Carl R. Darnall Army Medical Center

Technical Report 2

Building Energy Analysis Report

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Executive Summary

The purpose of technical report 2 is to analyze the current mechanical design using Trace 700 modeling program. A few assumptions will be made to the model in order to easily model it in Trace 700. Rooms were grouped together according to exterior exposure, and space types. The miscellaneous equipment loads were modeled using the design documents to input typical wattage per square footage. ASHRAE Standard 90.1 was used to fill any loads unidentified in the design documents. Different room conditions were used according to the space type such as the patient rooms, medical support spaces: the nursing stations and chart rooms, and the offices located on the sixth level.

The energy consumption was analyzed using an average energy cost for the city of Fort Hood Texas. Energy consumption was broken down according to building component loads, and the highest energy consuming load was identified. This will help with later analysis of different types of mechanical designs for the proposal. The Trace model was also modeled slightly differently from the building's current central utility plant. Since the medical center's central utility plant provides heating hot water and chilled water for the entire building, the Trace 700 model has one centrifugal chiller and one gas fired steam boiler. Overall, the building uses 3,550 MWh annually on electrical energy. The average annual operating cost for the two floors of the medical center is $368,148 which is $5.49/SF per year.

Mechanical Overview

The army medical center has an off-site central utility plant which consists of its chilled water plant and heating hot water plant. The medical center receives the services from an underground tunnel. The two heat recovery chillers help provide chilled water during colder weather, and they preheat the heating hot water return. It is base loaded, so during the winter, the centrifugal chillers and cooling towers do not need to run. Each of the four centrifugal chillers has a capacity of 1,250 tons, and the heat recovery chiller provides a capacity of 150 tons. Overall, the system provides enough capacity for future air handlers. The chilled water system provides a supply temperature of 44°F to the air handlers, fan coil units for electrical and telecom rooms. The building uses hot water produced by four gas fired steam boilers. The heated hot water system provides a supply temperature of 140°F.

Floors 5 and 6 of the east bed tower are conditioned by two dedicated outdoor air system (DOAS) air handlers in the penthouse on the roof. Both air handlers have an enthalpy recovery wheel which recovers energy from the exhaust air. AHU-2 serves constant air volume terminal units on floor 5 which consists of the pediatric department, as well as, a general medical / surgical department. AHU-3 serves constant air volume terminal units on floor 6 which consists of offices for the departments, officers, and the medical library.

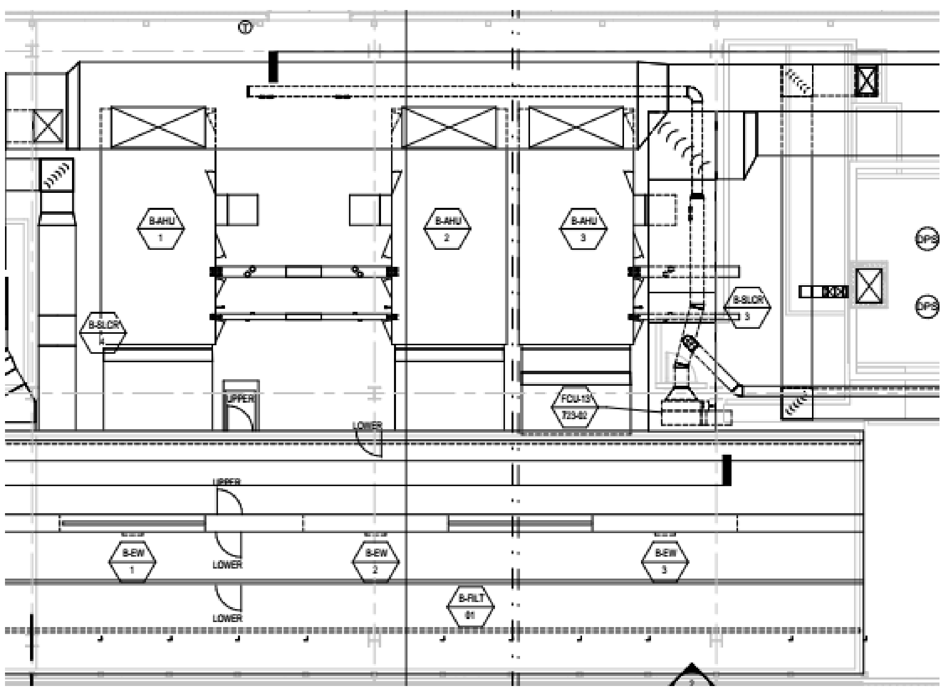

Figure 1 Bedtower Penthouse

Design Load Estimation

Design Conditions

Location

Carl R. Darnall Army Medical Center is located on the base of Fort Hood, Texas, so the climate data for Fort Hood, Texas was used for the energy model. Using Trace 700, a energy model was created using design conditions from the design documents as well as climate data from ASHRAE 2009 Fundamentals. As shown in Figure 1, Fort Hood experiences harsh summers with temperatures in the high 90s. All of the climate data can be found in Appendix A.

Table 1 Climate Data for Coldest & Hottest Months

Coldest Month	Heating DB (99.6%)	Humidification DP/MCDB and HR (99.6%)		
		DP	HR	MCDB
January	23.7	9.8	9.4	33.5

Hottest Month	Cooling DB/MCWB (0.4%)	
	DB	MCWB
August	99.9	73.4

Building Construction

The army medical center was modeled in Trace 700 using the building construction listed in table 2: Building Construction U-Values. The building construction meets the required building construction U-values set by ASHRAE 90.1 section 5.5 as mentioned previously in Tech Report 1. The hospital was modeled as tight construction with a pressurization of 0.06 cfm/SF of wall. This prevents dirty unconditioned outdoor air from coming in.

Building Construction			
Construction	Description	U-Value (Btu/h*ft^2*F)	SC
Slab	8" HW Concrete	0.491	-
Roof	12" HW Conc. 8" Insul	0.0345	-
Wall	4 in. Brick, 6 in ins, 8 in HW Conc. Block	0.0432	-
Partition	0.75" Gyp Frame	0.3879	-
Glass	3mm Dbl Low-E	0.295	0.5

Table 2 Building Construction U-Values

The average wall heights of a patient medical room is listed in Table 3 below. Table 3 displays the effect of the interstitial building services floors between each level of medical space. The IBS floors are floors specifically for building services such as chilled water, hot water, plumbing, conduit, medical gas, and other services. It is over 7 feet tall thus providing access for maintenance to each of the building systems. With the height of the IBS, the floor to floor heights for each floor is about 19 ft.

