ARMY ADMINISTRATION FACILITY

Mid-Atlantic, USA

TECHNICAL REPORT TWO

Building and Plant Energy Analysis

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Table of Contents

Executive Summary

The purpose of this report is to perform block load and energy estimates on the Army Administration Facility using a computer-based whole building load and energy simulation program. For the purposes of this report Trane TRACE™ 700 Version 6.2 was used to perform the energy load analysis and energy consumption per the actual design values provided in the design documents submitted by the mechanical engineers at Southland Industries. The model constructed for this report was then compared to the design loads modeled by the mechanical engineer.

The load simulation made for this report resulted in an estimated cooling load of 302 SF/ton and a heating load of 22 BTUh/SF. These values are around 10% different than the design loads. A total air supply of around 0.96 CFM/SF and a ventilation supply air of 0.25 CFM/SF were also calculated and compared to be around 9% and 0.3 % different than the design loads, respectively.

An analysis of the annual utility consumption was also conducted and concluded a total energy utilization of 5,633,341 kBtu/yr, about 70% of which is consumed by electric energy and the remaining 30% by gas. A monthly breakdown of these systems shows that larger electric loads are met in the summer months, reaching peaks around 140,000 kWh, while the gas loads reach their peak in the winter months around 2,500 therms.

Considering a cost analysis, the building uses about one and a half times more kBtu per year of electric energy than gas energy; however, due to the differences in economic rates, about seven times more money is spent on electric than gas. Regular operation of the building can expect to cost about $107,000 annually for gas and electric utilities.

A final analysis was conducted on the expected pollution emitted from the Army Administration Facility each year. Based on the estimated gas and electric consumption, the building can expect to generate about 1.7 million lbs/year of CO_2.

Building Overview

Located in the heart of the mid-Atlantic region, the Army Administration Facility is a government administration building serving as a Command Headquarters for the U.S. Army. The 97,000 square foot brick facility will house approximately 400 personnel of the U.S. Army Legal Service Agency (USALSA) and JAG Corps. The building's four stories include administrative space, an emergency operations center, a data processing center, executive office suites, a sensitive compartmented information facility, and an adjoining courtroom, as well as a separate above grade parking garage.

The project is actually comprised of two buildings. One, a 20 million dollar, 89,000 SF building for the Office of the Chief, Army Reserve (OCAR) and the second, a 30 million dollar, 97,000 SF general administration facility for USALSA. Both buildings have their own separate above ground parking structures. This project will focus on the second building for USALSA. The contract was awarded in September 2010 and its expected completion is planned -for September 11, 2011 to commemorate the ten year anniversary of 9/11. With only one year to design and construct the facility, the project was considered fast tracked and needed to be design-build to keep on schedule.

An interesting feature to the building is the attached courtroom. The facility houses what could be considered the equivalent to the Supreme Court for the Army, so the majority of the main building contains legal offices. With information sensitive spaces, the building's private offices and conference rooms require floor to ceiling walls to minimize sound dispersion. The end user also requested more thermostatic control, so an RFP was written that specified that a *maximum* of three rooms can be conditioned by any one unit. Since each room is just a small closed office, this made for creative designs of the mechanical systems.

The Army Administration Facility is composed mainly of a prefabricated brick and Concrete Masonry Unit façade. The attached courtroom and adjoining spaces are also prefabricated brick and CMU, with a large percentage of double-paned glazing framed by aluminum panels. An interesting feature of the building is the penthouse; in accordance with height restrictions, the penthouse was placed in a "well" on the fourth floor of the building. This means that a portion of the floor space on the fourth floor was designated for the penthouse, but the façade continues around the building, camouflaging the rooftop units.

The roof at this facility is composed of a reflective white roof membrane, adding to the sustainability of the facility. The building was designed and built to achieve LEED Silver certification. Such features lending to the sustainability of the design include a reflective white roof membrane, a continuous air barrier at all exterior wall assemblies to prevent infiltration and exfiltration, lowering energy consumption, and increased U-values of roof, walls, and windows past the ASHRAE 90.1 baseline minimums.

Mechanical System Overview

The spaces in the Army Administration Building are ventilated with Fan Powered Induction Units (FPIUs) each served by a Dedicated Outdoor Air Unit (DOAU), also known as a Dedicated Outdoor Air System (DOAS), located on the south end of the fourth level. This DOAU is a packaged unit that supplies 100% of the outside air to the building. The FPIU was developed by the Mechanical Engineers at Southland Industries and they serve to both cool and heat the space. This induction unit is similar to old induction units from the 1970s, but this new version utilizes a series fan powered unit controlled by an Electronically Commutated Motor (ECM) that includes an inlet control damper and an airflow ring. These new induction units also include a sensible cooling coil, an optional heating coil, and a face loading filter. The FPIU is able to produce a consistent supply of filtered dry ventilation air and requires 20% of the duct distribution as compared to a VAV system. This is made possible because an FPIU takes in return air directly from the plenum space rather than exhaust duct circulating the air back through an air handling unit. Each FPIU has its own sensible chilled water cooling coil that modulates to space conditions and can operate independently from the main air handler for sensible loads. They are fed by an evaporative condensing chiller supplying 55 degree water throughout the building. The bulk of air conditioning capacity can be carried through small chilled water piping instead of ductwork, reducing infrastructure space requirements by a factor of four. To heat each space the FPIUs also have a heating coil that is served by two boilers in the penthouse. There is a solar hot water heater in the penthouse that provides 30% of the peak domestic hot water load. The remaining 70% of the load is provided by gas fired burners. However, the building will rarely reach its peak load, so the solar hot water heater should consistently provide a majority of the domestic hot water. If the solar hot water heater were to fail, the boilers in the penthouse are also connected to a heat exchanger in the domestic hot water heater as a back-up.

There are also several Variable Air Volume (VAV) units in spaces that have a higher latent load and require more primary air. An FPIU has a limit on the amount of primary air it can handle, so larger spaces, such as the conference rooms and the courtroom, require a VAV to provide more CFMs.

To help increase occupant controlled thermal comfort, each FPIU serves no more than three rooms. They are capable of trending zone conditions and outdoor air rates to avoid issues with indoor air quality.

There are two risers in the core of this building for the mechanical systems to utilize. One is in the north sector of the building. This riser primarily serves exhaust duct from the toilets serviced by an exhaust fan on the roof. The courtroom has its own exhaust fan to service the toilet in that area. The other riser contains the supply duct from the DOAU to each FPIU.

I. System Design Load Estimation

Trane TRACE 700 Version 6.2 was used to determine the design load energy consumption of the Army Administration Facility. Mechanical equipment, lighting, electrical, occupancy, infiltration, direct solar gain, and ventilation loads were taken into consideration and used for the analysis. All other information needed will be taken directly from the drawings or submitted load models provided by the project's mechanical engineers, Southland Industries. A block load analysis was performed for the purposes of this analysis and compared to the space by space analysis performed by the mechanical engineer.

Assumptions

Sample templates and room templates for common office spaces used in the TRACE analysis can be found in ***Appendix A***.

Design Occupancy and Ventilation

Occupancy levels for each space were provided by the mechanical engineer, Southland Industries, and were shown in Appendix A of Technical Report One. The densities for certain rooms, such as conference, break, and reception, were determined from furniture drawings and adjusted from the ASHRAE recommended standards to represent more appropriate densities. The ventilation rates were taken directly from ventilation schedules provided with the submittals and are shown in ***Table 1***.

Table 1- Typical Ventilation Rates

Space Type	SF/ PERSON	OSA CFM /PERSON
Office	143	20
Conference	20	20
Toilet	0	0
Janitor	0	0
Electrical	0	0
Telecom	0	0
Files	0	0
Break	40	20
Storage	0	0
Reception	45	20
Lobby	44	20
Training Room	11	20
Courtroom	20	20
UPS	0	0
Classroom	20	20
Corridor	143	20
Mechanical	0	0
Vestibule	0	0

Infiltration

It was assumed that the Army Administration Facility would have an infiltration cooling and heating rate of 0.03 cfm/sq ft of wall. This is representative of a pressurized, tightly constructed building. This means that the air pressure inside the building is larger than the ambient surrounding, so air is less likely to leak into the spaces. The tight construction is reflective of the building envelope and prevents air from leaking into or out of the conditioned spaces.

