Mechanical Tech Report 2

Design Load Estimation and Energy Analysis

M Resort Spa and Casino

Henderson, Nevada

Tom M. Chirdon

Mechanical Option

Faculty Advisor; William P. Bahnfleth

October 24, 2008

Table of Contents

1.0 Executive Summary

Part I of this report utilizes building simulation software, Trane TRACE, to estimate the loads of The M Resort for one calendar year. The design documents were utilized to obtain the necessary information required by TRACE to run the simulation. In some instances information was not available and estimations were used such as in the case of the schedules.

The results of the load analysis fell within a marginal percentage of those values found in the design documents. In a majority of cases the Trace model yielded results that were conservative as compared to the design data. The model was tweaked and re run several times however there are still areas in which more detail could be added with knowledge from the design team as to correct occupancy and equipment use.

The second portion of this report focuses on the energy analysis of the M Resort. The Trace model developed in part one was again used to attain the needed yearly energy use requirements of the building. Energy costs were found through the Nevada Power Company and the Southwest Gas Corporation.

An important observation that was made during the energy analysis had to do with the demand charge for the electricity. During the peak summer hours the electrical demand charge per kW is $8.47 compared to about $0.50 for the non summer period of the year. This increases costs significantly and is an issue that needs to be addressed in the future. It is also important to note how very sensitive the model is to change. Small changes in the schedules and other loads can have big impacts on the bottom dollar.

The overall cooling cost per square foot was found to be $9.86, which seems high, therefore a more detailed look at the model must be completed although there are climatic concerns as well as the demand charge that affect this value.

Part I

Design Load Estimation

2.0 Design Load Estimation

Trane Air Conditioning Economics (TRACE) 700H software was used as the building simulation program to estimate the design loads for The M Resort. In order to accurately calculate the design loads, information from the design documents was used when available, or conservative assumptions were made using industry standards such as ASHRAE documents.

Many variables, including but not limited to internal thermal generation and heat gain through the building envelope, contribute to a building's design cooling and heating load. Internal thermal generation loads stem from mechanical and electrical systems, lighting, plug loads, and people while solar gain would be an example of a load incurred through the building envelope.

Through the design documents the room areas, wall areas, orientation, fenestration areas, ventilation rates, equipment loads and lighting loads were calculated and entered into the simulation program. Table 1 shows some of the various U-Values that were input into Trace to determine the thermal resistive properties of the walls, roofs, and glass items.

Table 1 - Building Envelope Construction

Section	U-Value (Btu/hr-ft^2-°F)	R-Equivalent (hr-ft2-°F/Btu)	Solar Heat Gain Factor
Low Rise Walls	0.09	11.0	-
Tower Walls	0.09	11.0	-
Below Grade Walls	0.05	19.0	-
Low Rise Roof	0.04	25.0	-
Tower Roof	0.05	19.0	-
Low Rise Glass	0.29	-	0.26
Tower Glass	0.29	-	0.36

The M Resort is comprised of a variety of spaces including casinos, retail, health spa, restaurants, and guest rooms. These spaces are not all occupied the same throughout the course of a typical day. In order for Trane TRACE to accurately model the building it is necessary to create schedules for the varying occupancies of the spaces. The guest rooms are more heavily occupied in the late evening and overnight while the conference rooms and spa areas have higher occupancies during the day. The casino on the other hand has a steadier load profile with people in the space at all times of the day, meaning that it does not close. Schedules for each of the spaces were not available from the design documents; therefore assumptions were made and in many cases the default Trace schedules were used for the simulation. Typical Trace inputs have been included in Appendix A of this report.

Table 2 lists the design weather data taken from ASHRAE Handbook of Fundamentals as well as the weather data found in Trace for Las Vegas, Nevada. The most conservative values were used for this analysis to attain the worst case scenario for cooling and heating loads.

Table 2 - Design Weather Data

Annual Cooling Design Conditions				Annual Heating Design Conditions	
ASHRAE 2005, 0.4%		Trace Weather Data		ASHRAE 2005, 99.6%	Trace Weather Data
Cooling DB (°F)	Evaporation WB (°F)	Cooling DB (°F)	Evaporation WB (°F)	Heating DB (°F)	Heating DB (°F)
108.4	71.4	106	70	28.9	28

Table 3 is a summary of the computed loads compared to the actual design conditions. In some cases the Model values are close to the design documents. The inconsistency in the numbers could be due to estimation of equipment loads, occupancy loads, and lighting loads. Diversities could also have been factored into the design document values, without these numbers a more conservative result would be attained.

