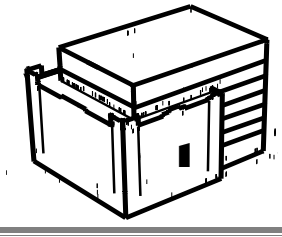
Energy Analysis Report

Tech 2 – AE 481 Senior Project

October 31, 2005

Jenny Hamp
Mechanical Option BAE/MAE
Advisor – Dr. Freihaut



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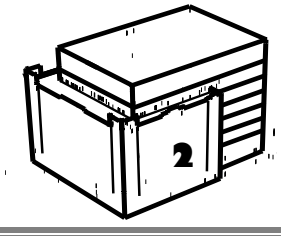


Introduction

The seven story building has 6 floors of condominiums, one floor of retail space, and an unoccupied basement. Two roof top air handling units provide the breathing zone fresh air. A 15000 CFM unit supplies outdoor air to individual fan coil units in the apartments. A 1755 CFM unit supplies 100% OA to egress corridors. For the retail space, only a capped duct between the first floor and roof is provided for 3000 CFM. The basement receives tempered outdoor air from the larger RTU. The duct for the apartment supply is capped at the basement to allow for basement ventilation fit-out as well. Two fans on the roof supply unconditioned ventilation to the boiler room and to pressurize the stairwell, and several exhaust fans reject air.

Using Trane TRACE to model the building, it appears that the engineered systems are sized sufficiently to meet peak loads for its location 99.6% of the time. The mechanical systems uses 6% of the rentable area. The envelope and lighting satisfy ASHARE 90.1 sections 5 and 9. Numerous LEED points are accomplished by the mechanical systems.

A: LEED Credits

Sections of LEED 2.1, New Construction, that should be addressed primarily by the Mechanical Engineers, and how they are met or not met for Hoboken Residential

WE C3.1, C3.2 – Water use reduction

A 27% decrease in water use is achieved thru low flow toilets, showerheads, lavatories and kitchen sinks. This will accomplish credit C3.1 only.

EA P1 – Fundamental Building Systems Commissioning

The Mechanical specifications call for basic commissioning of building systems

EA P2 – Minimum Energy Performance

Design Documents are to code, and meet ASHRAE 90.1

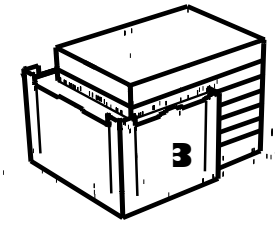
EA P3 – CFC Reduction in HVAC&R Equipment

The chillers use 407c as the refrigerant, and CFC's are not used in any equipment.

EA C1.2 thru C1.10 – Optimize Energy Performance

It is estimated that the building will use between 15 and 30 percent energy less than ASHRAE 90.1 minimum requirements

EA C2.1thru C2.3 – Renewable Energy



The building will not use renewable energy besides what in the municipal electric mix is renewable

EA C3 – Additional Commissioning

The extent of commissioning specified in this section is not met by the contract documents.

EA C4 – Ozone Depletion

No HCFC's or Halons are used in the mechanical systems of this building. As stated above, 407c refrigerant, an HFC mix, is used in the chillers, and there are no other heat pumps in the mechanical system. The fire suppressant system is a water sprinkler system.

EA C5 – Measurement & Verification

There is no long term verification or metering plan for all the items required for this credit.

EA C6 – Green Power

The municipal power which is used to provide electricity for the building, is less than 50% renewable.

IEQ P1 – Minimum IAQ Performance

The building is to code and meets ASHRAE Standard 62

IEQ P2 – Environmental Tobacco Smoke

Public spaces in this building will be non-smoking.

IEQ C1 – Carbon Dioxide Monitoring

Carbon dioxide monitoring is not designed for any spaces

IEQ C2 – Ventilation Effectiveness

An air change effectiveness of greater than 0.9 for all spaces cannot be assured

IEQ C3.2 – Construction IAQ Management Plan

A building flushout is difficult with the present design; an IAQ test may be specified depending on quantity of points needed to attain a silver rating at that time.