Table 3 Patient Room Wall Heights

Patient Room Wall Construction	
Floor-to-Floor	19
Floor-to-Ceiling	9
Plenum	10

Block Layout

Due to the monstrosity of the hospital, it was analyzed using the block layouts below. Two air handlers located in the penthouse feed both levels 5 and 6 respectively. The two floors were broken down into exterior, exterior corner, and interior rooms. Then they were broken down according to design conditions. As seen in figure 1, the zones were created according to exposure and activity of the occupants. Since level 6 has a large number of offices, the zones were split according to exposure and design conditions as well.

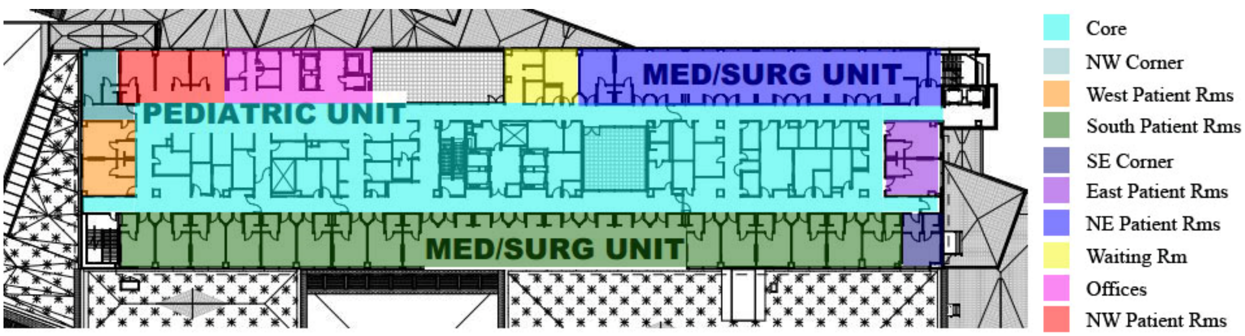

Figure 2 Level 5 Block Layout

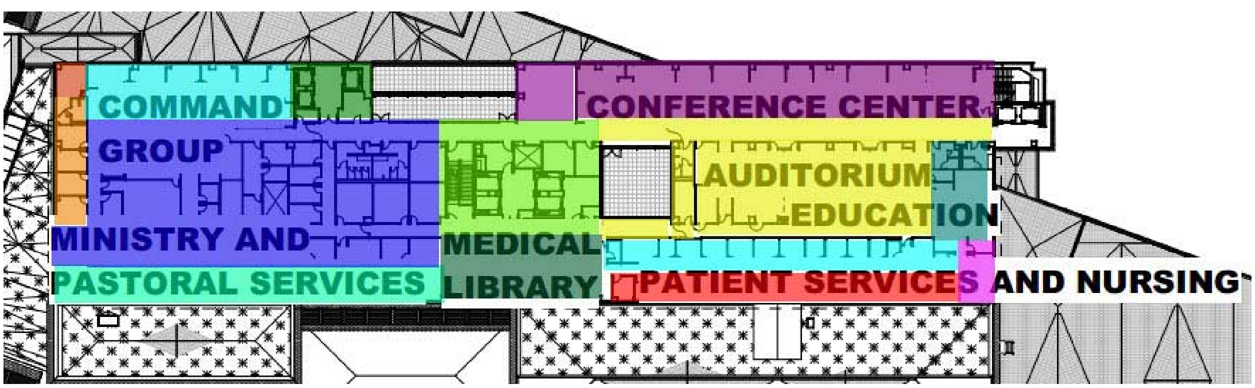

Figure 3 Level 6 Block Layout

Load Assumptions

Occupancy

The occupancy for the building were found using mainly the design documents for the medical spaces. The ASHRAE 62.1 standard was also used to find the occupant densities for the office spaces on level 6.

Lighting

The lighting power densities were referenced from the design documents, specifically the electrical plans. The lighting power densities varied for each space type. The LPD for the patient rooms were slightly lower than the medical support rooms, and the LPD for the office spaces were higher than some of the patient medical rooms. A few of the major templates used for the building spaces are included in Appendix B.

Miscellaneous Equipment Loads

The sixth level is mainly patient medical rooms, so the miscellaneous is on the lower side even though it is a hospital. The rooms for medical support such as the treatment rooms, equipment storage and labs have a higher miscellaneous equipment load of 15 W/sq. ft., these miscellaneous equipment loads can be found in the templates in Appendix B.

Thermostat Settings

The set points for the thermostats vary depending on the building space. The relative humidity for all building spaces is 55%, however the cooling dry bulb and drift point vary according to table 3 below.

Thermostat Settings		
Space	Cooling DB/DP	Heating DB/DP
Conference/Office	78/81	70/64
Medical Room	75/81	75/64
Medical Support	78/81	68/64

Table 4 Thermostat Settings

Schedule

The demand for a hospital is high, and not always consistent through a 24-hour period. Therefore, a 100% diversity factor was taken into account for the occupant, miscellaneous equipment, and lighting loads. The greatest load for lighting, occupancy, and equipment will be during typical work hours of 7 a.m. to 5 p.m., however, the medical center is designed to condition the space for no less than 80% of the occupancy. Although schedules were taken into account, the medical center is designed for close to maximum capacity.

System Equipment

Heating & Cooling

Although the central utility plant consists of four centrifugal chillers and four gas fired steam boilers, the Trace model for this analysis used only one centrifugal chiller and one gas fired steam boiler. The proposed CUP is designed for the entire building, so a smaller CUP should be modeled for the building to obtain reasonable energy consumption. Future analysis of the central utility plant is required to measure an accurate capacity for the two levels being analyzed.

Air Side Equipment

Two rooftop air handlers were modeled for the two levels. Each air handler was modeled with air to air energy recovery in the form of an energy recovery wheel recovering energy from the general exhaust air. Both air handlers supply to Constant Air Volume Terminal Units on the IBS floors for the building spaces.

Conclusion

The following results display the comparisons in cooling loads and heating loads with both the design engineers proposed system and the modeled system. There are slight differences in total supply CFM which may be due to overcompensating in equipment and lighting loads for the building spaces. There are significant differences in the heating and cooling loads, this error may be due to the central utility plant being over designed. The CUP for the hospital was designed to serve the entire building, so for this model, only one gas fired steam boiler and one centrifugal chiller was modeled. In order to keep the models consistent, the same capacity for both pieces of equipment were used. By modeling equipment with a high capacity for the spaces' needs, the system is producing extra energy. The central utility plant may be of interest to analyze further later, however, it is beyond the scope of this project.