Table 3 - Load Calculations

System	Output	Cooling ft2/ton	Percent Different Cooling	Supply Air CFM/ft2	Percent Different Supply	Ventilation Air CFM/ft2	Percent Different Ventilation
AHU-T1	TRACE	116.7	-7.3	1.62	-0.6	0.84	-2.3
	DESIGN	135.0		1.63		0.88	
AHU-1-1	TRACE	31.4	-10.5	8.16	-0.9	1.40	-5.1
	DESIGN	38.8		8.30		1.55	
AHU-1-2	TRACE	201.9	-0.6	1.27	-0.6	0.52	9.0
	DESIGN	204.3		1.29		0.43	
AHU-1-3	TRACE	155.8	4.5	1.61	-1.5	0.91	6.0
	DESIGN	142.5		1.66		0.81	
AHU-1-4	TRACE	183.5	-14.7	1.21	0.5	0.82	0.6
	DESIGN	246.7		1.20		0.82	
AHU-1-5	TRACE	409.5	-9.7	0.56	-1.9	0.15	-8.2
	DESIGN	497.7		0.58		0.17	
AHU-1-6	TRACE	304.0	12.7	0.90	0.3	0.48	-5.6
	DESIGN	235.6		0.89		0.54	
AHU-1-7	TRACE	170.8	-20.7	1.21	-2.7	0.24	0.7
	DESIGN	260.2		1.28		0.24	
AHU-1-8	TRACE	85.0	1.5	2.68	-0.7	1.43	2.1
	DESIGN	82.4		2.72		1.37	

Table 3 cont. - Load Calculations							
System	Output	Cooling ft2/ton	Percent Different Cooling	Supply Air CFM/ft2	Percent Different Supply	Ventilation Air CFM/ft2	Percent Different Ventilation
AHU-1-9	TRACE	431.1	-29.0	0.58	3.4	0.04	7.1
	DESIGN	782.6		0.54		0.04	
AHU-1-10	TRACE	317.6	1.1	0.85	-2.2	0.25	-12.4
	DESIGN	310.6		0.89		0.32	
AHU-2-1	TRACE	109.1	-8.2	1.51	-2.7	0.62	-7.4
	DESIGN	128.6		1.59		0.72	
AHU-2-3	TRACE	143.6	-2.3	1.71	3.0	0.83	-1.2
	DESIGN	150.4		1.61		0.85	
AHU-2-4	TRACE	104.9	9.1	2.78	2.1	1.55	-5.7
	DESIGN	87.3		2.66		1.74	
AHU-2-5	TRACE	59.1	7.7	3.39	0.4	3.39	0.4
	DESIGN	50.6		3.36		3.36	
AHU-2-6	TRACE	48.2	-2.0	3.24	-2.0	3.24	-2.0
	DESIGN	50.1		3.37		3.37	
AHU-2-7	TRACE	12.9	-3.0	12.85	-3.5	12.85	-3.5
	DESIGN	13.7		13.77		13.77	
AHU-2-8	TRACE	47.7	-3.8	3.42	-3.5	3.42	-3.5
	DESIGN	51.5		3.67		3.67	
AHU-2-9	TRACE	226.6	-21.2	0.61	1.0	0.26	-13.3
	DESIGN	348.8		0.60		0.34	
AHU-2-10	TRACE	33.5	-1.6	5.28	-1.7	5.28	-1.7
	DESIGN	34.6		5.45		5.45	
AHU-2-11	TRACE	87.4	-16.6	1.95	-0.9	0.98	5.9
	DESIGN	122.2		1.98		0.87	
AHU-2-12	TRACE	152.5	1.9	1.48	-3.3	0.51	-10.4
	DESIGN	146.8		1.58		0.63	
AHU-2-13	TRACE	115.0	-7.7	1.45	-2.9	1.45	-2.9
	DESIGN	134.1		1.53		1.53	
AHU-3-1	TRACE	126.0	-7.3	2.02	1.0	0.59	-8.2
	DESIGN	145.7		1.98		0.69	
AHU-3-2	TRACE	44.5	-5.8	4.90	-0.5	1.73	-4.3
	DESIGN	49.9		4.95		1.88	
AHU-3-3	TRACE	294.3	-14.0	0.72	-0.3	0.25	6.8
	DESIGN	389.7		0.72		0.22	

Note: Negative percentages for cooling indicate that the Trace value is smaller than the design value. Negative percentages for the airflows indicate that the design values are larger than the Trace Values.

The cooling capacity design values seen in Table 3 were taken from the capacities listed in the coiling coil schedule in the design documents. The over all cooling capacity of the building in tons should also be compared to the design. The Peak cooling load is listed as 5,061 tons while the maximum block load is 4,269 tons, each taken from the Trace model. However, the design documents indicate that the total current cooling capacity of the system is 3,900 tons, which shows that diversities and other assumptions based on demand were made for the design.

Part II

Energy Analysis

3.0 Energy Analysis

Trane Trace was again used for this section of this report. The design assumptions used in part one of this report were used again in this section. Motor efficiencies and other performance data was taken from the design documents and some of which can be found in tech report one. A summary of some of the Trace outputs for the energy analysis can be found in Appendix B of this report.

In order to conduct this analysis, local utility rates were found and applied to the same Trane Trace load estimation model used in section 2.0 of this report. Table 4 breaks down the various charges for electricity into the time of use charges, basic charges, and demand charges. Also listed in this table is the break down of the Natural Gas charges. For calculation purposes the peak load values have been used in conjunction with the Trace output.

