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Penn State University

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Mechanical Option

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[TECHNICAL REPORT 2]

Building and Plant Energy Analysis Report for Felix Hotel

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EXECUTIVE SUMMARY

Building energy consumption and pollution generation is a very important tool that every engineer can utilize when designing a mechanical system. By doing this technical assignment, we will learn about the mechanical system and their effects on the environment and how much energy they consume to satisfy the customers that will be staying over at the hotel.

Hotel Felix is 85,700 SF and located at the heart of downtown Chicago. It was recently renovated in 2009 with sustainability and energy efficiency in mind and became the first LEED Silver certified building in Chicago. Energy consumption analysis and pollution generation calculation was most likely a big factor in choosing the right mechanical system.

There are many products out in the market that can successfully predict building energy consumption. Trane TRACE 700 will be used due to its ease of use for students at The Pennsylvania State University. Simulation of the energy consumption will be performed using the program and will go a further step to calculate monthly and annual bills along with the pollutants generated due to the mechanical systems in the building.

After performing a block load calculation using TRACE, the annual energy consumption for the building was calculated to be 759,870 kWh of electricity and 11,189 therms of natural gas. For this particular building, lighting loads and heating loads were the biggest contributor to energy consumption at 44% and 41% respectively.

MECHANICAL SYSTEM SUMMARY

The Felix Hotel was recently renovated in 2009 to improve the mechanical system and sustainability of the building to become a LEED Silver certified hotel. There is a self contained air conditioning unit located at the basement with VAV terminal units to serve the basement, ground, and mezzanine level of the hotel. The self contained air conditioning unit is rated at 8,000 CFM with a 22 ton cooling load. The chilled air is then distributed to the VAV boxes and then heated using a reheat coil. A roof top unit rated at 7,500 CFM and 36 ton serves the corridors of levels 2-12 at a constant volume. Also, in the recent renovation in 2009, water source heat pumps were designed to provide cooling and heating to each individual guest room in the twelve story building. Hot water for the heat pumps are provided by (2) boilers located on the roof and the heat is rejected through a air source cooling tower located on the roof.

A block load estimate will be performed on the building for this assignment. In order to do so, the building will be divided into 3 zones which correspond to their respective air conditioning unit. A basic model of the building was created using REVIT from the construction documents to be used by a program to analyze the building. Figure 1 below illustrates the model and the three zones that will be used to analyze the building.