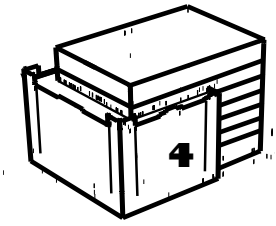
IEQ C5 – Indoor Chemical & Pollutant Source Control

Chemical use will exist only in housekeeping areas, and that space is not designed as part of these contract documents. Architect specifies entryway grilles.

IEQ C6.1- Controllability of Systems, Perimeter

Since condominiums have full lighting control and operable windows, it is assumed that this credit will be met when the supporting calculations are done.

IEQ C6.2 - Controllability of Systems, Non-Perimeter



It is assumed each apartment has more than two occupants, but there is one HVAC control for each apartment, so this requirement that 50% of the occupants have individual control is not met.

IEQ C7.1 – Thermal Comfort, ASHRAE 55-1992

Residential thermal conditions are determined by occupants, so it can not be shown that spaces will comply with ASHRAE 55-1992

IEQ C7.2 – Thermal Comfort, Permanent Monitoring System

There is no permanent monitoring system for the condominium AC

ID C2 – LEED Accredited Professional

The MEP design team includes an engineer who has passed the LEED Accredited Professional exam.

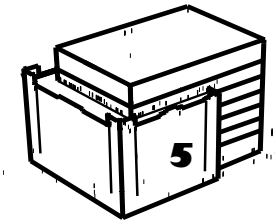
LEED Summary - Given the above statements, the Mechanical Design and specifications will accomplish between 13 and 21 points towards a LEED rating, and will not accomplish at least 14 points that are attributed to the mechanical system.

B: Compliance to ASHRAE 90.1

Section 5, Envelope Requirements:

Since the building has less than 20% glazing, the envelope is evaluated by the prescriptive method. It is modeled for Bergen, NJ Zone 5A. U- Value calculations are shown in reference P-1

	90.1 Requirements		Design Values	
	Assembly Maximum U Value	Insulation Minimum R Value	Assembly U Value	
Roof (Insulation Entirely Above Deck)	0.063	15 ci	0.051	
Walls (Steel Frame)	0.064	13+7.5ci	0.046	
Walls (Other)	0.089	13	0.059	
	Assembly Maximum U Value	SHGC	Assembly Maximum U Value	SHGC
Glazing, Operable, 10-20% of Wall	0.67	0.39	0.31	0.31



Section 9, Lighting requirements:

- Residential spaces are considered 24 hour operation and the lights do not have automatic shut-off.
- Lighting Controls in apartments each control areas of less than 2500 sf
- Corridors and basements spaces have occupancy sensors and remain on for ½ hour of having no occupants.
- Lighting densities is a maximum of 130 fixtures per floor, at 32 W per compact fluorescent, for 9700 sf per floor. This is a lighting density of less than 0.5 W/SF, which is less than the maximum 0.7

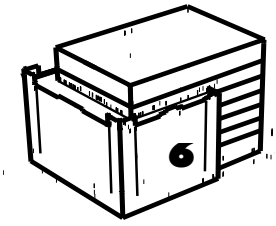
C - Lost Rentable Space to MEP

Space lost includes: Boiler Room, Domestic Hot Water Room. Electrical Room, MEP shafts, Gas Meter Room, Mechanical closets in all apartments.
MEP space not rentable includes: Area between the double-helix stairs and space used on the roof
Not included: Elevators, Garbage Chute

Mechanical Space Each Floor

Floors	MEP Rooms	MEP Shafts	Rentable Space	MEP space not rentable
0	2280	77	6500	0
1	-	-	-	-
2	110	100	9700	60
3	110	100	9700	60
4	110	100	9700	60
5	110	100	9700	60
6	60	110	7300	60
7	80	120	6800	60
Roof	0	0	0	1500

Percent of Rentable Space lost to Mechanical	6.0%



D: Mechanical First Costs

From bid documents:

	First Cost	Price per SF
Sprinkler	$8,771	$4.44
Plumbing	$37,400	$18.92
HVAC	$40,000	$20.24
Electrical	$22,000	$11.13