Table 4 - Utility Rates

<table>
<tr><th colspan="5">Electric Utility Rates (Nevada Power Company) Rate Structure LGS-3</th></tr>
<tr><th>Period</th><th>Time</th><th>Service Charge Per month</th><th>Consumption Charge Per kW</th><th>Demand Charge Per kW</th></tr>
<tr><td>Summer On-Peak</td><td>1PM-7PM</td><td rowspan="4">$167.70 + $0.00627/kWh</td><td>$0.10034</td><td>$8.47</td></tr>
<tr><td>Summer Mid-Peak</td><td>10AM-1PM, 7PM-10PM</td><td>$0.08649</td><td>$0.63</td></tr>
<tr><td>Summer Off Peak</td><td>10PM-10AM</td><td>$0.06281</td><td>$0.50</td></tr>
<tr><td>All Other Periods</td><td>Winter (October-May)</td><td>$0.06281</td><td>$0.50</td></tr>
</table>

<table>
<tr><th colspan="5">Natural Gas Utility Rates (Southwest Gas Corporation) Rate Structure SG-5L</th></tr>
<tr><th>Period</th><th>Time</th><th>Service Charge Per month</th><th>Consumption Charge Per therm</th><th>Demand Charge Per therm</th></tr>
<tr><td>All Periods</td><td>All Times</td><td>$150.00</td><td>$1.1310</td><td>$0.00</td></tr>
</table>

Figure 1

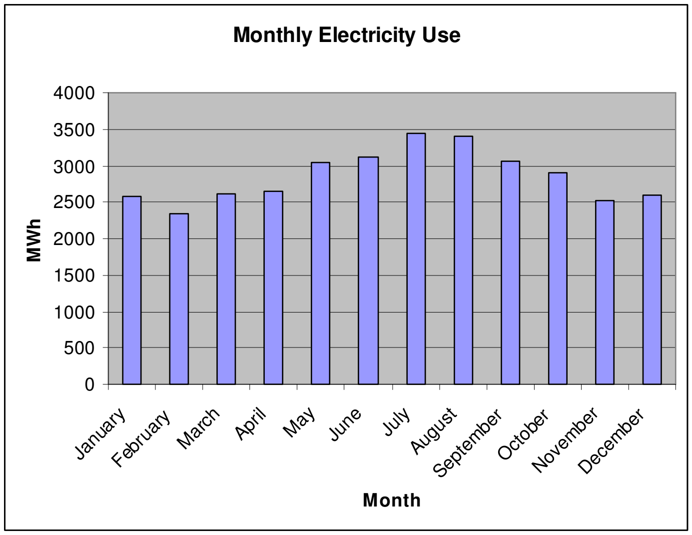


Figure 1 shows the electricity use per month for twelve consecutive months. The peak electricity use is during the summer months as suspected. However the base load is relatively high in comparison to the peaks. This is due in large part to the use of the spaces in the building, the casino for instance is open twenty four hours a day and although it is not at full occupancy for all 24 hours, there is still significant electrical use for all hours. Without detailed occupancy schedules from the owner it will be difficult to fully investigate the base load demand. Many of the schedules had to be assumed for the spaces based on the most logical knowledge available, which may not be the intended design schedules. After the first trace model was run the schedules were tweaked and a similar large base load resulted. Further investigation with the design team will be helpful in determining more accurate assumptions and considerations.

Figure 2

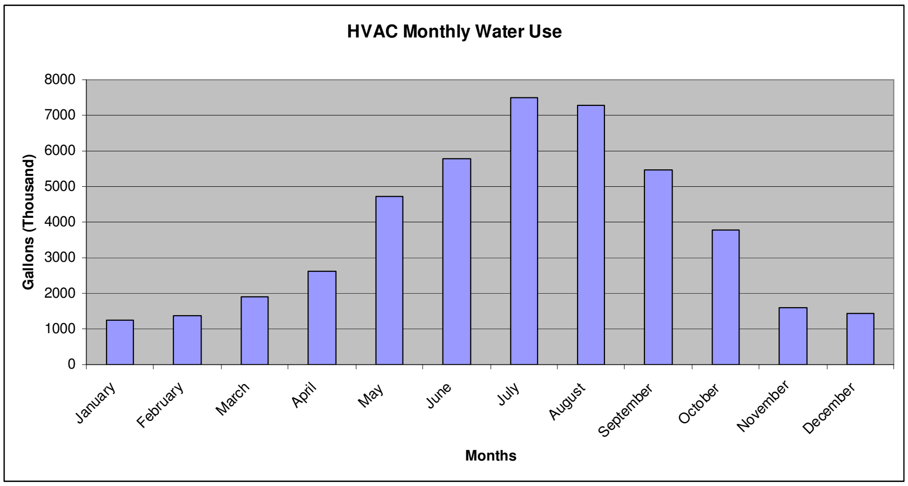
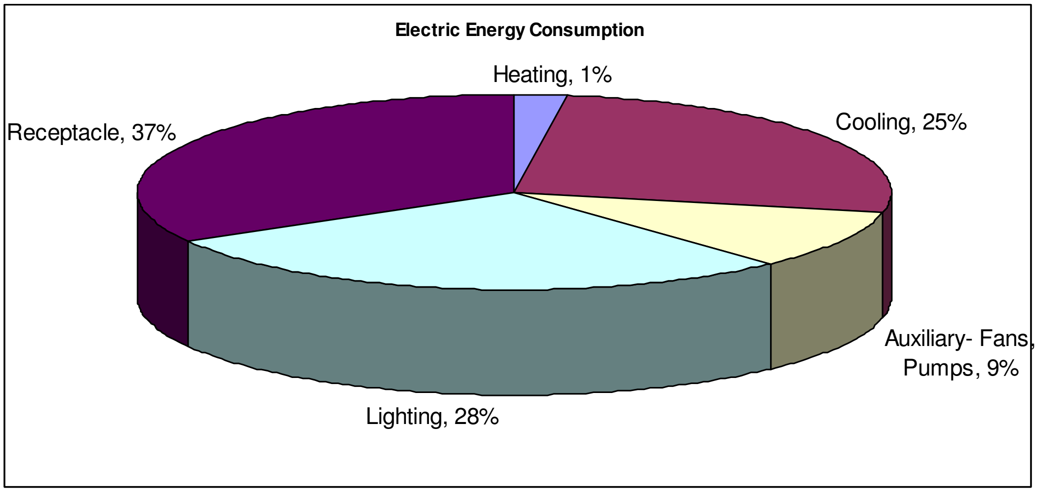