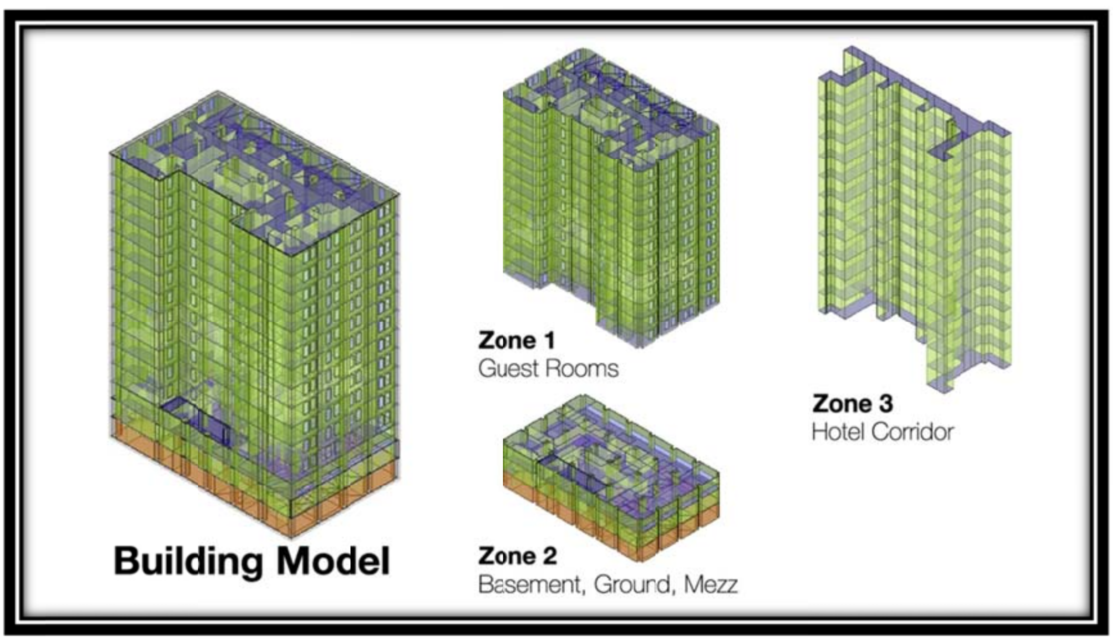


Figure 1: Building Information and Zone Diagram.

DESIGN LOAD ESTIMATION

Trane TRACE 700 was used to run the analysis for this technical assignment. TRACE 700 was used because of its relative ease to run an energy analysis. With the block load estimate method, the program will not take long to calculate our desired results and will be easy to setup with TRACE 700's easy layout.

ASSUMPTIONS

There were a couple assumptions established to simplify the results while retaining its relative accuracy.

1. Floors 2-11 have the exact same floor layout and same air conditioning unit zones. In order to gain a faster result, the hotel is assumed to be 5 story high with the 4th floor ten times as large to gain the same results.
2. The heat pump for the guest room will be assumed to be one big system instead of individual units at each guest room.
3. Assume Chicago Ohare ITL Airport, Illinois.

DESIGN CONDITIONS

Design conditions will be based on data for Chicago Ohare ITL Airport, Illinois.

Cooling Design Conditions (0.4%)		Heating Design Conditions (99.6%)
OA DB (°F)	OA WB (°F)	OA DB (°F)
91.9	74.6	-4.0

Table 1: Design condition for Chicago Ohare ITL Airport, Illinois

LOADS

Although block load estimation is used to simplify the process, internal loads need to be accounted for to obtain results that can represent the true energy consumption for the building. The internal loads that will be included in the model will be lighting loads, occupancy loads, and miscellaneous loads. The values that are entered for the internal loads are shown in table 2.

Room Type	Lighting Load	Occupancy Load	Misc Load
Guest Rooms	0.5 W/SF	2 people	0.5 W/SF
Corridor	0.5 W/SF	0	0 W/SF
Conference Room	1 W/SF	20 SF/person	0.5 W/SF

Office	1 W/SF	100 SF/person	1 W/SF

Table 2: Internal loads

RESULTS

The design schedule for the mechanical system was not available for comparison in this assignment. But using the data from the construction documents and knowledge of ASHRAE, it was possible to come up with the following data using Trane TRACE 700 after modeling the building in REVIT and importing it into the program.

	Cooling (SF/ton)	Heating (Btuh/SF)	Ventilation (cfm/SF)
Roof Top Unit	536.7	29.59	1.26
Self Contained AHU	837.0	20.59	0.6
Heat Pump	2182	18.54	1.26

Table 3: Overall Results

ENERGY CONSUMPTION AND OPERATING COSTS

For this part of the report, the actual bill was not available for comparison.

ANNUAL ENERGY CONSUMPTION

The fuel costs that were used to find estimate the annual energy consumption is listed below.

Electricity	Cost $/kWh
Off Peak Apr – May	0.0677
Off Peak June – Dec	0.0795
Off Peak Jan – may	0.0791
Peak Apr – May	0.0731
Peak June – Dec	0.0852
Peak Jan – May	0.0843
Demand Apr – May	8.452
Demand June – Dec	8.915
Demand Jan – May	8.706

Table 4: Electricity Costs

Gas	Price (cents/therm)
Off Peak	65.38
Peak	72.38

Table 5: Gas Price

After using the fuel costs above and inserting necessary information, the annual energy consumption can be calculated using Trane TRACE 700.

