				Sept	Oct	Nov	Dec	Total
					May	June	July	Aug					
Pressurized Tight Construction													
Electric													
On-Pk Cons. (\$)	1,048	946	1,081	1,069	1,401	1,815	1,842	1,940	1,564	1,218	1,014	1,028	15,966
On-Pk Demand (\$)	271	274	274	432	594	670	727	702	660	529	331	271	5,736
Total (\$):	1,319	1,220	1,355	1,501	1,995	2,486	2,569	2,642	2,224	1,747	1,345	1,299	21,702
Gas													
On-Pk Cons. (\$)	1,030	729	615	246	119	67	61	77	117	251	524	804	4,640
Monthly Total (\$):	2,348	1,948	1,971	1,747	2,115	2,553	2,630	2,719	2,342	1,998	1,869	2,103	26,343

Building Area = 22,966 ft²
 Utility Cost Per Area = 1.15 \$/ft²

Loose Construction (0.6 ACH)													
Electric													
On-Pk Cons. (\$)	1,068	966	1,109	1,086	1,412	1,853	1,896	1,990	1,575	1,237	1,036	1,047	16,275
On-Pk Demand (\$)	260	263	266	415	598	695	772	741	670	513	318	262	5,773
Total (\$):	1,329	1,229	1,375	1,500	2,010	2,548	2,669	2,731	2,244	1,750	1,355	1,309	22,049
Gas													
On-Pk Cons. (\$)	1,197	809	721	281	123	68	61	77	118	270	598	910	5,234
Monthly Total (\$):	2,526	2,038	2,096	1,782	2,133	2,616	2,729	2,808	2,362	2,021	1,952	2,219	27,283

Building Area = 22,966 ft²
 Utility Cost Per Area = 1.19 \$/ft²

3.6% Increase

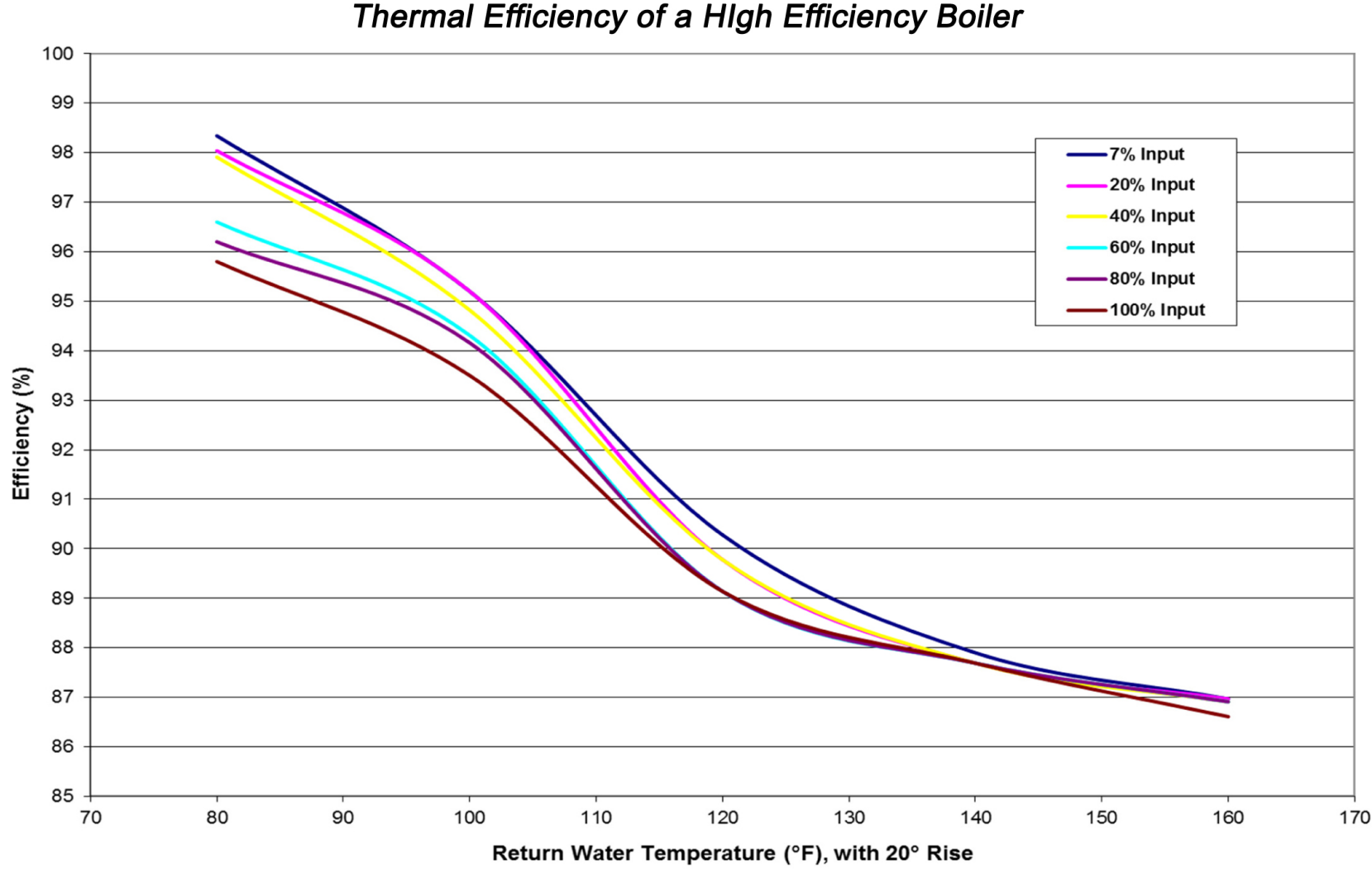
Mechanical Systems



What About High Efficiency Boilers?