Table 5 Load Comparison for Design and Calculation

System	Total Supply / OA (CFM)		Cooling (SF/ton)		Heating (Btuh/ft^2)	
	Design	Calculated	Design	Calculated	Design	Calculated
BAHU-2	25,751	28,583	280.37	220.64	22.7	26.05
BAHU-3	24,188	30,633	280.37	177.18	22.7	28.88

Annual Energy Consumption

Fuel Consumption

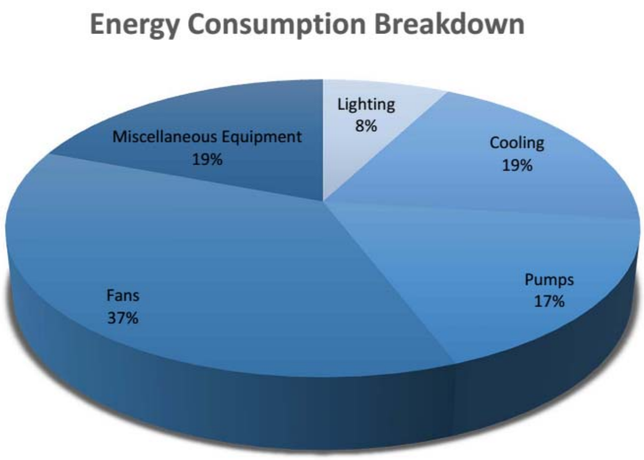

Figure 4 Energy Consumption Breakdown

The Trace 700 Model was analyzed to break out the energy consumption for each of the building components: lighting, miscellaneous equipment, cooling plant, pumps, and fans. As shown in figure 3 to the left, most of the electrical energy usage comes from the fans, however, the heating plant is not modeled in this because it uses mainly natural gas to operate. Overall, the building uses a total of 3550 MWh of electricity.

Figure 4 displays the monthly energy consumption broken down into building loads. The cooling plant load increases during the summer as expected, however the fan does not increase significantly. Since Fort Hood has hot weather year round, it may be the cause of the skewed results.

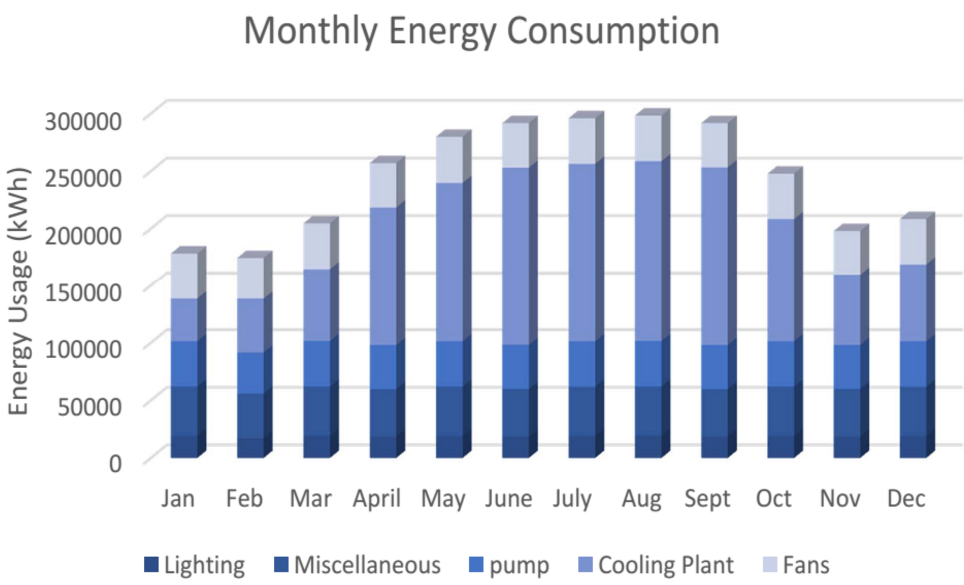

Figure 5 Monthly Energy Consumption

Water Consumption

Figure 5: Monthly Water Consumption, shown below, displays the water consumption in kgal per month with an average increase during the summer months of May through September. Since Fort Hood has higher average temperatures, there is a spike in water usage during the summer because of the demand to cool outdoor air. During the months of June through September, which have the extreme temperature spikes in weather, the water consumption oscillates between 450, and 500 kgal per month. The highest consumption occurs in June with an average of 490 kgal of water.

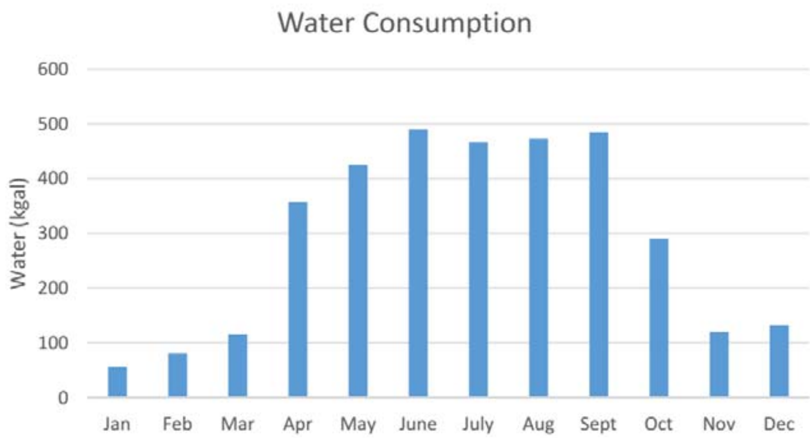

Figure 6 Monthly Water Consumption

Annual Consumption Results

The analysis for the medical center shows most energy is consumed by the cooling process. Since the weather is harsh in Texas, this was expected. However, the fan energy does not equally reflect the spike in cooling demands during the summer. The monthly water consumption is parallel with cooling demand spikes during the summer. The energy breakdown for the modeled building shows most energy being consumed by the fans. The design engineer also had an energy analysis performed. Their energy breakdown according to use showed the miscellaneous equipment load consuming the most energy. The difference in energy consumption may be because of the over design of the CUP which means more energy is going towards the heating and cooling plants in the modeled building in this analysis. The design engineer's energy analysis results showed the designed medical center outperformed the baseline model by 44.5% in energy savings.

Annual Operating Cost

Energy consumption was determined using the average utility costs of Fort Hood, Texas. The average electricity cost is $0.094/kWh, and the average natural gas cost is $0.642/therm. The energy consumption was broken down into the major building components that consume the most energy. The average annual operating cost for the two floors of the medical center is $368,148 which is $5.49/SF per year.

The monthly utility costs are displayed in figure 6: monthly energy costs. This figure shows the energy costs between the two largest energies in demand: natural gas and electricity. Since the weather is extremely hot in Fort Hood, not a lot of heat is needed year round. Therefore, the cost in natural gas stays consistent. The boilers create enough heating hot water for the equipment, and exterior zones, but the bulk of the monthly energy costs go to electricity because of the lighting, miscellaneous equipment loads, and fan energy.