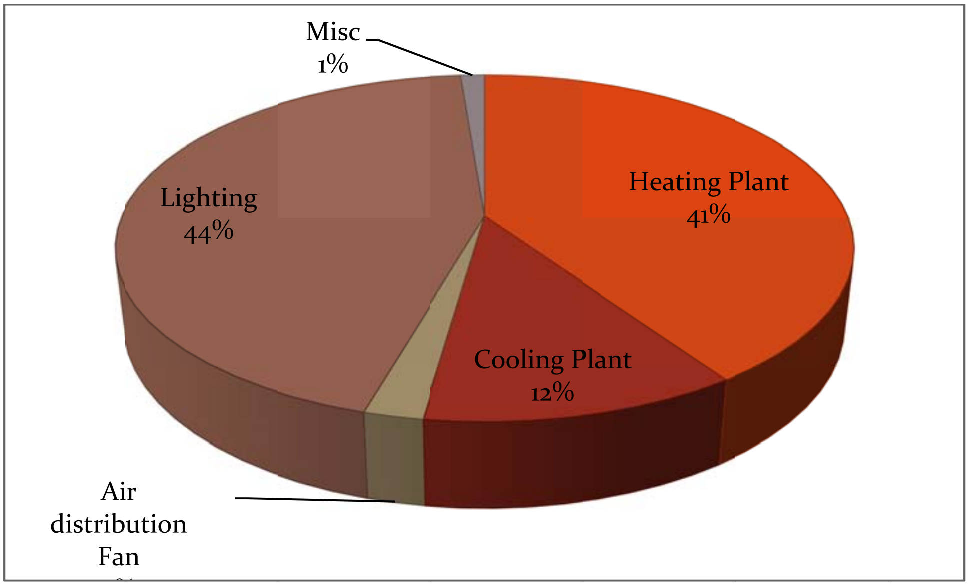


Figure 1: Energy Consumption per Component Annually

	Electricity (kWh)	Gas (therms)	Water (1000 gal)
Annual Consumption	759,870	11,189	411

Table 6: Annual Energy Consumption by Utility

Diagram shows clearly that heating and lighting is the two major source of energy consumption for Hotel Felix. The heating plant dominates HVAC energy consumption because of its load during the cold winterer design temperatures while the cooling plant is second to cover air conditioning and cold water for the building. Here is a more detailed diagram of how the HVAC systems divide up for energy consumption.