Figure 2 illustrates the water use for the mechanical systems per month for one calendar year. The volumes shown are in thousand gallons with the peak usage being about 7,505,000 gallons. This is a large water usage for the area, especially with the concerns for water supply in the future.

A further analysis of the system splits the annual electrical loads in to the various main branches including HVAC, Lighting, and other various loads which can be seen in Figure 3. This is helpful in verifying the split of the electrical use of the building. As a rule of thumb certain components of the building should have higher electrical demand than others, lighting, for instance, should be on of the largest loads for this type of space use, and in Figure 3 it is shown as the second highest load. Heating in this figure is one of the smallest sectors because much of the heat is from natural gas combustion as well as the climatic conditions Las Vegas, Nevada experiences in the off summer months. Temperatures do not drop down as far as they do elsewhere in the country as in Southern Nevada in the winter; therefore the electric heat required is not a high.

Figure 3



Tables 5, 6 and 7 list the energy cost per month broken up into electrical, natural gas and total cost respectively. It is important to note the high rise in the cost of electricity in the months of June through September. During these months the demand cost of the electricity explodes and the demand charge rises almost $8.00. This is a significant cost which would warrant a future investigation into possible solutions. The natural gas cost is a cost per therm given.

Table 7 gives the cost of energy per square foot to be $136.10 which seems high, however this again is due to the extremely high demand charges put in place for the summer peak months. The cooling cost per square foot came out to be $9.86, which seems high growing up on the east coast; however this may be higher due to the climate conditions in Las Vegas Nevada and mainly from the high electricity demand cost in the summer. Also, the assumptions used for schedules and equipment must be validated in order to for this value to be true.

Table 5 - Electricity Cost

Month	Electricity					
	Electric Energy Usage	Basic Electric Service Charge	Basic Charge per kW	Consumption Charge per kW	Demand Charge per kW	Total Electricity Monthly Cost
January	2,577,001	$167.70	$0.00627	$0.06281	$0.50	$1,466,687
February	2,345,305	$167.70	$0.00627	$0.06281	$0.50	$1,334,834
March	2,620,900	$167.70	$0.00627	$0.06281	$0.50	$1,491,669
April	2,651,593	$167.70	$0.00627	$0.06281	$0.50	$1,509,136
May	3,042,703	$167.70	$0.00627	$0.06281	$0.50	$1,731,709
June	3,110,550	$167.70	$0.00627	$0.10034	$8.47	$26,678,142
July	3,433,024	$167.70	$0.00627	$0.10034	$8.47	$29,443,876
August	3,400,223	$167.70	$0.00627	$0.10034	$8.47	$29,162,554
September	3,068,154	$167.70	$0.00627	$0.10034	$8.47	$26,314,528
October	2,905,252	$167.70	$0.00627	$0.06281	$0.50	$1,653,489
November	2,525,747	$167.70	$0.00627	$0.06281	$0.50	$1,437,520
December	2,593,591	$167.70	$0.00627	$0.06281	$0.50	$1,476,128

Table 6 - Natural Gas Cost

Month	Natural Gas			
	Gas Usage (Therms)	Gas Demand Charge	Gas Charge per Therm	Total Gas Monthly Cost
January	36,197	$150.00	$1.13	$41,088.81
February	25,954	$150.00	$1.13	$29,503.97
March	17,174	$150.00	$1.13	$19,573.79
April	7,030	$150.00	$1.13	$8,100.93
May	2,329	$150.00	$1.13	$2,784.10
June	1,981	$150.00	$1.13	$2,390.51
July	2,033	$150.00	$1.13	$2,449.32
August	2,024	$150.00	$1.13	$2,439.14
September	2,050	$150.00	$1.13	$2,468.55
October	4,112	$150.00	$1.13	$4,800.67
November	20,388	$150.00	$1.13	$23,208.83
December	28,903	$150.00	$1.13	$32,839.29

Table 7 - Total Energy Cost

Utility	Annual Cost	Annual Cost Per SF
Electric	$123,700,273	$135.91
Natural Gas	$171,648	$0.19
Total	$123,871,921	$136.10

A final note, it is important to reiterate that the above analysis is simplified and very conservative. Small changed in the occupancy, lighting schedules, and equipment loads can have drastic impacts of the overall output of the simulation. In order to make complete conclusions from a simulation like this, a more accurate model must be created along with consultation from the design engineers to determine the correct schedules and detailed loads.