What About High Efficiency Boilers?



What About High Efficiency Boilers?



MONTHLY UTILITY COSTS

By Design Collaborative

Utility	Jan	Feb	Mar	Apr	----- May	----- June	----- July	----- Aug	Sept	Oct	Nov	Dec	Total
160 Degree Water													
Electric													
On-Pk Cons. (\$)	1,074	970	1,106	1,085	1,412	1,822	1,847	1,948	1,573	1,237	1,038	1,054	16,166
On-Pk Demand (\$)	274	277	277	436	594	670	727	702	660	532	334	274	5,757
Total (\$):	1,348	1,246	1,383	1,521	2,006	2,493	2,574	2,650	2,233	1,768	1,372	1,328	21,923
Gas													
On-Pk Cons. (\$)	1,166	824	696	275	130	70	63	82	128	282	593	911	5,222
Monthly Total (\$):	2,514	2,071	2,079	1,796	2,136	2,563	2,638	2,732	2,361	2,050	1,964	2,240	27,145

Building Area = 22,966 ft²
 Utility Cost Per Area = 1.18 \$/ft²

140 Degree Water													
Electric													
On-Pk Cons. (\$)	1,074	972	1,115	1,099	1,437	1,857	1,881	1,982	1,601	1,251	1,041	1,053	16,363
On-Pk Demand (\$)	271	274	274	433	594	671	727	702	660	528	331	271	5,736
Total (\$):	1,345	1,246	1,389	1,532	2,032	2,527	2,607	2,685	2,261	1,780	1,372	1,324	22,099
Gas													
On-Pk Cons. (\$)	1,010	711	600	234	113	64	59	73	111	238	506	784	4,504
Monthly Total (\$):	2,355	1,957	1,989	1,766	2,145	2,591	2,666	2,758	2,372	2,018	1,878	2,107	26,603

Building Area = 22,966 ft²
 Utility Cost Per Area = 1.16 \$/ft²

2.0% Savings

What Does Chiller Efficiency Gain Me?



Chiller Operating Cost
Annual Operating Cost - 100 Ton Chiller

Part Load Condition	Cost To Operate
0.5 kw/ton	\$18,600
0.6 kw/ton	\$22,300
0.7 kw/ton	\$26,000
0.8 kw/ton	\$29,700
0.9 kw/ton	\$33,400
1.0 kw/ton	\$37,100
1.1 kw/ton	\$40,900
1.2 kw/ton	\$44,600
1.3 kw/ton	\$48,300

What Does Chiller Efficiency Gain Me?



MONTHLY UTILITY COSTS

By Design Collaborative

Utility	----- Monthly Utility Costs -----												Total
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
Standard Chiller at 1.0 kW/Ton													
Electric													
On-Pk Cons. (\$)	1,074	970	1,106	1,085	1,412	1,822	1,847	1,948	1,573	1,237	1,038	1,054	16,166
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 Utility Cost Per Area = 1.18 \$/ft²