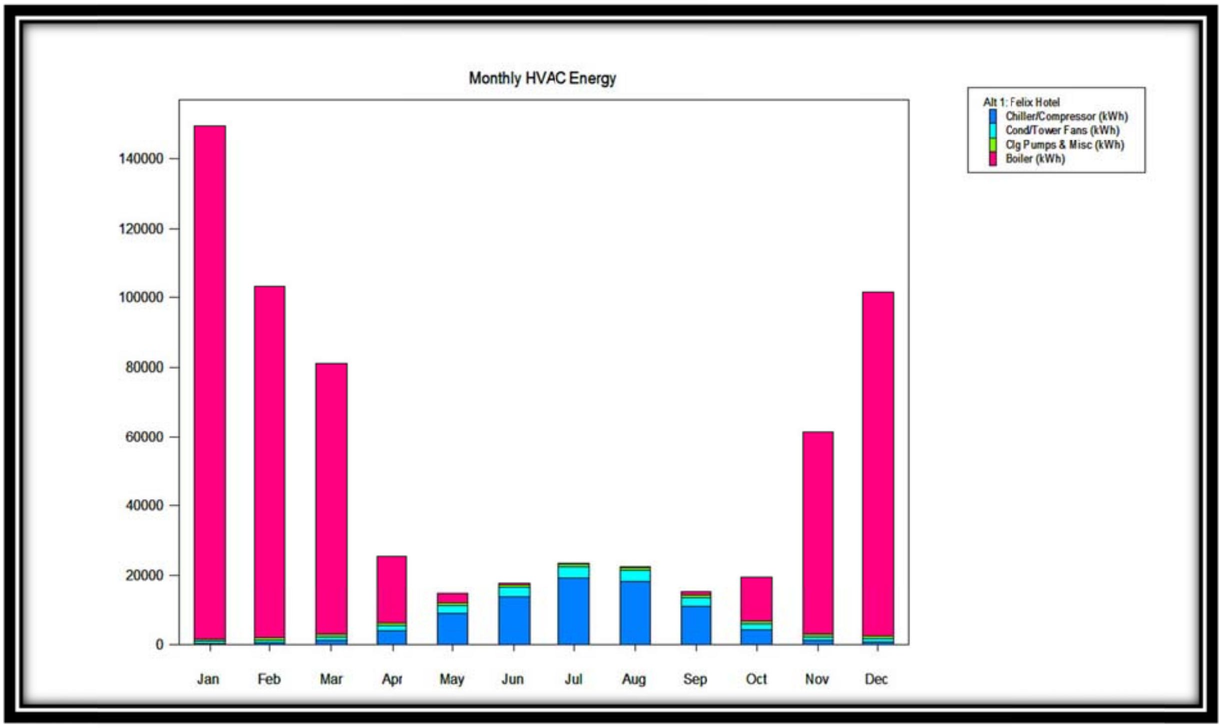


Figure 2: Monthly HVAC Energy Consumption

From Figure 2, a large portion of HVAC energy is consumed by the boiler during winter. This can be contributed to the fact that the hotel is located in Chicago with a low heating design temperature and low heating design temperature. For a majority of the year the boiler will be running to supply heat to the water source heat pump and domestic hot water to the hotel itself. The condenser will be running to chiller will be the main source of energy consumption during the summer but it will not require as much energy as the Boiler

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Electric												
On-Pk (kWh)	41,618	28,649	25,489	22,950	26,333	28,878	32,605	31,246	27,464	24,249	24,101	30,142
Off-Pk (kWh)	67,360	48,525	37,460	23,141	25,365	25,664	29,399	29,273	24,806	24,390	31,605	49,157
On Demand (kW)	159	123	99	88	103	113	122	119	110	90	94	111
Off Demand (kW)	196	172	132	101	104	111	119	117	108	100	127	154
GAS												
On-Pk (therms)	1,053	790	692	67	0	0	0	0	0	3	464	767
Off-Pk (therms)	1,642	1,285	1,229	514	47	0	0	0	3	310	1,007	1,315
Water												
Cons. (1000gal)	1	2	7	26	53	67	80	78	58	28	6	4