The design team conducted basic energy analysis through the simulation software that was used, however a detailed analysis was not conducted. The owner had no requirements for this type of analysis to be conducted in the request for proposal nor is this a LEED rated building. The M Resort had a very demanding time schedule for design, therefore energy use was kept in mind throughout the development of the construction documents; however a detailed analysis of the building component energy use was not conducted.

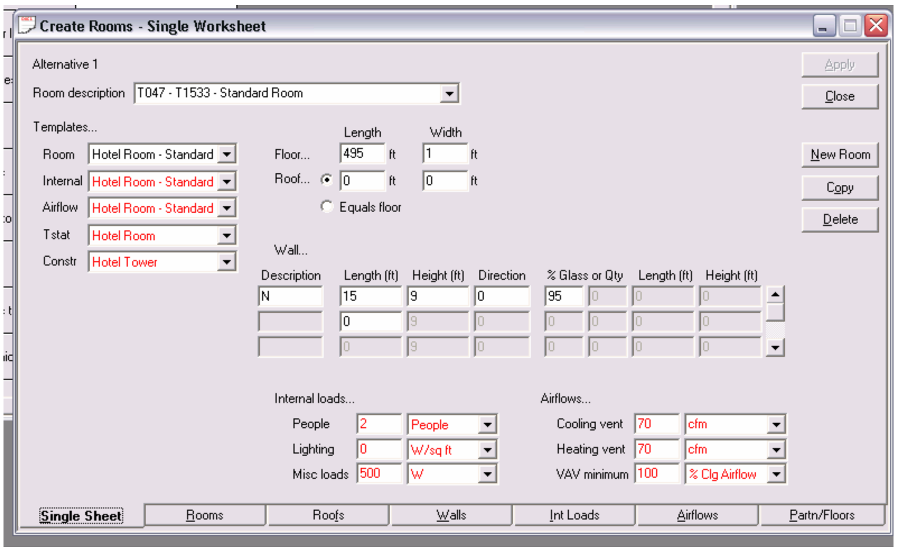
4.0 References:

1. ASHRAE Handbook of Fundamentals 2005.
2. Trane Trace 700h.
3. Southland Industries, Mechanical Drawings and Specifications.
4. Mike Hallenbeck and Jessica Lucas, Thesis Consultants, Southland Industries.
5. JBA Consulting Engineers, Electrical Drawings and Specifications.
6. Marnell Architecture, Drawings and Specifications.
7. The Pennsylvania State University Architectural Engineering Program, Thesis Advisor, Dr. William P. Bahnfleth
8. Past Thesis Technical Reports, e-Studio Archives, 2006-2008