Weather Data

Using the ASHRAE Handbook of Fundamentals 2009, the weather data for the Mid-Atlantic region of the country was used (exact location not disclosed per owner's request). The indoor air conditions were taken directly from the design documents and were also discussed in Technical Report One. Indoor and outdoor air conditions were determined and are shown below in ***Table 2a*** and ***Table 2b***.

Table 2a- Summer Design Weather Data

	Summer (0.4%)		
	Indoor Design (F)	Dry Bulb Temp (F)	Wet Bulb Temp (F)
Vestibules	95	93.2	75.1
All Other Spaces	75	93.2	75.1

Table 2b- Winter Design Weather Data

	Winter (99.6 %)		
	Indoor Design (F)	Dry Bulb Temp (F)	Wet Bulb Temp (F)
Vestibules	60	9.6	-
All Other Spaces	70	9.6	-

Miscellaneous and Lighting Loads

The Lighting Power Density (LPD) values and the expected miscellaneous loads for each type of space were provided by the Mechanical Engineers at Southland Industries. These values, rather than those set by ASHRAE Standard 90.1, will be used for the TRACE model because these are the actual values calculated by the engineer based on the luminaires chosen for the spaces. The LPD and Miscellaneous loads for each space type can be found in ***Table 3***.

Table 3- Lighting and Misc. Loads

Space Type	Area ft^2	Lighting W/ft^2	Misc. W/ft^2
Office	41420	1.05	2.5
Conference	4665	1.05	1.5
Toilet	2698	1.05	0.25
Janitor	284	0.5	0.25
Electrical	1120	0.7	35
Server	400	0.7	75
Telecom	540	0.7	40
Files	1867	1.05	1
Break	1384	1.05	1.5
Storage	4046	0.5	0
Reception	2924	1.1	2
Lobby	2022	2.5	0.5
Training Room	2250	1.05	1.5
Courtroom	1780	1.05	0.5
UPS	300	0.7	26
Classroom	602	1.05	20
Corridor	17405	0.7	0
Mechanical	492	0.7	0.5
Vestibule	502	2	0
Total	86701		

Exterior Wall Construction

The exterior wall types for the Army Administration Facility are composed of pre-fabricated face brick on a metal frame with roughly 3” insulation. The wall’s U-Value of U=0.064 was known and input directly into the TRACE templates and a face brick, 2.42” insulation wall type was chosen as the wall construction type because it most closely represented the design of the actual wall. The glazing was designed with a U-factor of 0.4 Btu/h-ft^2-°F. This was most closely related to the Double Coated ¼” window type.

Schedules

Utilization schedules were taken directly from the TRACE model created by the mechanical engineer and reflect the designed operation percentages for different times of the day. Occupancy densities will change depending on the time of the day (ie. offices are mainly occupied between 8 a.m. and 5 p.m.), so the ventilation rates can vary accordingly. Typical occupancy schedules can be found in ***Appendix B***.

Load Results

The results of the TRACE energy analysis show that the load values calculated for this report are within about 10 percent of the design values as documented. ***Table 4*** compares the computed TRACE analysis to the design loads specified in the design documents.

Table 4- Computed and Designed Load Analysis

	Cooling SF/ton	Heating BTUh/SF	Total Supply CFM/SF	Ventilation Supply CFM/SF
Computed	302.18	21.85	0.96	0.251
Designed	279.54	24.67	1.05	0.250
% Difference	8.1%	11.4%	8.9%	0.3%

The largest difference is the heating capacity at 11.4%. The percent differences could be due to many things. The most impacting factor could be differences in assumptions. For example, occupancy densities and miscellaneous loads were calculated for this report using furniture drawings. Also, fenestration calculations were made using elevations and interpretation of a Revit model. These could all result in errors if done differently than the design engineers. Other factors could include the plants selected and omitted. The heating plant, for example, includes a solar hot water heater that could not be modeled in TRACE. It was assumed that this solar hot water heater supplies about 30% of the hot water utilized in the building, so this needs to be taken into consideration when analyzing the energy usage results. Simplifications are made when modeling block loads to make modeling the building easier, so some errors are inevitable, especially when compared to a space by space model.

II. Annual Energy Consumption and Operating Costs

This section of the report will analyze the Army Administration Facility's annual energy consumption and operating costs. The same TRACE model that was used for the system design load estimations earlier in this report will be used to perform a full year energy simulation, using the same ventilation rates and internal generation and envelope values as the previous analysis. A heating and a cooling plant was added to the TRACE model in order to perform this analysis. The building's cooling plant utilizes an evaporative condensing chiller supplying 55 degree water to the cooling coils in the terminal units. This was modeled in TRACE as an air-cooled chiller with a cooling tower, since an evaporative condensing chiller is essentially an air-cooled chiller that has an evaporative component that sprays water across the condensing unit. The heating plant utilizes two 85% efficient gas-fired boilers servicing the heating coils in the terminal units.

Energy Consumption

A breakdown of the systems' energy consumption by component is shown in ***Table 5*** below. As can be seen, the heating loads account for most of the building's annual energy consumption utilizing 29.2% of the total building energy. However, in reality this number would be smaller than represented in the TRACE model. As was already mentioned, the Army Administration Facility has a solar hot water heater that provides 30% of the building's hot water, so the gas loads from the boilers would be much lower. The smallest energy consumer in this building is the auxiliary loads from supply fans and pumps. Advantages of using FPIU units are that each unit is fed from one DOAS unit and each unit has a small

ECM motor. Also, there are no return fans required since all return air is taken directly from the plenum space. This is a large reason why the auxiliary loads are low.

This can be more easily seen in ***Figure 1*** below, which shows a visual breakdown of the annual energy consumption per load category.

Table 5- Energy Usage Breakdown

	Electric kWh	Gas kBtu	Water 1000 gal	Total Building Energy kBtu/yr	% of Total Building Energy
Primary Heating					
Primary Heating		1,631,456		1,631,456	29.0%
Heating Accessories	3,301		51	11,266	0.2%
Heating Subtotal	**3,301**	**1,631,456**	**51**	**1,642,722**	**29.2%**
Primary Cooling					
Cooling Compressor	305,277			1,041,912	18.5%
Tower/Cond Fans	138,821		1,488	473,795	8.4%
Cooling Accessories	876			2,990	0.1%
Cooling Subtotal	**444,974**	**0**	**1,488**	**1,518,697**	**27.0%**
Auxilary					
Supply Fans	10,522			35,913	0.6%
Pumps	6,564			22,403	0.4%
Aux Subtotal	**17,086**	**0**	**0**	**58,316**	**1.0%**
Lighting	**245,155**	**0**	**0**	**836,714**	**14.9%**
Receptacles	**462,025**	**0**	**0**	**1,576,892**	**28.0%**
Total	**1,172,541**	**1,631,456**	**1,539**	**5,633,341**	**100.0%**

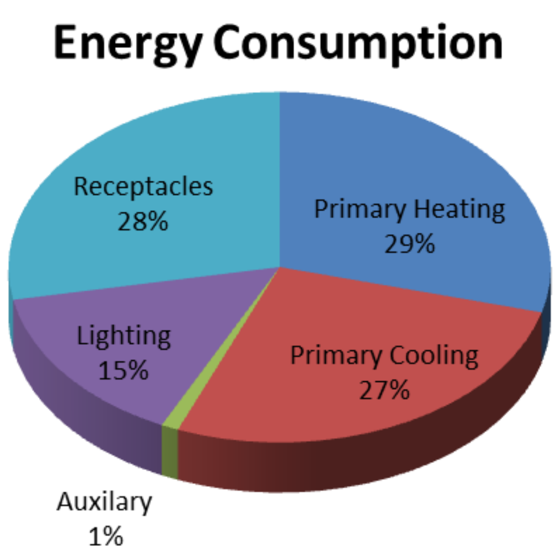

Figure 1- Energy Usage

A monthly breakdown of the energy consumption for electric, gas, and water are shown in ***Table 6*** below. As can be seen by the table and ***Figure 2a***, ***Figure 2b***, and ***Figure 2c***, the electricity and water loads reach their peaks in the summer months, while the gas loads reach their peaks in the winter months. This is a typical trend that would be assumed since the chiller and other cooling equipment require the majority of the water and electricity. Likewise, the boilers are gas-fired and consume all of the gas loads, working at a larger load in the colder months.