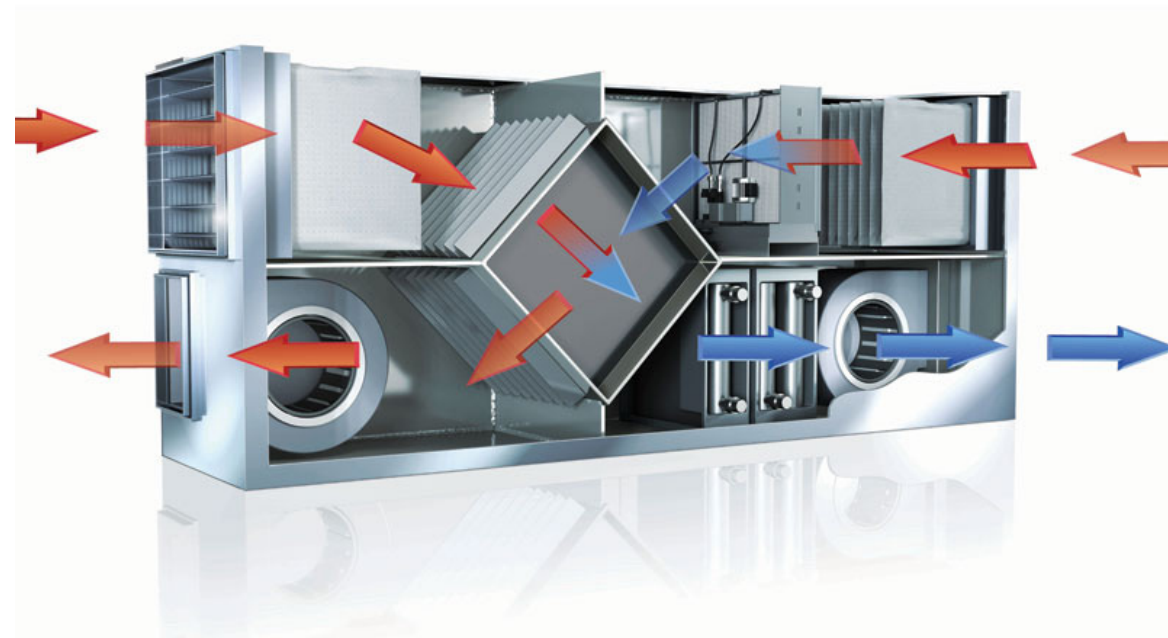
10% Efficiency Increase

Electric													
On-Pk Cons. (\$)	1,100	995	1,139	1,111	1,410	1,770	1,787	1,886	1,547	1,252	1,065	1,079	16,141
On-Pk Demand (\$)	274	277	277	416	553	620	670	649	612	500	328	274	5,450
Total (\$):	1,374	1,272	1,417	1,527	1,963	2,389	2,457	2,535	2,159	1,752	1,393	1,353	21,591
Gas													
On-Pk Cons. (\$)	1,154	814	689	267	126	68	61	79	123	273	582	901	5,136
Monthly Total (\$):	2,528	2,086	2,105	1,794	2,089	2,457	2,518	2,614	2,282	2,025	1,976	2,253	26,728

Building Area = 22,966 ft²
 Utility Cost Per Area = 1.16 \$/ft²

1.5% Savings

Energy Savings Strategy - ERV



ERV's are a cost-effective means in reducing energy consumption without reducing indoor environmental quality.

- ERV's can reduce HVAC load by **30-70%**
(Center for Energy and Environment)
- Reduces main equipment sizing
- Couple this with the DOAS for added benefit
- Tie into environmental air exhaust to eliminate other equipment

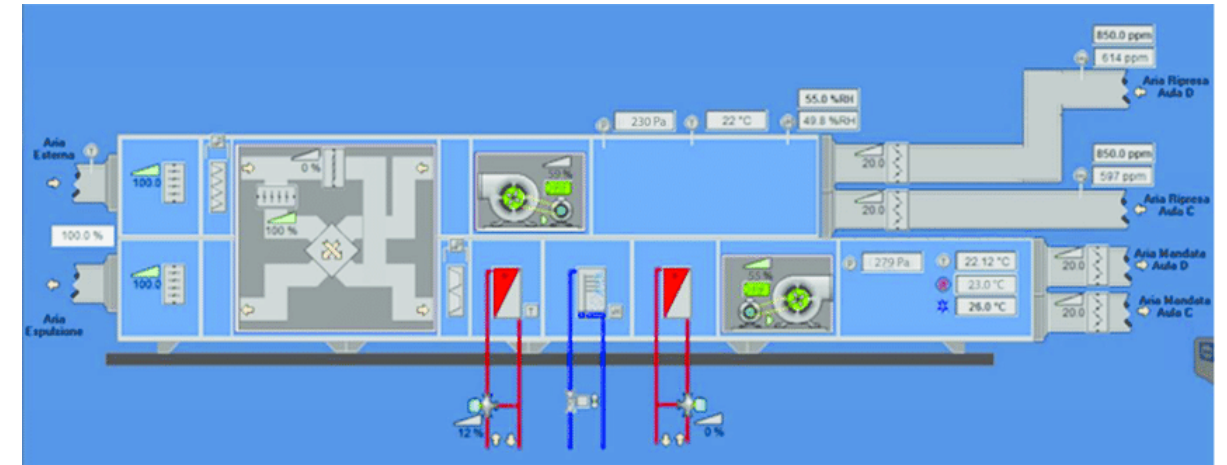
Controls & Commissioning



Controls



- Digital controls can reduce energy usage
- Couple BMS with **IAQ sensors** for real time feedback
- Advances in **AI** are coming to BMS manufacturers to allow anticipation of control needs
- AI can classify, group and analyze vast amounts of data to identify complex patterns
- Predictive maintenance will no longer be a thing of the future



Commissioning



- Typically cost 1.5% - 2.5% of mechanical system cost
- Savings up to 5% - 16% of energy costs
- Improved IAQ
- Better comfort
- Greater productivity or safety
- Extended equipment life
- Reduced need for repairs or warranty claims

Preventative Maintenance



Regular HVAC Inspections &
Filter Replacements

Calibrate Thermostats
& Sensors

Inspect & Tune Mechanical
Equipment

Benchmarking



How Does Your Building Stack Up?



wellcertified.com



energystar.gov



usgbc.org/leed

Summary



Utilize Digital Controls to Their Fullest

Calibrate Sensors



Reduce Infiltration

Glass/Shading



Energy Recovery

Questions?



JASON BAKER PE
Senior Mechanical Engineer | Partner