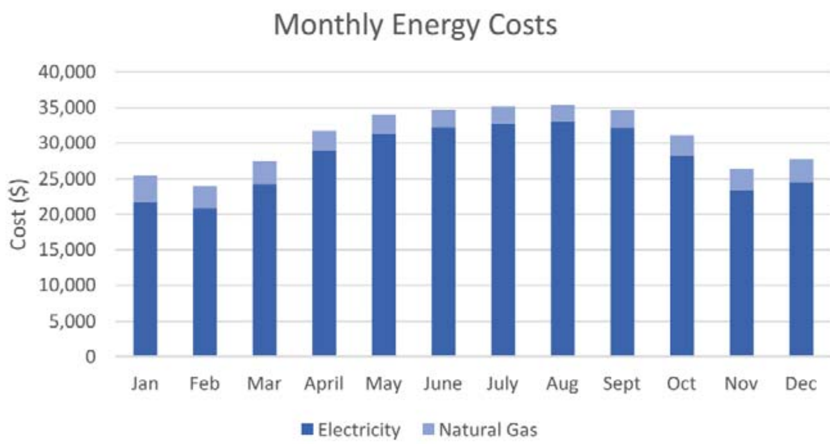

Figure 7 Monthly Energy Costs

Operating Costs per Equipment Use

The operating costs were broken down into monthly costs for the different equipment and space loads in figure 7: monthly energy costs per use. The cooling plant cost the most according to this analysis by a significant amount. The other loads were roughly the same cost, with miscellaneous loads being the highest. The lighting costs did not change from month to month since they operate on a set schedule, the fan cost also stayed roughly the same which was mentioned previously with figure 4.

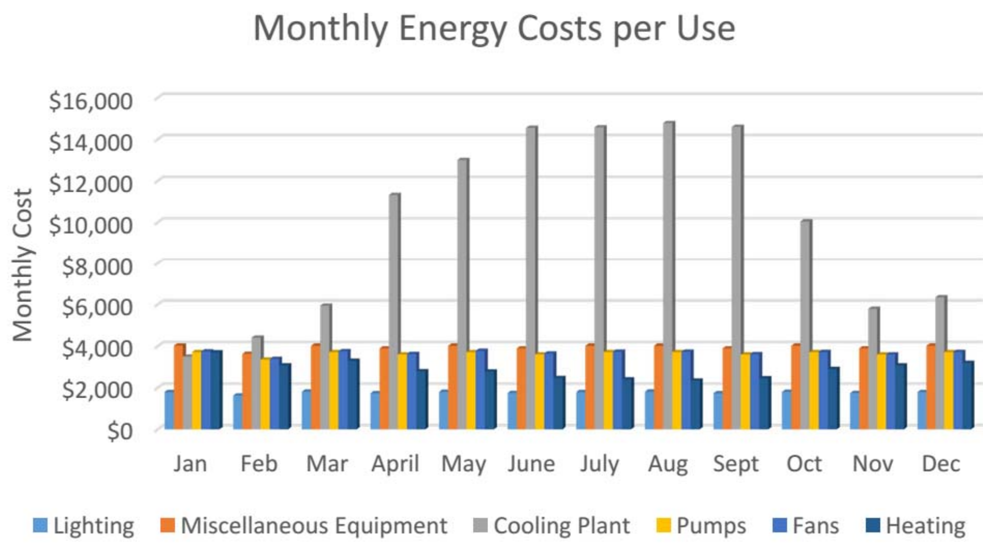

Figure 8 Monthly Energy Costs Per Use

Using the monthly operating costs analyzed by the Trace 700 model, the annual costs for the different loads were found. The annual operating costs are displayed in table 6. The highest annual operating cost is for the cooling plant which is $118,810, this is over double the second highest annual cost, the miscellaneous load.

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total Cost
Lighting	$1,795	$1,621	$1,809	$1,735	$1,802	$1,748	$1,788	$1,809	$1,735	$1,802	$1,742	$1,788	$21,171
Miscellaneous Equipment	$4,019	$3,628	$4,016	$3,887	$4,016	$3,887	$4,016	$4,016	$3,887	$4,016	$3,887	$4,017	$47,293
Cooling Plant	$3,495	$4,404	$5,941	$11,313	$12,998	$14,546	$14,574	$14,773	$14,590	$10,042	$5,789	$6,345	$118,810
Pumps	$3,713	$3,353	$3,713	$3,593	$3,713	$3,593	$3,713	$3,713	$3,593	$3,713	$3,593	$3,713	$43,714
Fans	$3,738	$3,388	$3,750	$3,623	$3,771	$3,642	$3,726	$3,727	$3,608	$3,714	$3,594	$3,720	$43,999
Heating	$3,700	$3,065	$3,290	$2,789	$2,779	$2,464	$2,400	$2,344	$2,452	$2,895	$3,066	$3,191	$34,438

Table 6 Annual Energy Cost per Load

Emissions

The location of the army medical center puts it on the Electric Reliability Council of Texas (ERCOT) Interconnection. Using the emission factors for the ERCOT electricity grid in Source Energy and Emission Factors for Energy Use in Buildings in Appendix C, the delivered energy to the building emits 6.07 million lbs of CO_2, 7810 lbs of NOx, and 34,435 lbs of SO_2. Although the CO_2 emission is significantly larger than the other greenhouse gases, the amount of CO_2 is not considered dangerous.

Pollutant	Emission (lb/yr)
CO_2	6,070,500
SO_2	34,435
NO_x	7,810

Table 7 Emission Pollutants

Appendix A: Climate Data

2009 ASHRAE Handbook - Fundamentals (IP)

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FORT HOOD/GRAY AAF, TX, USA WMO#: **722576**

Lat: **31.07N** Long: **97.83W** Elev: **1024** StdP: **14.16** Time Zone: **-6.00 (NAC)** Period: **82-06** WBAN: **99999**

Annual Heating and Humidification Design Conditions

Coldest Month	Heating DB		Humidification DP/MCDB and HR						Coldest month WS/MCDB				MCWS/PCWD to 99.6% DB	
			99.6%			99%			0.4%		1%			
	99.6%	99%	DP	HR	MCDB	DP	HR	MCDB	WS	MCDB	WS	MCDB	MCWS	PCWD
1	23.7	28.2	9.8	9.4	33.5	14.8	12.1	37.6	25.8	52.7	23.4	53.6	8.8	350

Annual Cooling, Dehumidification, and Enthalpy Design Conditions

Hottest Month	Hottest Month DB Range	Cooling DB/MCWB						Evaporation WB/MCDB						MCWS/PCWD to 0.4% DB	
		0.4%		1%		2%		0.4%		1%		2%			
		DB	MCWB	DB	MCWB	DB	MCWB	WB	MCDB	WB	MCDB	WB	MCDB	MCWS	PCWD
8	21.6	99.9	73.4	98.1	73.3	95.8	73.5	77.7	90.0	76.9	89.1	76.0	88.0	9.4	160