Table 6- Monthly Energy Consumption

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Electric [kWh]	72,889	66,283	82,985	80,053	112,102	132,904	140,617	139,980	108,427	86,136	78,901	71,266	1,172,543
Gas [therms]	2,814	2,494	1,574	1,004	762	771	755	831	791	1,097	1,275	2,147	16,315
Water [1000 gal]	44	40	66	79	172	238	275	257	171	87	68	43	1,540

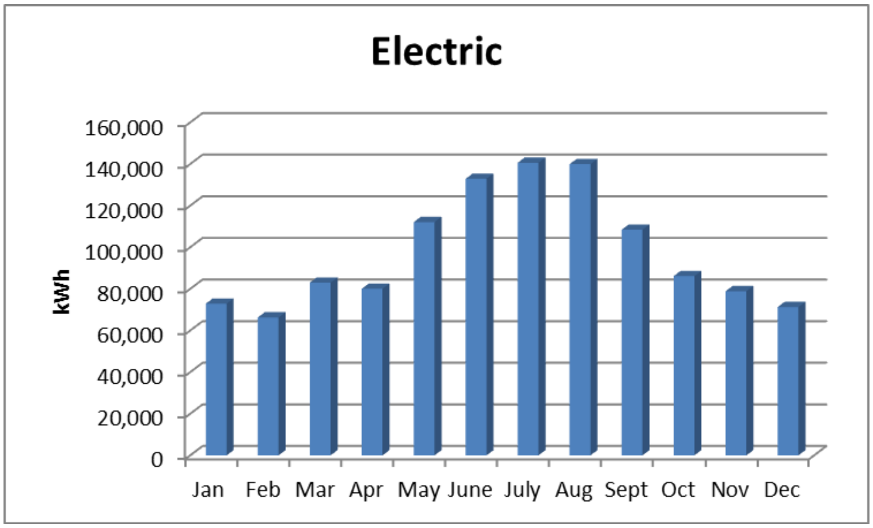

Figure 2a- Electrical Monthly Energy Consumption

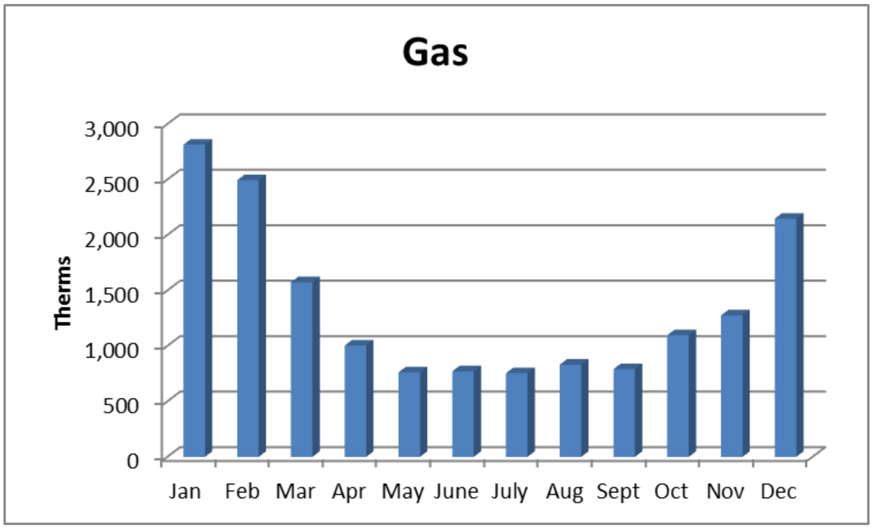

Figure 2b- Gas Monthly Energy Consumption

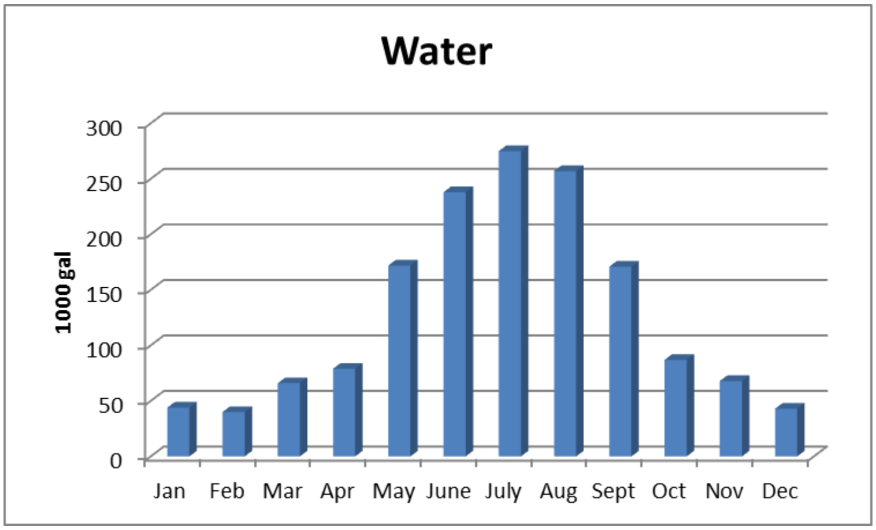

Figure 2c- Water Monthly Energy Consumption

Electrical Consumption

As was just discussed, the heating loads were a major source of the energy consumed annually in the Army Administration Facility. However, heating loads receive the majority of their energy from natural gas, as is reflected in ***Table 7*** and visually in ***Figure 3***, a breakdown of solely the electrical power consumption by component. Primary heating is the smallest consumer of electric power in this building. Receptacles, as can be anticipated, require a large portion (39%) of the electric supply. This is most likely due to the miscellaneous loads added to each room in the TRACE model. Large receptacle loads can result from equipment such as computers, projectors, and other general office equipment that can give off heat.

Table 7- Electric Consumption per Component

	Electric Consumption kWh
Primary Heating	3,301
Primary Cooling	444,974
Auxilary	17,086
Lighting	245,155
Receptacles	462,025
Total	**1,172,541**

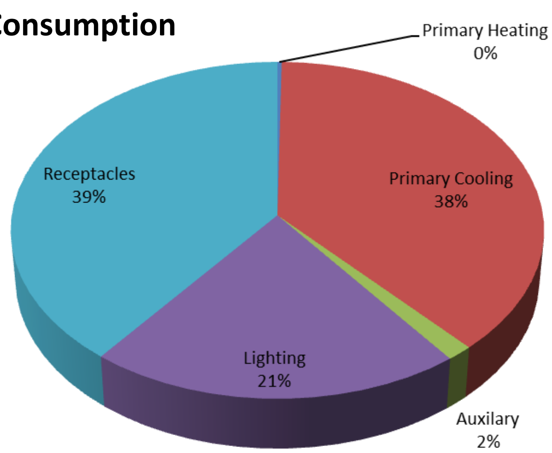

Figure 3- Electric Energy Consumption

Cost Analysis

Assumptions

The Army Administration Facility was opened only recently in September, 2011, so actual utility bills were unable to be obtained. Therefore, the electricity and natural gas rates for the Army Administration Facility's local area were taken from the US Energy Information Administration (EIA) website and shown in ***Table 8***.