Table 7: monthly Energy Consumption

ENERGY COSTS

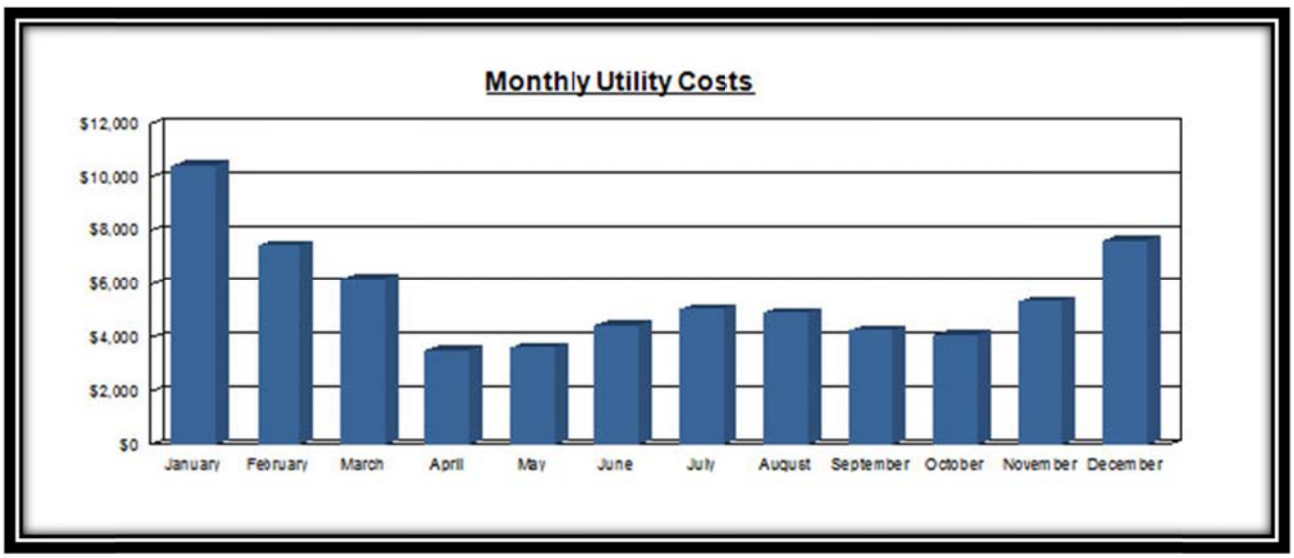


Figure 3: Monthly Utility Costs

Figure 3 shows the monthly breakdown of the utility cost for the Felix Hotel. As expected, the utility cost is at its highest in the winter because of its large heating load requirements because of the cold temperature in Chicago. The monthly rises momentarily in the summer due to its cooling load but it is not very big compared to the heating bill.