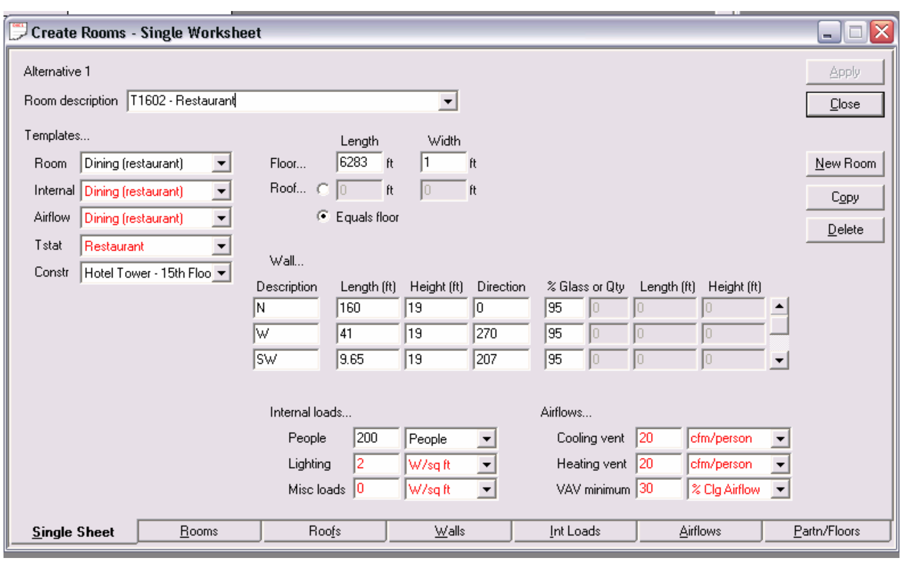
Appendix A

Typical Trace Load Estimation Input Parameters

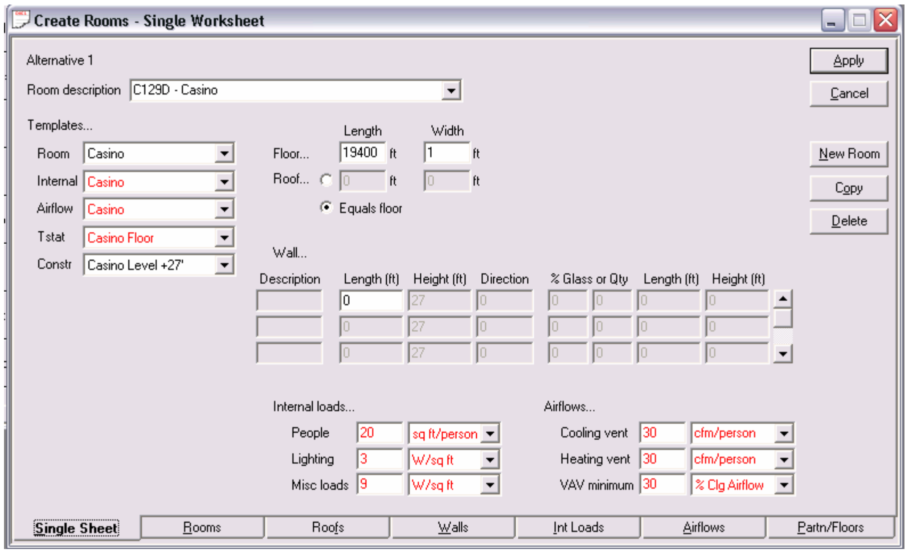
Typical Guest Suite Trace inputs.



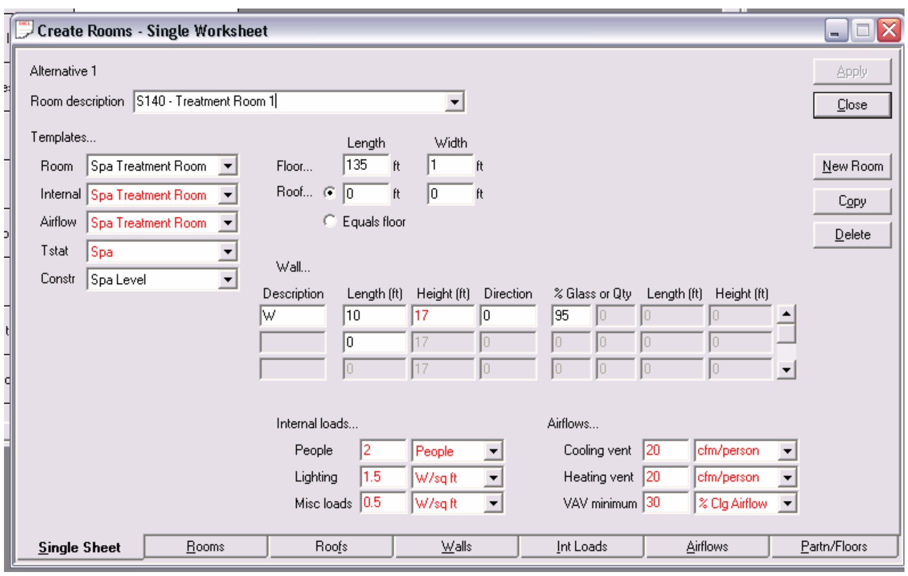
Typical Restaurant Trace inputs.



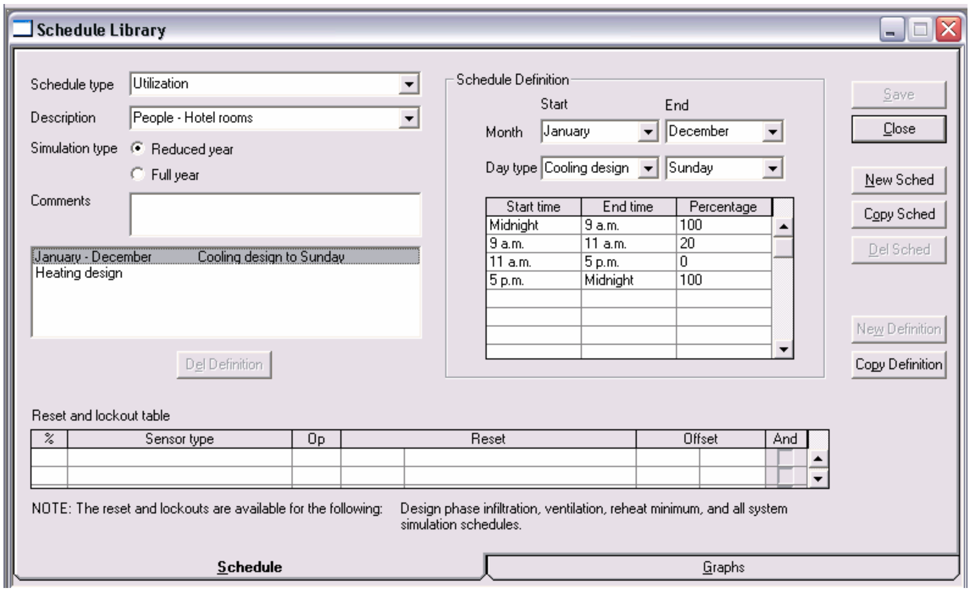
Typical Casino Trace inputs.