Table 8- Local Utility Rates

		Local Rates
Electricity Cost	$/kWh	0.0798
Natural Gas Cost	$/Mcf	8.37

These values were used to perform the cost analysis described below.

Economic Results

Using the electricity and natural gas rates from the EIA for the local (undisclosed) area, it can be concluded that the Army Administration should expect to spend roughly $107,224 per year on gas and electric utilities. This translates to about $1.23 per square foot of energy consumed each year. The building uses about one and a half times more kBtu per year of electric energy than gas energy; however, due to the differences in rates, about seven times more money is spent on electric than gas. These conclusions are summarized below in ***Table 9***.

Table 9- Annual Energy Costs

Rate= 0.0798 $/kWh	**Electric Consumption kWh**	**Cost Per Year $**	**Cost Per SF $**
Primary Heating			
Heating Accessories	**3,301**	**263**	**0.003**
Primary Cooling			
Cooling Compressor	305,277	24,361	0.280
Tower/Cond Fans	138,821	11,078	0.127
Cooling Accessories	876	70	0.001
Cooling Subtotal	**444,974**	**35,509**	**0.408**
Auxilary			
Supply Fans	10,522	840	0.010
Pumps	6,564	524	0.006
Aux Subtotal	**17,086**	**1,363**	**0.016**
Lighting			
Lighting	**245,155**	**19,563**	**0.225**
Receptacles			
Receptacles	**462,025**	**36,870**	**0.424**
Electric Subtotal	**1,172,541**	**93,569**	**1.075**

Rate= 0.837 $/therm Rate= 0.00837 $/kBtu	**Gas Consumption kBtu**	**Cost Per Year $**	**Cost Per SF $**
Primary Heating	1,631,456	13,655	0.157
Primary Cooling	0	0	0.000
Auxilary	0	0	0.000
Lighting	0	0	0.000
Receptacles	0	0	0.000
Gas Subtotal	**1,631,456**	**13,655**	**0.157**

Electric Subtotal [kBtu]	**4,001,885**	**93,569**	**1.075**
Gas Subtotal [kBtu]	**1,631,456**	**13,655**	**0.157**
Energy Total	**5,633,341**	**107,224**	**1.23**

A monthly breakdown of the energy costs for electric and gas are shown in ***Table 10*** below. As can be seen by the table and ***Figure 4***, the electricity costs reach their peaks in the summer months when the load is higher, while the gas loads reach their peaks in the winter months. These trends follow those summarized earlier in the monthly energy consumption section of this report. This is to be expected since the chiller and other cooling equipment require the majority of the electricity. Likewise, the boilers are gas-fired and consume all of the gas loads, working at a larger load in the colder months, thus acquiring higher gas costs in the winter.

Table 10- Monthly Energy Costs

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Electric [$]	5,817	5,289	6,622	6,388	8,946	10,606	11,221	11,170	8,653	6,874	6,296	5,687	93,569
Gas [$]	2,355	2,087	1,318	840	638	645	632	695	662	918	1,067	1,797	13,654

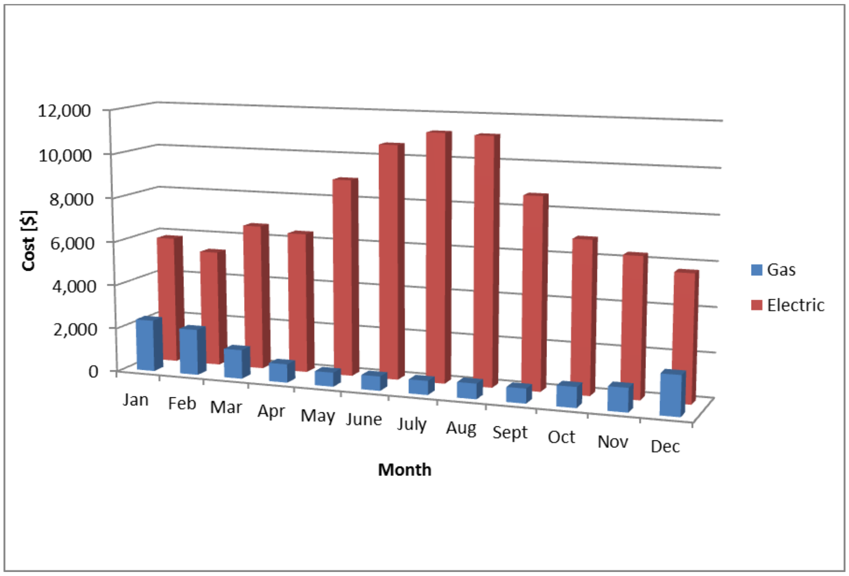

Figure 4- Electric/Gas Monthly Energy Costs

Building Emission Rates

Using the total electric and gas energy consumptions per year from ***Table 5***, the emission rates for the pollutants CO_2, NOx, SOx, and particulates were calculated and are bolded in ***Table 11***.

Table 11- Pollution Emission Rates

	Delivered Electricity by Local State			On-Site Combustion in a Commercial Boiler			
Pollutant	Emission Factor lb/kWh	Electric Consumption kWh/year	Electric Total lbs/year	Emission Factor lbs/1000 ft^3	Gas Consumption 1000 ft^3/year	Gas Total lbs/year	**Total Pollutants lbs/year**
CO_{2e}	1.40E+00	1,172,543	1,641,560	1.23E+02	1,632	200,675	1,842,235
CO_2	**1.33E+00**	**1,172,543**	**1,559,482**	**1.22E+02**	**1,632**	**199,043**	**1,758,525**
CH_4	2.52E-03	1,172,543	2,955	2.50E-03	1,632	4	2,959
N_2O	2.81E-05	1,172,543	33	2.50E-03	1,632	4	37
NO_x	**2.67E-03**	**1,172,543**	**3,131**	**1.11E-01**	**1,632**	**181**	**3,312**
SO_x	**8.04E-03**	**1,172,543**	**9,427**	**6.32E-04**	**1,632**	**1**	**9,428**
CO	9.74E-04	1,172,543	1,142	9.33E-02	1,632	152	1,294
TNMOC	8.77E-05	1,172,543	103	-	-	-	103
VOC	-	-	-	6.13E-03	1,632	10	10
Lead	1.02E-07	1,172,543	0	5.00E-07	1,632	0	0
Mercury	3.24E-08	1,172,543	0	2.60E-07	1,632	0	0
PM10	**7.25E-05**	**1,172,543**	**85**	**8.40E-03**	**1,632**	**14**	**99**
Solid Waste	1.47E-01	1,172,543	172,364	-	-	-	172,364

The emission factors were taken from tables found in the National Renewable Energy Laboratory (NREL) and can be referenced in ***Appendix C***. As is shown, CO_2 pollution is expected to be the major product of both the electric and gas utilization with 1,758,525 lbs/year, while the particulate pollution rate is the smallest product emitting 99 lbs/year.

Conclusion

Modeling a building's performance is important to the engineer when calculating loads and selecting appropriate equipment. Models are also important to the owner when estimating building construction and operation costs, especially with the rising concerns for sustainability and the desire to conserve energy. However, the model is only as accurate as the modeler. The modeling approach and assumptions made by the modeler can alter any model's results, as was evident by the comparisons of the model made for this report and the ones made by the engineers.

The load simulation made for this report resulted in an estimated cooling load of 302 SF/ton and a heating load of 22 BTUh/SF. These values are around 10% different than the design loads. A total air supply of around 0.96 CFM/SF and a ventilation supply air rate of 0.25 CFM/SF were also calculated and compared to be around 9% and 0.3 % different than the design loads, respectively.