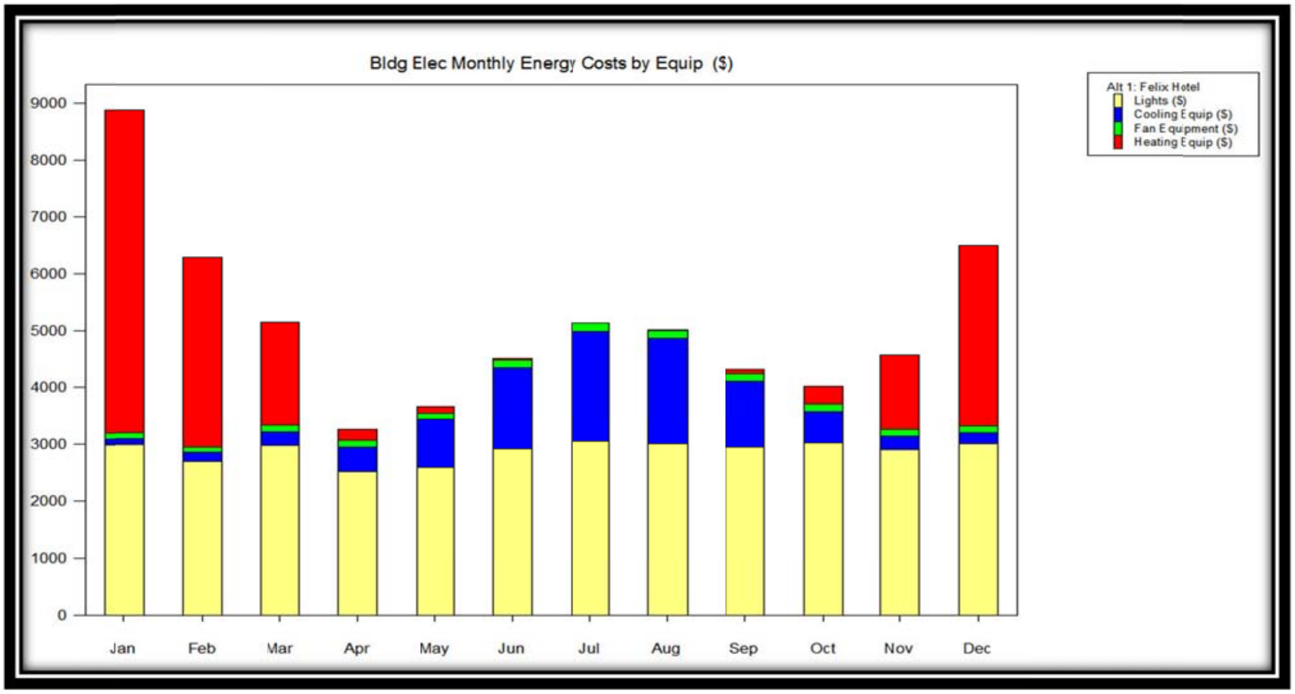


Figure 4: Building Electric Monthly Energy Costs by Equipment

Through Figure 4, the monthly energy costs can be shown in terms of equipment type. This figure is consistent with our previous results where a majority of the monthly cost will go into heating during the winter. One interesting fact is that it costs more to light the building than to cool the building in the summer time. This is something that might be needed to be addressed to decrease our monthly energy costs not only in the summer, but also in the winter.

	Annual Cost
Total Building Operation Cost ($)	68,499
Annual Building operation cost ($/SF)	0.86

Table 8: Total Building Operational Cost

ANNUAL CARBON FOOTPRINT

Using the Regional Grid Emission Factors document provided by the university, a further step was taken to calculate how much pollutant the hotel was producing annually through the electricity and also our boiler on-site generation.

	lb of pollutant per kWh of electricity	Annual Total due to Electricity (LB)
CO2e	1.74	1322173
CO2	1.64	1246186
CH4	3.59E-3	2727.93
H2O	3.87E-5	29.41
NOx	3.00E-3	2279.61
Sox	8.57E-3	5212.0
Particulates	2.05E-1	155773.35

Table 9: Pollutant due to Electricity

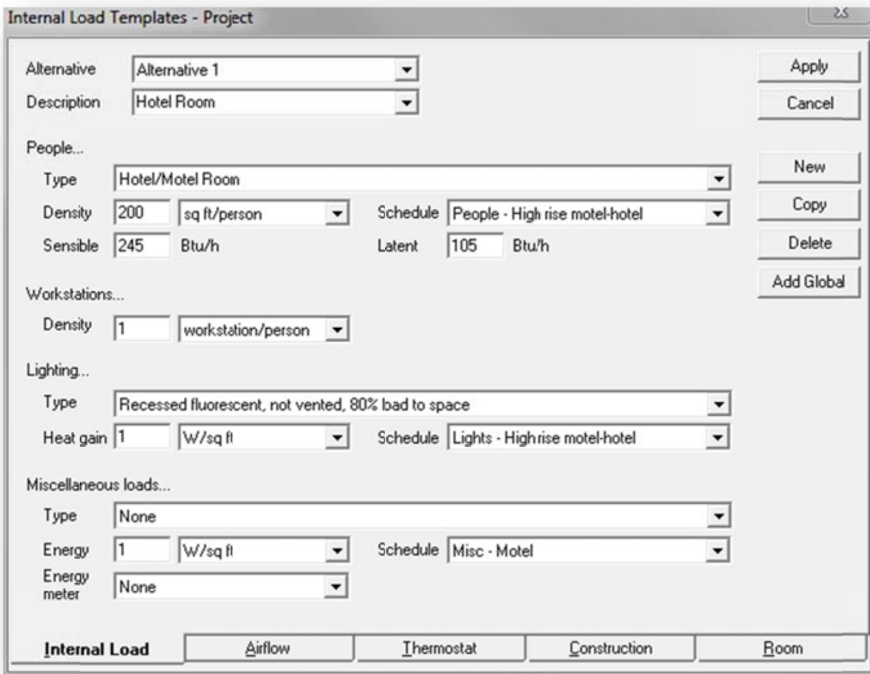
	lb of pollutant per 1000 ft^3 of Natural Gas	Annual Total due to Natural Gas (LB)
CO2e	27.8	31105
CO2	11.16	12486
CH4	7.04E-1	787.7
N2O	2.35E-4	0.263
NOx	1.64E-2	18.35
SOx	1.22	1365.07
Particulates	1.6	1790.24