Dehumidification DP/MCDB and HR									Enthalpy/MCDB						Hours 8 to 4 & 55/69
0.4%			1%			2%			0.4%		1%		2%		
DP	HR	MCDB	DP	HR	MCDB	DP	HR	MCDB	Enth	MCDB	Enth	MCDB	Enth	MCDB	
75.0	136.4	81.0	73.6	130.2	80.1	73.0	127.2	79.8	41.9	89.7	40.9	89.1	40.1	87.7	707

Extreme Annual Design Conditions

Extreme Annual WS			Extreme Max WB	Extreme Annual DB				n-Year Return Period Values of Extreme DB							
				Mean		Standard deviation		n=5 years		n=10 years		n=20 years		n=50 years	
1%	2.5%	5%		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
22.0	19.4	17.8	84.0	18.5	103.4	7.1	2.7	13.3	105.3	9.2	106.8	5.2	108.3	0.0	110.3

Monthly Climatic Design Conditions

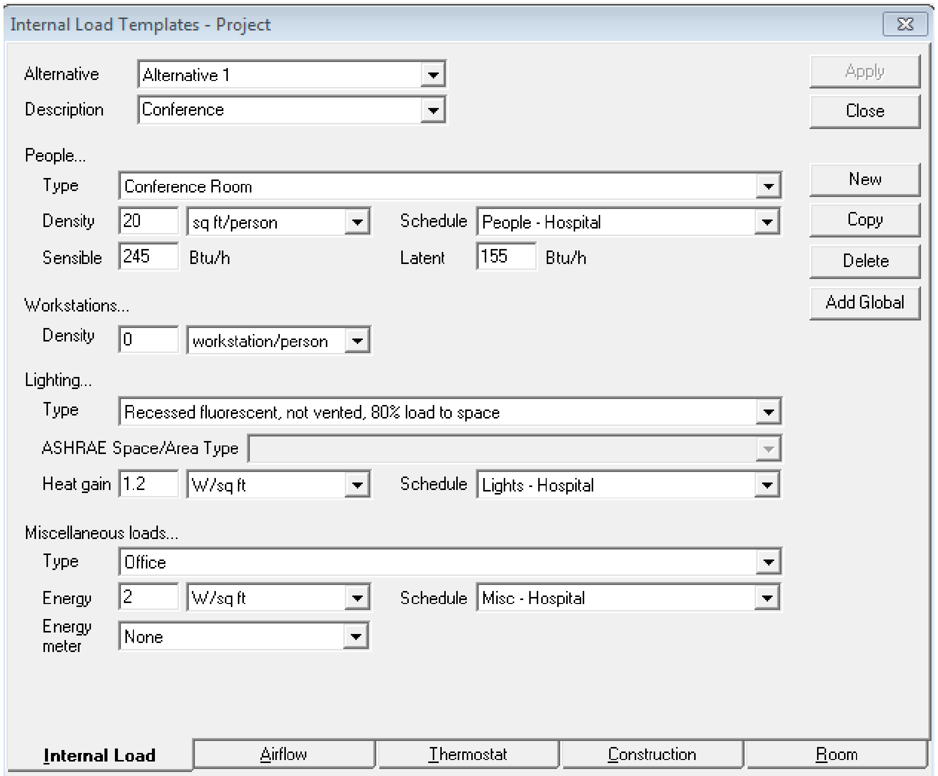
			Annual	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperatures, Degree-Days and Degree-Hours	Tavg		67.6	49.7	52.7	59.7	67.4	74.7	80.5	84.3	84.7	78.4	69.3	58.6	50.1
	Sd			10.17	10.55	8.97	7.38	5.90	4.06	3.39	3.81	6.36	7.72	9.47	10.41
	HDD50		396	131	84	24	1	0	0	0	0	0	2	30	124
	HDD65		1870	480	360	210	60	5	0	0	0	5	47	233	470
	CDD50		6822	123	159	324	524	767	916	1064	1076	852	601	289	127
	CDD65		2817	7	15	44	132	307	466	599	611	406	181	41	8
	CDH74		30323	49	124	331	1070	2713	4999	7441	7634	4210	1470	243	39
	CDH80		14713	6	34	71	319	1066	2380	4074	4228	1996	499	37	3
Monthly Design Dry Bulb and Mean Coincident Wet Bulb Temperatures	0.4%	DB		79.3	84.2	86.3	92.7	97.2	99.7	102.3	102.5	100.2	92.5	84.2	79.0
		MCWB		59.7	60.1	63.5	67.6	71.8	74.7	72.6	73.4	73.1	70.8	67.7	61.6
	2%	DB		73.5	77.3	81.4	86.9	92.5	95.5	99.8	100.0	96.0	89.0	80.2	73.3
		MCWB		59.6	59.5	63.8	67.0	72.7	74.4	73.7	73.2	72.9	69.0	65.8	61.8
	5%	DB		70.0	72.5	77.5	83.6	89.6	93.1	97.4	98.5	93.1	85.9	76.7	70.0
		MCWB		58.3	58.8	62.7	66.7	72.1	74.0	73.5	73.2	72.3	68.9	65.2	60.6
	10%	DB		66.1	68.5	73.5	80.5	86.1	90.8	95.1	96.2	90.3	82.0	72.9	66.3
		MCWB		57.7	58.3	61.9	65.4	71.5	74.1	73.7	73.5	72.0	68.1	64.0	59.3
Monthly Design Wet Bulb and Mean Coincident Dry Bulb Temperatures	0.4%	WB		67.4	67.3	70.2	74.1	78.3	79.1	78.4	78.4	78.1	76.1	72.1	68.4
		MCDB		70.8	71.7	77.4	82.5	88.5	90.9	91.1	92.0	88.5	83.4	78.4	71.5
	2%	WB		64.8	65.6	68.2	72.2	75.9	77.4	77.2	77.2	76.5	74.2	69.9	66.0
		MCDB		68.9	70.9	74.9	80.1	85.8	89.5	90.6	90.4	86.7	81.7	75.5	69.8
	5%	WB		62.4	63.3	66.7	70.6	74.4	76.5	76.2	76.3	75.3	72.7	68.3	63.5
		MCDB		67.2	68.9	72.9	77.9	83.9	88.0	89.5	89.4	85.5	80.3	73.4	68.1
	10%	WB		58.6	60.1	64.7	69.0	73.1	75.4	75.4	75.3	74.3	71.1	66.5	60.2
		MCDB		64.7	66.8	70.6	76.0	82.3	86.3	88.3	88.3	84.5	78.5	71.5	65.0
Mean Daily Temperature Range		MDBR		20.3	19.8	20.6	21.2	19.6	19.6	21.3	21.6	20.9	20.4	19.9	19.6
	5% DB	MCDBR		26.1	25.3	24.4	25.2	22.6	22.0	24.1	24.2	23.5	23.1	22.2	23.7
		MCWBR		15.8	14.0	12.6	12.0	8.4	6.7	5.9	6.0	7.0	9.8	12.3	14.6
	5% WB	MCDBR		20.0	20.0	19.0	19.3	19.2	19.4	21.1	21.2	19.5	18.2	18.3	19.1
		MCWBR		14.8	14.1	12.5	11.2	9.0	7.5	6.2	6.2	7.0	9.4	13.1	14.6
Clear Sky Solar Irradiance	taub			0.324	0.343	0.356	0.388	0.416	0.437	0.440	0.443	0.411	0.360	0.339	0.321
	taud			2.470	2.379	2.338	2.231	2.179	2.143	2.161	2.148	2.259	2.416	2.441	2.523
	Ebn,noon			287	291	294	287	278	270	269	267	273	282	279	283
	Edh,noon			31	36	39	45	47	49	48	48	42	34	31	28