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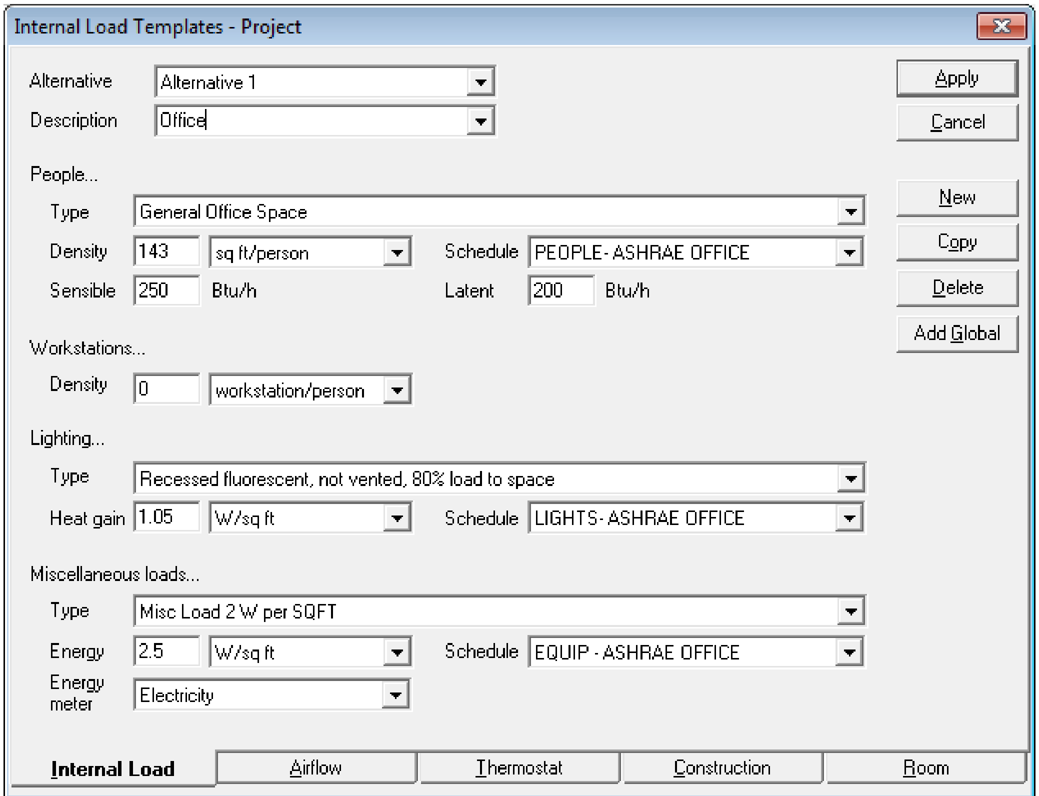
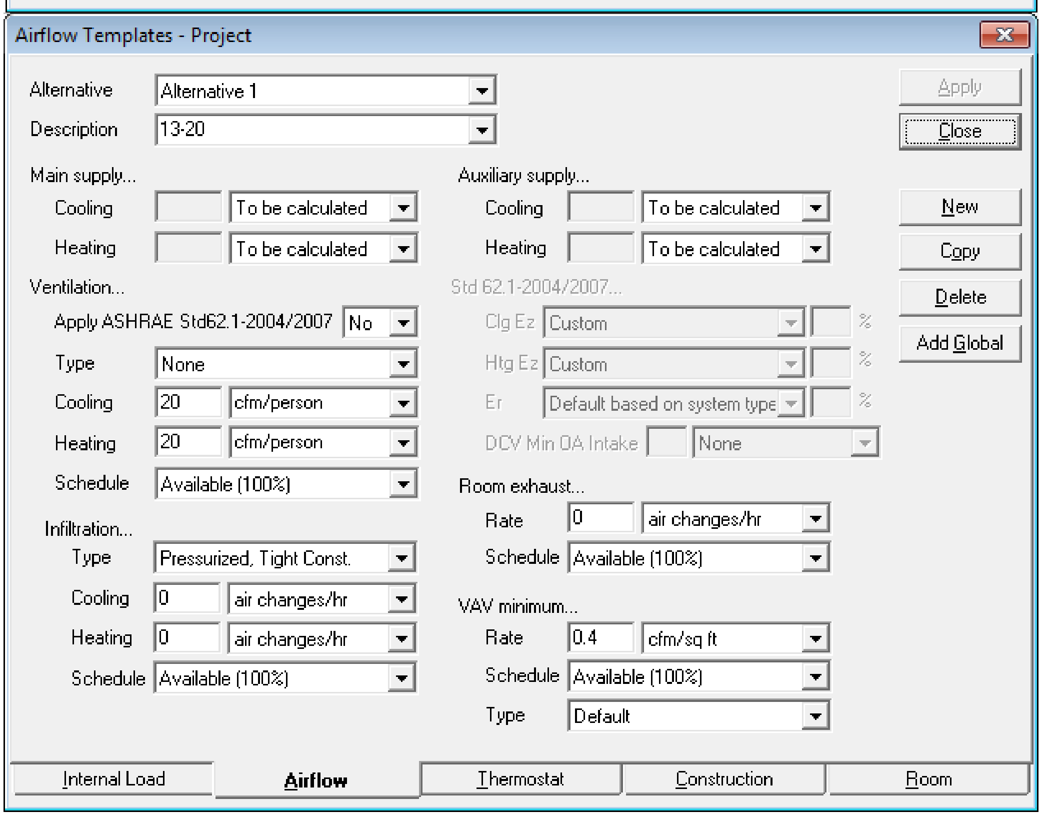
Considering a cost analysis, the building uses about one and a half times more kBtu per year of electric energy than gas energy; however, due to the differences in economic rates, about seven times more money is spent on electric than gas. Regular operation of the building can expect to cost about $107,000 annually for gas and electric utilities.

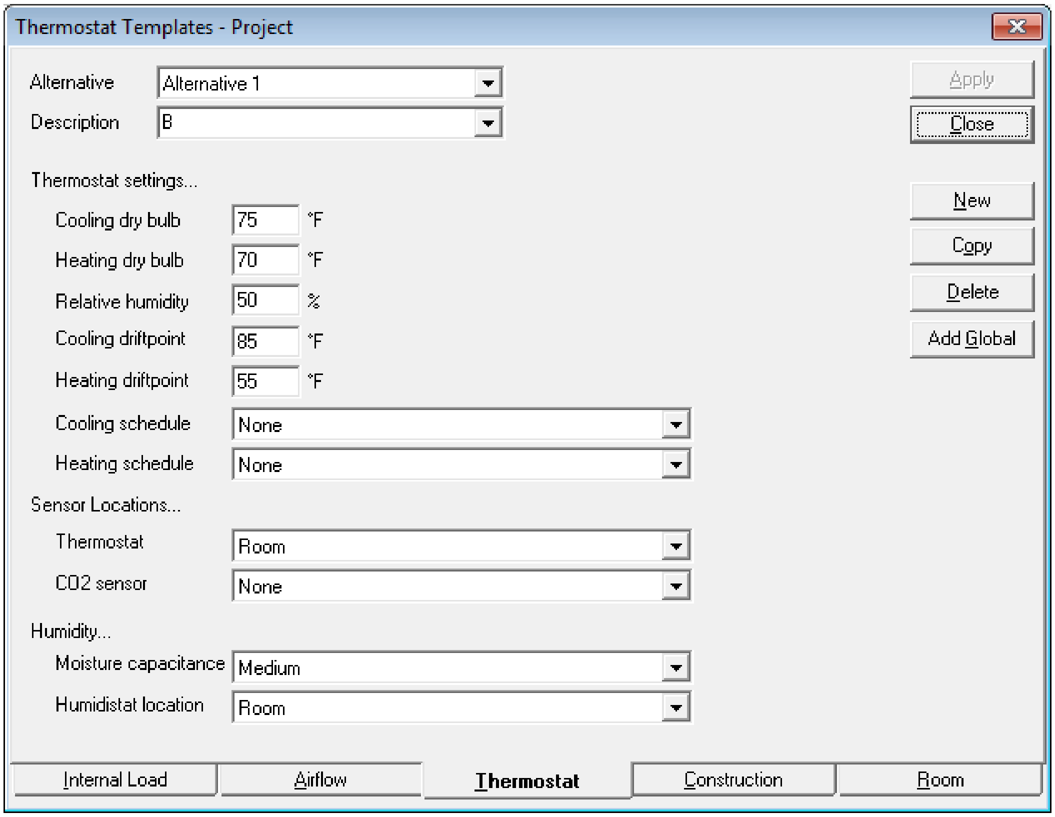
Based on the estimated gas and electric consumption, the building can expect to generate about 1.7 million lbs/year of CO_2.