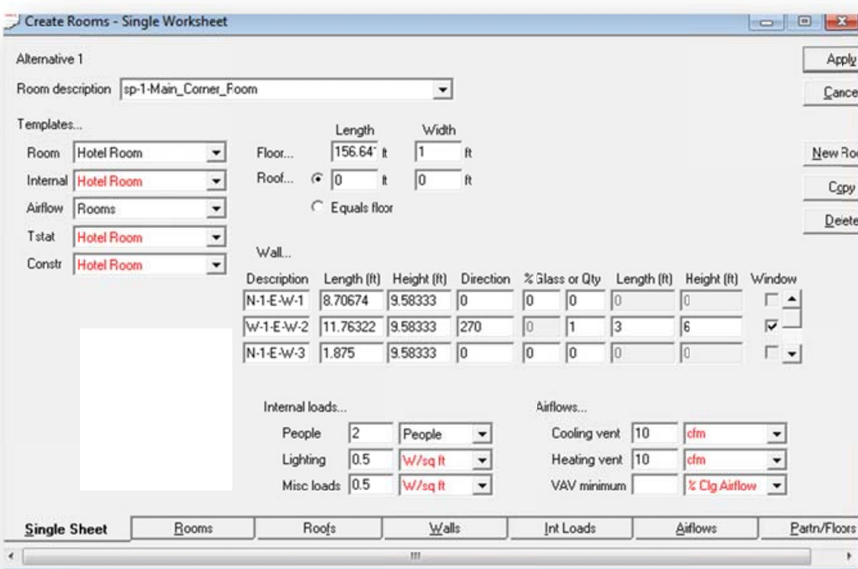
Table 10: Pollutant due to Natural Gas

Although these numbers don't mean much right now, this will be essential for us later in the semester when we are evaluating our proposed change in the mechanical system to see if it improved our carbon footprint.