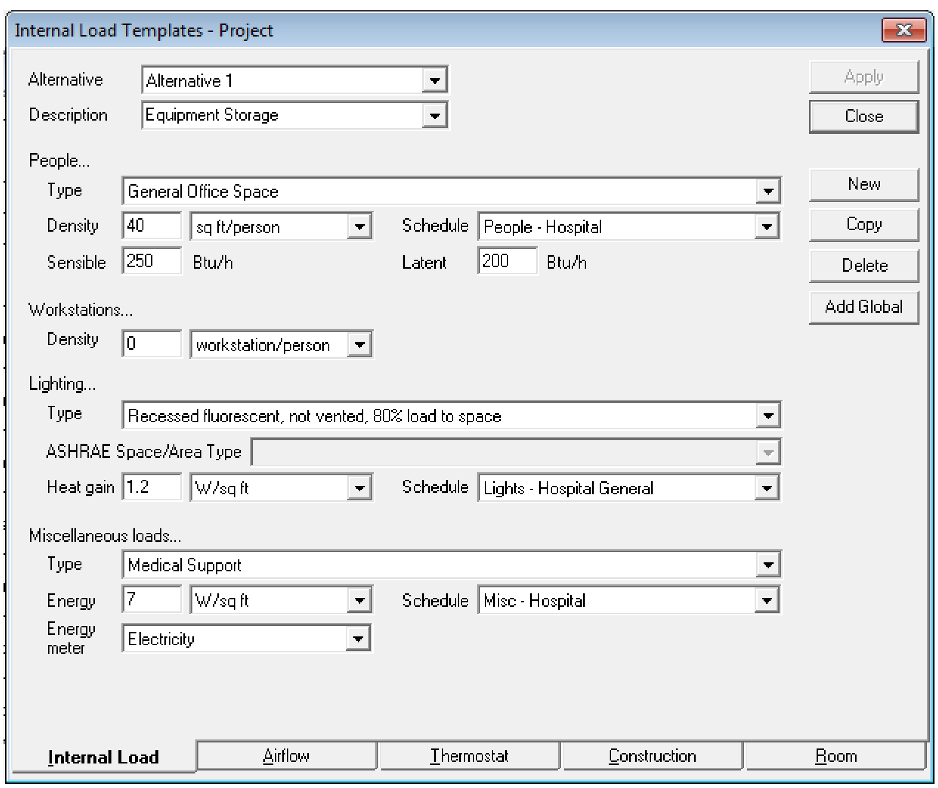
CDD*n* Cooling degree-days base n°F, °F-day
CDH*n* Cooling degree-hours base n°F, °F-hour
DB Dry bulb temperature, °F
DP Dew point temperature, °F
Ebn,noon } Clear sky beam normal and diffuse hori-
Edh,noon } zontal irradiances at solar noon, Btu/h/ft2
Elev Elevation, ft
Enth Enthalpy, Btu/lb
HDD*n* Heating degree-days base n°F, °F-day
Hours 8/4 & 55/69 Number of hours between 8 a.m. and 4 p.m with DB between 55 and 69 °F
HR Humidity ratio, grains of moisture per lb of dry air

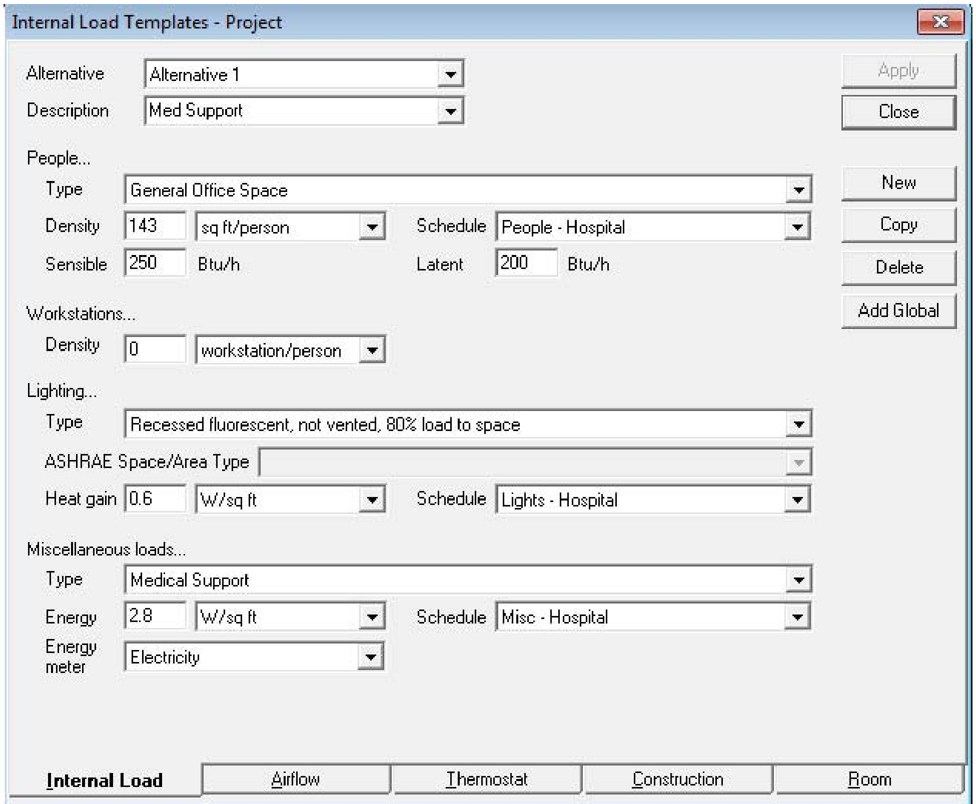
Lat Latitude, °
Long Longitude, °
MCDB Mean coincident dry bulb temperature, °F
MCDBR Mean coincident dry bulb temp. range, °F
MCDP Mean coincident dew point temperature, °F
MCWB Mean coincident wet bulb temperature, °F
MCWBR Mean coincident wet bulb temp. range, °F
MCWS Mean coincident wind speed, mph
MDBR Mean dry bulb temp. range, °F
PCWD Prevailing coincident wind direction, °, 0 = North, 90 = East