E - Energy Model Assumptions

The following building loads are evaluated in this report for energy consumption and cost:

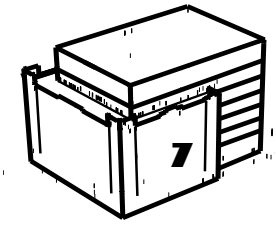
- HVAC loads
- Lighting loads
- Kitchen Loads
- Domestic Hot Water Heating

The following loads are not evaluated:

- Elevators – Assumed negligible and independent of mechanical design
- Domestic Cold Water – The building specifies low-flow fixtures, and is it assumed the energy used to pump water and clean water will be independent of future alterations. However, this number is of interest, and I will continue to look for a reasonable way to calculate this.

The true existing MEP systems are as follows:

- Outdoor air is supplied via a rooftop air handling unit which tempers air to 70 deg F in the winter and 58 deg F in the summer. This is supplied at a set quantity of ventilation to the apartments and 100% OA to the corridors and basement.
- Hydronic Fin Tube Radiators provide sensible heat to all the apartments
- Fan coil units in each apartment provide cooling with the air tempered by the RTU and a chilled water loop. The air is supplied at 56 deg F.
- A Central Chiller/Cooling Tower plant supplies the cooling coils. Each apartment has one or two FCU's.
- The boiler and domestic hot water are fed by natural gas.



The TRACE building HVAC, lighting, and kitchen loads are modeled as follows:

- VAV with Baseboard heating
- RTU's condition the outdoor air sufficiently in winter to meet the load added by ventilation, and the building latent loads in winter.
- All rooms are modeled individually, each apartment is modeled as one zone, and the building is modeled as one system.
- Cooling Coils are in "zones", or each apartment
- 1.5 W/SF lighting load for apartments
- 300 W/SF for kitchen equipment loads
- 3-5 People for each apartment, or for each floor in the duplexes
- 0.15 Air Changes per hour infiltration rate
- Fans are specified for main supply, zone supply, and exhaust

The domestic hot water demand is assumed to be 100 gallons per day per family approximately.

Utility costs:

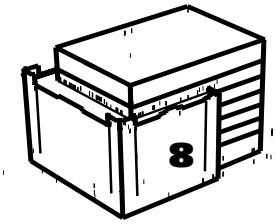
- Gas and electricity costs are modeled for PSE&G energy rates (R-1)
- Water costs are modeled from United Water Delaware (R-2)
- Costs are evaluated for the entire building, not for individual apartments. This will be evaluated in the future to determine the cost effects of HVAC changes to apartment owners.
- Do not include maintenance, or excluded loads stated above.

F – Loads and Design Capacity, Energy Consumption, Results and Comparison

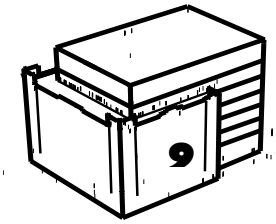
Outdoor Air Heated in RTU's for all spaces

RTU-1 Apartment and Basement OA Supply	OA CFM	MBh
Apartment OA Conditioning Loads	13710	852
Basement Conditioning Load	0	127
Design	15000	1430

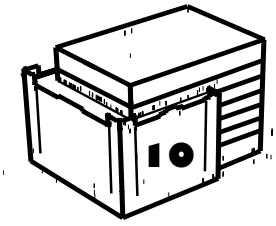
RTU-2 Corridor Supply		
Corridor OA Conditioning Loads	683	50
Design	1755	155