Appendix A

The following screenshots are taken from typical office spaces used as templates and room templates in the TRACE model used for this analysis. These are just one example of the templates used.



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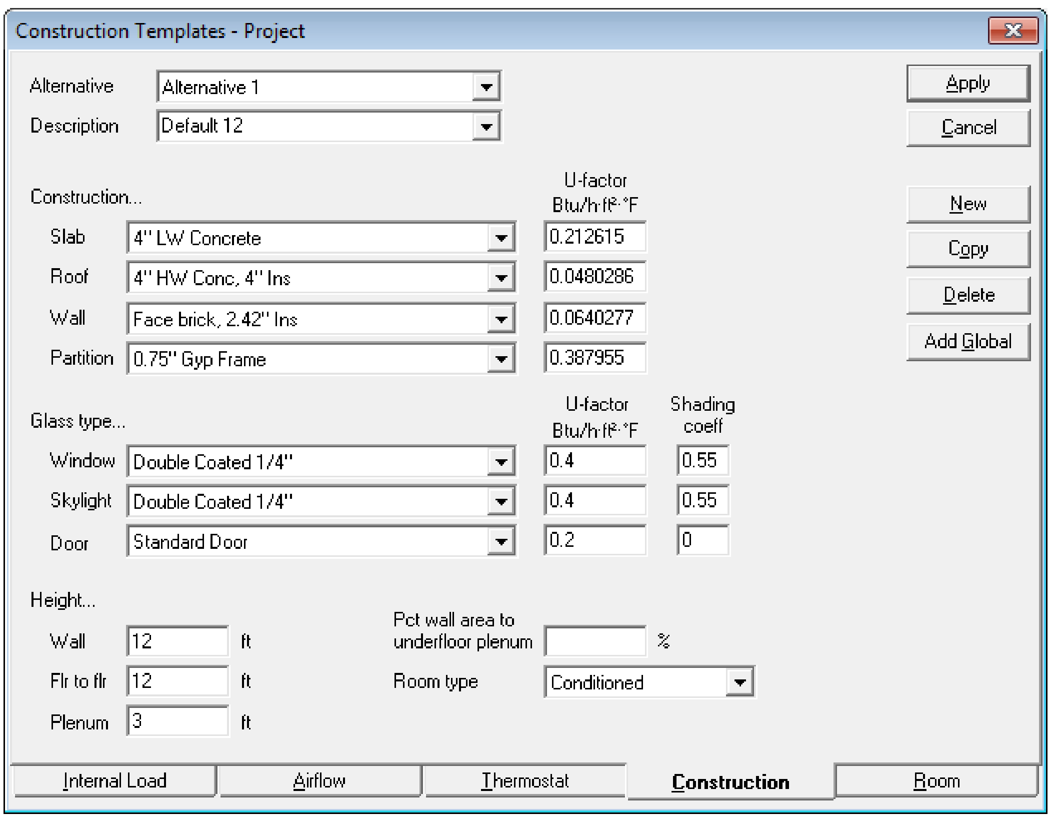
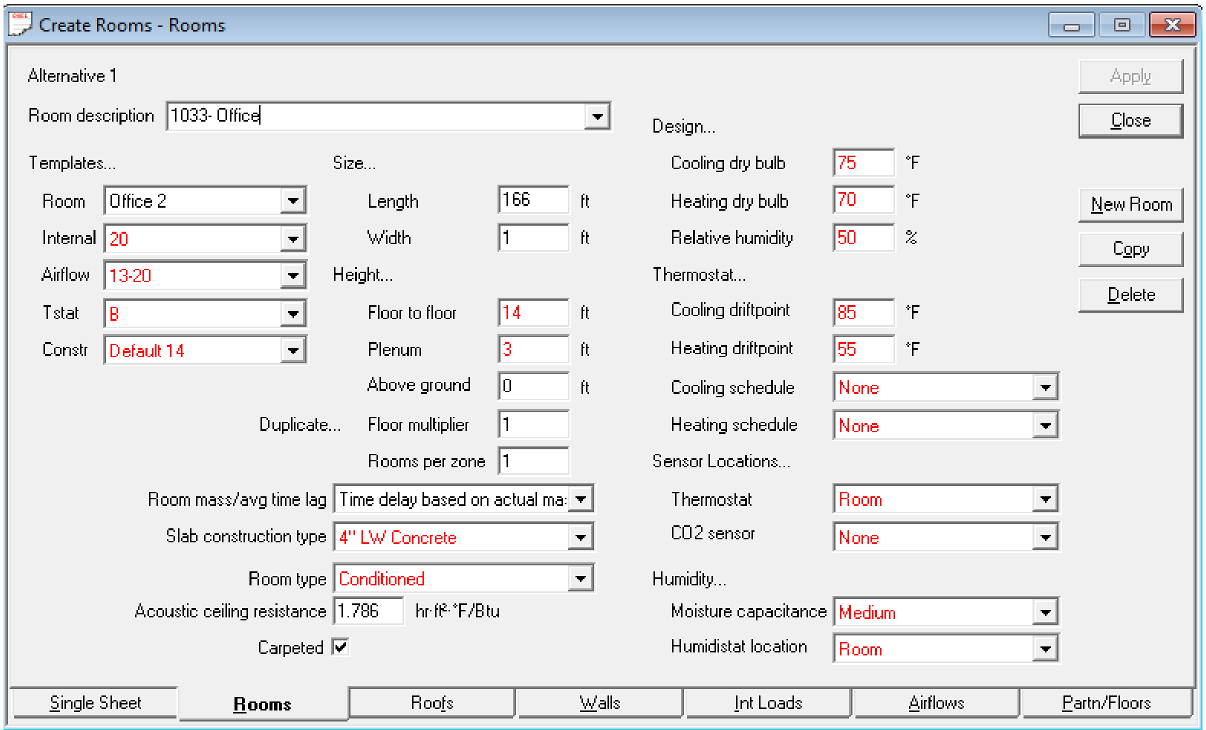
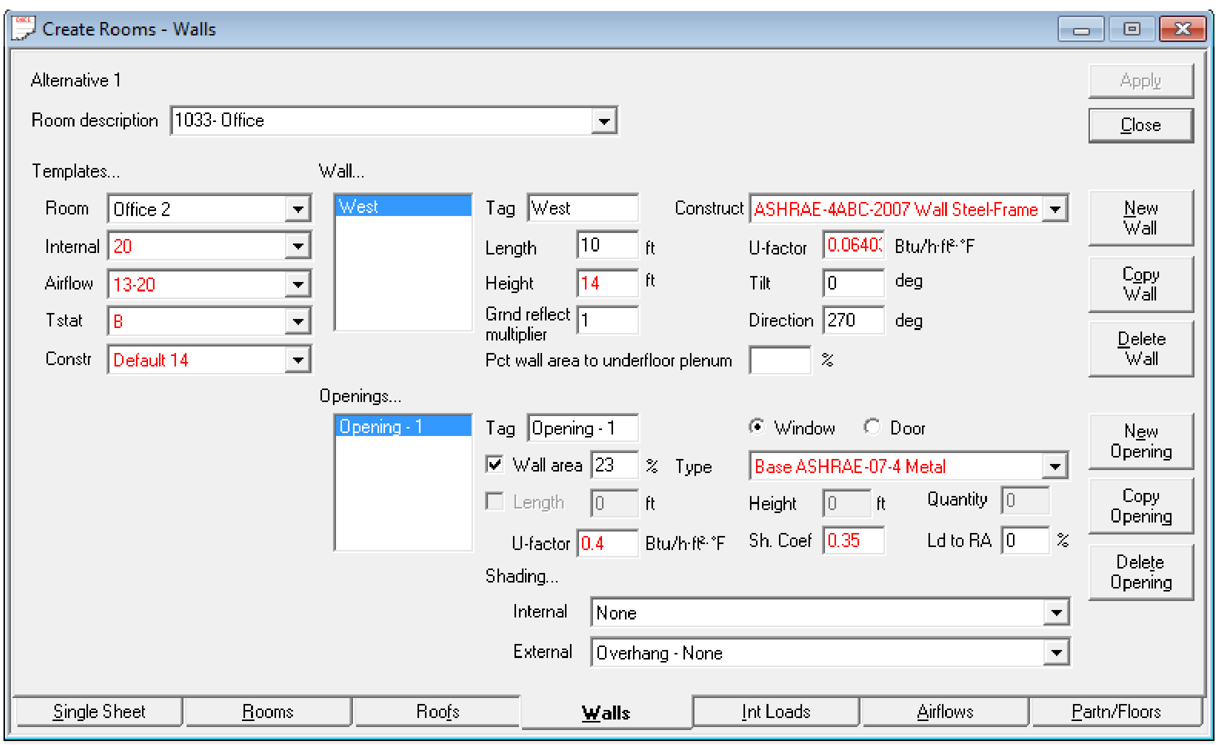
Alternative
Alternative 1
Description
B
Apply
Close
Thermostat settings...
Cooling dry bulb
75
°F
Heating dry bulb
70
°F
Relative humidity
50
%
Cooling driftpoint
85
°F
Heating driftpoint
55
°F
Cooling schedule
None
Heating schedule
None
New
Copy
Delete
Add Global
Sensor Locations...
Thermostat
Room
CO2 sensor
None
Humidity...
Moisture capacitance
Medium
Humidistat location
Room
Internal Load
Airflow
Thermostat
Construction
Room