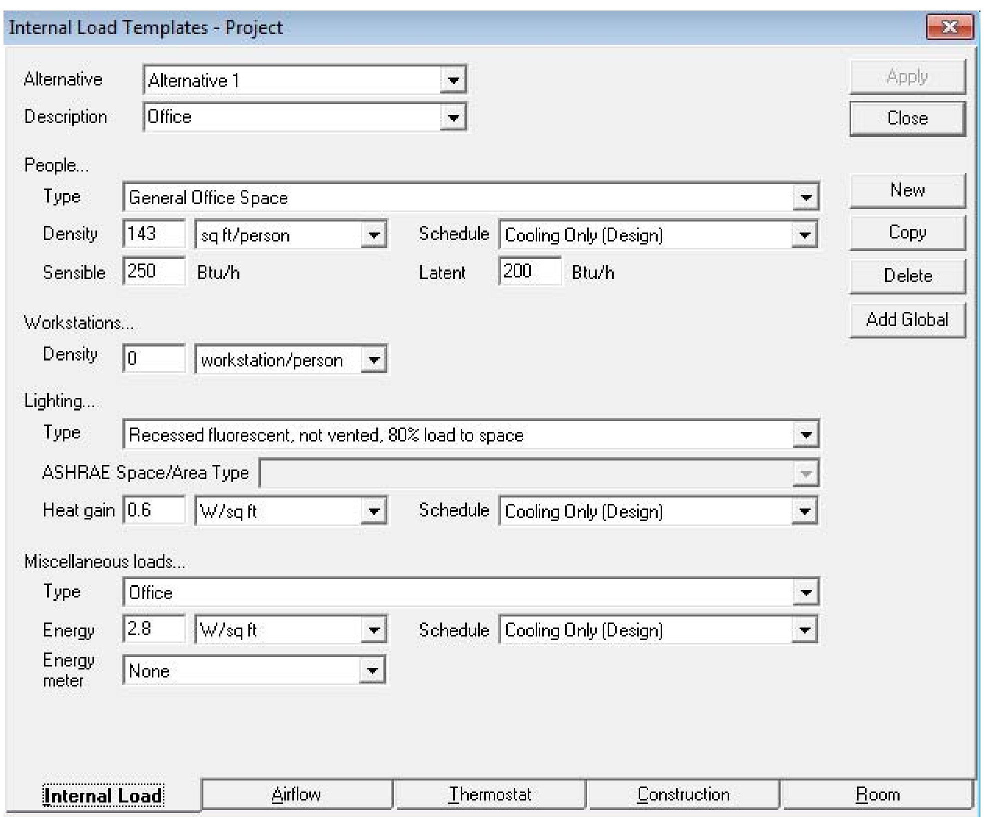
Period Years used to calculate the design conditions
Sd Standard deviation of daily average temperature, °F
StdP Standard pressure at station elevation, psi
taub Clear sky optical depth for beam irradiance
taud Clear sky optical depth for diffuse irradiance
Tavg Average temperature, °F
Time Zone Hours ahead or behind UTC, and time zone code
WB Wet bulb temperature, °F
WBAN Weather Bureau Army Navy number
WMO# World Meteorological Organization number
WS Wind speed, mph