Design Cooling Capacity					TRACE Cooling Load Calculations		
Apartment	FCU	SA CFM	Total MBH	Sensible MBH	SA CFM	Total MBH	Sensible MBH
2 A	2-1	1200	16.1	16.1	1160	32.8	26.9
2 A	2-2	1200	23.0	21.9	-	-	-
2 B	2-7	1200	20.3	19.8	1270	35.4	29.3
2 B	2-8	1500	25.0	24.0	-	-	-
2 C	2-3	1200	20.3	19.8	400	13.2	10.1
2 D	2-6	1200	20.3	19.8	500	14.8	11.5
2 E	2-4	1200	23.0	21.9	600	18.3	14.2
2 F	2-5	1400	32.2	29.4	900	26	21.1
3 A	3-1	1200	16.1	16.1	1100	31.5	25.7
3 A	3-2	1200	21.5	20.9	-	-	-
3 B	3-7	1200	18.7	18.5	1300	35.1	29.1
3 B	3-8	1500	25.0	24.0	-	-	-
3 C	3-3	1200	18.7	18.5	400	13.1	10
3 D	3-6	1200	18.7	18.5	450	14.3	11.1
3 E	3-4	1400	30.0	28.2	500	16.6	12.8
3 F	3-5	1800	38.8	36.4	800	23.1	18.4
4 A	4-1	1200	14.6	14.6	1100	31.5	25.6
4 A	4-2	1200	21.5	20.9	-	-	-
4 B	4-7	1200	19.7	18.9	1200	33.1	27.2
4 B	4-8	1500	25.0	24.0	-	-	-
4 C	4-3	1200	19.7	18.9	400	13	9.9
4 D	4-6	1200	18.7	18.5	450	14.4	11.1
4 E	4-4	1400	32.2	29.4	550	16.9	13
4 F	4-5	1950	41.9	39.8	850	24.7	19.8
5 A	5-1	1200	17.7	17.7	1250	34.1	28.1
5 A	5-2	1200	23.0	21.9	-	-	-
5 B	5-7	1200	20.3	19.8	1350	36.4	30.3
5 B	5-8	1500	28.9	27.1	-	-	-
5 C	5-3	1200	18.7	18.5	450	14.7	11.3
5 D	5-6	1200	20.3	19.8	550	16	12.6
5 E	5-4	1200	21.5	20.9	550	16.8	13
5 F	5-5	1400	32.8	29.6	900	25.3	20.4
6 A	6-1	1400	30.0	28.2	1050	29.3	23.7
7 A	7-1	1200	15.1	15.1	-	-	-
6 B	6-5	1900	40.4	38.1	1900	49.6	42.7
7 B	7-5	1500	33.8	31.1	-	-	-
6 C	6-2	1400	29.9	27.4	800	24.4	19.4
6 C	6-3	1200	7.2	7.2	-	-	-
6 D	6-4	1500	33.8	31.1	950	28	22.2
7 C	7-2	1400	30.0	28.2	1000	28.9	23.4
7 C	7-3	1200	7.2	7.2	-	-	-
7 D	7-4	1800	38.8	36.4	1100	30.1	24.9



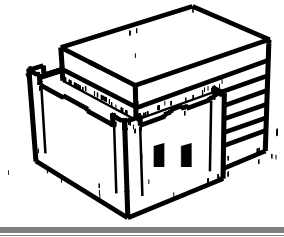
Design Heating Capacity, Fin Tube Radiators				TRACE Heating Loads
Apartment	Feet of FTR	Btu/ LF	MBH	Sensible MBH
2 A	32.5	520	16.9	12.5
2 A	-	-	-	-
2 B	32.5	520	16.9	13.0
2 B	-	-	-	-
2 C	15	520	7.8	5.9
2 D	13	520	6.8	5.2
2 E	27	520	14.0	8.7
2 F	26	520	13.5	9.1
3 A	32.5	520	16.9	11.6
3 A	-	-	-	-
3 B	32.5	520	16.9	12.6
3 B	-	-	-	-
3 C	16	520	8.3	6.0
3 D	12.5	520	6.5	4.8
3 E	26	520	13.5	7.8
3 F	24	520	12.5	8.3
4 A	29.5	520	15.3	11.6
4 A	-	-	-	-
4 B	30.5	520	15.9	11.8
4 B	-	-	-	-
4 C	14.5	520	7.5	5.5
4 D	12.5	520	6.5	4.8
4 E	24.5	520	12.7	8.7
4 F	26.5	520	13.8	9.0
5 A	38	520	19.8	14.9
5 A	-	-	-	-
5 B	35.5	520	18.5	15.2
5 B	-	-	-	-
5 C	18	520	9.4	7.0
5 D	16	520	8.3	6.5
5 E	22.5	520	11.7	8.5
5 F	22	520	11.4	9.1
6 A	35	520	18.2	17.3
7 A	15	520	7.8	-
6 B	33.5	670	22.4	26.2
7 B	27.5	520	14.3	-
6 C	40.5	520	21.1	13.0
6 C	-	-	-	-
6 D	28	520	14.6	9.8
7 C	48	520	25.0	18.1
7 C	-	-	-	-
7 D	28	520	14.6	12.9