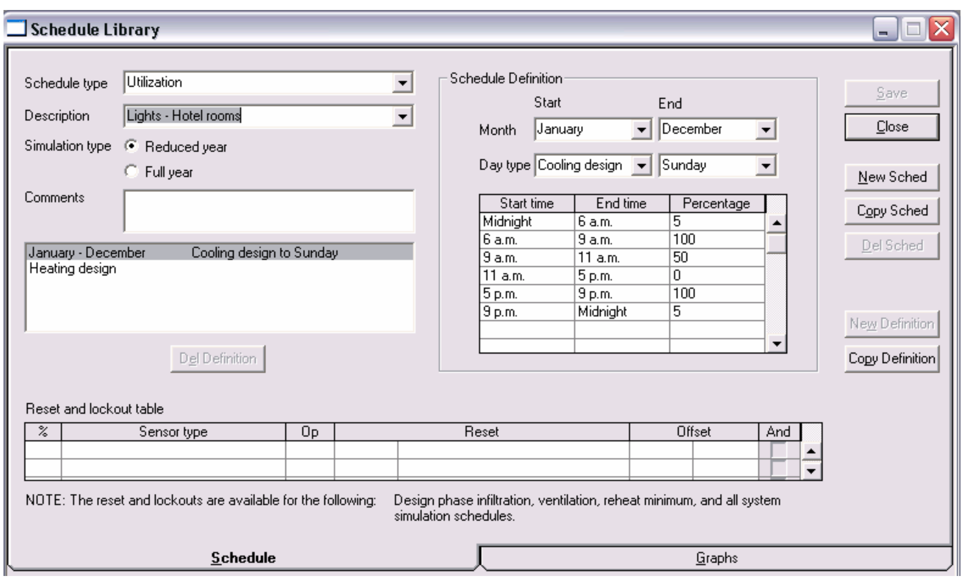
Typical Spa Treatment Room Trace inputs.



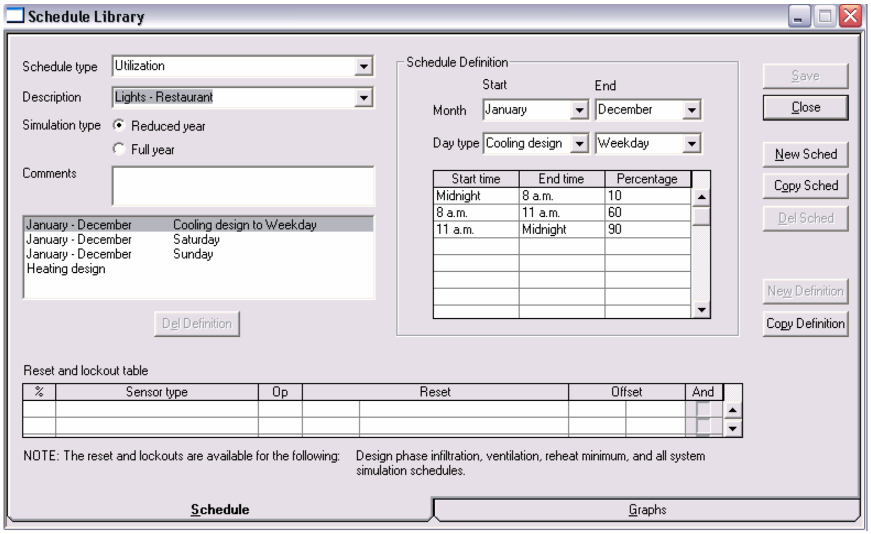
Typical Hotel Room People Schedule



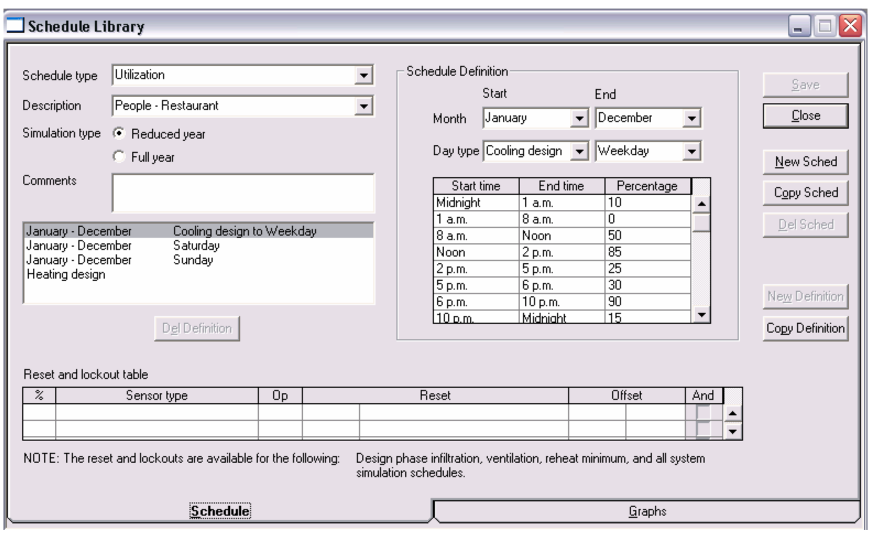
Typical Hotel Room Lighting Schedule.