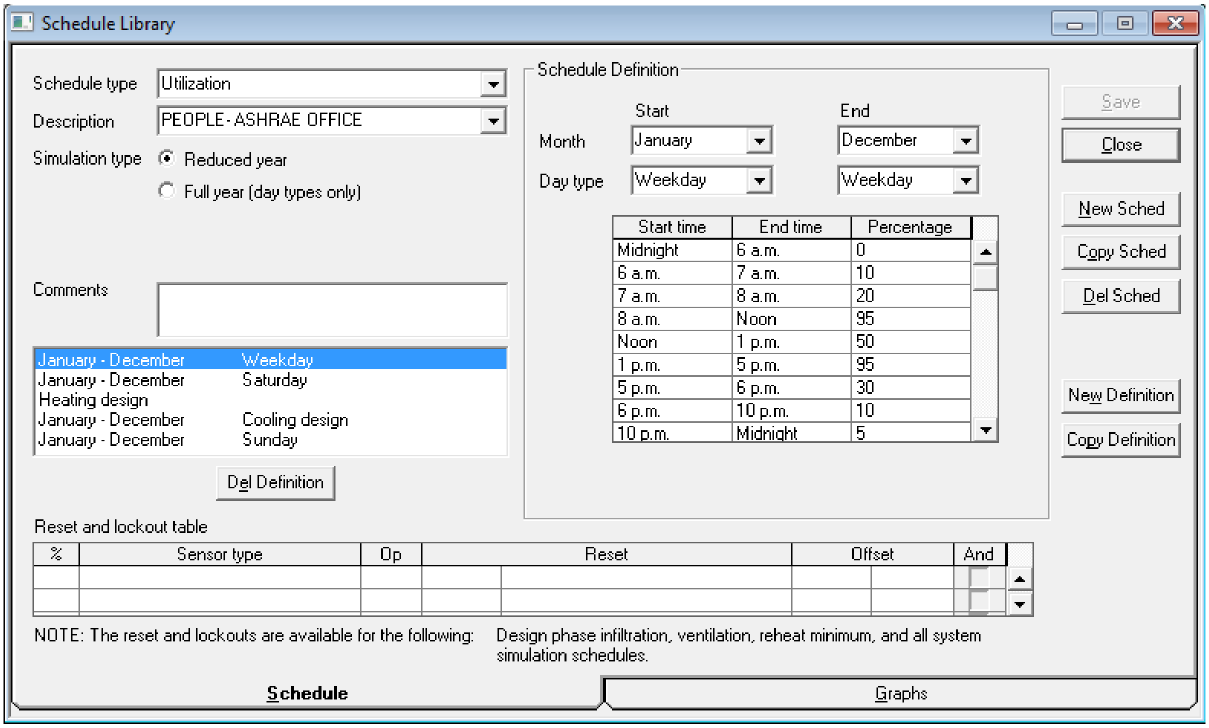

Construction Templates - Project
Alternative
Alternative 1
Description
Default 12
Apply
Cancel
Construction...
U-factor Btu/h·ft²·°F
Slab
4" LW Concrete
0.212615
Roof
4" HW Conc, 4" Ins
0.0480286
Wall
Face brick, 2.42" Ins
0.0640277
Partition
0.75" Gyp Frame
0.387955
New
Copy
Delete
Add Global
Glass type...
U-factor Btu/h·ft²·°F
Shading coeff
Window
Double Coated 1/4"
0.4
0.55
Skylight
Double Coated 1/4"
0.4
0.55
Door
Standard Door
0.2
0
Height...
Wall
12
ft
Flr to flr
12
ft
Plenum
3
ft
Pct wall area to underfloor plenum
%
Room type
Conditioned
Internal Load
Airflow
Thermostat
Construction
Room