Residential Apartments

Annual Hot Water Consumption	People	Gallons per year	Grams Water	Delta T deg C	Calorie Load	Joule Load	Joules in Nat.Gas with boiler eff	Cost $	Gallons Natural Gas
Floors 2-5									
Unit A	5	43800	165800520	55.6	9.219E+09	38597896815	55139852592	836.244	380630
Unit B	5	43800	165800520	55.6	9.219E+09	38597896815	55139852592	836.244	380630
Unit C	3	32850	124350390	55.6	6.914E+09	28948422611	41354889444	627.183	285473
Unit D	3	32850	124350390	55.6	6.914E+09	28948422611	41354889444	627.183	285473
Unit E	5	43800	165800520	55.6	9.219E+09	38597896815	55139852592	836.244	380630
Unit F	5	43800	165800520	55.6	9.219E+09	38597896815	55139852592	836.244	380630
Floor 6									
Duplex A	5	43800	165800520	55.6	9.219E+09	38597896815	55139852592	836.244	380630
Duplex B	5	43800	165800520	55.6	9.219E+09	38597896815	55139852592	836.244	380630
Unit C	4	36500	138167100	55.6	7.682E+09	32164914012	45949877160	696.87	317192
Unit D	4	36500	138167100	55.6	7.682E+09	32164914012	45949877160	696.87	317192
Floor 7									
Duplex A	-	-	-	-	-	-	-	-	-
Duplex B	-	-	-	-	-	-	-	-	-
Unit C	4	36500	138167100	55.6	7.682E+09	32164914012	45949877160	696.87	317192
Unit D	4	36500	138167100	55.6	7.682E+09	32164914012	45949877160	696.87	317192
						Totals:	5.97348E+11		10403889

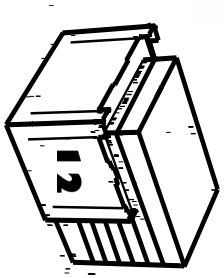
Constants used listed in R-3



ENERGY CONSUMPTION SUMMARY

By ae

	Elect Cons. (kWh)	Gas Cons. (therms)	Water Cons. (1000 gals)	Percent of Total Energy	Total Source Energy* (kBtu/yr)
Primary heating					
Primary heating	19,710.0	11,660.9		29.9 %	14,292.9
Primary cooling					
Cooling Compressor	153,728.6			12.7 %	15,741.9
Tower/Cond Fans	14,837.1		631.3	1.2 %	1,519.3
Condenser Pump				0.0 %	0.0
Other CLG Accessories	4,645.0			0.4 %	475.7
Cooling Subtotal....	173,210.7		631.3	14.3 %	17,736.8
Auxiliary					
Supply Fans	129,999.4			10.8 %	13,312.0
Circ Pumps				0.0 %	0.0
Base Utilities				0.0 %	0.0
Aux Subtotal....	129,999.4			10.8 %	13,312.0
Lighting					
Lighting	543,444.1			45.0 %	55,648.8
Receptacle					
Receptacles				0.0 %	0.0
Heating plant load					
Base Utilities				0.0 %	0.0
Cogeneration					
Cogeneration				0.0 %	0.0
Totals					
Totals**	866,364.1	11,660.9	631.3	100.0 %	100,990.5