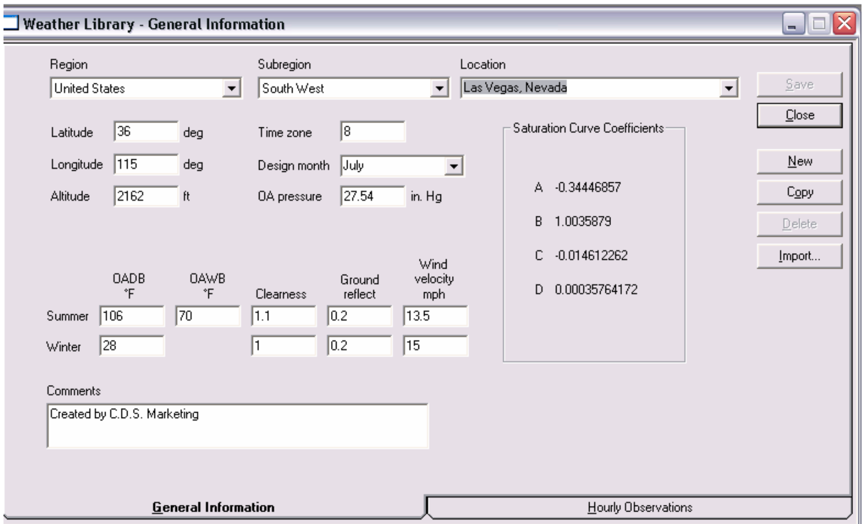
Typical Restaurant Lighting Schedule.



Typical Restaurant People Schedule.



Weather Data Trace Values.



Appendix B

Trace Energy Analysis Output files

ENERGY CONSUMPTION SUMMARY

By PSUAE

	Elect Cons. (kWh)	Gas Cons. (kBtu)	Water Cons. (1000 gals)	% of Total Building Energy	Total Building Energy (kBtu/yr)	Total Source Energy* (kBtu/yr)
Alternative 1						
Primary heating						
Primary heating	502,517	15,017,323		12.7 %	16,732,412	20,953,490
Other Htg Accessories	258,092			0.7 %	880,867	2,642,865
Heating Subtotal	**760,608**	**15,017,323**		**13.3** %	**17,613,279**	**23,596,356**
Primary cooling						
Cooling Compressor	6,653,564			17.2 %	22,708,614	68,132,656
Tower/Cond Fans	2,307,778		44,727	6.0 %	7,876,446	23,631,702
Condenser Pump				0.0 %	0	0
Other Clg Accessories	8,760			0.0 %	29,898	89,703
Cooling Subtotal....	**8,970,102**		**44,727**	**23.2** %	**30,614,958**	**91,854,056**
Auxiliary						
Supply Fans	3,306,535			8.6 %	11,285,202	33,858,992
Pumps				0.0 %	0	0
Stand-alone Base Utilities				0.0 %	0	0
Aux Subtotal....	3,306,535			8.6 %	11,285,202	33,858,992
Lighting						
Lighting	9,785,095			25.3 %	33,396,529	100,199,600
Receptacle						
Receptacles	11,451,696			29.6 %	39,084,638	117,265,640
Cogeneration						
Cogeneration				0.0 %	0	0
Totals						
Totals**	**34,274,036**	**15,017,323**	**44,727**	**100.0** %	**131,994,608**	**366,774,656**

* Note: Resource Utilization factors are included in the Total Source Energy value.
** Note: This report can display a maximum of 7 utilities. If additional utilities are used, they will be included in the total.

MONTHLY ENERGY CONSUMPTION

By PSUAE

------- Monthly Energy Consumption -------

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Alternative: 1	**M Resort Load Calculations**												
Electric													
On-Pk Cons. (kWh)	2,577,001	2,345,305	2,620,900	2,651,593	3,042,703	3,110,550	3,433,024	3,400,223	3,068,154	2,905,252	2,525,747	2,593,591	34,274,040
On-Pk Demand (kW)	4,649	4,584	4,470	4,710	5,174	5,426	5,767	5,686	5,330	4,982	4,404	4,742	5,767
Gas													
On-Pk Cons. (therms)	36,197	25,954	17,174	7,030	2,329	1,981	2,033	2,024	2,050	4,112	20,388	28,903	150,173
On-Pk Demand (therms/hr)	90	78	49	21	5	3	3	3	3	12	56	73	90
Water													
Cons. (1000gal)	1,263	1,366	1,900	2,631	4,723	5,770	7,505	7,288	5,458	3,792	1,599	1,431	44,727

Energy Consumption		
Building	157,880	Btu/(ft2-year)
Source	438,703	Btu/(ft2-year)
Floor Area	836,043	ft2

Environmental Impact Analysis		
CO_2	166,799,760	lbm/year
SO_2	319,452	gm/year
NOX	318,505	gm/year