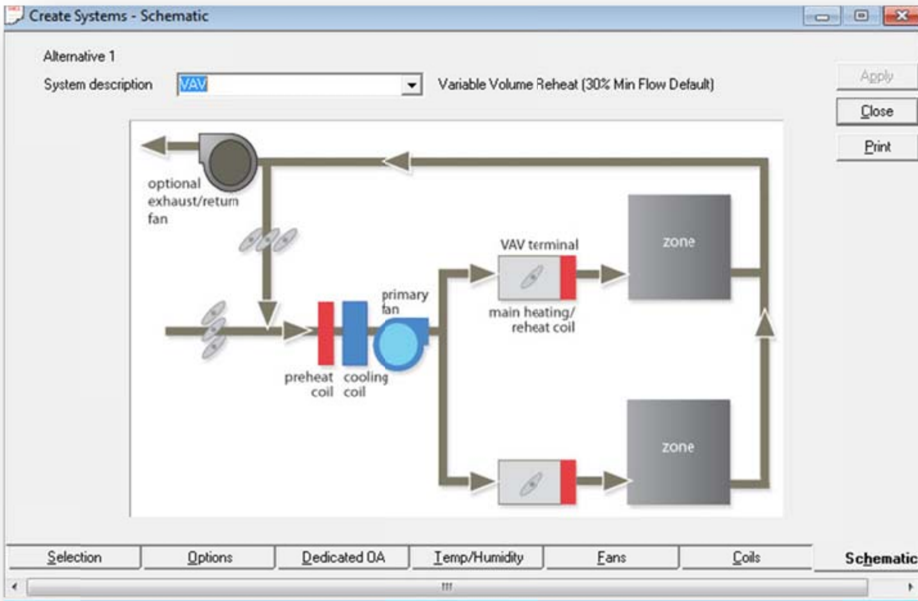
APPENDIX

Typical Hotel Room Template

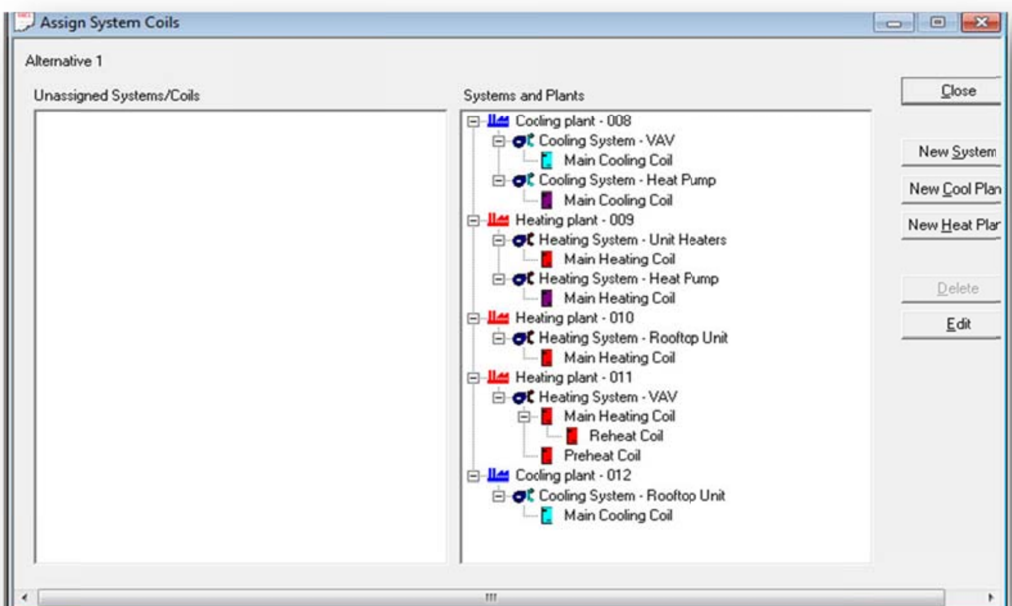




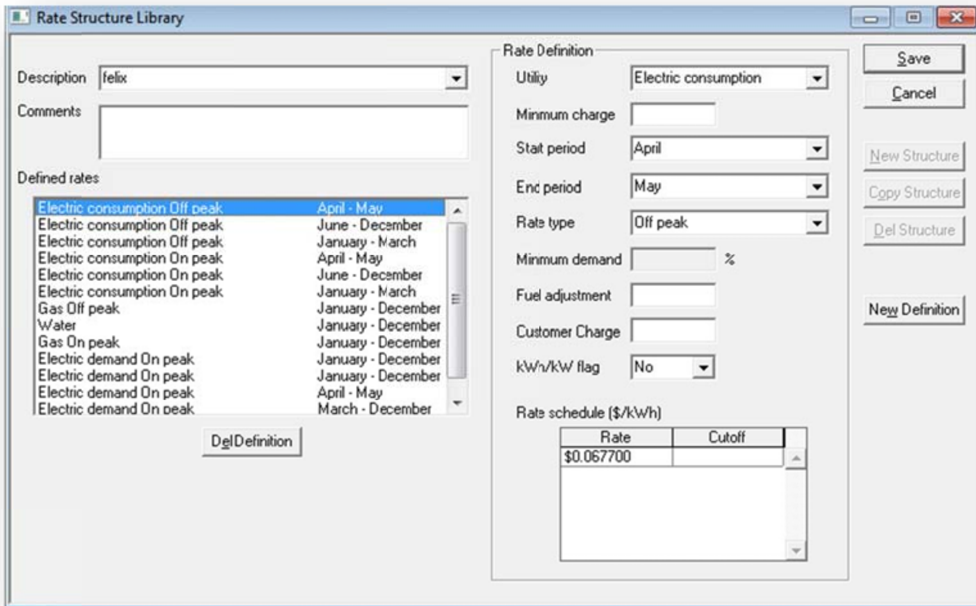
Typical System Schematic



Systems and their plant assignments.



Utility Costs



Overall Setup