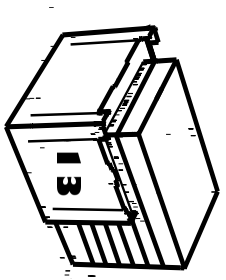


MONTHLY UTILITY COSTS

By ae

Alternative: 1

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
					------- Monthly Utility Costs -------								
Electric													
On-Pk Cons. ($)	3,027	2,791	3,072	3,592	4,513	6,823	7,664	7,949	6,201	3,883	3,330	3,036	55,879
Off-Pk Cons. ($)	1	1	1	1	1	0	0	0	0	0	0	0	5
Total ($):	3,028	2,792	3,073	3,593	4,514	6,823	7,664	7,949	6,201	3,883	3,330	3,036	55,884
Gas													
On-Pk Cons. ($)	2,858	2,401	3,007	1,262	783	729	744	748	743	913	1,375	3,094	18,657
Water													
On-Pk Cons. ($)	0	1	0	40	142	319	399	435	255	60	17	0	1,668
Monthly Total ($):	5,885	5,193	6,080	4,895	5,439	7,871	8,807	9,132	7,199	4,856	4,722	6,130	76,209



H – Emissions Reference data in table R-4

Yearly Emissions Estimate

Electricity	866400	kWh	866400	kWh
Natural Gas Heating	11661	Therms	11661000000	Btu
Domestic HW Heating Nat Gas	5.97E+11	Joules	5.66E+08	Btu

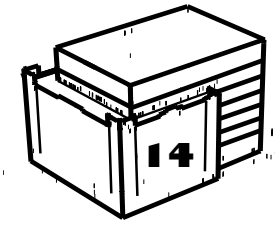
lbm of:	Particulates	SO_2	Nox	CO_2
Electricity	5.57E+02	6.53E+03	3.84E+03	1.20E+06
Natural Gas Heating	8.16E+01	1.17E+01	2.58E+03	1.36E+06
Domestic HW Heating Nat Gas	3.96E+00	5.66E-01	1.25E+02	6.62E+04
	6.42E+02	6.54E+03	6.55E+03	2.63E+06

Conclusion:

Using Trane TRACE to model the building, it appears that the engineered systems are sized sufficiently to meet peak loads for its location 99.6% of the time. The mechanical systems uses 6% of the rentable area. The envelope and lighting satisfy ASHARE 90.1 sections 5 and 9. Numerous LEED points are accomplished by the mechanical systems.

The heating system, or the fin tube radiators, are only slightly oversized. The cooling coils are roughly twice the needed capacity according to the TRACE calculations. I assume since they are both reasonable, there is a definite reason for this, which would be interesting to know.

I look forward to defining what the monthly utility bills will actually be for the apartments. This building has central cooling and heating instead of heat pumps fed individually by cooling towers, which would have relieved the building owner from defining utility bills. My guess is that central heating and cooling is used because it is a higher efficiency, to attain a LEED rating. What difference this makes to the residents could be significant.



R - References

R-1 Utility Costs

PUBLIC SERVICE ELECTRIC AND GAS COMPANY
B.P.U.N.J. No. 14 ELECTRIC

First Revised Sheet No. 67A
Superseding
Original Sheet No. 67A

BASIC GENERATION SERVICE – FIXED PRICING (BGS-FP)
ELECTRIC SUPPLY CHARGES
(Continued)

BGS ENERGY CHARGES:

Applicable to Rate Schedules GLP and LPL-Sec.

Charges per kilowatthour:

Rate Schedule	For usage in each of the months of October through May: Charges	For usage in each of the months of October through May: Charges Including SUT	For usage in each of the months of June through September: Charges	For usage in each of the months of June through September: Charges Including SUT
GLP	5.4921 ¢	5.8216 ¢	6.7786 ¢	7.1853 ¢
GLP Night Use	4.1632 ¢	4.4130 ¢	4.0329 ¢	4.2749 ¢
LPL-Sec. under 750 kW				
On-Peak	6.5705 ¢	6.9647 ¢	8.7655 ¢	9.2914 ¢
Off-Peak	4.1632 ¢	4.4130 ¢	4.0329 ¢	4.2749 ¢
LPL-Sec. equal to or greater than 750 kW but less than 1,250 kW				
On-Peak	7.0705 ¢	7.4947 ¢	9.2655 ¢	9.8214 ¢
Off-Peak	4.6632 ¢	4.9430 ¢	4.5329 ¢	4.8049 ¢