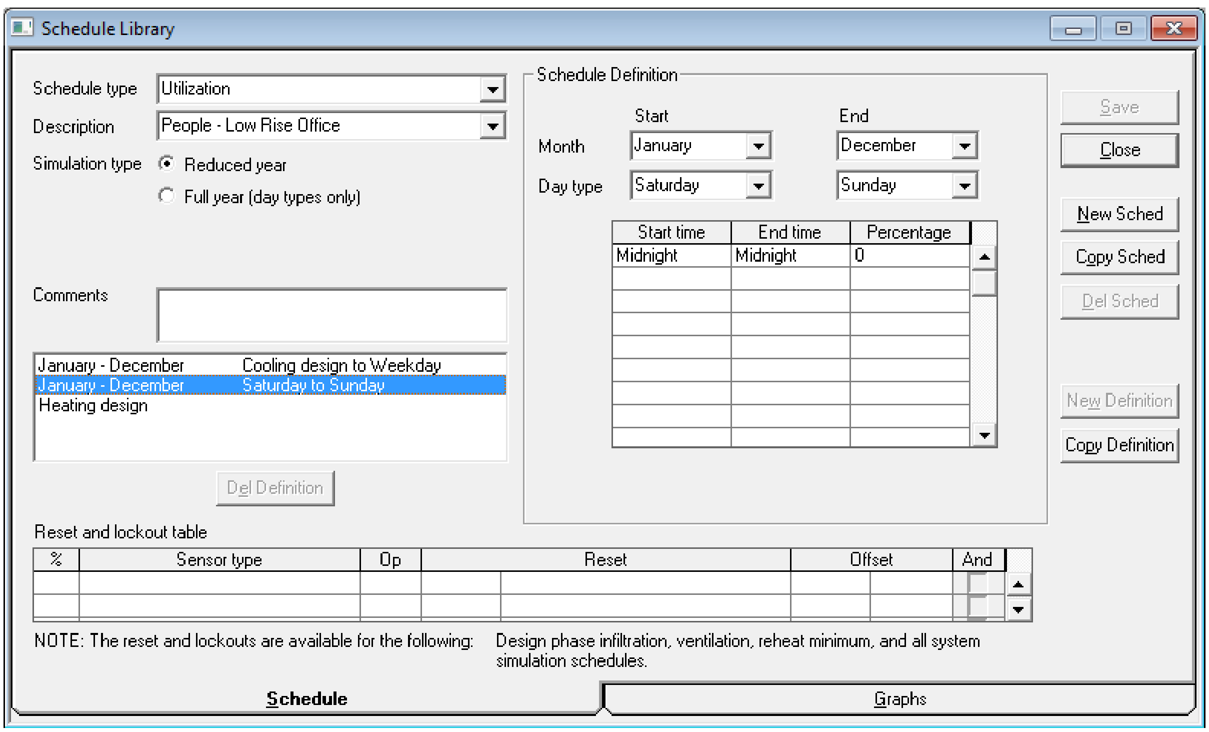

Create Rooms - Rooms
Alternative 1
Apply
Close
Room description 1033- Office
Design...
Templates...
Size...
Cooling dry bulb 75 °F
Room Office 2
Length 166 ft
Heating dry bulb 70 °F
New Room
Internal 20
Width 1 ft
Relative humidity 50 %
Copy
Airflow 13-20
Height...
Thermostat...
Delete
Tstat B
Floor to floor 14 ft
Cooling driftpoint 85 °F
Constr Default 14
Plenum 3 ft
Heating driftpoint 55 °F
Above ground 0 ft
Cooling schedule None
Duplicate...
Floor multiplier 1
Heating schedule None
Rooms per zone 1
Sensor Locations...
Room mass/avg time lag Time delay based on actual ma:
Thermostat Room
Slab construction type 4" LW Concrete
CO2 sensor None
Room type Conditioned
Humidity...
Acoustic ceiling resistance 1.786 hr·ft²·°F/Btu
Moisture capacitance Medium
Carpeted
Humidistat location Room
Single Sheet
Rooms
Roofs
Walls
Int Loads
Airflows
Partn/Floors


Create Rooms - Walls
Alternative 1
Apply
Close
Room description 1033- Office
Templates...
Wall...
Room Office 2
West
Tag West
Construct ASHRAE-4ABC-2007 Wall Steel-Frame
New Wall
Internal 20
Length 10 ft
U-factor 0.0640
Btu/h·ft²·°F
Airflow 13-20
Height 14 ft
Tilt 0 deg
Copy Wall
Tstat B
Grnd reflect multiplier 1
Direction 270 deg
Delete Wall
Constr Default 14
Pct wall area to underfloor plenum %
Openings...
Opening - 1
Tag Opening - 1
Window
Door
New Opening
Wall area 23 %
Type Base ASHRAE-07-4 Metal
Length 0 ft
Height 0 ft
Quantity 0
Copy Opening
U-factor 0.4 Btu/h·ft²·°F
Sh. Coef 0.35
Ld to RA 0 %
Shading...
Delete Opening
Internal None
External Overhang - None
Single Sheet
Rooms
Roofs
Walls
Int Loads
Airflows
Partn/Floors

Appendix B

Typical Occupancy Schedules





Appendix C

Table 8 Emission Factors for On-Site Combustion in a Commercial Boiler (lb of pollutant per unit of fuel)

Pollutant (lb)	Commercial Boiler					
	Bituminous Coal *	Lignite Coal **	Natural Gas	Residual Fuel Oil	Distillate Fuel Oil	LPG
	1000 lb	1000 lb	1000 ft^3 ***	1000 gal	1000 gal	1000 gal
CO_{2e}	2.74E+03	2.30E+03	1.23E+02	2.56E+04	2.28E+04	1.35E+04
CO_2	2.63E+03	2.30E+03	1.22E+02	2.55E+04	2.28E+04	1.32E+04
CH_4	1.15E-01	2.00E-02	2.50E-03	2.31E-01	2.32E-01	2.17E-01
N_2O	3.68E-01	ND †	2.50E-03	1.18E-01	1.19E-01	9.77E-01
NO_X	5.75E+00	5.97E+00	1.11E-01	6.41E+00	2.15E+01	1.57E+01
SO_X	1.66E+00	1.29E+01	6.32E-04	4.00E+01	3.41E+01	0.00E+00
CO	2.89E+00	4.05E-03	9.33E-02	5.34E+00	5.41E+00	2.17E+00
VOC	ND †	ND †	6.13E-03	3.63E-01	2.17E-01	3.80E-01
Lead	1.79E-03	6.86E-02	5.00E-07	1.51E-06	ND †	ND †
Mercury	6.54E-04	6.54E-04	2.60E-07	1.13E-07	ND †	ND †
PM10	2.00E+00	ND †	8.40E-03	4.64E+00	1.88E+00	4.89E-01

* from the U.S. LCI data module: Bituminous Coal Combustion in an Industrial Boiler (NREL 2005)
** from the U.S. LCI data module: Lignite Coal Combustion in an Industrial Boiler (NREL 2005)
*** Gas volume at 60°F and 14.70 psia.
† no data available

Table B-10 Total Emission Factors for Delivered Electricity by State (lb of pollutant per kWh of electricity)

Pollutant (lb)	RI	SC	SD	TN	TX	UT	VA	VT	WA	WI	WV	WY
CO_{2e}	1.18E+00	1.00E+00	1.45E+00	1.46E+00	1.99E+00	2.62E+00	1.40E+00	1.88E-02	4.11E-01	2.03E+00	2.41E+00	2.67E+00
CO_2	1.04E+00	9.57E-01	1.36E+00	1.40E+00	1.85E+00	2.51E+00	1.33E+00	1.78E-02	3.82E-01	1.92E+00	2.31E+00	2.52E+00
CH_4	5.65E-03	1.72E-03	3.02E-03	2.43E-03	5.80E-03	4.21E-03	2.52E-03	2.25E-05	1.13E-03	4.13E-03	3.85E-03	5.42E-03
N_2O	2.04E-05	2.12E-05	3.91E-05	3.28E-05	4.37E-05	5.53E-05	2.81E-05	1.70E-06	1.05E-05	5.32E-05	5.08E-05	7.30E-05
NO_X	7.91E-04	1.90E-03	2.45E-03	2.77E-03	2.42E-03	5.00E-03	2.67E-03	1.38E-04	6.13E-04	3.51E-03	4.62E-03	4.58E-03
SO_X	9.90E-03	5.73E-03	3.97E-03	7.32E-03	1.05E-02	1.47E-02	8.04E-03	1.13E-04	1.70E-03	6.60E-03	1.35E-02	7.05E-03
CO	8.52E-04	3.22E-04	5.26E-04	4.14E-04	9.77E-04	6.89E-04	9.74E-04	5.90E-05	1.80E-04	7.13E-04	6.50E-04	9.00E-04
TNMOC	9.92E-05	4.89E-05	4.12E-05	4.17E-05	8.22E-05	5.78E-05	8.77E-05	1.02E-04	3.74E-05	8.26E-05	5.26E-05	7.43E-05
Lead	6.87E-09	7.66E-08	1.47E-07	1.24E-07	1.49E-07	2.08E-07	1.02E-07	6.33E-10	3.21E-08	1.97E-07	1.92E-07	2.77E-07
Mercury	4.09E-09	1.62E-08	3.01E-08	2.50E-08	2.96E-08	4.15E-08	3.24E-08	1.03E-09	6.62E-09	4.01E-08	3.87E-08	5.54E-08
PM10	7.02E-05	4.61E-05	8.12E-05	6.75E-05	1.37E-04	1.14E-04	7.25E-05	7.67E-06	2.46E-05	1.11E-04	1.05E-04	1.49E-04
Solid Waste	1.31E-02	1.17E-01	2.26E-01	1.91E-01	1.82E-01	3.20E-01	1.47E-01	2.83E-04	4.96E-02	3.03E-01	2.95E-01	4.26E-01

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