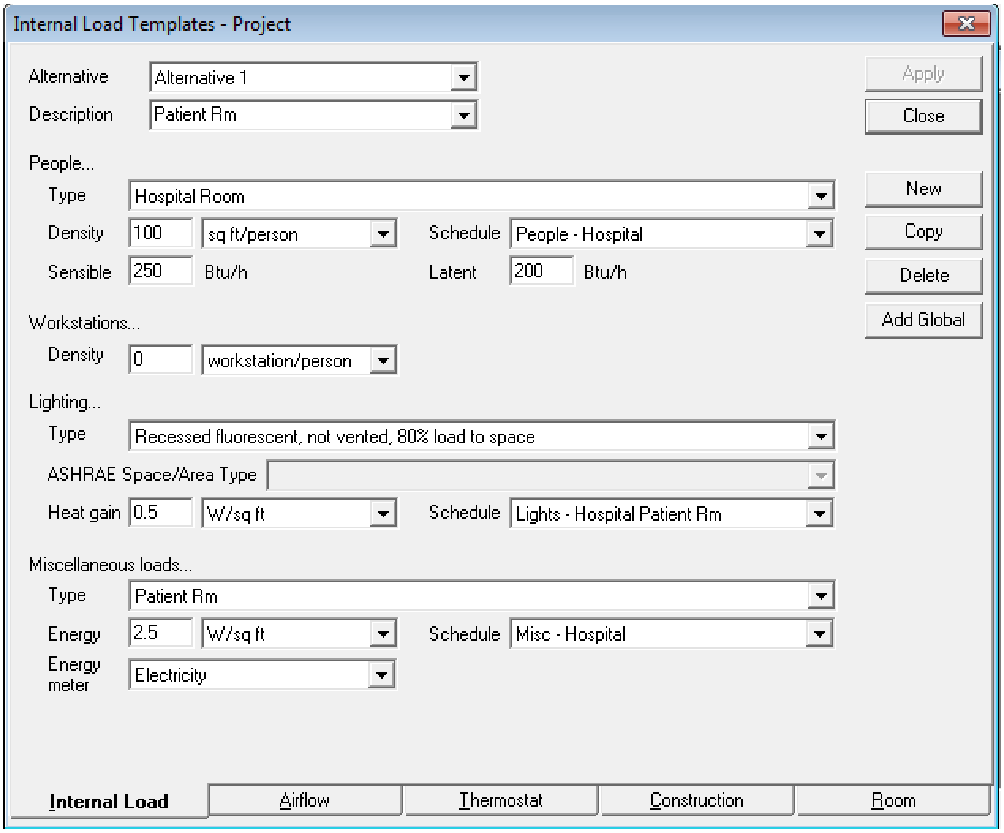
Appendix B: Trace 700 Templates

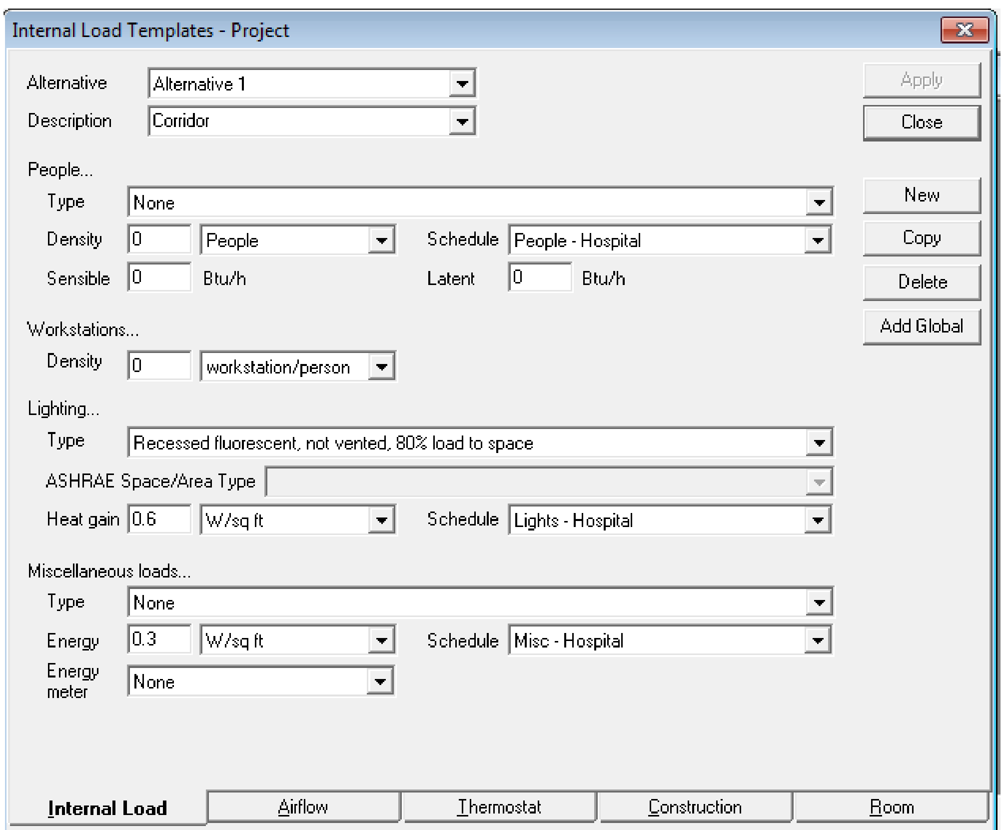





Internal Load Templates - Project
Alternative
Alternative 1
Description
Med Support
Apply
Close
People...
Type
General Office Space
Density
143
sq ft/person
Schedule
People - Hospital
Sensible
250
Btu/h
Latent
200
Btu/h
New
Copy
Delete
Add Global
Workstations...
Density
0
workstation/person
Lighting...
Type
Recessed fluorescent, not vented, 80% load to space
ASHRAE Space/Area Type
Heat gain
0.6
W/sq ft
Schedule
Lights - Hospital
Miscellaneous loads...
Type
Medical Support
Energy
2.8
W/sq ft
Schedule
Misc - Hospital
Energy meter
Electricity
Internal Load
Airflow
Thermostat
Construction
Room


Internal Load Templates - Project
Alternative
Alternative 1
Description
Office
Apply
Close
People...
Type
General Office Space
Density
143
sq ft/person
Schedule
Cooling Only (Design)
Sensible
250
Btu/h
Latent
200
Btu/h
New
Copy
Delete
Add Global
Workstations...
Density
0
workstation/person
Lighting...
Type
Recessed fluorescent, not vented, 80% load to space
ASHRAE Space/Area Type
Heat gain
0.6
W/sq ft
Schedule
Cooling Only (Design)
Miscellaneous loads...
Type
Office
Energy
2.8
W/sq ft
Schedule
Cooling Only (Design)
Energy meter
None
Internal Load
Airflow
Thermostat
Construction
Room


Internal Load Templates - Project
Alternative
Alternative 1
Description
Patient Rm
Apply
Close
People...
Type
Hospital Room
Density
100
sq ft/person
Schedule
People - Hospital
Sensible
250
Btu/h
Latent
200
Btu/h
New
Copy
Delete
Add Global
Workstations...
Density
0
workstation/person
Lighting...
Type
Recessed fluorescent, not vented, 80% load to space
ASHRAE Space/Area Type
Heat gain
0.5
W/sq ft
Schedule
Lights - Hospital Patient Rm
Miscellaneous loads...
Type
Patient Rm
Energy
2.5
W/sq ft
Schedule
Misc - Hospital
Energy meter
Electricity
Internal Load
Airflow
Thermostat
Construction
Room


Internal Load Templates - Project
Alternative
Alternative 1
Description
Corridor
Apply
Close
People...
Type
None
Density
0
People
Schedule
People - Hospital
Sensible
0
Btu/h
Latent
0
Btu/h
New
Copy
Delete
Add Global
Workstations...
Density
0
workstation/person
Lighting...
Type
Recessed fluorescent, not vented, 80% load to space
ASHRAE Space/Area Type
Heat gain
0.6
W/sq ft
Schedule
Lights - Hospital
Miscellaneous loads...
Type
None
Energy
0.3
W/sq ft
Schedule
Misc - Hospital
Energy meter
None
Internal Load
Airflow
Thermostat
Construction
Room

Appendix C: Emission Factors

Table 3 Total Emission Factors for Delivered Electricity
(lb of pollutant per kWh of electricity)

Pollutant (lb)	National	Eastern	Western	ERCOT	Alaska	Hawaii
CO_{2e}	1.67E+00	1.74E+00	1.31E+00	1.84E+00	1.71E+00	1.91E+00
CO_2	1.57E+00	1.64E+00	1.22E+00	1.71E+00	1.55E+00	1.83E+00
CH_4	3.71E-03	3.59E-03	3.51E-03	5.30E-03	6.28E-03	2.96E-03
N_2O	3.73E-05	3.87E-05	2.97E-05	4.02E-05	3.05E-05	2.00E-05
NO_X	2.76E-03	3.00E-03	1.95E-03	2.20E-03	1.95E-03	4.32E-03
SO_X	8.36E-03	8.57E-03	6.82E-03	9.70E-03	1.12E-02	8.36E-03
CO	8.05E-04	8.54E-04	5.46E-04	9.07E-04	2.05E-03	7.43E-03
TNMOC	7.13E-05	7.26E-05	6.45E-05	7.44E-05	8.40E-05	1.15E-04
Lead	1.31E-07	1.39E-07	8.95E-08	1.42E-07	6.30E-08	1.32E-07
Mercury	3.05E-08	3.36E-08	1.86E-08	2.79E-08	3.80E-08	1.72E-07
PM10	9.16E-05	9.26E-05	6.99E-05	1.30E-04	1.09E-04	1.79E-04
Solid Waste	1.90E-01	2.05E-01	1.39E-01	1.66E-01	7.89E-02	7.44E-02

Appendix D: Trace 700 Outputs