Gas Commodity Price

2000

Billing Period	Cents/Therm
January-00	23.380
February-00	25.830
March-00	25.607
April-00	29.257
May-00	31.120
June-00	42.383
July-00	45.383
August-00	37.477
September-00	46.437
October-00	53.040
November-00	46.213
December-00	63.203

2001

Billing Period	Cents/Therm
January-01	97.880
February-01	69.397
March-01	50.903
April-01	54.423
May-01	49.833
June-01	39.217
July-01	33.417
August-01	31.903
September-01	24.180
October-01	18.883
November-01	30.603
December-01	25.393

2002

Billing Period	Cents/Therm
January-02	27.870
February-02	19.837
March-02	23.813
April-02	34.183
May-02	33.443
June-02	33.490
July-02	33.857
August-02	29.380
September-02	34.627
October-02	36.407
November-02	41.100
December-02	42.203

2003

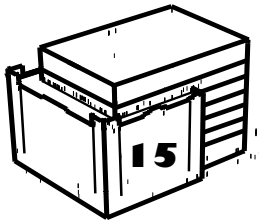
Billing Period	Cents/Therm
January-03	50.320
February-03	55.000
March-03	92.823
April-03	51.067
May-03	53.580
June-03	59.880
July-03	55.817
August-03	46.997
September-03	50.160
October-03	45.200
November-03	44.857
December-03	47.200

2004

Billing Period	Cents/Therm
January-04	62.240
February-04	57.393
March-04	51.180
April-04	53.653
May-04	58.577
June-04	66.897
July-04	63.263
August-04	59.980
September-04	51.897
October-04	54.590
November-04	79.727
December-04	71.770

2005

Billing Period	Cents/Therm
January-05	63.470
February-05	63.597
March-05	62.393
April-05	71.280
May-05	70.070
June-05	62.623
July-05	71.580
August-05	74.520
September-05	101.363
October-05	130.010
November-05	
December-05	



R-2
Water Utility Prices:

Quarterly Conservation Residential Rate effedctive January 1, 2005:

Consumption (1,000 gallons)	**Rate** per 1,000 Gallons
0 - 5,000	$2.480
5,001 - 20,000	$2.642
Over 20,000	$3.077

R-3 Constants used to calculate DHWH costs

Assume 100 Gallons of HW per day per 4 person family

Assume 0.7 efficiency of gas-fired storage water heater

Water=1 Cal/g C

Delta C=100 F=55.6 C

1 gal = 3785.4 g water

Natural Gas-

1 Therm = 105.5 MJ

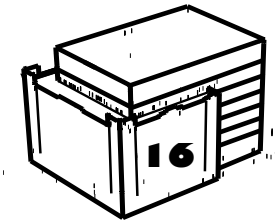
160 Cents/Therm

1027 Btu/ft3

1 cal = 4.1868 Joules

1 cubic feet = 7.48051945 US gallons

1 btu = 1 055.05585 joules



R-4 Emission Constants

Estimating Emissions Associated with On-Site Electricity Use
U.S. Power Generation Mix

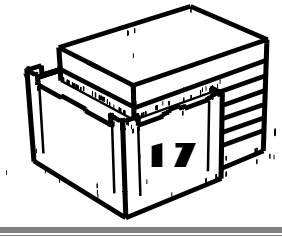
			Short Tons				lbm Pollutant$_j$/kWh			
Fuel	**kWh(1999)**	**% Total**	**SO_2**	**NO_x**	**CO_2**		**Particulates**	**SO_2/kWh**	**NO_x/kWh**	**CO_2/kWh**
Coal	1.77E+12	55.7	1.13E+07	6.55E+06	1.90E+09		1.10E-03	1.28E-02	7.41E-03	2.15E+00
Oil	8.69E+10	2.7	6.70E+05	1.23E+05	9.18E+07		1.10E-03	1.54E-02	2.83E-03	2.11E+00
Nat. Gas	2.96E+11	9.3	2.00E+03	3.76E+05	1.99E+08		0.00E+00	1.35E-05	2.54E-03	1.34E+00
Nuclear	7.25E+11	22.8	0.00E+00	0.00E+00	0.00E+00		0.00E+00	0.00E+00	0.00E+00	0.00E+00
Hydro/Wind	3.00E+11	9.4	0.00E+00	0.00E+00	0.00E+00		0.00E+00	0.00E+00	0.00E+00	0.00E+00
Totals	3.18E+12	100.0	1.20E+07	7.05E+06	2.19E+09		6.42E-04	7.54E-03	4.44E-03	1.38E+00

Source: Electric Power Annual 1999, Vol.II, October 2000, DOE/EIA-0348(99)/2, Energy Information Administration, US DOE, Washington, D.C. 20585-065
http://www.eia.doe.gov/eneaf/electricity/epav2/epav2.pdf

Fossil Fuel Emission Levels
- Pounds per Billion Btu of Energy Input

Pollutant	Natural Gas	Oil	Coal
Carbon Dioxide	117,000	164,000	208,000
Carbon	40	33	208
Nitrogen Oxides	92	448	457
Sulfur Dioxide	1	1,122	2,591
Particulates	7	84	2,744
Mercury	0.000	0.007	0.016

Source: EIA - Natural Gas Issues and Trends 1998



P – Calculations

TRACE results and inputs can be found on Y Drive / Bananas /Trace Results

P-1 U-Value Calculations

Wall Assembly Name: **Renovated Wall**
Outside Surface Color: Dark Absorptivity: **0.900**

Layers: Inside to Outside	Thickness in	Density lb/ft³	Specific Ht. BTU/lb/F	R-Value hr-ft²-F/BTU	Weight lb/ft²
Inside surface resistance	0.000	0.0	0.00	0.68500	0.0
5/8-in gypsum board	0.625	50.0	0.26	0.56004	2.6
Air space	0.000	0.0	0.00	0.91000	0.0
R-14 board insulation	2.000	2.0	0.22	13.88889	0.3
8-in HW concrete	8.000	140.0	0.20	0.66667	93.3
Outside surface resistance	0.000	0.0	0.00	0.33300	0.0
Totals	10.625			17.04	96.3

Overall U-Value: 0.059 BTU/hr/ft²/F

Wall Assembly Name: **New Construction**
Outside Surface Color: Dark Absorptivity: **0.900**

Layers: Inside to Outside	Thickness in	Density lb/ft³	Specific Ht. BTU/lb/F	R-Value hr-ft²-F/BTU	Weight lb/ft²
Inside surface resistance	0.000	0.0	0.00	0.68500	0.0
5/8-in gypsum board	0.625	50.0	0.26	0.56004	2.6
Air space	0.000	0.0	0.00	0.91000	0.0
R-11 batt insulation	3.500	0.5	0.20	11.21795	0.1
R-7 board insulation	1.000	2.0	0.22	6.94445	0.2
Air space	0.000	0.0	0.00	0.91000	0.0
"zinc" siding	0.150	446.0	0.22	0.01250	5.6
Outside surface resistance	0.000	0.0	0.00	0.33300	0.0
Totals	5.275			21.57	8.5

Overall U-Value: 0.046 BTU/hr/ft²/F

Roof Assembly Name: **Roof**
Outside Surface Color: Dark Absorptivity: **0.900**

Layers: Inside to Outside	Thickness in	Density lb/ft³	Specific Ht. BTU/lb/F	R-Value hr-ft²-F/BTU	Weight lb/ft²
Inside surface resistance	0.000	0.0	0.00	0.68500	0.0
5/8-in gypsum board	0.625	50.0	0.26	0.56004	2.6
Air space	0.000	0.0	0.00	0.91000	0.0
22 gage steel deck	0.034	489.0	0.12	0.00011	1.4
4-in LW concrete	4.000	40.0	0.20	3.33333	13.3
R-14 board insulation	2.000	2.0	0.22	13.88889	0.3
Slate	0.500	270.0	0.30	0.05002	11.3
Outside surface resistance	0.000	0.0	0.00	0.33300	0.0
Totals	7.159			19.76	28.9

Overall U-Value: 0.051 BTU/hr/ft²/F